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REPORT ON

FOUNDATION INVESTIGATION AND DESIGN
HIGHWAY 401 WIDENING AND REHABILITATION
GWP 288-99-00
FROM 2.0 KM WEST OF REGIONAL ROAD 97
EAST TO 1.3 KM WEST OF
HOMER WATSON BOULEVARD
REGIONAL MUNICIPALITY OF WATERLOO

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PART A - FOUNDATION INVESTIGATION

HIGHWAY 401 WIDENING AND REHABILITATION
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EAST TO 1.3 KM WEST OF
HOMER WATSON BOULEVARD
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Dillon Consulting Limited (Dillon) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation for the detailed design work as part of GWP 288-99-00. The project involves design work for the upgrading of about 7.8 kilometres of Highway 401 from 2.0 kilometres west of Regional Road 97 east to 1.3 kilometres west of Homer Watson Boulevard in the Regional Municipality of Waterloo. The work includes highway upgrades, widening and realignment. The foundation component of the project includes a new 61 metre long, 4.5 by 1.75 metre culvert at Station 17+463 and a retaining wall approximately between Station 17+545 and 17+700 near the new north limit of the highway right-of-way.

The purpose of the foundation investigation was to determine the subsurface conditions at the site by means of a limited number of boreholes, in-situ tests and laboratory tests on selected samples. Based on our interpretation of the data obtained, recommendations on the foundation aspects of the design of the proposed works are provided. Comments are also provided on anticipated construction problems where they may affect design of the culvert and retaining wall.

The terms of reference for the scope of work are outlined in MTO's Request for Proposal, in our proposal dated August 13, 2001 and our supplementary letter dated August 30, 2001. The work was carried out in accordance with our Quality Control Plan for Foundation Investigation and Design Services, dated September 2001.

2.0 SITE DESCRIPTION

GWP 288-99-00 comprises about 7.8 kilometres of Highway 401 extending from 2.0 kilometres west of Regional Road 97 to about 1.3 kilometres west of Homer Watson Boulevard in the Regional Municipality of Waterloo. The location of the project is shown on the Key Plan, Figure 1. The project chainages extend from Station 12+828 to Station 20+112, Township of North Dumfries and from Station 10+000 to Station 10+500, City of Kitchener/City of Cambridge.

This portion of Highway 401 is a Class I divided four lane highway. The existing pavement cross-section is four 3.75 metre wide lanes typically with 3.0 metre wide partially paved outside shoulders and 1.0 metre wide inside shoulders. Fully paved outside shoulders are present in the horizontal curve immediately west of Regional Road 46 from Station 17+200 to Station 18+100. The median width throughout this section of Highway 401 is typically 15 metres.

This report addresses the subsurface conditions for the proposed retaining wall to be constructed adjacent to the new northerly limit of the right-of-way approximately between Station 17+545 and 17+700 and a new 61 metre long, 4.5 by 1.75 metre culvert at Station 17+463. The topography of the site is relatively flat with an earth berm at the location of the proposed retaining wall. A small pond is located behind the berm near the westerly limit of the proposed retaining wall. The pond drains to a small stream, a tributary of Cedar Creek, to the south through an existing culvert. The ground surface elevations at the borehole locations for this investigation ranged between about 301 and 304 metres. The top of the berm is at about elevation 307 metres and the pond water level was at 301.3 metres at the time of investigation. Vegetation cover on both sides of the existing highway consists of grass, shrubs and a narrow band of large, mature trees. Site photographs taken during the field investigation are provided in Appendix A.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between August 12 and November 2, 2001. At this time thirteen (13) boreholes were put down at the site. Three boreholes (boreholes 1, 3 and 4) were put down for the proposed new culvert, four boreholes (boreholes 11 to 14) were manually drilled along the existing berm and boreholes 5 to 10 were drilled by machine for the retaining wall. Also, one median borehole (borehole 2) from the pavement design investigation has been included for the new culvert crossing. The table below summarizes the borehole locations, ground surface elevations and depths.

BOREHOLE	CHAINAGE	GROUND SURFACE ELEVATION	BOREHOLE DEPTH
	(m)	(m)	(m)
Culvert Crossing			
1	17+495, 47.7 m RT	302.89	8.08
2	17+500, 25.1 m RT	301.85	3.05
3	17+463, 6.5 m LT	302.55	8.08
4	17+447, 21.8 m LT	300.94	6.71
Retaining Wall			
5	17+546, 27.5 m LT	301.75	13.93
6	17+567, 14.8 m LT	301.58	14.94
7	17+595, 20.7 m LT	302.07	15.45
8	17+620, 13.9 m LT	302.18	12.65
9	17+655, 21.1 m LT	303.95	12.65
10	17+678, 24.5 m LT	304.18	12.65
Existing Berm			
11	17+630, 24.4 m LT	306.54	1.01
12	17+667, 30.5 m LT	306.72	0.94
13	17+726, 28.6 m LT	306.83	1.83
14	17+667, 25.5 m LT	305.58	1.37

NOTES: RT right of the proposed centerline of Highway 401 median
LT left of the proposed centreline of Highway 401 median

The investigation was carried out using track and all-terrain vehicle mounted CME 55 and CME 750 drill rigs supplied and operated by Lantech Drilling Services Inc. Four boreholes were drilled manually on the existing earth berm where access to larger drilling equipment was not available. In the boreholes, samples of the overburden were obtained at suitable intervals of

depth using 50 millimetre outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedures and dynamic cone penetration testing was carried out adjacent to selected boreholes. The manual borehole sampling was carried out with a 31.8 kilogram sample hammer and the measured driving resistances were adjusted to reflect a standard 63.5 kilogram hammer. The machine-drilled boreholes were terminated between 3.1 metres and 15.5 metres depth below existing ground surface. The manual boreholes encountered auger refusal to drilling on cobbles at depths of 0.9 to 1.8 metres below the existing berm surface. Groundwater conditions in the boreholes were observed throughout the drilling operations. Standpipes were installed in selected boreholes to permit monitoring of the groundwater levels at the site. The boreholes were backfilled using MTO recommended procedures.

The field work was supervised on a full-time basis by members of our engineering staff who located the boreholes in the field, directed the drilling, sampling and in-situ testing operations, carried out the manual drilling and logged the boreholes. The samples were identified in the field, placed in labeled containers and transported back to our laboratory in London for further examination. Index and classification tests were carried out on selected samples. The results of the testing are shown on the Record of Borehole sheets and in Appendix B.

The as-drilled borehole locations and elevations were provided by AGM Surveying and Engineering on October 10, 2001. Elevations at the borehole locations are understood to be referenced to geodetic datum. The location and elevation of borehole 7 was determined by our staff on November 2, 2001 relative to the adjacent boreholes. The locations of the boreholes are shown on the Record of Borehole sheets and on Drawing 1, attached. Stratigraphic profiles along the proposed culvert crossing and retaining wall alignment are shown on Drawing 2.

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Site Geology

Highway 401 in the area of the project crosses the Waterloo Hills geographic region, which is identified in the Physiography of Southern Ontario by Chapman and Putnam (1984). This region is predominantly characterized by hilly terrain, which is the result of the convergence of three lobes of the Laurentian Ice Sheet, in the vicinity of the Cities of Kitchener and Waterloo. The Ontario Lobe advanced from the east, the Georgian Bay Lobe from the north and the Huron Lobe from the north-northwest during an approximate 1,000 year period some 13,000 to 14,000 years ago. This glacial activity resulted in ice contact deposits, such as kames, which occasionally appear as high conical hills, hummocky kame moraines and a few eskers, made up mainly of sand and gravel. There are also lateral and end moraine ridges consisting of sandy silt tills. During the melting of the ice lobes, major outwash deposits and spillways were formed in the low areas between the hills which contain a significant amount of sand and gravel. In some of the lower areas, especially in areas of till deposits, peat and muck were deposited.

This foundation investigation is located in a portion of the project where sand and gravel spillways are present. The lower levels of this moraine contain some organic deposits. The bedrock beneath this portion of the project is of the Middle Silurian Guelph Formation, consisting of buff to brown, fine to medium fossiliferous limestone. Bedrock formations are too far below the surface to have any effect on the foundation design for the proposed retaining wall and culvert.

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, Drawing 2 and in Appendix B, following the text of this report. The stratigraphic boundaries shown on the borehole sheets are inferred from non-continuous sampling and, therefore, may 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 to 4 at the proposed culvert crossing and from boreholes 5 to 14 at the proposed retaining wall. In summary, the topsoil and/or fill materials overlie a complex sequence of layers of sand and gravel, sands and silts. Detailed descriptions of the subsurface conditions encountered in the boreholes for the proposed culvert site and the proposed retaining wall site are provided in the following Sections 4.2.1 and 4.2.2, respectively.

4.2.1 Culvert Site

Topsoil and Fill Materials

Sandy to silty black to dark brown topsoil layers between 0.2 and 1.2 metres thick were encountered at ground surface in boreholes 1 to 4. Borehole 3 encountered a 2.0 metre thick layer of granular fill beneath the topsoil. The fill layer is loose to compact with SPT 'N' values of 7 and 19 blows per 0.3 metres penetration. Measured water contents of two fill samples were 8 and 14 per cent.

Sand and Gravel

Brown sand and gravel layers were encountered beneath the topsoil in borehole 1 and at depth in boreholes 1 to 4. The surface elevations of the sand and gravel layers ranged from 299.4 to 302.7 metres. The sand and gravel layers are 1.2 metres to 3.4 metres thick where fully penetrated in boreholes 1 and 4. Boreholes 2, 3 and 4 were terminated in sand and gravel layers after penetrating them for some 0.8 to 1.5 metres. SPT 'N' values ranging from 12 to 48 blows per 0.3 metres of penetration were measured within the sand and gravel layers, indicating a generally compact to dense state. Measured water contents of samples from the sand and gravel layers ranged from about 3 to 20 per cent, with an average of about 11 per cent. A grain size distribution curve for a sample of the sand and gravel from borehole 1 is shown on Figure B-1.

Sand and Silty Sand

Layers of sand and silty sand were encountered beneath the sand and gravel in borehole 1 and beneath the topsoil and fill materials in boreholes 2, 3 and 4. The surface of the sands and silty sand layers ranged from elevation 299.2 to 301.7 metres. A sand layer was also encountered at depth between layers of sand and gravel in borehole 4. Where fully penetrated, the sand layers were between 0.9 and 5.0 metres thick. SPT 'N' values measured within the sand deposits range from 2 to 48 blows per 0.3 metres, indicating very loose to dense materials, with an average 'N' value of about 13 blows per 0.3 metres penetration. Dynamic cone penetration testing within the sand materials adjacent to borehole 1 to below 7 metres depth indicated driving resistances between 14 and 35 blows per 0.3 metres penetration, with an average of about 24 blows per 0.3 metres penetration. Samples of the sand deposits had measured water contents from about 15 to 28 per cent, with an average of about 21 per cent. Grain size distribution curves for two samples of the sand from borehole 3 are shown on Figure B-2.

Silt

Borehole 1 encountered a layer of silt at elevation 295.7 metres and was terminated in this layer after penetrating it for some 0.9 metres. The silt deposit was loose and had a single SPT 'N' value of 9 blows per 0.3 metres penetration.

4.2.2 Retaining Wall Site

Topsoil and Fill Materials

All the boreholes drilled for the proposed retaining wall encountered surficial layers of sandy to silty black to brown topsoil. The topsoil layers ranged in thickness between 0.2 and 1.2 metres and had SPT 'N' values of 7 and 20 blows per 0.3 metres of penetration, where measured, indicating a loose to compact state. Measured water contents of two topsoil samples were about 108 and 126 per cent.

Boreholes 11 to 14 encountered granular earth berm fill beneath the topsoil layers. These boreholes were terminated in the earth berm fill materials due to refusal to augering and sampling on cobbles after exploring them for some 0.9 to 1.8 metres. The fill layers are dense to very dense with SPT 'N' values ranging between 43 blows per 0.3 metres penetration and 50 blows per 25 millimetres penetration.

Sand and Gravel

Brown sand and gravel layers were encountered beneath the topsoil in boreholes 5 to 10. The surface of these layers ranged from elevation 300.7 metres to elevation 303.9 metres. The sand and gravel layers are 0.3 metres to 3.5 metres thick where fully penetrated. Borehole 10 was terminated in a sand and gravel layer after penetrating it for some 0.6 metres. SPT 'N' values ranging from 15 blows per 0.3 metres of penetration to 100 blows for 175 millimetres of penetration were measured within the sand and gravel layers, indicating a compact to very dense state. Auger refusal was encountered in the sand and gravel layers in boreholes 5 and 6 at depths of 6.0 and 8.4 metres, respectively. Measured water contents of samples from the sand and gravel layers ranged from about 6 to 22 per cent, with an average of about 12 per cent. Grain size distribution curves for five samples of the sand and gravel are shown on Figure B-1.

Sand and Silty Sand

Layers of sand and silty sand were encountered between layers of silt and/or layers of sand and gravel at depth in boreholes 5 to 10. Where fully penetrated, the sandy layers were between 0.8 and 7.2 metres thick. Boreholes 5 to 7 were terminated in sandy soils at depths of about 13.9 to 15.5 metres after penetrating them for some 2.0 to 5.7 metres.

SPT 'N' values measured within the sandy deposits ranged from 2 blows per 0.3 metres of penetration to 50 blows per 50 millimetres penetration, indicating very loose to very dense materials, with an average 'N' value of about 44 blows per 0.3 metres penetration. Dynamic cone penetration testing within the sandy materials indicated driving resistances between 15 and 100 blows per 0.3 metres penetration, with an average of about 39 blows per 0.3 metres penetration. Dynamic cone penetration testing carried out to depths of 9.5 to 10.0 metres at the locations of boreholes 7, 8 and 10 indicated a generally compact density for the granular materials. Samples of the sandy deposits had measured water contents from about 9 to 31 per cent, with an average water content of about 18 per cent. Grain size distribution curves for samples of the sand and silty sand samples are shown on Figures B-2 and B-3, respectively.

Silt and Sandy Silt

Layers of silt and sandy silt were encountered in boreholes 5 to 10, typically below the sand and gravel. The surface elevation of these layers ranged from 297.2 to 300.4 metres. Where fully penetrated, these layers were 0.5 to 6.1 metres thick. Borehole 9 was terminated in a silt deposit after penetrating it for some 0.2 metres. The silty deposits had SPT 'N' values between 6 and 103 blows per 0.3 metres penetration, with an average of about 24 blows per 0.3 metres penetration. Measured water contents of samples from the silt and sandy silt layers ranged from about 17 to 29 per cent, with an average water content of about 22 per cent. Grain size distribution curves for samples of silt and sandy silt are shown on Figure B-4 and B-5, respectively.

4.3 Groundwater Conditions

Groundwater conditions were observed during and on completion of drilling operations. Standpipes were installed in boreholes 1 and 3 to 10 to monitor the groundwater conditions at the site. Details of the standpipe installations are provided on the attached Record of Borehole sheets. The table below summarizes the groundwater conditions in the boreholes. Groundwater levels are expected to fluctuate seasonally and are expected to be higher during wet periods.

Groundwater was encountered in the boreholes at elevations between 299.2 and 303.0 metres. The water levels measured in the standpipes generally ranged between elevation 300.6 metres at borehole 4 in the southwest end of the site and elevation 301.3 at borehole 10 in the north end of the site, indicating groundwater flow in a southwesterly direction towards the existing creek. The measured groundwater level in borehole 8 was at elevation 297.3 metres, indicating that it had not yet stabilized.

A summary of the observed and subsequently measured groundwater levels in the boreholes is provided below.

BOREHOLE NUMBER	GROUND SURFACE ELEVATION	GROUNDWATER LEVEL IN OPEN BOREHOLE ON COMPLETION OF DRILLING		GROUNDWATER LEVEL IN STANDPIPE ON OCT. 29 / NOV. 1, 2001	
		Depth Below Existing Ground Surface	Elevation	Depth Below Existing Ground Surface	Elevation
	(m)	(m)	(m)	(m)	(m)
1	302.89	2.7	300.2	1.9	301.0
2	301.85	1.2	300.6	-	-
3	302.55	2.1	300.4	1.8	300.8
4	300.94	1.2	299.7	0.3	300.6
5	301.75	2.1	299.6	0.9	300.8
6	301.58	1.5	300.1	0.7	300.9
7	302.07	2.9	299.2	0.8	301.3
8	302.18	1.8	300.4	4.9	297.3
9	303.95	3.1	300.9	2.6	301.3
10	304.18	1.2	303.0	2.9	301.3
11	306.54	Dry	-	-	-
12	306.72	Dry	-	-	-
13	306.83	Dry	-	-	-
14	305.58	Dry	-	-	-

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PART B - FOUNDATION DESIGN

HIGHWAY 401 WIDENING AND REHABILITATION
GWP 288-99-00
FROM 2.0 KM WEST OF REGIONAL ROAD 97
EAST TO 1.3 KM WEST OF
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5.0 ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides our recommendations on the foundation aspects of design for the construction of the new culvert and retaining wall which form part of the Highway 401 upgrades, widening and realignment. Our recommendations are 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.

The works described in this report are associated with the foundation component of the project, which includes the construction of a new 61 metre, long 4.5 by 1.75 metre culvert at Station 17+463, and a retaining wall approximately between Station 17+545 and 17+700 adjacent to the new northern limit of the right-of-way.

5.2 New Culvert

It is understood that the existing open footing concrete box culvert at Station 17+610 will be abandoned and a new culvert constructed some 147 metres to the west. It is understood that the creek invert at the proposed culvert location will be at approximately elevation 300.1 metres. The subsurface conditions at the proposed culvert location are detailed on Records of Boreholes 1 to 4. Based on the results of the boreholes, the proposed culvert will be founded in compact native sand and sand and gravel materials below the groundwater level which is at approximately elevation 301 metres. Based on the reports of substantial lowering of the groundwater level during the temporary dewatering carried out for the existing culvert construction together with the results of the boreholes, it is clear that temporary dewatering will have a substantial impact on the adjacent creek. It is understood that this is not acceptable from environmental considerations and substantial dewatering will not, therefore, be permitted.

The following options have been considered for the new culvert:

i) A culvert with precast box concrete sections. This alternative would have an invert elevation of about 299.8 metres and an underside of concrete at about elevation 299.4 metres. The provision of stone bedding would lower the founding elevation to about elevation 299.0 metres or some 2.0 metres below the groundwater level. Since temporary dewatering is not permitted and this installation cannot be carried out properly in the wet, this option is not considered feasible. In addition, upwelling of groundwater into the culvert, as presently occurs, would not be re-established.

ii) A cast-in-place concrete box culvert. This alternative would have an invert elevation of about 299.8 metres and an underside of concrete elevation at about 299.3 metres. Since temporary dewatering cannot be carried out, construction of the base slab and lower portions of the walls would have to be carried out in the wet and groundwater upwelling into the culvert would not be re-established. This alternative is therefore not considered feasible.
iii) An open footing culvert founded on footings constructed at elevation 298.5 metres inside steel sheet pile cofferdams and bearing on a 1 metre thick layer of unreinforced tremie concrete. This option can be constructed without temporary dewatering of the granular soils and maintains groundwater upwelling into the completed culvert.

Option iii) is therefore the only feasible option. The following paragraph provides design details for option iii).

The culvert footings would be carried out in sections using sheet piling cofferdams driven to elevation 296 metres and a 1.0 metre thick unreinforced tremie concrete plug extending between elevation 297.5 and 298.5 metres constructed in the wet. After the tremie plug is poured, the excavation will be pumped dry and the remainder of the culvert constructed in the dry before moving onto the next section.

For the culvert founded as described above, a factored bearing resistance at Ultimate Limit States (ULS) of 175 kilopascals (kPa) and bearing resistance at Serviceability Limit States (SLS) of 150 kPa may be assumed for design. The culvert should be designed to withstand the appropriate weight of fill and traffic loading.

Backfill around the culvert should be carried out as per Ontario Provincial Standard Drawing (OPSD) 802.02. Culvert backfill material should consist of free-draining, non-frost susceptible granular materials such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B, Type II.

Heavy compaction equipment should not be used adjacent to the walls and roof of the culvert. The height of backfill adjacent to the culvert walls should be maintained equal on both sides of the structure during all stages of backfill placement. Temporary diversion of surface water flow may be required during culvert installation. Adequate erosion protection, such as suitable non–woven geotextile and rip rap, as determined by hydraulic assessment, should be provided at the inlet and the outlet.

5.2.1 Lateral Earth Pressures for Design

The lateral pressures acting on the proposed culvert will depend on the backfill soils and, where used, the type and method of placement of the backfill materials behind the wall, as well as the subsequent lateral movement of the structure. The following recommendations are made concerning the design of the culvert wall in accordance with Ontario Highway Bridge Design Code (OHBDC).

Backfill behind the culvert walls should consist of select, free-draining granular fill meeting the specifications of OPSS Granular A or Granular B Type II but with less than 5 per cent passing the No. 200 sieve.

Where backfill soils are placed and compacted behind the walls, a compaction surcharge equal to 16 kPa should be included in the lateral earth pressures for structural design, in accordance with OHBDC. Compaction equipment should be used in accordance with OPSS 501.06.

The granular fill should be placed in a zone with a width equal to at least 1.2 metres behind the culvert walls. For walls backfilled as noted above, the following parameters (unfactored) may be assumed:

Fill unit weight:	22 kN/m^3
Coefficients of lateral earth pressure:	
'active', K_a	0.31
'at rest', K_o	0.47

If the wall support allows lateral yielding (unrestrained structure), active earth pressures may be used in the geotechnical design of the structure. If the culvert wall support does not allow lateral yielding (restrained structure), at-rest pressures should be assumed for geotechnical design.

Resistance to sliding may be based on an unfactored angle of shearing resistance of 32 degrees. The unfactored coefficient of passive pressure for the portion of the culvert wall and footing below invert may be taken as 3.1.

5.3 Retaining Wall

It is understood that in conjunction with the realignment of the horizontal curve for Highway 401 at approximately station 17+600, it is proposed to construct a new retaining wall in the existing berm adjacent to the new northern limit of the right-of-way. The work will include the construction of a privacy wall at the top of the retaining wall and two storm sewer catchbasins adjacent to the retaining wall and at the northern edge of the proposed pavement. Boreholes 5 to 14 are relevant to the proposed retaining wall. Based on the subsurface conditions in the boreholes and site limitations, shallow foundations are not considered suitable for the proposed retaining wall and consideration is being given to constructing the proposed retaining wall as a cantilever sheet pile wall, concrete panel wall (caisson wall) or soldier pile and lagging wall. While it is considered that the refusal conditions encountered in the manually drilled boreholes advanced from the top of the berm do not indicate that piling cannot be driven through the existing berm fill materials, some pre-excavation of the surface fill may be required to avoid difficult driving and to facilitate maintaining proper alignment of driven piles.

5.3.1 Cantilever Sheet Pile Wall

A cantilever sheet pile wall is one of the retaining wall options being considered. The interlocking steel sheet pile sections will be driven prior to excavating the berm south of the wall and for the proposed pavements.

Given the relatively low overall height of the sheet pile wall (about 4 metres) and the presence of the berm fill materials sloping down from behind the wall, it is anticipated that the wall can be cantilevered without requiring anchors; although the wall must be designed to withstand the loading from the existing berm and proposed privacy wall. Further, the sheet pile wall should be designed to withstand the loading conditions during excavation for pavement construction and the wind loading on the proposed privacy wall.

For design purposes, a groundwater level at elevation 301 metres may be used with the following unfactored geotechnical parameters to calculate the required sheet pile section and embedment:

Soil unit weight, γ:	20 kN/m^3
Angle of internal friction, ϕ:	35 degrees

Coefficients of lateral earth pressure:

	GROUND SURFACE PROFILE		
	Berm Sloping Down Away From Wall	Level With Wall	Berm Sloping Up Away From Wall
'active', K_a	0.23	0.27	0.39
'passive', K_p	3.69	3.69	3.69

5.3.2 Caisson Wall

Another option being considered is a concrete panel wall supported on steel H-piles with caisson foundations. Based on the anticipated dimensions and location of the wall, it would be very difficult to construct the caissons without removing the existing berm or building an extensive temporary fill. Further, based on preliminary calculations, the caissons will extend well below the measured groundwater level and extensive dewatering will be required to complete the caissons without disturbing the founding soils. Based on the anticipated level of difficulty and project limitations, a caisson wall is not considered feasible at this site.

5.3.3 Soldier Pile Wall

A soldier pile with timber lagging and/or permanent concrete panel wall would be supported on steel H-piles driven into the granular deposits. Some pre-augering of the surface fills may be required to ensure that the H-piles are driven plumb. To reduce the potential for damage from the cobbles and boulders, the piles should be provided with cast steel driving shoes. Given the relatively low overall height of the proposed wall (a 4 metre retaining wall with a 3 metre privacy wall), it is anticipated that the wall can be cantilevered without requiring anchors. Suitable surface drainage should be provided behind this type of wall.

For design, the factored axial resistance at ULS for steel HP 310 x 110 piles driven into the compact granular deposits at about elevation 296 metres may be taken as 800 kilonewtons (kN), and the axial resistance at SLS for 25 millimetres of settlement may be taken as 600 kN. However, the final design of the soldier piles, including section selection and embedment length, will depend on lateral resistance rather than geotechnical axial resistance.

For determining lateral resistance of the soldier piles below the adjacent finished grade, an unfactored coefficient of passive lateral earth pressure, K_p, for the compact to very dense native granular deposits may be taken as 3.69, as indicated in Section 5.3.1 above. Passive toe resistance to the soldier piles may be determined using a triangular pressure distribution acting over an equivalent width equal to three times the pile width.

It is understood that the detailed design of the wall requires that the soldier piles be driven as deep as elevation 294.5 metres. Relatively difficult driving conditions should therefore be expected together with some problems in maintaining alignment, particularly if boulders are encountered.

5.4 Excavations

Excavations will be required at the proposed new culvert crossing location, retaining wall location and for localized sewer construction adjacent to the retaining wall location. Excavations should be carried out in accordance with the guidelines outlined in the current edition of the Occupational Health and Safety Act and Regulations for Construction Projects. The fills and the granular soils below the groundwater level at this site would be classified as Type 3 soils. All native granular soils above the groundwater level would be classified as Type 2 soils. Generally, temporary open-cut slopes should be maintained no steeper than 1 horizontal to 1 vertical (1H:1V). Where space restrictions dictate or excavations extend below the groundwater level, the excavation could also be carried out within vertical cuts within a braced steel sheet pile excavation.

The design of braced sheeting should be based on a rectangular earth pressure distribution using the design parameters given above and an unfactored coefficient of passive earth pressure of 3.1.

GOLDER ASSOCIATES LTD.

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AMH/PRB/FJH/cb
n:\active\3200\001-3200\001-3230-2 dillon - foundations - 401\reports\001-3230-2 (rpt)\0321 (final) foundation & design (part a&b).doc

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPES

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

II. PENETRATION RESISTANCES

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

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

WH sampler advanced by static weight-weight, hammer

PH sampler advanced by hydraulic force

PM sampler advanced by manual force

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

Relative Density	"N" Blows/0.3 m or Blow/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

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

IV. SOIL TESTS

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

NOTES:

1. Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.
2. Undrained triaxial tests in which pore pressures are measured are shown as Q or R.

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$
e = base of natural logarithms 2.7183
$\log_e$ a or ln a, natural logarithm of a
$\log_{10}$ a or log a, logarithm of a to base 10
t time
g acceleration due to gravity
V volume
W weight
m mass
M moment
F factor of safety

II. STRESS AND STRAIN

u pore pressure
σ normal stress
σ' normal effective stress (σ is also used)
τ shear stress
ε linear strain
ε_{sy} shear strain
υ Poisson's ration (μ is also used)
E modulus of linear deformation (Young's modulus)
G modulus of shear deformation
K modulus of compressibility
η coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

γ unit weight of soil (bulk density)
γ_s unit weight of solid particles
γ_w unit weight of water
γ_d unit dry weight of soil (dry density)
γ' unit weight of submerged soil
G_s specific gravity of solid particles $G_s = \gamma_s/\gamma_w$
e void ratio
n porosity
w water content
S_r degree of saturation

(b) *Consistency*

w_L liquid limit
w_P plastic limit
I_P plasticity index
w_S shrinkage limit
I_L liquidity index = $(w - w_p)I_p$
I_C consistency index - $(w_L - w)/I_p$
e_{max} void ratio in loosest state
e_{min} void ratio in densest state
D_r relative density = $(e_{max} - e)/(e_{max} - e_{min})$

(c) *Permeability*

h hydraulic head or potential
q rate of discharge
v velocity of flow
i hydraulic gradient
κ coefficient of permeability
j seepage force per unit volume

(d) *Consolidation (one-dimensional)*

m_v coefficient of volume change = $-\Delta e/(1+e)\Delta\sigma'$
C_c compression index = $-\Delta e/\Delta\log_{10}\sigma'$
c_v coefficient of consolidation
T_F time factor = $c_v t/d^2$ (d, drainage path)
U degree of consolidation

(e) *Shear strength*

τ_f shear strength
c' effective cohesion intercept
ϕ' effective angle of shearing resistance, or friction

(in terms of effective stress: $\tau_f = c' + \sigma' \tan\phi$)

S_u apparent cohesion*
ϕ_u apparent angle of shearing resistance, or friction

(in terms of total stress: $\tau_f = cu + \sigma \tan\phi_u$)

μ coefficient of friction
S_t sensitivity

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

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 1

1 OF 1 **METRIC**

PROJECT 001-3230-2
G.W.P. 288-99-00
DIST HWY 401
DATUM GEODETIC

LOCATION Sta. 17+495 o/s 47 7m Right of Proposed Centreline
BOREHOLE TYPE POWER AUGER (HOLLOW STEM)
DATE 12.9.01

ORIGINATED BY DJM
COMPILED BY DJM
CHECKED BY GMH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
302.89	GROUND SURFACE								
0.00	TOPSOIL, sand and gravel Brown								
0.24	SAND AND GRAVEL, trace silt, with cobbles Compact to dense Brown		1	SS	17		302		
			2	SS	48		301		
			3	SS	19				
			4	SS	24		300		
299.23									
3.66	SAND, fine to medium, trace silt, trace gravel Compact Brown		5	SS	12		299		
298.47									
4.42	SAND, fine to medium, trace silt Very loose to loose Brown		6	SS	(2)		298		
			7	SS	(7)				
296.95							297		
5.94	SAND AND GRAVEL, trace silt Dense Brown		8	SS	35				40 51 8 1
295.73							296		
7.16	SILT, trace sand Loose Grey		9	SS	9		295		
294.81									
8.08	End of Borehole								

Water level encountered at elev. 300.15m during drilling 12.09.01

Water level at elev. 301.00m 29.10.01

"N" Value is concidered to be impacted by sand 'blown back' inside the hollow stem augers after auger advance

"N" Value is concidered to be impacted by sand 'blown back' inside the hollow stem augers after auger advance

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

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

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 2

1 OF 1 **METRIC**

PROJECT 001-3230-2 | G.W.P. 288-99-00 | LOCATION Sta. 17+500 o/s 25.1m Right of Proposed Centreline | ORIGINATED BY DJM
DIST | HWY 401 | BOREHOLE TYPE POWER AUGER (HOLLOW STEM) | COMPILED BY DJM
DATUM GEODETIC | DATE 12.3.01 | CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
301.85	GROUND SURFACE										
0.00	TOPSOIL, sandy Black										
0.20	SAND, fine to coarse, trace silt, trace gravel Compact Brown		1	SS	18	▽	301				
300.64											
1.21 300.33	SAND, with silt, trace gravel. Brown										
1.52	SAND AND GRAVEL, Compact Brown		2	SS	20		300				
298.80			3	SS	25		299				
3.05	End of Borehole Water level encountered at elev. 300.64m during drilling 12.3.01										

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

ON_MOT 00132302.GPJ ON_MOT.GDT 24/3/02 DATA INPUT:

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London, Ontario

RECORD OF BOREHOLE No 3

1 OF 1 **METRIC**

PROJECT 001-3230-2 | G.W.P. 288-99-00 | DIST | HWY 401 | DATUM GEODETIC

LOCATION Sta. 17+463 o/s 6.5m Left of Proposed Centreline | BOREHOLE TYPE POWER AUGER (HOLLOW STEM) | DATE 12.9.01

ORIGINATED BY DJM | COMPILED BY DJM | CHECKED BY DJM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
302.55	GROUND SURFACE										
0.00	TOPSOIL, silty										
0.15	Dark Brown FILL, sandy silt with clay, trace gravel Compact to loose Brown		1	SS	19		302		○		
			2	SS	7		301		○		
300.42											
2.13	SAND, fine to medium, trace silt, trace gravel Compact Brown		3	SS	10		300		○		
			4	SS	15				○		
			5	SS	26		299		○		94 4 2
298.13											
4.42	SAND AND SANDY SILT, Layered Compact Brown		6	SS	17		298		○		
297.06											
5.49	SAND, fine to medium, trace silt Compact Brown		7	SS	10		297		○		1 93 5 1
295.39							296				
7.16	SAND AND GRAVEL Compact Grey		8	SS	22		295		○		
294.47											
8.08	End of Borehole										

Water level encountered at elev. 300.42m during drilling 12.9.01

Water level at elev. 300.75m 29.10.01

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

ON_MOT 00132302.GPJ ON_MOT.GDT 24/3/02 DATA INPUT:

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

PROJECT 001-3230-2
G.W.P. 288-99-00
DIST _____ HWY 401
DATUM GEODETIC

LOCATION Sta. 17+447 o/s 21.8m Left of Proposed Centreline
BOREHOLE TYPE POWER AUGER (HOLLOW STEM)
DATE 13.9.01

ORIGINATED BY DJM
COMPILED BY DJM
CHECKED BY [signature]

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
300.94	GROUND SURFACE										
0.00 / 300.33	TOPSOIL, silty, Black										
0.61 / 299.42	SAND, fine to medium, with silt, with gravel, Loose, Grey		1	SS	4		300				
1.52 / 298.04	SAND AND GRAVEL, Compact, Grey		2	SS	12		299				
			3	SS	18						
2.90 / 296.52	SAND, fine to medium, trace gravel, Loose to compact, Grey		4	SS	8		298				
			5	SS	14		297				
4.42 / 295.00	SAND, fine, trace silt, Compact, Grey		6	SS	15		296				
			7	SS	21						
5.94 / 294.23	SAND AND GRAVEL, Dense, Grey		8	SS	31		295				
6.71	End of Borehole Water level encountered at elev. 299.72m during drilling 13.9.01 Water level at elev. 300.64m 29.10.01										

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

ON_MOT 00132302.GPJ ON_MOT.GDT 24/3/02 DATA INPUT:

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London, Ontario

RECORD OF BOREHOLE No 5

1 OF 1 **METRIC**

PROJECT 001-3230-2 | G.W.P. 288-99-00 | DIST _____ HWY 401 | DATUM GEODETIC

LOCATION Sta. 17+546 o/s 27.5m Left of Proposed Centreline | BOREHOLE TYPE POWER AUGER (HOLLOW STEM) | DATE 14.9.01

ORIGINATED BY DJM | COMPILED BY DJM | CHECKED BY DJM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
301.75	GROUND SURFACE										
0.00	TOPSOIL, silty sand Loose Black										
300.68			1	SS	20		301				
1.07	SAND AND GRAVEL, with cobbles and boulders Compact to very dense Grey		2	SS	48		300				
			3	SS	24		299				
			4	SS	59		298				61 34 4 1
297.18			5	SS	29						
4.57	SANDY SILT. Dense Grey		6	SS	30		297				
296.72											
5.03	SAND AND GRAVEL, with cobbles and boulders Dense to very dense Grey		7	SS	100/175mm		296	Practical auger refusal at 6.0m depth. Borehole moved 1.5m South and reaugered.			
			8	SS	47		295				
294.59			9	SS	58						
7.16	SILT, trace sand, trace clay Dense Grey		10	SS	35		294				2 10 81 7
293.52											
8.23	SAND, fine to medium Compact to dense Grey		11	SS	19		293				
			12	SS	42		292				3 73 17 3
			13	SS	19		291				
290.17											
11.58	SAND, fine to medium, trace silt, trace gravel Very dense Grey		14	SS	92		290				
							289				
287.82			15	SS	105/200mm		288				
13.93	End of Borehole Water level encountered at elev. 299.62m during drilling 14.9.01 Water level at elev. 300.84m 29.10.01										

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

ON_MOT 0013230-2.GPJ ON_MOT.GDT 24/3/02 DATA INPUT:

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London, Ontario

RECORD OF BOREHOLE No 6

1 OF 2 **METRIC**

PROJECT 001-3230-2 | G.W.P. 288-99-00 | LOCATION Sta. 17+567 o/s 14.8m Left of Proposed Centreline | ORIGINATED BY DJM
DIST | HWY 401 | BOREHOLE TYPE POWER AUGER (HOLLOW STEM) | COMPILED BY DJM
DATUM GEODETIC | DATE 24.9.01 - 26.9.01 | CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
301.58	GROUND SURFACE										
0.00 / 300.93	TOPSOIL, silty, Black						301				
0.65 / 300.21	SAND AND GRAVEL, trace silt, trace organic material, Compact, Brown		1	SS	23						
1.37 / 297.92	SAND AND GRAVEL, trace silt, with cobbles, Compact to dense, Brown		2	SS	15		300				
			3	SS	30		299				
			4	SS	33						26 69 4 1
3.66 / 297.31	SILT, some sand, trace clay, Compact, Brown		5	SS	12/150mm		298				
4.27 / 294.87	SANDY SILT, with gravel, cobbles and boulders, Compact, Brown		6	SS	22		297				
			7	SS	(11)		296	"N" Value is concidered to be impacted by sand 'blown back' inside the hollow stem augers after auger advance			
			8	SS	21						30 25 43 2
6.71 / 291.83	SAND AND GRAVEL, trace silt, with silt pockets, Compact to very dense, Brown		9	SS	20		295				
			10	SS	50		294				
			11	SS	61		293				47 48 4 1
			12	SS	35		292				
9.75 / 286.64	SAND, fine to coarse, trace silt, trace gravel, trace silt pockets, Compact to very dense		13	SS	(11)			"N" Value is concidered to be impacted by sand 'blown back' inside the hollow stem augers after auger advance			
			14	SS	37		291				
			15	SS	50		290				
			16	SS	110		289				
			17	SS	103						1 90 8 1
			18	SS	93		288				
			19	SS	107		287				

Continued Next Page

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

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 6

2 OF 2

METRIC

PROJECT 001-3230-2
G.W.P. 288-99-00
DIST HWY 401
DATUM GEODETIC

LOCATION Sta. 17+567 o/s 14.8m Left of Proposed Centreline
BOREHOLE TYPE POWER AUGER (HOLLOW STEM)
DATE 24.9.01 - 26.9.01

ORIGINATED BY DJM
COMPILED BY DJM
CHECKED BY AMM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
14.94	End of Borehole Practical refusal at 8.4m depth. Borehole moved 2.0m East and reaugered. Water level encountered at elev. 300.06m during drilling 24.9.01 Water level at elev. 300.88m 29.10.01										

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

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 7

1 OF 2 **METRIC**

PROJECT 001-3230-2
G.W.P. 288-99-00
DIST ____ HWY 401
DATUM GEODETIC

LOCATION Sta. 17+595 o/s 20.7m Left of Proposed Centreline
BOREHOLE TYPE POWER AUGER (HOLLOW STEM)
DATE 2.11.01

ORIGINATED BY DJM
COMPILED BY DJM
CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
302.07	GROUND SURFACE					
0.00	TOPSOIL, silty, with gravel and cobbles Loose Black		1	SS	7	
300.85						
1.22	SAND AND GRAVEL, with silt layers, Compact Brown and Grey		2	SS	21	
			3	SS	18	
299.33						
2.74	SANDY SILT, with clayey silt layers, Compact Grey		4	SS	17	
			5	SS	19	
297.65						
4.42	SILTY SAND, fine, trace gravel, Loose to dense Grey		6	SS	(8)	
			7	SS	37	
			8	SS	12	
			9	SS	10	
293.84						
8.23	SAND, fine to coarse, trace silt, with gravel and cobbles, Compact to very dense Grey		10	SS	20	
			11	SS	50	
290.49						
11.58	SANDY SILT, with gravel Very dense Grey		12	SS	103	
288.96						
13.11	SILTY SAND, fine, trace gravel, Very dense Grey		13	SS	104	

ELEVATION SCALE: 301, 300, 299, 298, 297, 296, 295, 294, 293, 292, 291, 290, 289, 288

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

126

"N" Value is concidered to be impacted by sand 'blown back' inside the hollow stem augers after auger advance.

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
	46	50	4
1	85	12	2

Continued Next Page

$+^{3}$, $\times^{3}$ Numbers refer to Sensitivity

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

ON_MOT 00132302.GPJ ON_MOT.GDT 24/3/02 DATA INPUT:

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 7

2 OF 2 **METRIC**

PROJECT 001-3230-2 | LOCATION Sta. 17+595 o/s 20.7m Left of Proposed Centreline | ORIGINATED BY DJM

G.W.P. 288-99-00 | BOREHOLE TYPE POWER AUGER (HOLLOW STEM) | COMPILED BY DJM

DIST ____ HWY 401 | DATE 2.11.01 | CHECKED BY [signature]

DATUM GEODETIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
286.62			14	SS	50/50mm				○		
15.45	End of Borehole										
	Water level encountered at elev. 299.17 during drilling 2.11.01										
	Water level in Standpipe at elev. 301.31m 2.11.01										

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

Golder Associates
London, Ontario

PROJECT 001-3230-2

RECORD OF BOREHOLE No 8

1 OF 1 **METRIC**

G.W.P. 288-99-00 LOCATION Sta. 17+620 o/s 13.9m Left of Proposed Centreline ORIGINATED BY DJM

DIST HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY DJM

DATUM GEODETIC DATE 24.9.01 - 26.9.01 CHECKED BY DJM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
302.18	GROUND SURFACE						302				
0.00 / 301.48	TOPSOIL: silty, Black										
0.70 / 299.89	SAND AND GRAVEL: trace silt,with cobbles, Compact to dense, Brown		1	SS	29		301				
			2	SS	30	▽	300				
2.29 / 297.91	SANDY SILT: trace clay, Compact, Brown		3	SS	15						
			4	SS	10		299				
			5	SS	16						34 63 3
4.27 / 297.00	SANDY SILT: with clayey silt layers, Loose, Brown		6	SS	6	▼	298				
5.18 / 293.80	SANDY SILT, Loose to compact, Grey		7	SS	8		297				
			8	SS	14		296				
			9	SS	24		295				
			10	SS	18						
8.38 / 292.43	SAND: fine to coarse, with silt, trace gravel, Loose to very dense, Grey		11	SS	(5)		294	"N" Value is concidered to be impacted by sand 'blown back' inside the hollow stem augers after auger advance			
			12	SS	55		293				7 81 11 1
9.75 / 291.21	SILTY SAND: fine to medium, with gravel, Very dense, Grey		13	SS	65		292				
10.97 / 290.90	SILTY SAND AND GRAVEL: Very dense, Grey		14	SS	66						
11.28 / 290.14	SILTY SAND: fine to medium, with gravel, Dense, Grey		15	SS	49		291				
12.04 / 289.53	SAND AND GRAVEL: with silt, Very dense, Grey		16	SS	77		290				
12.65	End of Borehole Water level encountered at 300.35m during drilling 24.9.01 Water level at elev. 297.27m 29.10.01										

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

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 9

1 OF 1 **METRIC**

PROJECT 001-3230-2 | G.W.P. 288-99-00 | LOCATION Sta. 17+655 o/s 21.1m Left of Proposed Centreline | ORIGINATED BY DJM

DIST _____ HWY 401 | BOREHOLE TYPE POWER AUGER (HOLLOW STEM) | COMPILED BY DJM

DATUM GEODETIC | DATE 25.9.01 | CHECKED BY DMA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
303.95	GROUND SURFACE										
0.00 / 303.30	TOPSOIL, silty, Black										
0.65	SAND AND GRAVEL, trace silt, with cobbles, Dense to very dense, Brown		1	SS	30		303				
			2	SS	36		302				43 43 13 1
			3	SS	53	▼	301				
300.44			4	SS	58	▽					
3.51	SILTY SAND, fine, with gravel, Compact to dense, Brown		5	SS	32		300				
298.77			6	SS	15		299				69 30 1
5.18	SAND, fine to medium, trace silt, trace gravel, Loose to very dense, Brown		7	SS	(6)			"N" Value is concidered to be impacted by sand 'blown back' inside the hollow stem augers after auger advance			
297.24			8	SS	51		298				
6.71	SAND AND GRAVEL, trace silt, with cobbles, Very dense, Brown		9	SS	55		297				
			10	SS	67		296				
			11	SS	50						
294.20			12	SS	87		295				
9.75	SAND, fine to medium, trace silt, trace gravel, Very dense, Brown		13	SS	83		294				
293.44											
10.51	SAND AND GRAVEL, trace silt, with cobbles, Very dense, Brown		14	SS	98		293				50 41 8 1
292.68											
11.27	SAND, fine to medium, trace silt, trace gravel, Compact, Brown		15	SS	20		292				
291.91											
12.04	SAND, fine to coarse, trace silt, trace gravel, Very dense, Brown		16	SS	111						
291.45											
12.50											
12.65	SILT, trace sand, trace gravel, Very dense, Brown, End of Borehole										

Water level encountered at elev. 300.90m during drilling 25.9.01

Water level at elev. 301.33m 29.10.01

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

ON_MOT 00132302.GPJ ON_MOT.GDT 24/3/02 DATA INPUT:

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 10

1 OF 1 **METRIC**

PROJECT 001-3230-2 | G.W.P. 288-99-00 | DIST _____ HWY 401 | DATUM GEODETIC

LOCATION Sta. 17+678 o/s 24.5m Left of Proposed Centreline | BOREHOLE TYPE POWER AUGER (HOLLOW STEM) | DATE 25.9.01

ORIGINATED BY DJM | COMPILED BY DJM | CHECKED BY AMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.18	GROUND SURFACE						304			
0.00 / 303.88	TOPSOIL, silty, Black									
0.30	SAND AND GRAVEL, trace silt with cobbles, Dense to very dense, Brown		1	SS	55					
			2	SS	113		303			
			3	SS	54					
			4	SS	37		302			
300.37										
3.81	SANDY SILT, Compact, Brown		5	SS	12		301			
			6	SS	13					27 71 2
299.00							300			
5.18	SILTY SAND, fine, Loose to very loose, Brown		7	SS	(7)			"N" Value is concidered to be impacted by sand 'blown back' inside the hollow stem augers after auger advance		
			8	SS	(2)		299	"N" Value is concidered to be impacted by sand 'blown back' inside the hollow stem augers after auger advance		
297.47										
6.71	SAND, fine to coarse, Very loose, Brown		9	SS	(3)		298	"N" Value is concidered to be impacted by sand 'blown back' inside the hollow stem augers after auger advance		
296.71										
7.47	SAND AND GRAVEL, some silt, with cobbles, Very dense, Brown		10	SS	71		297			
			11	SS	99					
			12	SS	100		296			
293.66										
10.52	SAND, fine to coarse, trace silt, Loose, Brown		13	SS	(6)		295	"N" Value is concidered to be impacted by sand 'blown back' inside the hollow stem augers after auger advance		
292.90										
11.28	SAND AND GRAVEL, trace silt, with cobbles, Very dense, Brown		14	SS	57		294			53 36 9 2
			15	SS	53					
291.53							293			
12.65	End of Borehole Water level encountered at elev. 302.96m during drilling 25.9.01 Water level at elev. 301.31m 29.10.01						292			

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

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

ON_MOT 00132302.GPJ ON_MOT.GDT 24/3/02 DATA INPUT:

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

PROJECT 001-3230-2
G.W.P. 288-99-00
DIST _____ HWY 401
DATUM GEODETIC

LOCATION Sta. 17+630 o/s 24.4m Left of Proposed Centreline
BOREHOLE TYPE MANUAL DRILLING (UNCASED)
DATE 1.10.01

ORIGINATED BY DEE
COMPILED BY DJM
CHECKED BY DJM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
306.54	GROUND SURFACE										
0.00	TOPSOIL, sandy Brown										
0.23	FILL, silty sand, with gravel, with cobbles Very dense Brown		1	SS	34/150mm		306				
305.53											
1.01	End of Borehole Auger refusal at 1.01m depth.							Note: Sampling and Dynamic cone carried out using 31.75Kg hammer. N Values shown are estimated equivalents.			

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

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 12

1 OF 1 **METRIC**

PROJECT 001-3230-2 | LOCATION Sta. 17+667 o/s 30.5m Left of Proposed Centreline | ORIGINATED BY DEE

G.W.P. 288-99-00 | BOREHOLE TYPE MANUAL DRILLING (UNCASED) | COMPILED BY DJM

DIST _____ HWY 401 | DATE 1.10.01 | CHECKED BY DJM

DATUM GEODETIC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, X LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
306.72	GROUND SURFACE										
0.00	TOPSOIL, sandy, with gravel Brown										
0.23	FILL, silty sand, with gravel, with cobbles Very dense Brown		1	SS	50/25mm		306				
305.78 0.94	End of Borehole Auger refusal at 0.94m depth.										

Note: Sampling and Dynamic cone carried out using 31.75Kg hammer. N Values shown are estimated equivalents.

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

ON_MOT 00132302.GPJ ON_MOT.GDT 24/3/02 DATA INPUT

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 13

1 OF 1 **METRIC**

PROJECT 001-3230-2 | G.W.P. 288-99-00 | DIST | HWY 401 | DATUM GEODETIC

LOCATION Sta. 17+726 o/s 28.6m Left of Proposed Centreline | BOREHOLE TYPE MANUAL DRILLING (UNCASED) | DATE 1.10.01

ORIGINATED BY DEE | COMPILED BY DJM | CHECKED BY AMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
306.83	GROUND SURFACE										
0.00	TOPSOIL, sandy, trace gravel, with cobbles Brown										
0.20	FILL, silty sand, with gravel and cobbles Dense to very dense Brown		1	SS	45		306				
305.00			2	SS	82						
1.83	End of Borehole Auger refusal at 1.83m depth.						305	Note: Sampling carried out using 31.75Kg hammer. N Values shown are estimated equivalents.			

+ 3 . × 3 Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

ON_MOT 00132302.GPJ ON_MOT.GDT 24/3/02 DATA INPUT:

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 14

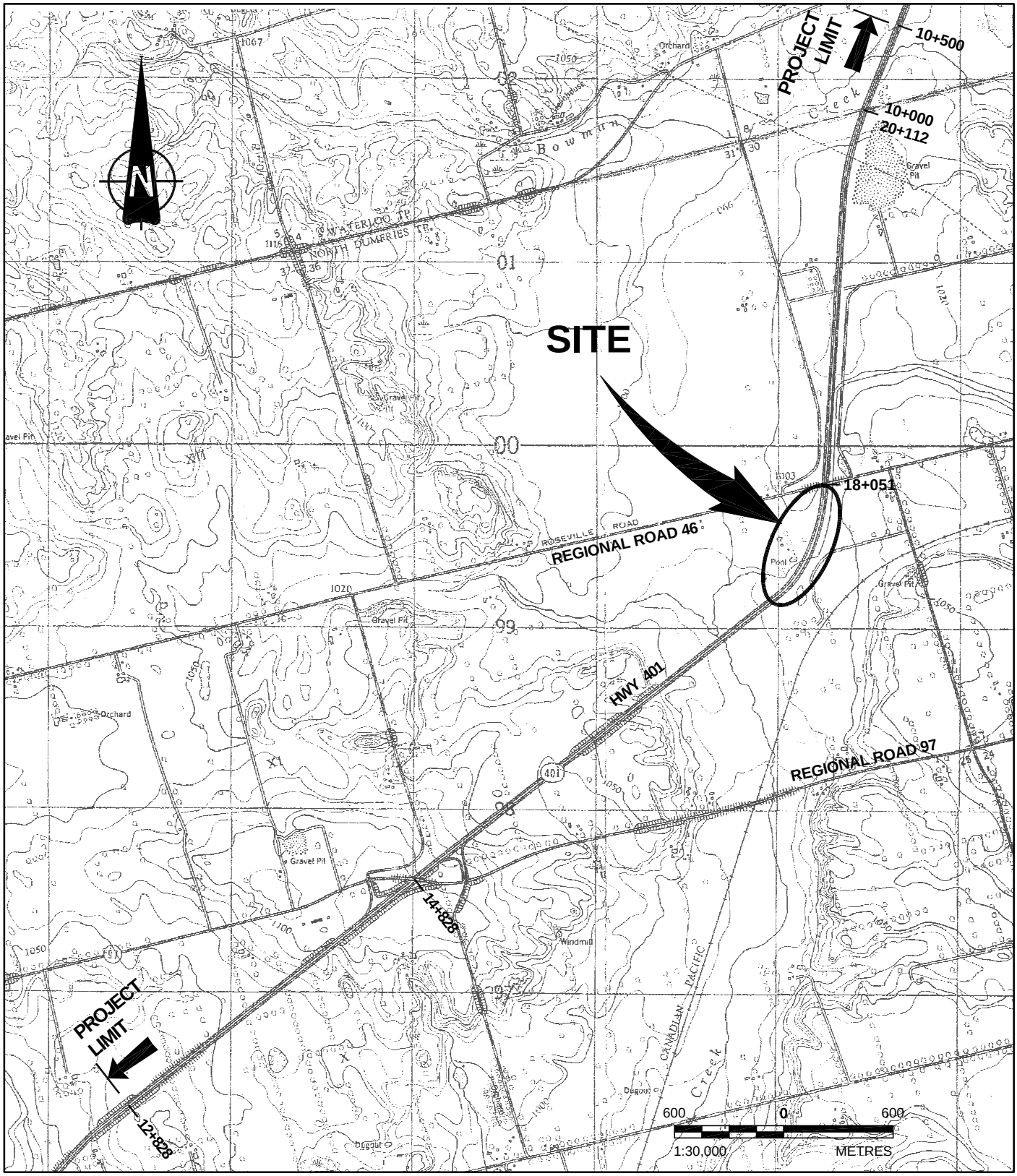
1 OF 1 **METRIC**

PROJECT 001-3230-2
G.W.P. 288-99-00 LOCATION Sta. 17+667 o/s 25.5m Left of Proposed Centreline ORIGINATED BY DEE
DIST _____ HWY 401 BOREHOLE TYPE MANUAL DRILLING (UNCASED) COMPILED BY DJM
DATUM GEODETIC DATE 1.10.01 CHECKED BY DJM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
305.58	GROUND SURFACE										
0.00	TOPSOIL, sandy, with gravel. Brown										
0.15	FILL, silty sand, with gravel and cobbles. Dense. Brown		1	SS	43		305				
304.21											
1.37	End of Borehole Auger refusal at 1.37m depth (3 attempts)							Note: Sampling carried out using 31.75Kg hammer. N Values shown are estimated equivalents.			

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

ON_MOT 00132302.GPJ ON_MOT.GDT 24/3/02 DATA INPUT:



THIS DRAWING IS APPROXIMATE ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

PROJECT

HIGHWAY 401
WIDENING AND REHABILITATION
GWP 288-99-00

TITLE

KEY PLAN

Golder Associates
LONDON, ONTARIO

PROJECT No.		001-3230-2	FILE No.		0013230D201
DESIGN			SCALE	AS SHOWN	REV. 0
CADD	WDF	03/25/02	FIGURE 1		
CHECK		03/25/02			
REVIEW					

Drawing file: 0013230D201.DWG Jul 18, 2002 - 2:06pm

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

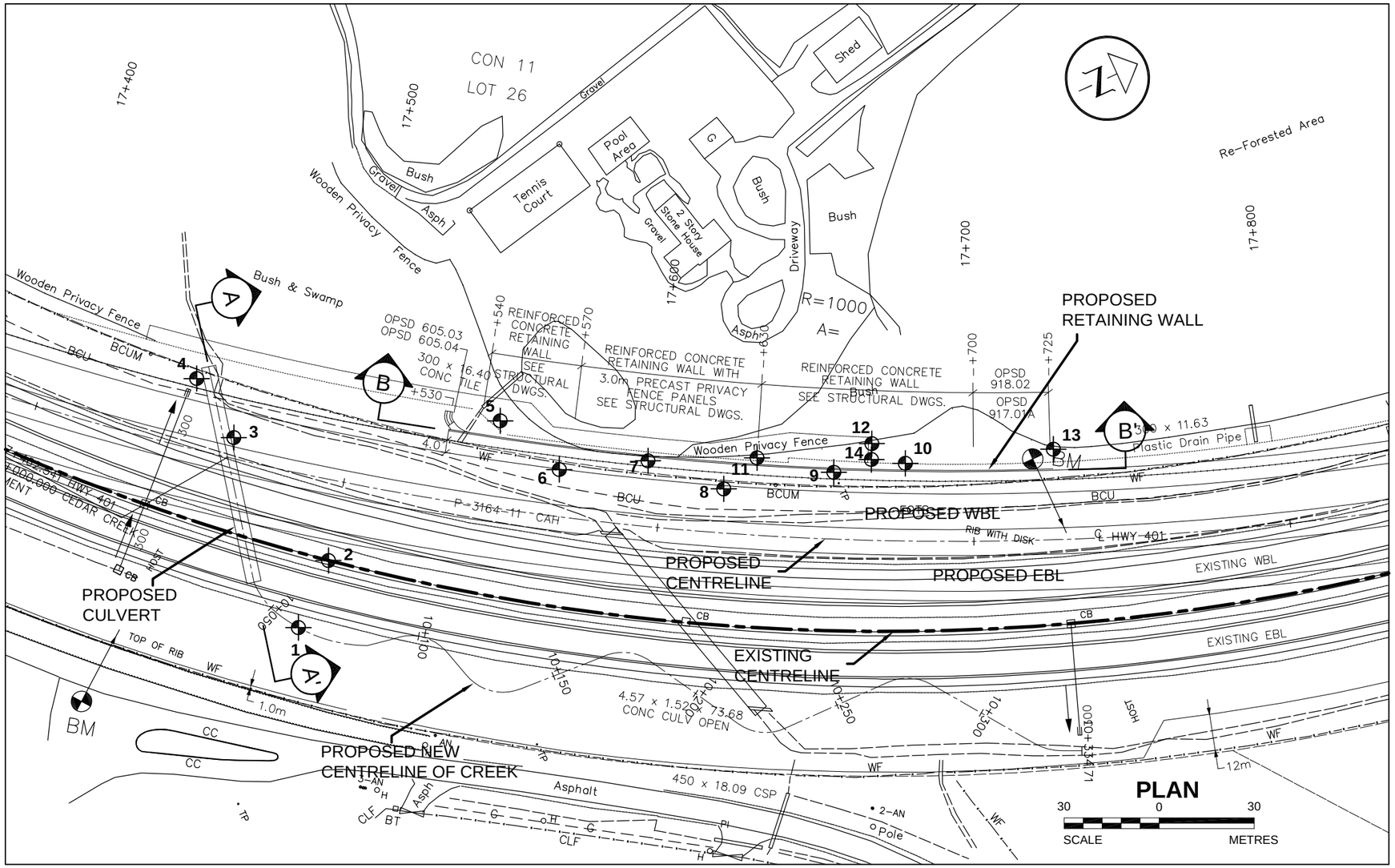
DIST HWY. 401
CONT. No.
GWP No. 288-99-00

PROPOSED CULVERT AND RETAINING WALL
BOREHOLE LOCATIONS

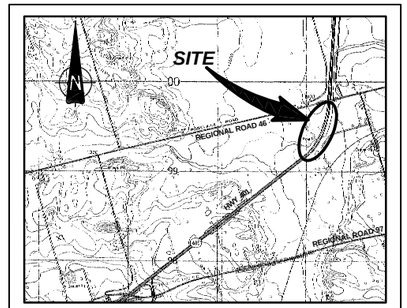
SHEET

Golder Associates Ltd.
LONDON, ONTARIO, CANADA

REFERENCE
DRAWING SUPPLIED BY
DILLON CONSULTING



REFERENCE
FOR SOIL STRATA REFER TO DRAWING 2



KEY PLAN

LEGEND

Borehole

No.	ELEVATION (metres)	STATION	CENTRELINE NEW MEDIAN OFFSET
1	302.89	17+495	47.7m RT
2	302.55	17+500	25.1m RT
3	302.55	17+463	6.5m LT
4	300.94	17+447	21.8m LT
5	301.75	17+546	27.5m LT
6	301.58	17+567	14.8m LT
7	302.07	17+595	20.7m LT
8	302.18	17+620	13.9m LT
9	303.95	17+655	21.1m LT
10	304.18	17+678	24.5m LT
11	306.54	17+630	24.4m LT
12	306.72	17+667	30.5m LT
13	306.83	17+726	28.6m LT
14	30.5.58	17+667	25.5m LT

NOTES
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION

Geocres No. 40P8-123

HWY. No. 401		PROJECT NO.: 001-3230-2	
SUBM'D. –	CHKD: –	DATE: MAR. 2002	
DRAWN: WDF	CHKD. AMH	APPD.	DWG. 1

1 = 1 metric D size dwg 22" x 32" 11" x 17" plot half scale

001323OD202.DWG

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

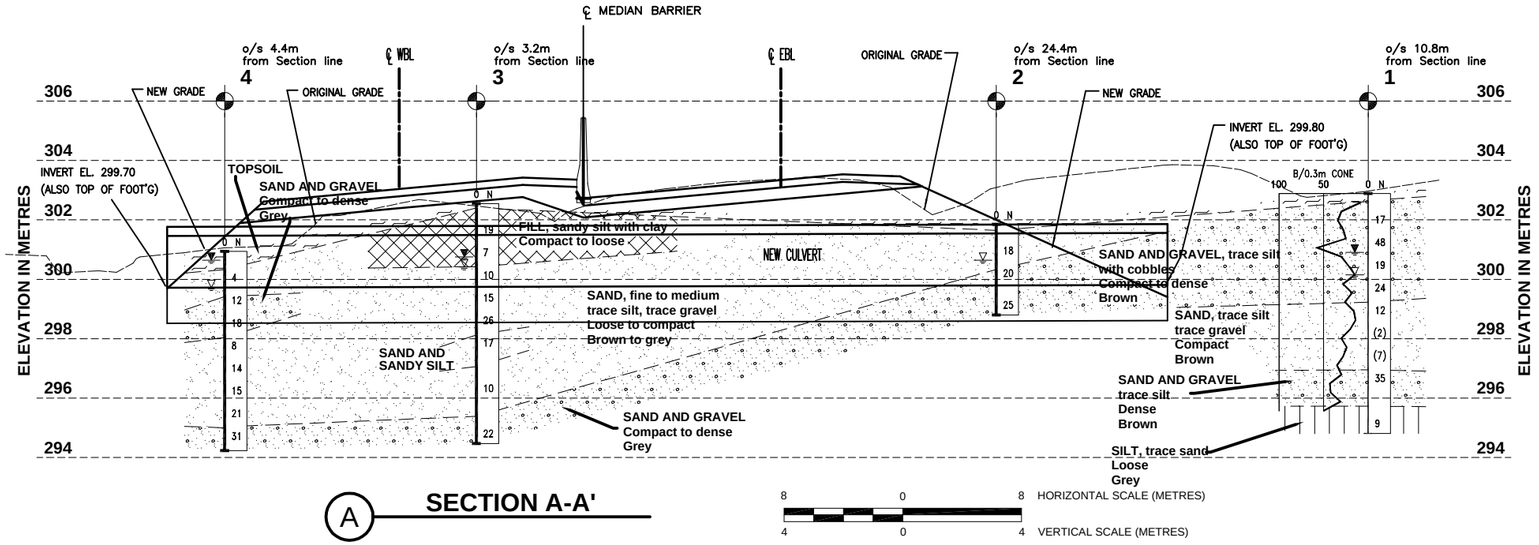
DIST HWY. 401
CONT. No.
GWP No. 288-99-00

PROPOSED CULVERT AND RETAINING WALL
SOIL STRATA

SHEET

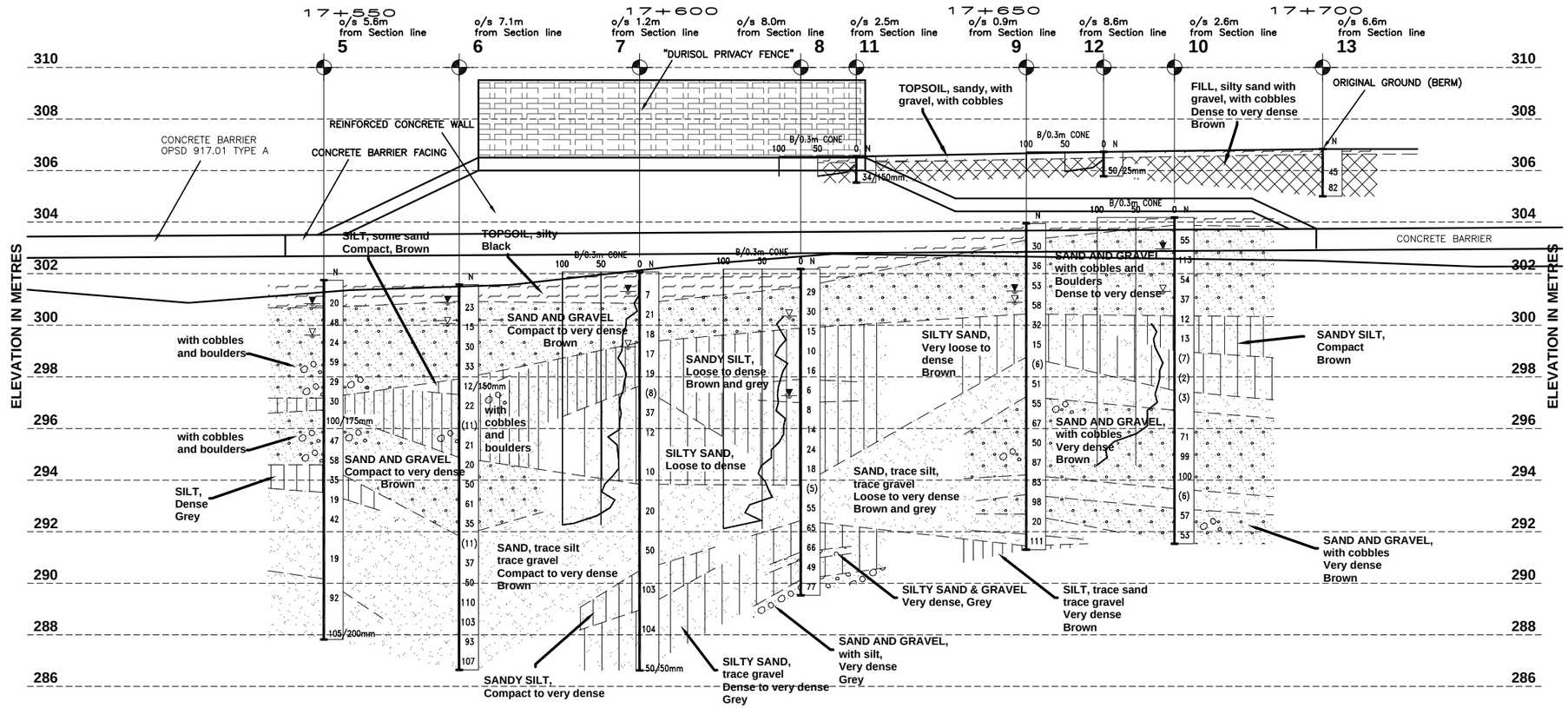
Golder Associates Ltd.
LONDON, ONTARIO, CANADA

REFERENCE
DRAWING SUPPLIED BY
DILLON CONSULTING



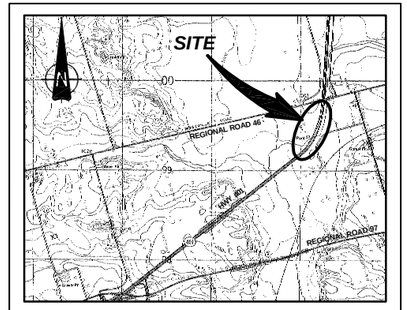
A **SECTION A-A'**

8 0 8 HORIZONTAL SCALE (METRES)
4 0 4 VERTICAL SCALE (METRES)



B **SECTION B-B'**

16 0 16 HORIZONTAL SCALE (METRES)
4 0 4 VERTICAL SCALE (METRES)



KEY PLAN

LEGEND

- Borehole
- N — Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL in standpipe
- WL during drilling
- (N) — "N" Value is concidered to be impacted by sand 'blown back' inside the hollow stem augers after auger advance.

No.	ELEVATION (metres)	STATION	CENTRELINE NEW MEDIAN OFFSET
1	302.89	17+495	47.7m RT
2	302.55	17+500	25.1m RT
3	302.55	17+463	6.5m LT
4	300.94	17+447	21.8m LT
5	301.75	17+546	27.5m LT
6	301.58	17+567	14.8m LT
7	302.07	17+595	20.7m LT
8	302.18	17+620	13.9m LT
9	303.95	17+655	21.1m LT
10	304.18	17+678	24.5m LT
11	306.54	17+630	24.4m LT
12	306.72	17+667	30.5m LT
13	306.83	17+726	28.6m LT
14	30.5.58	17+667	25.5m LT

NOTES
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION

Geocres No. 40P8–123

HWY. No. 401		PROJECT NO.: 001–3230–2	
SUBM'D. –	CHKD: –	DATE: MAR. 2002	
DRAWN: WDF	CHKD. AMH	APPD.	DWG. 2

1 = 1 metric D size dwg 22" x 32" 11" x 17" plot half scale

001323OD203.DWG

APPENDIX A

SITE PHOTOGRAPHS

SITE PHOTOGRAPHS

Photo 1: Looking northwest of existing culvert.

Photo 2: Borehole 7.

SITE PHOTOGRAPHS

Photo 3: West end of proposed wall.

Photo 4: Borehole 5, west end of wall.

SITE PHOTOGRAPHS

Photo 5: East of culvert.

Photo 6: Borehole 7.

SITE PHOTOGRAPHS

Photo 7: West of borehole 7.

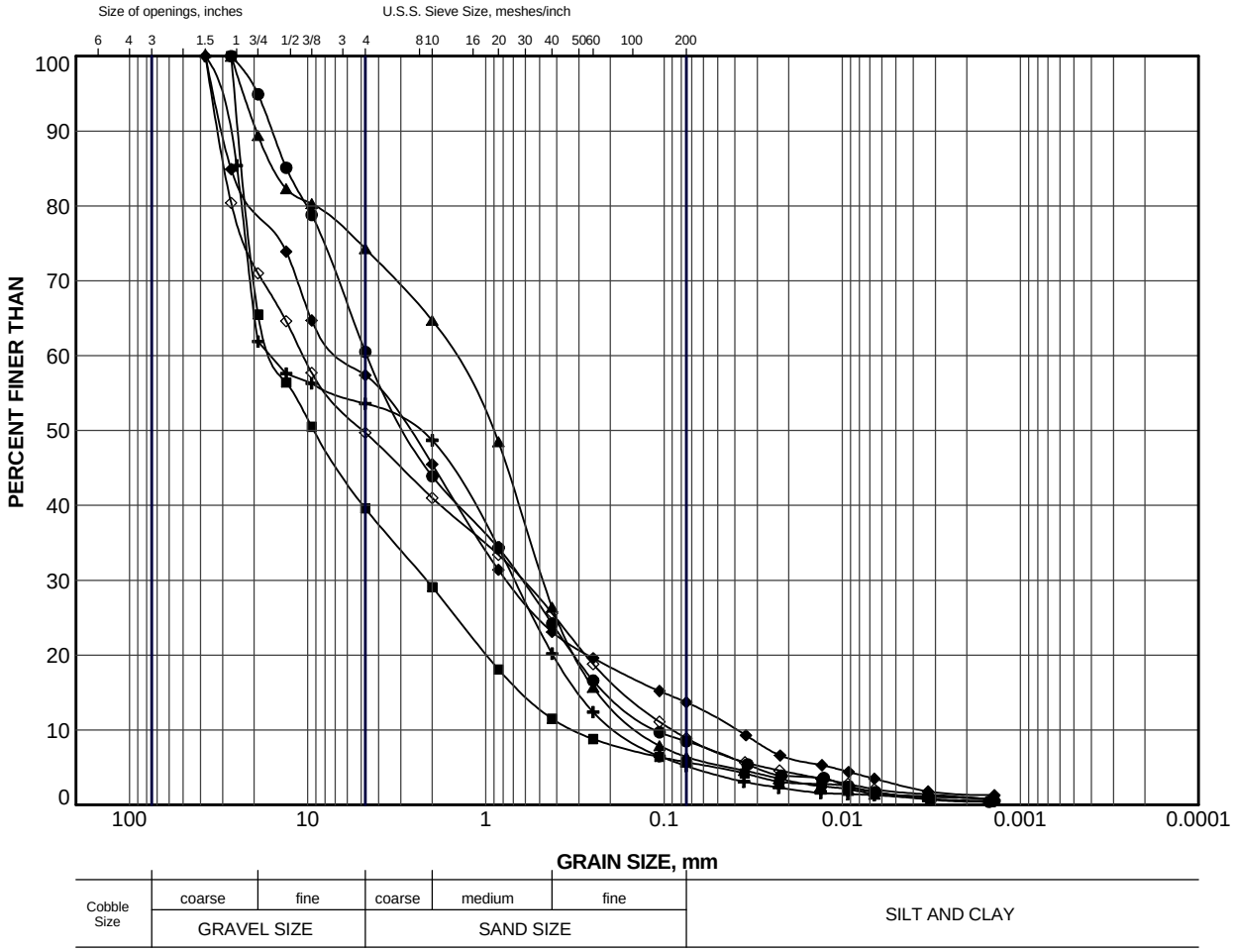
Photo 8: West of borehole 7.

SITE PHOTOGRAPHS

Photo 9: West of culvert, downstream.

APPENDIX B

LABORATORY DATA



LEGEND

SYMBOL	SAMPLE TYPE	ELEV (m)
●	8	296.6
■	4	298.5
▲	4	298.3
✚	11	293.0
◆	2	302.2
◇	14	293.1

POWER AUGER (HOLLOW STEM)

PROJECT

HIGHWAY 401
WIDENING AND REHABILITATION
GWP 288-99-00

TITLE

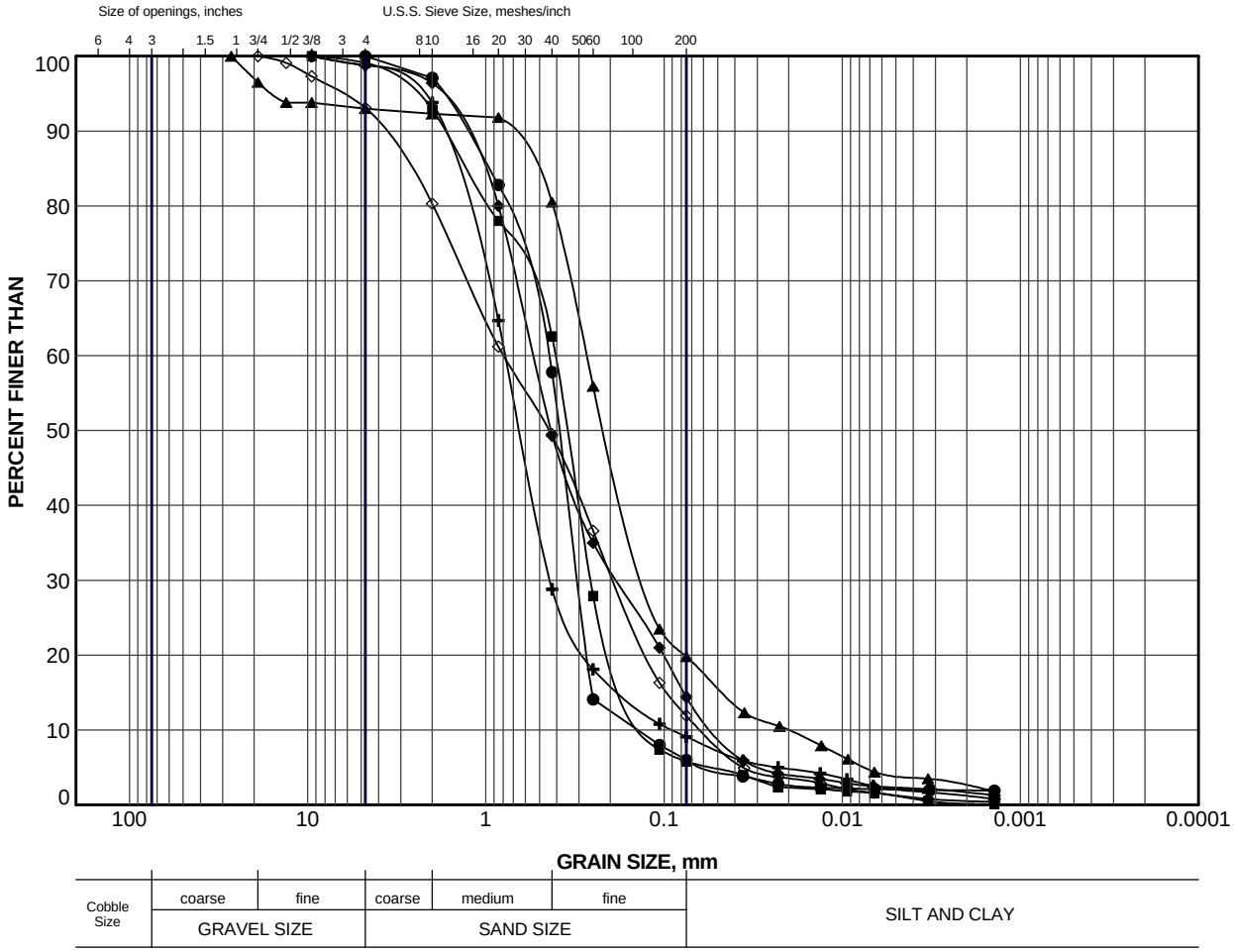
GRAIN SIZE DISTRIBUTION

SAND AND GRAVEL

Golder Associates
LONDON, ONTARIO

PROJECT No.			FILE No. 00132302.GPJ
			SCALE N/A REV.
DRAWN	WDF	03/25/02	
CHECK		03/25/02	**FIGURE B-1**

LDN_GSD_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	SAMPLE	ELEV (m)
	POWER AUGER (HOLLOW STEM)	
●	5	298.5
■	7	296.2
▲	12	292.4
✚	17	288.4
◆	10	292.7
◇	12	292.8

PROJECT

HIGHWAY 401
WIDENING AND REHABILITATION
GWP 288-99-00

TITLE

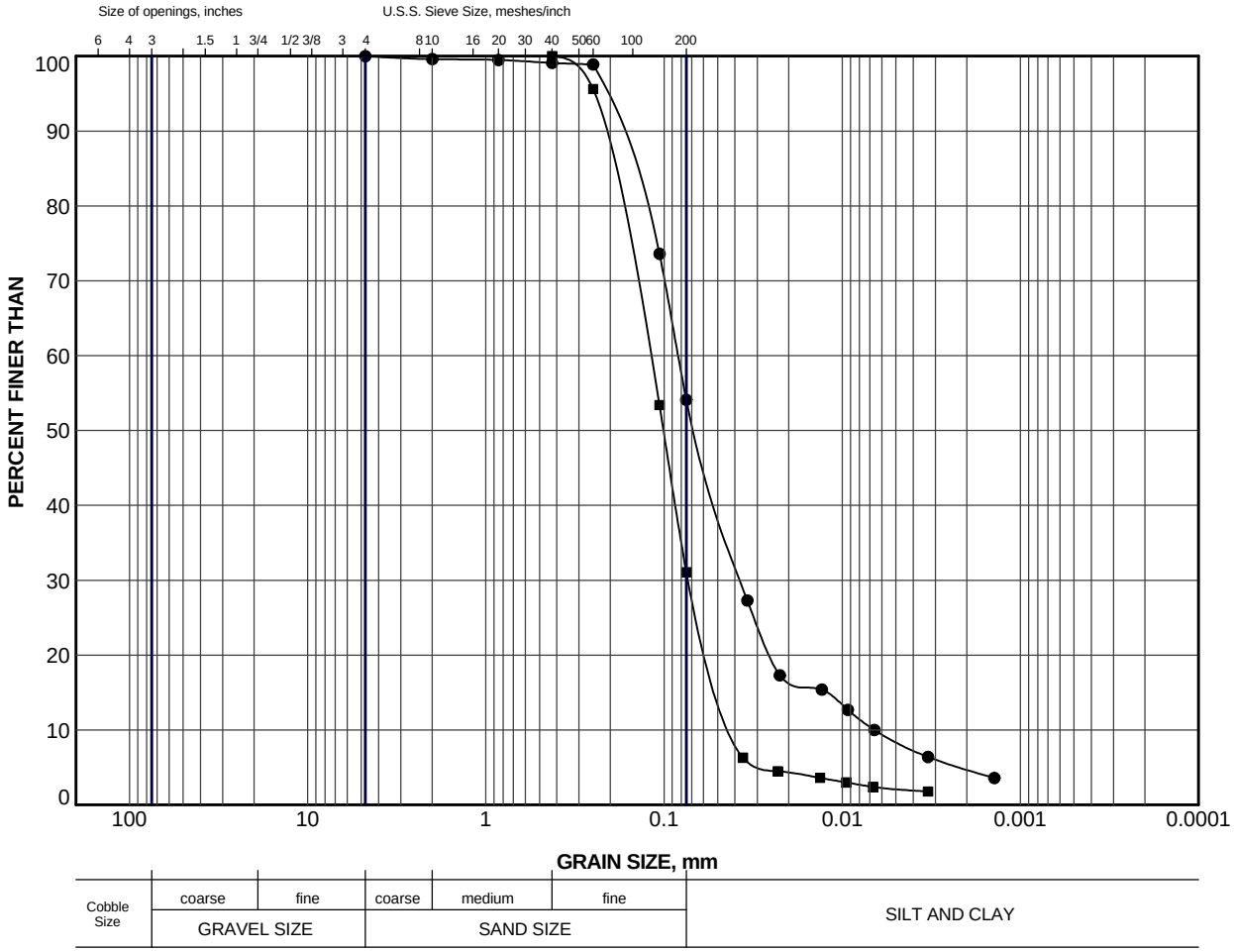
GRAIN SIZE DISTRIBUTION

SAND

Golder Associates
LONDON, ONTARIO

PROJECT No.			FILE No. 00132302.GPJ
			SCALE N/A REV.
DRAWN	WDF	03/25/02	
CHECK		03/25/02	**FIGURE B-2**

LDN_GSD_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	SAMPLE	ELEV (m)
POWER AUGER (HOLLOW STEM)		
●	6	297.3
■	6	299.2

PROJECT

HIGHWAY 401
WIDENING AND REHABILITATION
GWP 288-99-00

TITLE

GRAIN SIZE DISTRIBUTION

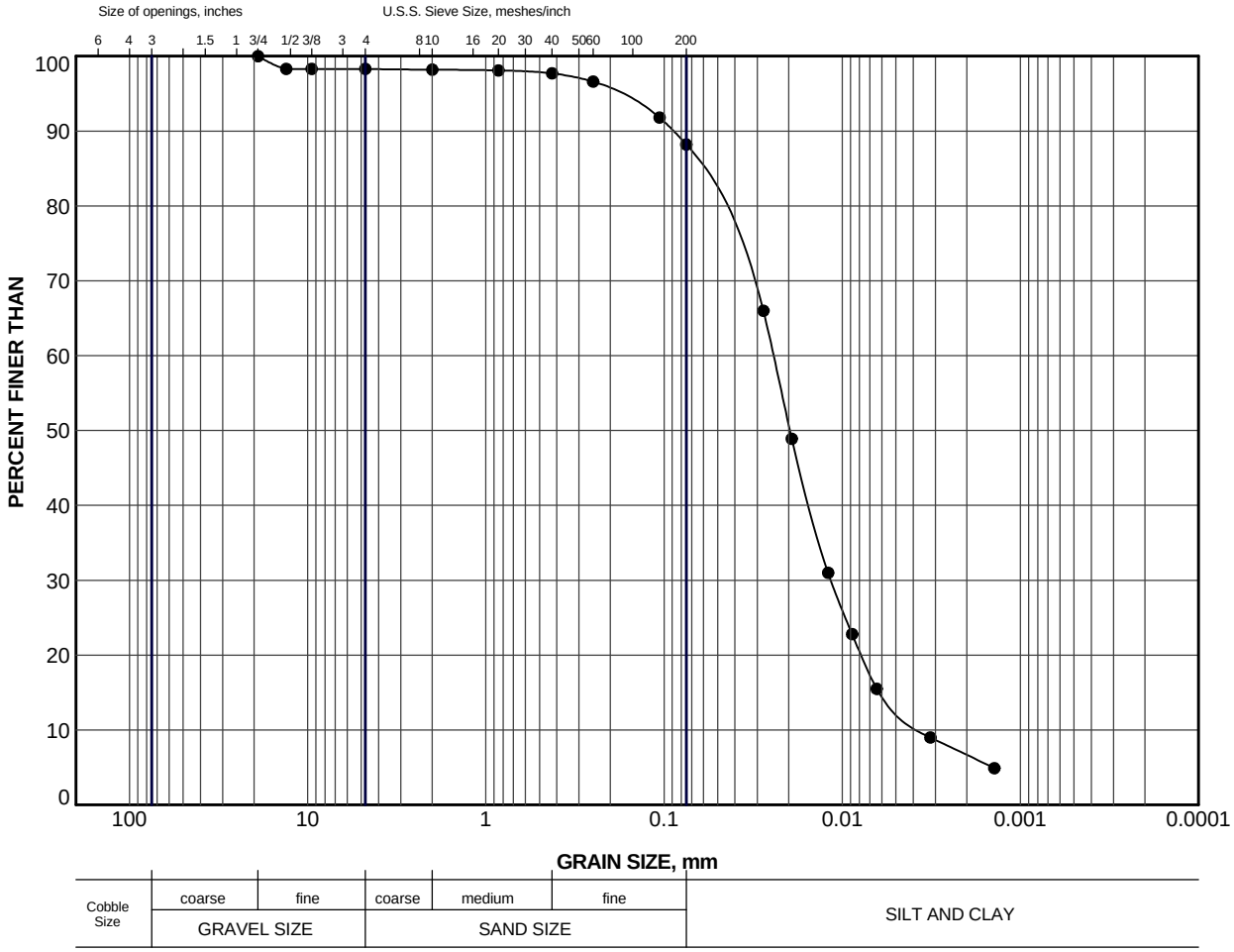
SILTY SAND

Golder Associates
LONDON, ONTARIO

PROJECT No.			FILE No.	00132302.GPJ
			SCALE	N/A REV.
DRAWN	WDF	03/25/02		
CHECK		03/25/02		

FIGURE B-3

LDN_GSD_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	SAMPLE	ELEV (m)
●	10	293.9

PROJECT

HIGHWAY 401
WIDENING AND REHABILITATION
GWP 288-99-00

TITLE

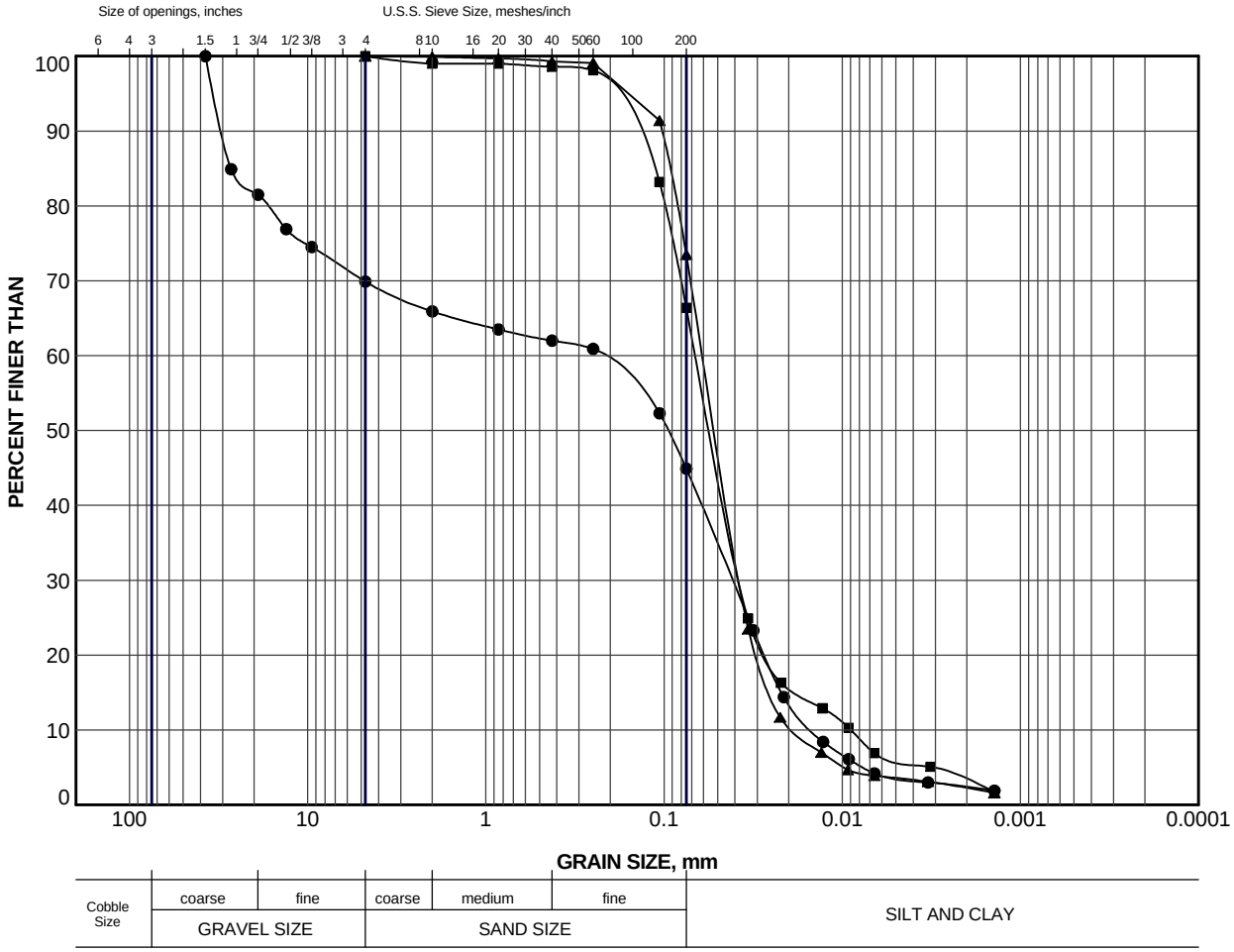
GRAIN SIZE DISTRIBUTION

SILT

Golder Associates
LONDON, ONTARIO

PROJECT No.			FILE No. 00132302.GPJ
			SCALE N/A REV.
DRAWN	WDF	03/25/02	
CHECK		03/25/02	**FIGURE B-4**

LDN_GSD_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	SAMPLE	ELEV (m)
	POWER AUGER (HOLLOW STEM)	
●	8	295.3
■	5	298.2
▲	6	299.4

PROJECT

HIGHWAY 401
WIDENING AND REHABILITATION
GWP 288-99-00

TITLE

GRAIN SIZE DISTRIBUTION

SANDY SILT

Golder Associates
LONDON, ONTARIO

PROJECT No.			FILE No. 00132302.GPJ	
			SCALE N/A	REV.
DRAWN	WDF	03/25/02		
CHECK		03/25/02		

FIGURE B-5

LDN_GSD_NEW GLDR_LDN.GDT