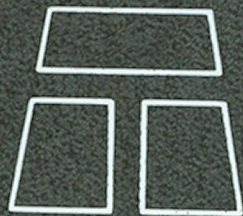


REPORT ON
FOUNDATION INVESTIGATION
AND DESIGN RECOMMENDATIONS
DRIFTWOOD RIVER
REPLACEMENT AND DETOUR BRIDGES
HIGHWAY 101, EAST OF TIMMINS
DISTRICT 53 - NEW LISKEARD, SITE 39E-132
G.W.P. 316-86-00, W.P. 316-85-01
GEOCRES NO. 42A-56



THURBER ENGINEERING

VICTORIA / VANCOUVER / CALGARY / EDMONTON / FORT McMURRAY / TORONTO

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Submitted

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1.0 INTRODUCTION

This report presents the results of a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the detailed design of the replacement and detour bridges, and the associated approach embankments at the Highway 101 crossing of Driftwood River, east of Timmins, Ontario. Thurber has been retained by Stantec Consulting Limited (Stantec) to carry out this work under MTO Purchase Order No. PO-5005-A-000198.

2.0 SITE AND PROJECT DESCRIPTION

The site is located at the Highway 101 crossing of the Driftwood River, some 500m west of Highway 577 near Shillington, Ontario. This site is situated within the MTO District 53, New Liskeard, and its location is shown on Drawings 17-308-294-D1 and 17-308-294-D2. This project site is designated by MTO as Site 39E-132.

The existing bridge consists of twelve 6 m spans. The structure is composed of a concrete deck on steel beams supported on timber pile bents. The width of the bridge deck is approximately 10 m.

The ground in the immediate vicinity of the bridge crossing is soft and swampy. The terrain is relatively flat-lying and the floodplain slopes adjacent to the river flow channel are gentle. The tree line is at about 20 m from the edge of the road in the northeast and southwest quadrants. In the northwest and southeast

quadrants, the area around the bridge is lightly vegetated with grass and occasional shrubs.

We understand that the replacement bridge and approaches will be constructed along the existing Highway 101 alignment. The new bridge will be a three span concrete structure of approximately 80 m in length (between abutment bearings) and 14.5 m in width. The design includes a final road grade raise of up to 1.6 m at both abutment locations.

It is also understood that prior to commencing construction of the replacement bridge, a detour structure will be constructed on an alignment located at 26 m, centerline to centerline, to the north of the existing Highway 101 alignment. The detour structure will be a three span temporary modular bridge (TMB) of approximately 76 m in length and 11.5 m in width. This bridge will be designed to accommodate one lane of traffic in each direction.

3.0 INVESTIGATION PROCEDURES

3.1 Field Investigation

The proposed alignment and foundation locations were provided to us on preliminary General Arrangement drawings (Dwgs. P-1, dated June 2002) prepared by Stantec. In the field, the locations of the piers and abutments for both the replacement and detour structures were either directly staked out, or marked/referenced with respect to existing surface features on site, by Tulloch Engineering & Surveying Inc. (Tulloch).

The field investigation was carried out in two phases, preliminary and detailed.

The preliminary investigation at this site was carried out from January 24 to 26, 2002, inclusive, when six sampled boreholes, numbered 02-5 to 02-10, were

drilled and sampled at selected locations. At the time of the preliminary investigation, decisions were yet to be made on the locations of the replacement and detour alignments. Accordingly, two boreholes were drilled at each of the three alignments, existing, north and south, to obtain preliminary information.

The detailed investigation at this site was carried out during the period of July 30 to September 8, 2002, inclusive, when another twelve boreholes, numbered 02-40 to 02-43, 02-43A, 02-44, 02-45, 02-45A, 02-46 to 02-48 were drilled and sampled. These boreholes were positioned at the finalized locations of replacement and detour bridge abutments, piers, and all associated approach embankments. The following table summarizes the borehole drilling dates.

Borehole Number	Date Drilled
02-8	January 24, 2002
02-6, 02-7, 02-9	January 25, 2002
02-5, 02-10	January 26, 2002
02-45	July 30, 2002
02-45A	July 31, 2002
02-41	August 11, 2002
02-47	August 12, 2002
02-43A, 02-46	September 4, 2002
02-48	September 5, 2002
02-47	September 6, 2002
02-40, 02-43	September 7, 2002
02-40A, 02-42	September 8, 2002

The approximate locations of all boreholes are shown on Drawings 17-308-294-D1 and 17-308-294-D2. Both phases of the investigation were carried out using

track mounted drill rigs supplied and operated by George Downing Estate Drilling Ltd., a specialist drilling contractor from Calumet, Quebec.

The depths of the boreholes at this site ranged from approximately 10 m to 40 m. In the boreholes, a majority of soil samples were obtained with a 50 mm outside diameter split spoon sampler driven in accordance with the Standard Penetration Test (SPT). Relatively undisturbed samples of the cohesive soils were recovered using 2-7/8 in. (70 mm) inside diameter thin-walled Shelby tubes. Field vane shear tests, using a vane conforming to the specified dimensions of an MTO 'N' size vane, were carried out at selected depths within the cohesive deposits. Pocket penetrometer readings were obtained from selected cohesive samples for qualitative strength correlation purposes. At several locations, rotary core drilling was carried out to advance the boreholes through boulders and cobbles.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers were installed with bentonite seals and cap in each of Boreholes 02-9, 02-43, 02-45A and 02-46 to permit longer term groundwater level monitoring. Where artesian conditions were encountered, the standpipes were extended high enough above ground surface to stop groundwater flow.

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. During the preliminary investigation in the winter, a local contractor was retained to clear snow to facilitate access to some of the borehole locations within the floodplain.

The soil samples were identified in the field, placed in appropriately labelled containers and transported back to Thurber's laboratory in Oakville for further examination and testing. Particular attention was paid to the handling,

packaging, insulation and transportation of Shelby tube samples to avoid undue disturbance at all times and potential freezing of the samples during winter. The cores were logged in the field to identify the boulders above the bedrock, secured in wooden core boxes, and transported to our laboratory for further examination.

Boreholes drilled during the preliminary investigation were initially established in the field by our staff based on surface features on site, and subsequently surveyed and tied in by Tulloch. During the detailed investigation, all as-drilled borehole locations were established in the field by Thurber's drilling supervisor based on surveyed stakes and/or marks established by Tulloch on site.

The piers are to be located in shallow waters (< 1 m depth of water at some locations). As suspected during the field work planning stage, the required borehole locations at the piers could not be accessed by water nor by land. Discussions regarding the locations of the pier boreholes were made with Ms. Anna Piascik, P.Eng. of the MTO Foundations Office (Thurber fax to Ms. Piascik dated July 15, 2002). Authorization was subsequently given to Thurber (MTO electronic mail message dated July 19, 2002) to relocate some boreholes, as necessary, to within reasonable distances outside of the proposed pier footprints.

Results of the field drilling, sampling and testing are presented on Drawings 17-308-294-D1 and 17-308-294-D2, and on the Records of Boreholes in Appendix A.

3.2 Laboratory Testing

Geotechnical laboratory testing consisted of natural moisture content determinations, visual classification and description of all soil samples. Grain size distribution analysis, Atterberg Limits tests and specific gravity tests were conducted on selected samples. Three undisturbed specimens of the silty clay, prepared from Shelby tubes, were subjected to laboratory oedometer tests to

determine its consolidation characteristics. Quick triaxial (UU) tests were carried out on selected undisturbed silty clay samples. The results of the laboratory testing are presented in the Records of Boreholes sheets included in Appendix A and in Appendix B.

4.0 GENERAL SITE GEOLOGY AND SUBSURFACE STRATIGRAPHY

4.1 General Site Geology

The general area of the project is covered by glacio-lacustrine sediments of clays and silts laid down by the Glacial Lake Barlow-Ojibway. These deposits are mostly massive clays with some varved zones. Below the glacio-lacustrine deposits are glacial outwash deposits of silts, sands and gravel underlain by Early Precambrian (Superior Province) metavolcanic rocks. The bedrock consists predominantly of mafic and pyroclastic rocks ¹.

4.2 Subsurface Stratigraphy

This section contains simplified descriptions of the subsurface conditions at this site. The detailed subsurface soil, rock and groundwater conditions encountered in the boreholes at this site are presented on the Records of Borehole sheets in Appendix A.

In general, the subsurface conditions encountered at the boreholes within the floodplain of the river consist of road embankment fill overlying a massive deposit of cohesive soils which is in turn underlain by cohesionless soils. The upper portion of this deposit is a silty clay with minor clayey silt to silt seams or layers. The frequency of clayey silt to silt varves increases with depth until the soil grades into a varved silty clay and clayey silt. Peat was encountered in some boreholes below the fill in the approach areas. Below the cohesive deposits lies

¹ "Geology of Ontario" OGS Special Volume 4, Geological Compilation Series Map 2205.

a layer of sand and gravel with boulders and cobbles. Artesian condition was encountered in all boreholes that had fully penetrated the cohesive deposits into the underlying bouldery layer.

4.2.1 Fill

Sand and gravel fill was encountered in Boreholes 02-5, 02-6, 02-7, 02-8, 02-9, 02-10, 02-45 and 02-46 located on the existing road embankment. Some 175 mm to 230 mm of pavement asphalt was encountered at ground surface in Boreholes 02-7, 02-8 and 02-45. This granular fill extends to depths ranging between 0.9 m and 3.2 m. Where measured in Boreholes 02-45 and 02-46, the compactness of this fill varies from loose to compact as indicated by SPT 'N' values of between 10 blows and 16 blows per 0.3 m penetration. Measured moisture contents were typically less than 5 %.

Layers of sand and silt fill ranging from 0.6 m to 2 m in thickness were encountered in Boreholes 02-40, 02-45 and 02-47. Measured 'N' values were between 1 and 2 blows indicating very loose conditions. Measured moisture contents were at approximately 2% and 25% in Boreholes 02-45 and 02-47, respectively.

Cohesive fill was encountered below the sand and gravel in Boreholes 02-7, 02-45 and 02-46. This fill is predominantly a silty clay mixed with organics and some wood fibres. The thickness ranges from 1.4 m to 2.3 m. Measured SPT 'N' value varied from 4 blows to 6 blows per 0.3 m penetration indicating a typically firm consistency. Figure B1 shows the grain size distribution of a sample of this cohesive fill. Moisture contents of generally greater than 20% were measured for samples of this fill.

4.2.2 Alluvium

Alluvium was encountered at the floodplain in Boreholes 02-40, 02-40A, 02-41, 02-43 and 02-44. These soils consist mainly of silty clay to silt, some clay mixed with organics, rootlets and/or wood fibres. The thickness of the alluvium varies between approximately 0.7 m and 3.4 m at the borehole locations. This alluvium has a very soft to soft consistency as indicated by SPT 'N' values of 1 to 4 blows. Measured moisture contents of the alluvium range approximately from 25% to 35%.

4.2.3 Peat

In Boreholes 02-7 and 02-8, peat was encountered below the fill with thicknesses of 0.6 m and 1.5 m, respectively. The peat was mixed with silty clay in Borehole 02-8. An SPT 'N' value of 7 blows was measured in Borehole 02-7 indicating a firm consistency. A moisture content of 101 % was measured for the same sample.

4.2.4 Upper Clayey Silt to Silty Clay

An upper clayey silt to silty clay deposit underlies the fill, alluvium or peat in Boreholes 02-5, 02-6, 02-7, 02-9, 02-10 and 02-46 (permanent alignment) and 02-42, 02-43, 02-43A and 02-44 (detour alignment). The thickness of this layer in the boreholes ranges between about 1.3 m and 3.5 m. This soil has a generally firm to stiff consistency based on correlation with SPT 'N' values, ranging typically from 4 to 11. One field vane test reading of 32 kPa was obtained within this soil in Borehole 02-7.

Figures B6 and B7 show results of Atterberg limits tests carried out on selected samples of this soil which gave plasticity indices ranging from 8 % to 20 %. The silty clay portion of this soil has medium to high plasticity (CI to CH), while the

clayey silt portion of this soil has a low plasticity (CL). Most measured moisture contents were in the range of 25% and 40%. Figure B2 presents the grain size distributions of selected samples.

4.2.5 Silty Clay

A massive deposit of silty clay underlies the alluvium, fill and/or the upper clayey silt to silty clay at this site. This deposit was fully penetrated in Boreholes 02-8, 02-45, 02-46, 02-47, 02-48 (permanent alignment), and 02-9, 02-40A, 02-41, 02-42, 02-43A (detour alignment).

This deposit can be roughly divided into three zones. The upper zone is between 5 m and 10 m thick and has typically no observable layering or varves. The middle zone is between 7 m and 12 m thick and contains occasional clayey silt to silt layers or varves; the frequency of these varves appears to increase with depth. The lower zone may be described as varved clayey silt and silty clay.

Atterberg limits tests carried out on selected samples of this silty clay deposit gave liquid limits ranging between approximately 35% and 55%, and plasticity indices ranging between 25% and 30%. These values indicate that the silty clay is typically of medium to high plasticity (CI to CH). Figures B8 to B10 presents plasticity charts showing the test results for the silty clay. Measured moisture contents of all samples of the silty clay generally ranged between 40% and 60%. Several values were higher than their corresponding liquid limits.

Figures B3 and B4 show grain size distribution curves of selected samples of the silty clay. All of the samples show a clay content of more than 50%. Unit weights of six samples ranged from 16.0 to 18.0 kN/m³.

Field vane shear strengths within the upper and middle zones of the silty clay were typically between 15 kPa and 30 kPa, indicating soft to firm consistency. Occasional values of up to 40 kPa were measured at locations just below the existing embankment. At the lower varved zone, vane shear strengths ranged between 25 kPa and 50 kPa, indicating firm consistency. Similar trends of consistency were inferred from pocket penetrometer and SPT 'N' values.

Three oedometer tests were carried out on samples prepared from Shelby tube samples obtained from Boreholes 02-9 and 02-40. Results of the tests are summarized in the following table.

Borehole and Sample Number	Estimated Pre-Consolidation pressure, σ'_p (kPa)	Estimated Compression Index C_c	Estimated Re-compression Index C_r	Initial Void Ratio e_0	Over-Consolidation Ratio OCR
02-9 TW 1	60	0.66	0.10	1.5	1
02-9 TW 2	80	0.87	0.13	1.9	1
02-40 TW 2	40	0.34	0.06	1.3	1

Borehole and Sample Number	Sample Depth (m)	Sample Elevation (m)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)
02-9 TW 1	7.9	254.9	56.6	45.2	26.5
02-9 TW 2	12.5	250.3	70.0	63.0	40.7
02-40 TW 2	7.9	252.8	47.3	42.6	24.0

Detailed results of the oedometer tests are included in Appendix B.

4.2.6 Sand and Gravel with Cobbles and Boulders

A deposit of sand, gravel with cobbles and boulders was found underlying the silty clay deposit in Boreholes 02-40A, 02-41, 02-42, 02-43A, 02-45, 02-45A to

02-48. Where it appeared to have been fully penetrated in Borehole 02-45A, the thickness of this deposit is in the order of 13 m. SPT 'N' values obtained within the sand and gravel matrix of this deposit ranged from 17 blows to 62 blows, indicating compact to very dense state. Figure B5 shows the grain size distribution of a sample of the sand. These boreholes were terminated upon the occurrence of three consecutive SPT refusal (i.e. > 50 blows per 0.15 m penetration) as per the MTO requirements.

The presence of boulders and cobbles were largely inferred from split spoon refusal and resistance to casing or core barrel advance. Cores of boulders and cobbles were, however, recovered from the bottom of Borehole 02-45A.

In summary, the depths and elevations at which boulders and cobbles were inferred or encountered are listed as follows.

Borehole		Ground Surface Elevation (m)	Inferred Top of Cobbles and Boulders	
Number	Location		Depth (m)	Elevation (m)
02-45A	West Abutment (replacement)	262.5	30.5	232.0
02-47	West Pier (replacement)	261.4	27.8	233.6
02-48	East Pier (replacement)	261.0	26.5	234.5
02-46	East Abutment (replacement)	262.8	28.5	234.3
02-40A	West Abutment (detour)	260.8	25.5	235.3
02-41	West Pier (detour)	261.2	27.3	233.9
02-42	East Pier (detour)	260.8	24.0	236.8
02-43A	East Abutment (detour)	261.0	24.5	236.5
02-8	East Approach (replacement)	263.2	27.1 (cone refusal)	236.1 (cone refusal)
02-9	West Approach (detour)	262.8	27.1 (auger refusal)	235.7 (auger refusal)

It is noted that the above referenced depths and elevations are often lower than the top surface of the sand and gravel.

4.2.7 Groundwater Conditions

During drilling, Boreholes 02-45, 02-45A (permanent alignment) and Boreholes 02-40A, 02-41, 02-42, 02-43A, 02-47, 02-48 and 02-49 (detour alignment) encountered artesian conditions. The water flow was slow to moderate during drilling. The water flow terminated upon caving of the boreholes as the drilling equipment was retrieved or backfilling of the open boreholes with cohesive drill cuttings and bentonite and/or cement.

Standpipe piezometers were installed in Boreholes 02-9, 02-45A, 02-46 (permanent alignment) and 02-43 (detour alignment). The following table summarizes the record of water levels obtained from the piezometers.

Borehole		Ground Surface Elevation (m)	Groundwater	
Number	Screen and Seal Location		Depth (m)	Elevation (m)
02-9	Screen and seal near bottom of clay	262.8	Frozen 0.5 0.5 0.5	Frozen (Jan.26, 2002) 262.3 (Aug.13, 2002) 262.3 (Aug. 24, 2002) 262.3 (Sep.15, 2002)
02-43	Screen and seal in silty clay	260.8	- 0.3 0.5 0.5	Dry (Aug.12, 2002) 260.5 (Aug.13, 2002) 260.3 (Aug.24, 2002) 260.3 (Sep.15, 2002)
02-45A	Screen in sand to sand & gravel Seal in silty clay	262.5	-2.1 -0.3 -0.3 (artesian)	264.6 (Aug.12, 2002) 262.8 (Aug.24, 2002) 262.8 (Sep.15, 2002)
02-46	Screen in sand with cobbles and boulders	262.8	-3.3 -2.9 -2.8 (artesian)	266.1 (Aug.13, 2002) 265.7 (Aug.24, 2002) 265.6 (Sep.15, 2002)

The piezometers in Borehole 02-45A and 02-46 indicated the presence of piezometric head of up to 2.1 m and 3.3 m, respectively, above ground surface. Piezometric levels in the other two boreholes were within 0.5 m depth below the existing ground surface.

It should be noted that groundwater levels are subject to seasonal fluctuations and may also be influenced by the water level in the river.

5.0 FOUNDATION EVALUATION AND RECOMMENDATIONS

5.1 General

This section of the report presents foundation recommendations for the design of the proposed replacement and detour bridges and approach embankments.

Design Options

Two alternatives were considered during preliminary design.

Option 1 includes the replacement of the bridge along the present alignment. The new bridge will be a three span structure of about 80 m in length, about 7 m longer than the existing bridge. The new west and east abutments will be located at 4 m and 3 m back from the existing abutments, respectively. An overall raise of the road grade up to 1.6 m is anticipated. A temporary modular bridge (TMB) with two piers and three spans will be utilized to accommodate the detour traffic during construction. The centreline of the detour bridge will be located at 26 m north of the existing highway centreline. The detours will include embankments of up to 2 m high behind the abutments of the TMB.

Option 2 has the same replacement scheme for the existing bridge as in Option 1, but it involves a detour bridge located to the south of the existing bridge.

Selected Option

Subsequent to discussions with MTO, Option 1 has been selected by Stantec for final design due to conflicts with private property for the south detour alignment.

The proposed horizontal and vertical alignments, and structure layouts for the proposed bridges were provided to Thurber on the Preliminary General

Arrangement Drawings P-1 titled "Driftwood River Bridge" and "Driftwood River Bridge – Temporary Modular Bridge" dated June 2002, prepared by Stantec.

5.2 Replacement Bridge Foundations

Spread footings are not considered a feasible foundation alternative for the replacement bridge at this site due to the anticipated magnitude of settlements that will occur if the underlying compressible foundation soils are subject to additional loading.

A design configuration involving integral abutments and piers has been selected by Stantec for the replacement bridge. It is therefore recommended that foundation support be provided by HP 310 x 110 steel piles driven to practical refusal within the very dense sand and gravel with cobbles and boulders.

It is anticipated that the steel piles will not penetrate deep into the very dense sand and gravel with cobbles and boulders. Based on the subsurface conditions established at the borehole locations, the following pile length and tip elevations are recommended for design purposes.

Foundation Unit	Reference Borehole	Estimated Pile Length Below Underside of Abutment/Pier * (m)	Estimated Pile Tip Elevation (m)
West Abutment (replacement)	02-45A	31	229
Pier 1 (west) (replacement)	02-47	26.5	231
Pier 2 (east) (replacement)	02-48	25.5	232
East Abutment (replacement)	02-46	28	232

* The proposed underside of abutment/pier elevations are shown on preliminary General Arrangement Drawing P-1 titled "Driftwood River Bridge", June 2002.

5.2.1 Factored Axial Pile Resistance

The factored geotechnical resistance at Ultimate Limit States (ULS) for HP 310 x110 piles driven into the very dense sand and gravel is 1,600 kN per pile for HP 310 x 110 piles. The SLS condition will not govern the pile design. For verification of SLS, the settlement of the pile head should be assumed equal to the elastic compression of the pile under unfactored design loads.

5.2.2 Downdrag on Abutment Piles

Construction of the new approach fills will be carried out by excavating the existing fills to sufficient depth and replacing with lightweight fill such that there will be no additional loading on the approach embankment subgrade. It is anticipated that there will be no observable settlement due to primary consolidation of the underlying cohesive deposits. Accordingly, downdrag forces do not need to be considered in the pile design.

5.2.3 Pile Installation

All piles shall be installed in accordance with SP No. 903S01 (March 2001).

The appropriate pile driving note to be shown on the contract drawing is "Piles to be driven in accordance with Standard SS103-11 using an ultimate geotechnical resistance of 3,200 kN per pile (Note 1 in Clause 3.3.3 of Section 3 Piles, the Ministry of Transportation, Ontario "Structural Manual", 2002).

In view of the presence of artesian conditions at this site, reinforcements of the pile tips are not considered suitable as they enlarge the pile tip cross-sectional area, thus increasing the potential for upward flow of groundwater and erosion of the soils around the piles.

The recommended pile capacities assume that scour protection is provided to all piles such that scouring will not occur below the underside of the pile caps.

5.2.4 Pile Horizontal Resistance

The values indicated in the table below may be assumed for numerical analysis of the interaction between the HP 310 x 110 pile and the surrounding soil. The lateral pressures obtained from the numerical analysis should not exceed the ultimate soil/pile pressure quoted in the table.

Elevation (m)	Soil Type	k_h (MPa/m)	Ultimate Soil-Pile Contact Pressure (kPa)
Above Elev.240 *	Alluvium and Silty Clays (very soft to firm)	4	180
Elev. 240 to 238	Silty Clay (varved) (firm to stiff)	6.5	270

* And below the CSP.

For integral abutments, the flexibility of the pile can be increased by providing a double or single corrugated steel pipe (CSP) system. The double concentric pipe liner involves the use of 600 mm and 800 mm diameter CSP pipes with a minimum length of 3 m below the underside of the abutment, placed around the H-pile. The space between the two pipes is left unfilled. The annular void between the H-pile and the inner pipe is backfilled with uncompacted uniformly graded sand. The unit of H-pile / sand / inner CSP is free to deflect within the outer CSP. Passive resistance over the length of the double pipe liner may be neglected in design. Figure C1 shows the details of a double pipe integral abutment CSP.

The single pipe system consists of a 600 mm diameter pipe, 3 m long, installed around the H-pile with the annular void between the pile and the CSP backfilled with uncompacted uniformly grade sand. Figure C2 schematically shows a single pipe system. Due to the low lateral resistance offered by the soils within 3 m below the abutment, the single pipe system is not as efficient as the double pipe system in reducing the lateral resistance below the abutment.

5.2.5 Artesian Groundwater Flow Around Piles

Artesian groundwater conditions were encountered in a number of boreholes drilled at this site. Water seepage along the piles is not considered at this site because of the following :

- The foundation soils adjacent to the upper portion of the piles are not erodible.
- The piles will be driven without shoe or rock point resulting in a continuous and tight contact between the pile and the soil.

5.2.6 Frost Protection

The underside of the abutments and the wingwalls must be provided with 2.4 m earth cover or equivalent insulation for frost protection purposes.

5.3 Detour Bridge Foundations

Steel HP 310 x 110 piles driven into the very dense deposit of boulders and cobbles are recommended to support the abutments and piers. The estimated pile lengths and tip elevations are provided in the following table .

Foundation Unit	Reference Borehole	Estimated Pile Length Below Ground Surface (m)	Estimated Pile Tip Elevation (m)
West Abutment (detour)	02-40A (ground surface)	28	233
Pier 1 (west) (detour)	02-41 (ground surface)	30	231
Pier 2 (east) (detour)	02-42 (ground surface)	26	235
East Abutment (detour)	02-43A (ground surface)	28	233

5.3.1 Pile Design Resistances and Pile Driving

Design of piled foundations for the TMB may be carried out according to the same foundation design recommendations provided for the permanent replacement structure. Previous recommendations for factored axial pile resistances and pile installation, as discussed in Sections 5.2.1, 5.2.3 and 5.2.4, are also applicable to the piles for the TMB.

5.3.2 Downdrag on Abutment Piles

The abutment piles will be subject to downdrag created by consolidation of the foundation soils under the influence of the construction of the approach embankments. A factored downdrag force of 690 kN should be added to the factored dead load and the resultant force used to check the structural adequacy of the pile at the neutral plane, at the top of the sand and gravel layer, in accordance with the CHBDC (2000) Clause 6.8.4.

Calculations carried out by Thurber indicate that the piles for the detour bridge abutment will adequately support the anticipated downdrag forces.

5.3.3 Pile Horizontal Resistance

The recommendations included in Section 5.2.4 for the analysis of laterally loaded piles are applicable to the detour bridge piles. Alternatively, the horizontal forces acting on the detour foundations can be resisted by means of battered piles.

5.4 Lateral Earth Pressures

Select free-draining granular fill meeting the specifications of OPSS Granular A or Granular B, Type I, but with less than 5 per cent passing the 200 sieve should be used as backfill behind the walls. It is recommended that the fill be placed in accordance with OPSS 501.

It is recommended that perforated sub-drains and weep holes be installed, where applicable, to provide positive drainage of the granular backfill.

For integral abutments, backfill should be placed in accordance with MTO Standard Drawing SS5-1 (MOD.), March 1997.

At locations where ultra lightweight blast furnace slag is used as backfill, properties of the MTO Type 2 slag shall be used.

It is recommended that the design of abutment and wing walls be carried out using the following unfactored triangular earth pressure distribution :

$$p_h = K\gamma h$$

where K = earth pressure coefficient
 γ = unit weight of soil
 h = depth below top of wall (m)

The earth pressure coefficient (K) is a function of the magnitude and direction of movement of the abutment and wing wall with respect to the backfill material. It is recommended that earth pressure coefficient values be selected according to Section C6.9.1 of the CHBDC (2000) and the following table.

Conditions Behind Wall	Earth Pressure Coefficient (K)					
	OPSS Granular A $\phi = 35^\circ$; $\gamma = 22 \text{ kN/m}^3$		OPSS Granular B, Type I $\phi = 30^\circ$; $\gamma = 21 \text{ kN/m}^3$		Ultra Lightweight Slag Type 2 $\phi = 30^\circ$; $\gamma = 11.5 \text{ kN/m}^3$	
	Horizontal Ground Behind Wall	Ground Sloping at 2H : 1V Behind Wall	Horizontal Ground Behind Wall	Ground Sloping at 2H : 1V Behind Wall	Horizontal Ground Behind Wall	Ground Sloping at 2H : 1V Behind Wall
"At-Rest" Coefficient, K_a	0.27	0.40	0.33	0.54	0.33	0.54
"Passive" Coefficient, K_p	3.7	8.0	3.0	7.0	3.0	7.0

A compaction surcharge up to 16 kPa should be applied in addition to the lateral earth pressures for the structural design of the abutment wall in accordance with Figure 6.9.3 in CHBDC.

Where the Type 2 slag is used, the handling and placement procedures must be in accordance with those specified in the NSSP included in Appendix E.

Other aspects of the abutment granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD-3501.00, where applicable.

5.5 Approach Embankments

5.5.1 General

The design of the approach embankments for both the detour and replacement bridges includes stability and settlement analyses. The potential impact of horizontal displacement of this soil due to the construction of the detour abutments on the existing bridge piles have also been assessed.

Consideration has been given to a variety of measures to maintain stability and to minimize settlements of the approach embankments. These measures include preloading, slope flattening, geosynthetics reinforcement, lightweight fill and their combinations.

5.5.2 Stability Analysis Methodology

For the purpose of embankment stability assessment, a commercially available slope stability analysis program GSLOPE developed by Mitre Software Inc. was used. Conventional total stress analyses were carried out for typical cross-sections using the Bishop's simplified method. Ladd (1991) indicated that for embankment fill placement on soft, cohesive soils, the generation of pore water pressures could constitute the most critical stability condition. Once the pore pressure is allowed to dissipate, there will be a corresponding gain in shear strength for the founding soil and resulting increase in stability of the embankment. The GSLOPE program allows simulation of these conditions as they relate to slope stability. Analyses in terms of effective stresses were also carried out to confirm long term stability.

Table D1 lists the simplified stratigraphic sequence and the foundation design parameters used in the stability analyses.

The following have been considered in our stability analyses :

- Fill materials – Select Subgrade Material (SSM) and lightweight fill for the permanent approach reconstruction; only SSM for the detour approach embankments.
- Embankment geometry – 2H : 1V and 3H : 1V for both side and forward slopes; grade raising and widening of the existing embankment platform.
- Embankment subgrade – all surficial organics and soft/loose soils are removed from the subgrade areas.
- Groundwater table – at the floodplain level.
- Use of geosynthetics to reinforce the subgrade.
- Minimum Factor of Safety during construction – 1.3.

Stability analyses of the approach embankments to the replacement bridge indicated the following :

- The reconstructed approach embankments using lightweight fill, with side and forward slopes of 2H : 1V or flatter, will be stable.
- Beyond the areas where lightweight fill will be used, stability can be maintained for a grade raise up to 0.5 m (maximum anticipated) and a platform widening of up to 2 m.

Stability analyses of the detour approach embankments indicated the following :

- Geosynthetic reinforcement with a minimum long term (allowable) design strength (LTDS) of 50 kN/m is required at the base of the embankment. Figure D3 shows the result of the analysis.

5.5.3 Settlement Analysis

Immediate settlements due to compression of cohesionless soils have been estimated based on elastic analysis methods.

Anticipated settlements due to primary consolidation of the cohesive and varved deposits have been estimated using methods based on Terzaghi's one dimensional consolidation theory.

The following correlation was employed for relating preconsolidation pressure to field vane shear strength (Mesri, 1975) :

$$C_u = 0.22 \sigma_p'$$

where C_u = field undrained shear strength (kPa)

σ_p' = preconsolidation pressure, kPa

The applicability of this relationship to soft and varved clays have been documented in the foundation/geotechnical literature such as Lacasse and Ladd (1977) and Tavenas et al (1978).

Based on field vane shear strength and oedometer test results from this site, over-consolidation ratio (OCR) values plotted with depth was established as shown on Figure D1.

Settlements due to secondary consolidation have been estimated using the following relationship.

$$S = C_{\alpha}^* \cdot H \cdot \log_{10}[t_{st} / t_p]$$

where S = settlement due to secondary consolidation

C_{α}^* = secondary consolidation ratio (see Table D1)

H	=	thickness of compressible layer
t_{st}	=	design life of structure
t_p	=	time to primary consolidation completion

Replacement Bridge Approaches

For both approach embankments of the replacement bridge, it is anticipated that there will be no observable settlement if lightweight fill is used to replace existing earth fill (within 20 m of the new bridge abutments) such that no additional loading will be induced on the embankment foundation.

Beyond the 20 m lightweight fill replacement zone, the estimated post construction settlements are within the range of 60 mm to 120 mm over a period of 75 years provided that the entire grade raise length is preloaded during the detour operation.

Detour Bridge Approaches

Settlement analysis of the detour bridge approach embankments was carried out assuming the following :

- The embankments will be constructed by placing 3 m of fill, 2 m and 1 m surcharge, as early as possible
- There will be a period of 8 months for the construction of the embankment and waiting period before the removal of surcharge.

The results of this analysis is shown in Figure D2 and summarized as follows :

- During embankment construction and waiting period :
 - 120 mm to 160 mm (8 months)
- During detour operation : - 30 mm to 50 mm (8 months)

A summary of the settlement analysis results is included in Table D2.

5.5.4 Lateral Displacement of Foundation Soils

The construction of the approach embankments of the detour bridge is anticipated to result in small lateral deflection (≈ 5 mm) along the existing bridge abutment piles.

For the detour approaches, the foundation soils around the detour abutment piles will continue to consolidate and displace laterally during detour operation. The maximum anticipated lateral deflection of the foundation soils at the detour abutment pile location during the detour operation is in the order of 5mm to 10mm.

5.5.5 Embankment Design

Table D3 summarizes the embankment design requirements of the selected Option 1.

Replacement Bridge Approach

In order to minimize the potential for additional settlement of the approach embankments due to the proposed grade raise, the following is recommended :

- Within 20 m behind the proposed abutment, remove the existing embankment and underlying native peat/organics, where required, which

are anticipated to be encountered up to 1 m below the underside of the existing embankment. Backfill with compacted SSM to Elevation 260.4 m, the normal river level. Above this elevation, construct the embankment to the underside of the pavement structure using ultra lightweight, Type 2, slag.

- Beyond the 20 m zone, the ultra lightweight fill will taper upwards at an inclination of 20H : 1V. This tapered zone will extend to about 90 m behind the new east abutment. At the end of the taper, the grade raise will be up to 0.5 m, reducing to 0 some 50 m further east. The design includes widening of the embankment platform at road grade. However, all the new fill will be placed within the footprint of the existing embankment.

In order to minimize post construction settlement beyond the 20 m zone where ultra lightweight fill will be used, it is recommended that fill be placed to the top of the final design grade without paving, and be left in place during the detour operation.

Expanded polystyrene (EPS) is an alternative to ultra lightweight (Type 2) slag. The use of this material will minimize the depth of excavation to 1 m below existing top of pavement since this material has a lower unit weight (approximately 1 kN/m³). Beyond the 20 m zone immediately behind the new abutment, the EPS blocks may be placed in a staggered fashion to provide a minimum overall taper of 20 H : 1 V. In the transverse direction, an overall slope of 2 H : 1 V is recommended. The design pavement thickness of 900 mm is considered sufficient to provide adequate earth cover on top of the EPS blocks.

An NSSP for the installation of EPS will be provided to Stantec if required.

Detour Bridge Approach

For constructing the detour approach embankment, it is recommended that SSM be placed in one stage to a height of 3 m (including a 1 m surcharge) at the beginning of the preloading period.

It is recommended that the detour embankment platform be sufficiently wide to accommodate any reduction in width at final grade level that will result from the anticipated settlements.

Geosynthetics are required at the base of the embankment in order to maintain stability of the detour approaches during construction. It is recommended that geosynthetic reinforcement be extended to 30 m behind the abutments. The geosynthetic reinforcement should have a combined minimum long term design (allowable) strength (LTDS) of 50 kN/m installed in SSM. The geosynthetic material shall be placed at embankment subgrade level after surficial organics and debris are stripped.

The NSSP for geosynthetics contained in Appendix E should be included in the contract documents.

5.6 Construction Considerations

5.6.1 Subgrade Preparation and Embankment Construction

It is recommended that topsoil and organic deposits be stripped from the subgrade areas and within the plan limits of the detour embankments, and that all subgrade compaction be carried out in accordance with OPSS 501 prior to fill placement.

Construction of the embankment above the prepared subgrade may be carried out using SSM in accordance with OPSS 1010. It is recommended that all fill be placed and compacted in accordance with OPSS 501.

5.6.2 Geotechnical Instrumentation and Monitoring

It is recommended that settlement of the detour approach embankments be monitored at two (2) locations in each of the east and west approaches during construction and operation of the detour.

NSSPs for supply and installation of instruments, and for the monitoring program, are included in Appendix E. The NSSP has been prepared assuming that the supply and installation of instruments will be carried out by the Contractor and that the monitoring program will be the responsibility of the Contract Administrator.

5.6.3 Slope Protection

Vegetation cover should be established on all exposed earth slopes to protect the embankment fill against erosion.

Scour protection should be provided to the permanent forward slopes.

5.6.4 Temporary Excavation and Shoring

Where required, temporary shoring system should be designed to resist an earth pressure distribution as shown on Figure D4. The design of all members of the support system should include the effects of surcharge loads such as those imposed by adjacent structures, construction equipment and road traffic. At locations on land, soil should not be stockpiled within a horizontal distance equal to the depth of the trench, measured from the wall of the trench. If this cannot be

avoided, the soil surcharge must be incorporated into the shoring design. The following parameters are recommended for use in conjunction with Figure D4.

where γ = unit weight of clay = 18 kN/m^3
 γ_w = unit weight of water = 9.8 kN/m^3
 K_a = "active" lateral earth pressure coefficient = 0.3
 K_p = "passive" lateral earth pressure coefficient = 3.0

Where shoring is required, an item titled "Roadway Protection" will have to be included in the contract documents.

Conventional excavation equipment should be suitable for all soil excavations at this site. All temporary excavations must be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act (OHSA), its regulations and other applicable regulations.

For the purposes of assessing slope inclination and excavation support requirements in compliance with OHSA, the following soil types would apply to the subsurface stratigraphy encountered at the borehole locations :

Fills (above groundwater table)	Type 3
Alluvium	Type 4
Silty Clays	Type 4
Sands and Silts (above groundwater table)	Type 3
Sands and Silts (below groundwater table)	Type 4

Decisions regarding dewatering, shoring methods and sequencing should be made by the contractor. All shoring system must be designed by a licensed Professional Engineer experienced in such designs.

5.7 Construction Sequencing

Based on the foundation considerations discussed above and scheduling information provided by Stantec, we envisage the construction sequencing as outlined below :

1. Relocate utilities.
2. Remove peat/organics where required.
3. Install all instrumentation and obtain baseline readings as per NSSP included in Appendix E.
4. Detour embankment construction :
 - Place geogrid to reinforce the subgrade.
 - Construct the detour embankments in one stage to the top of the surcharge.
 - Leave fill in place for 8 months.
 - Remove any excess fill and grade to final sub-grade elevation.
5. Pile Installation :
 - Drive piles.
 - Construct detour piers/abutments and install TMB during this period. It is preferable that the detour abutment piles be driven as late as possible during this stage to allow consolidation of the foundation soil to take place as much as possible.
6. Construct pavement structure on detour.
7. Move traffic from existing to detour alignment.
8. Place fill for preloading existing road alignment beyond the zone of lightweight fill placement.
9. Remove existing structure, drive piles, install abutments and construct new structure.
10. Replacement embankment construction :
 - Remove entire existing approach fill.

- Sub-excavate to remove peat/organics.
- Backfill with SSM to just above design river level.
- Reconstruct approach with lightweight slag up to new pavement subgrade elevation.

10. Construct new pavement structure (granular and asphalt) for the highway.

11. Move traffic from detour to reconstructed highway.

12. Remove TMB and a portion of the detour.

REFERENCES

Ladd, C.C. (1991). "Stability Evaluation during Staged Construction : 22nd Terzaghi Lecture", *J. Geot. Engr.*, ASCE, 117 (4), pp. 537-615.

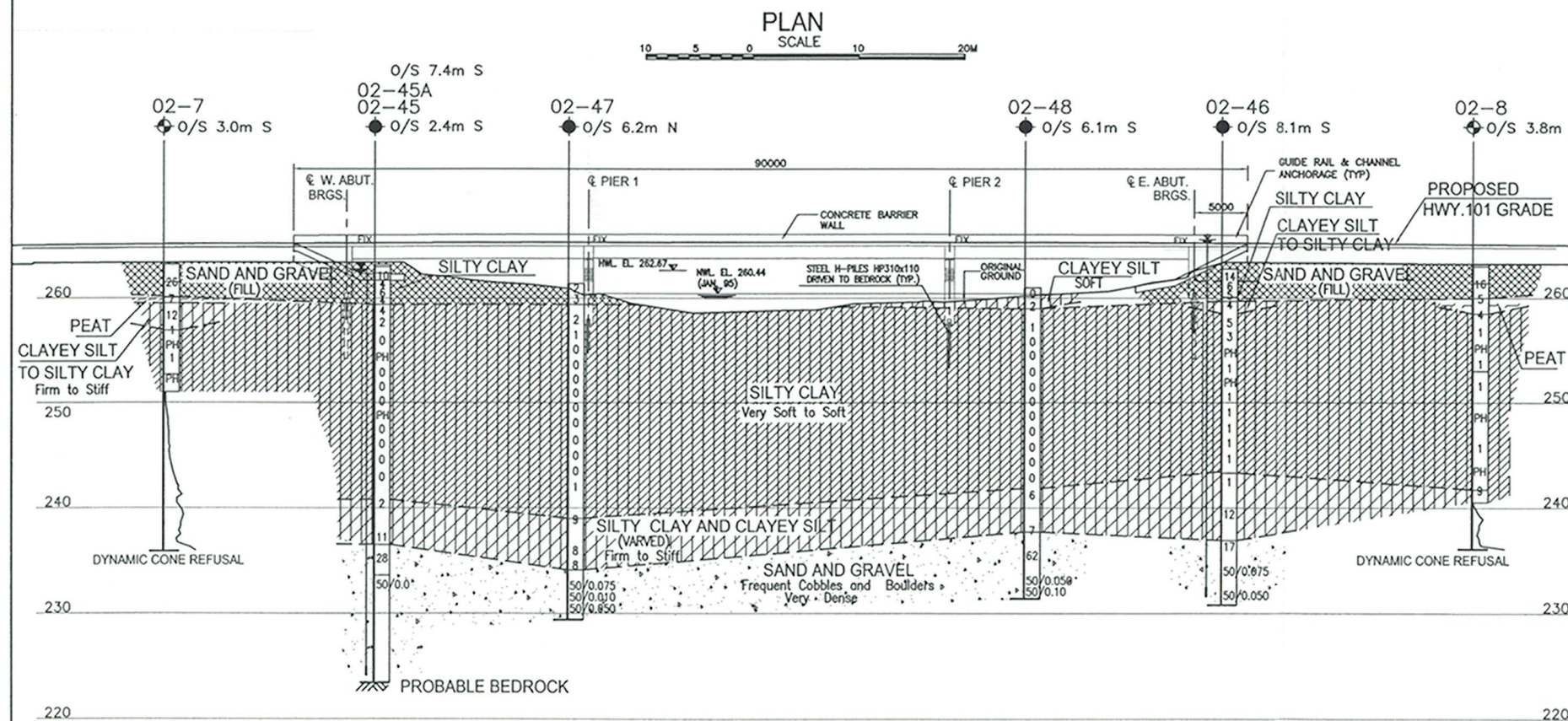
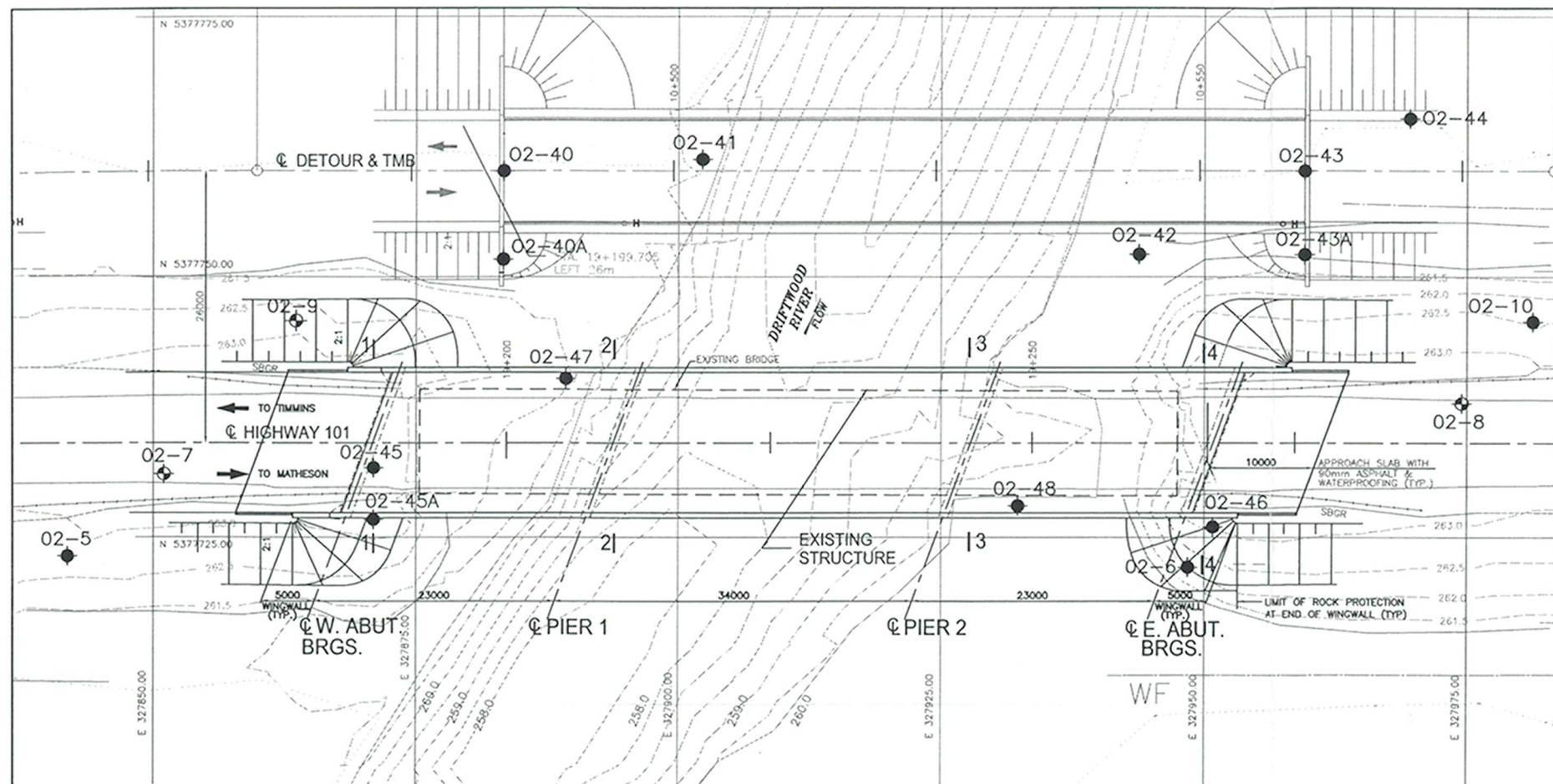
Mesri, G. (1975). "Coefficient of Secondary Compression", *J. Soil Mech. and Fdn. Div.*, ASCE, 9 (1), pp. 123-137.

Mesri, G. and Godlewski, P. (1977). "Time- and Stress- Compressibility Interrelationship", *J. Geot. Engr.*, ASCE, 103 (5), pp. 417 – 430.

Tavenas, F., Blanchet, R., Garneau, R. and Leroueil, S. (1978). "The Stability of Staged-Constructed Embankments on Soft Clays", *Can. Geot. J.*, 15 (2), pp. 293-305.

Lacasse, S., Ladd, C.C. and Barsvary, A. (1977). "Undrained Behavior of Embankments on New Liskeard Varved Clay", *Can. Geot. J.*, 14 (2), pp. 367-388.

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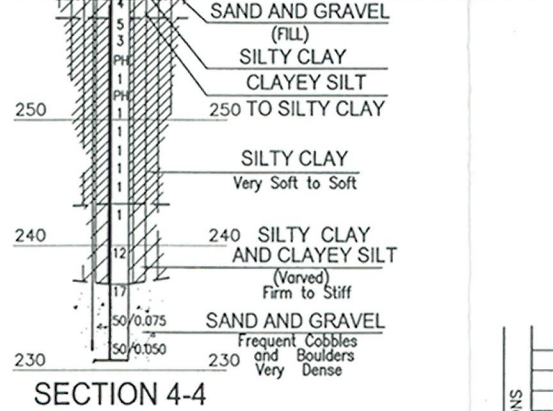
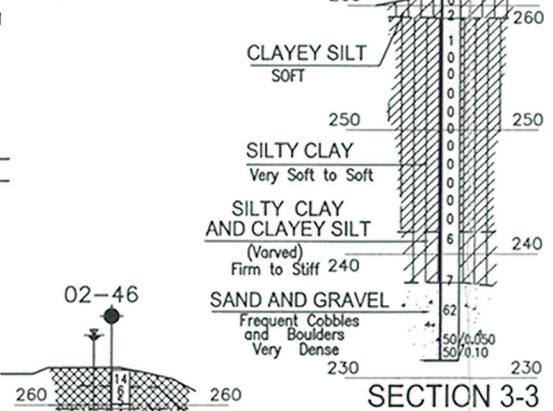
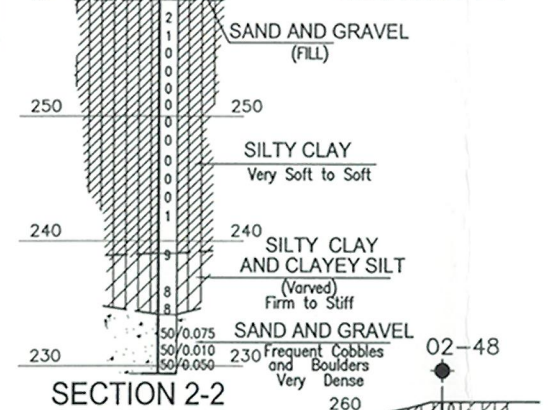
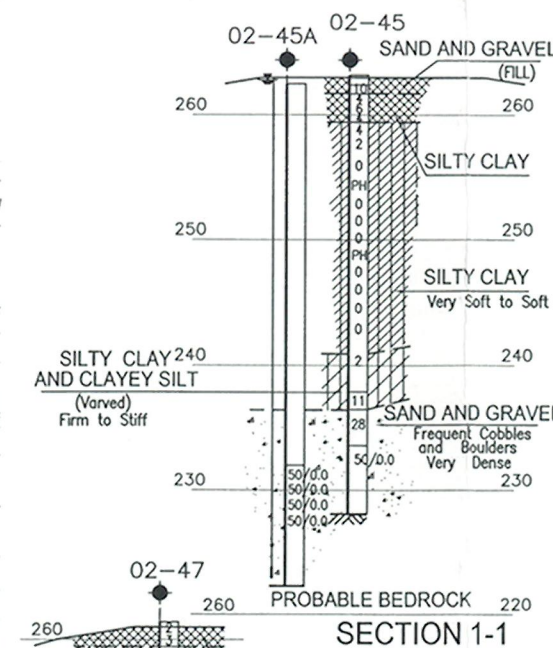


PROFILE \perp HIGHWAY 101

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UNLESS OTHERWISE SHOWN



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WP No. 316-85-01

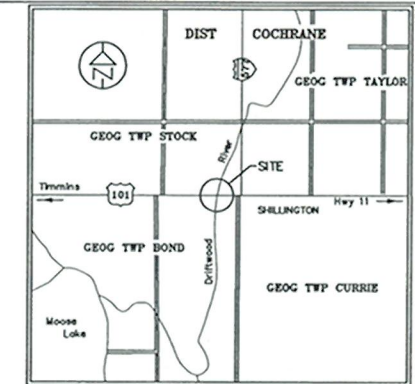
DRIFTWOOD RIVER
REPLACEMENT BRIDGE
BORE HOLE LOCATION & SOIL STRATA



Stantec Consulting Ltd.
1400 Rymal Road East
Hamilton, ON Canada
L8N 3N9
Tel. 905.385.3234
Fax. 905.385.3534
www.stantec.com



THURBER ENGINEERING LTD.



KEY PLAN

1 km 0 1 km

LEGEND

- Bore Hole
- ⊕ Dynamic Cone penetration Test (cone)
- ⊙ Bore Hole & Cone
- N Blow / 0.3m (std pen Test, 475 J / blow)
- CONE Blows / 0.3m (60' Cone, 475J/blow)
- WL at time of investigation 2002
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)

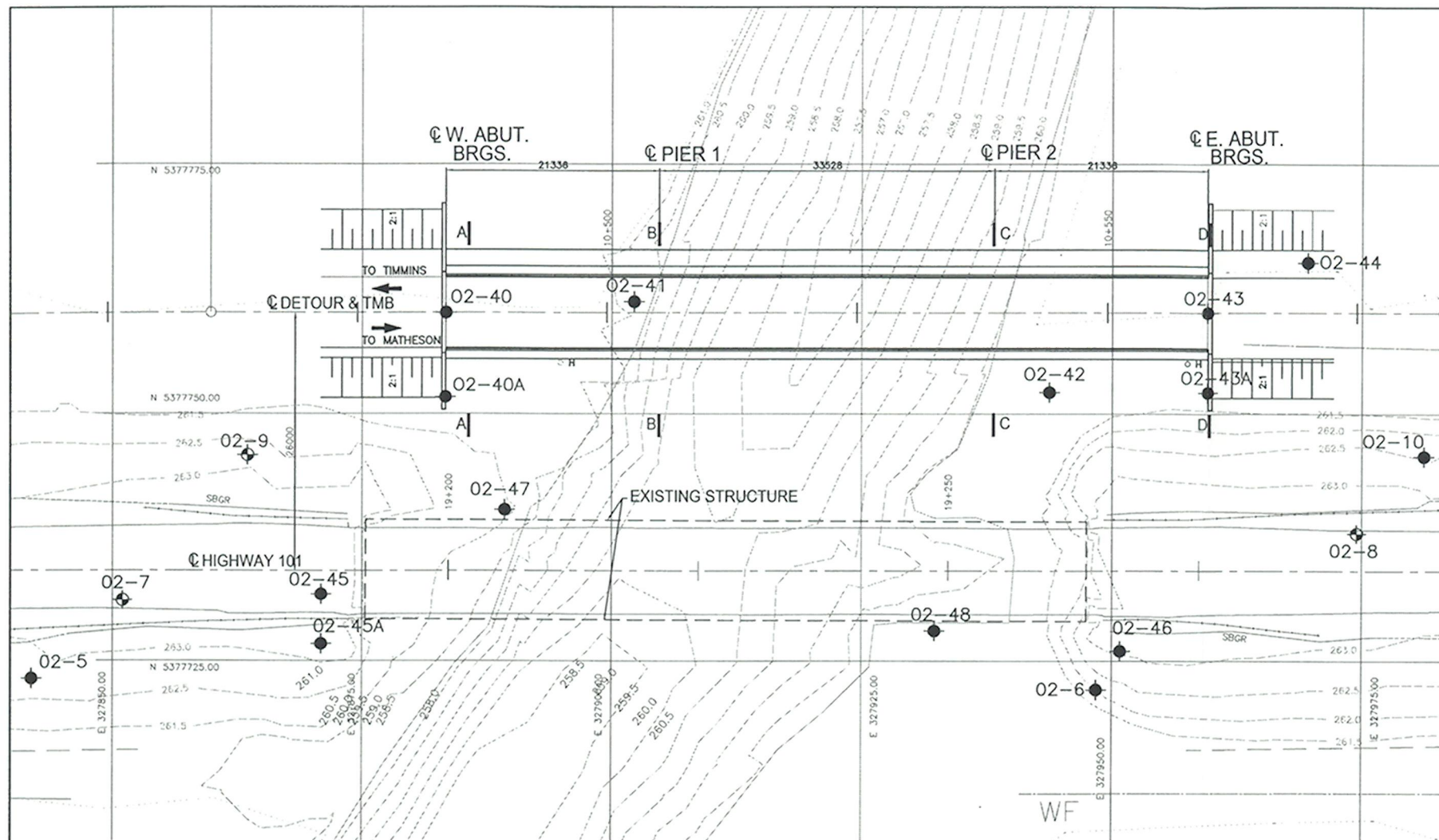
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02-8	263.2	5377737.9	327974.5
02-9	262.8	5377745.8	327863.5
02-10	262.6	5377745.7	327981.2
02-40	260.7	5377760.1	327883.4
02-40A	260.8	5377751.7	327883.3
02-41	261.2	5377761.2	327902.2
02-42	260.8	5377752.1	327943.8
02-43	260.8	5377760.1	327959.6
02-43A	261.0	5377752.1	327959.6
02-44	260.8	5377765.1	327969.6
02-45	263.2	5377731.7	327870.9
02-45A	262.5	5377726.7	327870.9
02-46	262.8	5377726.0	327950.8
02-47	261.4	5377740.3	327889.3
02-48	261.0	5377728.1	327932.3

NOTE

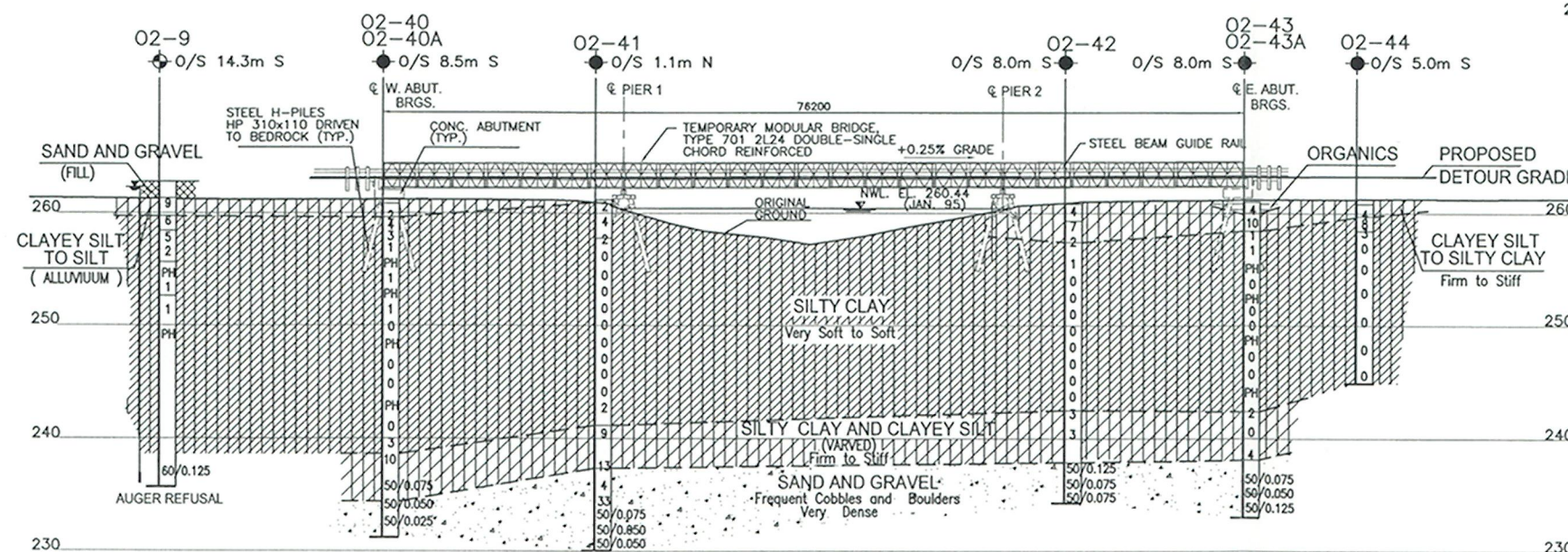
The boundaries between soil strata have been established only at Bore hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS

DATE	BY	DESCRIPTION
MR.05/03	SP	FINAL
OCT.15/02	SP	ISSUED AS DRAFT FOR REVIEW
DESIGN	SP	CHK PJB
DRAWN	SS	CHK SP
CHBDC	2000	LOAD
SITE	STRUCT	OWG.
DATE	MAR.2003	
17-308-294-01		

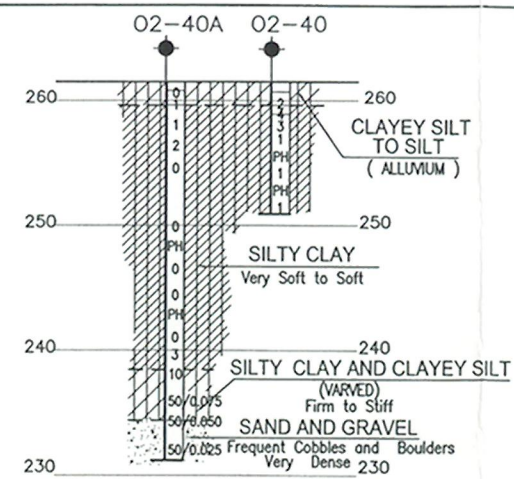


PLAN
SCALE
0 10 20M

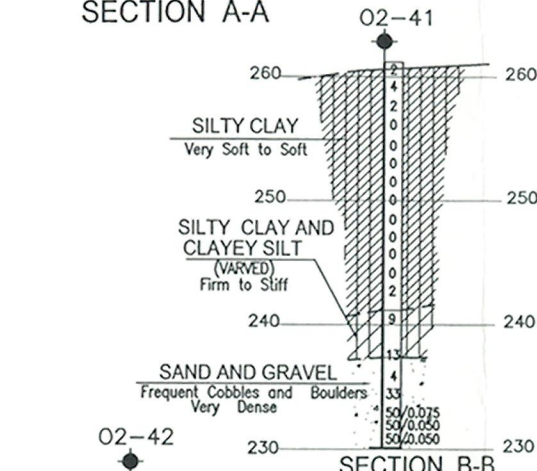


PROFILE @ DETOUR & TMB
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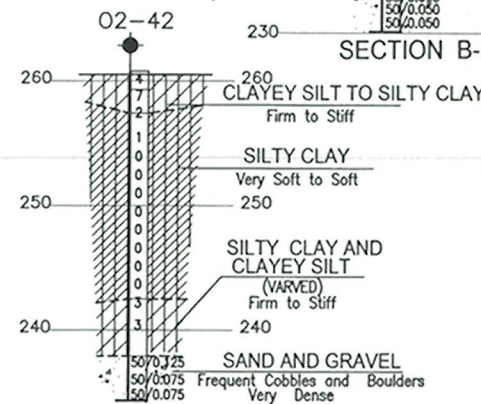
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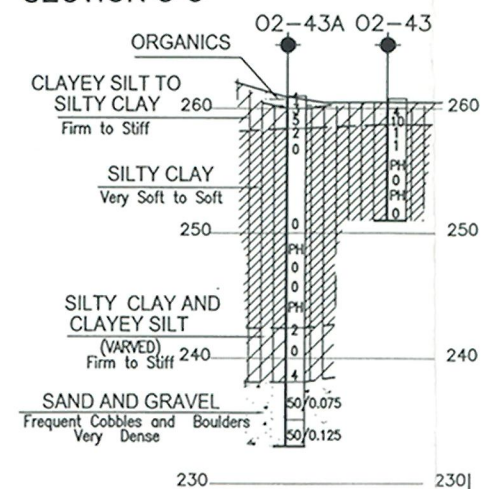
SECTION A-A



SECTION B-B



SECTION C-C



SECTION D-D

CONT No. 39E-132
WP No. 316-85-01

DRIFTWOOD RIVER
DETOUR BRIDGE

BORE HOLE LOCATION & SOIL STRATA

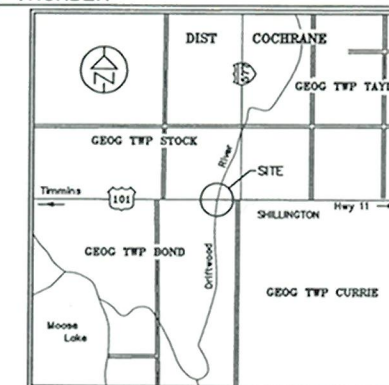


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KEY PLAN

1 km 0 1 km

LEGEND

	Bore Hole
	Dynamic Cone penetration Test (cone)
	Bore Hole & Cone
	Blow / 0.3m (std pen Test, 475 J / blow)
	Blows / 0.3m (60' Cone, 475J/blow)
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	Head Artesian Water
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	90% Rock Quality Designation (RQD)

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02-8	263.2	5377737.9	327974.5
02-9	262.8	5377745.8	327863.5
02-10	262.6	5377745.7	327981.2
02-40	260.7	5377760.1	327883.4
02-40A	260.8	5377751.7	327883.3
02-41	261.2	5377761.2	327902.2
02-42	260.8	5377752.1	327943.8
02-43	260.8	5377760.1	327959.6
02-43A	261.0	5377752.1	327959.6
02-44	260.8	5377765.1	327969.6
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02-45A	262.5	5377726.7	327870.9
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02-47	261.4	5377740.3	327889.3
02-48	261.0	5377728.1	327932.3

— NOTE —

The boundaries between soil strata have been established only at Bore hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION
WR.05/03	SP	FINAL	
OCT.15/02	SP	ISSUED AS DRAFT FOR REVIEW	
DATE	BY	DESCRIPTION	
DESIGN	SP	CHK PJB	CHBDC 2000
DRAWN	SS	CHK SP	SITE
LOAD	DATE	MAR.2003	
STRUCT	DWG.	17-308-294-02	

APPENDIX A
Records of Boreholes

RECORD OF BOREHOLE No 02-5 (DW)

1 OF 1

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377723.2 E 327841.8 ORIGINATED BY MT
DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
DATUM Geodetic DATE 26.01.02 - 26.01.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
262.7 0.0	SAND and GRAVEL Brown Moist (FILL.)						262							
261.8 0.9	Clayey SILT, some organics, some wood fibers, trace sand Firm to Stiff Grey-Brown			SS	11		261							
				SS	4		260							
259.8				SS	11		259							0 1 63 37
2.9	Silty CLAY, occasional oxide lenses, Stiff Grey-Brown			SS	10		258							
258.9				SS	2									
3.8	Silty CLAY Soft to Very Soft Grey Moist			SS	2									0 0 45 54
257.5				SS	2									
5.2	END OF BOREHOLE AT 5.18m. BOREHOLE DRY ON COMPLETION. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.													

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-6 (DW)

1 OF 1

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377722.1 E 327948.4 ORIGINATED BY MT
DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
DATUM Geodetic DATE 25.01.02 - 25.01.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
262.0 0.0	SAND and GRAVEL Brown, Moist (FILL)							20 40 60 80 100	20 40 60					GR SA SI CL
260.9														
1.1	Clayey SILT, some organics, some rootlets, some wood fibers Very stiff Grey			SS	24									
				SS	20									
259.6														
2.4	occasional silt laminations, no more organics Firm to Stiff Brown Moist			SS	5									
				SS	6									
				SS	11									
257.3														
4.7	Silty CLAY Soft to Very Soft Grey Moist			SS	2									
				SS	1									
253.8				TW	PH									
8.2	END OF BOREHOLE AT 8.23m. BOREHOLE DRY ON COMPLETION. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.													

RECORD OF BOREHOLE No 02-7 (DW)

1 OF 2

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377731.1 E 327851.0 ORIGINATED BY MT
DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
DATUM Geodetic DATE 25.01.02 - 25.01.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
263.2												
260.0	ASPHALT (175mm)						263					
0.2	SAND and GRAVEL Brown Moist (FILL)						262					
261.5							261					
1.7	Silty CLAY, some gravel, some organics, trace rootlets Very Stiff Brown (FILL)		SS		26		260					0 13 47 40
260.2							259					
3.1	PEAT, some wood fibers, trace rootlets Dark Brown		SS		7		258					
259.5							257					
3.7	Silty CLAY, occasional silt laminations Firm to Stiff Brown-Grey Moist		SS		12		256					
257.0							255					
6.3	Silty CLAY Very Soft to Soft Grey Moist to Wet		SS		1		254					0 0 31 69
							253					
252.7							252					
10.5	Soft						251					
							250					
251.0							249					
12.2	END OF SOIL SAMPLING AT 12.19m. DYNAMIC CONE PENETRATION TEST STARTED AT 12.19m.											

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-7 (DW)

2 OF 2

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377731.1 E 327851.0 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
 DATUM Geodetic DATE 25.01.02 - 25.01.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%) 20 40 60			
235.8	NO SAMPLING. DYNAMIC CONE PENETRATION TEST.						248					
							247					
							246					
							245					
							244					
							243					
							242					
							241					
							240					
							239					
							238					
							237					
27.4	END OF BOREHOLE AT 27.36m. REFUSAL TO DYNAMIC CONE PENETRATION. BOREHOLE DRY ON COMPLETION.						236					

RECORD OF BOREHOLE No 02-8 (DW)

2 OF 2

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377737.9 E 327974.5 ORIGINATED BY MT
DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
DATUM Geodetic DATE 24.01.02 - 24.01.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Becoming Firm			SS			248					
							247					
							246					
							245					
				TW	PH		244					
							243					
241.7							242					
21.5	Silty CLAY and Clayey SILT (Varved) Stiff Grey Wet		SS	9			241					0 0 68 32
240.5							240					
22.7	END OF SOIL SAMPLING AT 22.7m. DYNAMIC CONE PENETRATION TEST STARTED AT 22.7m.						239					
							238					
							237					
236.1												
27.1	END OF BOREHOLE AT 27.1m. REFUSAL TO DYNAMIC CONE PENETRATION. BOREHOLE DRY ON COMPLETION.											

+ 3, x 3: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-9 (DW)

1 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377745.8 E 327863.5 ORIGINATED BY MT
DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
DATUM Geodetic DATE 25.01.02 - 26.01.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
262.8 0.0	SAND and GRAVEL, Compact Brown Moist (FILL)						262					
261.3 1.5	Clayey SILT, some gravel, some organics, some rootlets, some wood fibers Stiff Grey		SS		9		261					
259.8 3.1	Silty CLAY, trace rootlets, trace wood fibers Firm Grey		SS		6		260					
258.4 4.4	Silty CLAY Firm Grey Moist to Wet		SS		5		259					
258.4 4.4							258					
257.2 7.2	Very Soft		SS		2		257	4.5				
255.6 7.2							256	2.5				
255.6 7.2	Oedometer Test		TW	PH			255					
254.4 7.2			SS		1		254	4.5				
253.6 10.2	Soft						253					
252.6 10.2			SS		1		252	4				
251.6 10.2							251	4				
250.6 10.2	Oedometer Test		TW	PH			250					
249.6 10.2							249	5				
248.6 10.2							248					

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

0 0 19 81

RECORD OF BOREHOLE No 02-9 (DW)

3 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377745.8 E 327863.5 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
 DATUM Geodetic DATE 25.01.02 - 26.01.02 CHECKED BY SP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa	W _p	W	W _L		
	WATER LEVEL READINGS: DATE ELEV. (m) 26/01/02 Frozen 13/08/02 262.3 24/08/02 262.3 15/09/02 262.3						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
							20 40 60 80 100	20 40 60					

RECORD OF BOREHOLE No 02-10 (DW)

1 OF 1

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377745.7 E 327981.2 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
 DATUM Geodetic DATE 26.01.02 - 26.01.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
262.6								20 40 60 80 100						
0.0	SAND and GRAVEL Brown (FILL)						262							
261.7														
0.9	Sandy SILT, some gravel Loose Grey, Moist			SS	12		261							
				SS	5									
260.3														
2.3	Silty CLAY, trace sand, occasional oxide lenses, occasional clayey silt laminations Very Stiff Grey-Brown			SS	16		260							
				SS	16									
258.6							259							0 1 76 24
4.0	Silty CLAY Firm to Soft Grey			SS	5									
							258							
257.4				SS	2									0 0 27 72
5.2	END OF BOREHOLE AT 5.18m. BOREHOLE DRY ON COMPLETION. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.													

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-40

1 OF 1

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377760.1 E 327883.3 ORIGINATED BY MT
DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
DATUM Geodetic DATE 12.08.02 - 12.08.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
260.7								20 40 60 80 100				
0.0	SAND and SILT, trace rootlets and organics											
259.6	Dark Brown (FILL)			SS	2		260					
1.1	Silty CLAY, trace sand, trace rootlets, trace wood fibers											
259.0	Soft			SS	4		259					
1.8	Brown (ALLUVIUM)											
	Silty CLAY			SS	3		258					
	Firm to Soft											
	Grey			SS	1		257					
	Moist											
							256					
	Becoming wet			TW	PH							
							255					
				SS	1							
							254					
							253					
	Oedometer Test			TW	PH							
							252					
				SS	1							
251.0							251					
9.8	END OF BOREHOLE AT 9.75m. Water level on completion of borehole at 7.85m.											

+ 3, x 3: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-40A

1 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377751.7 E 327883.3 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 75mm CASING COMPILED BY WM
 DATUM Geodetic DATE 07.09.02 - 07.09.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
260.8	Clayey SILT, some organics, trace rootlets, trace wood fragments		1	SS	0		260					
259.6	Very Soft Grey (ALLUVIUM)		2	SS	0		259					
1.2	Silty CLAY		3	SS	0		258					
	Very Soft to Soft Grey Moist		4	SS	2		257					
257.1			5	SS	0		256					
3.7	Augering without sampling to 10.7M depth.						255					
							254					
							253					
							252					
							251					
250.1							250					
10.7	Silty CLAY		6	SS	0		249					
	Soft to Firm Grey Wet occasional silt varves		1	TW	PH		248					
			7	SS	0		247					
							246					

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-40A

3 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377751.7 E 327883.3 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 75mm CASING COMPILED BY WM
 DATUM Geodetic DATE 07.09.02 - 07.09.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
	BOREHOLE BACKFILLED WITH DRILL CUTTINGS.																

RECORD OF BOREHOLE No 02-41

1 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377761.2 E 327902.2 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 75mm CASING COMPILED BY WM
 DATUM Geodetic DATE 05.09.02 - 05.09.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
261.2 0.0	Silty CLAY , trace sand, some organics, trace rootlets and wood fragments Soft Dark Brown (ALLUVIUM)		1	SS	2		261					
			2	SS	4		260					
							259					
257.9 3.4	Silty CLAY Very Soft Grey Wet		3	SS	2		258					
			4	SS	0		257					
							256					
			5	SS	0		255					
							254					
	Becoming Soft		6	SS	0		253					
							252					
	occasional clayey silt to silt layers or varves		7	SS	0		251					
	Artesian Pressure		8	SS	0		250					
							249					
			9	SS	0		248					
							247					
			10	SS	0							

Continued Next Page

+ 3. X 3; Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-41

2 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377761.2 E 327902.2 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 75mm CASING COMPILED BY WM
 DATUM Geodetic DATE 05.09.02 - 05.09.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
								SHEAR STRENGTH kPa				
								○ UNCONFINED + FIELD VANE				
								● QUICK TRIAXIAL × LAB VANE				
								WATER CONTENT (%)				
								20 40 60 80 100				
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				
								W _p W W _L				
241.2	occasional silt layers		11	SS	0		246					
			12	SS	0		245					
			13	SS	2		244					
							243					
							242					
20.0	Silty CLAY and Clayey SILT (Varved) Stiff Grey Wet		14	SS	9		241					
							240					
							239					
			15	SS	13		238					
237.4							237					
23.8	SAND and GRAVEL, frequent inferred cobbles and boulders Loose Grey Wet		16	SS	4		236					
							235					
	becoming Dense		17	SS	33		234					
			18	SS	50/ .075		233					
			19	SS	50/ .050		232					

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-41

3 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377761.2 E 327902.2 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 75mm CASING COMPILED BY WM
 DATUM Geodetic DATE 05.09.02 - 05.09.02 CHECKED BY SP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
						20	40	60	80	100	20	40	60			
230.1		•••••	20	SS	50/ .050	231										
31.1	END OF BOREHOLE AT 31.1m. NO ARTESIAN FLOW ON COMPLETION. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.															

+ 3, x 3; Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

METRIC

W.P.	G.W.P. 316-85-00	LOCATION	N 5377752.1 E 327943.8	ORIGINATED BY	MT
DIST	53 HWY 101	BOREHOLE TYPE	210mm HOLLOW STEM AUGERS / 75mm CASING	COMPILED BY	WM
DATUM	Geodetic	DATE	07.09.02 - 07.09.02	CHECKED BY	SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa					WATER CONTENT (%)				
							● QUICK TRIAXIAL × LAB VANE					w _p w w _L				
260.8 0.0	Clayey SILT, trace sand, trace organics and rootlets Soft to Firm Grey Moist		1	SS	4											
			2	SS	7											
			3	SS	2											
257.4 3.4	Silty CLAY Very Soft Grey Wet Becoming Soft occasional clayey silt to silt layers or varves		4	SS	1											
			5	SS	0											
			6	SS	0											
			7	SS	0											
			8	SS	0											
			9	SS	0											
			10	SS	0											

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-42

2 OF 2

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377752.1 E 327943.8 ORIGINATED BY MT
DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 75mm CASING COMPILED BY WM
DATUM Geodetic DATE 07.09.02 - 07.09.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
								SHEAR STRENGTH kPa				
								○ UNCONFINED + FIELD VANE				
								● QUICK TRIAXIAL × LAB VANE				
								20 40 60 80 100				
								WATER CONTENT (%)				
								20 40 60				
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				
								W _p W W _L				
								20 40 60				
								GR SA SI CL				
242.8	More frequent clayey silt layers or varves		11	SS	0		245					
			12	SS	0		244					
18.0	Silty CLAY and Clayey SILT (Varved) Soft Grey Wet		13	SS	3		243	2				
			14	SS	3		242					
	Artesian Pressure						241					
238.5							240					
22.3	SAND, fine to medium grained, trace silt, trace gravel frequent inferred cobbles and boulders Very Dense Grey		15	SS	50/.125		239					
			16	SS	50/.075		238					
			17	SS	50/.075		237					
234.3							236					
26.5	END OF BOREHOLE AT 26.52m. SLOW ARTESIAN FLOW ON COMPLETION OF DRILLING. ARTESIAN FLOW STOPPED UPON BACKFILLING OF BOREHOLE WITH DRILL CUTTINGS.						235					

+ 3, × 3: Numbers refer to Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-43

1 OF 1

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377760.1 E 327959.6 ORIGINATED BY MT
DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
DATUM Geodetic DATE 12.08.02 - 12.08.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
260.8								20 40 60 80 100						
0.0	SILT, trace sand, trace organics and rootlets													
260.0	Dark Brown													
0.8	(ALLUVIUM)													
	Silty CLAY, trace sand, occasional silt lenses, occasional iron oxide lenses		1	SS	4		260							
258.7	Firm to Stiff		2	SS	10		259							
2.1	Mottled Grey-Brown													
	Silty CLAY		3	SS	1		258							
	Soft to Firm													
	Grey		4	SS	1									
	Moist													
							257							
			1	TW	PH		256						17.4	0 0 36 64
							255							
			5	SS	0									
							254							
							253							
	occasional clayey silt to silt layers or varves		2	TW	PH									
							252							
251.1			6	SS	0									
9.8	END OF BOREHOLE AT 9.75m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE ELEV. (m) 12/08/02 Dry 13/08/02 260.5 24/08/02 260.3 15/09/02 260.3													

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-43A

2 OF 2

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377752.1 E 327959.6 ORIGINATED BY MT
DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 75mm CASING COMPILED BY WM
DATUM Geodetic DATE 08.09.02 - 08.09.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
242.4	More frequent clayey silt layers or varves		8	SS	0		246				17.4	
							245	4				
			2	TW	PH		244					
							243	3				
18.6	Silty CLAY and Clayey SILT (Varved) Soft to Firm Grey Wet		9	SS	2		242					
							241					
			10	SS	0		240	2.5				
238.7							239					
22.3	SAND, fine grained Loose Grey Wet		11	SS	4		238					
							237					
	inferred cobble / boulder		12	SS	50 .075		236					
235.7							235					
25.3	SAND and GRAVEL, frequent inferred cobbles and boulders Very Dense Grey Wet (boulders and cobbles fragments up to 0.1m size recorded)		13	SS	50 .050		234					
			14	SS	50 .125		233					
233.0												
28.0	END OF BOREHOLE AT 28.04m. SLOW ARTESIAN FLOW ON COMPLETION OF DRILLING. ARTESIAN FLOW STOPPED UPON BACKFILLING OF BOREHOLE WITH DRILL CUTTINGS.											

RECORD OF BOREHOLE No 02-44

1 OF 2

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377765.1 E 327969.6 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
 DATUM Geodetic DATE 11.08.02 - 11.08.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
260.8								20 40 60 80 100	20 40 60					
0.0	SILT, trace sand, trace organics, trace topsoil and organics Dark Brown (ALLUVIUM)						260							
259.7			1	SS	4									
1.1	Silty CLAY, occasional silt lenses, occasional iron oxide staining Stiff Brown		2	SS	8		259							
258.4														
2.4	Silty CLAY, Soft Grey Moist		3	SS	3		258							
			4	SS	0									
							257	2.5 +						
			5	SS	0		256							
							255	4 +						
			6	SS	0		254							
							253	4 +						
							252							
	becoming wet, some clayey silt to silt layers or varves		7	SS	0		251	1 +						
							250							
							249							
	Becoming Firm		8	SS	0		248	2 +						
							247							
							246							

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity 20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-44

2 OF 2

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377765.1 E 327969.6 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
 DATUM Geodetic DATE 11.08.02 - 11.08.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	20 40 60			
245.0				SS	0		245							
15.9	END OF BOREHOLE AT 15.85m. BOREHOLE DRY ON COMPLETION.													

METRIC

W.P.	G.W.P. 316-85-00	LOCATION	N 5377731.7 E 327870.9	ORIGINATED BY	GA
DIST	53 HWY 101	BOREHOLE TYPE	210mm HOLLOW STEM AUGERS / 75mm CASING	COMPILED BY	WM
DATUM	Geodetic	DATE	30.07.02 - 30.07.02	CHECKED BY	SP

[illegible]

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity


(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-45

3 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377731.7 E 327870.9 ORIGINATED BY GA
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 75mm CASING COMPILED BY WM
 DATUM Geodetic DATE 30.07.02 - 30.07.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)		
								20 40 60 80 100							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L								
228.2	SAND and GRAVEL, coarse grained, occasional becoming frequent cobbles and boulders Very Dense Grey Wet (boulders and cobbles fragments recovered)		10	SS	50/.0		233								
							232								
							231								
							230								
							229								
35.1	END OF BOREHOLE AT 35.05m. ARTESIAN PRESSURE HEAD AT 3.05m ABOVE GROUND. BOREHOLE BACKFILLED WITH CLAYEY DRILL CUTTINGS TO 4.5m DEPTH, SEAL WITH BENTONITE HOLEPLUG TO 0.15m DEPTH. RESURFACE ROAD WITH ASPHALT PATCH.														

RECORD OF BOREHOLE No 02-45A

1 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377726.7 E 327870.9 ORIGINATED BY GA
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS/ 75mm CASING COMPILED BY WM
 DATUM Geodetic DATE 31.07.02 - 31.07.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
262.5 0.0	Auger and wash bore, no sampling.													
262														
261														
260														
259														
258														
257														
256														
255														
254														
253														
252														
251														
250														
249														
248														

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-45A

2 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377726.7 E 327870.9 ORIGINATED BY GA
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS/ 75mm CASING COMPILED BY WM
 DATUM Geodetic DATE 31.07.02 - 31.07.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L	WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES							
247.5 15.0	Auger and wash bore, no sampling.											
247												
246												
245												
244												
243												
242												
241												
240												
239												
238												
237												
236												
235												
234												
233												

Auger to 4.6m depth, wash bore to
30.5m depth.
Artesian Pressure at 27.4m
frequent inferred cobbles and
boulders
Artesian flow moderate, then
becoming slow below 30.5m depth.

Continued Next Page

+ 3 × 3 : Numbers refer to
Sensitivity
20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-45A

3 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377726.7 E 327870.9 ORIGINATED BY GA
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS/ 75mm CASING COMPILED BY WM
 DATUM Geodetic DATE 31.07.02 - 31.07.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
232.0												
30.5	SAND and GRAVEL frequent cobbles and boulders Very Dense Wet		1	SS	50/ .0		232					
			2	SS	50/ .0		231					
			3	SS	50/ .0		230					
			4	SS	50/ .0		229					
			5	SS	50/ .0		228					
			6	SS	50/ .0		227					
	Ran core barrel at 36.5m depth TCR = 17% SCR = 0 RQD = 0		1	RUN			226					
	TCR = 19% SCR = 10% RQD = 0		2	RUN			225					
	TCR = 44% SCR = 13% RQD = 13%		3	RUN			224					
	TCR = 100% SCR = 0 RQD = 0		4	RUN			223					
222.3												
40.2	END OF BOREHOLE AT 40.21m. NO ARTESIAN FLOW UPON COMPLETION OF DRILLING. BOREHOLE REDRILLED TO 29.0m TO INSTALL PIEZOMETER. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE ELEV. (m) 12/08/02 264.6 24/08/02 262.8 15/09/02 262.8											

RECORD OF BOREHOLE No 02-46

1 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377726.0 E 327950.8 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
 DATUM Geodetic DATE 09.08.02 - 09.08.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
262.8 0.0	SAND and GRAVEL, some silt Compact Brown Moist (FILL)		1	SS	14		262					
261.4 1.4	Silty CLAY, some sand, some gravel Firm Brown Moist		2	SS	6		261					
260.1 2.7	(FILL)		3	SS	5		260					
259.7 3.1	Clayey SILT, some organics		4	SS	4		259					
	Firm Dark Brown (ALLUVIUM)		5	SS	5		258					
	Silty CLAY Firm Grey Moist		6	SS	3		257					
	Becoming Soft		1	TW	PH		256					
			7	SS	0		255					
			2	TW	PH		254					
	Occasional clayey silt to silt layers or varves		8	SS	0		253					
	Becoming Firm		9	SS	0		252					
			3	TW	PH		251					
							250					
							249					
							248					

Continued Next Page

+ 3, x 3, Numbers refer to
Sensitivity 20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-46

3 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377726.0 E 327950.8 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM
 DATUM Geodetic DATE 09.08.02 - 09.08.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	20 40 60			
230.8	Rock fragments encountered		17	SS	50/	.050	232							
32.0	END OF BOREHOLE AT 32.0m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE ELEV. (m) 13/08/02 266.1 (above ground) 24/08/02 265.7 (above ground) 15/09/02 265.6 (above ground)		18	SS	50/	.025	231							

RECORD OF BOREHOLE No 02-47

1 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377740.3 E 327889.3 ORIGINATED BY MT
DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 75mm CASING COMPILED BY WM
DATUM Geodetic DATE 04.09.02 - 04.09.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
261.4 0.0	SILT and SAND, some gravel, some topsoil, trace rootlets Very Loose Grey (FILL)		1	SS	2		261							
259.4			2	SS	3		260							
2.0	Silty CLAY Soft Grey Moist						259							
			3	SS	2		258							
			4	SS	1		257							
			5	SS	0		256	2						
			6	SS	0		255	2.5						
			7	SS	0		254							
			8	SS	0		253							
			9	SS	0		252							
			10	SS	0		251							
							250	3						
							249							
							248							
							247							
	Occasional clayey silt to silt layers or varves													

Continued Next Page

+ 3, × 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

METRIC

W.P.	G.W.P. 316-85-00	LOCATION	N 5377740.3 E 327889.3	ORIGINATED BY	MT
DIST	53 HWY 101	BOREHOLE TYPE	210mm HOLLOW STEM AUGERS / 75mm CASING	COMPILED BY	WM
DATUM	Geodetic	DATE	04.09.02 - 04.09.02	CHECKED BY	SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa						WATER CONTENT (%)	
							20 40 60 80 100							
			11	SS	0									
			12	SS	0									
	Becoming Firm		13	SS	0									
			14	SS	1									
	Becoming Wet													
	Artesian Pressure													
239.0														
22.4	Silty CLAY and Clayey SILT (Varved) Stiff Grey		15	SS	9									
			16	SS	8									
234.1			17	SS	8									
27.3	SAND and GRAVEL, trace silt, frequent inferred cobbles and boulders Wet		18	SS	50/ .075									
	Very Dense Grey		19	SS	50/ .010									

Continued Next Page

+ 3, × 3; Numbers refer to Sensitivity

RECORD OF BOREHOLE No 02-47

3 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377740.3 E 327889.3 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 75mm CASING COMPILED BY WM
 DATUM Geodetic DATE 04.09.02 - 04.09.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	20 40 60			
229.4							231							
230														
32.0	END OF BOREHOLE AT 32.00m. SLOW ARTESIAN FLOW ON COMPLETION OF DRILLING. FLOW TERMINATED UPON BACKFILLING WITH CLAYEY DRILL CUTTINGS.													

RECORD OF BOREHOLE No 02-48

1 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 537728.1 E 327932.3 ORIGINATED BY MT
DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 50mm CASING COMPILED BY WM
DATUM Geodetic DATE 06.09.02 - 06.09.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						
261.0 0.0	Clayey SILT, some organics, trace rootlets Very Soft Dark Brown (ALLUVIUM)		1	SS	0											
259.0 2.0	Silty CLAY Very Soft to Soft Grey Moist		2	SS	2											
			3	SS	1											
			4	SS	0											
			5	SS	0											
			6	SS	0											
			7	SS	0											
			8	SS	0											
			9	SS	0											
			10	SS	0											

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity 20 15 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-48

2 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377728.1 E 327932.3 ORIGINATED BY MT
DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 50mm CASING COMPILED BY WM
DATUM Geodetic DATE 06.09.02 - 06.09.02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60		
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
								WATER CONTENT (%) w _p w w _L				
241.0	Artesian Pressure		11	SS	0		246					
							245					
			12	SS	0		244					
							243	3.5				
			13	SS	0		242					
							241					
20.0	Silty CLAY and Clayey SILT (Varved) Firm Grey Wet		14	SS	6		240					
							239					
237.7			15	SS	7		238					
23.3	SAND and GRAVEL, trace silt, occasional inferred cobbles and boulders Loose Grey						237					
							236					
							235					
	Becoming Very Dense frequent inferred cobbles and boulders		16	SS	62		234					
			17	SS	50/ .050		233					
			18	SS	50/ .100		232					
231.4												
29.6	END OF BOREHOLE AT 29.57m.											

Continued Next Page

+ 3, × 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-48

3 OF 3

METRIC

W.P. G.W.P. 316-85-00 LOCATION N 5377728.1 E 327932.3 ORIGINATED BY MT
 DIST 53 HWY 101 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS / 50mm CASING COMPILED BY WM
 DATUM Geodetic DATE 06.09.02 - 06.09.02 CHECKED BY SP

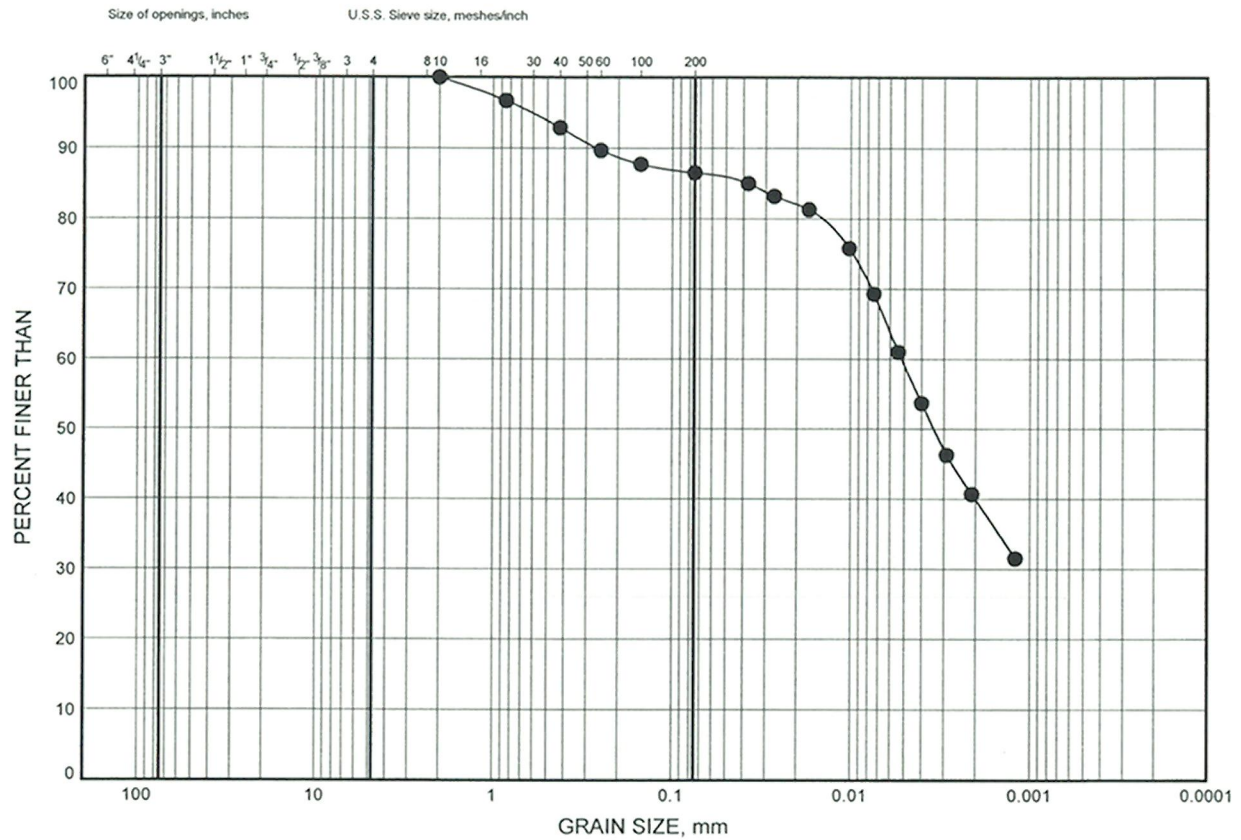
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	20 40 60 80 100	W _p W W _L	20 40 60		
	SLOW ARTESIAN FLOW UPON COMPLETION OF DRILLING. FLOW TERMINATED UPON BACKFILLING BOREHOLE WITH CLAYEY CUTTINGS.												

APPENDIX B
Laboratory Test Results

Hwy 101 Bridge Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B1



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	02-7	2.44	260.76

Date October 2002
Project G.W.P. 316-85-00

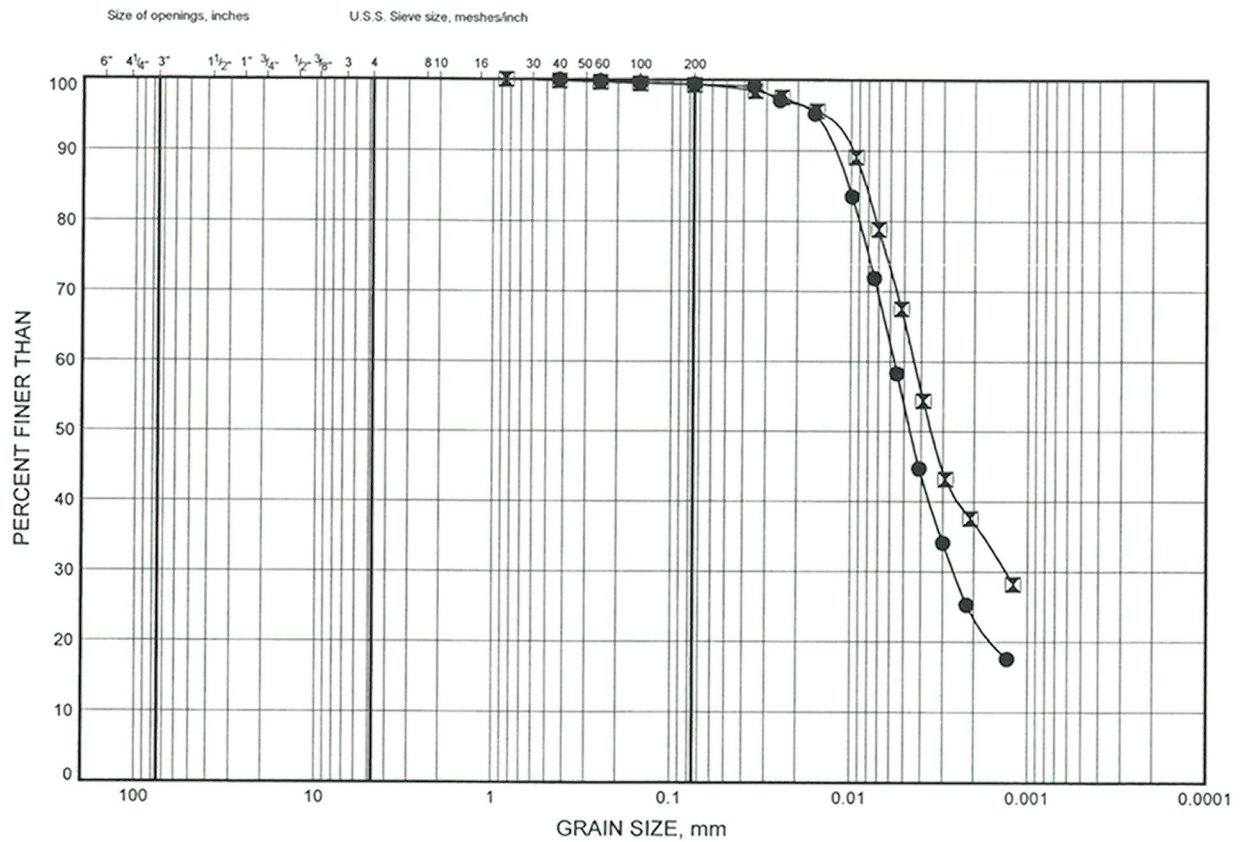


Prep'd WM
Chkd. SP

Hwy 101 Bridge Replacement

GRAIN SIZE DISTRIBUTION

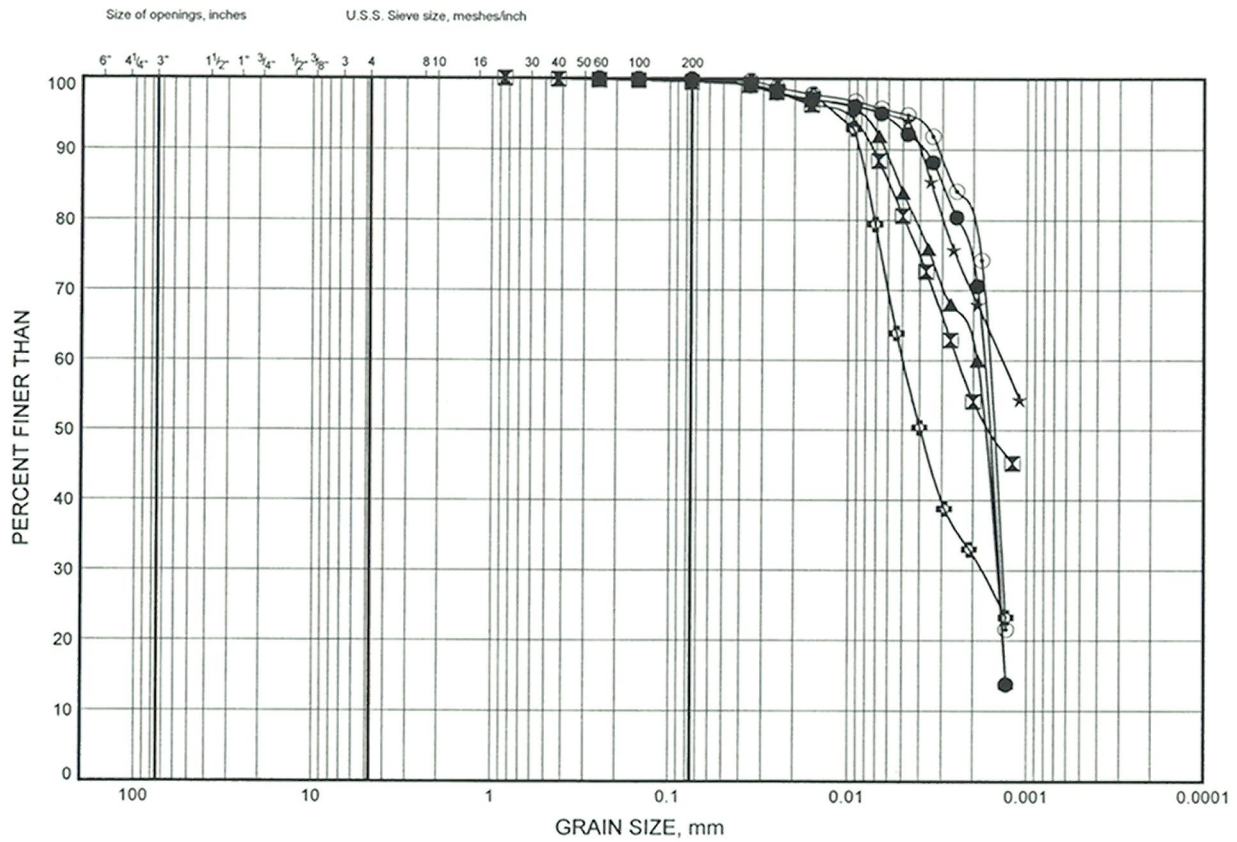
FIGURE B2



Hwy 101 Bridge Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B3



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	02-10	4.88	257.72
⊠	02-5	4.11	258.59
▲	02-6	4.88	257.12
★	02-7	6.40	256.80
⊙	02-8	9.45	253.75
⊗	02-8	21.64	241.56

Date October 2002
Project G.W.P. 316-85-00

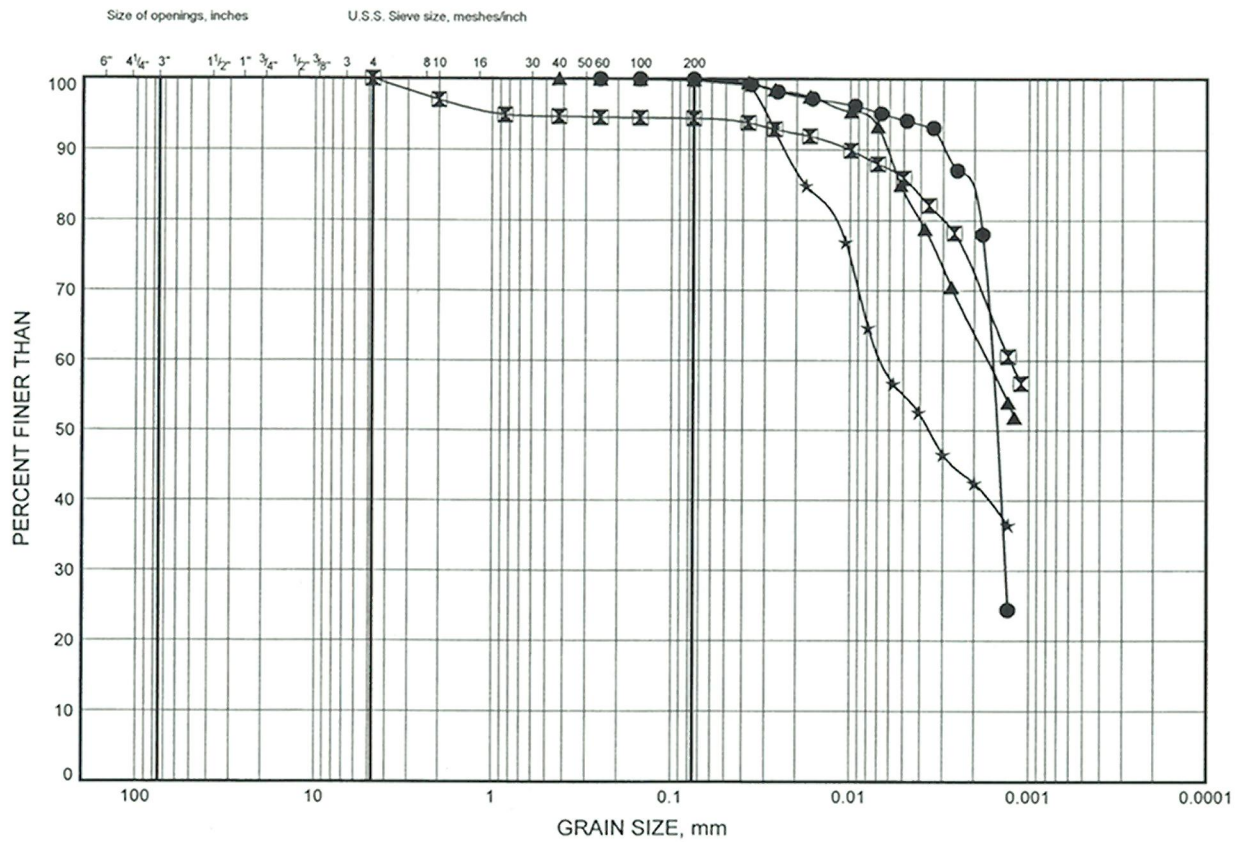


Prep'd WM
Chkd. SP

Hwy 101 Bridge Replacement

GRAIN SIZE DISTRIBUTION

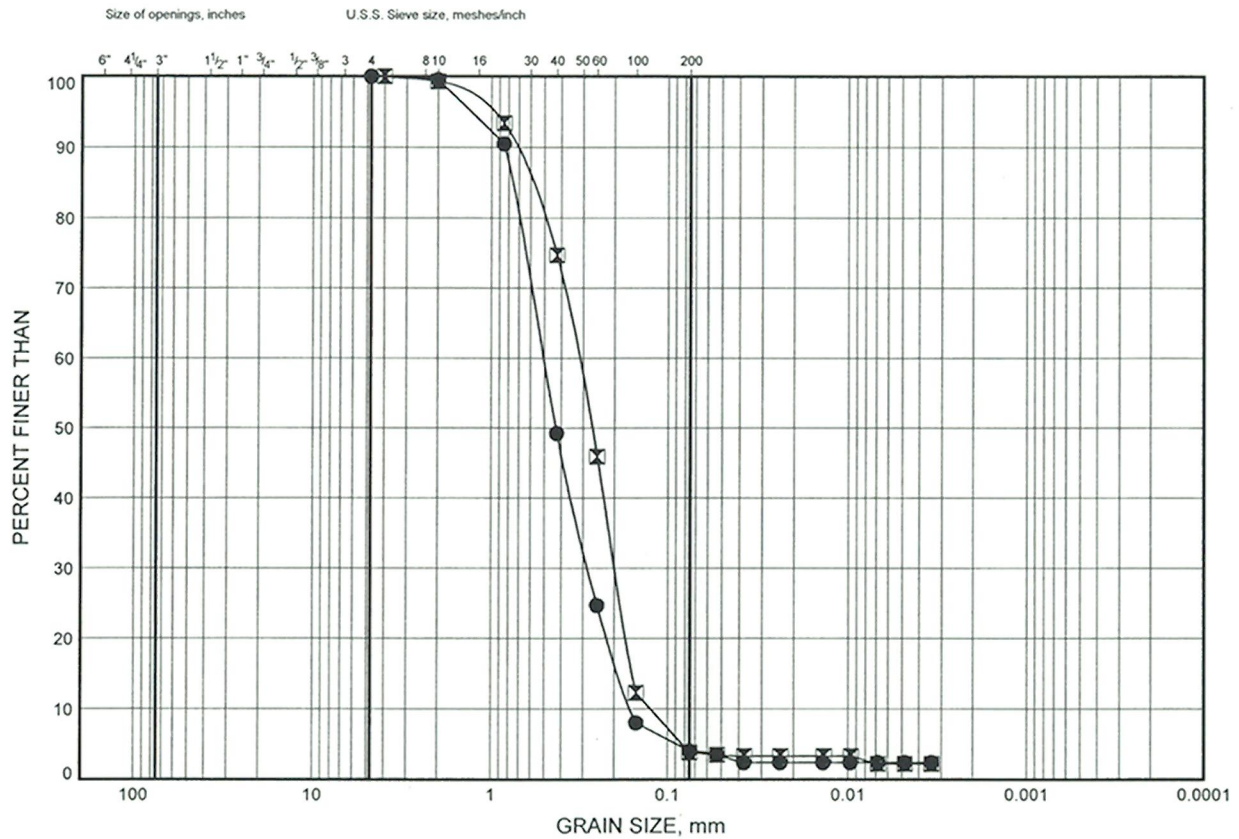
FIGURE B4



Hwy 101 Bridge Replacement

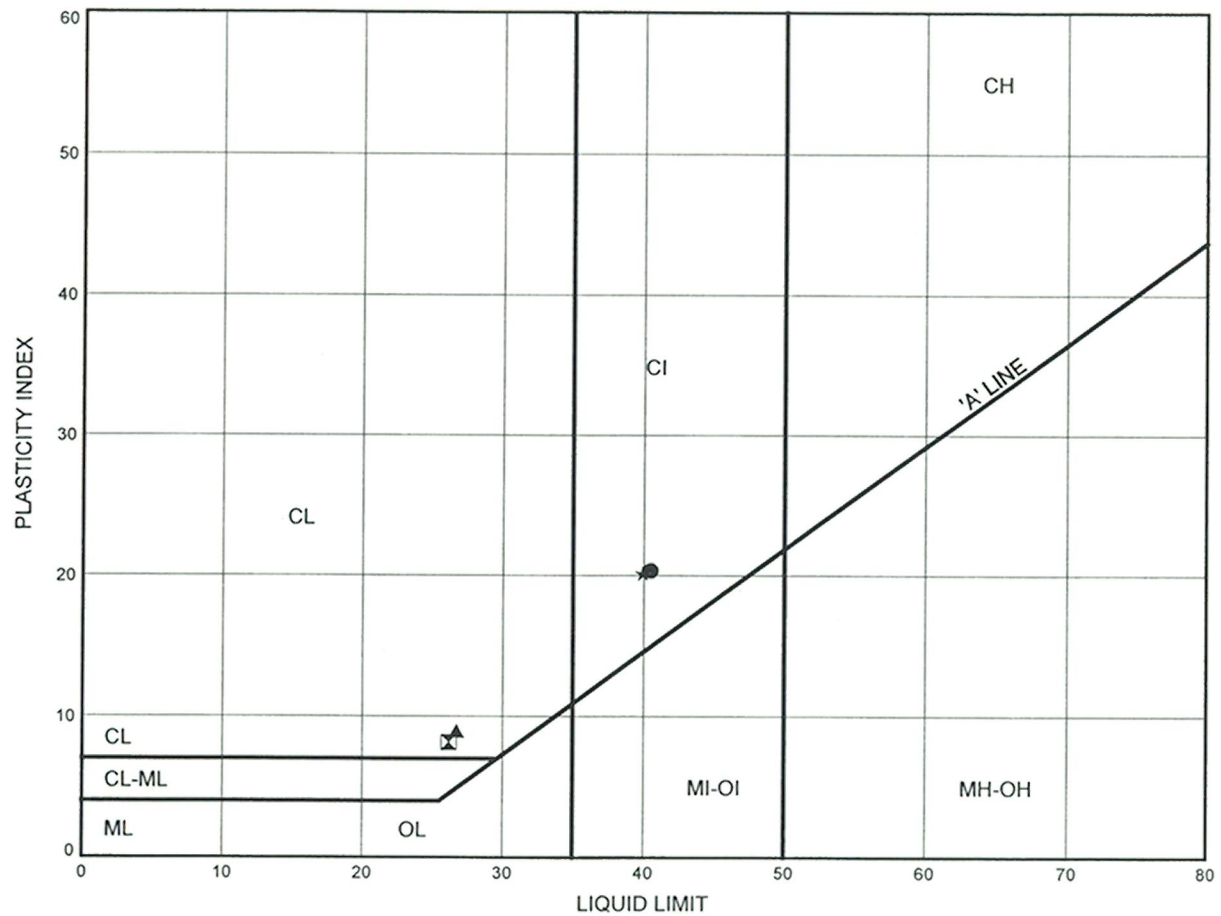
GRAIN SIZE DISTRIBUTION

FIGURE B5



Hwy 101 Bridge Replacement ATTERBERG LIMITS TEST RESULTS

FIGURE B6



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	02-10	2.59	260.01
⊠	02-10	3.35	259.25
▲	02-5	3.35	259.35
★	02-6	2.59	259.41

Date October 2002

Project G.W.P. 316-85-00

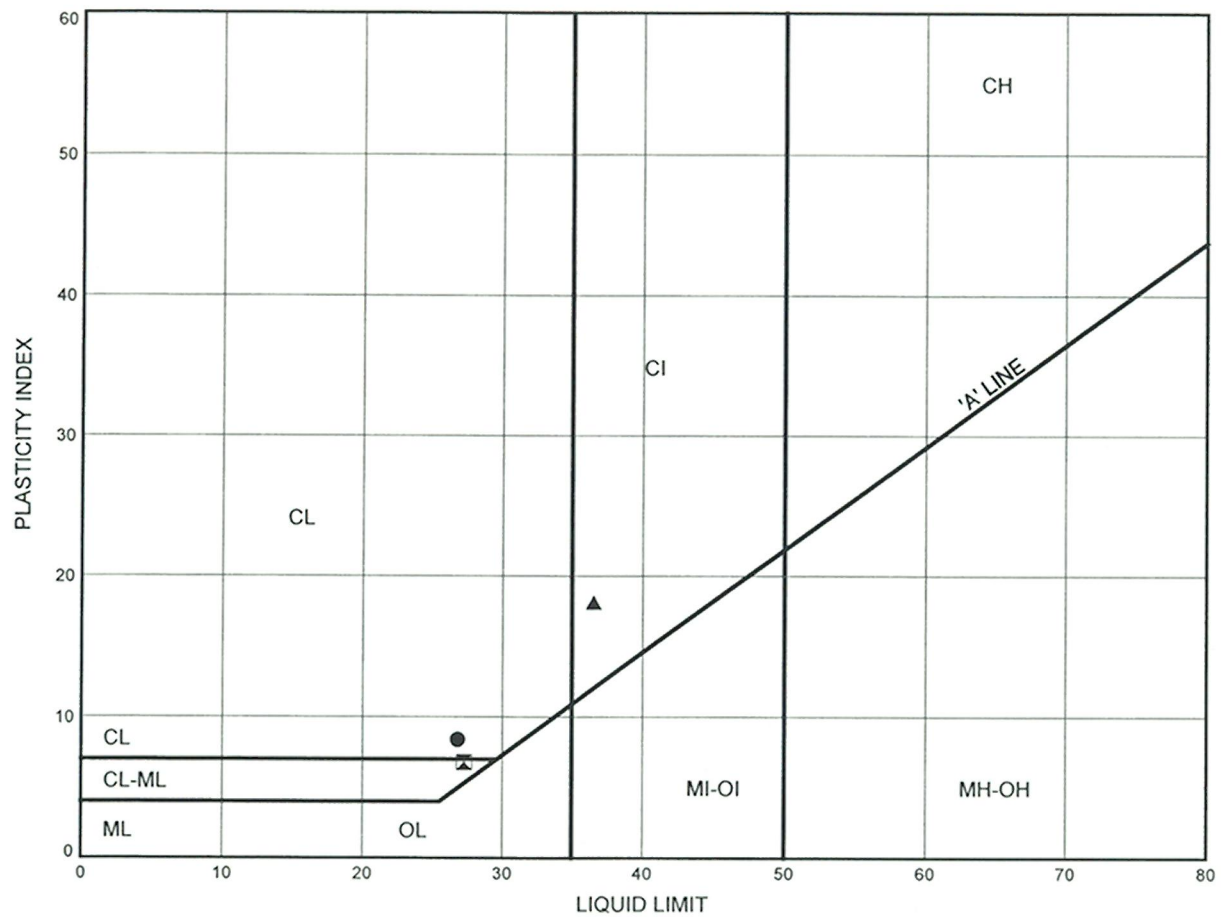


Prep'd WM

Chkd. SP

Hwy 101 Bridge Replacement ATTERBERG LIMITS TEST RESULTS

FIGURE B7



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	02-6	4.11	257.89
⊠	02-7	4.88	258.32
▲	02-9	3.35	259.45

Date October 2002
Project G.W.P. 316-85-00

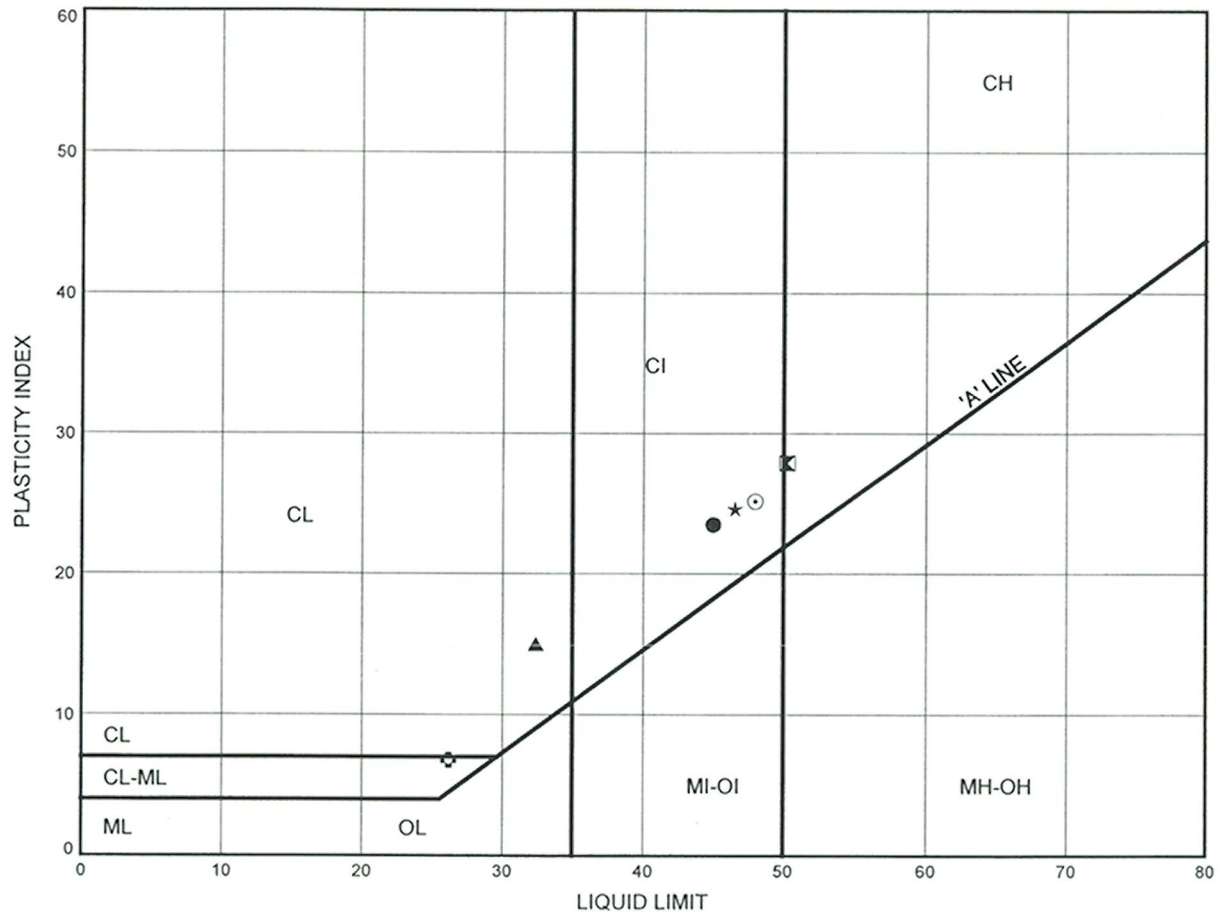


Prep'd WM
Chkd. SP

Hwy 101 Bridge Replacement

ATTERBERG LIMITS TEST RESULTS

FIGURE B8



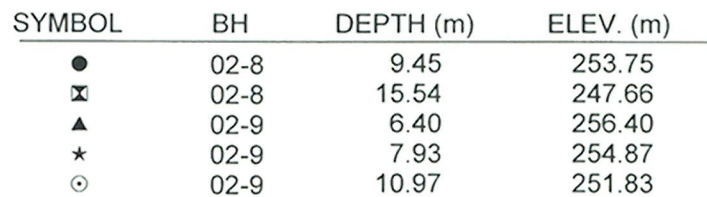
SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	02-10	4.88	257.72
⊠	02-5	4.88	257.82
▲	02-6	4.88	257.12
★	02-7	6.40	256.80
⊙	02-7	9.45	253.75
⊕	02-8	4.88	258.32

Date October 2002
 Project G.W.P. 316-85-00



Prep'd WM
 Chkd. SP

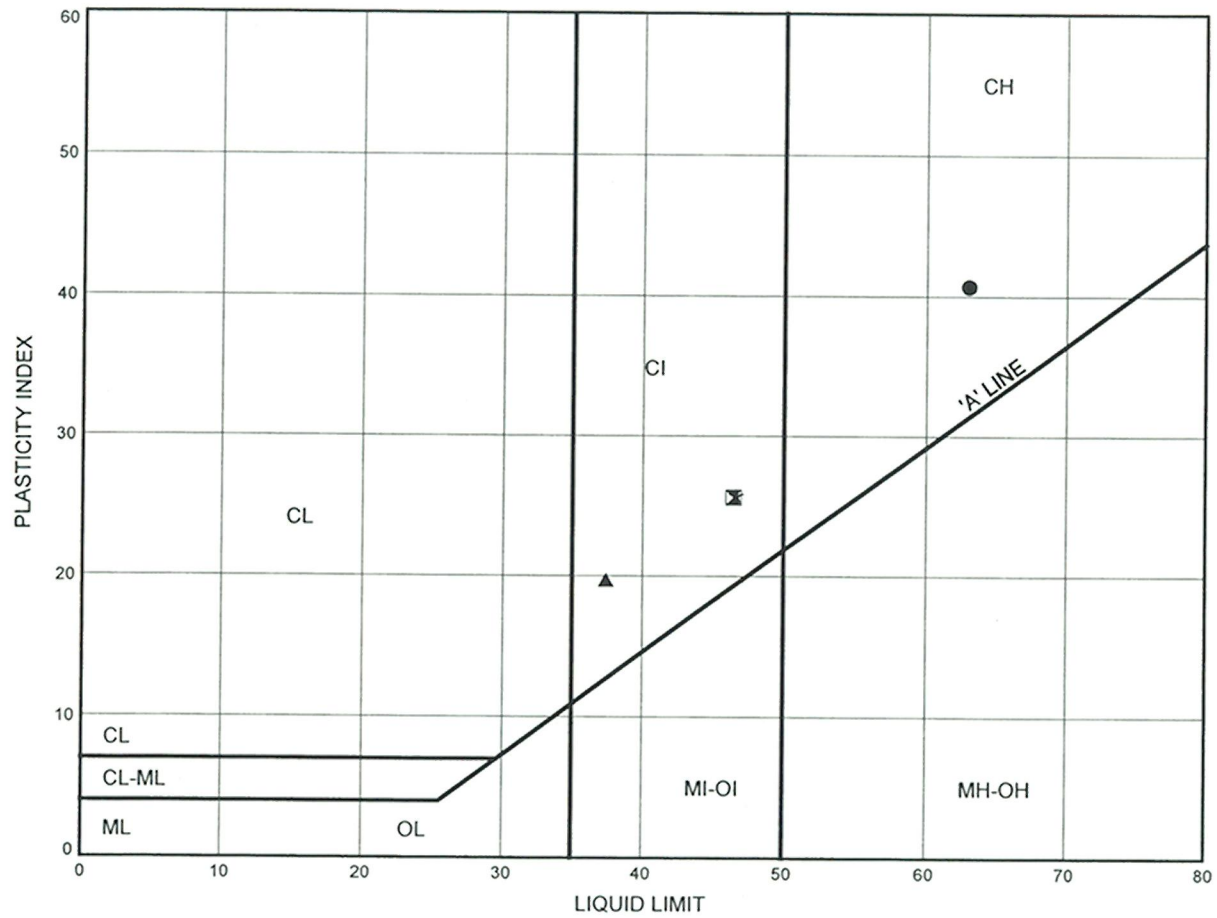
FIGURE B9



Prep'd WM
Chkd. SP

Hwy 101 Bridge Replacement ATTERBERG LIMITS TEST RESULTS

FIGURE B10



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	02-9	12.50	250.30
⊠	02-40	4.88	255.82
▲	02-40	7.92	252.78
★	02-43	4.88	255.92

Date October 2002

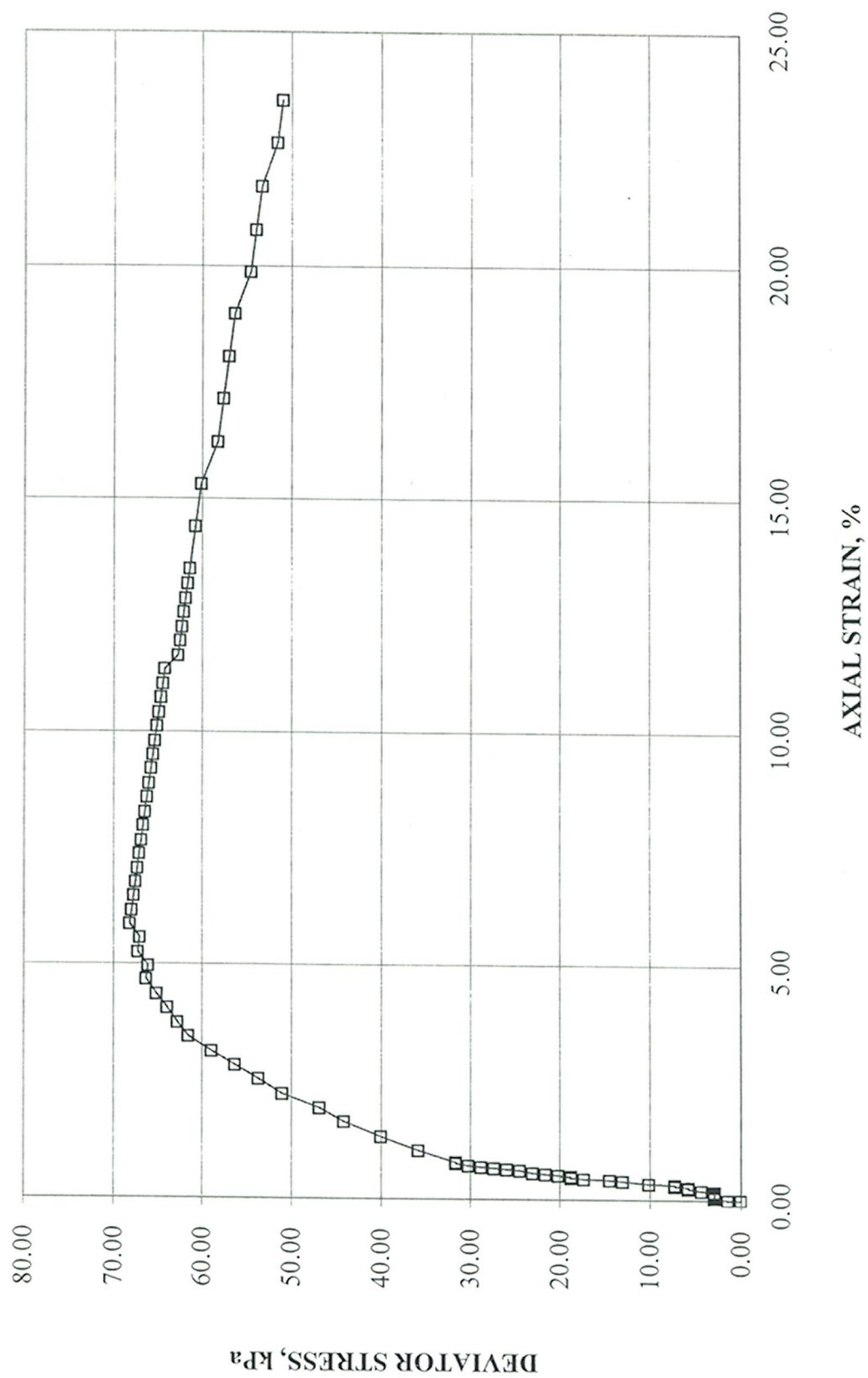
Project G.W.P. 316-85-00



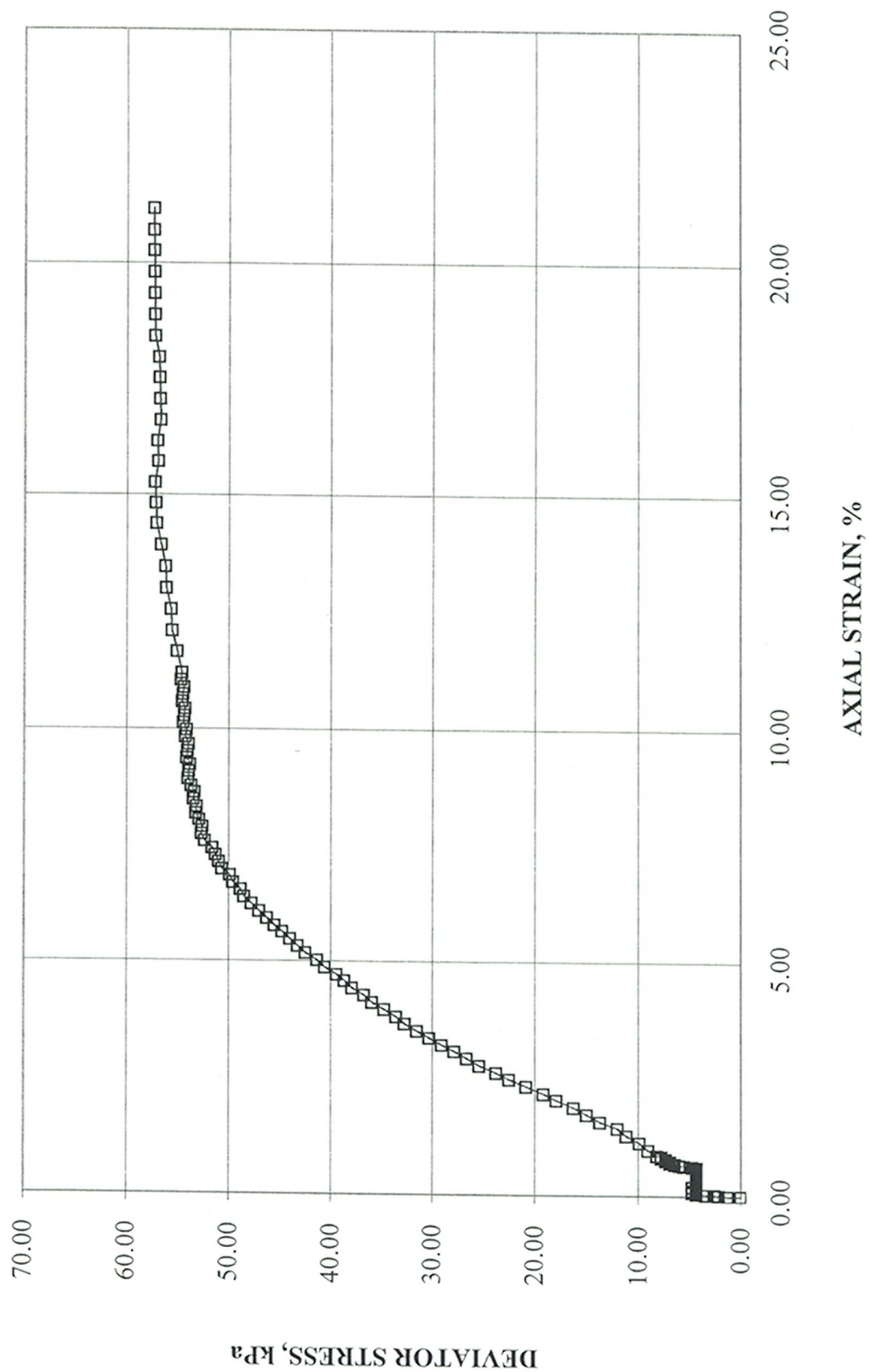
Prep'd WM

Chkd. SP

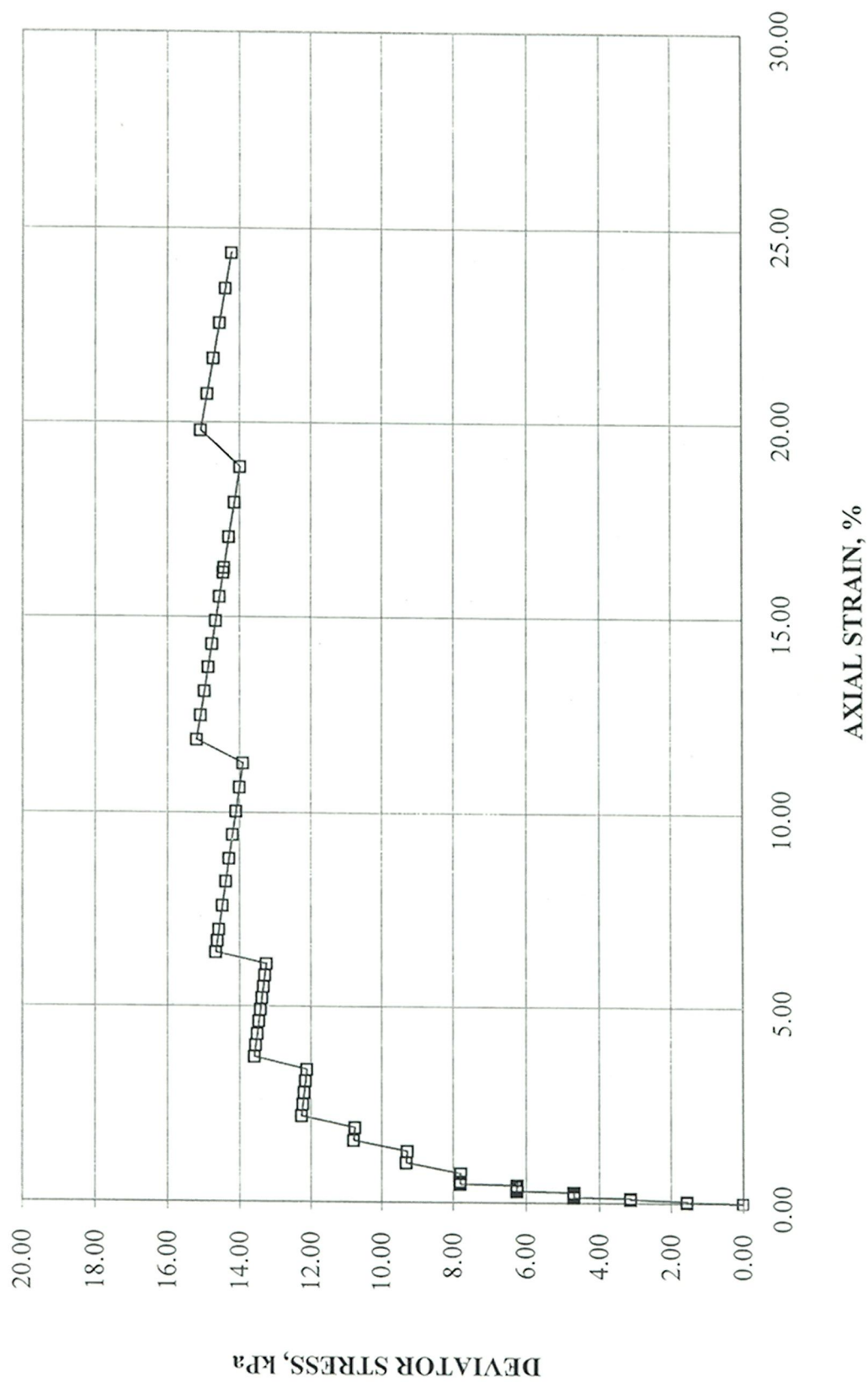
BOREHOLE 02-40A ST2, DEPTH 55'-57'



BOREHOLE 02-43A ST2, DEPTH 55'-57'



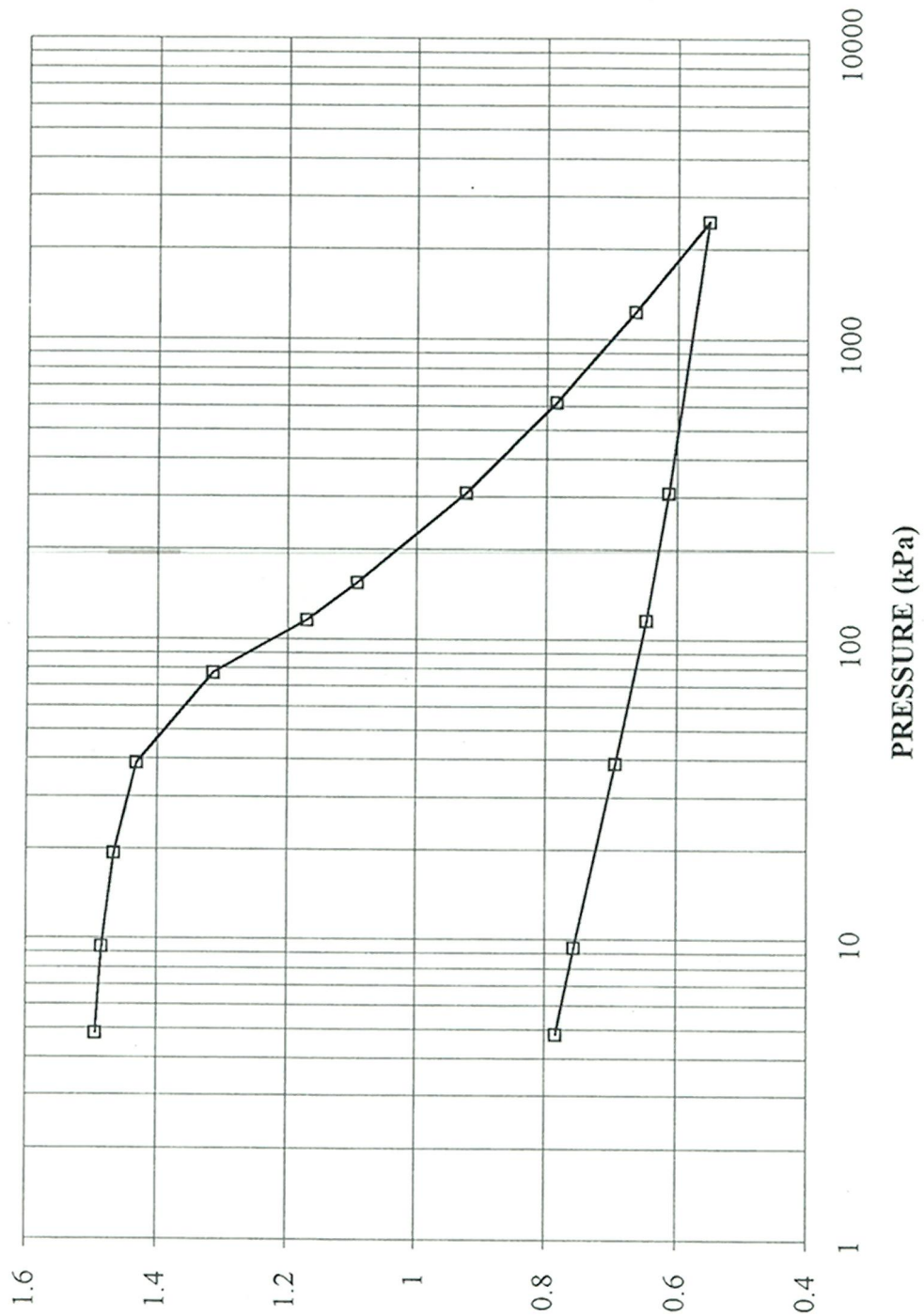
BOREHOLE 02-43 ST1, DEPTH 15'-17"



CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE B14

CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH 02-9 SA 1



Project No. 021-10103

VOID RATIO

OEDOMETER CONSOLIDATION SUMMARY

SAMPLE IDENTIFICATION

Project Number	021-10103	Sample Number	1
Borehole Number	02-9	Sample Depth, m	7.6-8.2

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	8		
Date Started	02-02-01		
Date Completed	02-02-13		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.91	Unit Weight, kN/m ³	16.74
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	10.69
Area, cm ²	31.65	Specific Gravity, measured	2.73
Volume, cm ³	60.45	Solids Height, cm	0.763
Water Content, %	56.62	Volume of Solids, cm ³	24.14
Wet Mass, g	103.21	Volume of Voids, cm ³	36.31
Dry Mass, g	65.9	Degree of Saturation, %	102.8

TEST COMPUTATIONS

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv, cm ² /s	mv m ² /kN	k cm/s
0.00	1.910	1.504	1.910				
4.83	1.902	1.493	1.906	329	2.34E-03	9.11E-04	2.09E-07
9.46	1.895	1.484	1.898	240	3.18E-03	8.02E-04	2.50E-07
19.51	1.880	1.465	1.887	289	2.61E-03	7.35E-04	1.88E-07
38.91	1.854	1.431	1.867	350	2.11E-03	7.12E-04	1.47E-07
77.57	1.765	1.314	1.809	585	1.19E-03	1.21E-03	1.41E-07
116.47	1.655	1.170	1.710	7223	8.58E-05	1.48E-03	1.24E-08
154.88	1.595	1.091	1.625	9959	5.62E-05	8.22E-04	4.53E-09
310.15	1.466	0.922	1.530	1485	3.34E-04	4.34E-04	1.42E-08
620.02	1.361	0.785	1.414	1173	3.61E-04	1.77E-04	6.27E-09
1238.16	1.269	0.663	1.315	480	7.64E-04	7.84E-05	5.87E-09
2475.66	1.184	0.552	1.226	336	9.48E-04	3.60E-05	3.34E-09
310.15	1.229	0.611	1.206				
116.47	1.256	0.646	1.242				
38.91	1.290	0.692	1.273				
9.46	1.339	0.755	1.314				
4.83	1.359	0.782	1.349				

Notes:

k calculated using cv based on t₉₀ values.

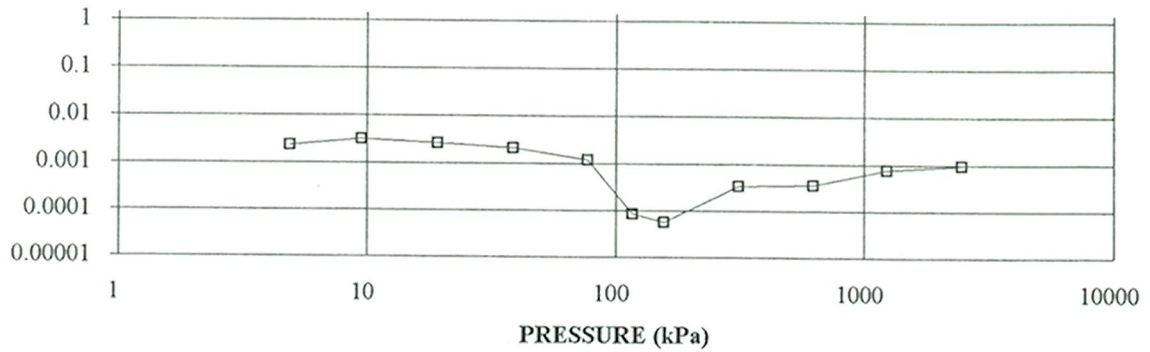
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.36	Unit Weight, kN/m ³	19.75
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	14.76
Area, cm ²	31.65	Specific Gravity, measured	2.73
Volume, cm ³	43.02	Solids Height, cm	0.749
Water Content, %	33.79	Volume of Solids, cm ³	23.72
Wet Mass, g	86.63	Volume of Voids, cm ³	19.30
Dry Mass, g	64.75		

OEDOMETER CONSOLIDATION SUMMARY

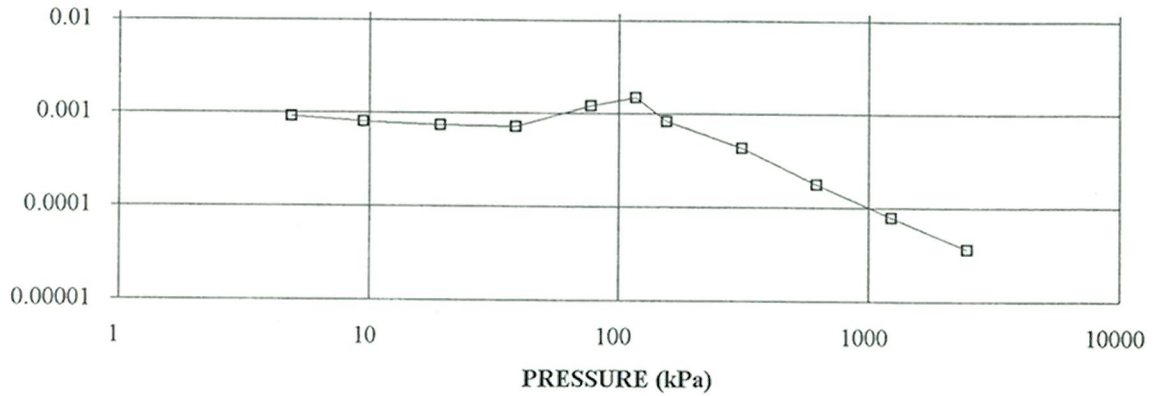
COEFFICIENT OF CONSOLIDATION, cm^2/s

CONSOLIDATION TEST
 $\text{cv cm}^2/\text{s}$ vs PRESSURE (kPa)
 BH 02-9 SA 1



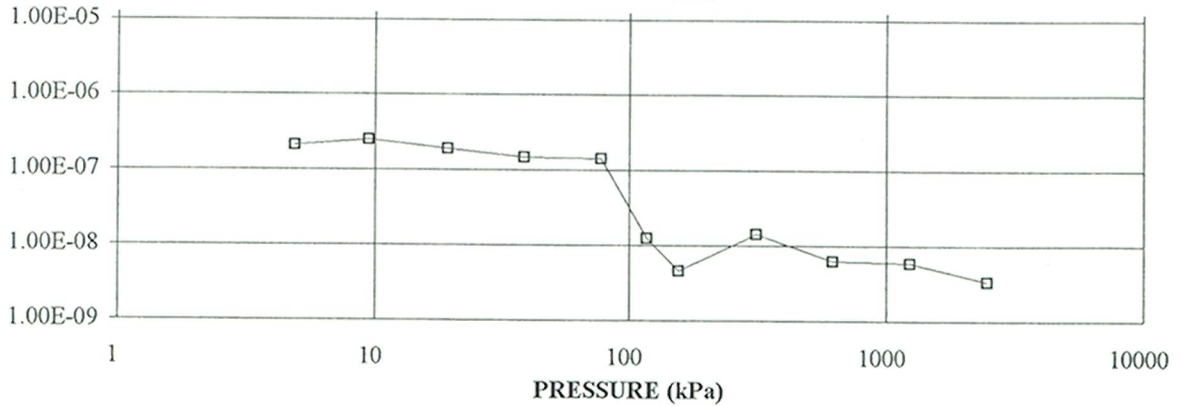
VOLUME
 COMPRESSIBILITY,
 m^2/kN

CONSOLIDATION TEST
 $\text{mv, m}^2/\text{kN}$ vs PRESSURE (kPa)
 BH 02-9 SA 1



HYDRAULIC
 CONDUCTIVITY, cm/s

CONSOLIDATION TEST
 HYDRAULIC CONDUCTIVITY vs PRESSURE
 BH 02-9 SA 1

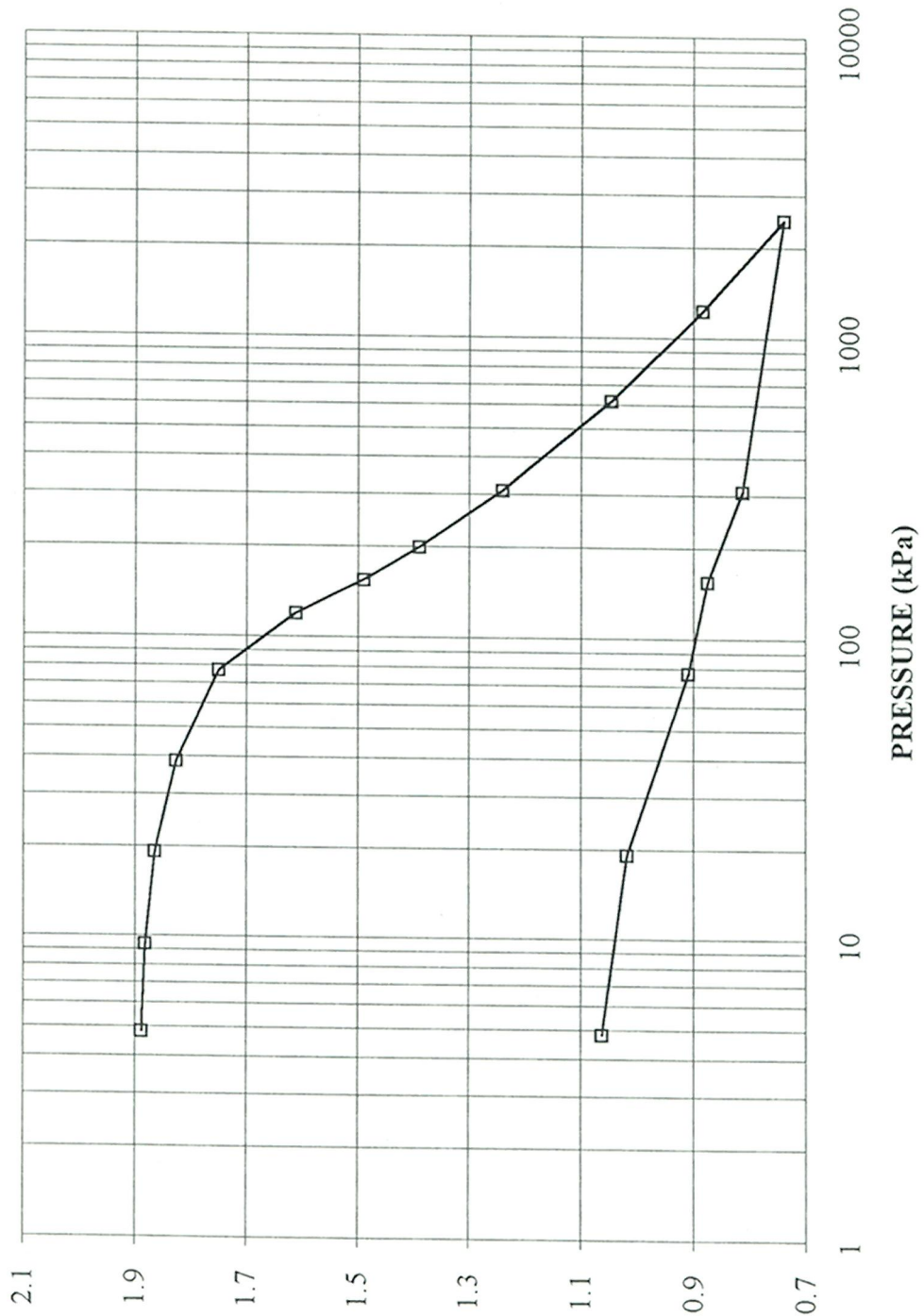


Project No. 021-10103

CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE B15

CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH 02-9 SA 2



Project No. 021-10103

VOID RATIO

OEDOMETER CONSOLIDATION SUMMARY

SAMPLE IDENTIFICATION

Project Number	021-10103	Sample Number	2
Borehole Number	02-9	Sample Depth, m	12.2-12.8

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	8		
Date Started	02-02-14		
Date Completed	02-02-27		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.91	Unit Weight, kN/m ³	15.72
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	9.25
Area, cm ²	31.65	Specific Gravity, measured	2.73
Volume, cm ³	60.45	Solids Height, cm	0.660
Water Content, %	69.97	Volume of Solids, cm ³	20.88
Wet Mass, g	96.90	Volume of Voids, cm ³	39.57
Dry Mass, g	57.01	Degree of Saturation, %	100.8

TEST COMPUTATIONS

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv, cm ² /s	mv m ² /kN	k cm/s
0.00	1.910	1.895	1.910				
4.83	1.906	1.888	1.908	101	7.64E-03	4.66E-04	3.49E-07
9.46	1.901	1.882	1.904	118	6.51E-03	4.97E-04	3.17E-07
19.29	1.890	1.864	1.896	296	2.57E-03	6.07E-04	1.53E-07
38.71	1.865	1.826	1.877	803	9.30E-04	6.79E-04	6.19E-08
77.48	1.814	1.750	1.839	603	1.19E-03	6.82E-04	7.95E-08
119.84	1.723	1.611	1.769	2602	2.55E-04	1.13E-03	2.82E-08
154.88	1.643	1.489	1.683	17340	3.46E-05	1.20E-03	4.08E-09
200.13	1.577	1.389	1.610	14602	3.76E-05	7.64E-04	2.81E-09
309.77	1.478	1.240	1.527	2838	1.74E-04	4.71E-04	8.04E-09
619.52	1.350	1.046	1.414	1316	3.22E-04	2.17E-04	6.84E-09
1238.08	1.243	0.883	1.296	700	5.09E-04	9.06E-05	4.52E-09
2475.88	1.147	0.738	1.195	603	5.02E-04	4.06E-05	2.00E-09
309.77	1.196	0.812	1.171				
154.88	1.237	0.875	1.216				
77.48	1.260	0.909	1.248				
19.29	1.332	1.018	1.296				
4.83	1.360	1.062	1.346				

Notes:

k calculated using cv based on t₉₀ values.

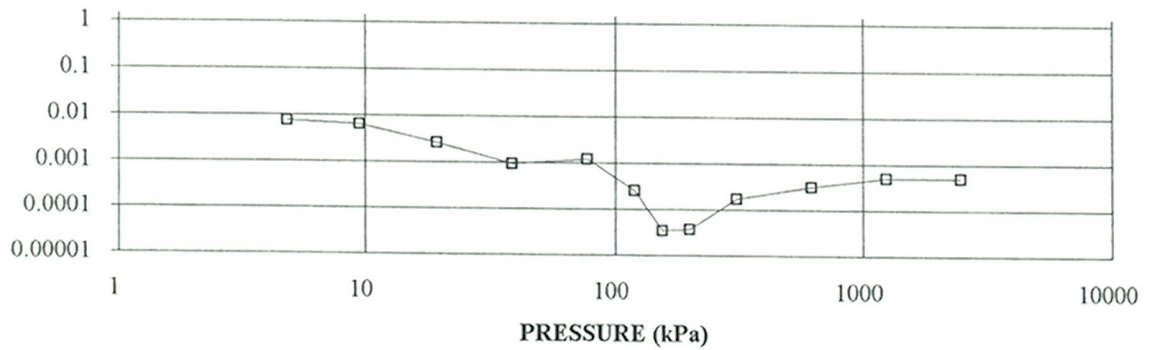
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.36	Unit Weight, kN/m ³	18.20
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	12.99
Area, cm ²	31.65	Specific Gravity, measured	2.73
Volume, cm ³	43.05	Solids Height, cm	0.660
Water Content, %	40.15	Volume of Solids, cm ³	20.88
Wet Mass, g	79.90	Volume of Voids, cm ³	22.17
Dry Mass, g	57.01		

OEDOMETER CONSOLIDATION SUMMARY

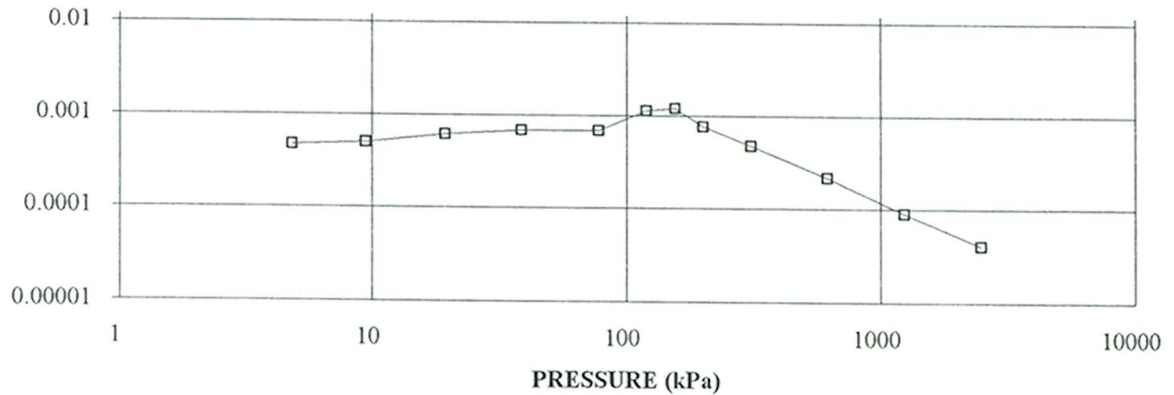
COEFFICIENT OF CONSOLIDATION, cm^2/s

CONSOLIDATION TEST
 c_v cm^2/s vs PRESSURE (kPa)
 BH 02-9 SA 2



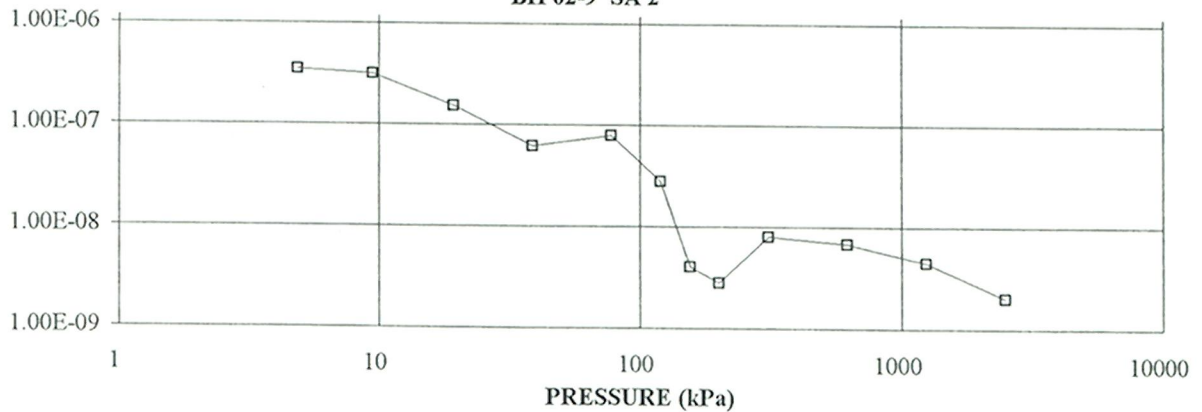
VOLUME
COMPRESSIBILITY,
 m^2/kN

CONSOLIDATION TEST
 m_v , m^2/kN vs PRESSURE (kPa)
 BH 02-9 SA 2



HYDRAULIC
CONDUCTIVITY, cm/s

CONSOLIDATION TEST
 HYDRAULIC CONDUCTIVITY vs PRESSURE
 BH 02-9 SA 2

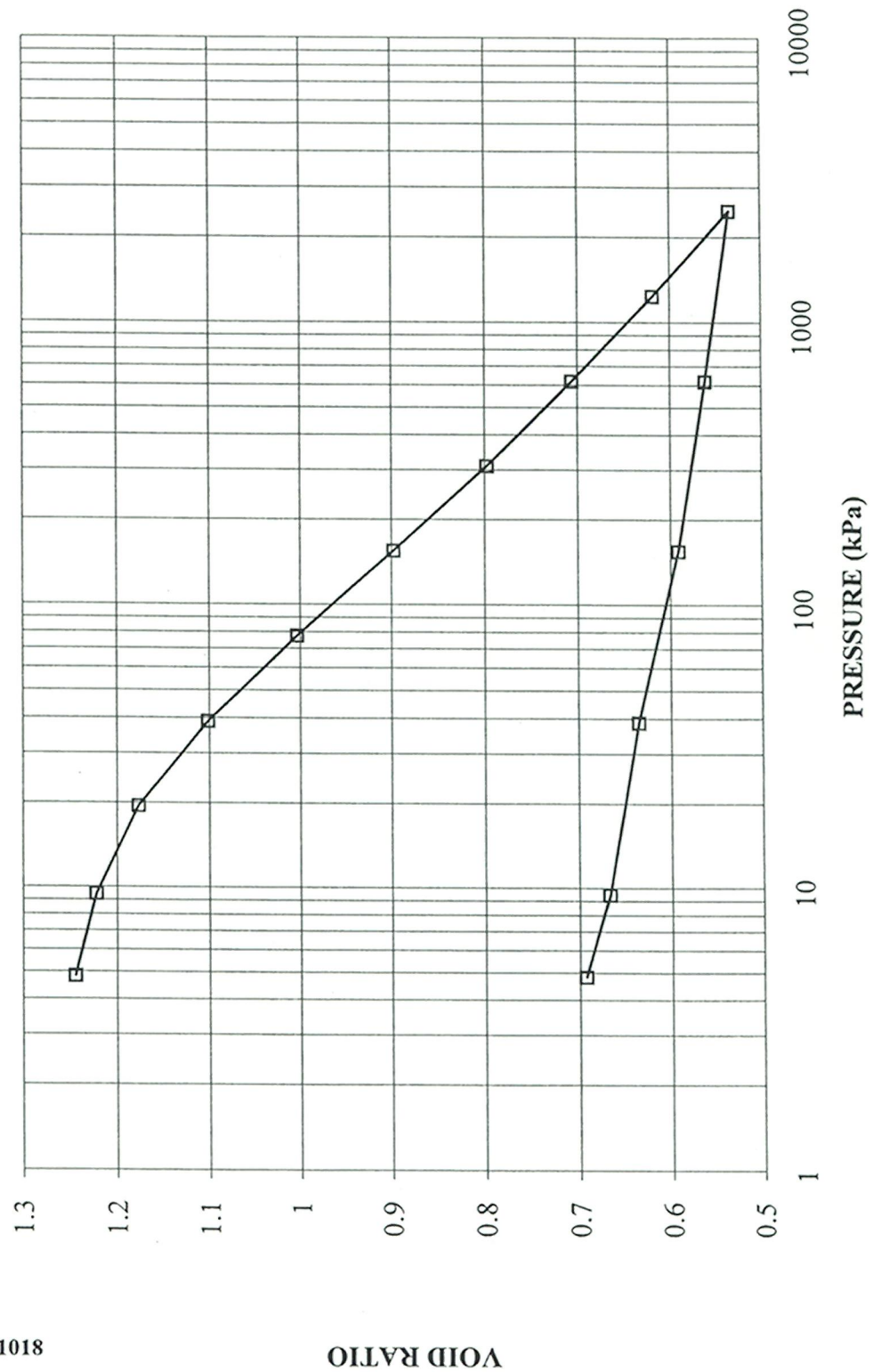


Project No. 021-10103

CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE B16

CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH 02-40 ST 2



OEDOMETER CONSOLIDATION SUMMARY

SAMPLE IDENTIFICATION

Project Number	021-101018	Sample Number	2
Borehole Number	02-40	Sample Depth, m	7.6-8.2

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	7		
Date Started	02-08-27		
Date Completed	02-09-07		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.91	Unit Weight, kN/m ³	17.07
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	11.59
Area, cm ²	31.67	Specific Gravity, measured	2.69
Volume, cm ³	60.49	Solids Height, cm	0.839
Water Content, %	47.27	Volume of Solids, cm ³	26.58
Wet Mass, g	105.31	Volume of Voids, cm ³	33.90
Dry Mass, g	71.51	Degree of Saturation, %	99.7

TEST COMPUTATIONS

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s
0.00	1.910	1.275	1.910				
4.82	1.884	1.245	1.897	1500	5.09E-04	2.80E-03	1.40E-07
9.45	1.865	1.222	1.875	2160	3.45E-04	2.15E-03	7.26E-08
19.49	1.827	1.177	1.846	2584	2.80E-04	1.99E-03	5.46E-08
38.88	1.764	1.101	1.795	2940	2.32E-04	1.71E-03	3.90E-08
77.52	1.682	1.003	1.723	2438	2.58E-04	1.11E-03	2.81E-08
154.78	1.593	0.898	1.637	1390	4.09E-04	6.02E-04	2.41E-08
309.56	1.509	0.797	1.551	930	5.48E-04	2.84E-04	1.53E-08
618.12	1.432	0.706	1.470	540	8.49E-04	1.30E-04	1.08E-08
1236.38	1.359	0.619	1.395	184	2.24E-03	6.22E-05	1.37E-08
2474.06	1.288	0.535	1.324	124	2.99E-03	2.97E-05	8.72E-09
618.12	1.311	0.562	1.300				
154.57	1.336	0.592	1.324				
38.69	1.373	0.635	1.354				
9.45	1.399	0.667	1.386				
4.82	1.421	0.693	1.410				

Notes:

k calculated using cv based on t₉₀ values.

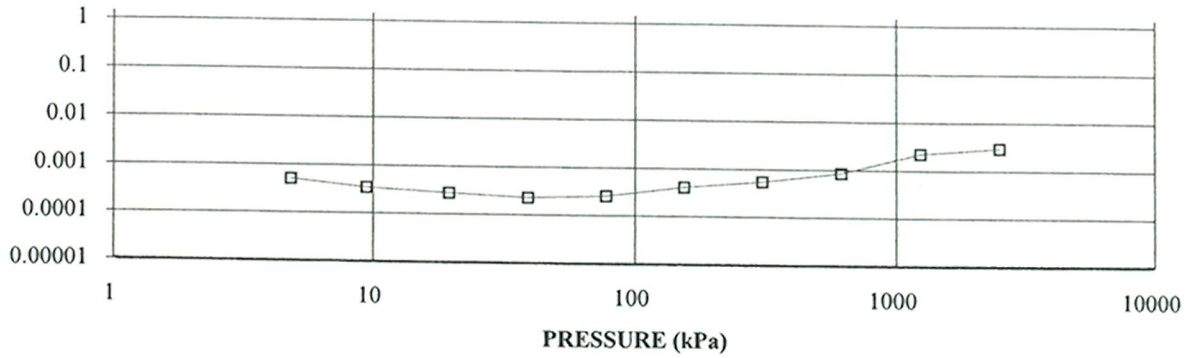
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.42	Unit Weight, kN/m ³	19.75
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	15.58
Area, cm ²	31.67	Specific Gravity, measured	2.69
Volume, cm ³	45.01	Solids Height, cm	0.839
Water Content, %	26.74	Volume of Solids, cm ³	26.58
Wet Mass, g	90.63	Volume of Voids, cm ³	18.42
Dry Mass, g	71.51		

OEDOMETER CONSOLIDATION SUMMARY

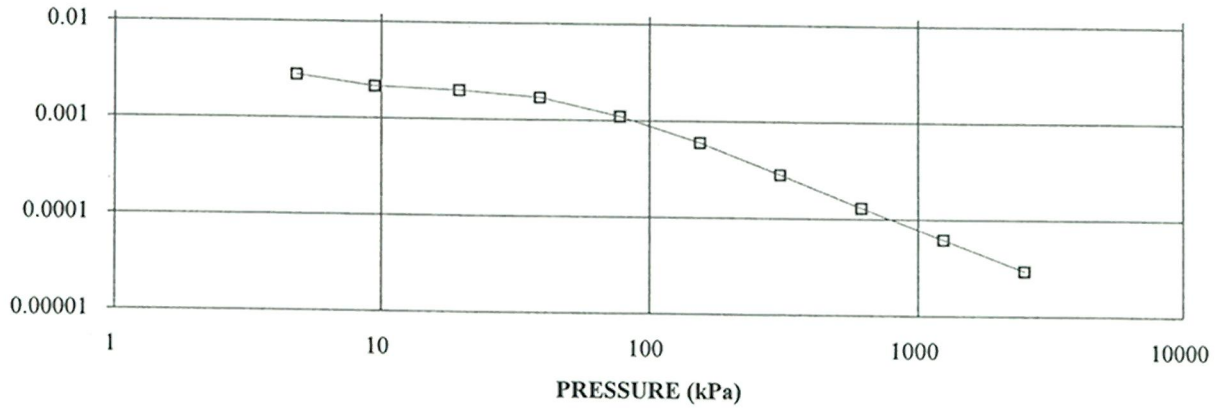
COEFFICIENT OF CONSOLIDATION, cm^2/s

CONSOLIDATION TEST
 $\text{cv cm}^2/\text{s}$ vs PRESSURE (kPa)
 BH 02-40 ST 2



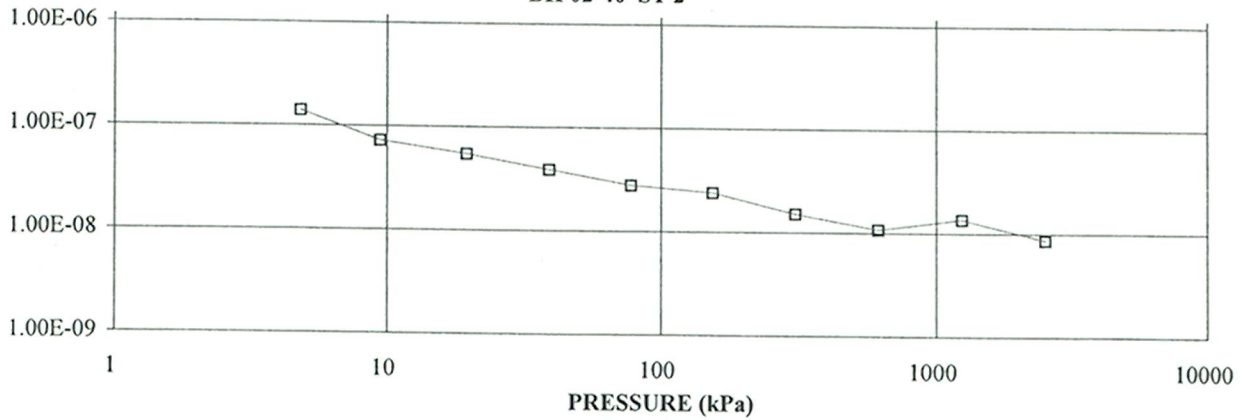
VOLUME
 COMPRESSIBILITY,
 m^2/kN

CONSOLIDATION TEST
 $\text{mv, m}^2/\text{kN}$ vs PRESSURE (kPa)
 BH 02-40 ST 2



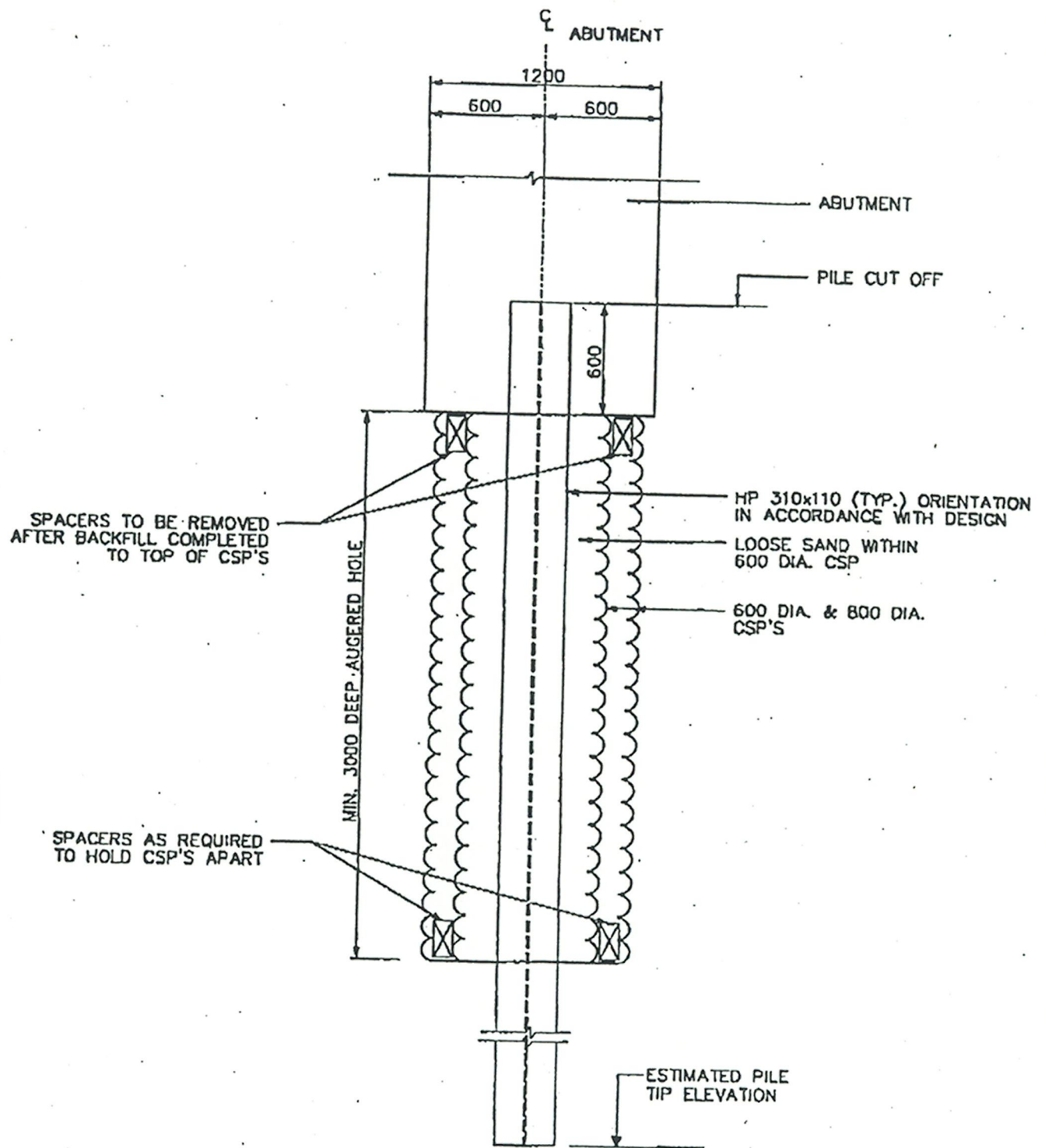
HYDRAULIC
 CONDUCTIVITY, cm/s

CONSOLIDATION TEST
 HYDRAULIC CONDUCTIVITY vs PRESSURE
 BH 02-40 ST 2



Project No. 021-101018

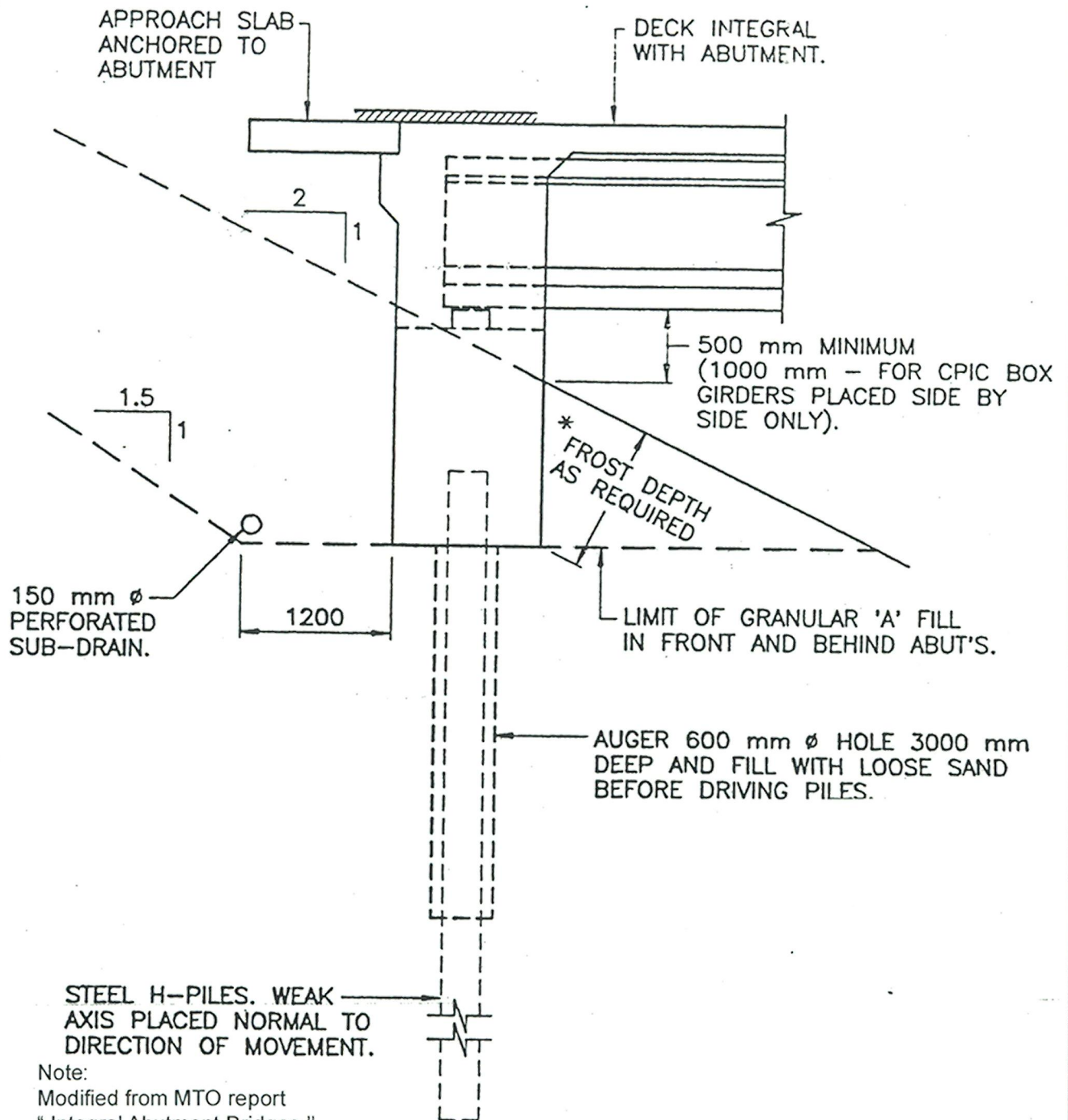
APPENDIX C



INTEGRAL ABUTMENT
 (DOUBLE PIPE) DETAIL

FIGURE C1





Note:
Modified from MTO report
"Integral Abutment Bridges",
Number SO-96-01, Revision 1, 1996.

INTEGRAL ABUTMENT
(SINGLE PIPE) DETAIL

FIGURE C2



APPENDIX D
Tables and Figures

Locations	Simplified Stratigraphy	Depth Interval (')		Undrained Cohesion (kPa)	Cu / σ'v (min.)	Friction Angle (for eff. stress) (deg)	Unit Weight (kN/m3)	Initial Void Ratio e0	Compression Index (Cc)	Recompression Index (Cr)	Compression Ratio		OCR	Coeff. Of Consolidation (m2/y)				Secondary Compression Ratio (Cα')
		From (m)	To (m)								Cc/(1+eo) (Cc')	Cr/(1+eo) (Cr')		Cv (lower limit)		Cv (upper limit)		
														O.C.	N.C.	O.C.	N.C.	
Permanent Embankment (West Abutment) Existing Fill Height = 3 Proposed Fill Height = 4.6 m	Embankment Fill	0	4	-	-	30	20	-	-	-	-	-	-	-	-	-	-	-
	Silty Clay (firm)	4	5	15	0.22	26	19	1	0.3	0.04	0.15	0.02	2	12	3	20	5	0.004
	Silty Clay (very soft)	5	8	10	0.22	24	17	2	0.87	0.13	0.29	0.04	1.3	12	3	20	5	0.008
	Silty Clay (soft)	8	13	15	0.22	24	18	1.5	0.66	0.09	0.26	0.04	1.3	12	3	20	5	0.008
	Silty Clay (firm)	13	20	25	0.22	24	18	1	0.3	0.04	0.15	0.02	1.3	12	3	20	5	0.004
	Sand & Gravel (boulders)	20	-	-	-	40	-	-	-	-	-	-	-	-	-	-	-	-
Permanent Embankment (East Abutment) Existing Fill Height = 3 Proposed Fill Height = 4.6 m	Embankment Fill	0	3	-	-	30	20	-	-	-	-	-	-	-	-	-	-	-
	Silty Clay (firm)	3	5	15	0.22	26	19	1	0.3	0.04	0.15	0.02	2	12	3	20	5	0.004
	Silty Clay (very soft)	5	8	10	0.22	24	17	2	0.87	0.13	0.29	0.04	1.3	12	3	20	5	0.008
	Silty Clay (soft)	8	13	15	0.22	24	18	1.5	0.66	0.09	0.26	0.04	1.3	12	3	20	5	0.008
	Silty Clay (firm)	13	21	25	0.22	24	18	1	0.3	0.04	0.15	0.02	1.3	12	3	20	5	0.004
	Sand & Gravel (boulders)	21	-	-	-	40	-	-	-	-	-	-	-	-	-	-	-	-
Detour Embankment (West Abutment) Existing Fill Height = 0 Proposed Fill Height = 3 m (including surcharge)	Alluvium (loose silt)	0	2	-	-	28	18	-	-	-	-	-	-	-	-	-	-	-
	Silty Clay (soft)	2	5	15	0.22	26	19	1	0.3	0.04	0.15	0.02	2	12	3	20	5	0.004
	Silty Clay (very soft)	5	8	10	0.22	24	17	2	0.87	0.13	0.29	0.04	1.3	12	3	20	5	0.008
	Silty Clay (soft)	8	12	15	0.22	24	18	1.5	0.66	0.09	0.26	0.04	1.3	12	3	20	5	0.008
	Silty Clay (incl. Varves)	12	22	25	0.22	24	18	1	0.3	0.04	0.15	0.02	1.3	12	3	20	5	0.004
	Sand & Gravel (boulders)	22	-	-	-	40	-	-	-	-	-	-	-	-	-	-	-	-
Detour Embankment (East Abutment) Existing Fill Height = 0 Proposed Fill Height = 3 m (including surcharge)	Alluvium (loose silt)	0	1	-	-	28	18	-	-	-	-	-	-	-	-	-	-	-
	Silty Clay (soft)	1	4	15	0.22	26	19	1	0.3	0.04	0.15	0.02	2	12	3	20	5	0.004
	Silty Clay (very soft)	4	7	10	0.22	24	17	2	0.87	0.13	0.29	0.04	1.3	12	3	20	5	0.008
	Silty Clay (soft)	7	11	15	0.22	24	18	1.5	0.66	0.09	0.26	0.04	1.3	12	3	20	5	0.008
	Silty Clay (firm)	11	18	25	0.22	24	18	1	0.3	0.04	0.15	0.02	1.3	12	3	20	5	0.004
	Sand & Gravel (boulders)	18	-	-	-	40	-	-	-	-	-	-	-	-	-	-	-	-

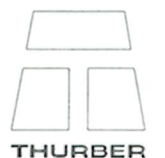
Notes:

O.C.: Over Consolidated Soil
N.C.: Normally Consolidated Soil

(*) Depth intervals refer to original ground surface. Depth 0m to 1.5m relates to depth from ground surface to 1.5m below ground surface

HIGHWAY 101 - DRIFTWOOD RIVER BRIDGE APPROACH
SUMMARY OF FOUNDATION DESIGN PARAMETERS

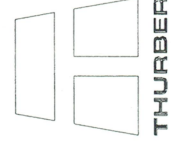
TABLE D1



Proposed Works	Estimated Settlement		
	Short Term		Long Term
	During Construction of Approach Embankments	During Detour Operation	Post Construction (including primary and secondary consolidation over 75 years)
Replacement Bridge (existing alignment) : Grade raise at both east and west approaches up to 1.6 m	No settlement	East Approach No observable settlements within the 20 m zone of full depth replacement Beyond the 20 m zone, estimated settlement in the order of 25 mm	East Approach No observable settlements within the 20 m zone of full depth replacement Beyond the 20 m zone, estimated settlement in the range of 60 mm to 120 mm
		West Approach Same as east approach	West Approach Same as east approach
Detour Bridge (north alignment) Fill up to 2 m at abutments	For up to 8 months : (fill placed in 1 stage to 3 m high) (remove surcharge at end of period) 120 mm to 160 mm	30 mm to 50 mm (8 months)	Not applicable

DRIFTWOOD REPLACEMENT AND DETOUR BRIDGES
ESTIMATED SETTLEMENTS FOR APPROACH EMBANKMENTS

TABLE D2

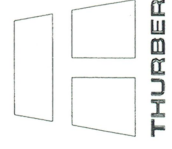


Proposed Works	Fill Height	Fill Type	Fill Slopes	Geosynthetics	Berm	Wick Drains
Replacement Bridge (existing alignment)	East Approach up to 1.6 m higher than existing road grade	Lightweight Fill (replacing a portion of existing fill)	2 H : 1 V	No	No	No
	West Approach up to 1.6 m higher than existing road grade			No	No	No
Detour Bridge (north alignment)	Up to 2 m high at abutments	Select Subgrade Material (placement in 1 stage, 3 m including surcharge)	2 H : 1 V 3 H : 1 V (where space permits)	Yes	No	No

DRIFTWOOD RIVER REPLACEMENT AND DETOUR BRIDGES APPROACH EMBANKMENT REQUIREMENTS

Option 1 (Selected) - Replacement Bridge on Existing Alignment and Detour Bridge on North Alignment

TABLE D3

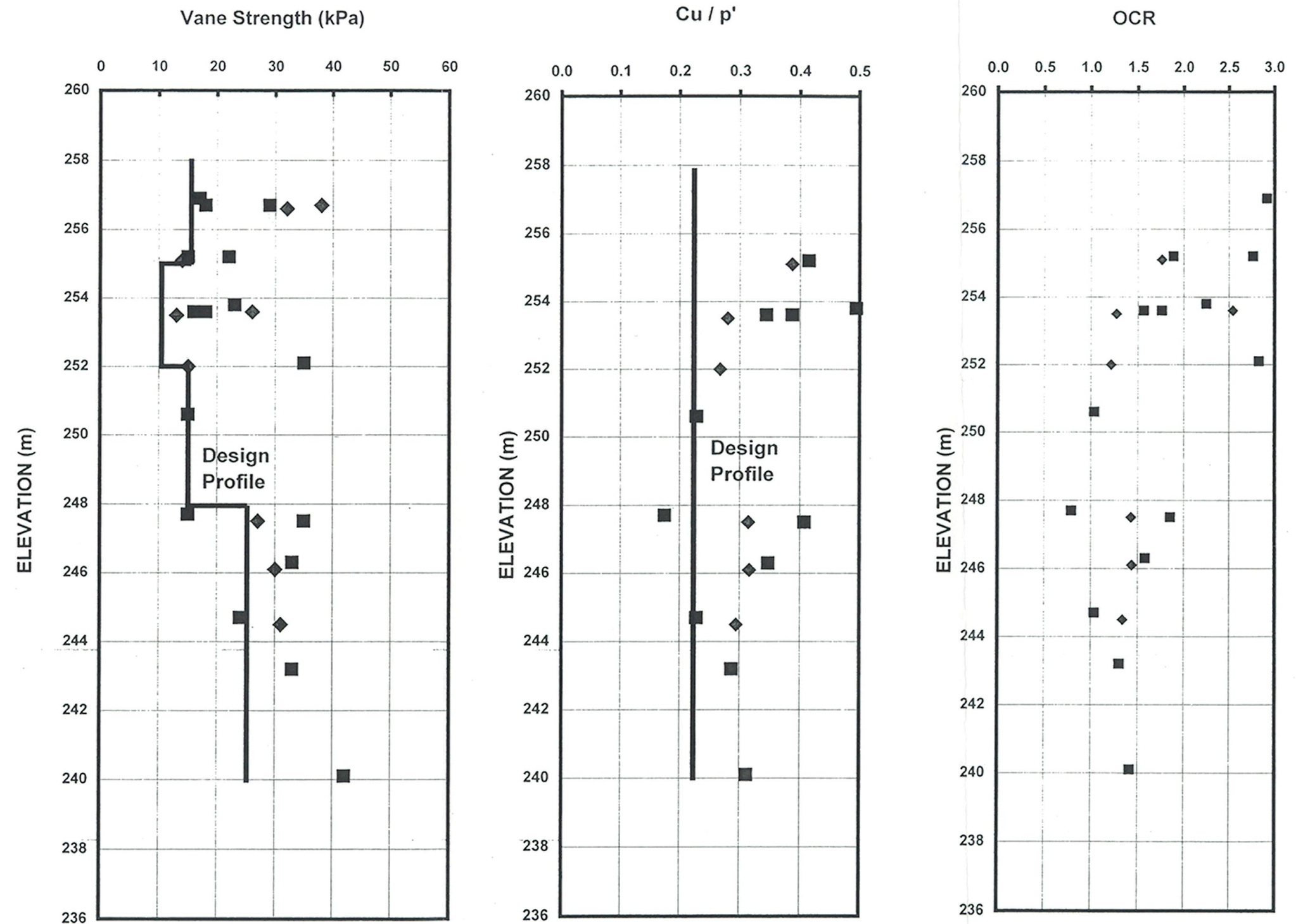


ALLUVIUM

SILTY CLAY

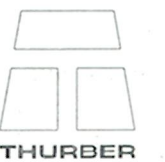
Varved CLAYS

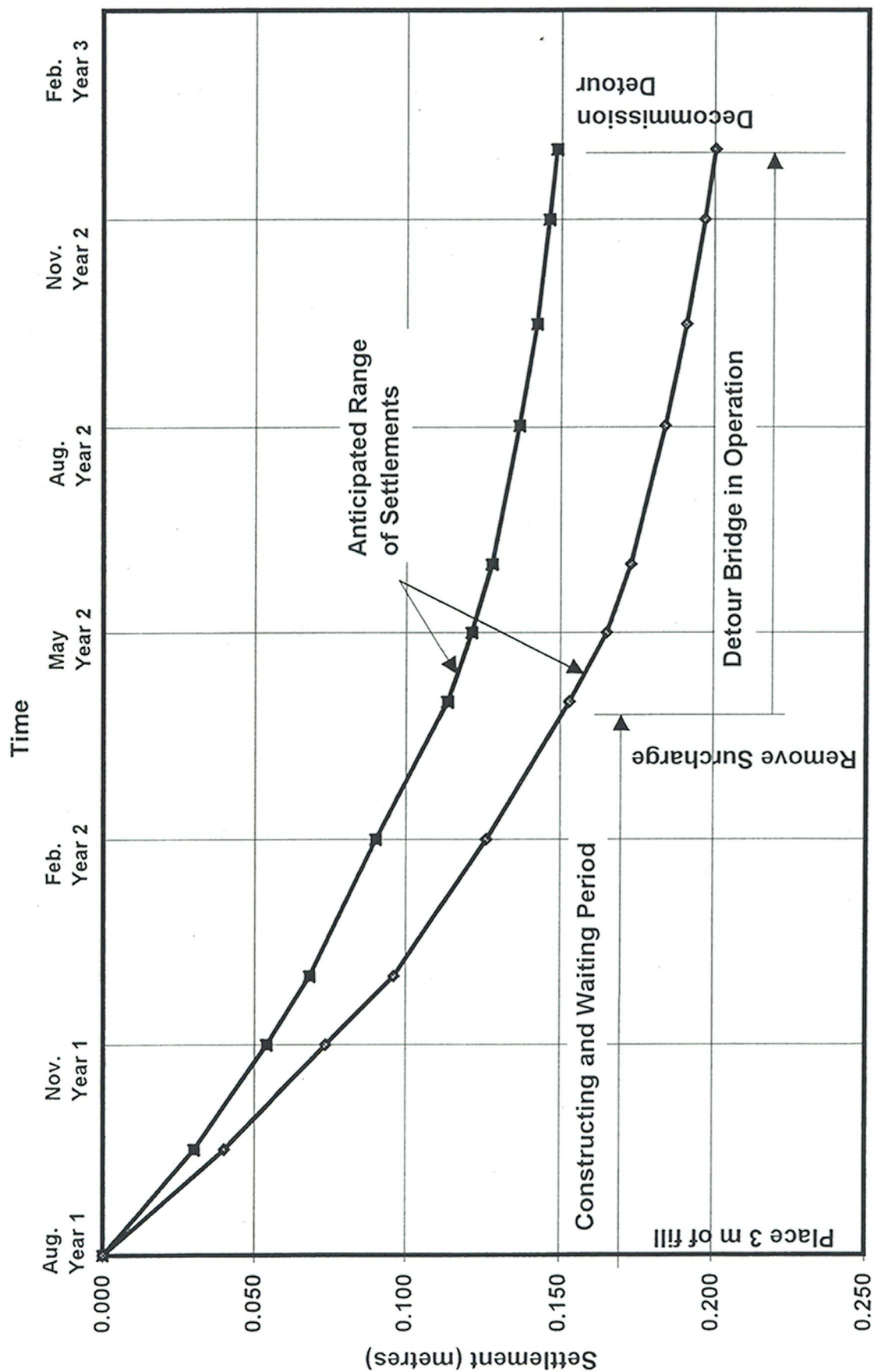
Boulders and Cobbles



SUMMARIZED SOIL PROPERTIES (DETOUR BRIDGE)

Figure D1





DRIFTWOOD RIVER DETOUR EMBANKMENT ON FLOODPLAIN
TIME - DEPENDENT SETTLEMENT
SINGLE STAGE FILL PLACEMENT

FIGURE D2



Thurber Engineering Ltd. - Toronto
 17-308-294
 Driftwood River Bridge
 January 8, 2003
 3 m New Detour Embankment on Floodplain - high water

FIGURE D3 SLOPE STABILITY AFTER FILL PLACEMENT ON FLOODPLAIN

Fill (second 1m)
 Alluvium (silt)
 Silty Clay (soft)
 S. Clay (v. soft)
 Silty Clay (soft)
 Silty Clay (firm)
 Silty Clay (stiff)

Gamma kN/m ³	C kPa	Phi deg	Min c/p	Piezo Surf.
21	0	32	0	0
18	0	28	0	1
18	15	0	.22	2
17	10	0	.22	3
18	15	0	.22	4
19	25	0	.22	5
19	25	0	.22	6

One stage (3 m fill) B=0.9 no dissipation
 GEOGRID REINFORCEMENT T allow. = 50 kN/m

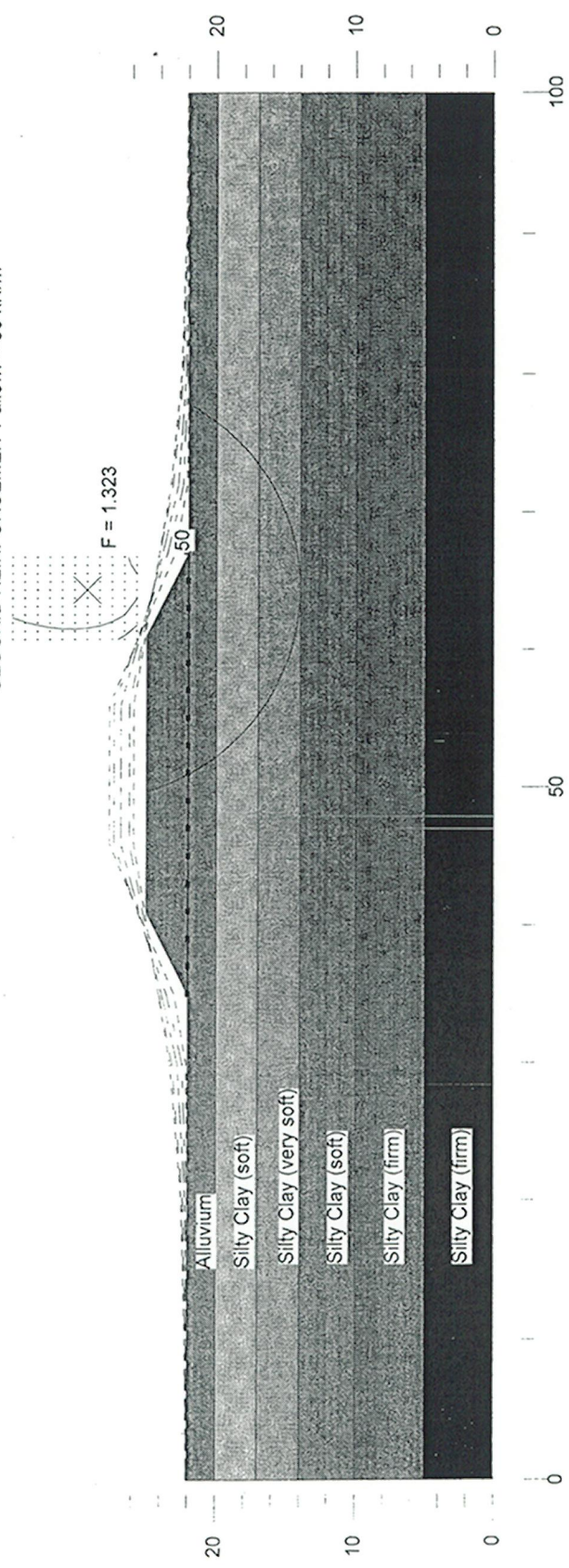
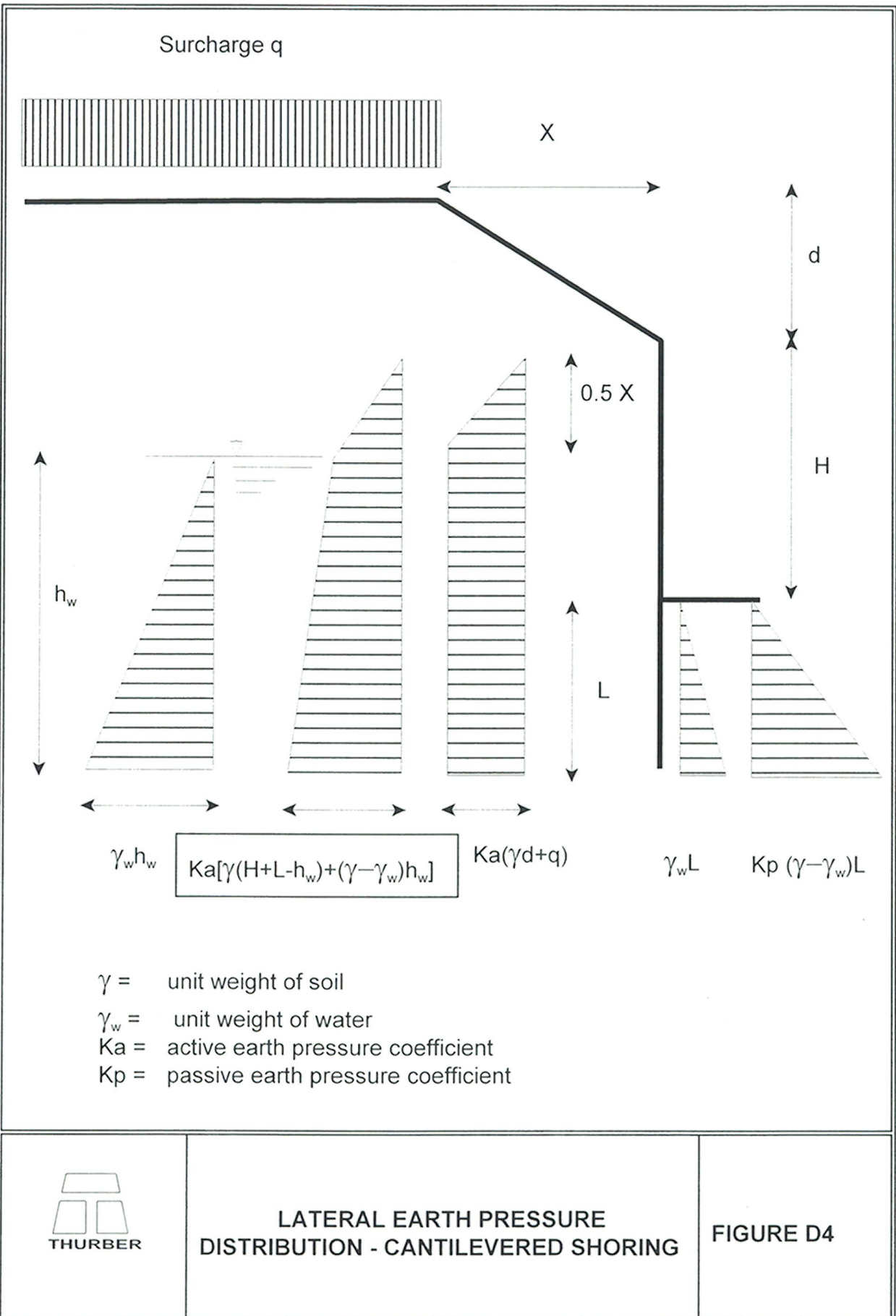


FIGURE D3

SLOPE STABILITY AFTER FILL PLACEMENT ON FLOODPLAIN



ULTRA LIGHTWEIGHT (TYPE 2) SLAG

Special Provision

February 2003

SCOPE

This non-standard special provision covers the requirements for the loading, hauling and placement of the ultra-lightweight blast furnace slag.

DEFINITIONS

Quality Verification Engineer: means an Engineer with a minimum of five (5) years experience related to embankment materials and construction, or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the Contract. The Quality Verification Engineer shall be retained by the Contractor to certify that the work is in general conformance with the contract documents and issue of certificate(s) of conformance.

SUBMISSION AND DESIGN REQUIREMENTS

The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer stating that the work has been carried out in general conformance with the contract documents and specifications.

The Contractor shall submit to the Contract Administrator, for information only, all Quality Control test results.

MATERIALS

It should be noted that suitable space be identified near the site for the purpose of stockpiling the slag material prior to placement.

CONSTRUCTION

The Contractor shall place the ultra-lightweight fill material and shall achieve compaction without crushing the material since crushing would increase its unit weight. The contractor is advised that the ultra lightweight blast furnace slag is susceptible to crushing if overcompacted and that careful construction supervision is required.

The Ultra Lightweight Blast Furnace Slag shall meet the following requirement:

In situ wet unit weight $\leq 11.5 \text{ kN/m}^3$

Placement and Compaction

For embankment construction, the Contractor shall place the ultra lightweight fill material without exceeding the specified In-situ Unit Weight and maintaining crushing of the material below 5%.

To prevent overcrushing and overcompaction , the ultra lightweight fill shall be placed as follows:

1. For embankments, the ultra lightweight fill shall be placed in lifts of 300 mm and compacted by three (3) passes using a single drum vibratory equipment such as a Bomag 142 or equivalent.
2. For backfill to structures, the ultra lightweight fill shall be placed in lifts of 300 mm and compacted with 8 passes of a manually guided tamper such as a Bomag BPR 30/38 D or equivalent.
3. The Contractor shall place and spread the loose lifts using a rubber tire front end loader such as a Caterpillar 980 F or equivalent.

Compaction equipment technical details are provided in Table 2.

Table 2 – Compaction Equipment Technical Details

	Bomag 142 D	Bomag BPR 30/38 D
Weights		
▪ Operating weight	4690 ±	175±
▪ Mass per square metre of base plate	N/A	1439±
Dimensions		
▪ Drum width(mm)	1426±	N/A
▪ Drum diameter(mm)	1058±	N/A
▪ Width of Base Plate(mm)	N/A	380
▪ Length of Base Plate(mm)	N/A	730
Drive		
▪ Performance DIN 6271 IFN(kW)	37±	3.7
▪ Performance SAE(Kw)	39.5	N/A
▪ Speed(rpm)	2300	3600
Vibratory System		
▪ Frequency(Hz)	32±	68±
▪ Amplitude(mm)	1.24±	N/A
▪ centrifugal force(Kn)	66±	30±

Quality Assurance/Quality Control

General

As specified elsewhere in the Contract, the Contractor shall establish in his Quality Control Plan Appendix the procedures necessary to meet the requirements of this Special Provision for the loading, hauling, and placement of the ultra lightweight fill material.

Notwithstanding the requirements for QA sampling as indicated in Table 3 below, the Owner reserves the right to obtain a sample at any time without notice for any purpose.

Sampling

QA/QC samples shall be taken in accordance with the individual test procedure requirements under the supervision of the Quality Verification Engineer (QVE). QA samples shall be obtained by the Contractor, in the presence of the Contract Administrator.

All Quality Assurance samples shall be delivered by the Contractor to a laboratory designated by the Owner within 500 km of the contract limits no later than 2 business days from the date of sampling.

For QA sampling, the Contractor shall provide new sample bags or containers that are constructed to prevent the loss of any part of the material or contamination or damage to the contents during shipment. The sample bags or containers shall be sufficiently strong and shall be securely fastened.

Table 3: Quality Assurance/Control Testing Frequencies for Supplied Ultra Lightweight Blast Furnace Slag

Property	Test Procedure	Frequency	Sample Size
Gradation (Before and After Compaction)	ASTM D422-63	1 for each 4000 m ³ placed, with a minimum frequency of 1 daily	Two 25 kg samples; One before and One after compaction
In-situ Density	ASTM D2922	1 for each 4000 m ³ placed, with a minimum frequency of 1 daily	N/A
Moisture Content	ASTM D2216	1 for each 4000 m ³ placed, with a minimum frequency of 1 daily	25 kg

Under the Supervision of the Quality Verification Engineer, the Contractor may choose to perform additional test methods and/or increase the frequency of testing shown in Table 3 for Quality Control purposes and as established in the Contractor's Quality Control Plan.

Control Strip

Under the Supervision of the Quality Verification Engineer, the Contractor shall build a control strip to verify that the placement and compaction procedure will achieve the requirements of this Special Provision without evidence of crushing and without exceeding the specified maximum in-situ unit weight of $\leq 12 \text{ kN/m}^3$.

Prior to incorporating any of the material into the work, the Contractor shall build a minimum trial area of 400 m² in area consisting of two equal lifts of 300 mm thickness. The Contractor shall give the Contract Administrator written notice of the construction of the control strip 48 hours prior to commencement of this work.

Material placed in the control strip shall have the moisture content that will yield the specified in-situ unit weight. For the Control Strip determination, the nuclear gauge method will not be considered an acceptable method of determining the in-situ moisture content of the ultra lightweight material. Moisture content shall be determined by oven dry method on selected compacted embankment material samples in accordance with ASTM D2216.

After the trial area is complete, samples for moisture content and in-situ unit weight determination shall be performed at three randomly selected locations. In-situ unit weight determination testing shall be as per ASTM D2922.

In addition, Gradation as per ASTM D422-63 before and after compaction effort shall be performed to determine that crushing is kept within 5%.

All test results will be used to determine compliance with the specification. Any proposed changes to the specified compaction method shall be reviewed and approved by the Contract Administrator prior to implementation. The requirements of the control strip must be satisfied as part of the acceptance criteria of any proposed change to the specified compaction method of this Special Provision.

MEASUREMENT OF PAYMENT

The unit measurement will be cubic metres for the ultra lightweight fill material placed in situ as per the requirements of the contract.

BASIS OF PAYMENT

Payment at the contract price for the above tender item shall be full compensation for all labour equipment and materials required to do the work.

GEOSYNTHETIC REINFORCEMENT

Special Provision

February, 2003

Material

Geosynthetic Reinforcement consisting of:

- Geogrid

The geosynthetic reinforcement should meet the following requirements:

- Minimum combined long term design (allowable) strength (LDTS) of 50 kN/m
- LDTS for geosynthetic placed on SSM as determined in accordance with GRI-GG1
- Geogrid to consist of High Density Polyethylene (HDPE) or PVC-coated polyester or approved equivalent

Supply of Materials

The geosynthetic reinforcement can be obtained from:

Armtec
<http://www.big-o.com>

Layfield Geosynthetics & Industrial Fabrics
<http://www.layfieldplastics.com>

Nilex Group Canada
<http://www.nilex.com>

Terrafix Geosynthetics Inc.
<http://www.terrafixgeo.com>

Geosynthetic Reinforcement Installation

The area shall be cleared of sharp objects that might damage the geosynthetic reinforcement.

The geosynthetic reinforcement shall be placed according the contract drawings and with fibres of maximum strength parallel to the bridge axis. The geosynthetic reinforcement shall be free continuous across the dimension parallel to the bridge axis without splicing.

Operational Constraint

No vehicle traffic shall be allowed directly on any of the geosynthetic reinforcement. There shall be 0.3m of cover over geosynthetic reinforcement layers prior to allowing any construction equipment over the area.

Measurement for Payment

Geosynthetic reinforcement will be measured in place in square metres with no allowance for overlap.

Basis for Payment

Payment at the contract price for this tender item shall be full compensation for all labour, equipment and material necessary to do the work.

SUPPLY AND INSTALLATION OF EMBANKMENT MONITORING EQUIPMENT

Special Provision

February 2003

1. GENERAL

Scope

This non-standard special provision contains the requirements for the supply and installation of the following geotechnical instruments:

- Settlement Rods (SR).

Purpose

The purpose of these instruments is to monitor the progress of settlement in the foundation soils under the detour embankments.

Personnel

The Contractor shall retain a Geotechnical Consultant with MTO classification of 'Geotechnical (Structures and Embankments) - High Complexity', to undertake the supply and installation of geotechnical instruments.

The Geotechnical Consultant shall be approved by the Contract Administrator. The Contractor shall be understood to refer to the Contractor and their Geotechnical Consultant.

Or equal

The term, 'or equal' shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration. Only one supplier should be selected for the supply of vibrating wire piezometers.

Notification

The Contract Administrator shall be notified a minimum of 15 working days in advance of commencing the installation of instruments.

Submission Requirements

The Contractor shall submit details of proposed installation methods, including location and types of survey Benchmarks, and installation schedule to the Contract Administrator, a minimum of 15 days before the start of instrument installation.

Drawings

Reference shall be made to the following drawing:

- Monitoring Instrument Details – Vibrating Wire Piezometer (VWP), Standpipe Piezometers (SSP) and Settlement Rod (SR) (Drawing No. 17-308-294-AP1)

Subsurface Conditions

The subsurface conditions at the sites are described in the reports:

- ▶ Report on Foundation Investigation, Driftwood River, Replacement and Detour Bridges, Highway 101, East of Timmins, District 53 – New Liskeard, Site 39E-132, G.W.P. 316-85-00, W.P. 316-85-01, prepared by Thurber Engineering Ltd.

1.1 INSTALLATION

Table 1a - Instrument Quantities and Locations at Detour East Approach

MONITORING LOCATION	LOCATION			NUMBER OF:
	Location	Lane	Station (existing centreline)	SR
EAST APPROACH	~10m behind east abutment	WBL	19+285	1
	~25m behind east abutment	EBL	19+300	1
			TOTAL	2

Table 1b - Instrument Quantities and Locations at Detour West Approach

MONITORING LOCATION	LOCATION			NUMBER OF:
	Location	Lane	Station (existing centreline)	SR
WEST APPROACH	~10m behind west abutment	EBL	19+190	1
	~25m behind west abutment	WBL	19+175	1
			TOTAL	2

Instrument Location

Prior to the installation of instruments, the Contractor shall accurately survey and stake the location of each instrument and obtain a ground elevation at each instrument location.

Survey Benchmarks

The Contractor shall provide non-yielding deep seated survey benchmarks.

The number and locations of benchmarks shall be such that direct sighting is possible from all settlement rods (SR) to at least one bench mark.

Accuracy of Surveying for Elevations

Elevations shall be surveyed to an accuracy of ± 2 mm or better.

Materials and Equipment

The Contractor shall supply all materials and equipment required for the installation of instrumentation unless noted otherwise.

Underground Utilities

The Contractor shall be responsible for locating and protecting all underground utilities prior to drilling boreholes for installing instruments. Any damage to underground utilities caused by the Contractor's work shall be repaired by the Contractor, at no cost to the Contract Administrator.

Marking and Labelling

The location of any above ground monitoring fixture shall be made clearly visible to nearby traffic before, during and after embankment and surcharge construction. Marking shall be of sufficient size to be visible from a reversing vehicle and after heavy snow falls.

Instruments or their data cables shall be clearly labelled in the field, each instrument having a unique identifier. The labelling shall remain legible for the full duration of detour operation.

Protection of Instruments

All instruments shall be adequately protected by the Contractor such that they are not damaged during construction. Any instrument damaged by the Contractor's work shall be immediately replaced at the Contractor's cost.

Installation Program

Table 2 gives a summary of the installation schedule requirements.

Table 2 - Installation Program

TYPE	START INSTALLATION	FINISH INSTALLATION
SR	Immediately after subgrade preparation is completed	Before detour fill placement

2.0 SETTLEMENT RODS (SR) - SUPPLY & INSTALLATION

2.1 GENERAL

Scope

This Section contains the requirements for the supply and installation of settlement rods.

The purpose of the settlement rods is to monitor settlements of the embankment base. Settlement is measured by survey of the top of the rod with reference to stable, non-settling benchmarks.

General Procedure

The settlement rods shall be attached to a plate at existing ground level. As embankment and surcharge construction proceeds the rods shall be extended above the new top of embankment and surcharge.

Sleeves around the rods shall be installed to reduce friction and allow uninhibited movement of the rod with the plate.

A protective surround shall be extended with the rods as embankment and surcharge construction proceeds.

Location

The locations of the settlement rods are shown on the attached drawings and are given in Table 2.

Table 2 - Approximate Settlement Rod Locations

Station/Offset	Lane	Monitoring Location	Approximate elevation of existing ground
19+285 6 m o/s N from centreline (middle of shoulder)	WBL	East Approach	261.2
19+300 6 m o/s S from centreline (middle of shoulder)	EBL	East Approach	261.2
19+190 6 m o/s N from centreline (middle of shoulder)	EBL	West Approach	261.2
19+175 6 m o/s S from centreline (middle of shoulder)	WBL	West Approach	261.2

2.2 MATERIALS

General

The Contractor shall supply all materials and equipment required for the installation of the settlement rods.

Plate

The Contractor shall supply a steel plate with thickness of at least 6.35 mm. The plate shall be at least 0.5 m by 0.5 m.

Rod

The Contractor shall supply a steel pipe Schedule 40 with an outside diameter not less than 25.4mm (1"), supplied in lengths as required to complete the installation as described in Section 4.3.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

Friction Reducing Sleeve

The Contractor shall supply a friction reducing sleeve consisting of Schedule 40 - 50.8mm (2") O.D. PVC pipe cut perpendicular to the axis of the pipe.

Protective Surround

The Contractor shall supply a protective surround for the portion of the rod within the embankment and surcharge.

The surround shall consist of 300 mm diameter corrugated steel pipe (CSP - OPSS 1801) with the ends cut perpendicular to the axis of the pipe and free of burrs and sharp edges. The space between the CSP and the Friction Reduction Sleeve (PVC pipe) shall be filled with medium to coarse sand.

2.3 INSTALLATION

General

The Contractor shall install settlement rods as per the drawings provided in addition to what is stated or emphasized below.

Settlement Plate

The settlement plate shall be installed horizontally on undisturbed native soil, just below the existing ground.

The elevation of the base of the plate shall be surveyed before backfilling.

Rod

The rod shall be fixed to the centre of the plate and perpendicular to the plate.

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

Friction Reducing Sleeve

The friction reducing sleeve shall be over the entire length of the rod that is below ground and within the embankment and surcharge fill except that the cap on top of the settlement rod shall extend 25 mm above the top of the friction sleeve at all times

Extension of Rod

The settlement rods shall be extended upwards as the embankment and surcharge are constructed so that the top of the rod is always at least 0.3 m but not more than 2m above the surrounding fill.

Protective Surround

The CSP, Friction Reducing Sleeve and sand protective surround shall be extended with the rods.

The settlement rod shall be in the centre of the CSP and friction-reducing sleeve.

The annulus between the CSP and the friction-reducing sleeve shall be filled with sand to a level not higher than the top of the sleeve.

Installation Details

The elevation, easting and northing of the centre of the base of the plate shall be surveyed.

The elevation, easting and northing of the top of the rod shall be surveyed.

The total distance from the base of the plate to the top of the rod shall be measured to an accuracy of ± 2 mm or better.

2.4 COORDINATION WITH MONITORING

Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a settlement rod. At this time the Contractor shall also supply the following information to the Contract Administrator.

- ▶ Elevation of plate and rod;
- ▶ Dates of installation;
- ▶ Installation notes / sketches;
- ▶ Description of settlement rods, sleeve, plate.

Throughout construction, adjustments to the length of any settlement rod shall be coordinated with the Contract Administrator to allow surveying by others of the elevation of the top of the rod immediately before and immediately after adjustment. This surveying is necessary to accurately track the settlement data.

Monitoring

Monitoring of the settlement rods shall be done by others. Monitoring shall be conducted during the embankment and surcharge construction. The Contractor shall provide installation information as specified above and provide access to the settlement rods for monitoring including, but not limited to a scaffolding platform and ladder if required and snow clearing in the winter. The contractor shall provide electric power and general area lighting as needed for reading the instruments.

2.5 REPORTING

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to :

- ▶ Settlement rod easting, northing;
- ▶ Elevation of the plate and the top of the rod;
- ▶ Distance between base of plate and top of rod;
- ▶ Dates of installation;
- ▶ Installation notes / sketches;

MONITORING PROGRAM

Special Provision

February 2003

1 GENERAL

1.1 This special provision includes:

- Requirements for instrumentation readings, data reduction and reporting;
- Criteria used to assess the embankment performance based on the monitoring data collected from instrumentation installed by others;
- Measurement and Basis of Payment for the Monitoring Program.

1.2 The Contract Administrator shall retain a Geotechnical Consultant with MTO classification of 'Geotechnical (Structures and Embankments) - High Complexity', to undertake the Monitoring Program. The Geotechnical Consultant shall not be the same Geotechnical Consultant retained by the Contractor for the supply and installation of embankment monitoring equipment.

2. PURPOSE

2.1 The purpose of the Monitoring Program is to monitor the progress of settlement of the detour embankments.

3. RESPONSIBILITIES

3.1 Responsibilities of the Geotechnical Consultant include:

- Review the Monitoring Program and, if deemed necessary, submit in writing to the Contract Administrator recommendations for modifications to the Monitoring Program;
- Meet with the Contractor in order to receive reports with details about installation of instruments installed by the Contractor, as specified in NSSP Entitled "Supply and Installation of Embankment Monitoring Equipment", included in the contract documents;
- All instruments installed by the Contractor, supply all materials and equipment that are required for the Monitoring Program;
- Take instrument readings, reduce data, prepare reports
- Transmittal of instrumentation readings and reports to the Contract Administrator
- Interpret instrumentation readings as needed for the purposes of on going construction, and notify the Contract Administrator of required modifications to the construction procedures accordingly, if necessary. Interpretation shall include making correlations between instrumentation data and specific construction activities.
- Notify the Contract Administrator if critical instrument readings, as specified herein, for any instrumentation are reached. Meet with the Contract Administrator within 8 hours to discuss response action(s), and submit a plan of actions, to prevent the critical instrument readings to be exceeded.

4 DRAWINGS

4.1 Reference shall be made to the following drawing:

- Monitoring Instrument Details – Settlement Rod (SR) (Drawing No. 17-308-294-AP1).

5 SUBSURFACE CONDITIONS

5.1 The subsurface conditions at the site are described in the following reports:

- Report on Foundation Investigation, Driftwood River Bridge, Replacement and Detour Bridges, Highway 101, East of Timmins, District 53 – New Liskeard, Site 39E-086, G.W.P. 315-85-00, W.P. 315-85-01, prepared by Thurber Engineering Ltd.

6 EQUIPMENT OPERATION AND WEATHER CONDITIONS

6.1 Monitoring shall be carried out until decommissioning of detour.

7 READING SCHEDULE AND FREQUENCY

7.1 The Geotechnical Consultant shall save and archive raw data in electronic and hard copy format.

7.2 Monitoring shall commence immediately after the installation of an instrument. Monitoring is anticipated to continue for a period of approximately 16 months, until the decommissioning of the detour.

7.3 The minimum monitoring frequencies and anticipated number of readings are given in Table 1. The monitoring frequency is the same for each individual instrument. Instruments shall be read more or less frequently if judged to be required by the Contract Administrator.

Table 1 - Minimum Monitoring Frequency

STAGE	FREQUENCY	ANTICIPATED NO. OF READINGS PER INSTRUMENT (**)
Baseline Reading (*)	3 readings on 3 consecutive days no sooner than 7 days following installation	3
Just prior to start of embankment construction	Once	1
During fill placement	Once every 1 m fill lift within 20 m of the monitoring instrument	3
After removal of surcharge and prior to paving	Once	1
During detour operation	Once every month until end of detour operation	8

- (*) Baseline Readings: Value of instrumentation readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements.
- (**) Number of readings may vary.

8 INSTRUMENTATION

8.1 The following instruments will be used in the Monitoring Program:

- Settlement Rods (SR) to monitor settlement at the base of the detour embankments

10. SETTLEMENT RODS (SR)

10.1 Surveying

10.1.1 The elevations of settlement rods shall be surveyed to an accuracy of plus/minus 2 mm or better.

10.1.2 Surveying for settlement monitoring shall be conducted by a registered surveyor with appropriate equipment and experience. The surveyor shall be retained by the Geotechnical Consultant.

10.2 Reporting

10.2.1 An updated processed copy of monitoring data accompanied by a brief interpretation, shall be provided to the Contract Administrator the day after each set of readings are obtained. The data shall be presented in tabular and graphical form.

10.2.2 As a minimum the following shall be reported to the Contract Administrator within 24 hours of obtaining a set of readings from SR instruments:

- a plot of settlement of the base of the embankment (SRs) versus time
- fill height versus time
- plan view, cross section and profile sketches showing the top of fill location while the SR readings were being taken

10.3 Embankment Stability

10.3.1 Typically embankment failures result in an acceleration of settlements after the fill lift placement. If any of this condition is observed, the Geotechnical Monitoring Consultant shall immediately inform the Contract Administrator and the Contract Administrator shall instruct the Contractor to stop all construction activities on and within the embankment. No construction shall take place on the affected embankment until all the following conditions are satisfied:

- The cause of the accelerated settlement has been identified and analyzed by the Geotechnical Engineer
- Any corrective action deemed necessary by the Geotechnical Engineer has been implemented
- The Contract Administrator deems it is safe to proceed.

11 MONITORING LEVELS

The monitoring program will provide input for the following :

- Settlement data monitored at SR allow an approximate assessment of settlements during preloading and the approximate range of settlements that can be expected during detour operation.
- The anticipated total settlement amount and the required time for settlements due to primary consolidation to stabilize may be assessed for each of the SR based on the following methods:
 - A. Sridharan, N.S. Murthy and K. Prakash (1987). Rectangular Hyperbola Method of Consolidation Analysis. *Geotechnique* 37, No. 3, 355-368
 - Thiam-Soon Tan, Toshiyuki Inoue and Seng-Lip Lee (1991), Hyperbolic Method for Consolidation Analysis. *ASCE Journal of Geotechnical Engineering*, Vol.117, No.11, November 1991, 1723-1737
 - Siew-Ann Tan (1993). Ultimate Settlements by Hyperbolic Plot for Clays with Vertical Drains. *ASCE Journal of Geotechnical Engineering*, Vol.119, No.5, May 1993, 950-956
 - Siew-Ann Tan (1994). Hyperbolic Method for Settlements in Clays with Vertical Drains. *Canadian Geotechnical Journal*, Vol.31, 1994, 125-131.

12 FINAL REPORT

At the completion of the monitoring program, a final monitoring report shall be issued to the Contract Administrator. The monitoring results shall be presented in tabular and graphical form as described above for each instrument type. Interpretation of the monitoring readings shall be included in the report.

13 PAYMENT

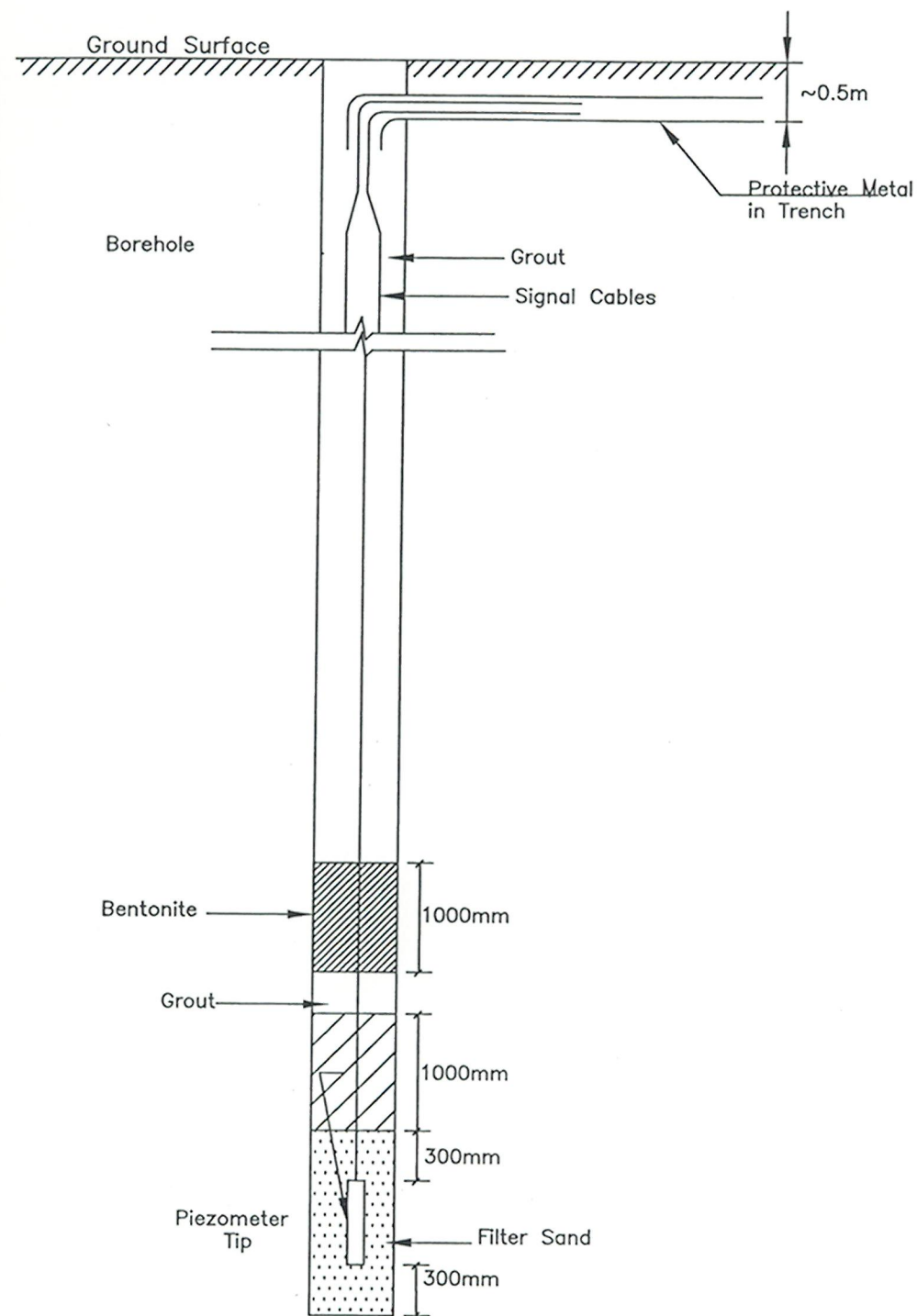
13.1 Measurement of Payment

Measurement of the item, 'Monitoring Program' is for the supply of services to collect, process and interpret all the instrumentation data for the anticipated number of readings per monitoring section shown in Table 1. This is a lump sum item.

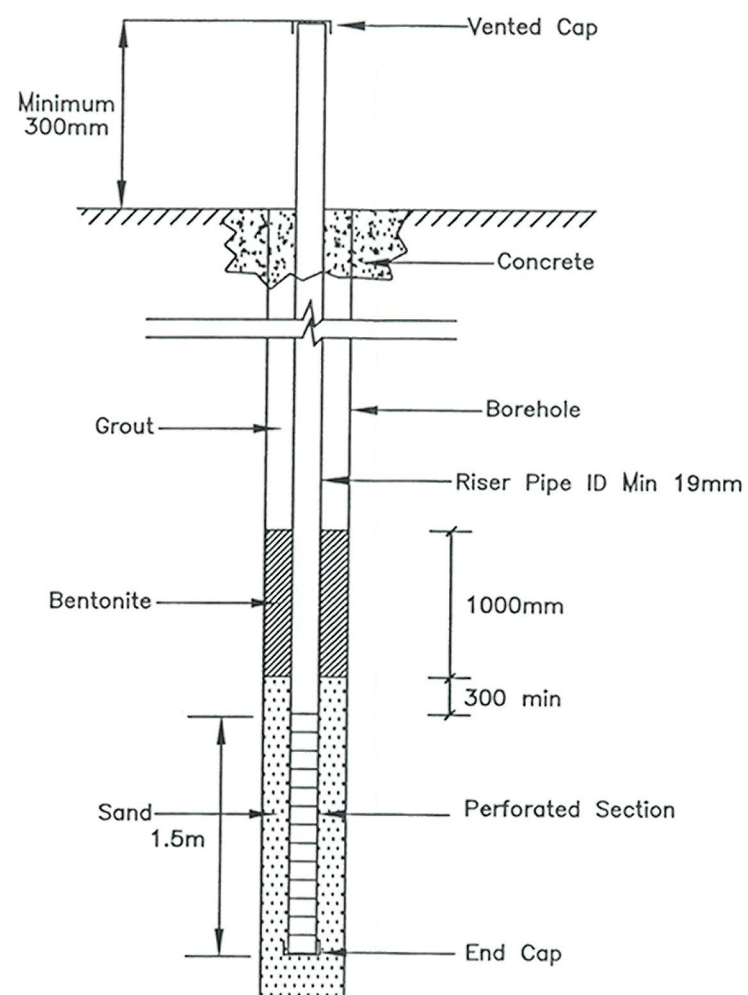
A unit rate shall be provided for each additional set of readings per monitoring section, including data reduction and reporting, over and above the specified quantity.

13.2 Basis of Payment

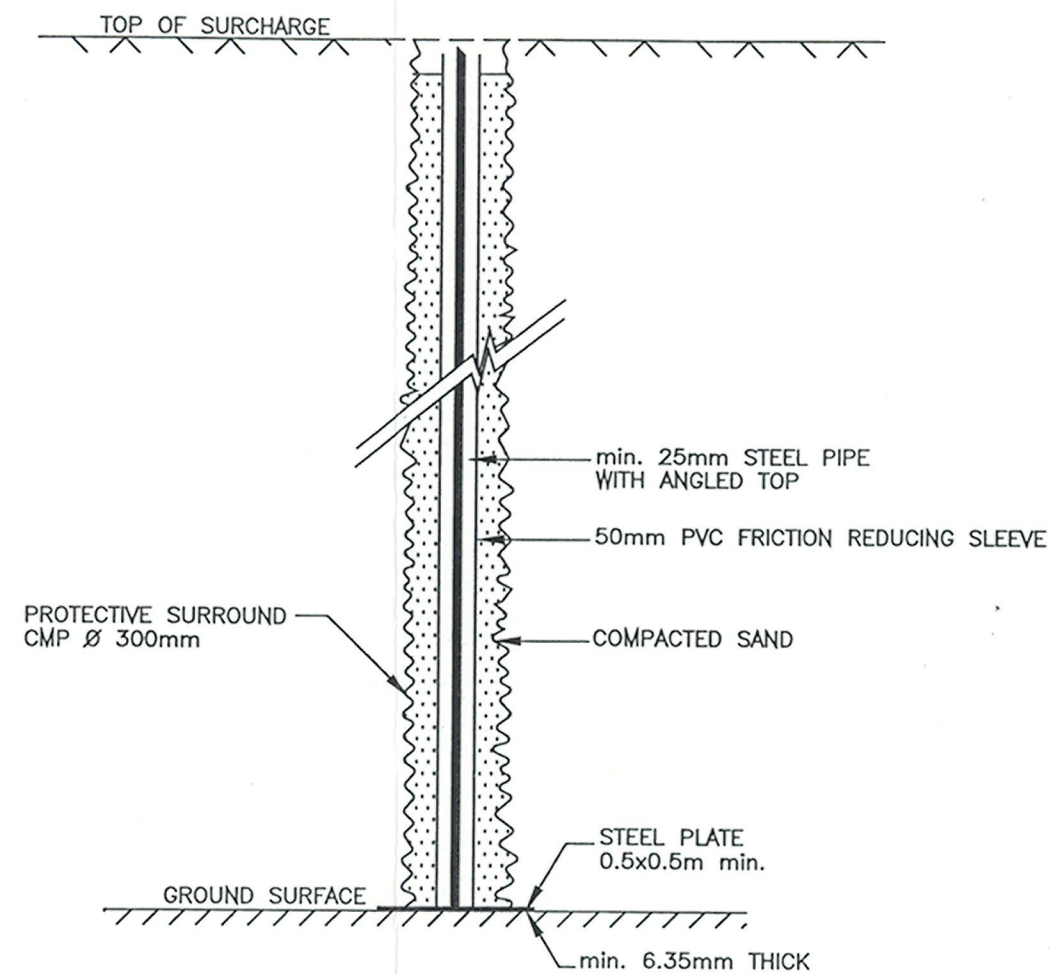
Payment at the contract price for the above item shall be full compensation for all labour, monitoring equipment and material to do the work.



VIBRATING WIRE PIEZOMETER (VWP)



STANDPIPE (SSP)



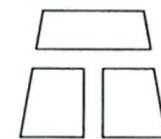
SETTLEMENT ROD (SR)

DESIGNED	PJB
DRAWN	WM
DATE	FEB. 2003
APPROVED	PJB
SCALE	NTS

STANTEC CONSULTING LTD.

FREDERICK HOUSE RIVER
PROPOSED DETOUR APPROACH
HIGHWAY 101

MONITORING INSTRUMENT DETAILS



THURBER

DRAWING No.
17-308-294-AP1