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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

Golder Associates Ltd.

2180 Meadowvale Boulevard
Mississauga, Ontario, Canada L5N 5S3
Telephone (905) 567-4444
Fax (905) 567-6561



REPORT ON

**FOUNDATION INVESTIGATION AND DESIGN
PROPOSED HIGHWAY 69 SOUTHBOUND
FOUR LANING OF THE PARRY SOUND BYPASS
McGOWN ROAD OVERPASS
G.W.P. 209-97-00, SITE 44-388S
MTO DISTRICT 52, HUNTSVILLE**

Final

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Submitted to:
Cole, Sherman & Associates
75 Commerce Valley Drive East
Thornhill, Ontario
L3T 7N9



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Lithological and Geotechnical Rock Description Terminology

Record of Borehole Sheets

Drawing N11102S McGown Road Overpass, Southbound Lanes (SBL), Borehole Locations
and Soil Strata

Figure 1

Figure 2

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PART A – FIELD INVESTIGATION

**PROPOSED HIGHWAY 69 SOUTHBOUND
FOUR LANING OF THE PARRY SOUND BYPASS
McGOWN ROAD OVERPASS
G.W.P. 209-97-00, SITE 44-388S
MTO DISTRICT 52, HUNTSVILLE**

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and Soil Strata

Figure 1

Figure 2

1.0 INTRODUCTION

Golder Associates Ltd. has been retained by Cole, Sherman & Associates (Cole, Sherman) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation at the site of the proposed bridge to carry the southbound lanes of the proposed Highway 69 over realigned McGown Road. The McGown Road overpass is part of the Parry Sound Bypass project which involves four laning of a section of Highway 69 from Badger Road northerly 10 km to Sequin River. The new alignment of Highway 69 at the bridge site is located approximately 800 m to the east of the existing Highway 69. This report addresses the proposed bridge and its approaches within 20 m of the structure. The site of the project is designated as Site 44-388S.

The purpose of this investigation is to determine the subsurface conditions at the site of the proposed bridge structure by drilling boreholes, and carrying out in situ tests and laboratory tests on selected samples. Based on our interpretation of the data obtained, recommendations on the geotechnical aspects of design of the proposed works are provided. Comments are also provided on anticipated construction problems where they may affect design of the proposed bridge and approach embankments.

The proposed horizontal and vertical alignment for Highway 69 overpass and the location of the bridge were provided to us on the 1:5000 plan and profile for the Route Planning Study drawings. The locations of the bridge abutments were staked in the field by Cole, Sherman.

The terms of reference for the scope of work are outlined in our proposal letter P71-1494, dated November 26, 1997. The work was carried out in accordance with our Quality Control Plan for Foundation Design Services, dated March 3, 1998. During the course of the field work, the number of boreholes was increased to accommodate the site conditions as encountered.

2.0 SITE DESCRIPTION

The site is located approximately 800 m to the east of the existing Highway 69 and 2 km to the south of Parry Sound, Ontario. The site is located within the MTO District 52, Huntsville and is designated as Site 44-388S.

The topography of the site is relatively flat; the ground surface on both sides of the road varies between Elevations 221.5 m and 223.2 m and generally rises to the south. The existing McGown Road is a gravel road about 5 m in width. The grade of the existing McGown Road in the area of the proposed bridge is at about Elevation 223.5 m. Thick forest extends on both sides of the existing McGown Road.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on May 11, 1998 and May 12, 1998. At this time ten boreholes were drilled at the proposed bridge site; Boreholes 1, 2 and PH1 to PH3, were drilled at the proposed north bridge abutment and Boreholes 3, 4 and PH4 to PH6 were drilled at the location of the south abutment. In addition, two boreholes, numbered Borehole 10 and 11, were put down within the north and south approach embankments, respectively. The investigation was carried out using a bombardier mounted CME 55 drill rig supplied and operated by Marathon Drilling Inc. of Ottawa. Boreholes 5 to 9, 12 and PH7 to PH12 were put down for the northbound lane structure and are reported separately.

Soil samples were obtained at regular intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with Standard Penetration Test (SPT) procedures. Boreholes 1 and 3 were advanced to 6.3 m and 7.7 m depths, respectively, with bedrock coring; NQ size core samples were obtained from the boreholes. Boreholes 2, 4, 10 and 11 and PH1 to PH6 were drilled to refusal on bedrock which was encountered between 0.6 m and 2.3 m depths. Groundwater conditions in the open boreholes were observed throughout the drilling operations. A piezometer was installed in Borehole 1 to permit monitoring of the groundwater level at the site.

The field work was supervised on a full-time basis by a member of our technical staff who located the boreholes in the field, directed the drilling, sampling and in situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labeled containers and transported back to our laboratory in Mississauga for further examination. Index and classification tests were carried out on selected samples.

The as-drilled borehole locations were determined by our field personnel based on the highway chainages and foundation unit limits as staked in the field. Surveyed borehole locations and elevations were provided by Cole, Sherman and we understand that the elevations are referenced to Geodetic Datum. The northing and easting co-ordinates of the borehole locations are indicated on the Record of Borehole sheets; the locations of the boreholes are shown on Drawing N111102S "Borehole Locations and Soil Strata", attached.

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Site Geology

From published geologic information, the site is located in the physiographic region known as the Laurentian Highlands which forms the southernmost part of the Canadian Precambrian Shield (Geology of Ontario; OGS Special Volume 4). The Laurentian Highlands comprises a southeast-trending, slightly elevated region underlain by Precambrian bedrock which was eroded to form an undulating surface with frequent rounded knobs and ridges. The terrain comprises large expanses of intrusive rocks such as gneisses and gneissic or massive granitic rocks. The rocks are geologically complex with considerable folding, intrusive activity, regional metamorphism and faulting. The local physiography is characterized by shallow overburden consisting mainly of outwash sand and gravel and irregular, variable bedrock surface with frequent rock outcrops and shallow bedrock. Since irregular bedrock surface is typical in the area, terrain with organic deposits is widespread.

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets, following the text of this report. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations.

Relevant information on subsurface conditions was obtained from Boreholes 1, 2 and PH1 to PH3 put down to the north of McGown Road (at the location of north abutment), Boreholes 3, 4 and PH4 to PH6 put down to the south of McGown Road (at the location of south abutment), and Boreholes 10 and 11 located within the north and south approaches.

In summary, the soils encountered in the boreholes consist of native silty sand and sand deposits extending to the bedrock surface which was encountered between 0.6 m and 2.3 m depths.

A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Silty Sand

Extending from the ground surface is a deposit of silty sand with trace clay and trace to some gravel. Trace to some organic matter and occasional cobbles were noted in this deposit. The silty sand extends to depths ranging from about 0.6 m to about 0.8 m. The sand is very loose to dense with measured Standard Penetration Test (SPT) 'N' values ranging from 1 blow to 35 blows for 0.3 m of penetration. Grain size distribution test results for one sample of silty sand are shown on Figure 1.

4.2.2 Sand

Underlying the silty sand in all boreholes, except in Boreholes 10 and 11, is a deposit of sand with trace to some silt, trace clay and some gravel. Occasional cobbles were noted within this deposit. The sand is compact to very dense; measured Standard Penetration Test (SPT) 'N' values vary from 28 blows for 0.3 m of penetration to in excess of 50 blows per 0.3 m penetration. The sand extends to the bedrock surface at depths ranging from 0.6 m to 2.3 m. Grain size distribution test results for two samples of the sand deposit are shown on Figure 2.

4.2.3 Bedrock

Refusal to further auger penetration in the boreholes was encountered at depths ranging from 0.6 m to 2.3 m. Bedrock was cored in Boreholes 1 and 3 commencing at 1.3 m depth and 1.67 m depth, respectively, confirming that the auger refusal met at the remainder of the borehole locations was very likely on the bedrock surface.

Based on the results of the borings, the bedrock surface is somewhat undulating with surface ranging between Elevation 219.5 m and 222.6 m. The bedrock surface depths and elevations at the borehole locations are summarized below:

<i>Borehole</i>		<i>Ground Surface</i>	<i>Bedrock Surface</i>	
<i>Number</i>	<i>Location</i>	<i>Elevation (m)</i>	<i>Depth (m)</i>	<i>Elevation (m)</i>
1	North Abutment	221.92	1.30	220.62
PH 1		221.90	1.25	220.65
PH 2		221.86	2.29	219.57
PH 3		221.82	2.29	219.53
2		221.66	1.80	219.86
10	North Approach	221.58	0.61	220.97
3	South Abutment	221.81	1.67	220.14
PH 4		221.86	1.22	220.64
PH 5		221.98	1.52	220.46
PH 6		222.25	1.62	220.63
4		222.53	1.60	220.93
11	South Approach	223.16	0.61	222.55

Rock coring was carried out in Boreholes 1 and 3 for lengths of about 5.0 m and 6.0 m, respectively. The Rock Quality Designation (RQD) measured on the core samples ranged from 81 per cent to 98 per cent. Based on the rock core obtained, the bedrock consists of slightly weathered to fresh, crystalline, granitic biotite-hornblende gneiss.

4.3 Groundwater Conditions

The water level in the piezometer installed into Borehole 1 was measured at 1.3 m depth (Elevation 220.6 m) on June 4, 1998. The water level in the open boreholes varied from 0.7 m to 1.2 m depth below the existing ground surface (between Elevations 220.7 m and 221.3 m) on completion of drilling operations. The water level is within the sand / silty sand deposit. It should be noted that water level is subject to seasonal fluctuations.

May 1999

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PART B – FOUNDATION DESIGN

**PROPOSED HIGHWAY 69 SOUTHBOUND
FOUR LANING OF THE PARRY SOUND BYPASS
McGOWN ROAD OVERPASS
G.W.P. 209-97-00, SITE 44-388S
MTO DISTRICT 52, HUNTSVILLE**

5.0 ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides our recommendations on the geotechnical aspects of design of the Highway 69 southbound bridge based on our interpretation of the factual information obtained during the investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

The works described in this report are associated with the proposed bridge and its approaches within 20 m of the structure. It is understood that the proposed Highway 69 southbound lanes will be carried over McGown Road by a one span structure about 12 m in length. It is understood that the final grade of Highway 69 will be at about Elevation 227.5 m and that the realigned McGown Road grade will vary between Elevation 221.0 m and Elevation 221.7 m.

The proposed horizontal and vertical alignment for the Highway 69 overpass and the location of the bridge were provided to us on the 1:5000 Route Planning Study drawings and details were shown on the General Arrangement Plan, McGown Road Overpass, Highway 69 – SBL, prepared by Cole, Sherman, dated February 1999.

5.2 Bridge Foundations

In general, the subsoils at the bridge site consist of a thin veneer of native silty sand and sand extending to the bedrock surface. At the location of the proposed north abutment, the bedrock surface is undulating between Elevation 219.5 m and Elevation 220.7 m, being at approximately 1.3 m to 2.3 m depth below ground surface. At the location of the south abutment, the bedrock surface was encountered between Elevation 220.1 m and Elevation 220.9 m at approximately 1.2 m to 1.7 m depth.

Based on the above, the use of spread footings placed on the bedrock surface is considered appropriate for support of the north and south abutments. Given the bedrock surface elevation at the north abutment, consideration could be given to placement of the spread footing at Elevation 219.4 m across the full length of the footing which would require excavation of as much as 1.2 m of the bedrock at some locations. Alternatively, the founding level could be varied to follow the bedrock surface maintaining the footing on the fresh bedrock. For design, the founding level may be assumed to be Elevation 220.5 m at the east end stepping down to Elevation 219.4 m at the west end of the abutment.

At the south abutment, the spread footing could be placed at Elevation 220 m and as much as 1 m of bedrock excavation would be required, or similarly stepped down between Elevations 220.8 m and 220 m from east to west. Alternatively, the bedrock surface could be exposed along the full length of the footings and the footings placed at the higher elevation with mass concrete used to raise the grade above the bedrock surface to the desired founding level.

In summary, the following founding elevations may be assumed for design:

<i>Abutment Location</i>	<i>Reference Borehole</i>	<i>Founding Elevation Alternatives (m)</i>
North Abutment	Boreholes 1, 2 and PH1 to PH3	219.4 m, or stepped from 220.5 m (east end) to 219.4 m (west end), or at higher elevation with mass concrete used to raise the founding level to the desired elevation
South Abutment	Boreholes 3 and 4 and PH4 to PH6	220.0 m, or stepped from 220.8 m (east end) to 220 m (west end), or at higher elevation with mass concrete used to raise the founding level to the desired elevation

The above founding levels for spread footings on the bedrock are the highest levels feasible. Lower founding levels are appropriate; however, they involve additional bedrock excavation.

A design founding level of Elevation 220.300 m at the north abutment and of Elevation 219.650 m at the south abutment has been provided by Cole, Sherman in the memorandum of May 05, 1999. These founding levels are considered appropriate. At the north abutment, the proposed founding level is between 0.4 m below the bedrock surface and 0.8 m above the bedrock surface as encountered in the boreholes. At the south abutment, the proposed founding level is between 0.5 m and 1.3 m below the bedrock surface. Mass concrete will be required over some portions of the footing at the north abutment, to raise the grade to the founding level after exposing the bedrock and removing any loosened / fractured bedrock.

Bedrock excavation is required for the footing construction at both abutments. In order to maintain the integrity of the bedrock underlying and adjacent to the foundation, special precautions including controlled blasting (pre-shearing or cushion blasting) will be required for the general cut where it is in close proximity to the footings. Good perimeter blasting control is a key to achieve the required competence of the foundations for the abutments, and as such, stringent specification of excavation and support standards is required.

At the above design levels, there may be loose / fractured rock at the bedrock surface which should be removed prior to placing concrete. There may be areas where there is no loosened rock at the bedrock surface in which case it would be feasible to merely expose and clean the surface and place the concrete without subexcavation. In addition, the design should be flexible enough to allow for some further variation in the bedrock surface.

5.2.1 Factored Geotechnical Resistance

Spread footings placed on the fresh bedrock at or below the elevations as specified above may be designed for a factored geotechnical resistance at Ultimate Limit States (ULS) of 10,000 kPa. This value is for vertical concentric loads only. Effects of load inclination and eccentricity need to be taken into account as appropriate. Serviceability Limit States (SLS) conditions do not apply to footings placed on the fresh bedrock.

The factored geotechnical resistance value given above assumes that controlled blasting for road and footing construction is used, that the bedrock at and below the founding level has not been fractured by the blasting and that no adverse jointing is present below the footing.

All footing excavations should be inspected prior to placing concrete to ensure that the base has been adequately cleaned and that the bedrock conditions as exposed at the founding level are consistent with the design assumptions. All loose or shattered rock within the footprint of the footings and at the footing level should be removed and replaced with concrete. If the footing is to be constructed at the higher design elevation, mass concrete may be used to raise the founding level to the desired elevation.

5.2.2 Horizontal Resistance

Resistance to lateral forces / sliding resistance between the concrete footings and bedrock should be calculated in accordance with Section 6-8.4.3 of the OHBDC assuming an unfactored angle of friction of 35 degrees. If necessary, sliding resistance can be supplemented by doweling into bedrock.

A value of 500 kPa may be used for the grout-to-rock bond stress for ULS design. This value refers to the rock-grout interface and can be used for tension design. The actual bond stress along the rock-grout interface may vary from the typical design value given and should therefore be verified in the field. The dowels should be a minimum of 1.0 m long within the rock and the structural strength of the dowel and the compressive strength of the grout should not be exceeded. Provision should also be made in the contract for longer dowels, in the event there are adversely oriented joints in the rock under the footing that could potentially result in a sliding failure toward the cut face.

5.2.3 Frost Protection

For spread footings placed on fresh granitic gneiss bedrock, frost protection cover is not required.

5.3 Lateral Earth Pressures

The lateral pressures acting on the bridge abutments will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill and on the subsequent lateral movement of the structure. The following recommendations are made concerning the design of the abutments and the retaining walls in accordance with OHBDC:

- Select free-draining granular fill meeting the specifications of OPSS Granular A or Granular B but with less than 5 per cent passing the 200 sieve should be used as backfill behind the walls. All granular fill should be compacted in lifts of loose thickness not greater than 200 mm to 95 per cent of the material's Standard Proctor maximum dry density.
- Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill.
- The granular fill may be placed either in a zone with width equal to at least 1.6 m behind the back of the stem (Case I) or within the wedge-shaped zone defined by a 60 degree line extending up and back from the bottom of the rear face of the footing (Case II).
- If the wall support allows lateral yielding of the stem (unrestrained structure), active earth pressures may be used in the geotechnical design of the structure. If the abutment support does not allow lateral yielding (restrained structure), at-rest pressures should be used for geotechnical design.
- A compaction surcharge equal to 16 kPa should be included in the lateral earth pressures for the structural design of the abutment wall in accordance with OHBDC Figure 6-7.4.3.
- For Case I, the pressures are based on the embankment fill materials and the following parameters (unfactored) may be used:

Soil unit weight (assuming clean earth fill)	21 kN/m ³
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Coefficients of lateral earth pressure:

'active'	0.31
'at rest'	0.47

- For Case II, the pressures are based on the granular fill as placed and the following parameters (unfactored) may be used:

	Granular A	Granular B
Soil Unit Weight	22 kN/m ³	21 kN/m ³
Coefficient of Lateral Earth Pressure		
'active'	0.27	0.31
'at rest'	0.43	0.47

It should be noted that the above design parameters assume level backfill and ground surface behind the wall. Other aspects of the abutment granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD-3501.00.

5.4 Excavations

It is understood that the design founding level for the north abutment footing is at Elevation 220.3 m and for the south abutment footing is at Elevation 219.65 m. The excavations for the footing construction will be as deep as 1.6 m at the north abutment and 2.9 m at the south abutment. The excavations will extend through very loose to dense silty sand and compact to very dense sand and will terminate within / on slightly weathered to fresh bedrock.

The water level in the piezometer installed in Borehole 1 located at the south abutment was at 1.3 m depth (Elevation 220.6 m) on June 4, 1998. The water level in the open boreholes ranged from 0.7 m to 1.2 m below the ground surface (between Elevation 220.7 m and Elevation 221.3 m) on completion of drilling operations. Excavations will be extended below the groundwater level and water inflow should be expected through the native sand and the fractured portion of the bedrock. Some form of groundwater control will be required to enable footing construction in the dry. It is anticipated that the inflow can be handled by conventional sump pumping and trenching with sumps located at the base of the excavation. Sumps should be maintained outside the footing area.

Excavations extended through the soils, which will be open for a relatively short period of time can be made in temporary unsupported cut with side slopes within the sand deposits maintained not steeper than 2 horizontal to 1 vertical. Alternatively, if lowering of the groundwater level within the sand is carried out prior to the excavation, the excavation side slopes may be steepened to 1.5 horizontal to 1 vertical.

For excavations extended through the bedrock, vertical sides will be suitable. For the permanent cut slopes through the bedrock, the overall slope to the cut face may be formed vertical to near vertical. The use of carefully controlled drill and blast excavation techniques will be required in order to ensure a neat excavation line and minimize face instabilities and long-term maintenance problems.

The blasting pattern and procedures for the rock excavation (both the general excavation and where adjacent to the proposed bridge footings) should be submitted for approval. The desired specification would be for 80% half barrels to be visible on the cut face after scaling. It is imperative that the joint set orientation be established in the field prior to significant excavation in order to ensure that the appropriate precautions are taken with respect to scaling and bolting. The permanent cut slopes will be up to 1.3 m in height within the bedrock and adverse jointing with inadequate bolting can result in wedge failures.

Inspection of the rock cut face by qualified geotechnical personnel immediately after blasting should be carried out in order to assess where scaling / loosened rock removal should be carried out adjacent to the footings and where rock bolting may be required.

5.5 Approach Embankments

Based on the Route Planning Study drawings showing the proposed horizontal and vertical alignment for the Highway 69 overpass and on General Arrangement Plan provided, the proposed Highway 69 grade will be at about Elevation 227.5 m. The proposed road grade at the overpass will involve approach embankments between 4.5 m and 6.0 m high. Based on the subsurface information, the subsoils within the approach embankments consist of about 0.6 m to 2.3 m of overburden comprising of very loose to dense silty sand and compact to very dense sand. The overburden is underlain by granitic biotite hornblende bedrock.

Given the above, stability of the proposed embankment is not a concern with respect to deep seated failure through the founding soils. There will be minimal settlement of the embankment due to consolidation of the very loose sands and this settlement will occur during embankment construction.

5.6 Subgrade Preparation and Embankment Construction

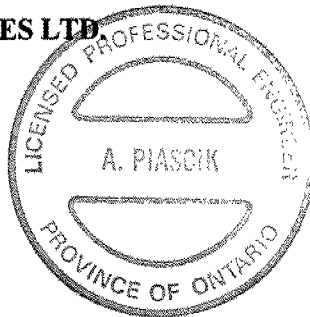
Topsoil and organic deposits should be stripped from below the fill embankment areas and the exposed subgrade soils should be proof-rolled prior to fill placement.

Construction of the embankment above the prepared subgrade may be carried out using clean earth fill (in accordance with OPSS 212) or Select Subgrade Material (in accordance with OPSS 1010), depending on material availability. All embankment fill should be placed in regular lifts with loose thickness not exceeding 300 mm, and be compacted to at least 95 per cent of the material's Standard Proctor maximum dry density. The final lift prior to placement of the granular subbase or base course should be compacted to 100 per cent of the Standard Proctor maximum dry density. Inspection and field density testing should be carried out by qualified geotechnical personnel during all fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved. The permanent slopes of the embankment should be maintained not steeper than 2 horizontal to 1 vertical. Vegetation cover should be established on all soil slopes to protect embankment fill against surficial erosion.

Alternatively, the approach embankments could be constructed using rockfill if available to the project. The permanent side slopes of the rockfill embankments should be maintained not steeper than 1.25 horizontal to 1 vertical.

GOLDER ASSOCIATES LTD

Anna M. Piascik, P.Eng.
Geotechnical Engineer



G. Anne S. Poschmann, P.Eng.
Principal



Fintan J. Heffernan, P.Eng.
Designated MTO Contact



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LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), 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 300 mm (12 in.).

Dynamic Penetration Resistance; N_d :

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 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT):

An electronic cone penetrometer with a 60° conical tip and a projected end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm 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	c_u, s_u kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_r	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane test (LV-laboratory vane test)
γ	unit weight

Note:

1. Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I GENERAL

π	= 3.1416
$\ln x$,	natural logarithm of x
$\log_{10} x$ or $\log x$,	logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stresses (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density \times acceleration due to gravity)

(a) Index Properties (con't.)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity Index $= (w_l - w_p)$
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
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(c) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(d) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (overconsolidated range)
C_s	swelling index
C_α	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	Overconsolidation ratio $= \sigma'_p / \sigma'_{vo}$

(e) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3) / 2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3) / 2$
q	$(\sigma_1 - \sigma_3) / 2$ or $(\sigma'_1 - \sigma'_3) / 2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1. $\tau = c' + \sigma' \tan \phi'$

2. Shear strength = (Compressive strength)/2

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 2 m
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
- Parallel To	
⊥ - Perpendicular To	

NS010001.BHS

DATA INPUT: ps feb 19/99

SOILS6

W.P. 209-98-00
 DIST. 52, SITE 44-338S, HWY 69
 LOCATION: N 5022509.87; E 266670.06

RECORD OF BOREHOLE 1

BORING DATE: MAY 11/98

SHEET 1 OF 2

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT Wp W Wl				
0	CME 55 BOMBARDIER FOLLOW STEM POWER AUGERS	GROUND SURFACE	221.92	1 50 DO	11						 BACKFILL Note: Water level in open hole influenced by water during rock coring.
Silty Sand, trace clay, some gravel, trace organics Compact Brown		0.00									
1		Sand, some silt, some gravel, trace clay, occ. cobble Dense Grey	221.16 0.76			2 50 DO	40				
2		BOREHOLE CONTINUED; FOR BEDROCK CORING DETAILS REFER TO SHEET 2.	220.82 1.30								
3											
4											
5											
6											
7											
8											
9											
10											

CONTINUED ON NEXT PAGE

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

NS010001 BHR

W.P. 209-97-00
 DIST. 52, SITE 44-388S, HWY 69
 LOCATION: N 5022509.87; E 266670.06

RECORD OF BOREHOLE: 1

DRILLING DATE: MAY 11/98
 DRILL RIG: CME 55 BOMBADIER
 DRILLING CONTRACTOR: MARATHON

SHEET 2 OF 2
 DATUM: GEODETIC
 PROJECT: 981-1111



DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	PENETRATION RATE (mm/min.)	FLUSH % RETURN	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	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION							
				DEPTH											RECOVERY TOTAL CORE %	SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k. cm/sec
				(m)																	
0		CONTINUED FROM PREVIOUS PAGE		221.92																	
				0.00																	
1		Borehole continued		220.62																	
				1.30																	
2	NQ CORING	Slightly weathered to fresh, grey crystalline, granitic biotite-hornblende gneiss. (BEDROCK)		1	100																
2				100																	
3																					
4				100																	
5																					
6	MAY 11/98			215.65																	
		END OF BOREHOLE		6.27																	
7																					
8																					
9																					
10																					

BACKFILL

BENTONITE SEAL

SAND

NOTE:
Water level in
piezometer at
Elev. 220.6m on
June 4/98.

NOTE:
 Water level in
 piezometer at
 Elev. 220.6m on
 June 4/98.

BACKFILL

BENTONITE
 SEAL

SAND

J.R.U.E

ST.R.U.E

DEPTH SCALE:

1 to 50

Golder Associates

LOGGED: SB

DATE: JUNE 6/98

CHECKED: AP

DATA INPUT: PS FEB 19/99

ROCKMVS

W.P. 209-97-00
DIST. 52, SITE 44-338S, HWY 69
LOCATION: N 5022501.33; E 266668.65

RECORD OF BOREHOLE 2

BORING DATE: MAY 11/98

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	nat V - + Q - ● rem V - ⊕ U - ○	WATER CONTENT, PERCENT Wp — W — Wl			
				DEPTH (m)									
0	CME 55 BOMBARDIER 101mm SOLID STEM AUGERS	GROUND SURFACE		221.86 0.00							MH		
		Silty Sand, trace clay, some gravel, trace organics Loose Brown			1	50 DO	4						
1		Sand, some silt, trace clay, some gravel, trace cobble Dense to very dense Grey		220.80 0.76	2	50 DO	36						
					3	50 DO	14/ 10						
2		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		219.86 1.80									
3													
4													
5													
6													
7													
8													
9													
10													

NOTE:
Water level in
open hole at 0.7m
depth on completion
of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

NS010003 BHS

DATA INPUT: PS/SIB MAR 1/99
SOILM6

W.P. 209-97-00
DIST. 52, SITE 44-388S, HWY 69
LOCATION: N 5022496.52; E 266680.11

RECORD OF BOREHOLE 3

BORING DATE: MAY 11/98

SHEET 1 OF 2

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT Wp — W — Wi		
0	CME 55 BOMBARDIER 101 SOLID STEM AUGERS	GROUND SURFACE		221.81							
		Silty Sand, trace clay, some gravel, trace organics Compact Brown		0.00	1	50 DO	22				
1		Sand, some gravel, trace clay, some silt, occ. cobble Dense Grey		0.76	2	50 DO	43				
				220.14	3	50 DO	33/ 13				
2		BOREHOLE CONTINUED; FOR BEDROCK CORING DETAILS REFER TO SHEET 2.		1.67							
3											
4											
5											
6											
7											
8											
9											
10		CONTINUED ON NEXT PAGE									

Note:
Water level in
open hole
influenced by
water used during
rock coring.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

NS010003 BHR

DATA INPUT: PS FEB 19/99
ROCKMVS


W.P. 209-97-00
DIST. 52, SITE 44-388S, HWY 69
LOCATION: N 5022496.52; E 266680.11

RECORD OF BOREHOLE: 3

DRILLING DATE: MAY 11/98
DRILL RIG: CME 55 BOMBARDIER
DRILLING CONTRACTOR: MARATHON

SHEET 2 OF 2
DATUM: GEODETIC
PROJECT: 981-1111



DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	PENETRATION RATE (mm/min.)	FLUSH % RETURN	COLOUR % RETURN	FR-FRACTURE		F-FAULT		SM-SMOOTH		FL-FLEXURED		BC-BROKEN CORE		DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION		
				DEPTH (m)	ELEV. (m)					CL-CLEAVAGE		J-JOINT		R-ROUGH		UE-UNEVEN		MB-MECH. BREAK					
										SH-SHEAR	VN-VEIN	P-POLISHED	S-SLICKENSIDED	ST-STEPPED	W-WAVY	B-BEDDING							
RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3 CORE AXES	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/sec																	
TOTAL CORE %	SOLID CORE %			DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION																		
0		CONTINUED FROM PREVIOUS PAGE		221.81 0.00																			
1																							
2		Borehole continued		220.14 1.67																			
3	NQ CORING	Slightly weathered to fresh, crystalline, grey granitic biotite-hornblende gneiss. (BEDROCK)			1	0.134	100																
4						2	0.14	100															
5																							
6						3	0.38	100															
7																							
8		END OF BOREHOLE		214.11 7.70																			
9																							
10																							

DEPTH SCALE:
1 to 50

Golder Associates

LOGGED: SB
DATE: JUNE 6/98
CHECKED: AP

W.P. 209-97-00

RECORD OF BOREHOLE 4

SHEET 1 OF 1

DIST. 52, SITE 44-388, HWY 69

BORING DATE: MAY 12/98

DATUM: GEODETIC

LOCATION: N 5022505.33; E 266680.94

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	nat V - + rem V - ⊕	q - ● u - ○			WATER CONTENT, PERCENT Wp — W — Wi
				DEPTH (m)									
0	CME 55 BOMBARDIER 101mm SOLID STEM AUGERS	GROUND SURFACE		222.53									
		Silty Sand, trace clay, some gravel, trace organics Very loose Brown		0.00	1	50 DO	2						
1		Sand, some silt, trace clay, some gravel Dense Grey		221.77 0.76	2	50 DO	46					MH	
				220.93 1.60	3	50 DO	50/ .08						
2		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK										NOTE: Water level in open hole at 1.3m depth on completion of drilling.	
3													
4													
5													
6													
7													
8													
9													
10													

NOTE:
Water level in
open hole at 1.3m
depth on completion
of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

NS010004 BHS

DATA INPUT: PS FEB 19/99

SOILM6

W.P. 209-97-00
DIST. 52, SITE 44-388S, HWY 69
LOCATION: N 5022512.73; E 266649.64

RECORD OF BOREHOLE 10

BORING DATE: MAY 12/98

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	nat V - + Q - ● rem V - ⊕ U - ○	WATER CONTENT, PERCENT Wp ——— W ——— Wt		
				DEPTH (m)								
0	CME 55 BOMBARDIER 101mm SOLID STEM AUGERS	GROUND SURFACE		221.58								
		Topsoil		0.00								
		Silty Sand, trace clay, trace gravel, trace organics Brown		0.10								
				220.97	1	AS						
		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		0.61								
1												Note: Open hole dry on completion of drilling.
2												
3												
4												
5												
6												
7												
8												
9												
10												

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

W.P. 209-97-00
DIST. 52, SITE 44-338S, HWY 69
LOCATION: N 5022492.61; E 266701.54

RECORD OF BOREHOLE 11

BORING DATE: MAY 12/98

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER TYPE	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT Wp				
0	CME 55 BOMBARDIER 101mm SOLID STEM AUGER	GROUND SURFACE		223.16							
		Silty Sand, trace clay, trace gravel, trace organics Brown		0.00	1 AS						
1		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		222.55							
				0.61							
2											
3											
4											
5											
6											
7											
8											
9											
10											

Note:
Open hole dry on
completion of
drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

N1111PH1 BHS
SOLM6
DATA INPUT: PS FEB 1999

W.P. 209-97-00

RECORD OF BOREHOLE PH1

SHEET 1 OF 1

DIST. 52, SITE 44-388S, HWY 69

BORING DATE: MAY 11, 1998

DATUM: GEODETIC

LOCATION: N 5022508.39; E 266669.64

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
								nat V - + Q - ● rem V - ⊕ U - ○		Wp -----○----- W							
0	CME 55 BOMBARDIER POWER AUGER WITH 101mm SOIL D S	GROUND SURFACE		221.90													
		Silty Sand, trace gravel, trace clay, trace rootlets Loose Brown		0.00	1	50 DO	6										
1		Sand, some silt, trace clay, some gravel Very dense Grey		221.15 0.75	2	50 DO	58										
		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		220.85 1.25													
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Note:
Open hole dry on
completion of
drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

W.P. 209-97-00
DIST. 52, SITE 44-388S, HWY 69
LOCATION: N 5022506.64; E 266669.26

RECORD OF BOREHOLE PH2

BORING DATE: MAY 11, 1998

SHEET 1 OF 1
DATUM: GEODETIC
PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
				DEPTH (m)				Cu, kPa		nat V - + rem V - ⊕	Q - ● U - ○	Wp —○— Wl					
0	CME 55 BOMBARDIER POWER AUGER, 10mm SOLID STEM	GROUND SURFACE		221.86 0.00													
		Silty Sand, trace gravel, trace clay, trace rootlets Loose Brown			1	SO DO	8										
1					221.10 0.76												
		Sand, trace silt, trace clay, some gravel Dense to very dense Grey			2	SO DO	43										
2					3	SO DO	52										
		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		219.57 2.29													
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Note:
Water level in
open hole at 1.0m
depth on completion
of drilling.

N1111PH3.BHS
SOLM6
DATA INPUT: PS FEB 19/99

W.P. 209-97-00

RECORD OF BOREHOLE PH3

SHEET 1 OF 1

DIST. 52, SITE 44-338S, HWY 69

BORING DATE: MAY 11, 1998

DATUM: GEODETIC

LOCATION: N 5022503.94; E 266669.61

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT Wp — W — Wi			
0	CME SS BOMBARDIER POWER AUGER, 101mm SOLID STEM	GROUND SURFACE	221.82								
		Silty Sand, some gravel, trace clay, occ. cobble, trace rootlets Compact Brown	0.00	1	50 DO	13					
1			221.08								
			0.76	2	50 DO	50					
		Sand, trace silt, trace clay, some gravel Dense to very dense Grey		3	50 DO	32					
2			219.53								
		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK	2.29								
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

NOTE:
Water level in
open hole at 1.1m
depth on completion
of drilling.

N1111PH4.BHS

DATA INPUT: PS FEB 19/99
SOILM6

W.P. 209-97-00
DIST. 52, SITE 44-388S
LOCATION: N 5022499.38; E 266680.51

RECORD OF BOREHOLE PH4

BORING DATE: MAY 12, 1998

SHEET 1 OF 1
DATUM: GEODETIC
PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, K, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m			SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT Wp — W — Wl
0	CME SS BOMBARDIER POWER AUGER, 101mm SOLID STEEL	GROUND SURFACE		221.86							
		Silty Sand, trace clay, trace gravel, trace organics Dense Brown		0.00	1	50 DO	35				
1		Sand, trace clay, some silt, some gravel, occ. cobble Dense Grey		221.10 0.76	2	50 DO	45				
		END OF BOREHOLE		220.64 1.22							
2											
3											
4											
5											
6											
7											
8											
9											
10											

NOTE:
Water level in
open hole at 1.0m
depth on completion
of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

N1111PH5 BHS

DATA INPUT: PS FEB 19/99
SOILM6

W.P. 209-97-00
DIST. 52, SITE 44-388S, HWY 69
LOCATION: N 5022501.80; E 266681.35

RECORD OF BOREHOLE PH5

BORING DATE: MAY 12, 1998

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m			HYDRAULIC CONDUCTIVITY, k, cm/s			ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	nat V - + rem V - ⊕	Q - ● U - ○	WATER CONTENT, PERCENT Wp — W — Wi			
				DEPTH (m)										
0	CME SS BOMBARDIER POWER AUGER, 101mm SOLID STEM	GROUND SURFACE		221.98										
		Silty Sand, trace clay, trace gravel, occ. cobble, trace organics Loose Brown		0.00	1	SO DO	6							
1		Sand, trace silt, trace clay, some gravel, occ. cobble Dense Grey		221.22 0.76	2	SO DO	48							
		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		220.46 1.52										
2														
3														
4														
5														
6														
7														
8														
9														
10														

NOTE:
Water level in
open hole at 1.2m
depth on completion
of drilling.

NOTE:
Water level in
open hole at 1.2m
depth on completion
of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

M1111PH6 BHS

W.P. 209-97-00
 DIST. 52, SITE 44-388S, HWY 69
 LOCATION: N 5022503.74; E 266681.37

RECORD OF BOREHOLE PH6

BORING DATE: MAY 12, 1998

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	nat V - + Q - ● rem V - ⊕ U - ○	WATER CONTENT, PERCENT Wp ——— W ——— Wi 10 20 30 40		
				DEPTH (m)								
0	CME 55 BOMBARDIER POWER AUGER, 101mm SOLID STEEL	GROUND SURFACE		222.25								
		Silty Sand, some gravel, trace clay, trace rootlets Very loose Brown		0.00	1	50 DO	1					
1		Sand, trace silt, trace clay, some gravel Compact to very dense Grey		221.49 0.76	2	50 DO	28					
				220.63 1.62	3	50 DO	30/ 13					
2		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK										
3												
4												
5												
6												
7												
8												
9												
10												

NOTE:
Water level in
open hole at 1.0m
depth on completion
of drilling.

NOTE:
 Water level in
 open hole at 1.0m
 depth on completion
 of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

DATA INPUT: ps feb 19/99

SOLM6

Golder Associates Ltd.

2180 Meadowvale Boulevard
Mississauga, Ontario, Canada L5N 5S3
Telephone (905) 567-4444
Fax (905) 567-6561



REPORT

**FOUNDATION INVESTIGATION AND DESIGN
PROPOSED HIGHWAY 69 NORTHBOUND
FOUR LANING OF THE PARRY SOUND BYPASS
McGOWN ROAD OVERPASS
G.W.P. 209-97-00, SITE 44-388N
MTO DISTRICT 52, HUNTSVILLE**

Final

Submitted to:
Cole, Sherman & Associates
75 Commerce Valley Drive East
Thornhill, Ontario
L3T 7N9

Final

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May 1999



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Table 1

List of Abbreviations and Symbols

Lithological and Geotechnical Rock Description Terminology

Record of Borehole Sheets

Drawing N111102N McGown Road Overpass, Northbound Lanes (NBL), Borehole
Locations and Soil Strata

Figure 1

Figure 2

May 1999

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PART A – FIELD INVESTIGATION

**PROPOSED HIGHWAY 69 NORTHBOUND
FOUR LANING OF THE PARRY SOUND BYPASS
McGOWN ROAD OVERPASS
G.W.P. 209-97-00, SITE 44-388N
MTO DISTRICT 52, HUNTSVILLE**

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Table 1

List of Abbreviations and Symbols

Lithological and Geotechnical Rock Description Terminology

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Drawing N111102N McGown Road Overpass, Northbound Lanes (NBL), Borehole
Locations and Soil Strata

Figure 1

Figure 2

1.0 INTRODUCTION

Golder Associates Ltd. has been retained by Cole, Sherman & Associates (Cole, Sherman) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation at the site of the proposed bridge to carry the northbound lanes of the proposed Highway 69 over realigned McGown Road. The McGown Road overpass is part of the Parry Sound Bypass project which involves four laning of a section of Highway 69 from Badger Road northerly 10 km to Sequin River. The new alignment of Highway 69 at the bridge site is located approximately 800 m to the east of the existing Highway 69. This report addresses the proposed bridge and its approaches within 20 m of the structure. The site of the project is designated as Site 44-388N.

The purpose of this investigation is to determine the subsurface conditions at the site of the proposed bridge structure by drilling boreholes, and carrying out in situ tests and laboratory tests on selected samples. Based on our interpretation of the data obtained, recommendations on the geotechnical aspects of design of the proposed works are provided. Comments are also provided on anticipated construction problems where they may affect design of the proposed bridge and approach embankments.

The proposed horizontal and vertical alignment for Highway 69 overpass and the location of the bridge were provided to us on the 1:5000 plan and profile for the route planning study drawings. The locations of the bridge abutments were staked in the field by Cole, Sherman.

The terms of reference for the scope of work are outlined in our proposal letter P71-1494, dated November 26, 1997. The work was carried out in accordance with our Quality Control Plan for Foundation Design Services, dated March 03, 1998. During the course of the field work, the number of boreholes was increased to accommodate the site conditions as encountered.

2.0 SITE DESCRIPTION

The site is located approximately 800 m to the east of the existing Highway 69 and 2 km to the south of Parry Sound, Ontario. The site is located within the MTO District 52, Huntsville and is designated as Site 44-388N.

The topography of the site is relatively flat; the ground surface varies between Elevations 222 m and 224 m and generally rises to the south. The existing McGown Road is a gravel road about 5 m in width. The grade of the existing McGown Road in the area of the proposed bridge is at about Elevation 223.5 m. Thick forest extends on both sides of the existing McGown Road.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on May 12, 1998 and May 13, 1998. At this time ten boreholes were drilled at the site of the proposed structure; Boreholes 5 and 6 and PH7 to PH9, were put down at the location of the south abutment, Boreholes 7 and 8 and PH10 to PH12 were drilled at the location of the north abutment. In addition, two boreholes, numbered Boreholes 9 and 12, were put down within the north and south approach embankments, respectively. The investigation was carried out using a bombardier mounted CME 55 drill rig supplied and operated by Marathon Drilling Inc. of Ottawa. Boreholes 1 to 4, 10, 11 and PH1 to PH6, were put down for the southbound lane structure and are reported separately.

Soil samples were obtained at regular intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with Standard Penetration Test (SPT) procedures. Boreholes 5 and 7 were drilled to 7.2 m and 6.1 m depths, respectively, with bedrock coring; NQ size core samples were obtained from the boreholes. Boreholes 6, 8, 9 and 12 and PH7 to PH12 were drilled to refusal on bedrock which was encountered between 0.6 m and 2.4 m depths. Groundwater conditions in the open holes were observed throughout the drilling operations.

The field work was supervised on a full-time basis by a member of our technical staff who located the boreholes in the field, directed the drilling, sampling and in situ testing operations, and logged the borings. The soil samples were identified in the field, placed in labeled containers and transported back to our laboratory in Mississauga for further examination. Index and classification tests were carried out on selected samples.

The as-drilled borehole locations were determined by our field personnel based on the highway chainages and foundation unit limits as staked in the field. Surveyed borehole locations and elevations were provided by Cole, Sherman and we understand that the elevations are referenced to Geodetic Datum. The northing and easting co-ordinates of the borehole locations are indicated on the Record of Borehole sheets; the locations of the boreholes are shown on Drawing N111102N "Borehole Locations and Soil Strata", attached.

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Site Geology

From published geologic information, the site is located in the physiographic region known as the Laurentian Highlands which forms the southernmost part of the Canadian Precambrian Shield (Geology of Ontario; OGS Special Volume 4). The Laurentian Highlands comprises a southeast-trending, slightly elevated region underlain by Precambrian bedrock which was eroded to form an undulating surface with frequent rounded knobs and ridges. The terrain comprises large expanses of intrusive rocks such as gneisses and gneissic or massive granitic rocks. The rocks are geologically complex with considerable folding, intrusive activity, regional metamorphism and faulting. The local physiography is characterized by shallow overburden consisting mainly of outwash sand and gravel and irregular, variable bedrock surface with frequent rock outcrops and shallow bedrock. Since irregular bedrock surface is typical in the area, terrain with organic deposits is widespread.

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets, following the text of this report. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations.

Relevant information on subsurface conditions was obtained from Boreholes 5 and 6 and PH7 to PH9 put down within the roadway of the existing McGown Road (at the location of the south abutment), Boreholes 7 and 8 and PH10 to PH12 put down to the north of McGown Road (at the location of north abutment), and from Boreholes 9 and 12 located within the north and south approaches.

In summary, the soils encountered consist of sand and gravel fill / road structure and / or native silty sand and sand extending to the bedrock surface encountered between 0.6 m and 2.4 m depths.

A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Road Structure

Boreholes 5, 6 and PH7 to PH9 were put down through the existing road embankment. The road structure consists of between 1 m to 1.5 m of fill materials ranging from silty sand with some gravel to sand and gravel fill with trace to some silt. The base of the road structure / fill was encountered between Elevation 222.1 m (about 1.5 m depth) and Elevation 222.7 m (about 1 m depth). The fill materials overlie a sand deposit in Borehole 5 and Probehole 7 and extend to the bedrock surface at the locations of Borehole 6 and PH8 and PH9.

The sand and gravel fill is compact to very dense with measured Standard Penetration Test (SPT) 'N' values ranging from 18 blows for 0.3 m of penetration to in excess of 50 blows for 0.3 m of penetration. Grain size distribution test results for samples of the fill material are shown on Figures 1 and 2.

4.2.2 Silty Sand

A silty sand deposit extends from ground surface or underlies about 100 mm to 150 mm of topsoil in Boreholes 7 to 9 and 12 and PH10 to PH12. Trace clay, trace to some gravel, occasional cobbles and trace organic matter were noted in this deposit. The silty sand deposit is typically very loose with measured Standard Penetration Test (SPT) 'N' value of 2 blows for 0.3 m of penetration. The thickness of the silty sand deposit varies from about 0.6 m to 0.9 m. The silty sand extends to the bedrock surface at about Elevation 221.1 m in Borehole 9 located to the north of McGown Road and at about Elevation 222.4 m in Borehole 12 located to the south of McGown Road. In Boreholes 7 and 8 and PH10 to PH12, where the silty sand is underlain by sand, the base of the deposit varies between Elevation 221.6 m and Elevation 221.9 m.

4.2.3 Sand

Underlying the silty sand in Boreholes 7 and 8 and Probeholes 10 to 12 located outside the existing McGown Road and the fill in Borehole 5 located within the McGown Road is a deposit of sand with trace to some silt, trace clay and trace gravel. Occasional cobbles and boulders

were noted within this deposit. The sand is dense to very dense with measured Standard Penetration Test (SPT) 'N' values varying from 44 blows for 0.3 m of penetration to in excess of 50 blows per 0.3 m penetration. The sand extends to the bedrock surface at depths ranging between 1.1 m and 2.4 m.

4.2.4 Bedrock

Refusal to further auger penetration in Boreholes 6, 8, 9, 12 and PH7 to PH12 was encountered at depths ranging from 0.6 m and 2 m (between Elevation 220.9 m and Elevation 222.7 m). Bedrock was cored in Boreholes 5 and 7 commencing at approximately 2.4 m depth and 1.5 m depth, respectively, confirming that the auger refusal met at the remainder of the borehole locations was very likely on the bedrock surface. The bedrock surface depths and elevations at the borehole locations are summarized below:

<i>Borehole</i>		<i>Ground Surface</i>	<i>Bedrock Surface</i>	
<i>Number</i>	<i>Location</i>	<i>Elevation (m)</i>	<i>Depth (m)</i>	<i>Elevation (m)</i>
8	North Abutment	222.69	1.49	221.20
PH10		222.47	1.52	220.95
PH11		222.27	1.07	221.20
PH12		222.48	1.60	220.88
7		222.39	1.52	220.87
9	North Approach	222.04	0.91	221.13
5	South Abutment	223.58	2.41	221.17
PH7		223.59	1.98	221.61
PH8		223.68	1.22	222.46
PH9		223.67	1.30	222.37
6		223.66	0.99	222.67
12	South Approach	222.99	0.55	222.44

Rock coring was carried out in Boreholes 5 and 7 for lengths of about 4.8 m and 4.6 m, respectively. The Rock Quality Designation (RQD) measured on the core samples ranged from 60 per cent to 96 per cent. Based on the rock core obtained, the bedrock consists of slightly weathered to fresh crystalline granitic biotite-hornblende gneiss.

Based on the results of these boreholes and the boreholes located to the west (drilled for the southbound lane structure), the bedrock surface is undulating between Elevation 220.9 m and Elevation 222.7 m in the north-south direction and is generally slightly lower to the west.

4.3 Groundwater Conditions

No piezometers were installed in the boreholes put down along the Highway 69 northbound bridge. The water level in the piezometer installed in a borehole located about 12 m to the west and to the south of the existing road was at 1.3 m depth below ground surface on June 04, 1998. This water level is within the sand deposit. It should be noted that water level is subject to seasonal fluctuations.

May 1999

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PART B – FOUNDATION DESIGN

**PROPOSED HIGHWAY 69 NORTHBOUND
FOUR LANING OF THE PARRY SOUND BYPASS
McGOWN ROAD OVERPASS
G.W.P. 209-97-00, SITE 44-388N
MTO DISTRICT 52, HUNTSVILLE**

5.0 ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides our recommendations on the geotechnical aspects of design of the Highway 69 northbound bridge based on our interpretation of the factual information obtained during the investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

The works described in this report are associated with the proposed bridge and its approaches within 20 m of the structure. It is understood that the proposed Highway 69 northbound lanes will be carried over McGown Road (which will be realigned to the north) by a one span structure about 12 m in length. It is understood that the final grade of Highway 69 will be at about Elevation 227.5 m and that the realigned McGown Road grade will vary between Elevation 221.5 m and Elevation 222.0 m.

The proposed horizontal and vertical alignment for Highway 69 overpass and the location of the bridge were provided to us on the 1:5000 Route Planning Study drawings and details were shown on the General Arrangement Plan, McGown Road Overpass, Highway 69 – NBL, prepared by Cole, Sherman, dated February 1999.

5.2 Bridge Foundations

In general, the subsoils at the north abutment of the bridge consist of a thin veneer of native silty sand and sand extending to the bedrock surface which was encountered between 0.6 m and 2.4 m depths. At the location of the proposed south abutment, the native soils are overlain by the granular fill forming the road structure. The overburden cover varies from about 1 m to 2.4 m at the borehole locations; the bedrock surface steps down from about Elevation 222.7 m at the east end of the south abutment to Elevation 221.2 m at the west end of the south abutment. At the

location of the north abutment, the bedrock surface is undulating between Elevation 220.9 m and Elevation 221.2 m with some 1.1 m to 1.6 m of overburden cover.

Based on the above, the use of spread footings placed on the bedrock surface is considered appropriate for support of the north and south abutments.

Given the somewhat undulating bedrock surface at the north abutment, consideration could be given to exposing the bedrock surface and excavating into the bedrock to form a level foundation. A design founding level at Elevation 220.8 m may be assumed; this would involve some local excavation of up to 0.4 m below the bedrock surface.

Given the variable depth to the bedrock surface at the south abutment, consideration could be given to stepping the footing down to follow the bedrock surface and maintaining the footing level on fresh bedrock. For design, the founding level may be assumed at Elevation 222.5 m at the east end; stepping down to Elevation 221 m at the west end of the abutment. Alternatively, the footing can be placed at the higher elevation with mass concrete used to raise the grade above the bedrock surface to the desired founding level.

In summary, the following founding elevations may be assumed for design:

<i>Abutment Location</i>	<i>Reference Borehole</i>	<i>Founding Elevation Alternatives (m)</i>
North Abutment	Boreholes 7 and 8 PH10 to PH12	220.8 m
South Abutment	Boreholes 5 and 6 PH7 to PH9	stepped from 222.5 m (east end) to 221 m (west end); or alternatively 222.5 m with mass concrete used to raise the founding level at the west end of the abutment, where required

The above founding levels for spread footings on the bedrock are the highest levels feasible. Lower founding levels are appropriate; however, they involve additional bedrock excavation.

A design founding level of Elevation 220.65 m at the north abutment and of Elevation 220.0 m at the south abutment has been provided by Cole, Sherman in the memorandum of May 05, 1999. These founding levels are considered appropriate.

At the north abutment, the proposed founding level is between 0.2 m and 0.6 m below the bedrock surface. At the south abutment the proposed founding level is 1.2 m to 2.7 m below the bedrock surface as encountered in the boreholes.

Bedrock excavation is required for the footing construction at both abutments. In order to maintain the integrity of the bedrock underlying the foundation, special precautions including controlled blasting (pre-shearing or cushion blasting) will be required for the general cut where it is in close proximity to the footings. Good perimeter blasting control is a key to achieve the required competence of the foundations for the abutments, and as such, stringent specification of excavation and support standards is required.

At the design levels there may be loose / fractured bedrock at the founding level, which should be removed prior to placing concrete. In addition, the design should be flexible enough to allow for some further variation in the bedrock surface elevation. At the north abutment, mass concrete may be required over some portions of the footing to raise the grade to the founding level after exposing the bedrock and removing any loosened / fractured bedrock. The bedrock surface at the north abutment is undulating and variable so it is not possible to identify specifically where the mass concrete is required until the bedrock surface is exposed.

5.2.1 Factored Geotechnical Resistance

Spread footings placed on the fresh bedrock at or below the elevations as specified above may be designed for a factored geotechnical resistance at Ultimate Limit States (ULS) of 10,000 kPa. This value is for vertical concentric loads only. Effects of load inclination and eccentricity need to be taken into account as appropriate. Serviceability Limit States (SLS) conditions do not apply to footings placed on the fresh bedrock.

The factored geotechnical resistance value given above assumes that controlled blasting for road and footing construction is used, that the bedrock at and below the founding level has not been fractured by the blasting and that no adverse jointing is present below the footing.

All footing excavations should be inspected prior to placing concrete to ensure that the base has been adequately cleaned and that the bedrock conditions as exposed at the founding level are consistent with the design assumptions. All loose or shattered rock within the footprint of the footings and at the footing level should be removed and replaced with concrete. If the footing is to be constructed at the higher design elevation, the bedrock surface should be exposed and cleaned and mass concrete may be used to raise the founding level to the desired elevation.

5.2.2 Horizontal Resistance

Resistance to lateral forces / sliding resistance between the concrete footings and bedrock should be calculated in accordance with Section 6-8.4.3 of the OHBDC assuming an unfactored angle of friction of 35 degrees. If necessary, sliding resistance can be supplemented by doweling into bedrock.

A value of 500 kPa may be used for the grout-to-rock bond stress for ULS design. This value refers to the rock-grout interface and can be used for tension design. The actual bond stress along the rock-grout interface may vary from the typical design value given and should therefore be verified in the field. The dowels should be a minimum of 1.0 m long within the rock and the structural strength of the dowel and the compressive strength of the grout should not be exceeded. Provision should also be made in the contract for longer dowels, in the event there are adversely oriented joints in the rock under the footing that could potentially result in a sliding failure toward the cut face.

5.2.3 Frost Protection

For spread footings placed on fresh granitic gneiss bedrock, frost protection cover is not required.

5.3 Lateral Earth Pressures

The lateral pressures acting on the bridge abutments will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill and on the subsequent lateral movement of the structure. The following recommendations are made concerning the design of the abutments and the retaining walls in accordance with OHBDC:

- Select free-draining granular fill meeting the specifications of OPSS Granular A or Granular B but with less than 5 per cent passing the 200 sieve should be used as backfill behind the walls. All granular fill should be compacted in lifts of loose thickness not greater than 200 mm to 95 per cent of the material's Standard Proctor maximum dry density.
- Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill.
- The granular fill may be placed either in a zone with width equal to at least 1.6 m behind the back of the stem (Case I) or within the wedge-shaped zone defined by a 60 degree line extending up and back from the bottom of the rear face of the footing (Case II).
- If the wall support allows lateral yielding of the stem (unrestrained structure), active earth pressures may be used in the geotechnical design of the structure. If the abutment support does not allow lateral yielding (restrained structure), at-rest pressures should be used for geotechnical design.
- A compaction surcharge equal to 16 kPa should be included in the lateral earth pressures for the structural design of the abutment wall in accordance with OHBDC Figure 6-7.4.3.
- For Case I, the pressures are based on the embankment fill materials and the following parameters (unfactored) may be used:

Soil unit weight (assuming clean earth fill)	21 kN/m ³
---	----------------------

Coefficients of lateral earth pressure:

'active'	0.31
'at rest'	0.47

- For Case II, the pressures are based on the granular fill as placed and the following parameters (unfactored) may be used:

	Granular A 22 kN/m ³	Granular B 21 kN/m ³
Soil Unit Weight		
Coefficient of Lateral Earth Pressure		
'active'	0.27	0.31
'at rest'	0.43	0.47

It should be noted that the above design parameters assume level backfill and ground surface behind the wall. Other aspects of the abutment granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD-3501.00.

5.4 Excavations

It is understood that design founding levels of 220.65 m at the north abutment and 220.00 m at the south abutment are proposed. Excavations for footing construction will be as deep as about 2.0 m at the north abutment and about 3.7 m deep at the location of the south abutment. The excavations will extend through the granular fill / road structure, very loose silty sand, dense to very dense sand and will terminate within / on slightly weathered to fresh bedrock.

The water level in the piezometer installed in a borehole located about 2.5 m to the west of the south abutment was at 1.3 m depth (Elevation 220.6 m) on June 04, 1998. Water was encountered at about 1.1 m depth (Elevation 221.4 m) in Borehole PH10. For excavations extended to below Elevation 221.4 m, water inflow should be anticipated through the existing embankment fill, native sand and the fractured portion of the bedrock. Some form of groundwater control will be required in order to construct the footing in the dry. It is considered that this inflow can be handled by conventional sump pumping at the base of the excavation. Sumps may have to be extended below the bedrock surface level. Sumps should be maintained outside the footing area.

Excavations extended through the soils, which will be open for a relatively short period of time can be made in temporary unsupported cut with side slopes within the granular deposits maintained not steeper than 2 horizontal to 1 vertical. Alternatively, if lowering of the groundwater level within the sand is carried out prior to the excavation, the excavation side slopes may be steepened to 1.5 horizontal to 1 vertical.

For excavations extended through the bedrock, vertical sides will be suitable. For the permanent cut slopes through the bedrock, the overall slope to the cut face may be formed vertical to near vertical. The use of carefully controlled drill and blast excavation techniques will be required in order to ensure a neat excavation line and minimize face instabilities and long-term maintenance problems.

The blasting pattern and procedures for the rock excavation (both the general excavation and where adjacent to the proposed bridge footings) should be submitted for approval. The desired specification would be for 80% half barrels to be visible on the cut face after scaling. It is imperative that the joint set orientation be established in the field prior to significant excavation in order to ensure that the appropriate precautions are taken with respect to scaling and bolting. The permanent cut slopes will be up to 2.7 m in height within the bedrock and adverse jointing with inadequate bolting can result in wedge failures.

Inspection of the rock cut face by qualified geotechnical personnel immediately after blasting should be carried out in order to assess where scaling / loosened rock removal should be carried out adjacent to the footings and where rock bolting may be required.

5.5 Approach Embankments

Based on the Route Planning Study drawings showing the proposed horizontal and vertical alignment for Highway 69 overpass and on the General Arrangement Plan provided, the proposed Highway 69 grade will be at about Elevation 227.5 m and will involve approach embankments between 4.5 m and 5.5 m in height. Based on the subsurface information, the subsoils within the approach embankments consist of about 0.6 m to 2.4 m of overburden comprising compact to very dense sand and gravel fill, very loose silty sand and dense to very dense sand. The overburden is underlain by granitic biotite-hornblende bedrock.

Given the above, stability of the proposed embankment is not a concern with respect to deep seated failure through the founding soils. There will be minimal settlement of the embankment due to consolidation of the very loose sands and this settlement will occur during embankment construction.

5.6 Subgrade Preparation and Embankment Construction

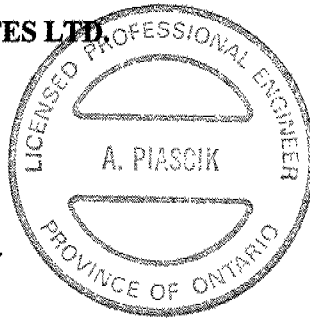
Topsoil and organic deposits should be stripped from below the fill embankment areas and the exposed subgrade soils should be proof-rolled prior to fill placement.

Construction of the embankment above the prepared subgrade may be carried out using clean earth fill (in accordance with OPSS 212) or Select Subgrade Material (in accordance with OPSS 1010), depending on material availability. All embankment fill should be placed in regular lifts with loose thickness not exceeding 300 mm, and be compacted to at least 95 per cent of the material's Standard Proctor maximum dry density. The final lift prior to placement of the granular subbase or base course should be compacted to 100 per cent of the Standard Proctor maximum dry density. Inspection and field density testing should be carried out by qualified geotechnical personnel during all fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved. The permanent slopes of the embankment should be maintained not steeper than 2 horizontal to 1 vertical. Vegetation cover should be established on all soil slopes to protect embankment fill against surficial erosion.

Alternatively, the approach embankments could be constructed using rockfill if available to the project. The permanent side slopes of the rockfill embankments should be maintained not steeper than 1.25 horizontal to 1 vertical.

GOLDER ASSOCIATES LTD.

Anna M. Piascik, P.Eng.
Geotechnical Engineer



For Anne S. Poschmann, P.Eng.
Principal



Fintan J. Heffernan, P.Eng.
Designated MTO Contact



AMP/ASP/FJH/amp/clg
WORD S/FINALDAT/1100/981-1111/1999/911111ER3

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), 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 300 mm (12 in.).

Dynamic Penetration Resistance; N_6 :

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 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT):

An electronic cone penetrometer with a 60° conical tip and a projected end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm 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	c_u, s_u kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane test (LV-laboratory vane test)
γ	unit weight

Note:

1. Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I GENERAL

π	= 3.1416
$\ln x$,	natural logarithm of x
$\log_{10} x$ or $\log x$,	logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stresses (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

(a) Index Properties (con't.)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity Index $= (w_l - w_p)$
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
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(c) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(d) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (overconsolidated range)
C_s	swelling index
C_α	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	Overconsolidation ratio $= \sigma'_p / \sigma'_{vo}$

(e) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3) / 2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3) / 2$
q	$(\sigma_1 - \sigma_3) / 2$ or $(\sigma'_1 - \sigma'_3) / 2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1. $\tau = c' + \sigma' \tan \phi'$

2. Shear strength = (Compressive strength)/2

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 2 m
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
- Parallel To	
⊥ - Perpendicular To	

W.P. 209-97-00
DIST. 52, SITE 44-388N, HWY 69
LOCATION: N 5022535.30; E 266690.72

RECORD OF BOREHOLE 5

BORING DATE: MAY 12/98

SHEET 1 OF 2

DATUM: GEODETIC

PROJECT: 981-1111



NS010003.BHS

DATA INPUT: PS/SIB MAR 199

SOIL M6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								nat V - + Cu, kPa	rem V - @ U - O			Wp	W
0	CME 55 BOMBARDIER 101 SOLID STEM AUGERS	GROUND SURFACE		223.58 0.00									
1		Silty Sand, some gravel, trace clay Compact Brown (FILL)		1	50 DO	28							
2				2	50 DO	18							
2		Sand, trace silt, trace clay, trace gravel, occ. boulder Very dense Grey		1.52	3	50 DO	72						
3		BOREHOLE CONTINUED; FOR BEDROCK CORING DETAILS REFER TO SHEET 2.		221.17 2.41									
4													
5													
6													
7													
8													
9													
10													
CONTINUED ON NEXT PAGE													

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

NS010005 BHR

DATA INPUT: PS FEB 1998

ROCKMVS

W.P. 209-97-00
 DIST. 52, SITE 44-388N, HWY 69
 LOCATION: N 5022535.30; E 266690.72

RECORD OF BOREHOLE: 5

DRILLING DATE: MAY 12/98
 DRILL RIG: CME 55 BOMBADIER
 DRILLING CONTRACTOR: MARATHON

SHEET 2 OF 2
 DATUM: GEODETIC
 PROJECT: 981-1111



DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	COLLOID % RETURN	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	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
0		CONTINUED FROM PREVIOUS PAGE		223.58 0.00										
1														
2														
3		Borehole continued		221.17 2.41	1	0.18	100							
4		Slightly weathered to fresh, crystalline, grey granitic biotite-hornblende gneiss. (BEDROCK)			2	0.38	100							
5														
6														
7														
8														
9														
10														
		END OF BOREHOLE		216.42 7.16										

Note:
 Water level in
 open borehole
 influenced by
 water used during
 rock coring.

DEPTH SCALE:
 1 to 50

Golder Associates

LOGGED: SB
 DATE: JUNE 6/98
 CHECKED: AP

NS01 0006 BHS

SOLM6
DATA INPUT: PS FEB. 1998

W.P. 209-97-00

RECORD OF BOREHOLE 6

SHEET 1 OF 1

DIST. 52, SITE 44-388N, HWY. 69

BORING DATE: MAY 12/98

DATUM: GEODETIC

LOCATION: N 5022542.78; E 266694.06

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	nat V - + Q - ● rem V - ⊗ U - ○			WATER CONTENT, PERCENT Wp ——— W ——— Wl
0	CME 55 BOMBARDIER 10 mm SOLID STEM AUGERS	GROUND SURFACE		223.68 0.00								
		Sand and Gravel, some silt Compact to very dense Brown (FILL)		1	50 DO	23						
1				2	50 DO	50/ 10						
		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		222.67 0.99								
2												
3												
4												
5												
6												
7												
8												
9												
10												

Note:
Borehole dry on
completion of
drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

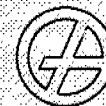
NS010007 BHS

DATA INPUT: ps feb.19/99
SOLM6

W.P. 209-97-00

RECORD OF BOREHOLE 7

SHEET 1 OF 2



DIST. 52, SITE 44-388N, HWY 69

BORING DATE: MAY 13/98

DATUM: GEODETIC

LOCATION: N 5022546.29; E 266682.46

PROJECT: 981-1111

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

0	CME 55 BOMBARDIER 101 SOLID STEM AUGERS	GROUND SURFACE		222.39												
		Topsoil		0.00												
		Silty Sand, trace clay, trace to some organics, trace gravel Very loose Brown		0.15	1	50 DO	2									
				221.63												
				0.76												
1		Sand, trace clay, trace silt, trace gravel, occ. cobble Very dense Grey		220.87	2	50 DO	65									
2		BOREHOLE CONTINUED; FOR BEDROCK CORING DETAILS REFER TO SHEET 2.		1.52												
3																
4																
5																
6																
7																
8																
9																
10																
		CONTINUED ON NEXT PAGE														

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

N5010007 BHR
ROCKMVS
DATA INPUT: PS JUNE 6/98

W.P. 209-97-00
DIST. 52, SITE 44-388N, HWY 69
LOCATION: N 5022546.29; E 266682.46

RECORD OF BOREHOLE: 7

DRILLING DATE: MAY 13/98
DRILL RIG: CME 55 BOMBARDIER
DRILLING CONTRACTOR: MARATHON

SHEET 2 OF 2
DATUM: GEODETIC
PROJECT: 981-1111



DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	PENETRATION RATE (mm/min)	COLLOID % RETURN	FR-FRACTURE			F-FAULT			SM-SMOOTH			FL-FLEXURED			BC-BROKEN CORE			DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
				DEPTH (m)				CL-CLEAVAGE		SH-SHEAR	J-JOINT		P-POLISHED	ST-STEPPED		PL-PLANAR	UE-UNEVEN		W-WAVY	MB-MECH. BREAK		B-BEDDING		
								VN-VEIN	S-SUCKENSIDED		R-Q.D. %	FRACT. INDEX PER 0.3 CORE AXIS		DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY k, cm/sec							
														TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION						
0		CONTINUED FROM PREVIOUS PAGE		222.39 0.00																				
1		Borehole continued		220.87 1.52																				
2	NQ CORING	Slightly weathered to fresh, crystalline, grey granitic biotite-hornblende gneiss with 50mm thick quartz layer at 2.4m depth. (BEDROCK)			1	0.44	100																	
3																								
4																								
5																								
6	MAY 13/98	END OF BOREHOLE		216.27 6.12																				
7																								
8																								
9																								
10																								

Note:
Water level in
open borehole
influenced by
water used during
rock coring.

DEPTH SCALE:

1 to 50

Golder Associates

LOGGED: SB
DATE: JUNE 6/98
CHECKED: AP

NS010008 BHS

DATA INPUT: PS FEB 19/99
SOILM6

W.P. 209-97-00

RECORD OF BOREHOLE 8

SHEET 1 OF 1

DIST. 52; SITE 44-388N, HWY 69

BORING DATE: MAY 13/98

DATUM: GEODETIC

LOCATION: N 5022537.37; E 266678.10

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	nat V - + Q - ● rem V - ⊕ U - ○	WATER CONTENT, PERCENT Wp — W — Wi 10 20 30 40		
				DEPTH (m)								
0	CME 55 BOMBARDIER 101mm SOLID STEM AUGERS	GROUND SURFACE		222.69								
		Silty Sand, trace clay, trace gravel, trace organics Very loose Brown		0.00	1	50 DO	2					
1		Sand, trace silt, trace gravel, occ. cobble Very dense Grey		221.93 0.76	2	50 DO	57					
2		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		221.20 1.49								
3												
4												
5												
6												
7												
8												
9												
10												

Note:
Open hole dry on
completion of
drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

NS010009 BHS

W.P. 209-97-00
 DIST. 52, SITE 44-388N, HWY 69
 LOCATION: N 5022553.03; E 266661.94

RECORD OF BOREHOLE 9

BORING DATE: MAY 12/98

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE					BLOWS/0.3m
				DEPTH (m)							
0	ONE 55 BOMBARDIER 101mm SOLID STEM AUGERS	GROUND SURFACE		222.04							
		Topsoil		0.00							
		Silty Sand, trace clay, trace gravel, trace organics Brown		0.10	1	AS					
1		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		221.13 0.91							
2											
3											
4											
5											
6											
7											
8											
9											
10											

Note:
Open hole dry on
completion of
drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

DATA INPUT: ps feb 19/99

SOILM6

W.P. 209-97-00

RECORD OF BOREHOLE 12

SHEET 1 OF 1

DIST. 52, SITE 44-388N, HWY 69

BORING DATE: MAY 12/98

DATUM: GEODETIC

LOCATION: N 5022526.10; E 266711.17

PROJECT: 981-1111



N50 0012 BHS

DATA INPUT: ps feb.19/99

SOLM6

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								nat V - + Cu, kPa	Q - ● rem V - ⊗ U - ○			Wp	W
0	CME55 BOMBARDIER 101mm SOLID STEM AUGER	GROUND SURFACE		222.99									
		Silty Sand, trace clay, trace gravel, trace organics Brown		0.00	1	AS							
		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		222.44 0.55									
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													

Note:
Open hole dry on
completion of
drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

N1111PH7 BHS

W.P. 209-97-00

RECORD OF BOREHOLE PH7

SHEET 1 OF 1

DIST. 52, SITE 44-388N, HWY 69

BORING DATE: MAY 12, 1998

DATUM: GEODETIC

LOCATION: N 5022536.54; E 266690.95

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								nat V - + rem V - ⊗ U - ○	Q - ● U - ○			Wp	W
0	CME 55 BOMBARDIER POWER AUGER, 101mm SOLID STEM	GROUND SURFACE		223.59									
		Sand and Gravel, some silt Compact Brown to grey (FILL)		0.00	1	50 DO	23						
1					2	50 DO	24						
		Sand, trace clay, trace silt, trace gravel Very dense Grey		222.09	3	50 DO	75/ 23						
2		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		221.61									
3				1.50									
4				1.98									
5													
6													
7													
8													
9													
10													

NOTE:
Open hole dry on
completion of
drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

DATA INPUT: PS FEB. 1998

SOLW6

W.P. 209-97-00
DIST. 52, SITE 44-388N, HWY 69
LOCATION: N 5022538.57; E 266691.97

RECORD OF BOREHOLE PH8

BORING DATE: MAY 12, 1998

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT Wp --- W --- Wl			
0	CME 55 BOMBARDIER POWER AUGER, 101mm SOLID STEEL	GROUND SURFACE	223.68 0.00								
1		Sand, trace to some gravel, trace silt Loose to compact Brown (FILL)		1	50 DO	26					
				2	50 DO	6					
		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK	222.48 1.22								
2											
3											
4											
5											
6											
7											
8											
9											
10											

NOTE:
Open hole dry on
completion of
drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

W.P. 209-97-00
DIST. 52, SITE 44-388N, HWY 69
LOCATION: N 5022540.86; E 266693.14

RECORD OF BOREHOLE PH9

BORING DATE: MAY 12, 1998

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT Wp W Wi				
0	CME 55 BOMBARDIER POWER AUGER, 101mm SOLID STEM	GROUND SURFACE	223.67 0.00	1	50 DO	26					
1		Sand and Gravel, trace to some silt, trace organics Compact to very dense Brown (FILL)		2	50 DO	56					
2		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK	222.37 1.30								
3											
4											
5											
6											
7											
8											
9											
10											

NOTE:
Open hole dry on
completion of
drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

N111PH10 BHS

DATA INPUT: PS FEB 19/98

SOILM6

W.P. 209-97-00
 DIST. 52, SITE 44-338N, HWY 69
 LOCATION: N 5022544.53; E 266681.33

RECORD OF BOREHOLE PH10

BORING DATE: MAY 13, 1998

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
				DEPTH (m)				nat V - + Q - ● rem V - ⊕ U - ○	Wp -----W----- Wi 10 20 30 40								
0	CME 55 BOMBARDIER POWER AUGER, 101mm SOLID STEM	GROUND SURFACE		222.47													
		Topsoil		0.00													
		Silty Sand, trace to some gravel, trace clay, trace organics Very loose Brown		0.10	1	SO DO	2							○			
1		Sand, trace silt, trace clay, trace gravel Dense Gray		0.75	2	SO DO	44							○			
		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		220.95 1.52													
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

NOTE:
Water level in
open hole at 1.1m
depth on completion
of drilling.

NOTE:
 Water level in
 open hole at 1.1m
 depth on completion
 of drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

N111PH11.BHS

W.P. 209-97-00
 DIST. 52, SITE 44-388N, HWY 69
 LOCATION: N 5022542.12; E 266680.08

RECORD OF BOREHOLE PH11

BORING DATE: MAY 13, 1998

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								nat V - + Q - ● rem V - ⊕ U - ○	Cu, kPa			Wp ----- W ----- Wt 10 20 30 40	
0	CME 55 BOMBARDIER POWER AUGER, 101mm SOLID STEEL	GROUND SURFACE		222.27									
		Topsoil		0.00									
		Silty Sand, trace to some gravel, trace clay, trace rootlets Very loose Brown		0.10	1	50 DO	2						
		Sand, trace silt, trace clay, trace gravel Very dense Grey		0.70	2	50 DO	65/ 20						
1			221.20										
		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		1.07									
2													
3													
4													
5													
6													
7													
8													
9													
10													

> 52.4

NOTE:
Open hole dry on
completion of
drilling.

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SB

CHECKED: AP

DATA INPUT: PS FEB 19/99

SOILM6

N11PH12 BHS

DATA INPUT: PS FEB 19/99

SOILM6

W.P. 209-97-00

DIST. 52, SITE 44-388N, HWY 69

LOCATION: N 5022539.81; E 266679.06

RECORD OF BOREHOLE PH12

BORING DATE: MAY 13, 1998

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 981-1111



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE				DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT					
				DEPTH (m)				Cu, kPa				Wp — W — Wl					
0	CME 55 BOMBARDIER POWER AUGER, 101mm SOLID STEM	GROUND SURFACE		222.48													
		Topsoil		0.00													
		Silty Sand, trace to some gravel, trace clay, trace rootlets, occ. cobble Very loose Brown		0.15	1	50 DO											
				221.68													
1				0.80													
		Sand, trace silt, trace clay, trace gravel Dense Grey			2	50 DO											
				220.88													
2		END OF BOREHOLE REFUSAL TO FURTHER AUGER PENETRATION PROBABLY ON BEDROCK		1.60													
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

NOTE:
Open hole dry on
completion of
drilling.

NOTE:
Open hole dry on
completion of
drilling.

DEPTH SCALE

1 to 50

Golder Associates

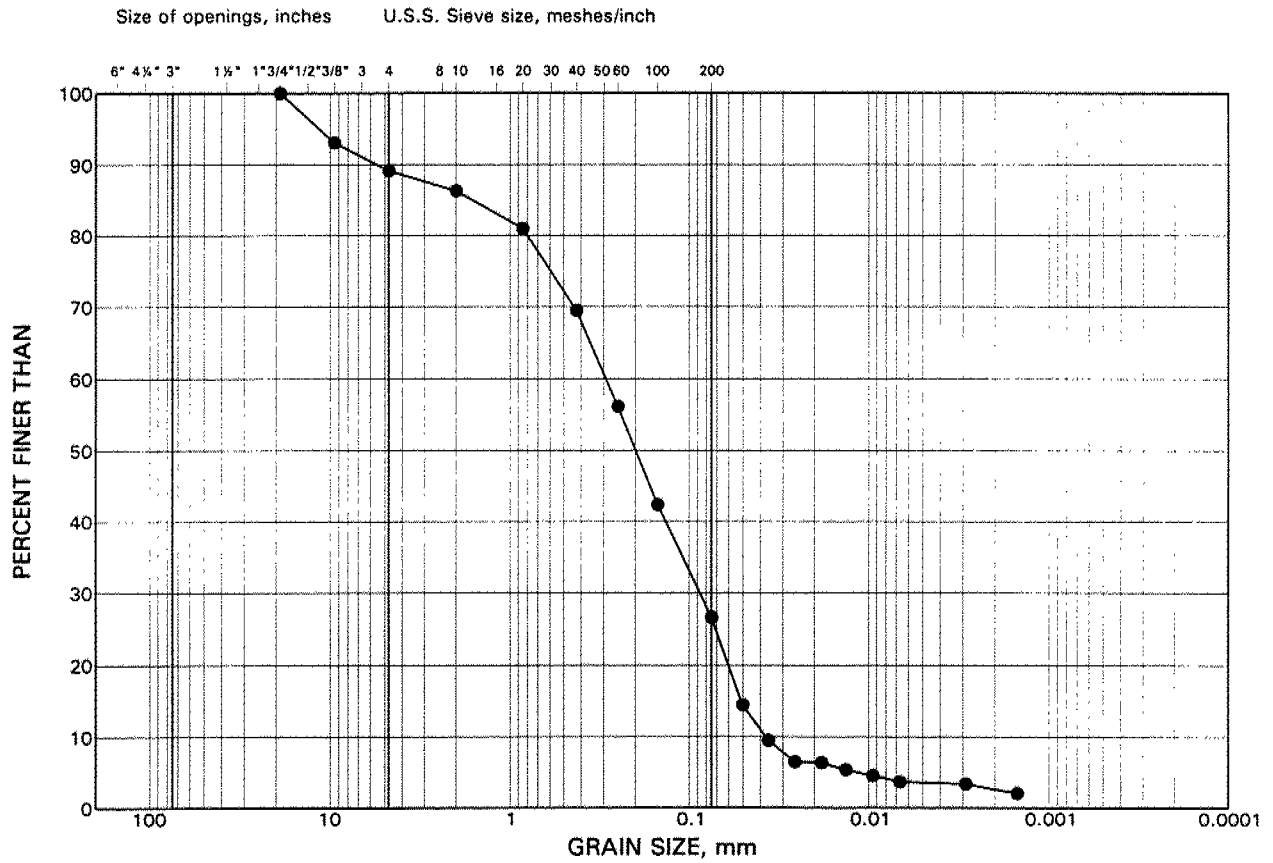
LOGGED: SB

CHECKED: AP

GRAIN SIZE DISTRIBUTION

Silty Sand (Fill)

FIGURE 1



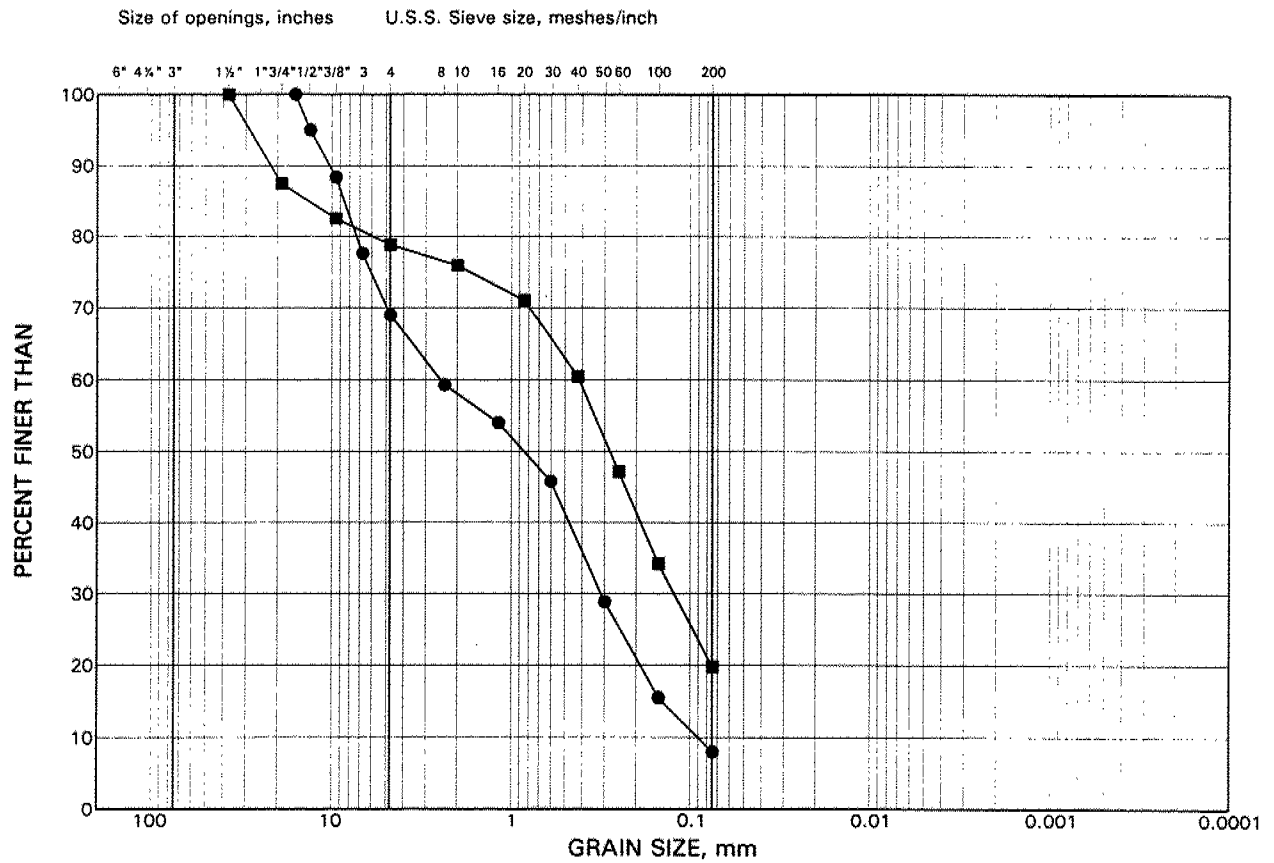
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	5	2	1.2

GRAIN SIZE DISTRIBUTION Sand and Gravel (Fill)

FIGURE 2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	6	1	0.5
■	PH 7	2	1.1

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DIST 52 HWY 69
CONT. No.
WP No. 209-97-00

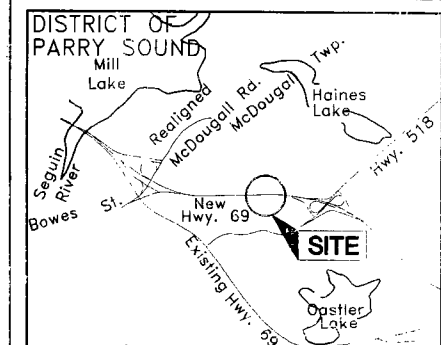


**McGOWN RD. OVERPASS
SOUTHBOUND LANES (SBL)**
BOREHOLE LOCATIONS & SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

LEGEND

- Borehole
- Probehole
- Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL on June 4, 1998
- 90% Rock Quality Designation (RQD)
- Bedrock Surface

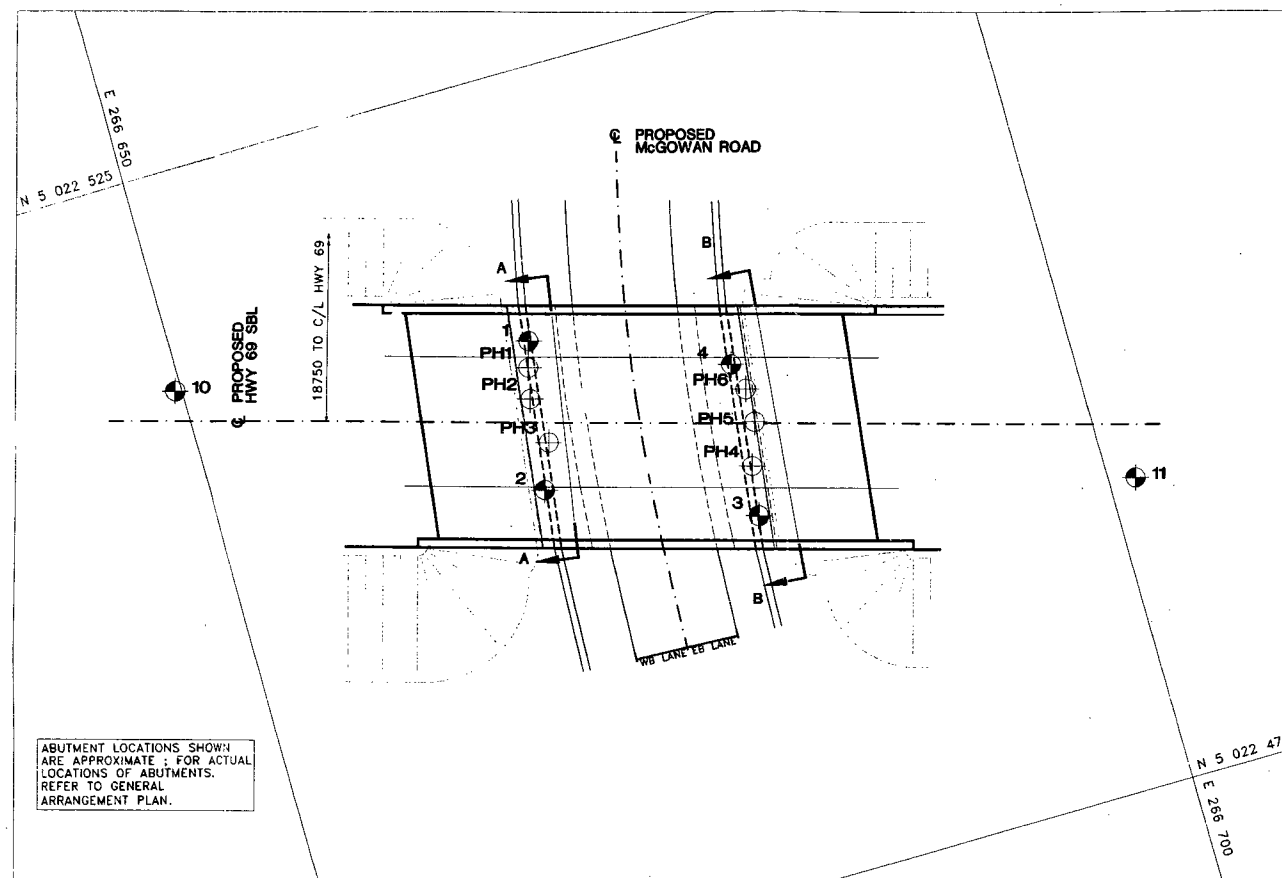
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		NORTHING	EASTING
1	221.92	5022509.87	266670.06
2	221.66	5022501.33	266668.65
3	221.81	5022496.52	266680.11
4	222.53	5022505.33	266680.94
10	221.58	5022512.73	266649.64
11	223.16	5022492.61	266701.54
PH1	221.90	5022508.39	266669.64
PH2	221.86	5022506.64	266669.26
PH3	221.82	5022503.94	266669.61
PH4	221.86	5022499.38	266680.51
PH5	221.98	5022501.80	266681.35
PH6	222.25	5022503.74	266681.37

NOTES
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence. General Arrangement drawing titled "McGown Road Overpass SBL", dated January 1999 provided by Cole Sherman in digital format.

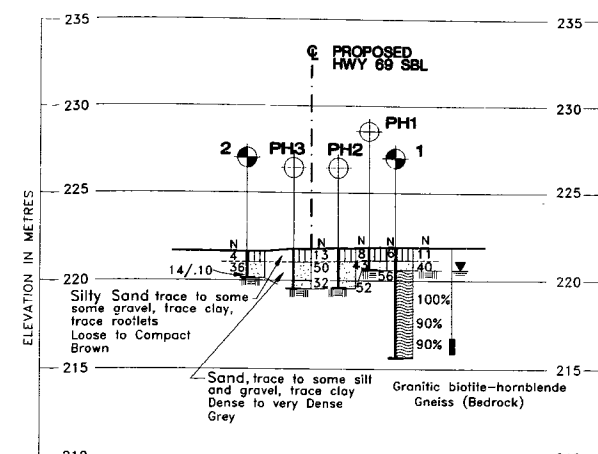
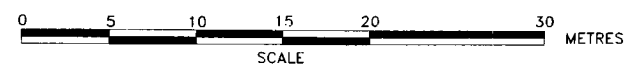
A	NOV. /98	AMP	ISSUED FOR REVIEW
NO.	DATE	BY	REVISION

Geocres No.

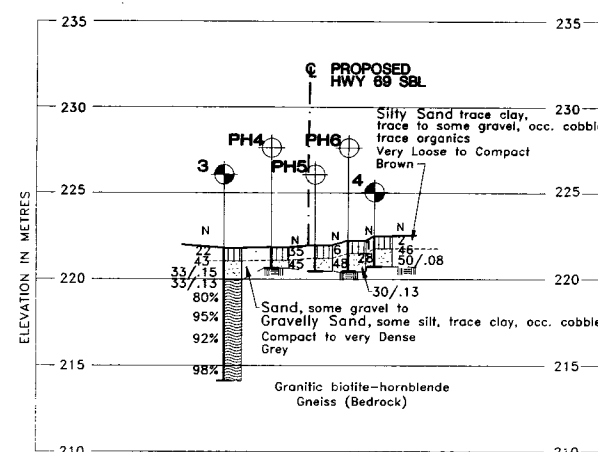
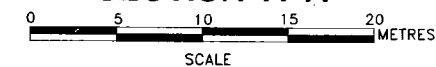
HWY. No. 69	PROJECT NO.: 981-1111	DIST. 52
SUBM'D. AMP	CHKD: ASP	DATE: 1998 05 26
DRAWN: JFC	CHKD. AMP	APPD. SITE 44-388S
		DWG. N111102C



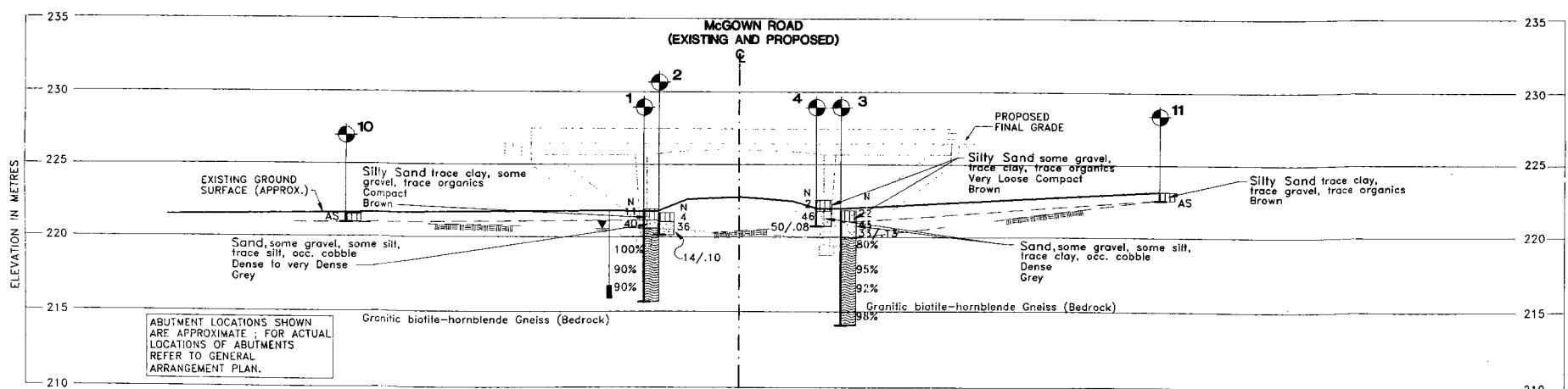
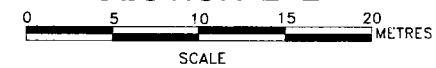
PLAN



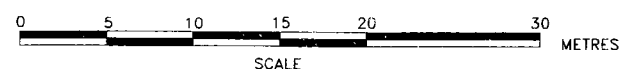
SECTION A-A



SECTION B-B



PROFILE ALONG HIGHWAY 69 CENTERLINE SBL



ACAD FILE N111102C.DWG

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DIST 52 HWY 69
CONT. No.
WP No. 209-97-00

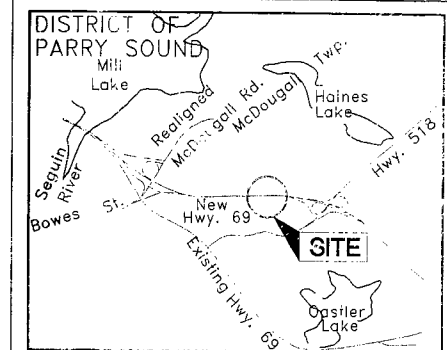


**McGOWN RD. OVERPASS
NORTHBOUND LANES (NBL)
BOREHOLE LOCATIONS & SOIL STRATA**

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

LEGEND

- Borehole
- Probehole
- Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL on June 4, 1998
- 90% Rock Quality Designation (RQD)
- Bedrock Surface

No.	ELEVATION	LOCATION	
		NORTHING	EASTING
5	223.58	5022535.30	266690.72
6	223.66	5022542.78	266694.06
7	222.39	5022546.29	266682.46
8	222.69	5022537.37	266678.10
9	222.04	5022553.03	266661.94
12	222.99	5022526.10	266711.17
PH7	223.59	5022536.54	266690.95
PH8	223.68	5022538.57	266691.97
PH9	223.67	5022540.86	266693.14
PH10	222.47	5022544.53	266681.33
PH11	222.27	5022542.12	266680.08
PH12	222.48	5022539.81	266679.06

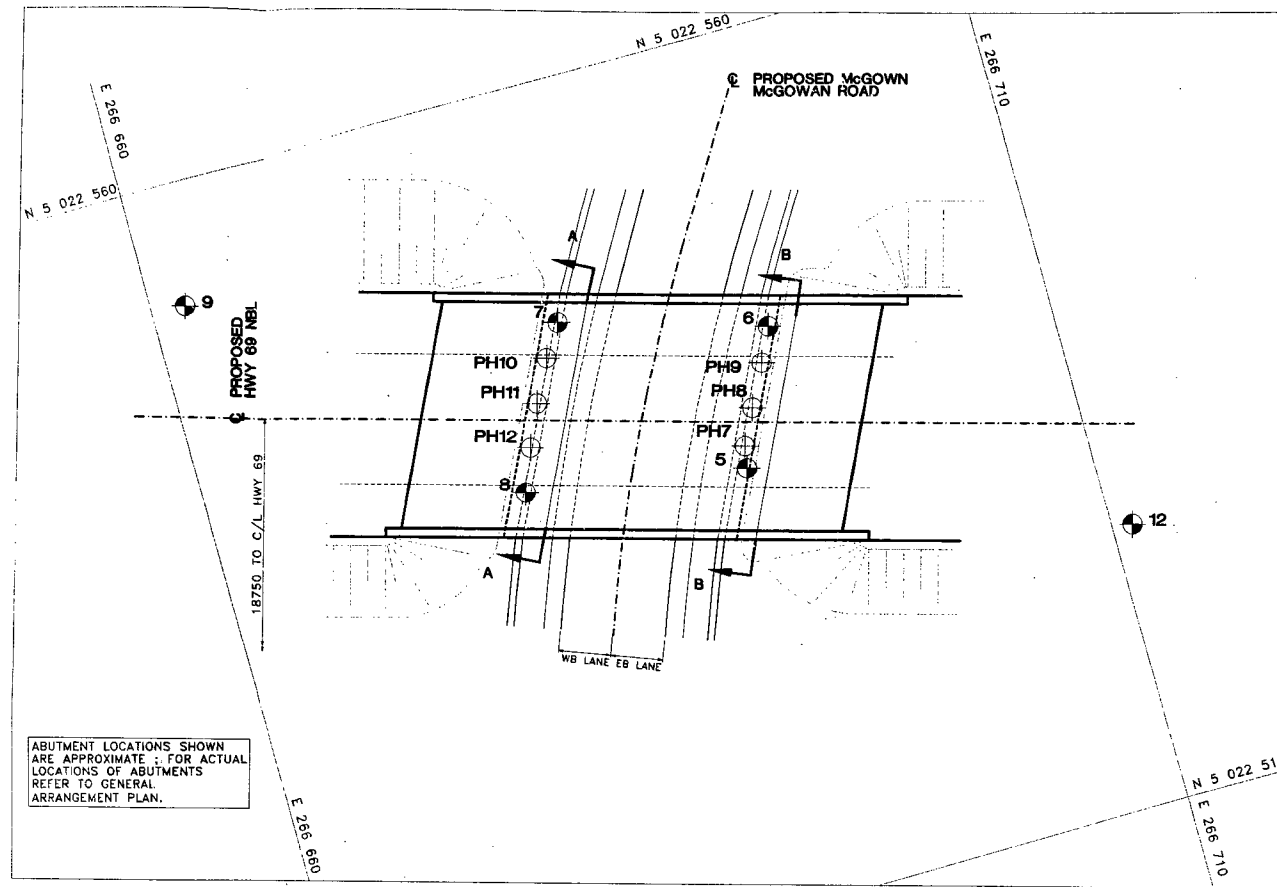
NOTES

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence. General Arrangement drawing titled "McGowan Road Overpass NBL", dated January 1999, provided by Cole Sherman in digital format.

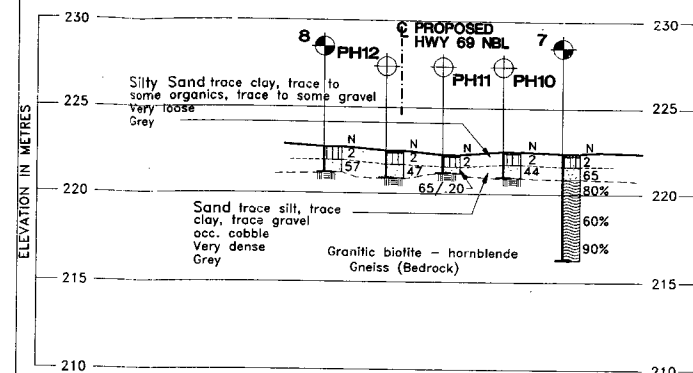
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NO.	DATE	BY	REVISION

Geocres No.

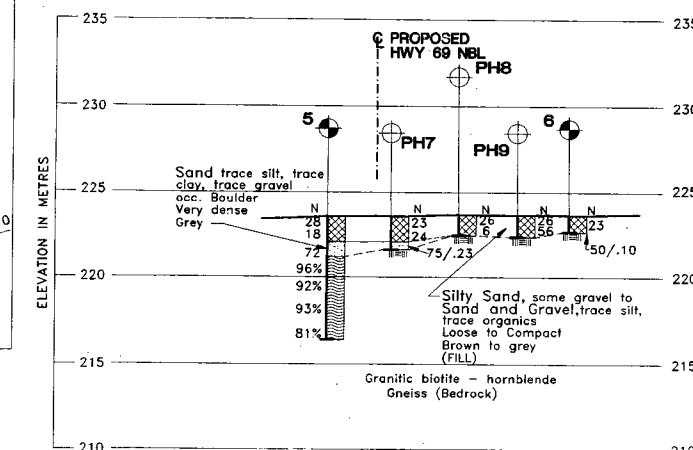
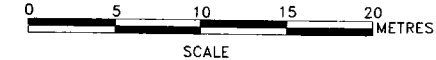
HWY. No. 69	PROJECT NO.: 981-1111	DIST. 52
SUBM'D. AMP	CHKD: ASP	DATE: 1998 05 26
DRAWN: JFC	CHKD. AMP	APPD.
		SITE 44-388N
		DWG. N111101C



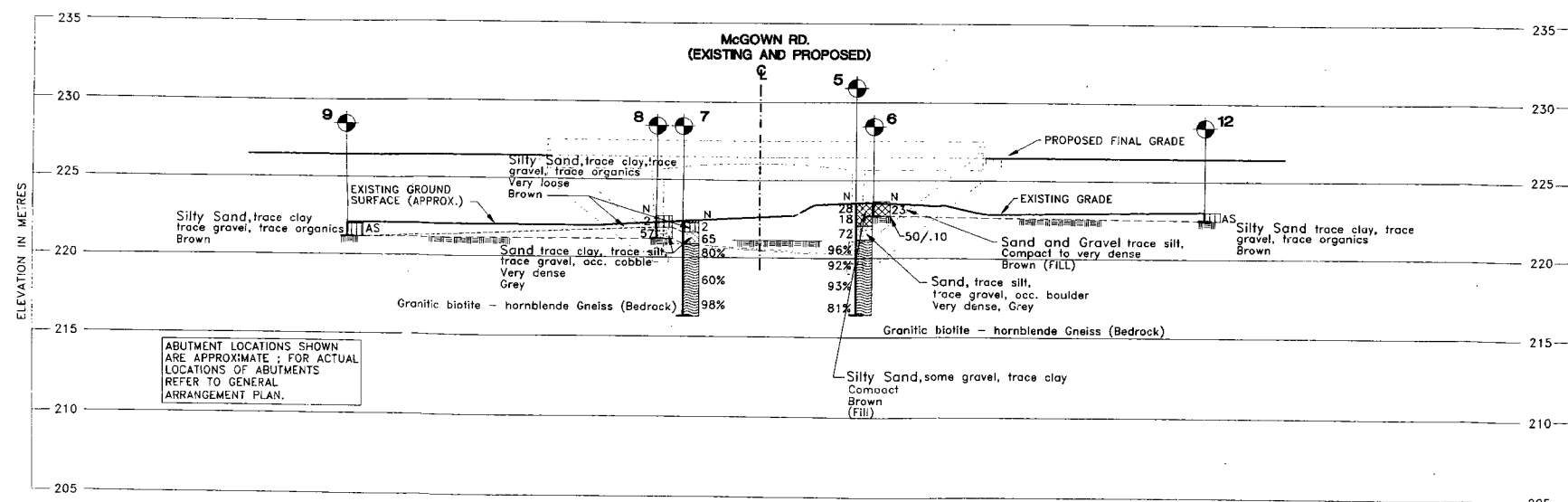
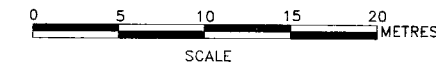
PLAN



SECTION A-A



SECTION B-B



PROFILE ALONG HIGHWAY 69 CENTERLINE NBL

