Geocres No:
52B-12

Foundation Investigation and Design Report

Bridge Structure
Little Savanne River

GWP 198-92-00

Highway 17
18.9 km east of Upsala

MTO Site No.: 48W-16
Geocres No.: 52B-12

Prepared for
Ministry of Transportation, Northwestern Region

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Part A FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering was retained by Stantec Consulting Ltd. to provide Foundation Engineering services for the proposed Little Savanne River Bridge replacement east of Upsala, Ontario. The design work is being undertaken as part of a Total Project Management assignment between Stantec and the Ministry of Transportation, Northwestern Region.

A foundation investigation was carried out to investigate subsurface conditions at the proposed structure site and at the approaches to the structure. The investigation consisted of a number of boreholes drilled in the vicinity of the proposed new structure, laboratory testing and geotechnical analysis of the data. This report provides a summary of that work and of the conditions encountered.

The Little Savanne River Bridge is identified as MTO Site 48W-16. It is located on Highway 17, 18.9 km east of Upsala, Twp. of Savanne, Sta 12+960, District 61, Thunder Bay.

The MTO Pavements and Foundations Section has assigned Geocres Number 52B-12.

2 Site Description

The site is located on Highway 17 approximately 18.9 km east of the east boundary of Upsala, Ontario. At this location Highway 17 runs in a generally east-west direction. The Little Savanne River flows southerly, into the Savanne River and into Lac Des Milles Lacs.

The area surrounding the bridge site is rural and generally covered with mixed bush. The terrain in the immediate surrounding area is flat and swampy. A tourist camp/outfitter is located on the southwest corner of the site.

The quaternary geology of the site is mapped (Ministry of Northern Development and Mines, Ontario Geological Survey, Map 2554) as recent fluvial deposits, including gravel, sand, silt and clay deposited on modern flood plains. Directly north of the site, the area is mapped as glacio-fluvial outwash deposits, gravel and sand. Bedrock geology in the vicinity is mapped (Ontario Geological Map No. 2199) to include Early Pre-Cambrian felsic metamorphic and igneous rock.

The current river channel is about 25 m wide and about 4 m deep at the structure. The existing bridge structure is constructed of closely spaced timber bents.

The highway grade is relatively flat, with a slight sag centered near the bridge location. The existing approach embankments are about 2.4 m above the river water level at the abutments. Photos of the site (from MTO project documentation files) are provided on Page 3.

East View, South Side

East View, North Side

3 Investigation Procedures

A site investigation was undertaken between February 16 and May 28, 2004. A total of 10 boreholes were drilled for the project at the locations indicated on the Borehole Location Plan (Enclosed). Three different drill rigs were mobilized to the site due to access and soil conditions.

A truck mounted CME 55 was used for boreholes drilled from the pavement grade and for accessible off-road boreholes. A skidder mounted Acker SX-70 drill was mobilized for scheduling purposes, and to those boreholes that were not accessible to the truck mounted drill. A large well drilling rig was used to advance holes through dense cobbles and boulders.

The boreholes were advanced using various methods depending on conditions encountered, proximity to the river and access conditions. A summary of the drill methods used is provided in Table 1.

Soil samples were obtained using the techniques of the Standard Penetration Test (SPT). The SPT involves driving a thick walled split spoon sampler into the soils under a standardized energy (63.5 kg, drop height 760 mm). The number of blows required to drive the sampler 0.3 m (after 0.15 m set) is recorded and is known as the SPT blow count (N). A representative disturbed soil sample is obtained from within the sampler.

Relatively undisturbed samples of cohesive deposits were obtained using Shelby tube samplers. Thin walled tubes are hydraulically pushed into the sub-soils and a clay sample is obtained. The samples were preserved in the field and transported to the laboratories for testing.

In-situ field shear (vane) measurements were taken at various depths, to aid in determining the consistency of clay materials. The field vane test involves advancing a standardized vane shaped probe into the soils at the base of the test hole and applying a torque to the vane. The torque required to shear a cylindrical element of soil is determined and used as a measure of the in situ vane shear strength of cohesive soils.

Both peak and ultimate shear strengths are measured. The ratio of the peak (undisturbed) to the ultimate (disturbed) shear strength is known as the sensitivity of the soil.

Rock core samples were obtained from the bedrock using a NQ sized core barrel. Bedrock samples were stored in core boxes for review. Total recovery and rock quality designation values were determined.

The boreholes were drilled to effective refusal, ('N' values of more than 100 blows/0.3 m), to 3 m past effective refusal, (14.9 m beyond refusal in the case of BH 2) or to where conditions made further advancement impractical or impossible. In many cases multiple attempts/boreholes were required at a single location to advance the borehole to the final depth. Borehole elevations and drill comments are provided in Table 1.

Borehole locations and elevations were measured using routine survey methods. Horizontal northings and eastings were calculated from highway chainages and are provided on the Borehole Location Drawing and in Table 2 below. Borehole elevations were referenced to the pavement surface at the centre of the existing bridge. (Elevation 458.77 m).

Soil samples were returned to TBT Engineering's laboratory for testing. Routine testing included moisture content, Atterberg Limit and grain size analysis. Complex testing included consolidation tests and unconfined compressive strength tests. Results of this testing are shown on the Records of Boreholes (Appendix A) and/or on the laboratory data reports (Appendix B).

Table 1. Drill Summary

Location	Surface Elev. (m)	Depth (Elev.) of Borehole (m)	Drill Method	Observations
BH 1	457.2	17.0 (440.2)	Hollow Stem Auger Diamond Rotary	Borehole terminated in cobbles and boulders. (Casing sheared off)
BH 1R	457.2	16.7 (440.5)	Hollow Stem Auger Diamond Rotary	Borehole terminated in cobbles and boulders. (Casing sheared off)
BH 2	457.3	29.8 (427.5)	Hollow Stem Auger Diamond Rotary	Auger Refusal @ 14.9 m. Bedrock encountered @26.5 m Cobbles and boulders @ 14 m Diamond drilling very slow numerous cobbles and boulders
BH 3	457.1	16.8 (440.3)	Hollow Stem Auger Diamond Rotary	Auger Refusal @ 13.7 m. Diamond drilling very slow numerous cobbles and boulders
BH 4	456.7	18.6 (438.1)	Hollow Stem Auger Water Well Rig	Auger Refusal @ 14.1 m Well Drill used through cobbles
BH 5	457.5	15.9 (441.6)	Hollow Stem Auger Water Well Rig	Auger Refusal @ 12.8 m Well Drill used through cobbles Steel casing deformed in cobbles.
BH 6	457.8	16.8 (441.0)	Hollow Stem Auger	Auger Refusal @ 16.8 m
BH 7	456.8	12.2 (444.6)	Hollow Stem Auger	Through Bridge Deck Auger Refusal @ 12.2 m
BH 8	456.6	11.6 (445.2)	Hollow Stem Auger	Through Bridge Deck Borehole terminated due to blowing sand
BH 9	458.9	15.7 (443.2)	Hollow Stem Auger	West Approach Embankment
BH 10	459.0	15.7 (443.3)	Hollow Stem Auger	East Approach Embankment

All boreholes were backfilled with a cement-bentonite grout. Boreholes drilled through the embankment were backfilled through the pavement structure with the excavated sand and gravel. The shoulder asphalt surface was replaced with cold-mix asphalt.

At Boreholes 3 and 4, slight artesian pressures (0.3 m above grade) were noted from depths near 12 to 14 m. (Approximate elevation 445 m). A bentonite seal was used to control the artesian pressure and the boreholes were backfilled above the seal with a cement bentonite grout.

Table 2 Borehole Locations

BH No.	Station	o/s		Northing	Easting
1	12+977	8.2	Rt	5424013.8	15 286227.6
2	12+989	10.9	Rt	5424008.1	15 286238.5
3	12+989	10.9	Lt	5424029.1	15 286244.0
4	12+956	8.2	Lt	5424034.9	15 286211.9
5	12+942	11.3	Lt	5424041.4	15 286199.2
6	12+942	11.4	Rt	5424019.6	15 286193.4
7	12+977	2.8	Lt	5424024.4	15 286230.4
8	12+956	2.3	Rt	5424024.7	15 286209.3
9	12+921	4.0	Lt	5424040.2	15 286177.1
10	13+040	5.1	Rt	5424000.6	15 286289.7

4 Subsurface Conditions

Details of the subsurface conditions are provided on the Record of Boreholes, Appendix A, and on the enclosed Subsurface Section Plan.

In general, the native subsurface conditions at the site consist of approximately 7 to 10 m of silt and clay. Below the fine-grained soils are is a zone of sand underlain with layered deposits of sand, gravel, cobbles and boulders. Bedrock was proven 26.5 m below grade (BH2) at elevation 430.8m.

The existing roadway embankment is about 1.9 m high consisting of the asphalt and granular base over sand and gravel sub-base and embankment fills. A thin surficial covering of topsoil (20-50 mm) is present over much of the exposed embankment.

Groundwater levels generally correspond to the level of the Little Savanne River (456.6m). Slight artesian pressures were present at two of the boreholes (3 and 4).

4.1 Fill

All boreholes encountered deposits of fill materials that are associated with the Highway 17 pavement structure and embankment grading. The pavement surface consists of 90 to 150 mm of hot mix asphalt. The granular fill includes approximately 0.8 m of granular base and sub-base overlying sand sub-grade fill to approximately 2.4 m below the pavement grade (Elev. 456.4 m +/-).

4.2 Clayey Silt

A deposit of clayey silt underlies the fill at all boreholes. The silt is brown/grey in color and of a soft to stiff consistency. Standard Penetration Test blow counts recorded in the silt were in the range of 3 to 11 blows /0.3 m.

The silt is found from near the base of the fill to approximately 2.5 to 2.8 m below grade (Elev. 453.2 to 454.8 m). Grain size data (Appendix B, Enclosure 1) indicates the silt contains between 8 and 30 % clay sizes and traces of sand. Atterberg Limit testing

(Appendix B, Enclosure 4) indicates these soils are non-plastic to slightly plastic (CL-ML). Natural moisture contents are generally greater than the liquid limits of the soil. The deposit is frequently varved or layered, with seams of varying plasticity. Seams of clay are present at increasing frequency with depth.

4.3 Clay

The silt changes gradually with depth to a soft to firm, medium to high plastic clay. The clay is frequently varved and brown /grey in colour. The clay becomes red/brown or red/grey with depth. The clay is present to depths in the order of 7.8 to 9.6 m below grade (elev. 448.2 to 449.7 m). Atterberg limit testing (Appendix B, Enclosure 5) indicates the natural moisture content of the clay as normally at or above the liquid limit.

The measured shear strength in the clay is variable, with strengths dependent on layering, plasticity and depth. Field vane shear strengths in the clay were in the order 15 to 53 kPa (average 37). The corrected vane shear strengths are in the order of 11 to 36 kPa. Shear strength sensitivities in the clay were between 2 and 5. Compressive strength testing indicated un-drained, unconfined compressive strengths of 36 and 43 kPa. There is a pronounced zone of softer clay (shear strength 11 to 20 kPa) near mid depth of the deposit. The softer clays tend to be red in colour, with much less layering, and are slightly fissured. A plot of the shear strength distribution with depth is provided on Figure 1 in Appendix C.

Several consolidation tests were completed using samples from this deposit. These tests indicate the clay is slightly over-consolidated and rather compressible (Table 3). In the stress range equivalent to the anticipated grade raise, volume compressibilities (m_v) in the order of 3.4 to 4.6 x10^{-3} m^2/kN ($1/m_v$=M=2.1 to 2.9 MPa) were measured. Test reports for the consolidation and compressive strength testing are provided in Appendix B.

Table 3 Clay - Consolidation Properties

Borehole No.	Depth (m)	Pre-consolidation Pressure	Estimated OCR
1	4.9	110	2.8
2	6.5	90	1.7
3	5.7	120	2.6
4	5.8	105	2.4

4.4 Sand

The clay is underlain by a deposit of grey/brown sand. The sand is fine to coarse grained and contains variable amounts of silt and gravel sizes with traces of clay sizes. In some zones the silt fraction was close to 50%, classifying these materials as sand and silt.

The sand was subject to blow-up into the hollow stem augers while drilling, consistent with a fine grained and cohesionless material under hydraulic pressure. Representative SPT 'N' values indicated that the deposit is in a compact to dense condition.

The sand is present to a depth of approximately 12.2 to 16.8 m below grade (elev. 442.7 to 444.7 m).

4.5 Cobbles and Boulders

The sand as described above becomes much coarser with numerous cobbles and boulders present. Based on recovery of core drill samples and behavior of the drill, the cobbles and boulders fraction is in the order of 40 to 60% of the deposit. Boulders in excess of 700 mm diameter are present. This coarse deposit is approximately 3 to 4 m in thickness (where penetrated), and is present from elevations 442.7 to 444.7 m. The hollow stem augers could not penetrate this material and SPT blow counts were typically in the order of 100+ blows /0.3 m with the hammer bouncing on the coarse cobbles and boulders.

Diamond coring drilling methods used in this material were very slow, resulting in numerous casing breaks and bit loss. A large well drilling rig was used to advance two of the holes beyond refusal depths. Steel well casing used at Boreholes 4 and 5 was damaged advancing through the cobbles and boulders.

4.6 Sand with Cobbles and Boulders

The granular deposit becomes somewhat finer with depth. Below approximately 440.3 to 442.4 m (depending on location) the fraction of cobbles and boulders decreases, such that the deposit is classified as grey sand, with cobbles and boulders. The fraction of cobbles and boulders was estimated to be between 20 and 30%.

The well drill advancement rates were somewhat faster in this deposit, as compared to the overlying cobble and boulder layer. (20 to 85 sec/0.3m versus 100 to 200 sec/0.3m).

4.7 Bedrock

Bedrock was confirmed with core sampling at Borehole 2. The bedrock consists of a felsic intrusive granitic rock (Granodiorite). The bedrock was of excellent quality with total core recovery of 100% and Rock Quality Designations (RQD) of between 81 and 100%.

4.8 Groundwater

Groundwater was noted to correspond to the level of the Little Savanne River, 456.6m at most boreholes. This level should be expected to fluctuate with changes in the seasons, precipitation patterns and with variations in the Little Savanne River levels.

At Boreholes 3 and 4, slight artesian pressures were noted in the sands near 12 to 14 m depth (approximate elevation 445 m). The groundwater in the augers or casing rose to about 0.3 m above grade (457.4 and 457.0 m).

Part B Foundation Design Recommendations

5 Discussions and Engineering Recommendations

The Little Savanne River Bridge on Highway 17, 18.9 km east of Upsala is to be replaced under WP 198-92-00. The design project is being carried out under a TPM Agreement between the Ministry of Transportation and Stantec Consulting Ltd. TBT Engineering is providing foundation engineering services as a sub-consultant to Stantec Consulting Ltd.

The existing two-lane structure is to be replaced with a new, three span two-lane section. The new bridge is anticipated to include an integral abutment design. Abutments will be placed near Stations 12+941 and 12+990. The design of the bridge will be conducted in accordance with the Canadian Highway Bridge Design Code [3] and the Integral Abutment Bridges Manual [4].

The highway grades will be revised including a grade raise of 0.8 m at the west approach and 1.2 m grade raise at the east approach of the bridge.

A foundation investigation was carried out to investigate subsurface conditions at the site. This investigation consisted of 10 boreholes drilled in the vicinity of the proposed new structure, laboratory testing and geotechnical analysis of the data.

In general, the native subsurface conditions at the site consist of approximately 7 to 10 m of silt and clay, which are underlain by granular deposits. These include a zone of sand above layered deposits of sand, gravel, cobbles and boulders. Bedrock was proven 26.5 m below grade at elevation 430.8 m.

The existing roadway embankment is about 1.9 m deep consisting of the asphalt and granular base over sand and gravel sub-base and embankment fills. A thin (21-50 mm) surficial covering of topsoil is present over much of the exposed embankment.

Groundwater levels generally correspond to the level of the Little Savanne River (456.6m). Slight artesian pressures were present at two of the boreholes.

The purpose of this section of the report (Part B) is to provide foundation design recommendations for the project. These are based on the conditions encountered at the test locations and interpretations of the subsurface conditions at the site.

5.1 Bridge Foundations

The preliminary design concepts for the bridge involved the use of an integral abutment design. Soil conditions at the site are suitable for integral abutments using driven piles bearing in the underlying cobbles and boulders.

The use of a shallow foundation (spread footings) is not suitable due to soft sub-grade conditions and the use of an integral abutment. Drilled piles bearing in the bedrock were reviewed but were not considered practical because of the depth to bedrock, the difficult drilling conditions, the high ground water table and the artesian pressures in the sand.

The design frost depth for this project is 2.4 m [5].

5.2 Driven Piles

5.2.1 Axial Capacity

The proposed structure is understood to be of integral abutment design. As such H-piles are the preferred foundation configuration.

Given the soil conditions, H-piles will be driven into the underlying coarse granular materials. Hard driving is expected, and refusal is anticipated in the cobble and boulder deposit.

The piles will terminate at variable elevations, resulting in piles of various lengths. For quantity estimating purposes only, the piles may be assumed to refuse near elevation 441. Actual pile tip elevations will vary.

$$\frac{132}{110} = 1.2$$

$1800 \times 1.2 = 2160$

$2000 \times 1.2 = 2400$

$1450 \times 1.2 = 1740$

$1600 \times 1.2 = 1920$

During driving, the piles will encounter large cobbles and boulders. There will be a tendency for the piles to be forced out of plumb and/or alignment. This may necessitate re-driving or replacement of piles.

The piles may consist of HP360x132 or HP310x110 sections. The heavier section will provide improved driving resistance, reduce the potential for pile damage and provide improved resistance to bending forces during installations. Piles driven to refusal may attain the load capacity provided in Table 4 below. The use of design pile loadings appreciably below the maximum pile capacities will reduce the driving energy that will be required (and therefore the reduce tendencies for pile damage and misalignment).

Table 4 Pile Capacities

Maximum Pile Capacities		
Loading	Pile Section HP 360X132	Pile Section HP 310X110
Maximum Factored Geotechnical Resistance at ULS Refusal in Cobbles and Boulders	2000 kN	1800 kN
Maximum Factored Geotechnical Resistance at ULS Refusal on Bedrock	2300 kN	2000 kN
Geotechnical Resistance at SLS Refusal in Cobbles and Boulders	1600 kN	1450 kN
Geotechnical Resistance at SLS Refusal on Bedrock	Does not govern	Does not govern

A driving shoe is to be specified to protect the pile during installations (Titus "H" Bearing Pile Point (standard model) or equivalent).

The new piles will be driven very close to the existing piles. The length and design of these piles are not known, and given the relatively close spacing between the timber piles, these could be relatively short friction piles. There is some potential that the driving vibrations from the new piles may cause a temporary soil strength reduction at the existing piles. It is not possible to predict with certainty if this will or will not occur.

It is suggested that a monitoring program be included in the design, along with a provision for interim support of the existing bridge structure, should settlements of the structure be measured. The monitoring system would involve regular elevation measurements on the existing structure during pile driving activities. Should settlements occur, additional piles may be placed adjacent to the existing bridge with the structure temporarily supported, in part, on the new piles.

Piles should be driven to a set consistent with the current MTO Special Provision 903.S01. Pile set should be verified in the field for the specific pile and pile driver combination in use. Piles should be installed in accordance with Note 1 of the MTO Structural Manual (Page 3-7) [8], with an ultimate geotechnical resistance of 2 times the design load at ULS (<2 times Factored Geotechnical Resistance, ~~2X800kN)~~. A minimum hammer energy of 50kJ should be specified. Pile driving criteria should not exceed a refusal rate of 20 blows per 25 mm in order to prevent/minimize damage to the hammer and pile.

It is anticipated that piles will attain the specified capacity in the cobble and boulder strata. However it is possible that some of the piles will penetrate the coarse strata. The length of pile required to attain the design capacity will vary, and the contractor should be prepared to drive piles of variable lengths. Contract provisions should include allowances for piles of variable lengths. The contractor is responsible for determining actual set criteria based on the provisions of Special Provision 903.S01.

Piles should be spaced at least 2.5 pile widths, apart (centre to centre). See CHBDC Section 6.8.9.2.

Piles driven below the cobble and boulder layer may encounter slight artesian pressures in the underlying sands. Given the small artesian pressures anticipated, (in the order of 0.3 m) the clay layer above the sand is expected to be self-sealing around the piles preventing upward flow from the confined aquifer.

5.2.2 Negative Skin Friction

Drag loads due to consolidation of the clays under the loading from the grade raise can be induced on the piles placed prior to completion of embankment fills. HP 310 x 110 piles should be designed with sufficient structural capacity to carry up to 600 kN factored down drag loading (700 kN for HP 360 x 132 piles) in addition to permanent loads. (see CHBDC C6.8.4 [3])

5.2.3 Pile Casing - Lateral Pile Resistance

It is understood that pre-drilled and cased holes filled with loose sand which will limit lateral loadings induced under thermal movements on the piles are to be used at this site. The CSP casing used may consist of a single or double walled system. If a single walled casing system is used (typically 600 mm in diameter) then the sand fill used around the piles should meet the following gradation specification:

Table 5 – Pile Casing Fill Gradation Specification

MTO Sieve Designation (mm)	Percent Passing Mass
2.0	100
0.6	80-100
0.425	40-80
0.250	5-25
0.150	*0-6*

Source: MTO – Integral Abutment Bridges [4]

Alternatively, where the above gradation of sand cannot practically be obtained, a double walled sleeve system similar to that shown on Fig. 7 of the Integral Abutment Bridges Manual [4] may be used. This involves a sand filled 600 mm diameter inner CSP, inside of an 800 mm diameter outer CSP. The sand fill used needs to meet only the requirements of Granular B, Type III, (MTO Standard Specification 110F13).

The CSP will be placed below the ground water table. Installation will be 'in the wet' or dewatering will be required.

Below the CSP the native soils consist of soft to firm clays. Lateral pile forces that the horizontal piles movement will induce may be estimated using the methods provided in the Canadian Foundation Engineering Manual [6], including ultimate lateral resistance and lateral deformation characteristics.

Ultimate lateral resistance may be calculated using Broms' method (CFEM [6{, Section 20.4.1, Fig 20.10) and the following soil parameters:

C_u=40 kPa

Lateral deformations may be calculated using the methods provided within the Canadian Foundation Engineering Manual [6], or using computer modeling. In either case, a co-efficient of lateral sub-grade reaction may be calculated from;

$K_s=67c_u/d$ kN/m^3

where: K_s = co-efficient of lateral sub-grade reaction per unit volume (kN/m^3)
c_u= shear strength use 20 - 40 kPa,
d = pile width (m)

Lateral soil resistance may also be considered with reference to the CHBDC 6.8.7. [3].

Reductions in estimates of lateral resistance due to group effects for a single row of piles are not required where the pile spacing is at least 2.5 pile diameters.

5.3 Lateral Loadings – Abutment

The foundations of the Little Savanne River Bridge will be constructed using integral abutments. As such the abutment foundations must be designed to resist the passive soil pressures that will be generated by thermal expansion. In addition, the abutments should be designed to resist a compaction pressure surcharge in accordance with CHBDC 6.9.3. . Backfill is to be placed as per OPSD 3501.000.

The lateral loadings due to the thermal expansion of the abutment may be calculated using estimated movements and passive pressures in accordance with the Canadian Highway Bridge Design Code(CHBDC) [3] and the Manual for Integral Abutments [4]. Passive pressures should be estimated assuming dense sand backfill conditions (Appendix 1 in Reference [4] also in Figure C6.9.1(a) CHBDC [3]). Design soil parameters as shown below in Table 5, Section 5.5 may be used. Where design is carried out in accordance with Table 6.9.2.3 of the CHBDC (equivalent fluid pressures) the values for ~~passive~~ active and at-rest pressures cited for backfill materials with angles of internal friction between 30 and 35 degrees may be used.

Backfill behind the abutments must be free draining. The fill may be specified as Granular B, Type III with an additional requirement that the fines (pass 0.075 mm) in the backfill be limited to a maximum of 5%. Sub-surface drainage in the form of weep holes and sub-drains should be provided as per Fig.12 of the Integral Abutments Manual [4].

A frost depth of 2.4 m [5] is appropriate for design purposes.

5.4 Embankments

The approach embankment to the bridge will be raised about 1.2 m on the east side (0.8 m on the west and the platform widened to accommodate the revised pavement section and the grade raise.

The higher embankment will induce stress on the sub-grade soils, both in the short term (construction case) and in the long term. Preliminary designs suggest that, using 2h:1 v side slopes, the toe of the new embankment on the northeast quadrant will be near the Little Savanne River for a short distance. Wing walls will be used at the abutments to increase the distance between the toe of the fill slope and the River edge. The added fill will stress the underlying clay soils and there is a potential for shear failures towards the River, particularly in the Northeast quadrant.

Stability calculations were carried out using Slope-W software and soil parameters determined by laboratory testing and from published correlations. A minimum target factor of safety of 1.3 was utilized. The analysis was carried out using Bishop and Morgenstern-Price analyses. The parameters listed in Table 6 were used for the stability analyses. Examples of results of the stability analyses carried out are attached in Appendix D.

Table 6- Soil Parameters used in Stability Analyses

Soil	Unit Weight (KN/m^3)	Cohesion (kPa)	Phi (Degrees)
Embankment fill	21	0	35
Silt	19	0	28
Clay (Drained)	17	0	24 & 22
Clay (Un-drained)	16	15 to 30	0
Sand	20	0	34
Rock Fill	18	0	45
Polystyrene	0.1	30	0

The analysis indicated that slopes adjacent to the river (East abutment to Sta. 13+005 +/-) would not be stable (F.S. <1.3) using design sections provided, both in the short term (construction) and long term conditions.

In the short term (construction) condition, calculated factors of safety were in the order of 1.1, with the failures occurring through the soft clay zone. Long term, drained analysis provided calculated factors of safety in the order of 1.2. While severe construction staging restrictions may permit the embankment to be built, the marginal drained stability will result in long-term embankment creep and deformations. The use of lightweight fill is recommended to limit the increased embankment loadings and increase the factor of safety of the embankment.

For the 1.2 m grade raise anticipated on the east side, a 0.9 m thickness of Type II polystyrene light weight fill (LWF) is suitable. The lightweight fill should be placed as deep as practical with a minimum granular thickness of 0.9 m over the LWF. As a minimum, the lightweight fill should be used across the full cross section, from the east abutment to Station 13+005. This will provide factors of safety (in terms of slope stability) in excess of 1.3 for both short and long term conditions.

The thickness of the fill should be reduced gradually (tapered) at the east end (beyond Sta. 13+005) to reduce differential settlement and frost heave effects across the transition.

Embankment fore-slopes constructed at a 2h:1v grade are suitable over the remaining length of the approach embankment.

The existing embankment slopes (including any under water sections) shall be benched in accordance with OPSD 208.010 prior to placement of fill.

In all cases, the riverbanks must be protected from future erosion using suitable rock protection. The face of the embankment below the high water mark to the toe of the riverbank slope should consist of at least a 0.6 m thickness of rock fill. The rock protection shall be well graded in sizes ranging from 100 mm to 500 mm in accordance with OPSS 1004.05.06.02. The fill should be separated from the native materials with a non-woven geotextile, (Class II, F.O.S. 0.075-0.150 mm).

The embankment fill used to the sub-grade level should consist of Granular B, Type III placed in maximum 300 mm lifts and compacted to at least 95% of Standard Proctor Maximum Dry Density (SPMDD). Above this the pavement fill structure should be placed as per the Geotechnical Design Report.

Total settlements of the approach embankment under the loadings imposed by the new 1.2 m of fill (beyond LWF zone) are estimated to be in the order of 80 mm. Most of the settlement will occur in the underlying clay soils, and will be time dependent. It is anticipated, based on consolidation test data, that approximately 50% of the settlement will occur within the first 45 days after placement of the fill. The remaining settlement will occur at a decreasing rate, with about 90 % of the settlement anticipated to occur within a year.

Below the lightweight fill at the abutment, settlements will be in the order of 20 mm. Consideration may be given to use of lightweight fill on the west approach to provide a more symmetrical settlement profile. The thickness of the LWF should tapered at the ends to reduce differential settlements. Total settlements will be approximately proportional to the amount of granular fill added.

Consideration may also be given to the use of lightweight fill over the length of the grade raise to effectively eliminate or limit settlements. To eliminate settlements due to the grade raise, a thickness of polystyrene light weight fill (LWF) equal to the thickness of the grade raise will be required, full width within the cross section. Alternatively the theoretical settlements under the new embankment may be limited to a nominal amount and the required amount of LWF significantly reduced. To limit theoretical settlements to approximately 25 mm the following thicknesses of polystyrene lightweight fill should be included within the roadway.

Depth of Grade Raise (m)	Thickness of LWF (m)
0	0
0.2	0
0.4	0.1
0.6	0.3
0.8	0.5
1.2	0.9

The use of a surcharge load to reduce long-term settlements may also be considered. Surcharge loadings in advance of construction can be used to induce anticipated settlements to take place prior to completion of the surfacing. However in this case, staging complications and the potential for shear failures near the river will reduce the applicability of this method for this site. Should pre-loading be required, detailed recommendations can be provided, following completion of conceptual grading and staging plans.

The longitudinal slopes of the embankments will be supported by the abutment.

5.5 Temporary Shoring

Temporary shoring, if required, should be designed to resist lateral loadings and to minimise deformations. These systems may be designed using the methods provided in the Canadian Highway Bridge Design Code Section 6.9 and 6.11 [3]. Lateral loads should include active or at-rest pressures as appropriate for soil and traffic loadings and the compaction surcharge as described in Section 5.3. Active loads are appropriate for yielding conditions while at-rest pressures should be used for non-yielding cases. Soil pressure coefficients are provided in Table 7.

Table 7 - Embankment Soil Parameters (unfactored)

Soil	Active Earth Pressure Co-efficient (Ka)	Passive Earth Pressure Co-efficient (Kp)	Unit Weight (KN/m^3)	Phi (Degrees)
Granular A	0.27	3.7	22	35
Granular B	0.30	3.4	21	33
Silt	0.4	2.8	18(8*)	28
Sand	0.30	3.4	20(10*)	33
Clay	$Pa=\sigma_Z'-2\ C_u$	$Pp=\sigma_Z'+2\ C_u$	16(6*)	C_u=20 kPa

* indicates submerged value

The temporary shoring may consist of sheet piles driven into the underlying silt, clay and sand soils. Alternates such as braced walls, closed cofferdams or pile and lagging systems may also be considered by the contractor.

The estimated permeabilities of the soils below the groundwater table vary from 10^{-2} cm/sec in the sands to less than 10^{-5} cm/sec in the silts and clays. The piling will have to be driven to sufficient depth to control underflow seepage and must be completely closed around the area to be dewatered. The depth required will depend on the configuration of the sheet pile cell, the use of well points or wells and the thickness of concrete (if any) used in the floor of the cell.

5.6 Temporary Road Protection

The grades at the bridge will be up to 1.2 m higher than the current grades. The bridge will be constructed in two stages. This will result in a grade differential across the road, with little room between lanes for the transition. It is anticipated that some form of longitudinal retaining system will be used to support the new embankment fill down the centre of the new approach until the remaining fill is placed. Details of this staging are to be left to the contractor. It is anticipated some form of gravity wall structure, sheet pile or alternatively geosynthetic or geogrid reinforced fills may be used to provide a nearly vertical face between the stages.

These systems may be designed using the methods provided in the Canadian Highway Bridge Design Code Section 6.9-6.11 [3]. Lateral loads should include active or at-rest pressures as appropriate for soil and traffic loadings and the compaction surcharge as described in Section 5.4. Active loads are appropriate for yielding conditions while at-rest pressures should be used for non-yielding cases. Soil pressure coefficients are provided in Table 8.

Table 8 - Embankment Soil Parameters (unfactored) Level Backfill

Soil	Active Earth Pressure Coefficient (Ka)	At-Rest Earth Pressure Coefficient (Ko)	Unit Weight (KN/m^3)	Phi (Degrees)
Sand/Silt Fill	0.35	0.52	18	29
Silt	0.40	0.53	18(8*)	28
Sand	0.30	0.45	20(10*)	33
Granular A	0.27	0.43	22	35
Granular B	0.30	0.45	21	33
Clay	$P=\sigma_Z'-2\ C_u$	0.6	16(6*)	C_u=20 kPa

* indicates submerged value

5.7 Red Flag Issues

The installation of piles will be to (or potentially through) a deposit of cobbles and boulders. Maximum geotechnical capacities have been provided for refusal conditions in both materials. Driving piles to or through the cobble and boulder deposit has a high potential for damage to and/or misalignment of the piles. The use of pile design capacities well below the maximum geotechnical capacity will allow the piles to be driven under a reduced energy (set), with a correspondingly reduced potential for damage or misalignment.

6 Limitations

Conclusions and recommendations presented in this report are based on the information determined at the test hole locations. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

The design recommendations provided in this report are based on the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

Benchmarks and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

Groundwater levels indicated are based on the information described within the report. Conditions that could affect the type and scope of dewatering procedures cannot all be readily determined from boreholes. This includes local and seasonal fluctuations of the groundwater level, changes in soil conditions between test locations, thin and/or discontinuous layers of highly permeable soils, etc.

The information contained within this report in no way reflects any environmental aspect of the site or soil.

7 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate the contact us at your convenience.

Yours truly,
For TBT ENGINEERING

Prepared by:

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Vice-President, Engineering

Reviewed By

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APPENDIX A

RECORD OF BOREHOLES

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_p	%	PLASTIC LIMIT
w_s	%	SHRINKAGE LIMIT
I_p	%	PLASTICITY INDEX $= w_L - w_p$
I_L	1	LIQUIDITY INDEX $= \frac{w - w_p}{I_p}$
I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_p}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE

e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n-PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Ministry of Transportation Ontario

TBT Engineering

RECORD OF BOREHOLE No 1

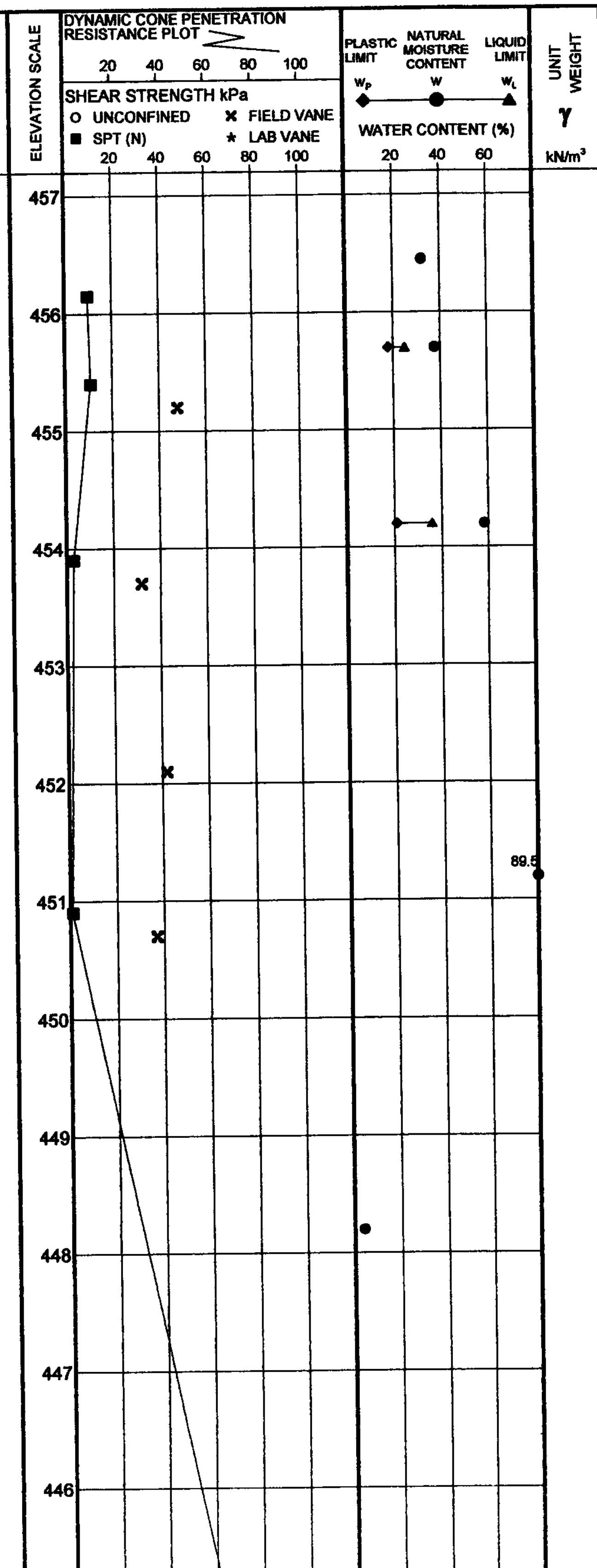
 METRIC

W.P. J03-140 PROJECT Little Savanne River Bridge SITE NO. 48W-16 ORIGINATED BY JN

DIST 61 HWY 17 LOCATION 18.9 km east of Upsala, ON TBTE JOB# J03-140 COMPILED BY SP

DATE 16 February 2004 BOREHOLE TYPE Hollow Stem Auger - 90mm ID DATUM Geodetic CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
457.2 / 0.0	FILL - fine to coarse gravelly sand, some silt, occasional cobbles, brown to grey, moist				25mm of topsoil
456.7 / 0.5	SILT - clayey, trace sand, grey, firm, (ML-CL)				0 2 69 29
		1	SS	10	
		2	SS	11	0 12 73 16
			VANE		
454.6 / 2.6	CLAY - medium to high plasticity, grey, firm, varved	3	SS	3	
			VANE		
		4	SH		
			VANE		
	reddish brown soft to firm, occ. silt veins	5	SS	1	Split spoon sank under weight of the hammer.
			VANE		
449.0 / 8.2	SAND - fine to medium, with silt, brown/grey	6	SS		Sand blow up 0.6 m into H.S. Auger. 0 86 (14)



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✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

ON_MOT_BH LOG 03-140.GPJ ON_MOT.GDT 3/8/04

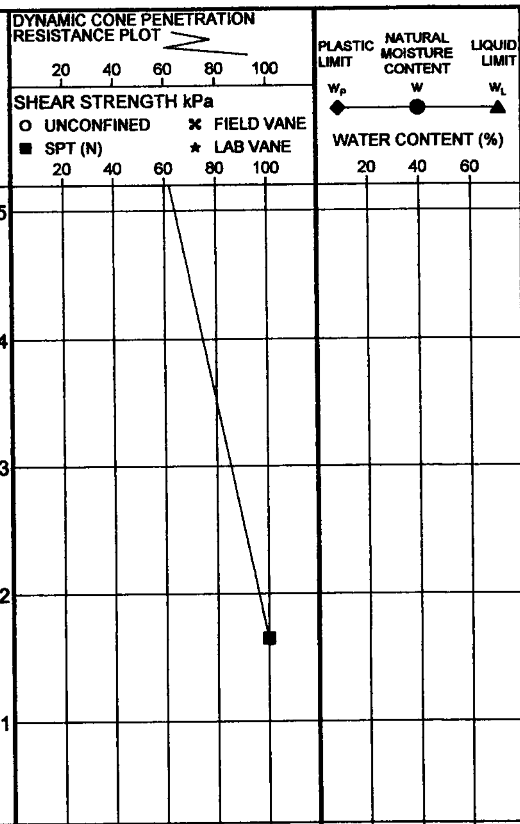
TBT Engineering

RECORD OF BOREHOLE No 1

METRIC

W.P. J03-140	PROJECT Little Savanne River Bridge		SITE NO. 48W-16		ORIGINATED BY JN
DIST 61	HWY 17	LOCATION 18.9 km east of Upsala, ON	TBTE JOB# J03-140		COMPILED BY SP
DATE 16 February 2004	BOREHOLE TYPE Hollow Stem Auger - 90mm ID		DATUM Geodetic		CHECKED BY WH

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	- Occasional cobbles					445, 444, 443	
442.7 / 14.5	COBBLES AND BOULDERS - with sand and gravel					442	
		7	SS	100		441	Spoon bouncing on boulder. No sample recovered Auger refusal on boulder. Casing refusal @ 16.55 m. Second attemp (BH 1R) carried out w/n 1m rad. of BH 1, extended to 17.0 m b.g. Casing refusal on boulder, hole terminated in bouldery zone.
	Casing sheared in cobbles/boulders						
440.2 / 17.0	End of hole at 17.0 m.						
	Hollow stem auger 0 - 15.6 m						
	Diamond Rotary 15.6 m to 17.0 m						



✖³, ★³: Numbers refer to Sensitivity   O ³% STRAIN AT FAILURE

Ministry of Transportation Ontario

TBT Engineering

RECORD OF BOREHOLE No 2

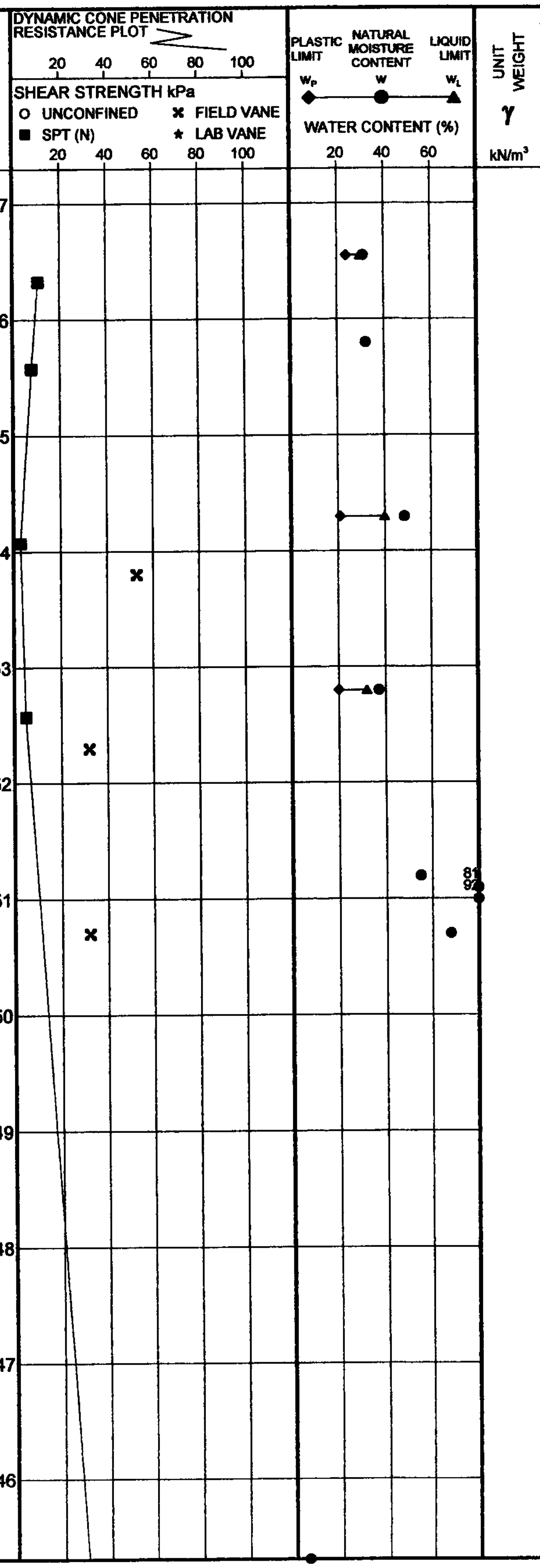
METRIC

W.P. J03-140 | PROJECT Little Savanne River Bridge | SITE NO. 48W-16 | ORIGINATED BY JN

DIST 61 | HWY 17 | LOCATION 18.9 km east of Upsala, ON | TBTE JOB# J03-140 | COMPILED BY SP

DATE 21 February 2004 | BOREHOLE TYPE Hollow Stem Auger - 90mm ID | DATUM Geodetic | CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%)
457.3 / 0.0	FILL - fine to coarse gravelly sand, occasional cobles, trace of silt, brown, moist					15 mm Topsoil
456.8 / 0.5	SILT - clayey, with sand, grey, firm, (ML-CL)				▼	
		1	SS	11		
		2	SS	8		
454.8 / 2.5	CLAY - medium to high plasticity, grey, firm, varved					
		3	SS	3		
			VANE			
		4	SS	5		
			VANE			
	reddish brown soft to firm, occ. silt veins					
		5	SH			
			VANE			
448.8 / 8.5	SAND - fine to medium, with silt, grey					Sand blow up into spoon.
		6	SS			
	compact					



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✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

ON_MOT_BH LOG 03-140.GPJ ON_MOT.GDT 3/8/04

TBT Engineering

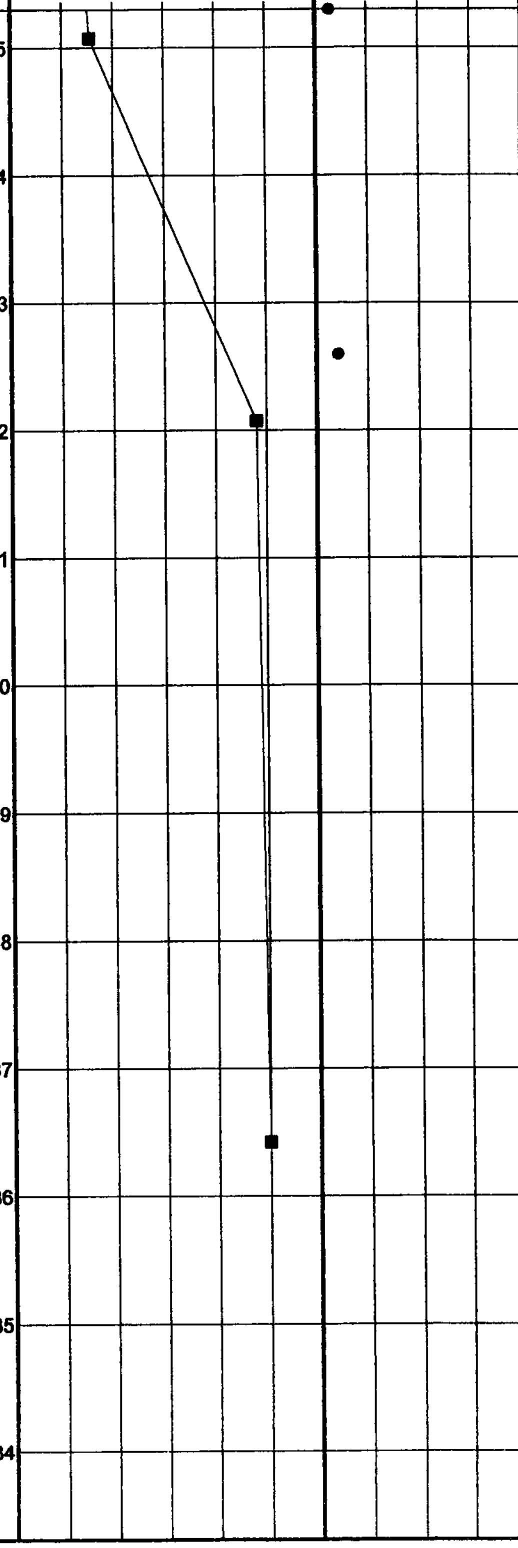
RECORD OF BOREHOLE No 2

METRIC

W.P. J03-140	PROJECT Little Savanne River Bridge	SITE NO. 48W-16	ORIGINATED BY JN
DIST 61 HWY 17	LOCATION 18.9 km east of Upsala, ON	TBTE JOB# J03-140	COMPILED BY SP
DATE 21 February 2004	BOREHOLE TYPE Hollow Stem Auger - 90mm ID	DATUM Geodetic	CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
						0 83 13 4
		7	SS	31	445	
					444	
443.0 / 14.3	COBBLES AND BOULDERS - with sand and gravel				443	0 74 22 4
		8	SS	96	442	
					441	
440.3 / 17.0	SAND - some silt and gravel, with cobbles & boulders, grey				440	
					439	27 % cobbles and boulders
	Boulder - 700 mm dia.				438	
	Cobble - 160 mm dia.				437	
	Boulder - 300 mm dia.	9	SS	100		Spoon bouncing on boulder, 15mm penetration, no sample retrieved.
					436	
	Cobble - 100 mm dia.					
	Cobble - 180 mm dia.					
	Cobble - 70 mm dia.				435	
					434	
	Cobble - 65 mm dia.					

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa O UNCONFINED ✖ FIELD VANE ■ SPT (N) ★ 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/m³



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✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 2

METRIC

W.P. J03-140	PROJECT Little Savanne River Bridge	SITE NO. 48W-16	ORIGINATED BY JN		
DIST 61 HWY 17	LOCATION 18.9 km east of Upsala, ON	TBTE JOB# J03-140	COMPILED BY SP		
DATE 21 February 2004	BOREHOLE TYPE Hollow Stem Auger - 90mm ID	DATUM Geodetic	CHECKED BY WH		

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
							433				Spoon bouncing on boulder, no sample retrieved.
	Boulder - 780 mm dia.										
							432				
	Boulder - 300 mm dia.										
							431				
430.8 26.5	BEDROCK - Felsic Intrusive Granitic rock (Granodiorite)		1	RC							100% REC 100% RQD
							430				
			2	RC			429				100% REC 81% RQD
			3	RC			428				100% REC 94% RQD
427.6 29.8	End of hole at 29.8 m.										

Legend: Dynamic cone penetration 20 40 60 80 100; Shear strength: O UNCONFINED, ■ SPT (N), ✖ FIELD VANE, ★ LAB VANE, 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; Water content 20 40 60.

Hollow stem auger
0 - 14.9 m

Diamond Rotary
13.7 m to 29.8 m

ON_MOT_BH LOG 03-140.GPJ ON_MOT.GDT 3/8/04

✖3, ★3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

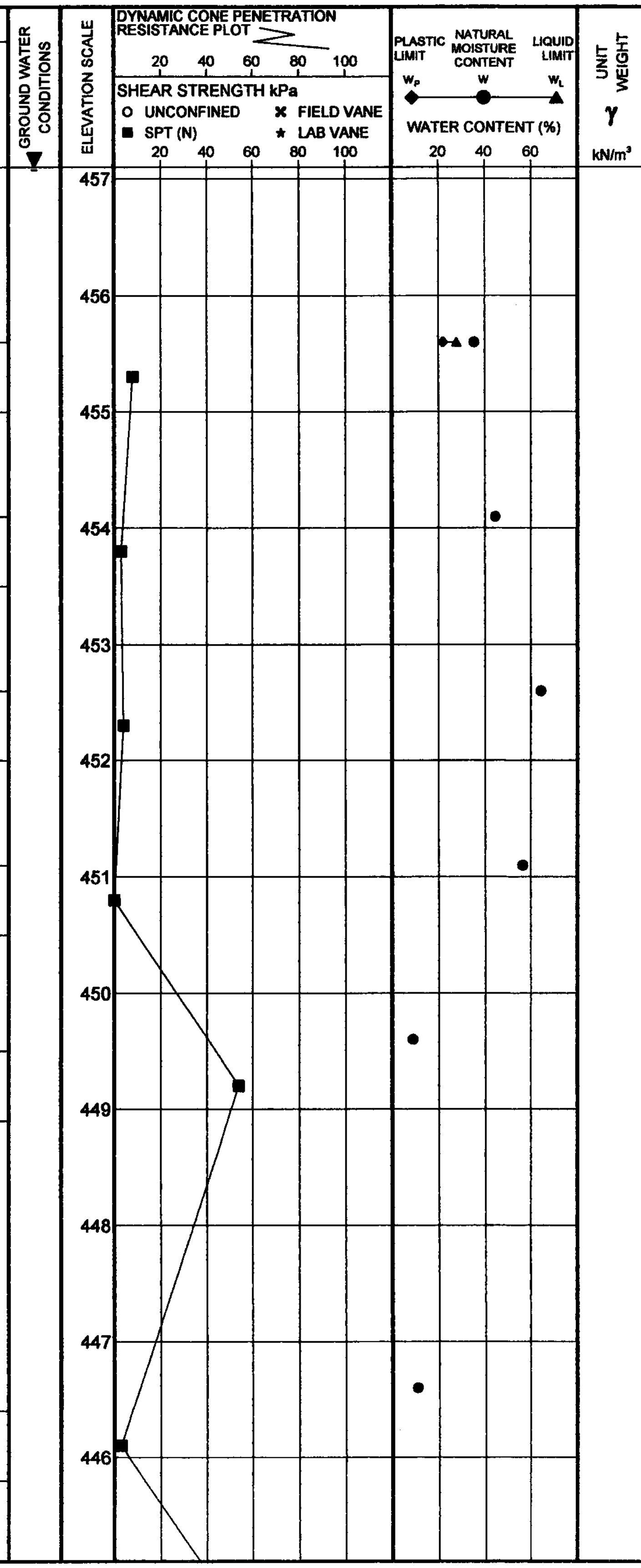
TBT Engineering

RECORD OF BOREHOLE No 3

METRIC

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16	ORIGINATED BY	JN
DIST	61 HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140	COMPILED BY	SP
DATE	22 March 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM	Geodetic	CHECKED BY	WH

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
457.1 / 0.0	FILL - fine to coarse gravelly sand, occasional cobbles and boulders, brown				Artesian groundwater to 0.3m above grade.
456.3 / 0.8	SILT - clayey, with sand, grey, firm, (ML-CL)	1	SS	8	
454.4 / 2.7	CLAY - medium to high plasticity, grey to brown, soft to firm	2	SS	3	
	reddish brown soft to firm, occ. silt veins	3	SS	4	
		4	SS	0	Split spoon sank under weight of hammer
449.7 / 7.4	SAND - fine to medium grained, silty, with gravel, trace clay, grey, dense	5	SS	54	7 53 30 1
					Sand blow up into H.S. augers
	- medium to coarse sand, loose	6	SS	3	



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✖ 3, ★ 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 3

METRIC

W.P.	**J03-140**	PROJECT	**Little Savanne River Bridge**	SITE NO.	**48W-16**
DIST	**61** HWY **17**	LOCATION	**18.9 km east of Upsala, ON**	TBTE JOB#	**J03-140**
DATE	**22 March 2004**	BOREHOLE TYPE	**Hollow Stem Auger - 90mm ID**	DATUM	**Geodetic**

ORIGINATED BY **JN**
COMPILED BY **SP**
CHECKED BY **WH**

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	- cobble					445	
	- cobble					444	
443.4 / 13.7	COBBLES AND BOULDERS - with sand and gravel 4 boulders (> 200mm) in 3 m run.	7	SS	100		443	Split spoon bouncing off of boulder, 0.2 m penetration
						442	
						441	Split spoon bouncing off of boulder, < 25mm penetration
440.4 / 16.8	End of hole at 16.8 m. Refusal on boulder. Hollow stem auger 0 - 13.7 m Diamond Rotary 13.7 m to 16.8 m	8	SS	100			

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED; ✖ FIELD VANE; ■ SPT (N); ★ 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/m³

GR SA SI CL

✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 4

 METRIC

TBT Engineering

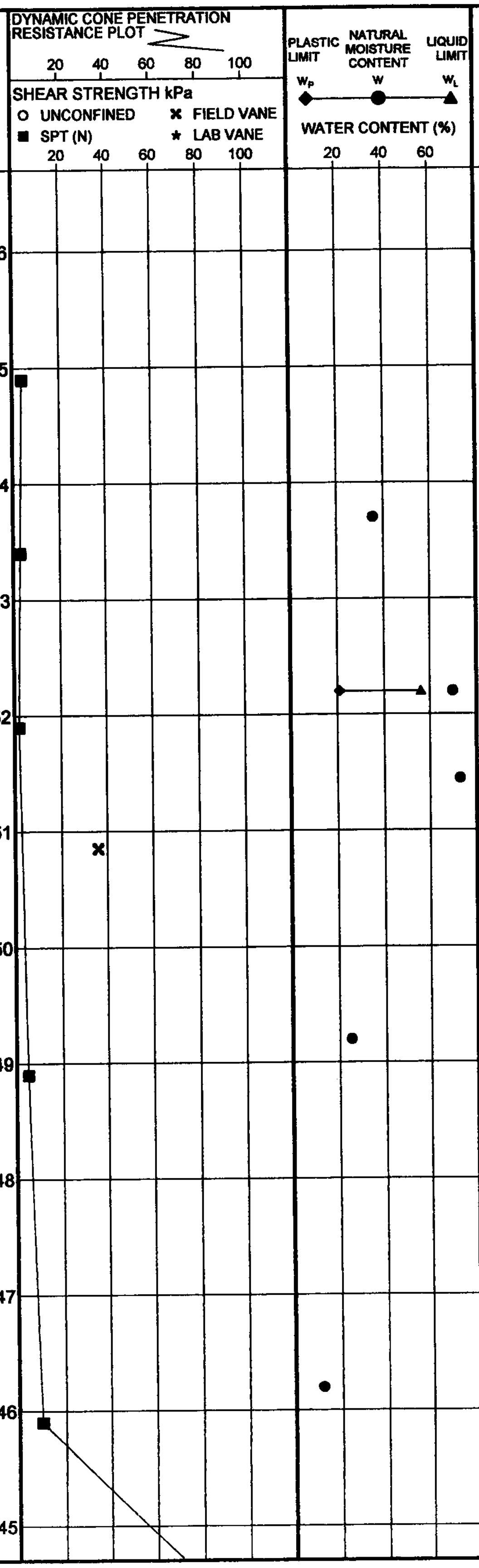
W.P. J03-140	PROJECT Little Savanne River Bridge	SITE NO. 48W-16	ORIGINATED BY JN
DIST 61 HWY 17	LOCATION 18.9 km east of Upsala, ON	TBTE JOB# J03-140	COMPILED BY SP
DATE 24 March 2004	BOREHOLE TYPE Hollow Stem Auger - 90mm ID	DATUM Geodetic	CHECKED BY WH

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
456.7	
0.0	FILL - fine to coarse sand, silty, some gravel, brown to grey, wet
456.4 / 0.3	SILT - clayey, with sand, grey, soft to firm (ML-CL)
454.0 / 2.7	CLAY - medium to high plasticity, grey, soft to firm, varved; reddish brown soft to firm, occ. silt veins; - cobble; - silty, some sand, grey
448.4 / 8.3	SAND and SILT - trace clay; - occ. cobble and boulder

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	4
2	SS	3
3	SS	2
4	SH	
	VANE	
5	SS	5
6	SS	10



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

25 mm Topsoil

Artesian groundwater to 0.3m above grade.

GR	SA	SI	CL
0	16	(84)	
8	49	(44)	

Sand blow - 0.15 m into auger

Continued Next Page

✖³, ★³: Numbers refer to Sensitivity

O³% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 4

METRIC

W.P. J03-140 PROJECT Little Savanne River Bridge SITE NO. 48W-16 ORIGINATED BY JN

DIST 61 HWY 17 LOCATION 18.9 km east of Upsala, ON TBTE JOB# J03-140 COMPILED BY SP

DATE 24 March 2004 BOREHOLE TYPE Hollow Stem Auger - 90mm ID DATUM Geodetic CHECKED BY WH

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%)
444.2 / 12.5	COBBLES AND BOULDERS - some sand and gravel	7	SS	100	Split spoon attempted, < 60mm penetration, 100+blows Advancement rate - 85 sec/300 mm
441.4 / 15.3	SAND - silty, some gravel, with boulders, grey				Advancement rate - 45 sec/300 mm (15.3 - 15.4 m) Advancement rate - 20 sec/300 mm (17.4 - 17.5 m) Advancement rate - 20 sec/300 mm (18.3 - 18.4 m)
438.1 / 18.6	End of hole at 18.6m. Hole terminated due to air pressure return loss at 18.6 m, surface venting of air. Truck mounted CME 55 rig refused @ 14.1 m below grade in dense boulder layer. Air powered rotary drill used to advance hole from 14.1 m to 18.6 m.				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (444, 443, 442, 441, 440, 439); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 5

 METRIC

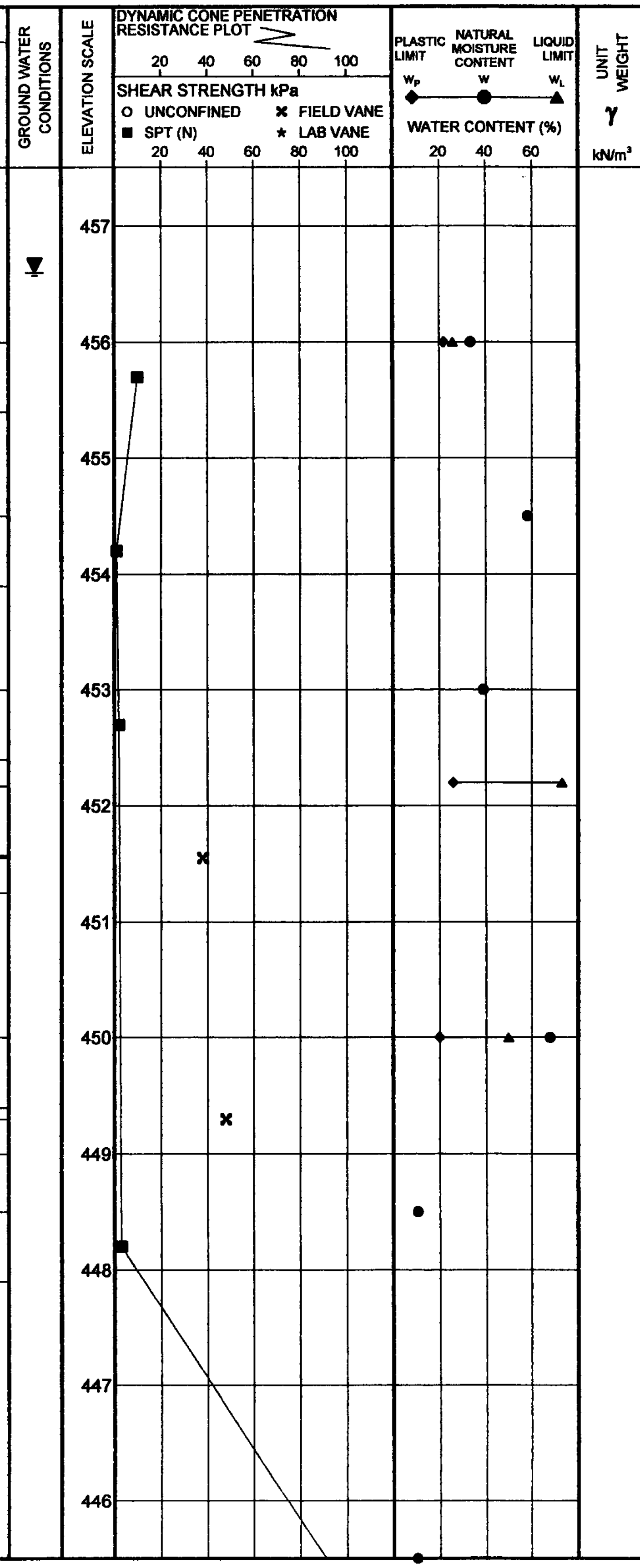
TBT Engineering

W.P. J03-140 PROJECT Little Savanne River Bridge SITE NO. 48W-16 ORIGINATED BY JN

DIST 61 HWY 17 LOCATION 18.9 km east of Upsala, ON TBTE JOB# J03-140 COMPILED BY SP

DATE 25 March 2004 BOREHOLE TYPE Hollow Stem Auger - 90mm ID DATUM Geodetic CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
457.5					
0.0	FILL - fine to coarse sand, gravelly, trace silt, brown				
456.9 / 0.6	SILT and CLAY - brown/grey, firm				0 0 78 22
		1	SS	10	
454.5	- some clay varves				
3.0	CLAY - medium to high plasticity, grey to brown, firm, varved	2	SS	1	
		3	SS	2	Spoon sank under weight of the hammer.
	reddish brown soft to firm, occ. silt veins	4	SH		
			VANE		
		5	SS		Spoon sank under weight of the hammer.
449.0			VANE		
8.5	SAND - fine to medium grained, silty, with gravel, trace clay, grey/brown	6	SS	3	
	occ. cobble				Sand blow up into H.S. augers



Continued Next Page

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

Ministry of Transportation Ontario

TBT Engineering

RECORD OF BOREHOLE No 5

 METRIC

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16
ORIGINATED BY	JN				
DIST	61 HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140
COMPILED BY	SP				
DATE	25 March 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM	Geodetic
CHECKED BY	WH				

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION / SHEAR STRENGTH kPa (○ UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ LAB VANE)	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		7	SS	100			■ 100			Sand blow up 3.6 m into H.S. auger. 100+ blows for 0.1 m pen. at 12.5m b.g.
444.9 / 12.6	COBBLES AND BOULDERS - some sand and gravel					445				Advancement rate - 200 - 220 sec/300 mm
						444				
						443				Rate retarded because of damaged casing tip - drilled through steel casing
						442				Advancement rate - 111 sec/300 mm
441.6 / 15.9	SAND - silty, some gravel, with boulders, grey									Advancement rate - 50 sec/300 mm
						441				
						440				Advancement rate - 85 sec/300 mm
						439				
						438				
						437				
						436				Advancement rate - 60 sec/300 mm
						435				
						434				Advancement

Continued Next Page

✖³, ★³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MOT_BH LOG 03-140.GPJ ON_MOT.GDT 3/8/04

TBT Engineering

RECORD OF BOREHOLE No 5

METRIC

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16	ORIGINATED BY	JN
DIST 61	HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140	COMPILED BY	SP
DATE	25 March 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM	Geodetic	CHECKED BY	WH

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ LAB VANE)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
							433				rate - 60 sec/300 mm
432.6 24.9	End of hole at 24.9 m. Hole terminated due to air pressure return loss at 24.9 m, surface air venting. Hollow stem auger 0 - 12.6 m Diamond rotary well drill 12.6 m - 24.9 m										

✖³, ★³: Numbers refer to Sensitivity O ³% STRAIN AT FAILURE

Ministry of Transportation
Ontario

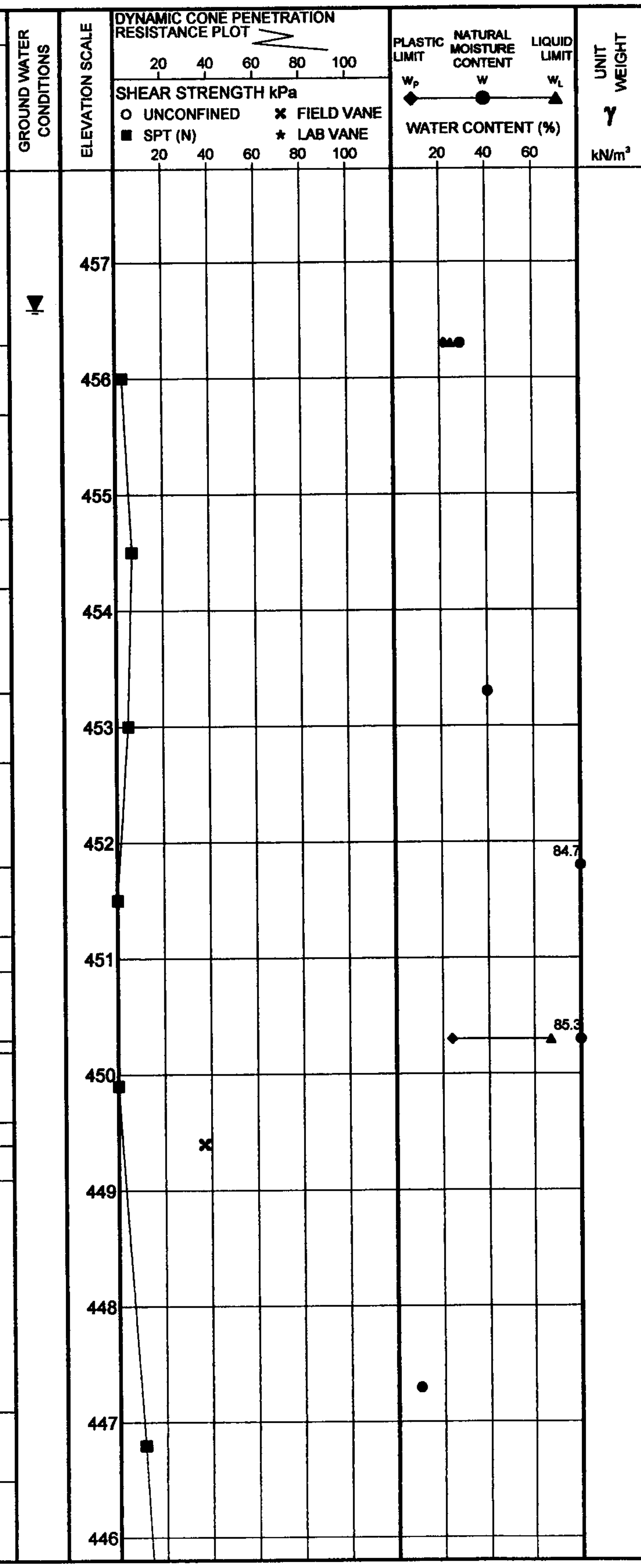
TBT Engineering

RECORD OF BOREHOLE No 6

METRIC

W.P. J03-140	PROJECT Little Savanne River Bridge	SITE NO. 48W-16	ORIGINATED BY JN
DIST 61 HWY 17	LOCATION 18.9 km east of Upsala, ON	TBTE JOB# J03-140	COMPILED BY SP
DATE 25 March 2004	BOREHOLE TYPE Hollow Stem Auger - 90mm ID	DATUM Geodetic	CHECKED BY WH

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
457.8 / 0.0	FILL - fine to medium gravelly sand, trace of silt, occasional cobbles, brown, moist				25mm topsoil
457.4 / 0.4	SILT - clayey, trace sand, brown and grey, soft (ML-CL)	1	SS	3	Spoon sank under weight of hammer
	- some clay seams, grey	2	SS	7	
454.0 / 3.8	CLAY - med to high plasticity, grey to brown, firm, varved				
	- occasional sand and gravel	3	SS	5	
	reddish brown soft to firm, occ. silt veins	4	SS	0	Spoon sank under weight of hammer
		5	SH		
		6	SS	0	Spoon sank under weight of hammer
			VANE		
448.2 / 9.6	SAND - fine to medium grained, silty, with gravel, trace clay, grey/brown	7	SS	11	



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✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

ON_MOT_BH LOG 03-140.GPJ ON_MOT.GDT 3/8/04

TBT Engineering — RECORD OF BOREHOLE No 6

 METRIC

W.P. J03-140 | PROJECT Little Savanne River Bridge | SITE NO. 48W-16 | ORIGINATED BY JN

DIST 61 HWY 17 | LOCATION 18.9 km east of Upsala, ON | TBTE JOB# J03-140 | COMPILED BY SP

DATE 25 March 2004 | BOREHOLE TYPE Hollow Stem Auger - 90mm ID | DATUM Geodetic | CHECKED BY WH

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
					445	
					444	
		8	SS	20		1.2 m of sand blow up into augers, 75 mm retrieval from split spoon.
					443	
					442	
441.0 / 16.8	End of hole at 16.8 m. Auger refusal on inferred boulder.				441	1.5 m of sand blow up into augers, unable to get spoon sample @16.75m.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³; GR SA SI CL; STRAT PLOT; GROUND WATER CONDITIONS.

✖³, ★³: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

TBT Engineering — RECORD OF BOREHOLE No 7

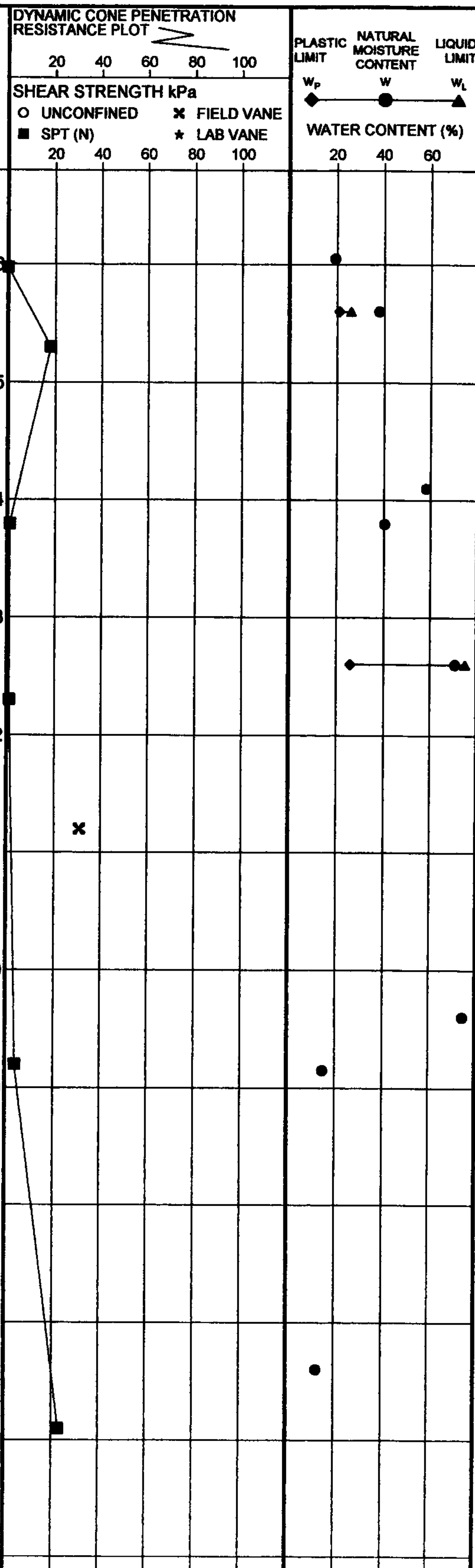
METRIC

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16
DIST	61 HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140
DATE	26 March 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM	Geodetic

ORIGINATED BY RL
COMPILED BY SP
CHECKED BY WH

SOIL PROFILE / SAMPLES

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
456.8 0.0	FILL - fine to medium sand, silty, occasional gravel and boulders, wet		1	SS	0	Spoon bouncing off large boulder, 50+ blows for 0.1 m pen.
455.7 1.1	SILT - clayey, grey, soft to firm (ML-CL)		2	SS	18	0 3 77 20
453.8 3.0	CLAY - med to high plasticity, grey to brown, firm, varved		3	SS	1	
			4	SS	1	Spoon sank 0.15 m under own weight
	reddish brown soft to firm, occ. silt veins		5	SH		
				VANE		
			6	SS	4	Spoon sank 0.15 m under own weight
449.0 7.8	Sand - fine to medium, trace silt, occasional gravel, grey, compact, wet		7	SS	23	



GROUND WATER CONDITIONS | ELEVATION SCALE: 456, 455, 454, 453, 452, 451, 450, 449, 448, 447, 446, 445 | UNIT WEIGHT γ kN/m³

Continued Next Page

✖3, ★3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 7

METRIC

W.P. **J03-140** PROJECT **Little Savanne River Bridge** SITE NO. **48W-16** ORIGINATED BY **RL**

DIST **61** HWY **17** LOCATION **18.9 km east of Upsala, ON** TBTE JOB# **J03-140** COMPILED BY **SP**

DATE **26 March 2004** BOREHOLE TYPE **Hollow Stem Auger - 90mm ID** DATUM **Geodetic** CHECKED BY **WH**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
444.6											
12.2	End of hole at 12.2 m. Auger refusal (cobbles/boulders)						444				3 m of sand blow up into auger, unable to get spoon sample.

✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

ON_MOT_BH LOG 03-140.GPJ ON_MOT.GDT 3/8/04

RECORD OF BOREHOLE No 8

METRIC

TBT Engineering

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16
DIST	61 HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140
DATE	27 March 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM	Geodetic

ORIGINATED BY RL · COMPILED BY SP · CHECKED BY WH

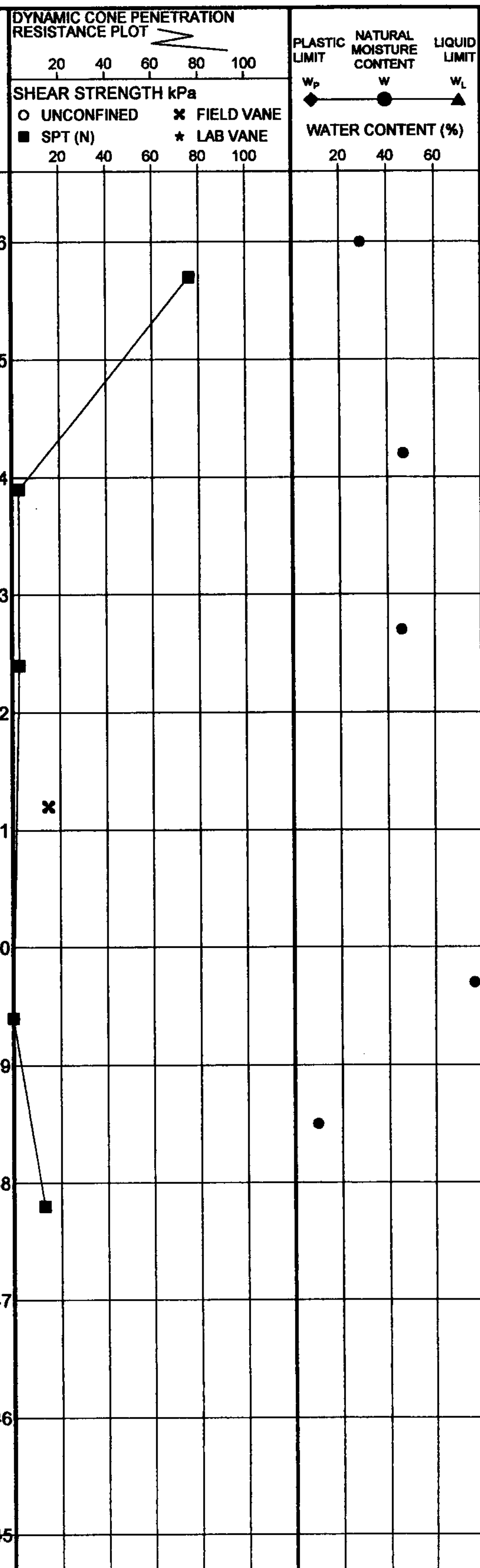
SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
456.6 / 0.0	Water
456.1 / 0.5	FILL- fine to medium sand, trace silt and clay, occasional gravel and wood chips, brown
454.6 / 2.0	SILT - clayey, some sand, grey, loose, moist
453.0 / 3.6	CLAY - medium to high plasticity, grey to brown, firm, varved — reddish brown soft to firm, occ. silt veins
448.7 / 7.9	SAND - fine to medium grained, silty, with gravel, trace clay, grey/brown
445.0 / 11.6	End of hole at 11.6m.

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	76
2	SH	
3	SS	3
4	SS	3
5	SH	
	VANE	
6	SS	0
7	SS	13

GROUND WATER CONDITIONS · ELEVATION SCALE (456 – 445)



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
0	15	77	8

Spoon sank 0.3 m under own weight, then sank 0.45 m under weight of (32) hammer.

6.0 m of sand blow up into H.S. augers.

✖3, ★3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 9

METRIC

TBT Engineering

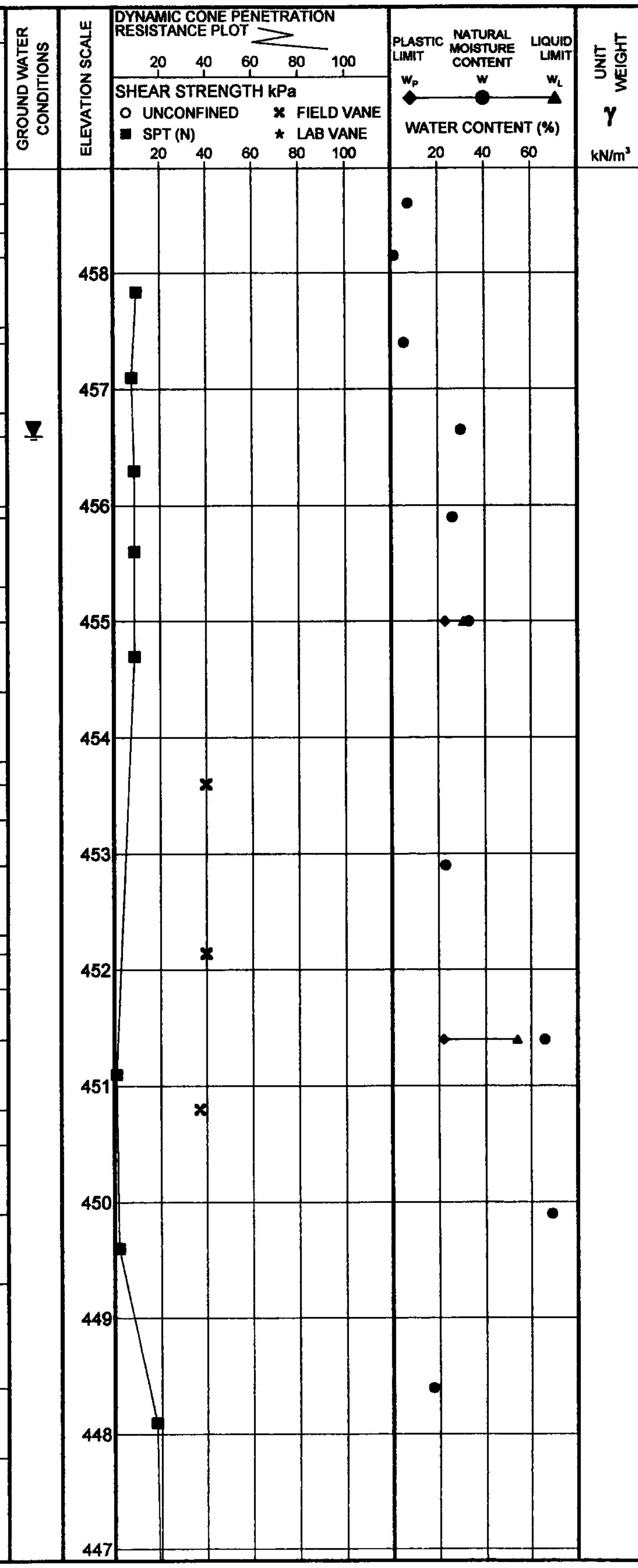
W.P. J03-140	PROJECT Little Savanne River Bridge	SITE NO. 48W-16	ORIGINATED BY DG
DIST ____ HWY 17	LOCATION 18.9 km east of Upsala, ON	TBTE JOB# J03-140	COMPILED BY SP
DATE 27 May 2004	BOREHOLE TYPE 80mm ID	DATUM Geodetic	CHECKED BY WH

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
458.9	
458.8 / 0.1	Asphalt
458.6 / 0.3	FILL - CR GRAVEL, sandy, brown, dry
	FILL - SAND, gravelly, trace silt, lt. brown, dry
457.1 / 1.8	SILT - grey, clayey (brown), moist increasing clay with depth +/- clay in 10mm layers
455.0 / 3.9	CLAY - medium to high plasticity, grey to brown, firm, varved ------ reddish brown soft to firm, occ. silt veins
449.3 / 9.6	SAND - fine, silty, trace clay, wet, grey

SAMPLES

NUMBER	TYPE	"N" VALUES
1	GRAB	
2	SS	10
3	SS	8
4	SS	9
5	SS	9
6	SS	9
7	SH	
	VANE	
8	SH	
	VANE	
9	SS	1
	VANE	
10	SS	2
11	SS	18



REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL	Remarks
7	82	7	3	
0	3	80	17	
				VARVES - 5-20mm Clay, 5-20mm Silt
				Weight of hammer advanced SS 380mm
				Weight of hammer advanced SS 200mm
0	22	(78)		Sand on HS Auger plug Sand/water 2.3m inside HS Auger

Continued Next Page

✖ 3, ★ 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

TBT Engineering

RECORD OF BOREHOLE No 9

METRIC

W.P. J03-140 PROJECT Little Savanne River Bridge SITE NO. 48W-16 ORIGINATED BY DG

DIST ____ HWY 17 LOCATION 18.9 km east of Upsala, ON TBTE JOB# J03-140 COMPILED BY SP

DATE 27 May 2004 BOREHOLE TYPE 80mm ID DATUM Geodetic CHECKED BY WH

ELEV DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ LAB VANE)	PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
							446				No SPT - sand blowing into HS Auger 0.3m/min
	Increasing cobbles with depth						445				Intermittent rough drilling No SPT - sand blowing into HS Auger 0.3m/min
							444				
443.3 15.6			12	SS	22						4 61 (35)
	End of hole at 15.7m										

✖3, ★3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

TBT Engineering

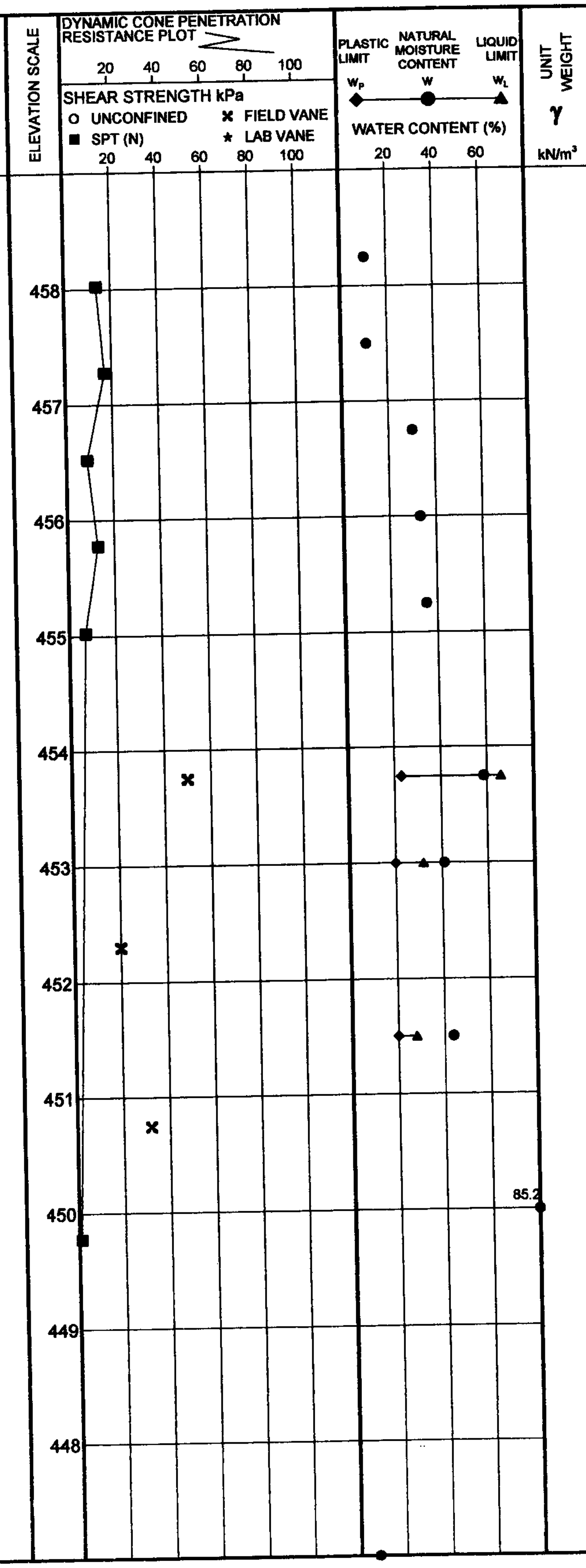
RECORD OF BOREHOLE No 10

METRIC

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16
DIST	61 HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140
DATE	1 June 2004	BOREHOLE TYPE	80mm ID	DATUM	Geodetic

ORIGINATED BY DG
COMPILED BY SP
CHECKED BY WH

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
459.0 / 0.0	FILL - CR GRAVEL, sandy, brown, dry					14 75 (11)
		1	SS	14		
		2	SS	17		5 79 (17)
457.2 / 1.8	SILT - clayey, some sand, grey/ brown, loose, moist				▼	
		3	SS	9		
		4	SS	13		
455.4 / 3.6	CLAY - medium to high plasticity, grey to brown, firm, varved	5	SS	7		
		6	SH			
			VANE			
		7	SH			
	soft		VANE			
	reddish brown soft to firm, occ. silt veins	8	SH			
			VANE			
		9	SS	1		Weight of hammer advanced SS 375 mm
448.8 / 10.2	SAND - fine, silty, trace clay, wet, grey					Blowing sand ~ 1.5 m up H.S. auger
	Increasing cobbles with depth Intermittent rough drilling					



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✖³, ★³: Numbers refer to Sensitivity   O³% STRAIN AT FAILURE

ON_MOT_BH LOG 03-140.GPJ ON_MOT.GDT 3/8/04

TBT Engineering

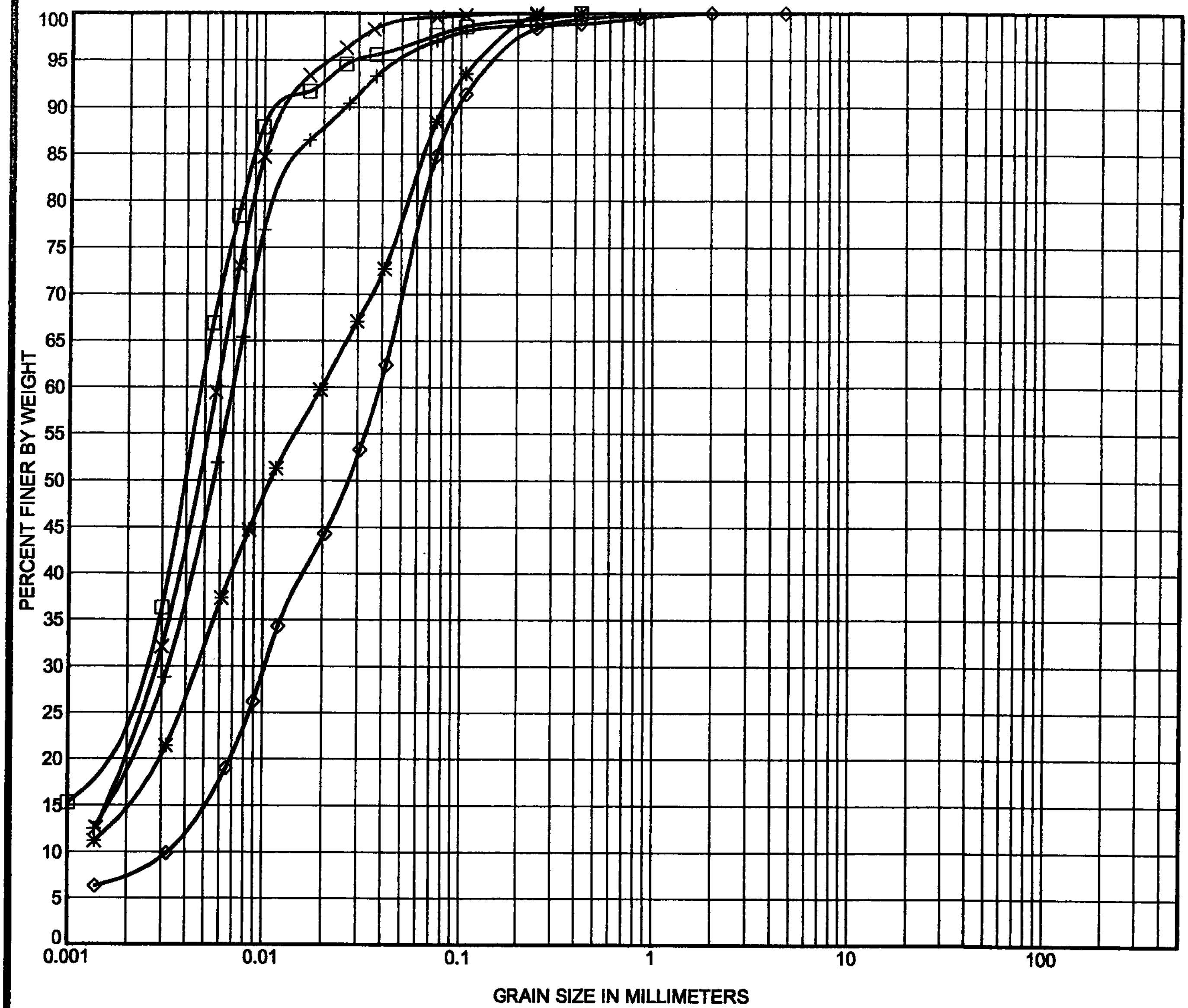
RECORD OF BOREHOLE No 10

METRIC

W.P. **J03-140**	PROJECT **Little Savanne River Bridge**		SITE NO. **48W-16**		ORIGINATED BY **DG**
DIST **61**	HWY **17**	LOCATION **18.9 km east of Upsala, ON**	TBTE JOB# **J03-140**		COMPILED BY **SP**
DATE **1 June 2004**	BOREHOLE TYPE **80mm ID**		DATUM **Geodetic**		CHECKED BY **WH**

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	SAMPLES – TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND - fine, silty, trace clay, wet, grey Increasing cobbles and gravel with depth		10	BS							
							446				
											Blowing sand ~ 1.5 m up H.S. auger
							445				
444.0 15.0							444				Blowing sand ~ 4.0 m up H.S. auger
	End of hole at 15.0 m below grade.										

✖³, ★³: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Material:

CLAYEY SILT DEPOSIT

	Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	1	0.75	0.425	0.005	0.002		0.0	2.3	69.2	28.5
✳	1	1.50	0.425	0.02	0.005		0.0	11.5	72.7	15.8
×	5	1.50	0.425	0.006	0.003		0.0	0.4	77.9	21.7
+	7	1.20	0.85	0.007	0.003		0.0	2.7	77.0	20.1
◇	8	2.40	4.75	0.039	0.01	0.003	0.0	15.2	76.9	7.9

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GRAIN SIZE DISTRIBUTION

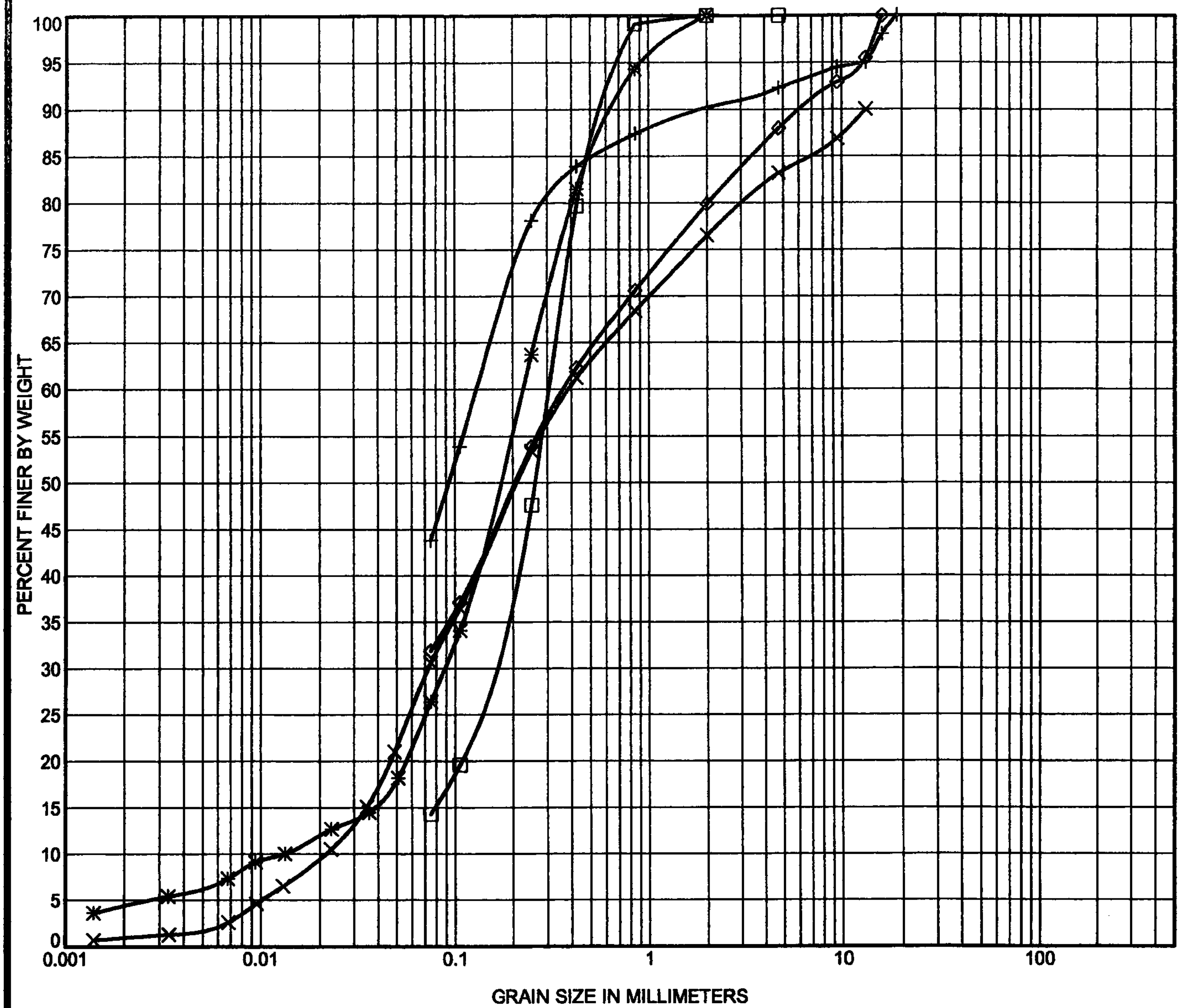
Project: Little Savanne River Bridge

Location: 17

Number: J03-140

ENCLOSURE 1

MTO_GS_03-140.GPJ CAN LAB.GDT 1/6/04



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Material:

SAND DEPOSIT

	Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	1	9.00	4.75	0.307	0.146		0.0	85.7	14.3	
✳	2	14.70	2	0.225	0.088	0.013	0.0	73.6	22.1	4.3
×	3	7.50	13.2	0.392	0.073	0.021	6.8	52.6	29.7	0.9
+	4	10.50	19	0.132			7.7	48.5	43.8	
◇	8	8.10	16	0.368			12.0	56.1	31.9	

MTO_GS_03-140.GPJ_CAN_LAB.GDT_3/6/04

TBT Engineering
Suite 314-101 Syndicate Ave. N
Thunder Bay, ON P7C 3V4
Telephone: (807) 624-5160
Fax: (807) 624-5161

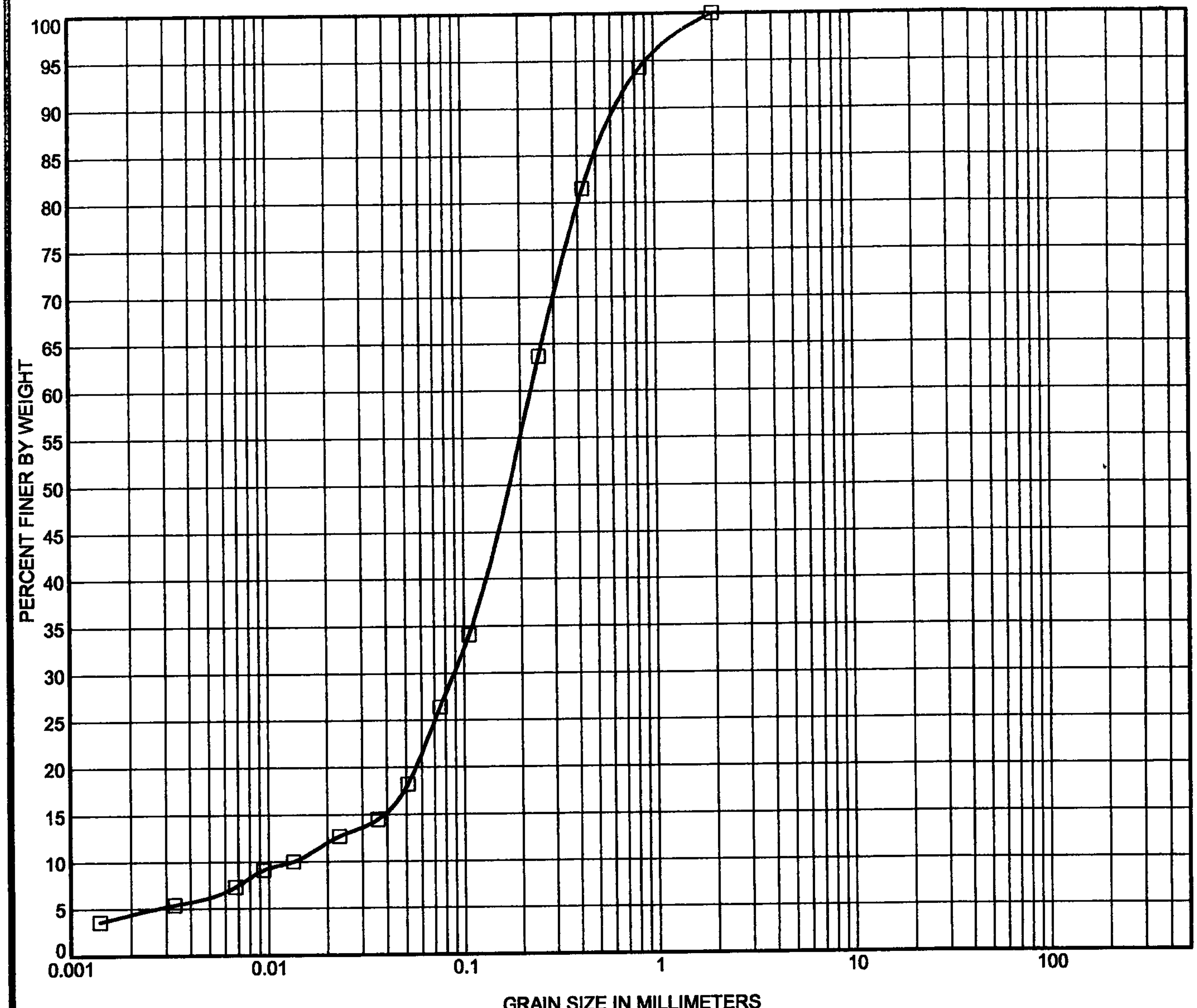
GRAIN SIZE DISTRIBUTION

Project: Little Savanne River Bridge

Location: 17

Number: J03-140

ENCLOSURE 2



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Material:

SAND with COBBLES and BOULDERS (fine fraction only)

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ 2	14.70	2	0.225	0.088	0.013	0.0	73.6	22.1	4.3

MTO_GS_03-140.GPJ CAN_LAB.GDT 1/8/04

TBT Engineering
Suite 314-101 Syndicate Ave. N
Thunder Bay, ON P7C 3V4
Telephone: (807) 624-5160
Fax: (807) 624-5161

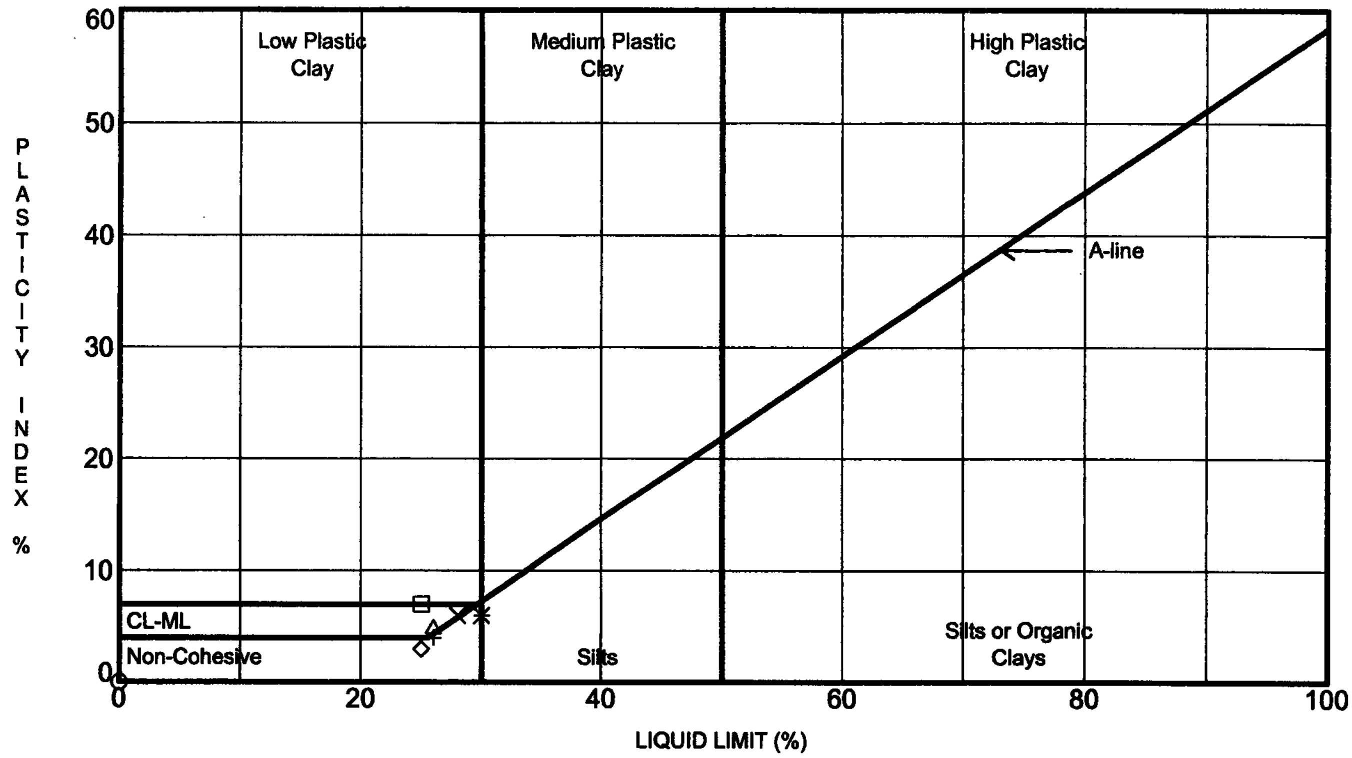
GRAIN SIZE DISTRIBUTION

Project: Little Savanne River Bridge

Location: 17

Number: J03-140

ENCLOSURE 3



Material:

CLAYEY SILT DEPOSIT

	Borehole No.	Sample No.	Depth	LL%	PL%	PI%	M/C%
□	**1**	**2**	**1.50**	**25**	**18**	**7**	**38**
✳	**2**	**1**	**0.75**	**30**	**24**	**6**	**31**
×	**3**	**1**	**1.50**	**28**	**22**	**6**	**36**
+	**5**	**1**	**1.50**	**26**	**22**	**4**	**34**
◇	**6**	**1**	**1.50**	**25**	**22**	**3**	**29**
△	**7**	**2**	**1.20**	**26**	**21**	**5**	**38**
○	**8**	**3**	**2.40**	**NP**	**NP**	**NP**	**47**

TBT Engineering
Suite 314-101 Syndicate Ave. N
Thunder Bay, ON P7C 3V4
Telephone: (807) 624-5160
Fax: (807) 624-5161

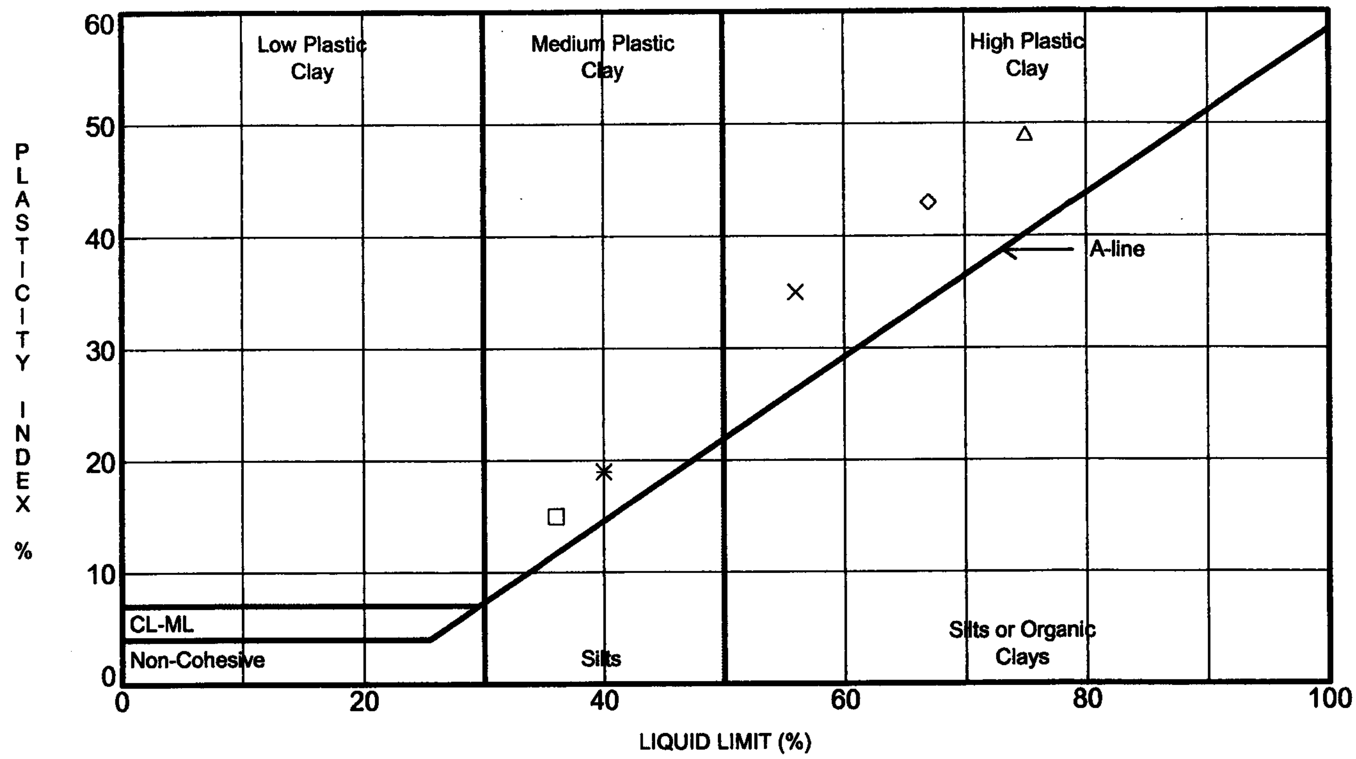
ATTERBERG LIMIT RESULTS

Project: Little Savanne River Bridge

Location: 17

Number: J03-140

ENCLOSURE 4



Material:

CLAY DEPOSIT

	Borehole No.	Sample No.	Depth	LL%	PL%	PI%	M/C%
□	**1**	**3**	**3.00**	**36**	**21**	**15**	**58**
✳	**2**	**3**	**3.00**	**40**	**21**	**19**	**49**
×	**4**	**3**	**4.50**	**56**	**21**	**35**	**70**
+	**5**	**5**	**7.50**	**50**	**20**	**30**	**68**
◇	**6**	**6**	**7.50**	**67**	**24**	**43**	**85**
△	**7**	**4**	**4.20**	**75**	**26**	**49**	**71**

TBT Engineering
Suite 314-101 Syndicate Ave. N
Thunder Bay, ON P7C 3V4
Telephone: (807) 624-5160
Fax: (807) 624-5161

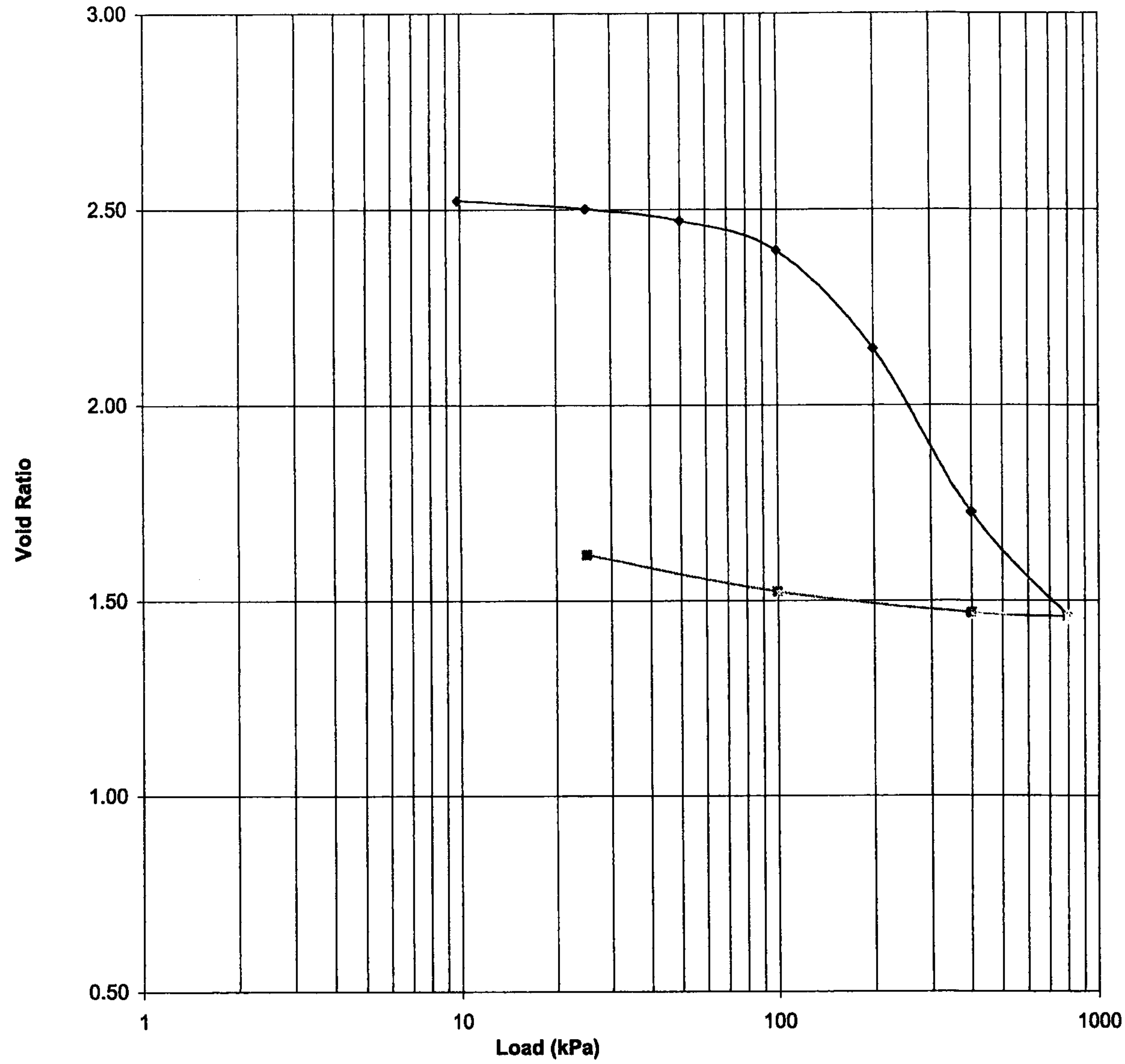
ATTERBERG LIMIT RESULTS

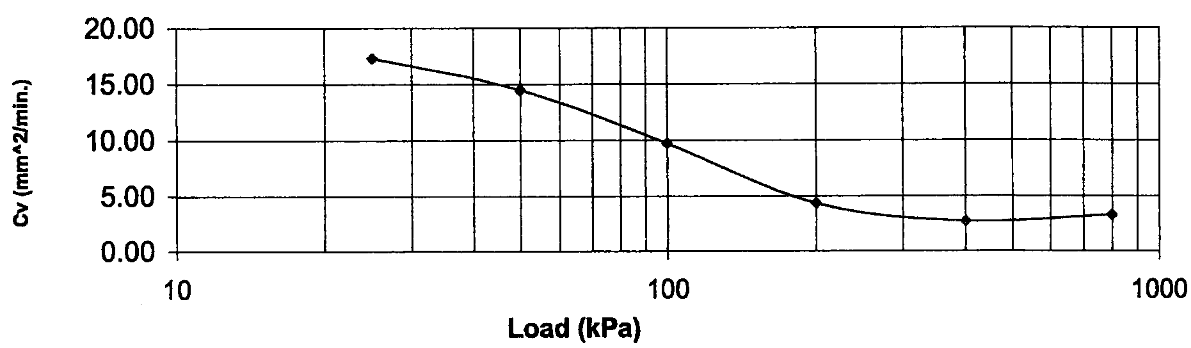
Project: Little Savanne River Bridge

Location: 17

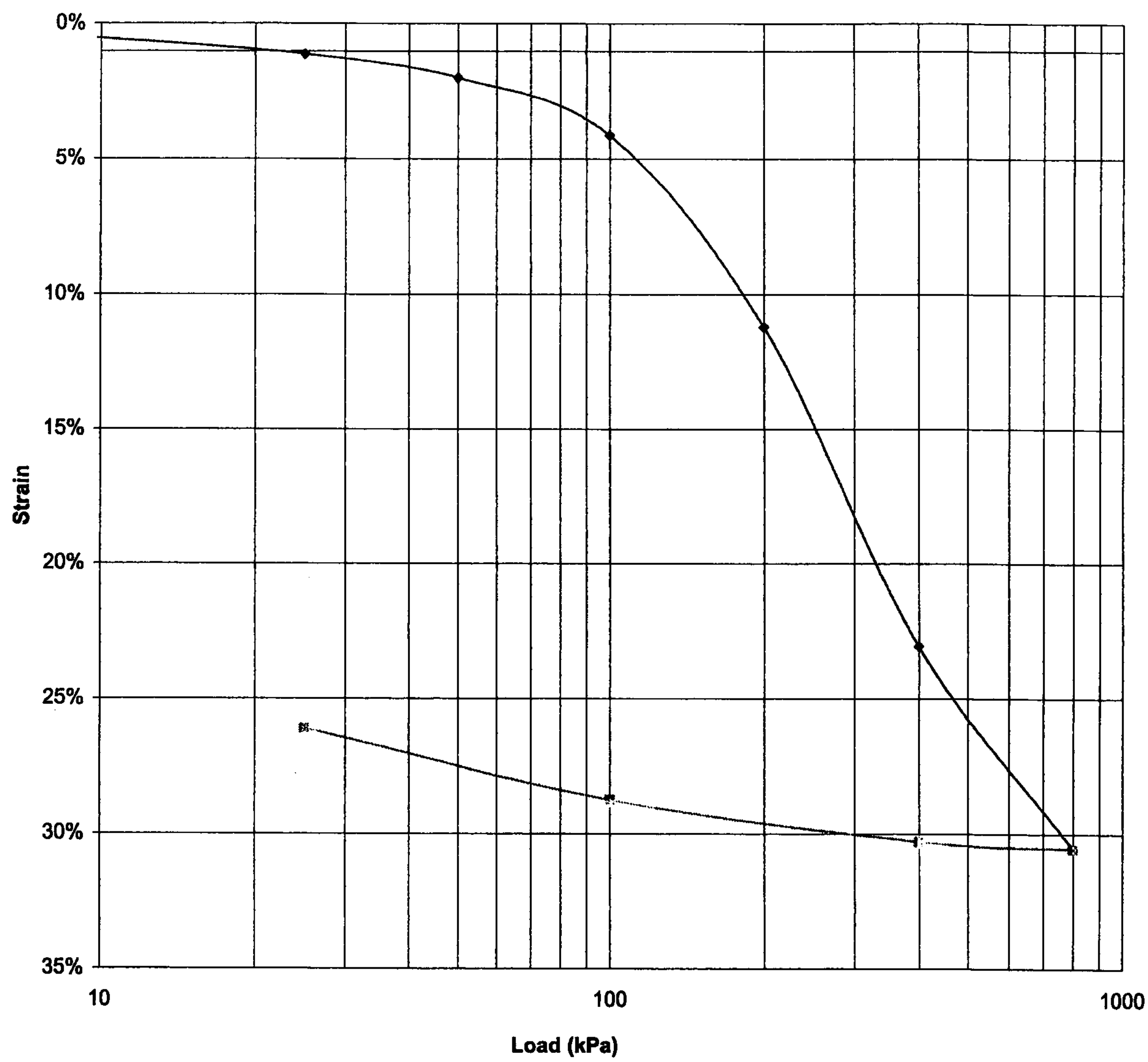
Number: J03-140

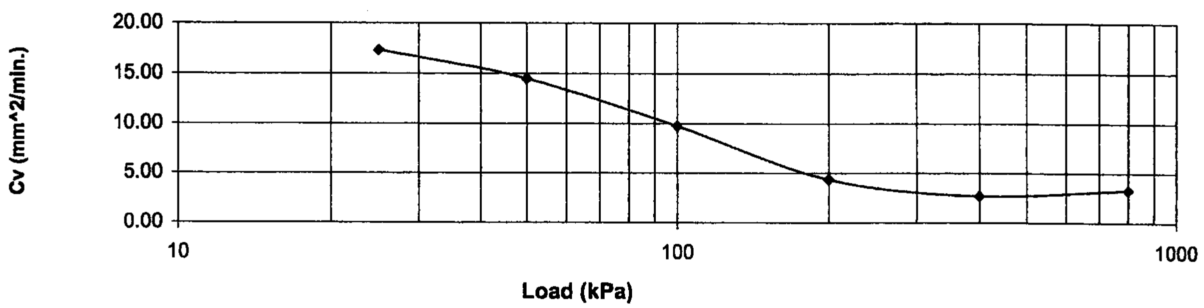
ENCLOSURE 5





	CONSOLIDATION TEST **Little Savanne River**	Project No.: 03-140
	Borehole 1 Depth: 4.9 Lab No. 143	Enclosure No.C-1



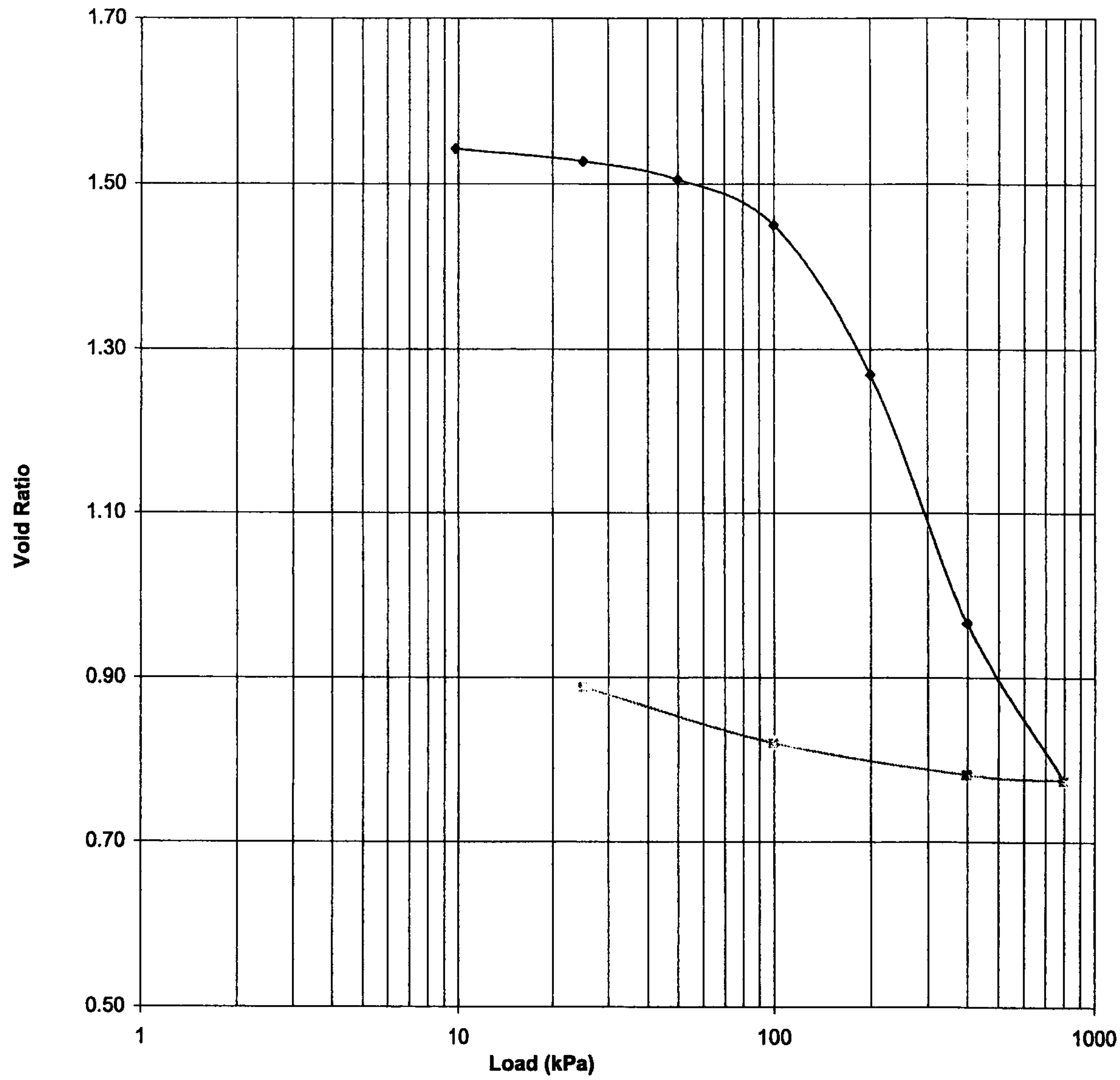


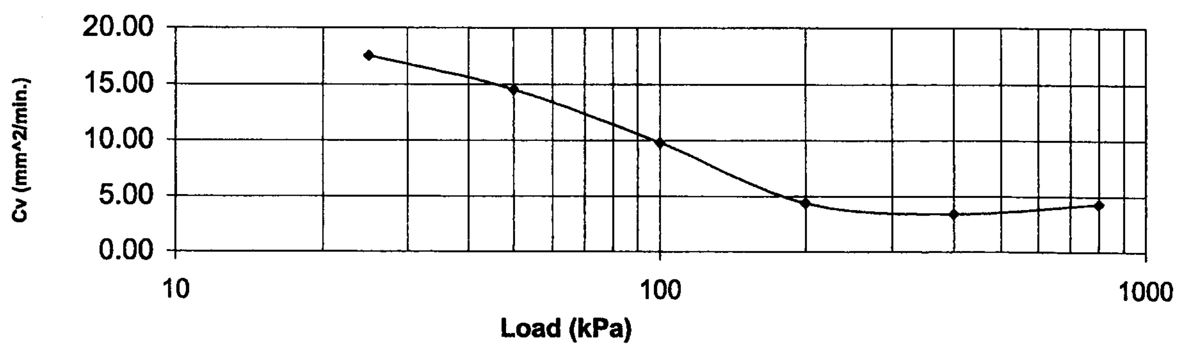
CONSOLIDATION TEST
Little Savanne River

Borehole 1 Depth: 4.9 Lab No.: 143

Project No.: 03-140

Enclosure No.C-1



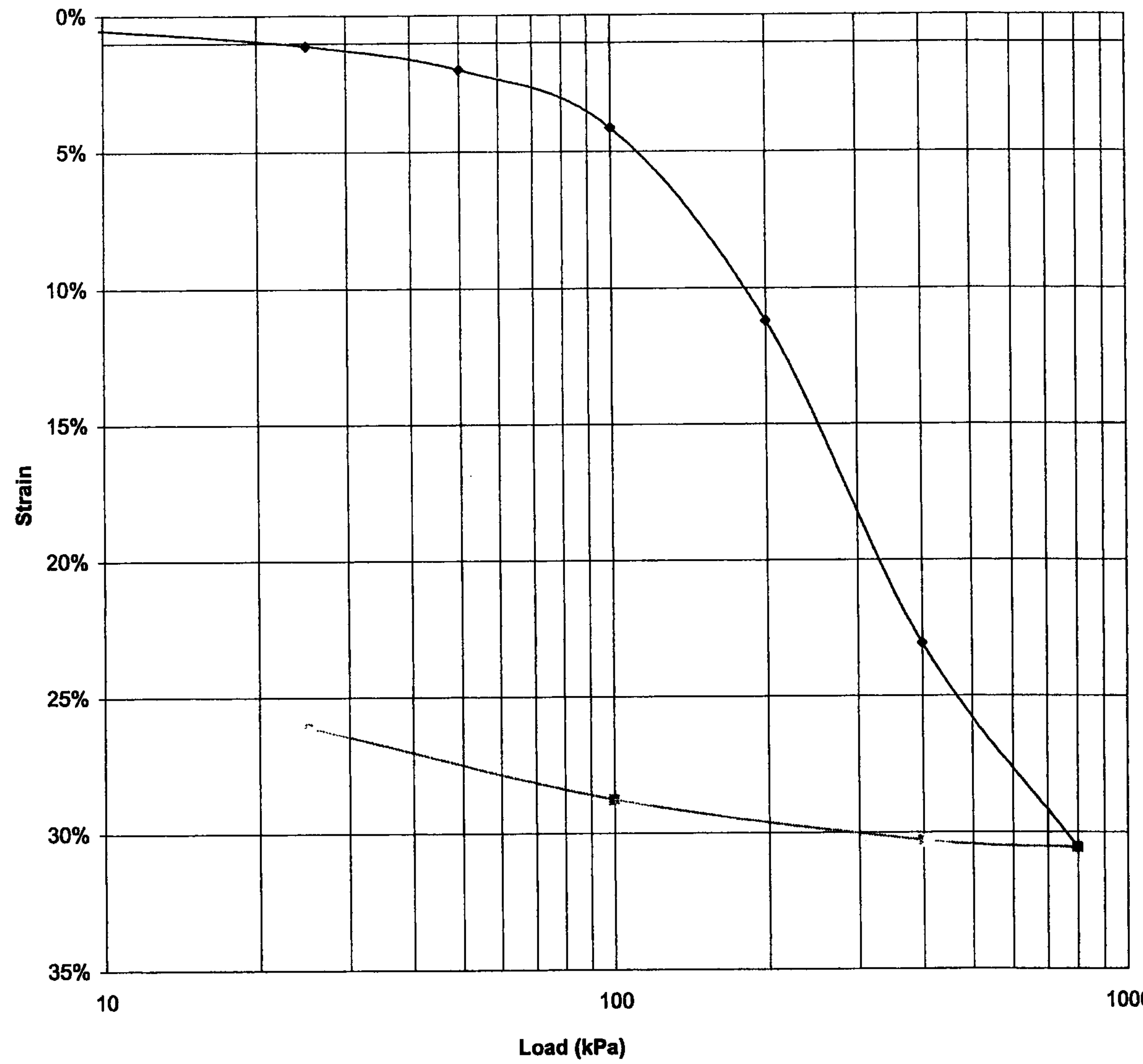


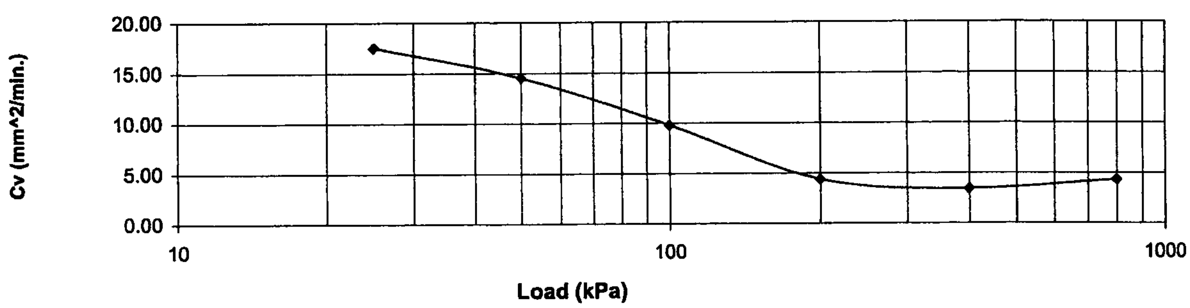
CONSOLIDATION TEST
Little Savanne River

Borehole 3 Depth: 5.8m Lab No. 122

Project No.: 03-140

Enclosure No.C-1

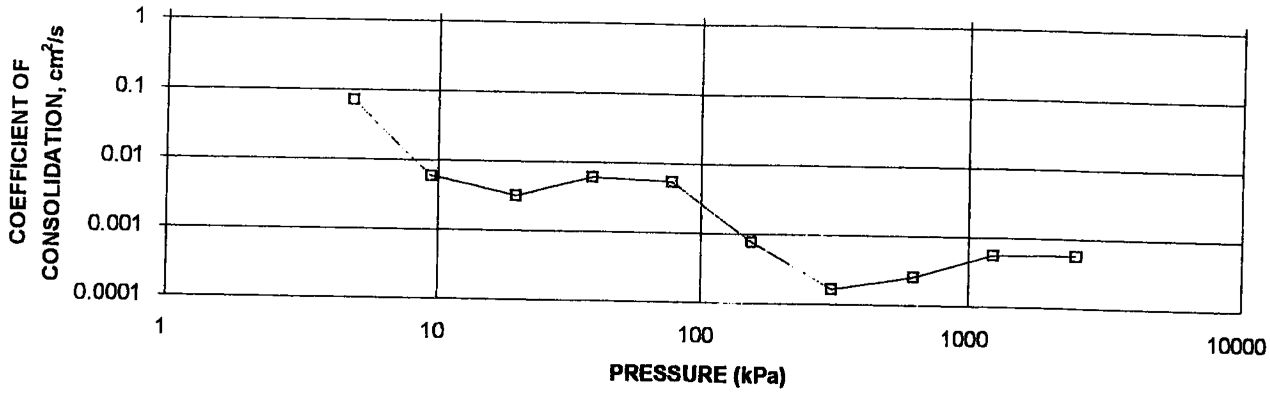




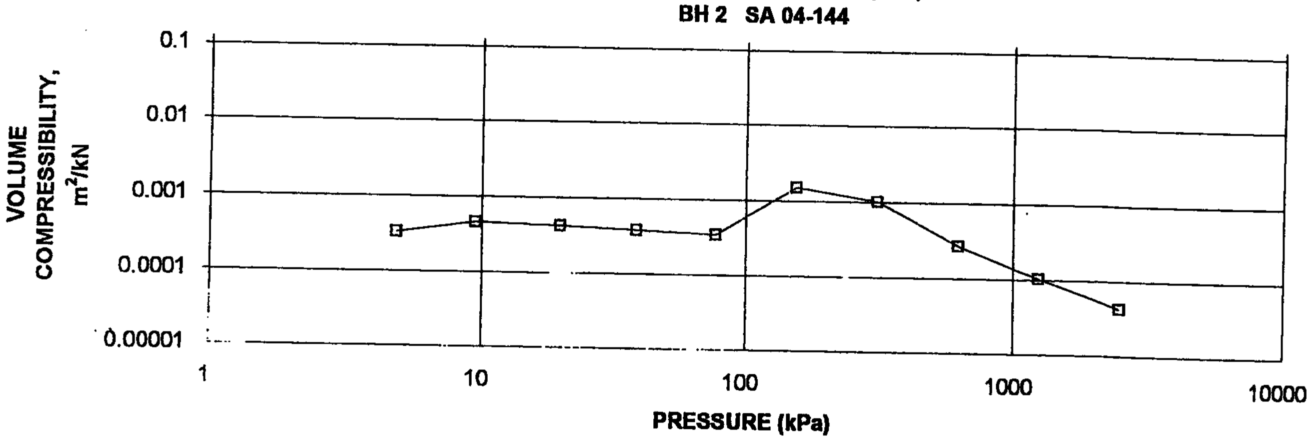
	CONSOLIDATION TEST **Little Savanne River**	Project No.: 03-140
	Borehole 3 Depth: 5.8m Lab No.: 122	Enclosure No.C-1

OEDOMETER CONSOLIDATION SUMMARY

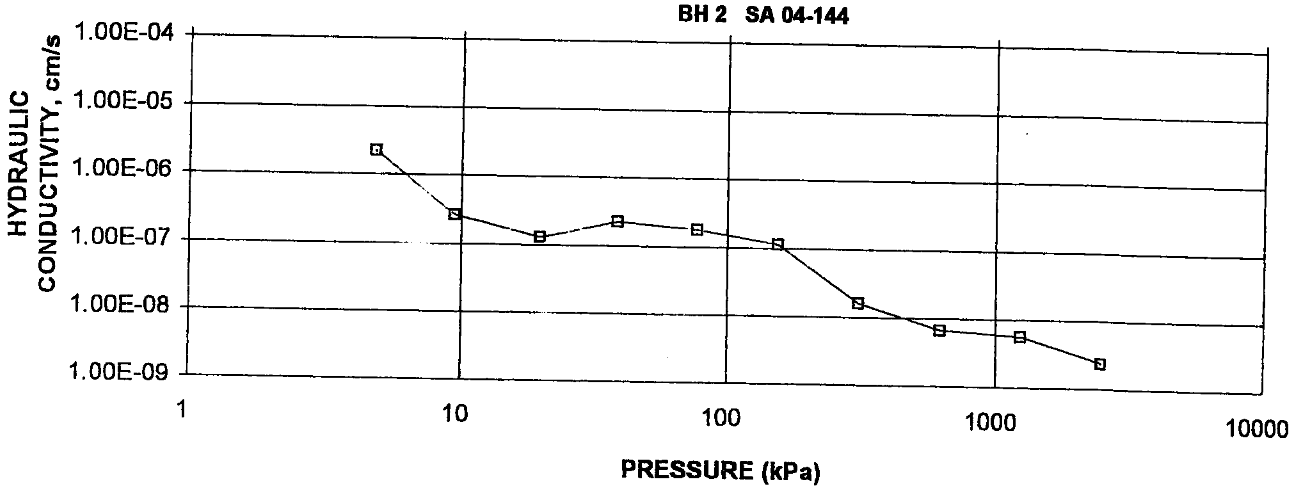
CONSOLIDATION TEST
CV cm^2/s VS PRESSURE (kPa)
BH 2 SA 04-144



CONSOLIDATION TEST
MV m^2/kN vs PRESSURE (kPa)
BH 2 SA 04-144



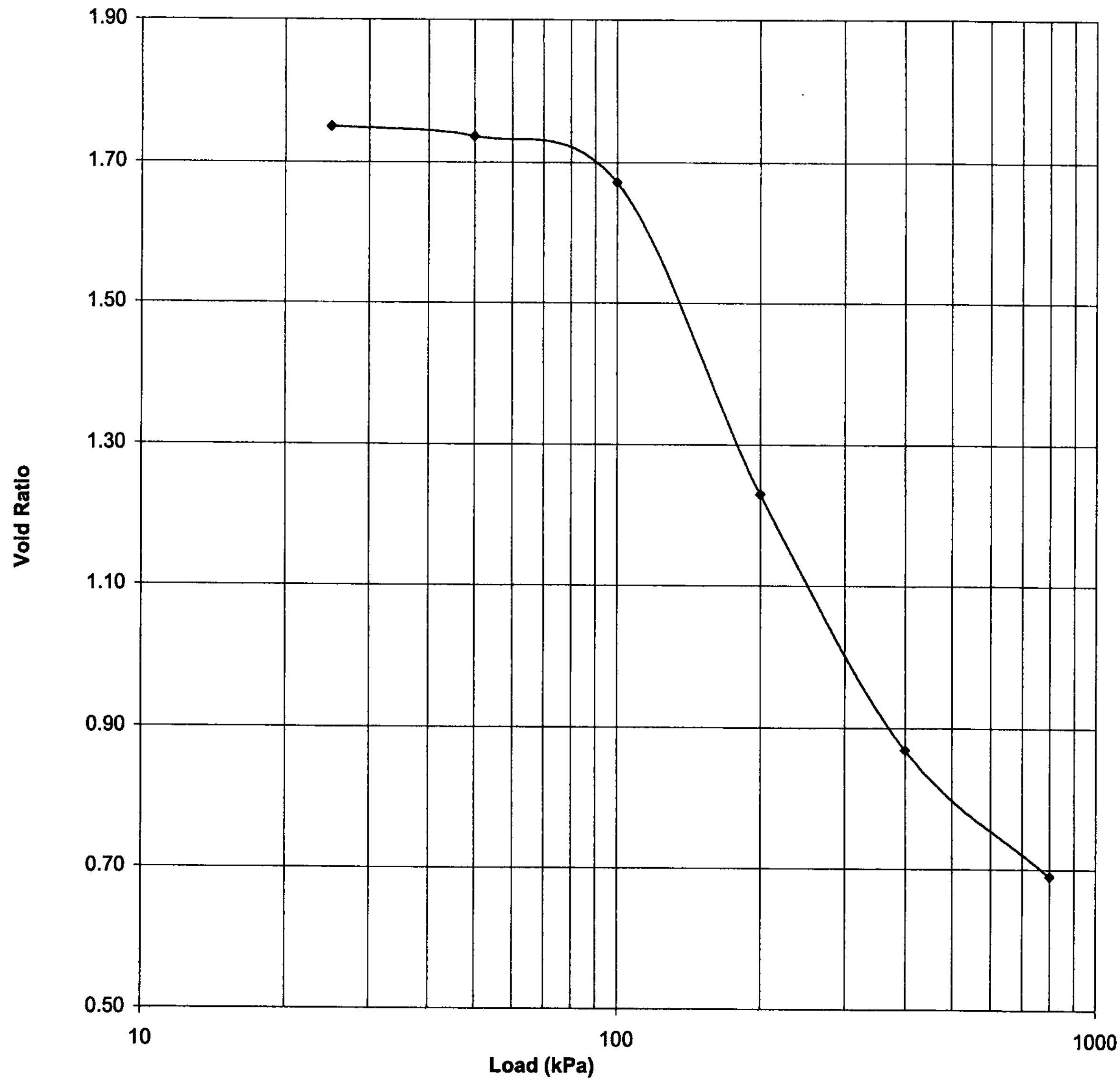
CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH 2 SA 04-144

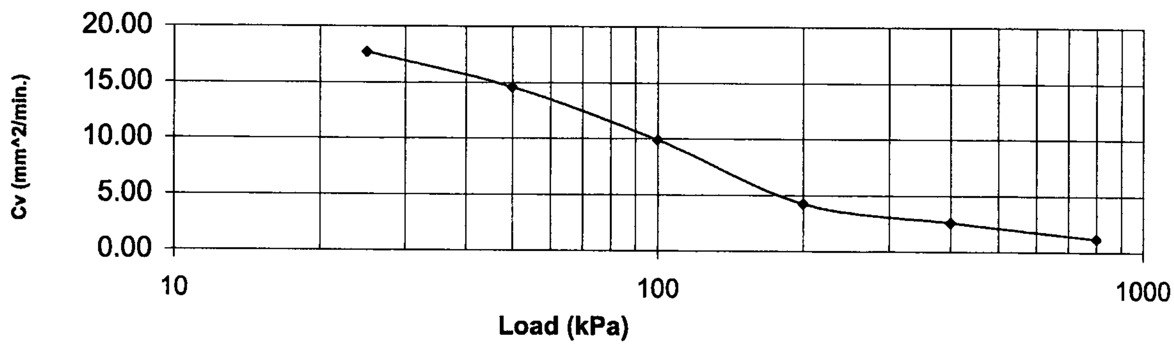


Project No. 04-1116-039
Prepared By: LFG

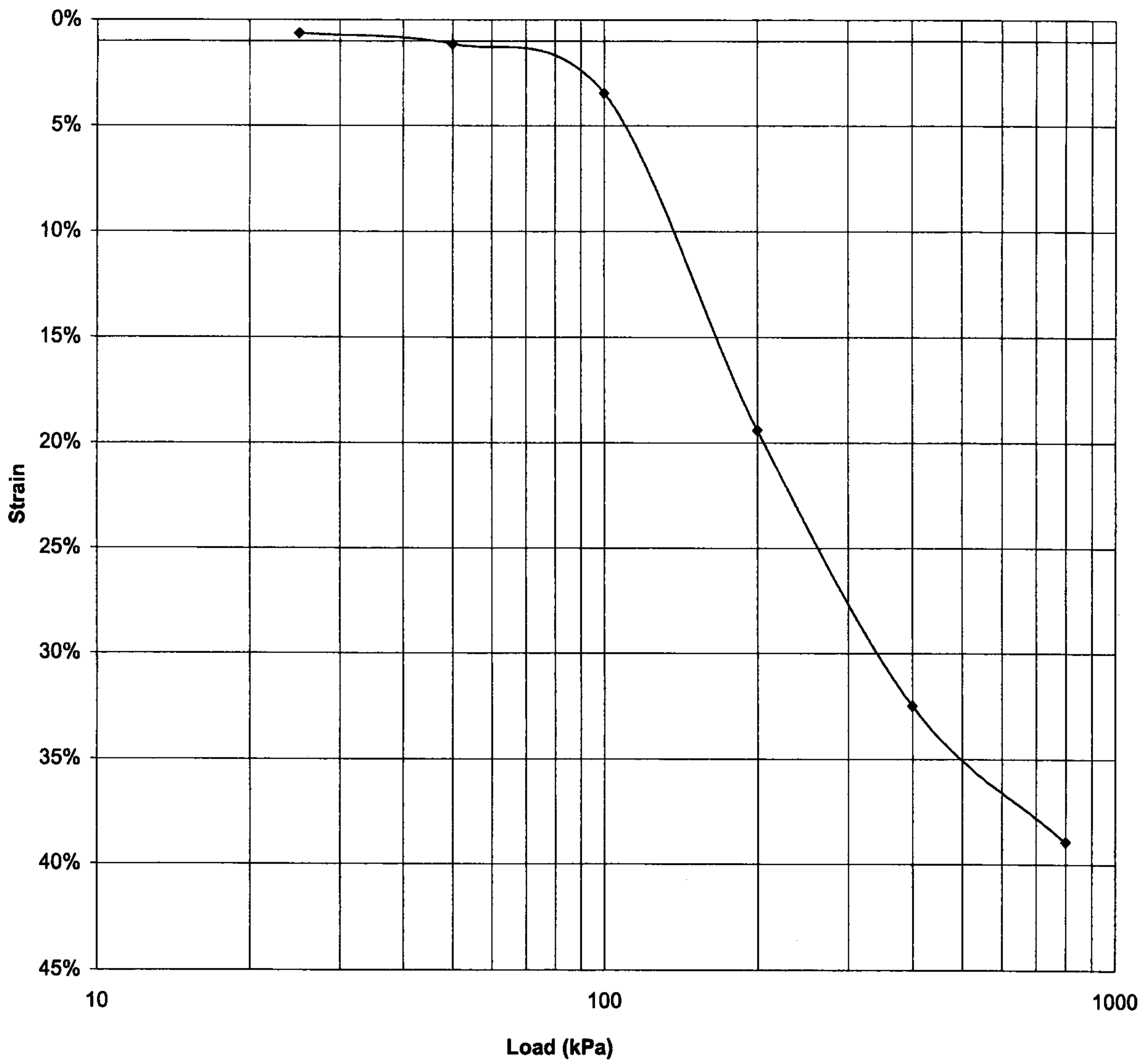
Golder Associates

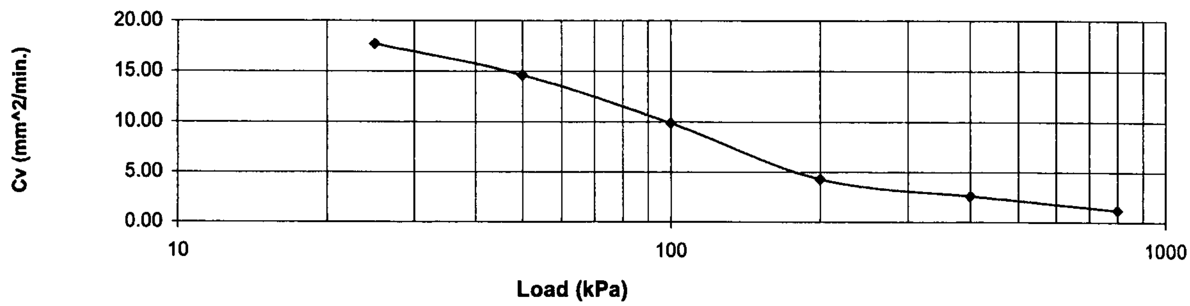
Checkey By: MM





CONSOLIDATION TEST **Little Savanne River**	Project No.: 03-140
Borehole 4 Depth: 5.3-5.9 m Lab No. 58	Enclosure No.C-1





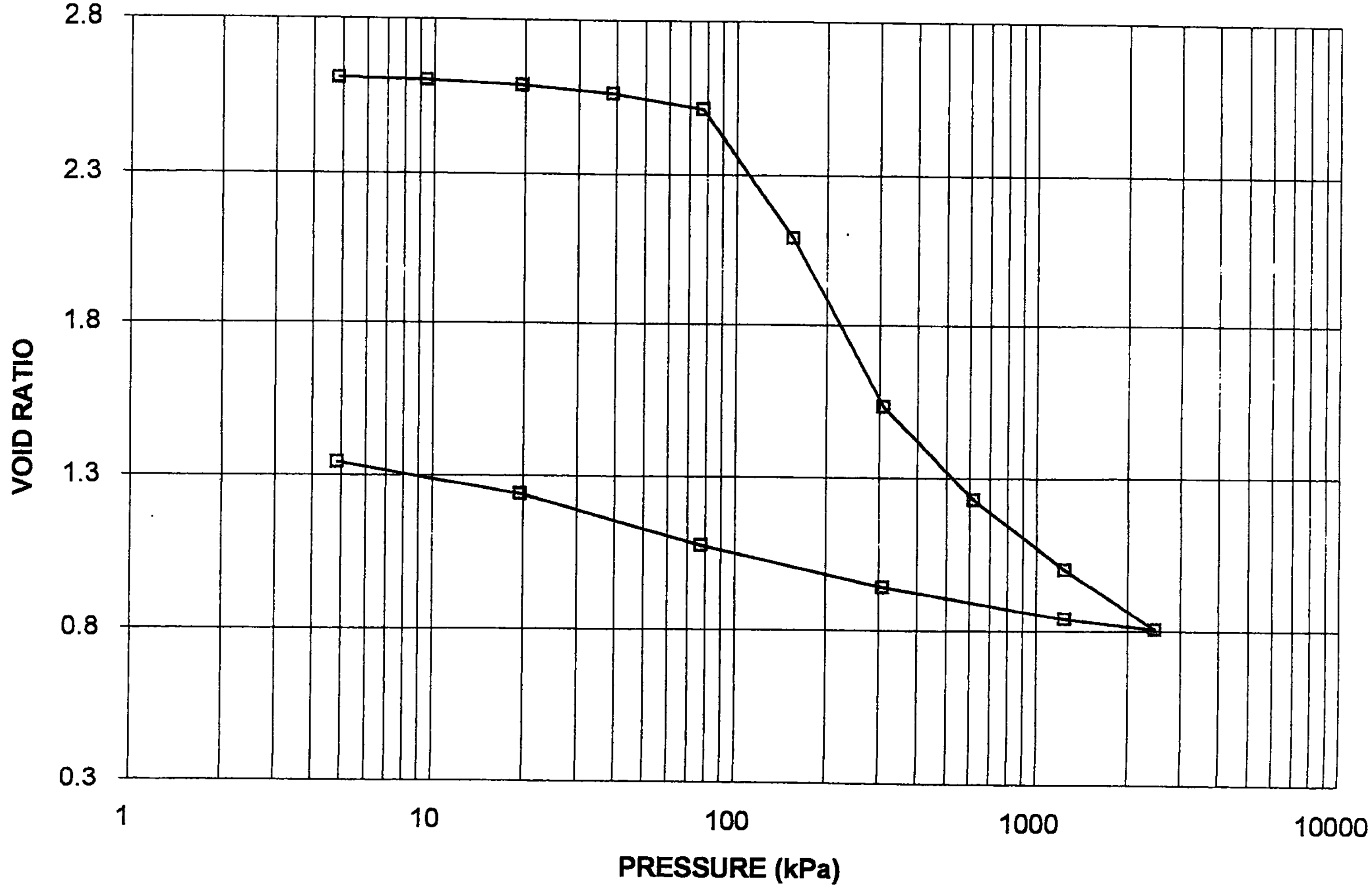
	CONSOLIDATION TEST **Little Savanne River**	Project No.: 03-140
	Borehole 4 Depth: 5.3-5.9 m Lab No.: 58	Enclosure No.C-1

Project No. 04-1116-039
Prepared By: LFG

Golder Associates

Checked By: MM

CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH 2 SA 04-144



CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE

UNCONFINED COMPRESSION TEST (UC)

ASTM D 2166-00

SAMPLE IDENTIFICATION

PROJECT NUMBER	04-1116-039	SAMPLE NUMBER	04-144
BOREHOLE NUMBER	2	SAMPLE DEPTH, m	6.1-6.7

TEST CONDITIONS

MACHINE SPEED, mm/min	1.40	TYPE OF SPECIMEN	
RATE OF AXIAL STRAIN, %/min	1.00	L/D	2.02

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.99	WATER CONTENT, (specimen) %	68.35
SAMPLE DIAMETER, cm	6.94	UNIT WEIGHT, kN/m^3	15.89
SAMPLE AREA, cm^2	37.83	DRY UNIT WT., kN/m^3	9.44
SAMPLE VOLUME, cm^3	529.21	SPECIFIC GRAVITY, measured	2.84
WET WEIGHT, g	857.90	VOID RATIO	0.66
DRY WEIGHT, g	509.59		

FAILURE SKETCH

TEST RESULTS

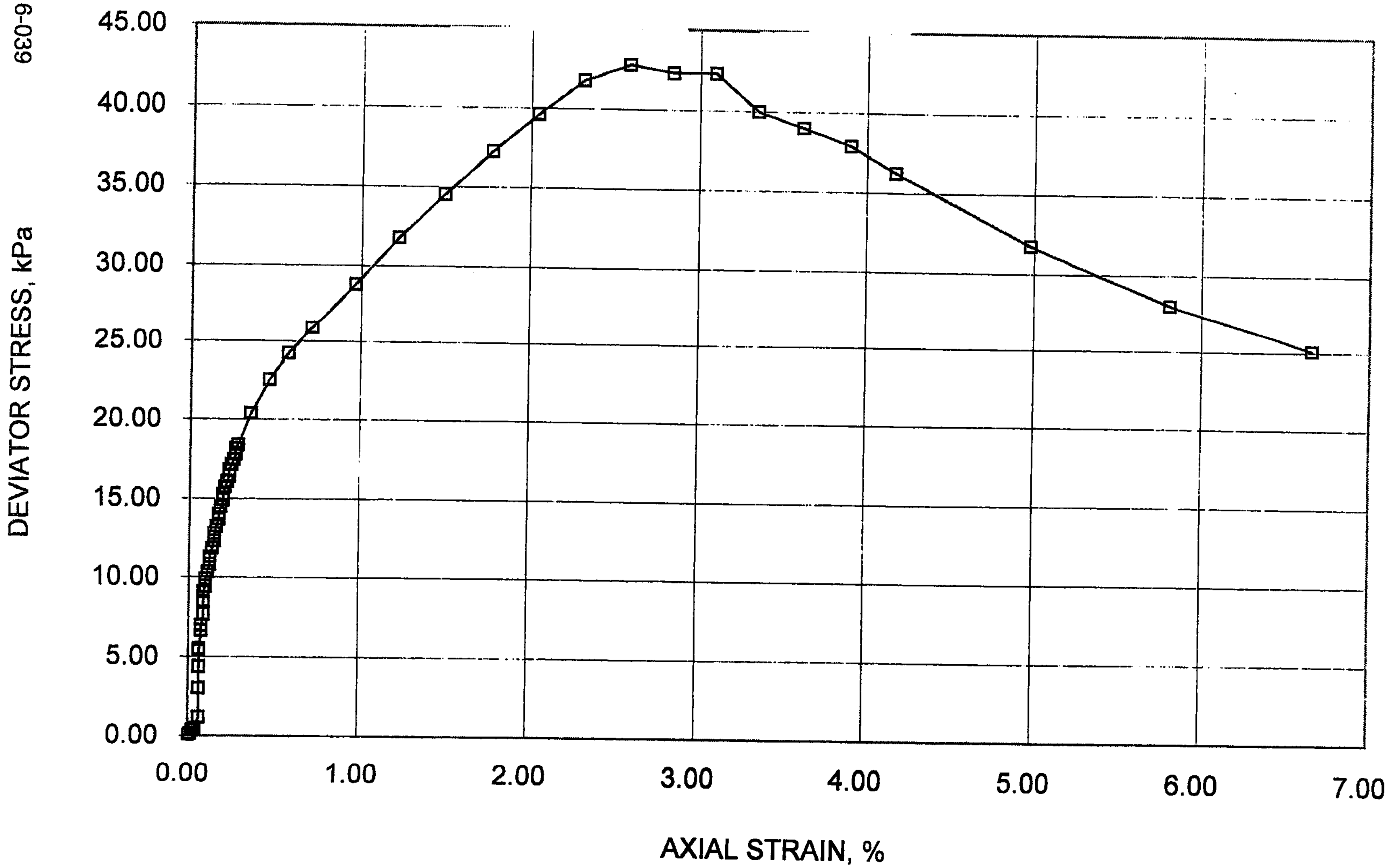
STRAIN AT FAILURE, %	2.6	COMPRESSIVE STRESS, kPa	43

REMARKS:		DATE:	5/5/2004
PREPARED BY:	MM	CHECKED BY:	RO

Golder Associates

Project No. 04-1116-039

BOREHOLE NUMBER 2 SAMPLE NUMBER 04-144 SAMPLE DEPTH, m 6.1-6.7



UNCONFINED COMPRESSION TEST (UC)

FIGURE

UNCONFINED COMPRESSION TEST (UC)

ASTM D 2166-00

SAMPLE IDENTIFICATION

PROJECT NUMBER	04-1116-039	SAMPLE NUMBER	04-068
BOREHOLE NUMBER	4	SAMPLE DEPTH, m	5.3-5.9

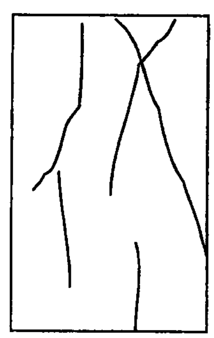
TEST CONDITIONS

MACHINE SPEED, mm/min	1.40	TYPE OF SPECIMEN	
RATE OF AXIAL STRAIN, %/min	1.01	L/D	1.91

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.81	WATER CONTENT, (specimen) %	47.89
SAMPLE DIAMETER, cm	7.24	UNIT WEIGHT, kN/m^3	17.21
SAMPLE AREA, cm^2	41.17	DRY UNIT WT., kN/m^3	11.64
SAMPLE VOLUME, cm^3	568.54	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	998.30	VOID RATIO	0.56
DRY WEIGHT, g	675.03		

FAILURE SKETCH



TEST RESULTS

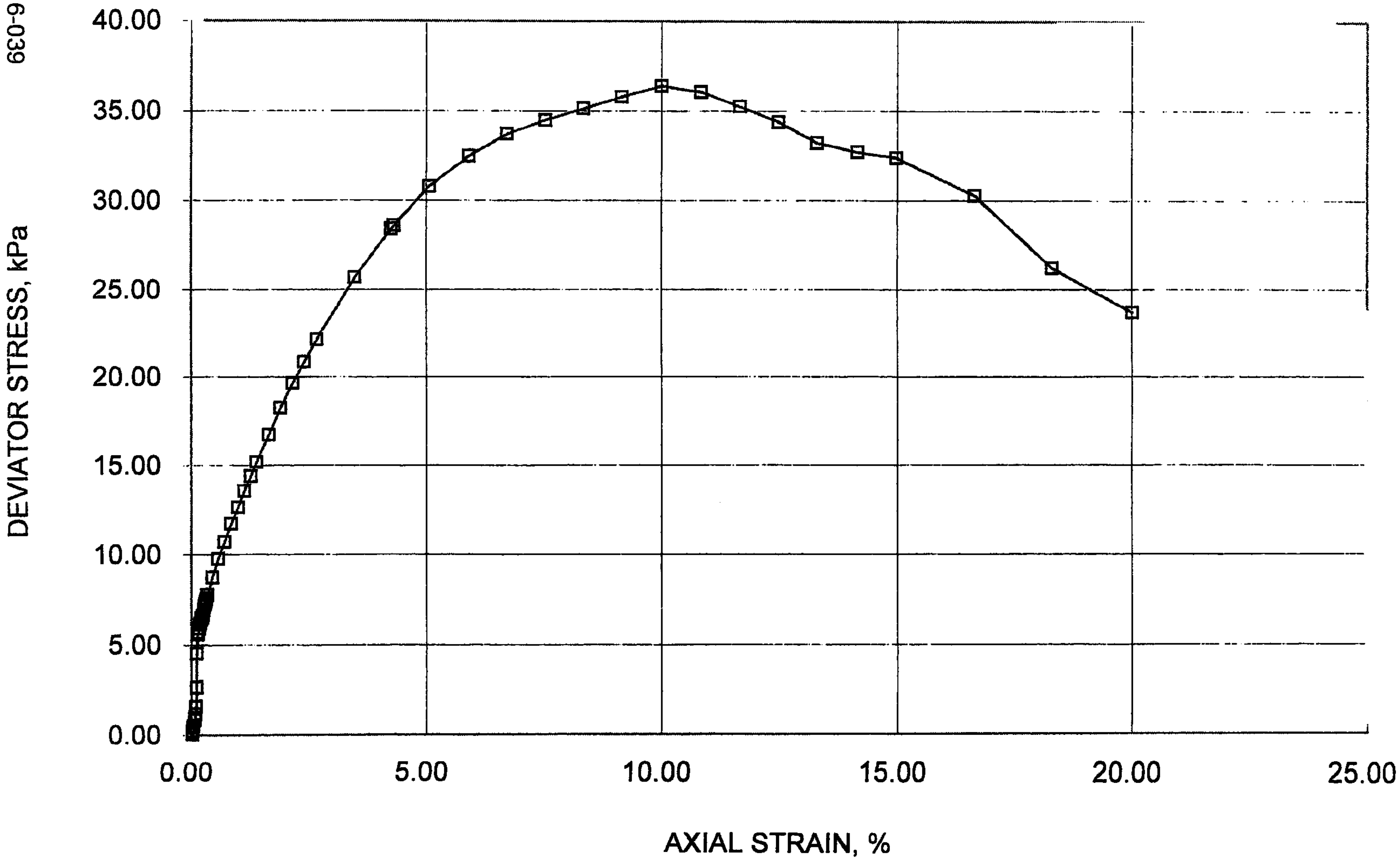
STRAIN AT FAILURE, %	10.0	COMPRESSIVE STRESS, kPa	36

REMARKS:		DATE:	5/5/2004
PREPARED BY:	MM	CHECKED BY:	RO

Golder Associates

Project No. 04-1116-039

BOREHOLE NUMBER 4 SAMPLE NUMBER 04-068 SAMPLE DEPTH, m 5.3-5.9



UNCONFINED COMPRESSION TEST (UC)

FIGURE

SPECIFIC GRAVITY TEST RESULTS

ASTM D 854-00 TEST METHOD A

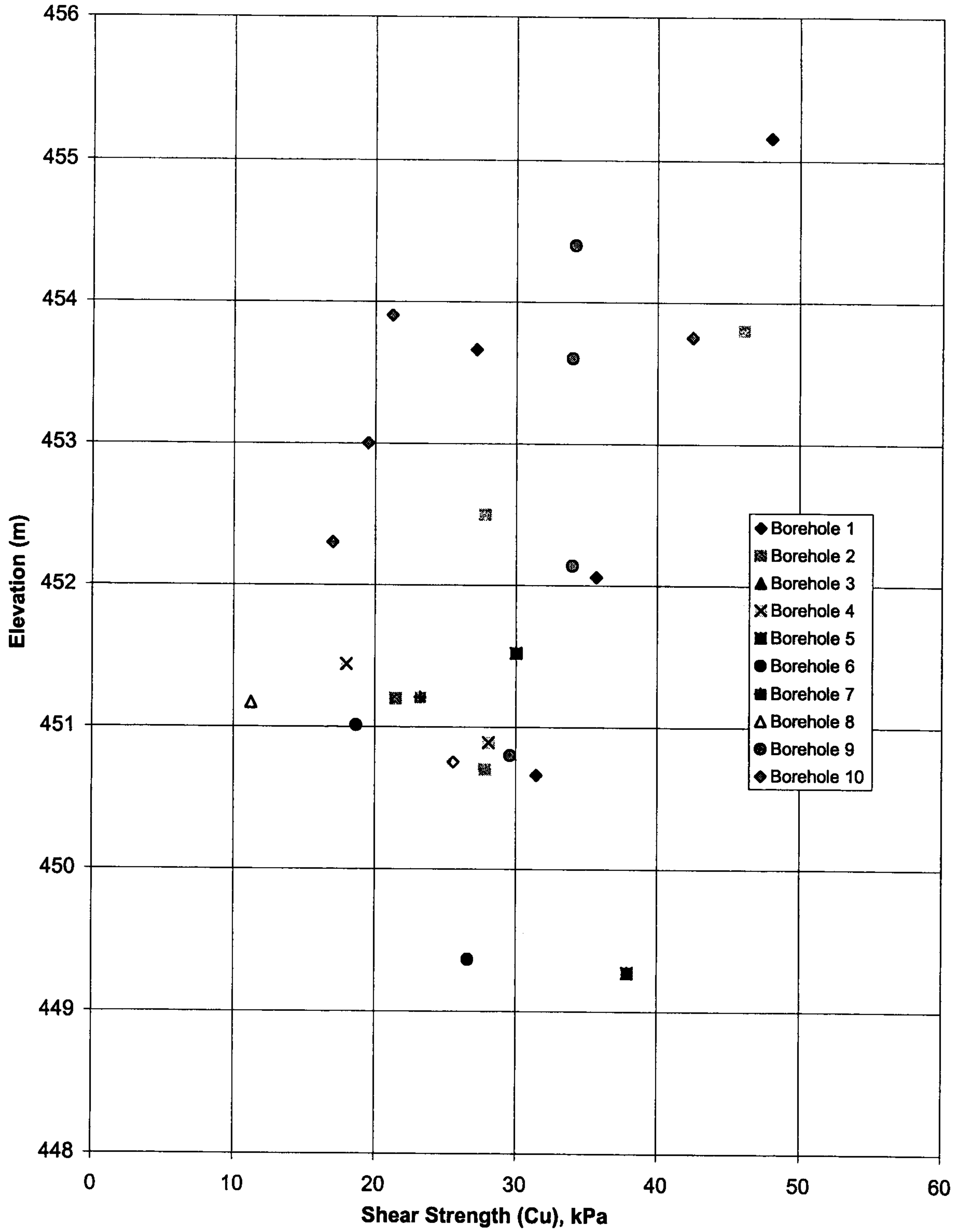
PROJECT NUMBER	04-1116-039
PROJECT NAME	TBT / Lab Testing / P.O. 3438
DATE TESTED	May, 2004

Borehole No.	Sample No.	Specific Gravity
2	04-144	2.84

Note: Test carried out on soil particles <4.75mm using distilled water.

APPENDIX C

Drawings and Figures



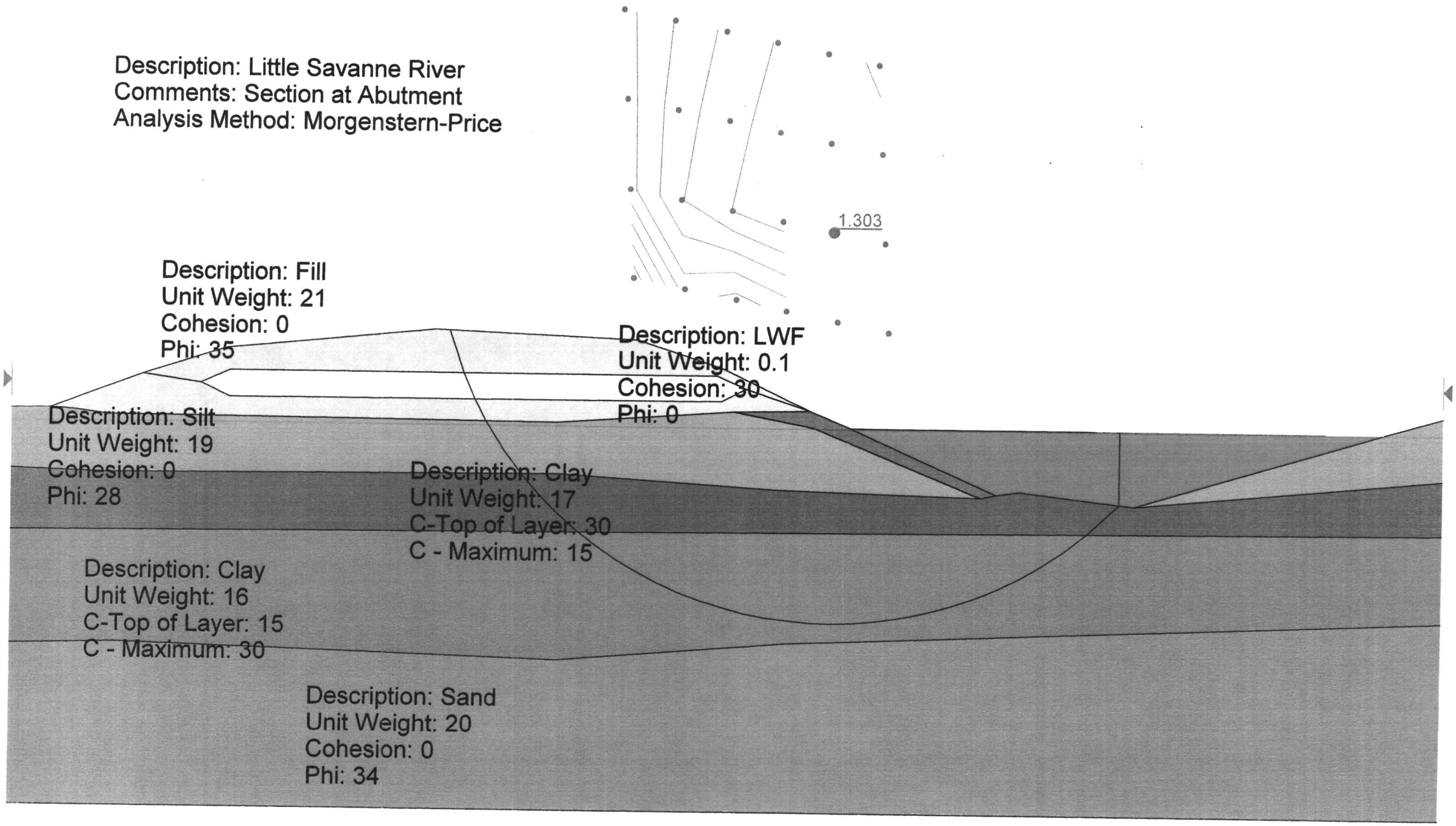
Little Savanne River Bridge

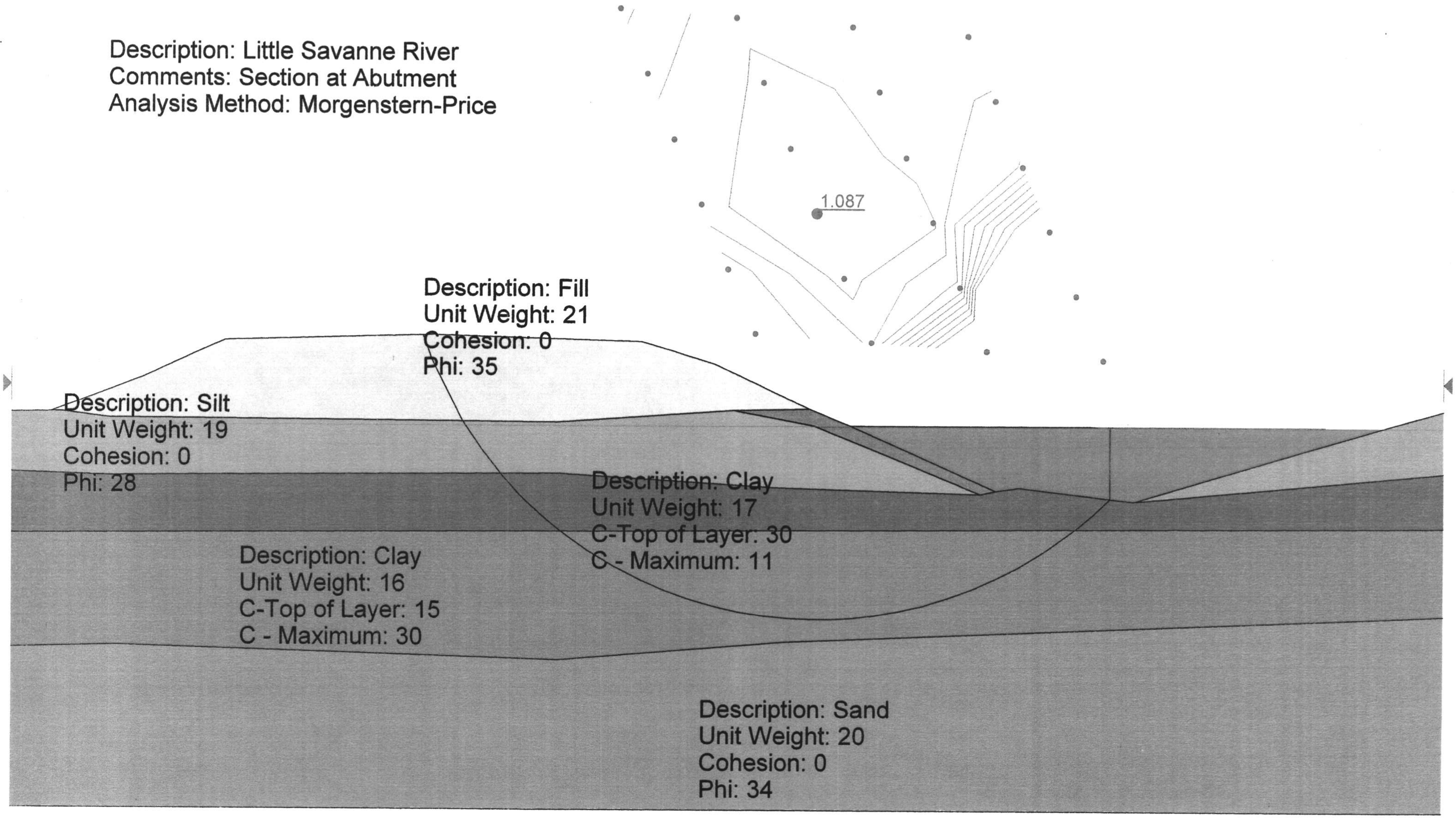
Shear Strength Profile - Clay Strata

TBT ENGINEERING

TBTE Ref. No. 03-140

Figure No.1


Description: Little Savanne River
Comments: Section at Abutment
Analysis Method: Morgenstern-Price
1.303
Description: Fill
Unit Weight: 21
Cohesion: 0
Phi: 35
Description: LWF
Unit Weight: 0.1
Cohesion: 30
Phi: 0
Description: Silt
Unit Weight: 19
Cohesion: 0
Phi: 28
Description: Clay
Unit Weight: 17
C-Top of Layer: 30
C - Maximum: 15
Description: Clay
Unit Weight: 16
C-Top of Layer: 15
C - Maximum: 30
Description: Sand
Unit Weight: 20
Cohesion: 0
Phi: 34


Description: Little Savanne River
Comments: Section at Abutment
Analysis Method: Morgenstern-Price
1.087
Description: Fill
Unit Weight: 21
Cohesion: 0
Phi: 35
Description: Silt
Unit Weight: 19
Cohesion: 0
Phi: 28
Description: Clay
Unit Weight: 17
C-Top of Layer: 30
C - Maximum: 11
Description: Clay
Unit Weight: 16
C-Top of Layer: 15
C - Maximum: 30
Description: Sand
Unit Weight: 20
Cohesion: 0
Phi: 34

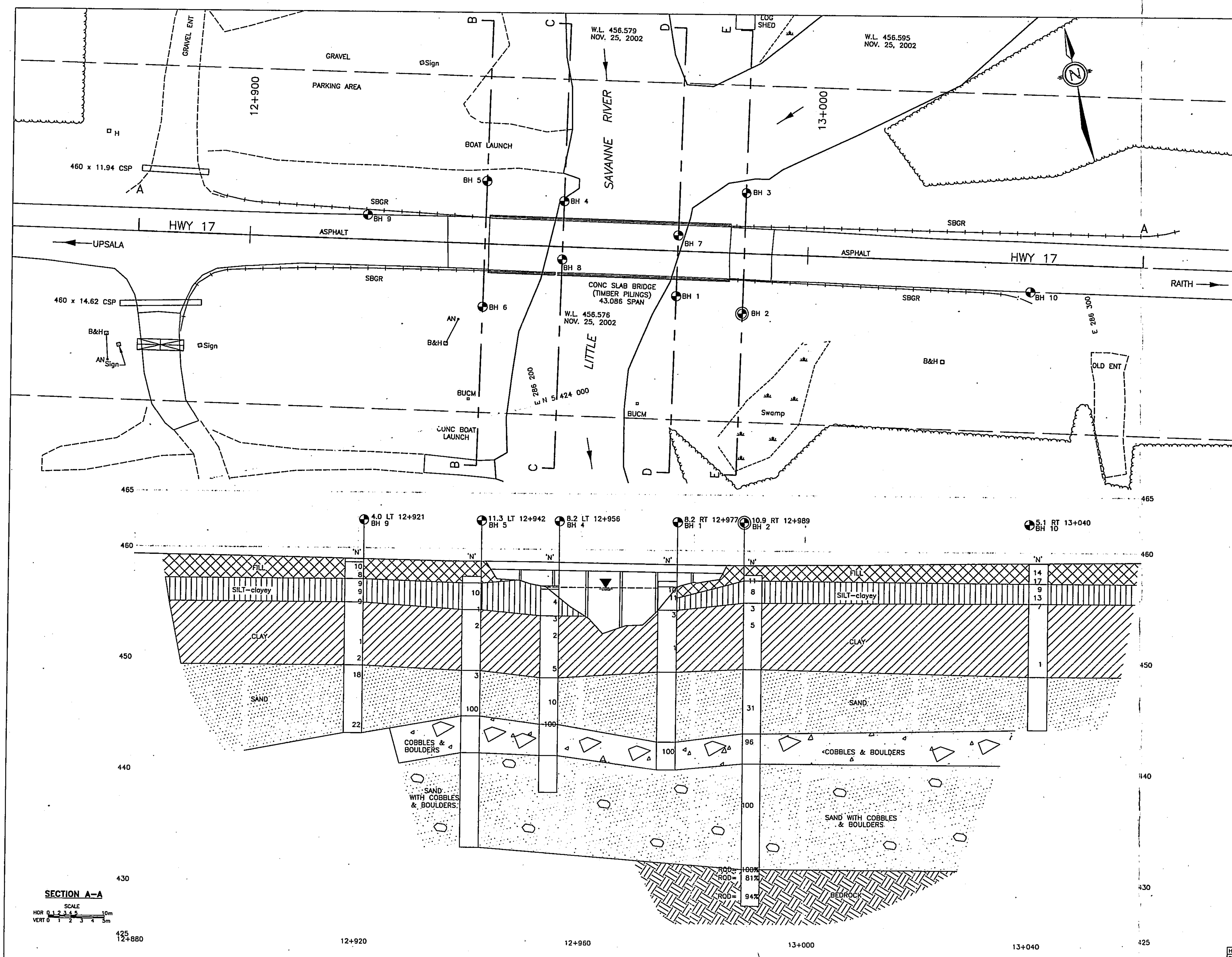
CONT No

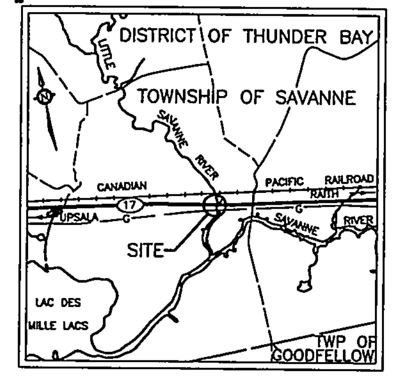
WP NO 198-92-00

LITTLE SAVANNE RIVER BRIDGE
HWY 17, Approx. 18.9km East of Upsala
BORHOLE LOCATIONS AND SOIL STRATA

SHEET 1

TBT ENGINEERING





KEY PLAN

1.0 km 0 1.0 km

SOIL STRATA SYMBOLS

- SAND
- SAND WITH COBBLES
- BEDROCK
- SILT–clayey
- FILL
- COBBLES & BOULDERS
- CLAY

LEGEND

- Borehole
- Borehole with Rock Core
- 'N' Std Pen Test (Blows/0.3m)
- WL at time of investigation FEB 2004

No	ELEVATION	BOREHOLE LOCATION STA.	O/S
1	457.2	12+977	8.2 RT
2	457.3	12+989	10.9 RT
3	457.1	12+989	10.9 LT
4	456.7	12+956	8.2 LT
5	457.5	12+942	11.3 LT
6	457.8	12+942	11.4 RT
7	456.8	12+977	2.8 LT
8	456.6	12+956	2.3 RT
9	459.0	12+921	4.0 LT
10	459.0	13+040	5.1 RT

HORIZONTAL DATUM
North American Datum 1983 (NAD83)(CSRS)
3 Degree Modified Transverse Mercator
(MTM Zone 15) Grid Coordinates

VERTICAL DATUM
Canadian Geodetic Vertical Datum
1928 Adjustment, Geodetic Elevations

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

REVISIONS

DRAWING REFERENCED FROM PLAN B&C-1039-17-3, HWY 17, TWP OF SAVANNE 12+698.832 TO 13+410.078, NOV 2002, MINISTRY OF TRANSPORTATION, NORTHWEST REGION

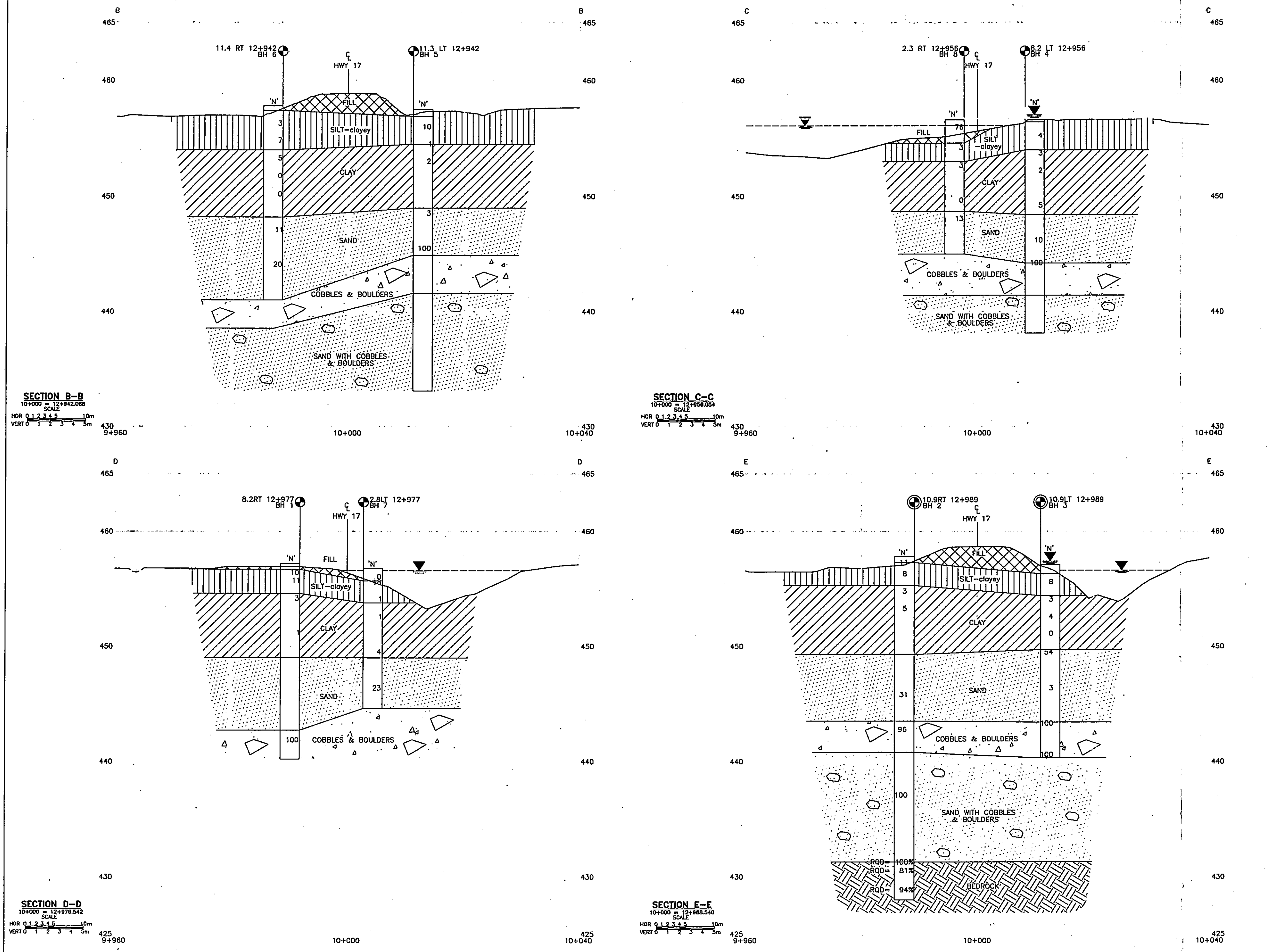
HWY 17 LITTLE SAVANNE RIVER BRIDGE				DIST	THUNDER BAY
SUBM'D	WH	CHECKED	DATE JUNE 2004	SITE	
DRAWN	CZ	CHECKED	APPROVED	DWG	2

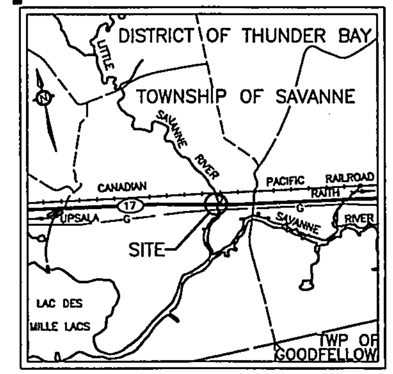
CONT No
WP NO 198-92-00

LITTLE SAVANNE RIVER BRIDGE
HWY 17, Approx. 18.9km East of Upsala
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 2

TBT ENGINEERING





KEY PLAN
1.0 km 0 1.0 km

SOIL STRATA SYMBOLS

SAND — SAND WITH COBBLES — BEDROCK — SILT-clayey — FILL — COBBLES & BOULDERS — CLAY

LEGEND

Borehole
Borehole with Rock Core
'N' Std Pen Test (Blows/0.3m)
WL at time of Investigation FEB 2004

No	ELEVATION	BOREHOLE LOCATION STA.	O/S
1	457.2	12+977	8.2 RT
2	457.3	12+989	10.9 RT
3	457.1	12+989	10.9 LT
4	456.7	12+956	8.2 LT
5	457.5	12+942	11.3 LT
6	457.8	12+942	11.4 RT
7	456.8	12+977	2.8 LT
8	456.6	12+956	2.3 RT
9	459.0	12+921	4.0 LT
10	459.0	13+040	5.1 RT

HORIZONTAL DATUM
North American Datum 1983 (NAD83)(CSRS)
3 Degree Modified Transverse Mercator
(MTM Zone 15) Grid Coordinates

VERTICAL DATUM
Canadian Geodetic Vertical Datum
1928 Adjustment, Geodetic Elevations

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

REVISIONS

DRAWING REFERENCED FROM PLAN B&C-1039-17-3, HWY 17, TWP OF SAVANNE 12+698.632 TO 13+410.078, NOV 2002, MINISTRY OF TRANSPORTATION, NORTHWEST REGION

HWY 17 LITTLE SAVANNE RIVER BRIDGE			DIST THUNDER BAY
SUBM'D WH	CHECKED	DATE JUNE 2004	SITE
DRAWN CZ	CHECKED	APPROVED	DWG 3

Foundation Investigation Report

Bridge Structure
Little Savanne River

GWP 198-92-00

Highway 17
18.9 km east of Upsala

MTO Site No.: 48W-16
Geocres No.: 52B-12

Prepared for
Ministry of Transportation, Northwestern Region

Prepared By:

TBT Engineering
314-101 Syndicate Ave. N
Thunder Bay, Ontario
P7C 3V4

August 2004

Ref. No. 03-140

Table of Contents

GEOCRES No:

52B-12

July 23/04

Part A FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering was retained by Stantec Consulting Ltd. to provide Foundation Engineering services for the proposed Little Savanne River Bridge replacement east of Upsala, Ontario. The design work is being undertaken as part of a Total Project Management assignment between Stantec and the Ministry of Transportation, Northwestern Region.

A foundation investigation was carried out to investigate subsurface conditions at the proposed structure site and at the approaches to the structure. The investigation consisted of a number of boreholes drilled in the vicinity of the proposed new structure, laboratory testing and geotechnical analysis of the data. This report provides a summary of that work and of the conditions encountered.

The Little Savanne River Bridge is identified as MTO Site 48W-16. It is located on Highway 17, 18.9 km east of Upsala, Twp. of Savanne, Sta 12+960, District 61, Thunder Bay.

The MTO Pavements and Foundations Section has assigned Geocres Number 52B-12.

2 Site Description

The site is located on Highway 17 approximately 18.9 km east of the east boundary of Upsala, Ontario. At this location Highway 17 runs in a generally east-west direction. The Little Savanne River flows southerly, into the Savanne River and into Lac Des Milles Lacs.

The area surrounding the bridge site is rural and generally covered with mixed bush. The terrain in the immediate surrounding area is flat and swampy. A tourist camp/outfitter is located on the southwest corner of the site.

The quaternary geology of the site is mapped (Ministry of Northern Development and Mines, Ontario Geological Survey, Map 2554) as recent fluvial deposits, including gravel, sand, silt and clay deposited on modern flood plains. Directly north of the site, the area is mapped as glacio-fluvial outwash deposits, gravel and sand. Bedrock geology in the vicinity is mapped (Ontario Geological Map No. 2199) to include Early Pre-Cambrian felsic metamorphic and igneous rock.

The current river channel is about 25 m wide and about 4 m deep at the structure. The existing bridge structure is constructed of closely spaced timber bents.

The highway grade is relatively flat, with a slight sag centered near the bridge location. The existing approach embankments are about 2.4 m above the river water level at the abutments. Photos of the site (from MTO project documentation files) are provided on Page 3.

East View, South Side

East View, North Side

3 Investigation Procedures

A site investigation was undertaken between February 16 and May 28, 2004. A total of 10 boreholes were drilled for the project at the locations indicated on the Borehole Location Plan (Enclosed). Three different drill rigs were mobilized to the site due to access and soil conditions.

A truck mounted CME 55 was used for boreholes drilled from the pavement grade and for accessible off-road boreholes. A skidder mounted Acker SX-70 drill was mobilized for scheduling purposes, and to those boreholes that were not accessible to the truck mounted drill. A large well drilling rig was used to advance holes through dense cobbles and boulders.

The boreholes were advanced using various methods depending on conditions encountered, proximity to the river and access conditions. A summary of the drill methods used is provided in Table 1.

Soil samples were obtained using the techniques of the Standard Penetration Test (SPT). The SPT involves driving a thick walled split spoon sampler into the soils under a standardized energy (63.5 kg, drop height 760 mm). The number of blows required to drive the sampler 0.3 m (after 0.15 m set) is recorded and is known as the SPT blow count (N). A representative disturbed soil sample is obtained from within the sampler.

Relatively undisturbed samples of cohesive deposits were obtained using Shelby tube samplers. Thin walled tubes are hydraulically pushed into the sub-soils and a clay sample is obtained. The samples were preserved in the field and transported to the laboratories for testing.

In-situ field shear (vane) measurements were taken at various depths, to aid in determining the consistency of clay materials. The field vane test involves advancing a standardized vane shaped probe into the soils at the base of the test hole and applying a torque to the vane. The torque required to shear a cylindrical element of soil is determined and used as a measure of the in situ vane shear strength of cohesive soils.

Both peak and ultimate shear strengths are measured. The ratio of the peak (undisturbed) to the ultimate (disturbed) shear strength is known as the sensitivity of the soil.

Rock core samples were obtained from the bedrock using a NQ sized core barrel. Bedrock samples were stored in core boxes for review. Total recovery and rock quality designation values were determined.

The boreholes were drilled to effective refusal, ('N' values of more than 100 blows/0.3 m), to 3 m past effective refusal, (14.9 m beyond refusal in the case of BH 2) or to where conditions made further advancement impractical or impossible. In many cases multiple attempts/boreholes were required at a single location to advance the borehole to the final depth. Borehole elevations and drill comments are provided in Table 1.

Borehole locations and elevations were measured using routine survey methods. Horizontal northings and eastings were calculated from highway chainages and are provided on the Borehole Location Drawing and in Table 2 below. Borehole elevations were referenced to the pavement surface at the centre of the existing bridge. (Elevation 458.77 m).

Soil samples were returned to TBT Engineering's laboratory for testing. Routine testing included moisture content, Atterberg Limit and grain size analysis. Complex testing included consolidation tests and unconfined compressive strength tests. Results of this testing are shown on the Records of Boreholes (Appendix A) and/or on the laboratory data reports (Appendix B).

Table 1. Drill Summary

Location	Surface Elev. (m)	Depth (Elev.) of Borehole (m)	Drill Method	Observations
BH 1	457.2	17.0 (440.2)	Hollow Stem Auger Diamond Rotary	Borehole terminated in cobbles and boulders. (Casing sheared off)
BH 1R	457.2	16.7 (440.5)	Hollow Stem Auger Diamond Rotary	Borehole terminated in cobbles and boulders. (Casing sheared off)
BH 2	457.3	29.8 (427.5)	Hollow Stem Auger Diamond Rotary	Auger Refusal @ 14.9 m. Bedrock encountered @26.5 m Cobbles and boulders @ 14 m Diamond drilling very slow numerous cobbles and boulders
BH 3	457.1	16.8 (440.3)	Hollow Stem Auger Diamond Rotary	Auger Refusal @ 13.7 m. Diamond drilling very slow numerous cobbles and boulders
BH 4	456.7	18.6 (438.1)	Hollow Stem Auger Water Well Rig	Auger Refusal @ 14.1 m Well Drill used through cobbles
BH 5	457.5	15.9 (441.6)	Hollow Stem Auger Water Well Rig	Auger Refusal @ 12.8 m Well Drill used through cobbles Steel casing deformed in cobbles.
BH 6	457.8	16.8 (441.0)	Hollow Stem Auger	Auger Refusal @ 16.8 m
BH 7	456.8	12.2 (444.6)	Hollow Stem Auger	Through Bridge Deck Auger Refusal @ 12.2 m
BH 8	456.6	11.6 (445.2)	Hollow Stem Auger	Through Bridge Deck Borehole terminated due to blowing sand
BH 9	458.9	15.7 (443.2)	Hollow Stem Auger	West Approach Embankment
BH 10	459.0	15.7 (443.3)	Hollow Stem Auger	East Approach Embankment

All boreholes were backfilled with a cement-bentonite grout. Boreholes drilled through the embankment were backfilled through the pavement structure with the excavated sand and gravel. The shoulder asphalt surface was replaced with cold-mix asphalt.

At Boreholes 3 and 4, slight artesian pressures (0.3 m above grade) were noted from depths near 12 to 14 m. (Approximate elevation 445 m). A bentonite seal was used to control the artesian pressure and the boreholes were backfilled above the seal with a cement bentonite grout.

Table 2 Borehole Locations

BH No.	Station	o/s		Northing	Easting
1	12+977	8.2	Rt	5424013.8	15 286227.6
2	12+989	10.9	Rt	5424008.1	15 286238.5
3	12+989	10.9	Lt	5424029.1	15 286244.0
4	12+956	8.2	Lt	5424034.9	15 286211.9
5	12+942	11.3	Lt	5424041.4	15 286199.2
6	12+942	11.4	Rt	5424019.6	15 286193.4
7	12+977	2.8	Lt	5424024.4	15 286230.4
8	12+956	2.3	Rt	5424024.7	15 286209.3
9	12+921	4.0	Lt	5424040.2	15 286177.1
10	13+040	5.1	Rt	5424000.6	15 286289.7

4 Subsurface Conditions

Details of the subsurface conditions are provided on the Record of Boreholes, Appendix A, and on the enclosed Subsurface Section Plan.

In general, the native subsurface conditions at the site consist of approximately 7 to 10 m of silt and clay. Below the fine-grained soils are is a zone of sand underlain with layered deposits of sand, gravel, cobbles and boulders. Bedrock was proven 26.5 m below grade (BH2) at elevation 430.8m.

The existing roadway embankment is about 1.9 m high consisting of the asphalt and granular base over sand and gravel sub-base and embankment fills. A thin surficial covering of topsoil (20-50 mm) is present over much of the exposed embankment.

Groundwater levels generally correspond to the level of the Little Savanne River (456.6m). Slight artesian pressures were present at two of the boreholes (3 and 4).

4.1 Fill

All boreholes encountered deposits of fill materials that are associated with the Highway 17 pavement structure and embankment grading. The pavement surface consists of 90 to 150 mm of hot mix asphalt. The granular fill includes approximately 0.8 m of granular base and sub-base overlying sand sub-grade fill to approximately 2.4 m below the pavement grade (Elev. 456.4 m +/-).

4.2 Clayey Silt

A deposit of clayey silt underlies the fill at all boreholes. The silt is brown/grey in color and of a soft to stiff consistency. Standard Penetration Test blow counts recorded in the silt were in the range of 3 to 11 blows /0.3 m.

The silt is found from near the base of the fill to approximately 2.5 to 2.8 m below grade (Elev. 453.2 to 454.8 m). Grain size data (Appendix B, Enclosure 1) indicates the silt contains between 8 and 30 % clay sizes and traces of sand. Atterberg Limit testing

(Appendix B, Enclosure 4) indicates these soils are non-plastic to slightly plastic (CL-ML). Natural moisture contents are generally greater than the liquid limits of the soil. The deposit is frequently varved or layered, with seams of varying plasticity. Seams of clay are present at increasing frequency with depth.

4.3 Clay

The silt changes gradually with depth to a soft to firm, medium to high plastic clay. The clay is frequently varved and brown /grey in colour. The clay becomes red/brown or red/grey with depth. The clay is present to depths in the order of 7.8 to 9.6 m below grade (elev. 448.2 to 449.7 m). Atterberg limit testing (Appendix B, Enclosure 5) indicates the natural moisture content of the clay as normally at or above the liquid limit.

The measured shear strength in the clay is variable, with strengths dependent on layering, plasticity and depth. Field vane shear strengths in the clay were in the order 15 to 53 kPa (average 37). The corrected vane shear strengths are in the order of 11 to 36 kPa. Shear strength sensitivities in the clay were between 2 and 5. Compressive strength testing indicated un-drained, unconfined compressive strengths of 36 and 43 kPa. There is a pronounced zone of softer clay (shear strength 11 to 20 kPa) near mid depth of the deposit. The softer clays tend to be red in colour, with much less layering, and are slightly fissured. A plot of the shear strength distribution with depth is provided on Figure 1 in Appendix C.

Several consolidation tests were completed using samples from this deposit. These tests indicate the clay is slightly over-consolidated and rather compressible (Table 3). In the stress range equivalent to the anticipated grade raise, volume compressibilities (m_v) in the order of 3.4 to 4.6 x10^{-3} m^2/kN ($1/m_v$=M=2.1 to 2.9 MPa) were measured. Test reports for the consolidation and compressive strength testing are provided in Appendix B.

Table 3 Clay - Consolidation Properties

Borehole No.	Depth (m)	Pre-consolidation Pressure	Estimated OCR
1	4.9	110	2.8
2	6.5	90	1.7
3	5.7	120	2.6
4	5.8	105	2.4

4.4 Sand

The clay is underlain by a deposit of grey/brown sand. The sand is fine to coarse grained and contains variable amounts of silt and gravel sizes with traces of clay sizes. In some zones the silt fraction was close to 50%, classifying these materials as sand and silt.

The sand was subject to blow-up into the hollow stem augers while drilling, consistent with a fine grained and cohesionless material under hydraulic pressure. Representative SPT 'N' values indicated that the deposit is in a compact to dense condition.

The sand is present to a depth of approximately 12.2 to 16.8 m below grade (elev. 442.7 to 444.7 m).

4.5 Cobbles and Boulders

The sand as described above becomes much coarser with numerous cobbles and boulders present. Based on recovery of core drill samples and behavior of the drill, the cobbles and boulders fraction is in the order of 40 to 60% of the deposit. Boulders in excess of 700 mm diameter are present. This coarse deposit is approximately 3 to 4 m in thickness (where penetrated), and is present from elevations 442.7 to 444.7 m. The hollow stem augers could not penetrate this material and SPT blow counts were typically in the order of 100+ blows /0.3 m with the hammer bouncing on the coarse cobbles and boulders.

Diamond coring drilling methods used in this material were very slow, resulting in numerous casing breaks and bit loss. A large well drilling rig was used to advance two of the holes beyond refusal depths. Steel well casing used at Boreholes 4 and 5 was damaged advancing through the cobbles and boulders.

4.6 Sand with Cobbles and Boulders

The granular deposit becomes somewhat finer with depth. Below approximately 440.3 to 442.4 m (depending on location) the fraction of cobbles and boulders decreases, such that the deposit is classified as grey sand, with cobbles and boulders. The fraction of cobbles and boulders was estimated to be between 20 and 30%.

The well drill advancement rates were somewhat faster in this deposit, as compared to the overlying cobble and boulder layer. (20 to 85 sec/0.3m versus 100 to 200 sec/0.3m).

4.7 Bedrock

Bedrock was confirmed with core sampling at Borehole 2. The bedrock consists of a felsic intrusive granitic rock (Granodiorite). The bedrock was of excellent quality with total core recovery of 100% and Rock Quality Designations (RQD) of between 81 and 100%.

4.8 Groundwater

Groundwater was noted to correspond to the level of the Little Savanne River, 456.6m at most boreholes. This level should be expected to fluctuate with changes in the seasons, precipitation patterns and with variations in the Little Savanne River levels.

At Boreholes 3 and 4, slight artesian pressures were noted in the sands near 12 to 14 m depth (approximate elevation 445 m). The groundwater in the augers or casing rose to about 0.3 m above grade (457.4 and 457.0 m).

5 Limitations

Conclusions and recommendations presented in this report are based on the information determined at the test hole locations. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

Benchmarks and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

Groundwater levels indicated are based on the information described within the report. Conditions that could affect the type and scope of dewatering procedures cannot all be readily determined from boreholes. This includes local and seasonal fluctuations of the groundwater level, changes in soil conditions between test locations, thin and/or discontinuous layers of highly permeable soils, etc.

The information contained within this report in no way reflects any environmental aspect of the site or soil.

6 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate the contact us at your convenience.

Yours truly,
For TBT ENGINEERING

Prepared by:

Wayne Hurley, P.Eng
Vice-President, Engineering

Reviewed By:

Dieter Eigenbrod, PhD., P.Eng

References

1. Barnett, P.J., Henry, A.P., and Babuin, D., 1991, Quaternary Geology of Ontario, West Central Sheet, Ontario Geological Survey, Map 2554

2. Ontario Department of Mines ands Northern Affairs, Ontario Geological Map, West Central Sheet, Map 2199

APPENDIX A

RECORD OF BOREHOLES

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX $= w_L - w_P$
I_L	1	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE
e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n-PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Ministry of Transportation Ontario

TBT Engineering

RECORD OF BOREHOLE No 1

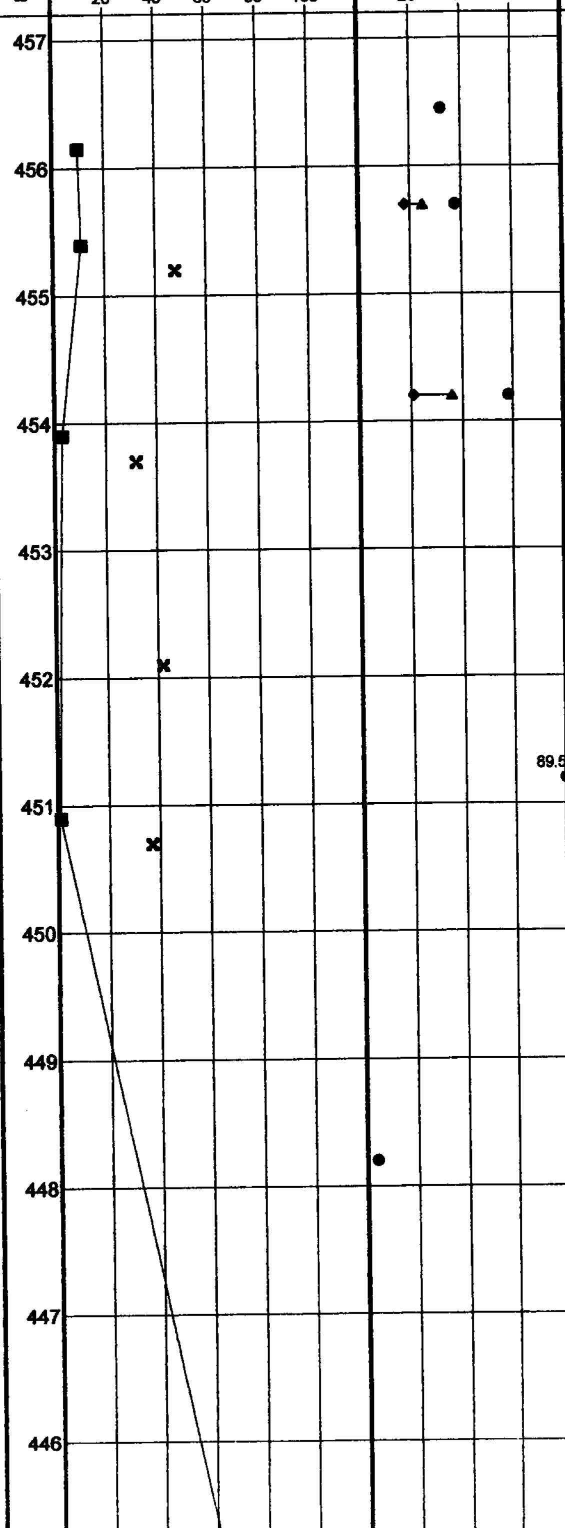
METRIC

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16
DIST	61 HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140
DATE	16 February 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM	Geodetic

ORIGINATED BY JN
COMPILED BY SP
CHECKED BY WH

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
457.2 / 0.0	FILL - fine to coarse gravelly sand, some silt, occasional cobbles, brown to grey, moist				▼	25mm of topsoil
456.7 / 0.5	SILT - clayey, trace sand, grey, firm, (ML-CL)					0 2 69 29
		1	SS	10		
						0 12 73 16
		2	SS	11		
			VANE			
454.6 / 2.6	CLAY - medium to high plasticity, grey, firm, varved					
		3	SS	3		
			VANE			
		4	SH			
			VANE			
	reddish brown soft to firm, occ. silt veins	5	SS	1		Split spoon sank under weight of the hammer.
			VANE			
449.0 / 8.2	SAND - fine to medium, with silt, brown/grey					Sand blow up 0.6 m into H.S. Auger.
		6	SS			0 86 (14)

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)
SHEAR STRENGTH kPa: O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³



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✖3, ★3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 1

METRIC

W.P. J03-140 | PROJECT Little Savanne River Bridge | SITE NO. 48W-16 | ORIGINATED BY JN

DIST 61 HWY 17 | LOCATION 18.9 km east of Upsala, ON | TBTE JOB# J03-140 | COMPILED BY SP

DATE 16 February 2004 | BOREHOLE TYPE Hollow Stem Auger - 90mm ID | DATUM Geodetic | CHECKED BY WH

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	- Occasional cobbles				445, 444, 443	
442.7 14.5	COBBLES AND BOULDERS - with sand and gravel				442	
		7	SS	100	441	Spoon bouncing on boulder. No sample recovered Auger refusal on boulder. Casing refusal @ 16.55 m. Second attemp (BH 1R) carried out w/n 1m rad. of BH 1, extended to 17.0 m b.g. Casing refusal on boulder, hole terminated in bouldery zone.
440.2 17.0	Casing sheared in cobbles/boulders					
	End of hole at 17.0 m.					
	Hollow stem auger 0 - 15.6 m					
	Diamond Rotary 15.6 m to 17.0 m					

Column headings also include: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³; GR SA SI CL.

✖3, ★3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

TBT Engineering

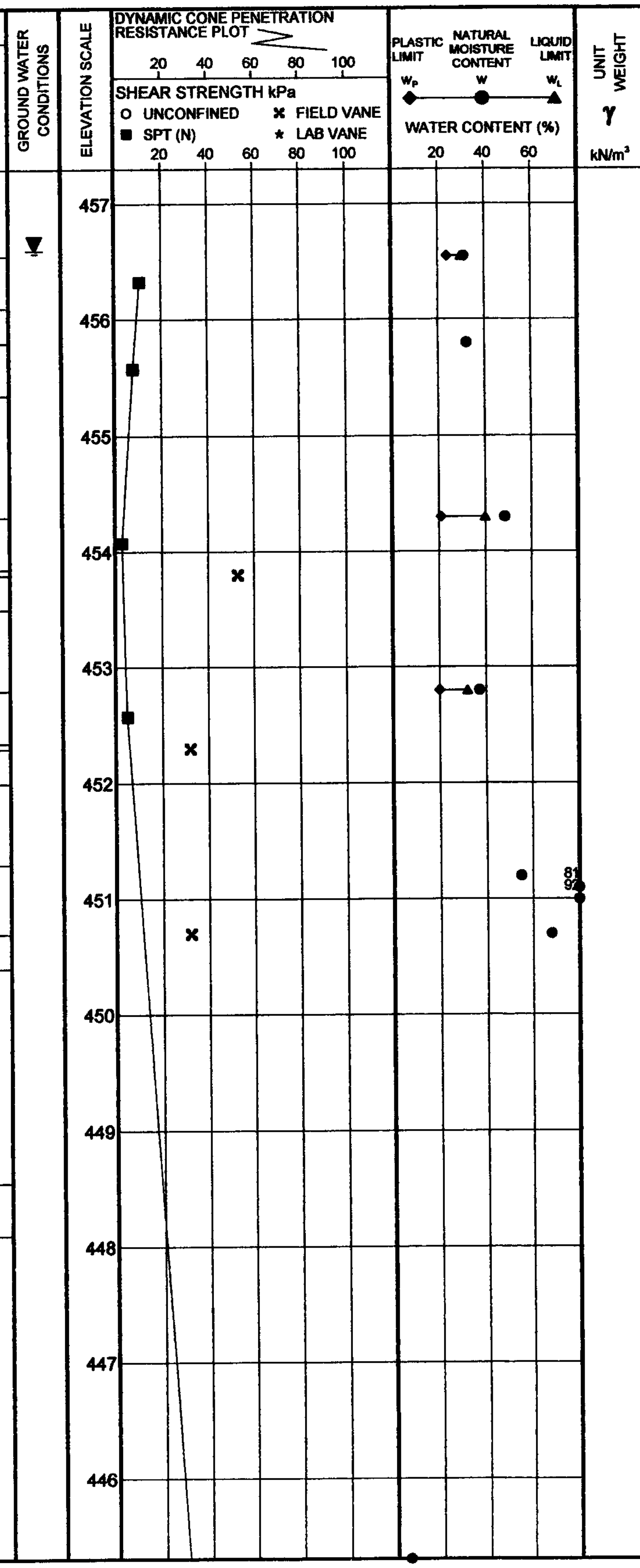
RECORD OF BOREHOLE No 2

METRIC

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16
DIST	61 HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140
DATE	21 February 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM	Geodetic

ORIGINATED BY JN
COMPILED BY SP
CHECKED BY WH

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%)
457.3					
0.0	FILL - fine to coarse gravelly sand, occasional cobles, trace of silt, brown, moist				15 mm Topsoil
456.8 / 0.5	SILT - clayey, with sand, grey, firm, (ML-CL)	1	SS	11	
		2	SS	8	
454.8 / 2.5	CLAY - medium to high plasticity, grey, firm, varved	3	SS	3	
			VANE		
		4	SS	5	
			VANE		
	reddish brown soft to firm, occ. silt veins	5	SH		
			VANE		
448.8 / 8.5	SAND - fine to medium, with silt, grey	6	SS		Sand blow up into spoon.
	compact				



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✖³, ★³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

ON_MOT_BH LOG 03-140.GPJ ON_MOT.GDT 3/8/04

Ministry of Transportation
Ontario

TBT Engineering

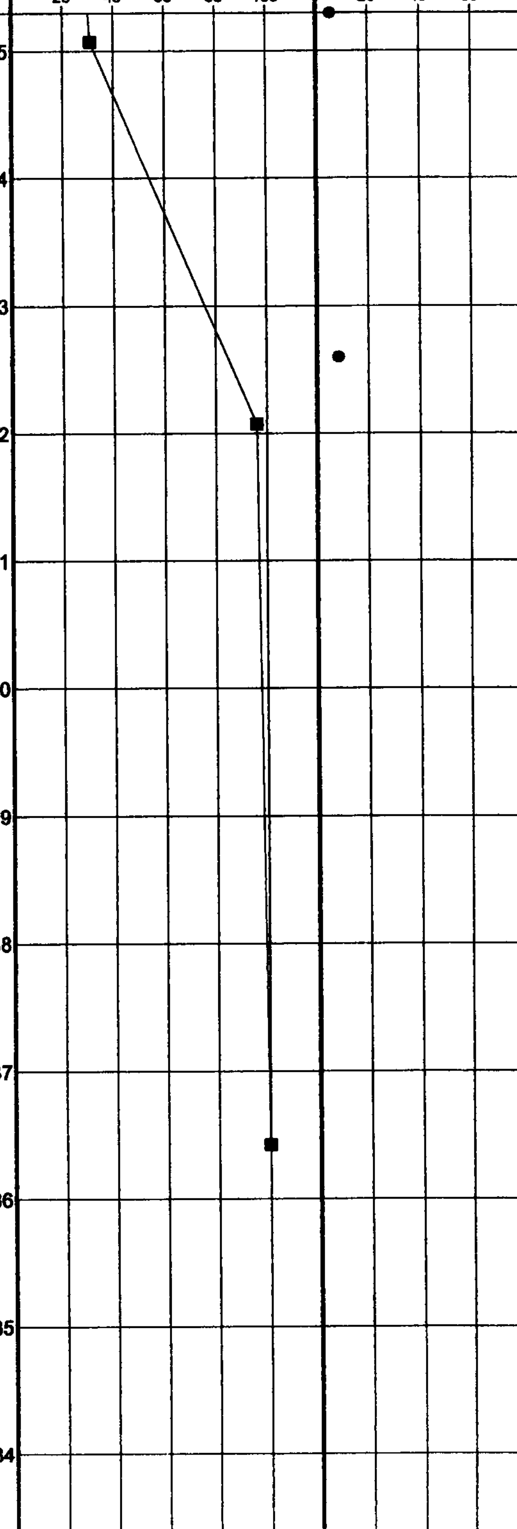
RECORD OF BOREHOLE No 2

METRIC

W.P. **J03-140**	PROJECT **Little Savanne River Bridge**		SITE NO. **48W-16**		ORIGINATED BY **JN**
DIST **61**	HWY **17**	LOCATION **18.9 km east of Upsala, ON**	TBTE JOB# **J03-140**		COMPILED BY **SP**
DATE **21 February 2004**	BOREHOLE TYPE **Hollow Stem Auger - 90mm ID**		DATUM **Geodetic**		CHECKED BY **WH**

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
						0 83 13 4
		7	SS	31	445	
					444	
443.0 / 14.3	**COBBLES AND BOULDERS - with sand and gravel**				443	0 74 22 4
		8	SS	96	442	
					441	
440.3 / 17.0	**SAND - some silt and gravel, with cobbles & boulders, grey**				440	
					439	27 % cobbles and boulders
	Boulder - 700 mm dia.				438	
	Cobble - 160 mm dia.				437	
	Boulder - 300 mm dia.	9	SS	100		Spoon bouncing on boulder, 15mm penetration, no sample retrieved.
	Cobble - 100 mm dia.				436	
	Cobble - 180 mm dia.					
	Cobble - 70 mm dia.				435	
					434	
	Cobble - 65 mm dia.					

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³



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✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 2

METRIC

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16
DIST	61 HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140
DATE	21 February 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM	Geodetic

ORIGINATED BY JN
COMPILED BY SP
CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	SAMPLE TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ■ SPT (N), ✖ FIELD VANE, ★ LAB VANE)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Boulder - 780 mm dia.						433				Spoon bouncing on boulder, no sample retrieved.
	Boulder - 300 mm dia.						432				
430.8 / 26.5	BEDROCK - Felsic Intrusive Granitic rock (Granodiorite)						431				
			1	RC							100% REC 100% RQD
			2	RC			430 / 429				100% REC 81% RQD
			3	RC			428				100% REC 94% RQD
427.6 / 29.8	End of hole at 29.8 m.										

Hollow stem auger
0 - 14.9 m

Diamond Rotary
13.7 m to 29.8 m

✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 3

METRIC

W.P. J03-140 | PROJECT Little Savanne River Bridge | SITE NO. 48W-16 | ORIGINATED BY JN

DIST 61 | HWY 17 | LOCATION 18.9 km east of Upsala, ON | TBTE JOB# J03-140 | COMPILED BY SP

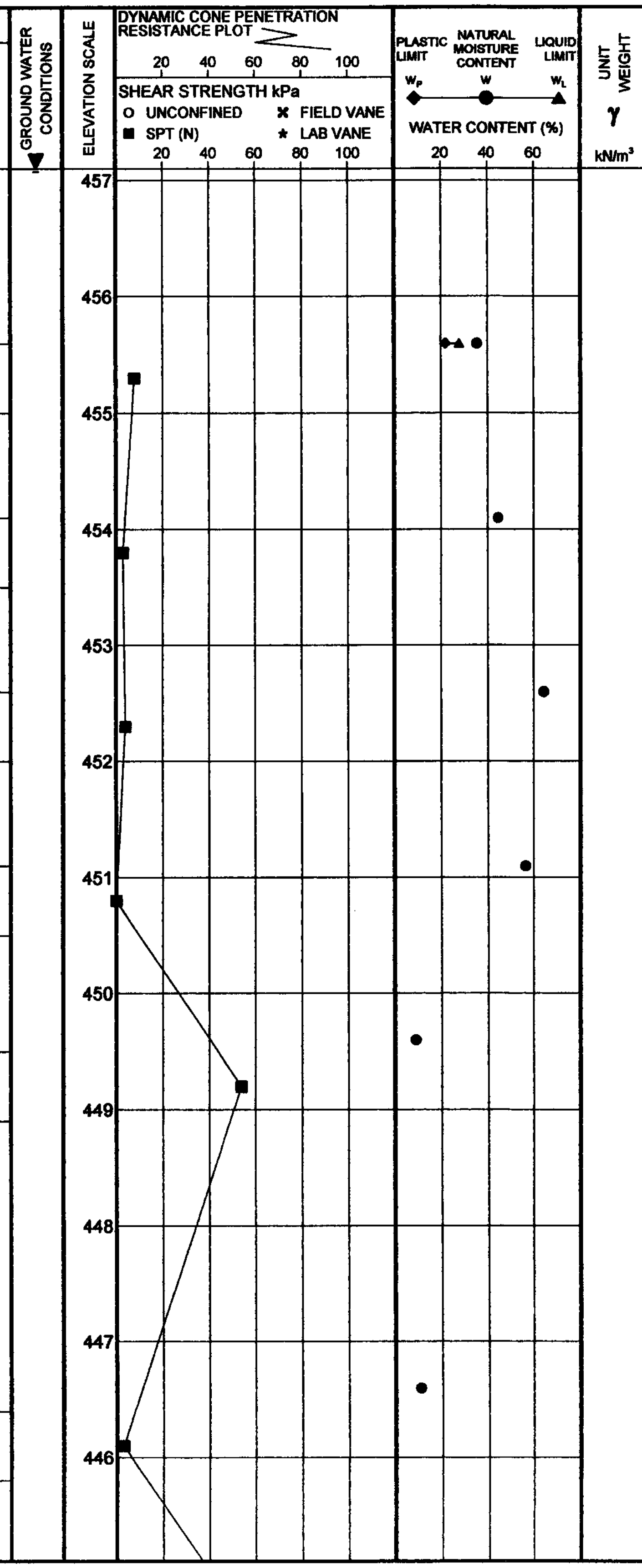
DATE 22 March 2004 | BOREHOLE TYPE Hollow Stem Auger - 90mm ID | DATUM Geodetic | CHECKED BY WH

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
457.1 / 0.0	FILL - fine to coarse gravelly sand, occasional cobbles and boulders, brown	Artesian groundwater to 0.3m above grade.
456.3 / 0.8	SILT - clayey, with sand, grey, firm, (ML-CL)	
454.4 / 2.7	CLAY - medium to high plasticity, grey to brown, soft to firm; — reddish brown soft to firm, occ. silt veins	Split spoon sank under weight of hammer
449.7 / 7.4	SAND - fine to medium grained, silty, with gravel, trace clay, grey, dense; — - medium to coarse sand, loose	7 53 30 1; Sand blow up into H.S. augers

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	8
2	SS	3
3	SS	4
4	SS	0
5	SS	54
6	SS	3



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✖3, ★3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

ON_MOT_BH LOG 03-140.GPJ ON_MOT.GDT 3/8/04

Ministry of Transportation Ontario

TBT Engineering

RECORD OF BOREHOLE No 3

METRIC

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16
DIST	61 HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140
DATE	22 March 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM	Geodetic

ORIGINATED BY JN
COMPILED BY SP
CHECKED BY WH

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	- cobble - cobble				
443.4 13.7	COBBLES AND BOULDERS - with sand and gravel 4 boulders (> 200mm) in 3 m run.	7	SS	100	Split spoon bouncing off of boulder, 0.2 m penetration
		8	SS	100	Split spoon bouncing off of boulder, < 25mm penetration
440.4 16.8	End of hole at 16.8 m. Refusal on boulder. Hollow stem auger 0 - 13.7 m Diamond Rotary 13.7 m to 16.8 m				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (445, 444, 443, 442, 441); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

✖3, ★3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

TBT Engineering

RECORD OF BOREHOLE No 4

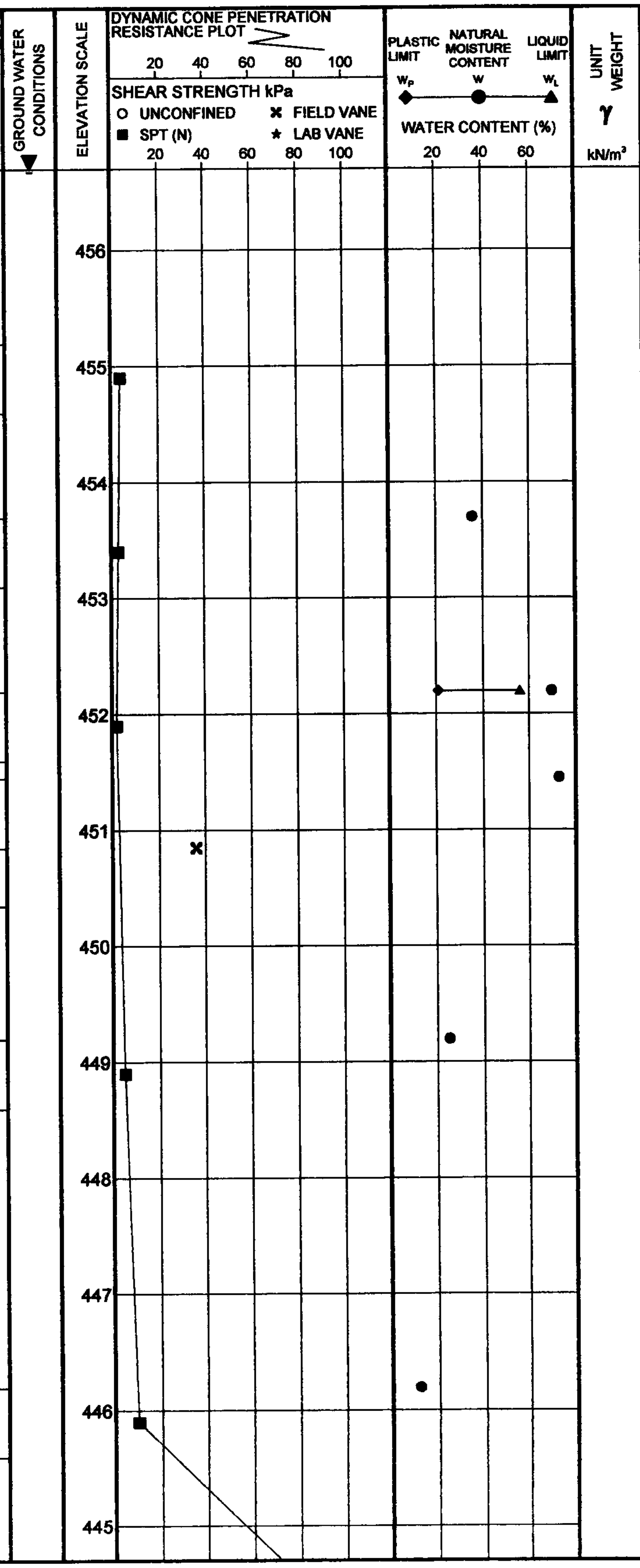
 METRIC

W.P. **J03-140** PROJECT **Little Savanne River Bridge** SITE NO. **48W-16** ORIGINATED BY **JN**

DIST **61** HWY **17** LOCATION **18.9 km east of Upsala, ON** TBTE JOB# **J03-140** COMPILED BY **SP**

DATE **24 March 2004** BOREHOLE TYPE **Hollow Stem Auger - 90mm ID** DATUM **Geodetic** CHECKED BY **WH**

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
456.7 / 0.0	FILL - fine to coarse sand, silty, some gravel, brown to grey, wet				25 mm Topsoil
456.4 / 0.3	SILT - clayey, with sand, grey, soft to firm (ML-CL)				Artesian groundwater to 0.3m above grade.
		1	SS	4	
454.0 / 2.7	CLAY - medium to high plasticity, grey, soft to firm, varved				0 16 (84)
		2	SS	3	
		3	SS	2	
	reddish brown soft to firm, occ. silt veins	4	SH		
			VANE		
	- cobble				
	- silty, some sand, grey	5	SS	5	
448.4 / 8.3	SAND and SILT - trace clay				8 49 (44)
	- occ. cobble and boulder	6	SS	10	Sand blow - 0.15 m into auger



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✖3, ★3: Numbers refer to Sensitivity O3% STRAIN AT FAILURE

ON_MOT_BH LOG 03-140.GPJ ON_MOT.GDT 3/8/04

TBT Engineering

RECORD OF BOREHOLE No 4

METRIC

W.P. J03-140	PROJECT Little Savanne River Bridge	SITE NO. 48W-16	ORIGINATED BY JN
DIST 61 HWY 17	LOCATION 18.9 km east of Upsala, ON	TBTE JOB# J03-140	COMPILED BY SP
DATE 24 March 2004	BOREHOLE TYPE Hollow Stem Auger - 90mm ID	DATUM Geodetic	CHECKED BY WH

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%)
444.2 / 12.5	COBBLES AND BOULDERS - some sand and gravel	7	SS	100	Split spoon attempted, < 60mm penetration, 100+blows Advancement rate - 85 sec/300 mm
441.4 / 15.3	SAND - silty, some gravel, with boulders, grey				Advancement rate - 45 sec/300 mm (15.3 - 15.4 m) Advancement rate - 20 sec/300 mm (17.4 - 17.5 m) Advancement rate - 20 sec/300 mm (18.3 - 18.4 m)
438.1 / 18.6	End of hole at 18.6m. Hole terminated due to air pressure return loss at 18.6 m, surface venting of air. Truck mounted CME 55 rig refused @ 14.1 m below grade in dense boulder layer. Air powered rotary drill used to advance hole from 14.1 m to 18.6 m.				

Elevation scale: 444, 443, 442, 441, 440, 439

Dynamic Cone Penetration Resistance Plot (20, 40, 60, 80, 100); Shear Strength kPa: O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³; GR SA SI CL

✖3, ★3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 5

 METRIC

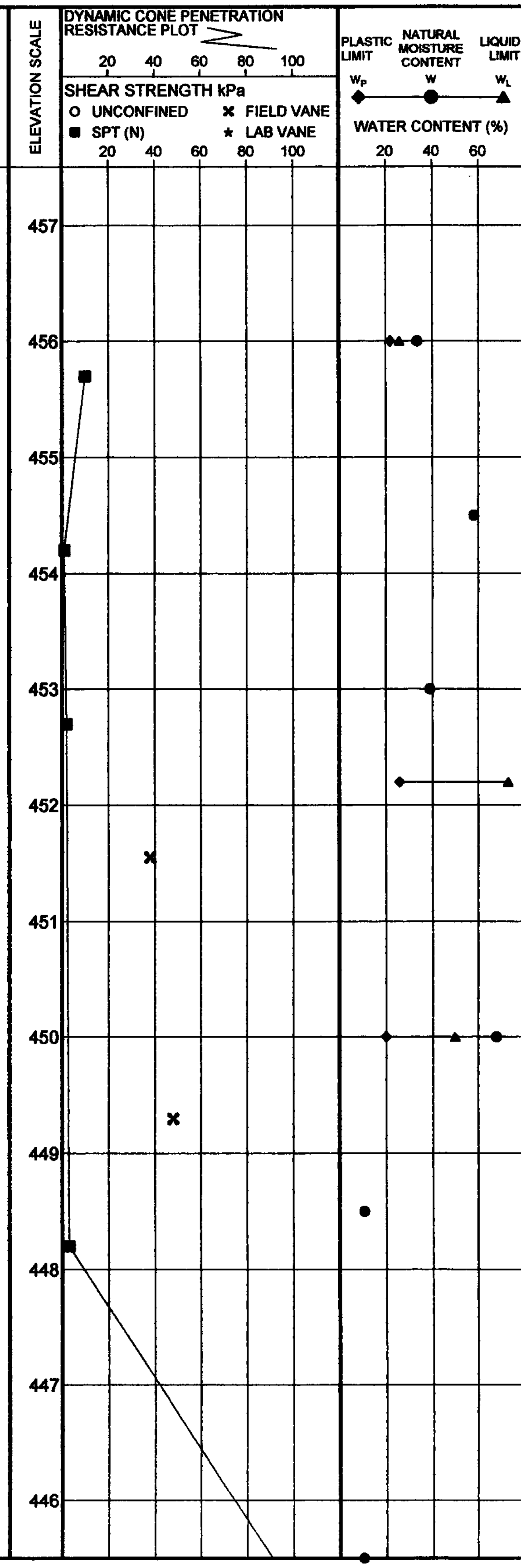
TBT Engineering

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16
DIST	61 HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140
DATE	25 March 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM	Geodetic

ORIGINATED BY JN
COMPILED BY SP
CHECKED BY WH

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
457.5					
0.0	FILL - fine to coarse sand, gravelly, trace silt, brown				
456.9 / 0.6	SILT and CLAY - brown/grey, firm				0 0 78 22
		1	SS	10	
	- some clay varves				
454.5 / 3.0	CLAY - medium to high plasticity, grey to brown, firm, varved	2	SS	1	
		3	SS	2	Spoon sank under weight of the hammer.
	reddish brown soft to firm, occ. silt veins	4	SH		
			VANE		
		5	SS		Spoon sank under weight of the hammer.
			VANE		
449.0 / 8.5	SAND - fine to medium grained, silty, with gravel, trace clay, grey/brown	6	SS	3	
					Sand blow up into H.S. augers
	occ. cobble				

GROUND WATER CONDITIONS: water level symbol shown at approx. elev. 456.7



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✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 5

METRIC

W.P. J03-140 | PROJECT Little Savanne River Bridge | SITE NO. 48W-16 | ORIGINATED BY JN

DIST 61 | HWY 17 | LOCATION 18.9 km east of Upsala, ON | TBTE JOB# J03-140 | COMPILED BY SP

DATE 25 March 2004 | BOREHOLE TYPE Hollow Stem Auger - 90mm ID | DATUM Geodetic | CHECKED BY WH

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT (WATER CONTENT %)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			7	SS	100			SPT (N) = 100			Sand blow up 3.6 m into H.S. auger. 100+ blows for 0.1 m pen. at 12.5m b.g.
444.9 / 12.6	COBBLES AND BOULDERS - some sand and gravel						445				
							444				Advancement rate - 200 - 220 sec/300 mm
							443				Rate retarded because of damaged casing tip - drilled through steel casing
							442				Advancement rate - 111 sec/300 mm
441.6 / 15.9	SAND - silty, some gravel, with boulders, grey										
							441				Advancement rate - 50 sec/300 mm
							440				Advancement rate - 85 sec/300 mm
							439				
							438				
							437				
							436				Advancement rate - 60 sec/300 mm
							435				
							434				Advancement

Continued Next Page

×³, ★³: Numbers refer to Sensitivity   O³% STRAIN AT FAILURE

Legend: O UNCONFINED; ✖ FIELD VANE; ■ SPT (N); ★ LAB VANE

TBT Engineering

RECORD OF BOREHOLE No 5

METRIC

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16	ORIGINATED BY	JN
DIST 61	HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140	COMPILED BY	SP
DATE	25 March 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM	Geodetic	CHECKED BY	WH

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER (SAMPLES)	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
							433				rate - 60 sec/300 mm
432.6 24.9	End of hole at 24.9 m. Hole terminated due to air pressure return loss at 24.9 m, surface air venting. Hollow stem auger 0 - 12.6 m Diamond rotary well drill 12.6 m - 24.9 m										

✖³, ★³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 6

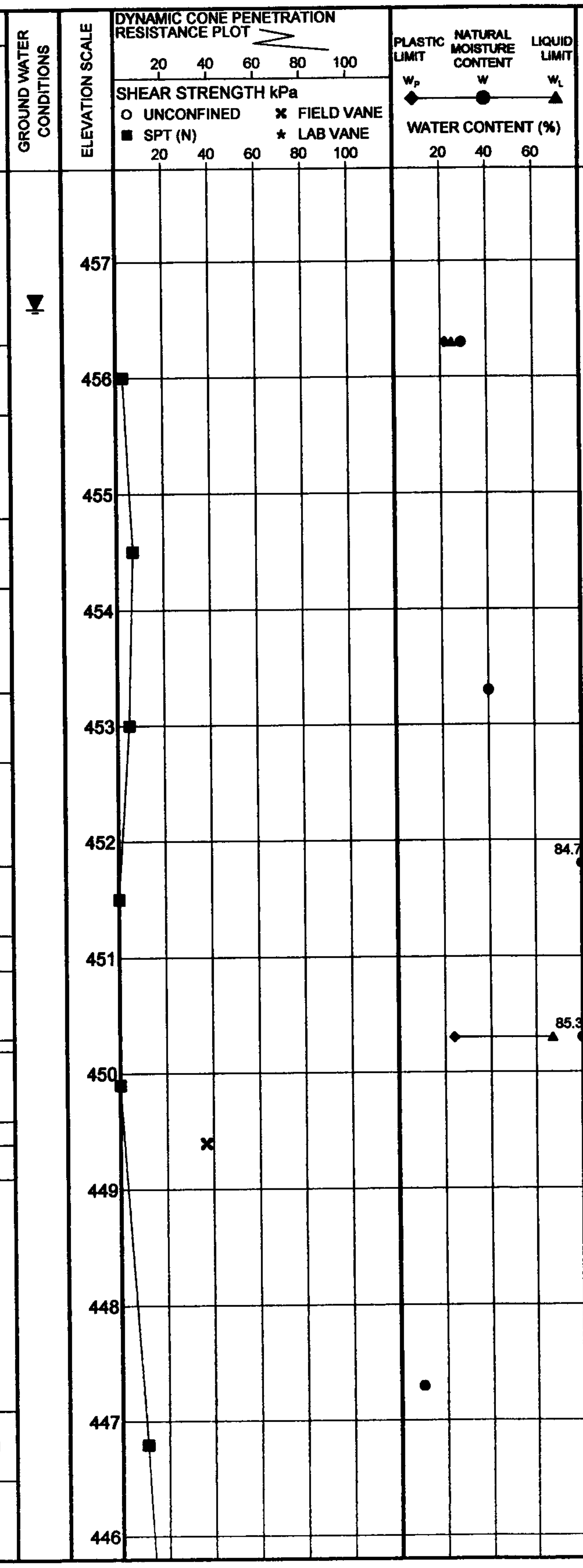
METRIC

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16
DIST	61 HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140
DATE	25 March 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM	Geodetic

ORIGINATED BY JN
COMPILED BY SP
CHECKED BY WH

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
457.8 / 0.0	FILL - fine to medium gravelly sand, trace of silt, occasional cobbles, brown, moist				25mm topsoil
457.4 / 0.4	SILT - clayey, trace sand, brown and grey, soft (ML-CL)	1	SS	3	Spoon sank under weight of hammer
	- some clay seams, grey	2	SS	7	
454.0 / 3.8	CLAY - med to high plasticity, grey to brown, firm, varved				
	- occasional sand and gravel	3	SS	5	
	reddish brown soft to firm, occ. silt veins	4	SS	0	Spoon sank under weight of hammer
		5	SH		
		6	SS	0	Spoon sank under weight of hammer
			VANE		
448.2 / 9.6	SAND - fine to medium grained, silty, with gravel, trace clay, grey/brown	7	SS	11	



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✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

TBT Engineering

RECORD OF BOREHOLE No 6

METRIC

W.P. J03-140	PROJECT Little Savanne River Bridge		SITE NO. 48W-16	ORIGINATED BY JN
DIST 61	HWY 17	LOCATION 18.9 km east of Upsala, ON	TBTE JOB# J03-140	COMPILED BY SP
DATE 25 March 2004	BOREHOLE TYPE Hollow Stem Auger - 90mm ID		DATUM Geodetic	CHECKED BY WH

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
							445				
							444				
			8	SS	20			■ 20			1.2 m of sand blow up into augers, 75 mm retrieval from split spoon.
							443				
							442				
441.0 / 16.8	End of hole at 16.8 m. Auger refusal on inferred boulder.						441				1.5 m of sand blow up into augers, unable to get spoon sample @16.75m.

✖³, ★³: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

ON_MOT_BH LOG 03-140.GPJ ON_MOT.GDT 3/8/04

TBT Engineering — RECORD OF BOREHOLE No 7

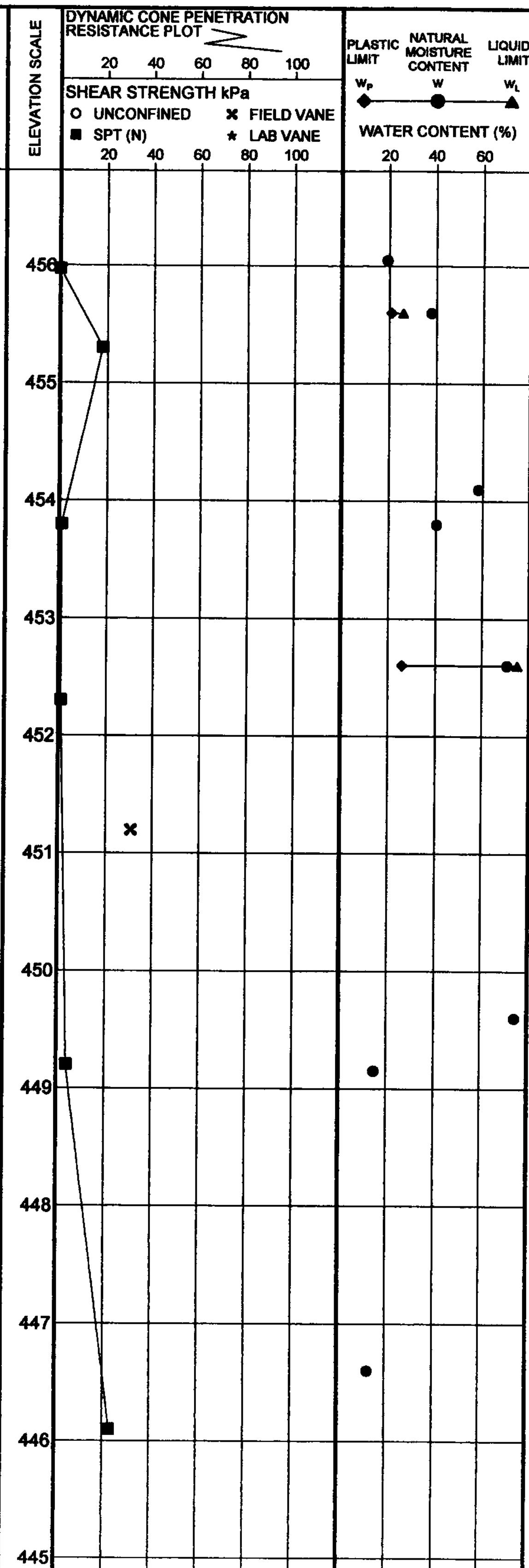
 METRIC

W.P. J03-140 | PROJECT Little Savanne River Bridge | SITE NO. 48W-16 | ORIGINATED BY RL

DIST 61 | HWY 17 | LOCATION 18.9 km east of Upsala, ON | TBTE JOB# J03-140 | COMPILED BY SP

DATE 26 March 2004 | BOREHOLE TYPE Hollow Stem Auger - 90mm ID | DATUM Geodetic | CHECKED BY WH

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
456.8 / 0.0	FILL - fine to medium sand, silty, occasional gravel and boulders, wet	1	SS	0		
455.7 / 1.1	SILT - clayey, grey, soft to firm (ML-CL)	2	SS	18	Spoon bouncing off large boulder, 50+ blows for 0.1 m pen.	0 3 77 20
453.8 / 3.0	CLAY - med to high plasticity, grey to brown, firm, varved	3	SS	1		
		4	SS	1	Spoon sank 0.15 m under own weight	
	reddish brown soft to firm, occ. silt veins	5	SH			
			VANE			
		6	SS	4	Spoon sank 0.15 m under own weight	
449.0 / 7.8	Sand - fine to medium, trace silt, occasional gravel, grey, compact, wet	7	SS	23		



GROUND WATER CONDITIONS | UNIT WEIGHT γ kN/m³

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✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 7

METRIC

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO. 48W-16	ORIGINATED BY RL
DIST 61	HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB# J03-140	COMPILED BY SP
DATE	26 March 2004	BOREHOLE TYPE	Hollow Stem Auger - 90mm ID	DATUM Geodetic	CHECKED BY WH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
444.6											
12.2	End of hole at 12.2 m. Auger refusal (cobbles/boulders)						444				3 m of sand blow up into auger, unable to get spoon sample.

✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 8

1 OF 1 **METRIC**

W.P. J03-140 PROJECT Little Savanne River Bridge SITE NO. 48W-16 ORIGINATED BY RL

DIST 61 HWY 17 LOCATION 18.9 km east of Upsala, ON TBTE JOB# J03-140 COMPILED BY SP

DATE 27 March 2004 BOREHOLE TYPE Hollow Stem Auger - 90mm ID DATUM Geodetic CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
456.6					
0.0	Water				
456.1 / 0.5	FILL- fine to medium sand, trace silt and clay, occasional gravel and wood chips, brown	1	SS	76	
		2	SH		
454.6 / 2.0	SILT - clayey, some sand, grey, loose, moist				0 15 77 8
		3	SS	3	
453.0 / 3.6	CLAY - medium to high plasticity, grey to brown, firm, varved	4	SS	3	
		5	SH		
	reddish brown soft to firm, occ. silt veins		VANE		
		6	SS	0	Spoon sank 0.3 m under own weight, then sank 0.45 m under weight of (32) hammer.
448.7 / 7.9	SAND - fine to medium grained, silty, with gravel, trace clay, grey/brown	7	SS	13	
					6.0 m of sand blow up into H.S. augers.
445.0 / 11.6	End of hole at 11.6m.				

Chart column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³; GROUND WATER CONDITIONS; ELEVATION SCALE 456–445; STRAT PLOT.

✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 9

METRIC

TBT Engineering

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16
ORIGINATED BY	DG	DIST		HWY	17
LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140	COMPILED BY	SP
DATE	27 May 2004	BOREHOLE TYPE	80mm ID	DATUM	Geodetic
CHECKED BY	WH				

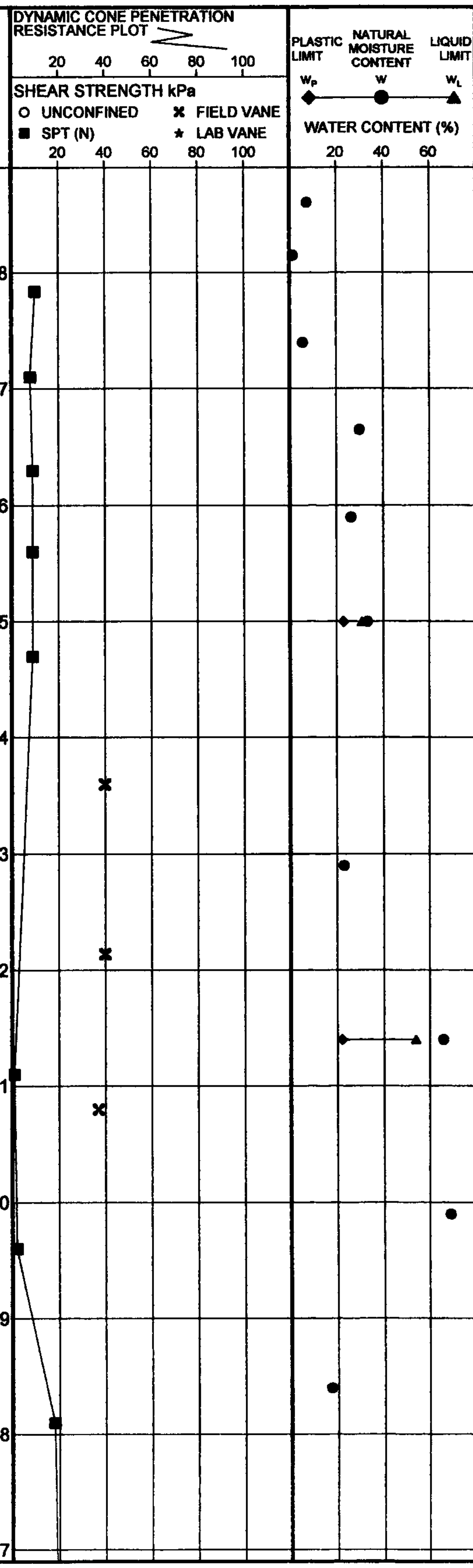
SOIL PROFILE

ELEV DEPTH	DESCRIPTION
458.9	(ground surface)
	Asphalt
458.6 / 0.3	FILL - CR GRAVEL, sandy, brown, dry
	FILL - SAND, gravelly, trace silt, lt. brown, dry
457.1 / 1.8	SILT - grey, clayey (brown), moist; increasing clay with depth; +/- clay in 10mm layers
455.0 / 3.9	CLAY - medium to high plasticity, grey to brown, firm, varved; —— reddish brown; soft to firm, occ. silt veins
449.3 / 9.6	SAND - fine, silty, trace clay, wet, grey

SAMPLES AND REMARKS

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL	REMARKS
1	GRAB		7	82	7	3	
2	SS	10					
3	SS	8					
			0	3	80	17	
4	SS	9					
5	SS	9					
6	SS	9					
7	SH						
	VANE						
8	SH						VARVES - 5-20mm Clay, 5-20mm Silt
	VANE						
9	SS	1					Weight of hammer advanced SS 380mm
	VANE						
10	SS	2					Weight of hammer advanced SS 200mm
				22	(78)		Sand on HS Auger plug
11	SS	18					Sand/water 2.3m inside HS Auger

GROUND WATER CONDITIONS: water level symbol at approx. elev. 456.7



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✖3, ★3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

ON_MOT_BH_LOG 03-140.GPJ ON_MOT.GDT 3/8/04

TBT Engineering

RECORD OF BOREHOLE No 9

METRIC

W.P. J03-140 PROJECT Little Savanne River Bridge SITE NO. 48W-16 ORIGINATED BY DG

DIST HWY 17 LOCATION 18.9 km east of Upsala, ON TBTE JOB# J03-140 COMPILED BY SP

DATE 27 May 2004 BOREHOLE TYPE 80mm ID DATUM Geodetic CHECKED BY WH

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
											No SPT - sand blowing into HS Auger 0.3m/min
							446				
	Increasing cobbles with depth										Intermittent rough drilling No SPT - sand blowing into HS Auger 0.3m/min
							445				
							444				4 61 (35)
443.3			12	SS	22						
15.6	End of hole at 15.7m										

Legend: SHEAR STRENGTH kPa — O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ LAB VANE. PLASTIC LIMIT W_p, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L.

✖[3], ★[3]: Numbers refer to Sensitivity O[3%] STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10

METRIC

TBT Engineering

W.P.	J03-140	PROJECT	Little Savanne River Bridge	SITE NO.	48W-16
DIST	61 HWY 17	LOCATION	18.9 km east of Upsala, ON	TBTE JOB#	J03-140
DATE	1 June 2004	BOREHOLE TYPE	80mm ID	DATUM	Geodetic

ORIGINATED BY DG; COMPILED BY SP; CHECKED BY WH

ELEV / DEPTH (m)	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
459.0 / 0.0	FILL - CR GRAVEL, sandy, brown, dry	1	SS	14	14 75 (11)
		2	SS	17	5 79 (17)
457.2 / 1.8	SILT - clayey, some sand, grey/ brown, loose, moist	3	SS	9	
		4	SS	13	
455.4 / 3.6	CLAY - medium to high plasticity, grey to brown, firm, varved	5	SS	7	
		6	SH		
			VANE		
		7	SH		
	soft		VANE		
	reddish brown soft to firm, occ. silt veins	8	SH		
			VANE		
		9	SS	1	Weight of hammer advanced SS 375 mm (85.2)
448.8 / 10.2	SAND - fine, silty, trace clay, wet, grey. Increasing cobbles with depth. Intermittent rough drilling				Blowing sand ~ 1.5 m up H.S. auger

Ground water level: approx. elev. 457.0.

Elevation scale: 458, 457, 456, 455, 454, 453, 452, 451, 450, 449, 448

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED; ✖ FIELD VANE; ■ SPT (N); ★ 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/m³

Continued Next Page

✖3, ★3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 10

METRIC

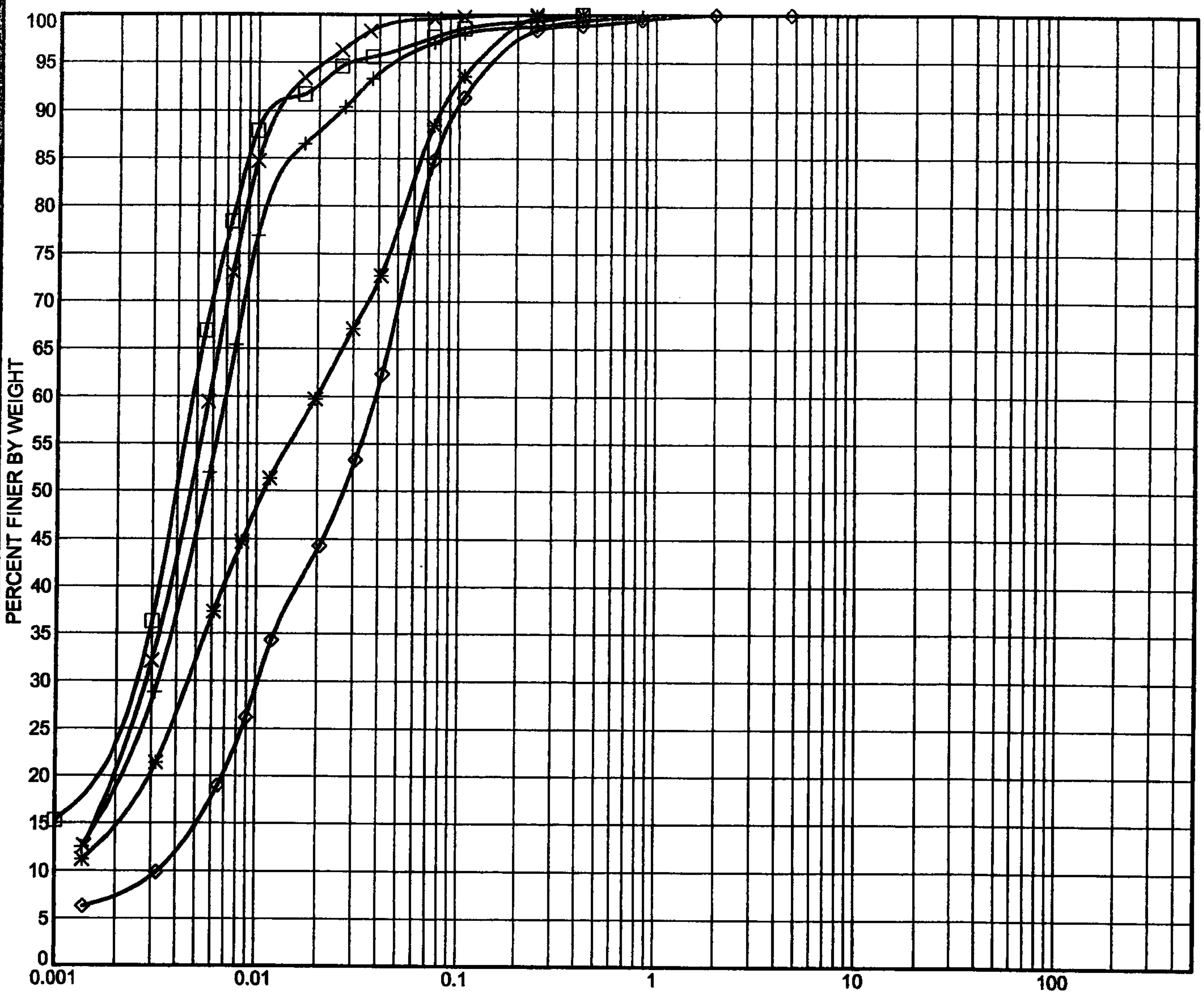
W.P. **J03-140** PROJECT **Little Savanne River Bridge** SITE NO. **48W-16** ORIGINATED BY **DG**

DIST **61** HWY **17** LOCATION **18.9 km east of Upsala, ON** TBTE JOB# **J03-140** COMPILED BY **SP**

DATE **1 June 2004** BOREHOLE TYPE **80mm ID** DATUM **Geodetic** CHECKED BY **WH**

SOIL PROFILE: ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, ✖ FIELD VANE, ■ SPT (N), ★ 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND - fine, silty, trace clay, wet, grey Increasing cobbles and gravel with depth		10	BS			446 445				Blowing sand ~ 1.5 m up H.S. auger
444.0 15.0	End of hole at 15.0 m below grade.						444				Blowing sand ~ 4.0 m up H.S. auger

✖ 3, ★ 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Material:

CLAYEY SILT DEPOSIT

	Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	1	0.75	0.425	0.005	0.002		0.0	2.3	69.2	28.5
✳	1	1.50	0.425	0.02	0.005		0.0	11.5	72.7	15.8
×	5	1.50	0.425	0.006	0.003		0.0	0.4	77.9	21.7
+	7	1.20	0.85	0.007	0.003		0.0	2.7	77.0	20.1
◇	8	2.40	4.75	0.039	0.01	0.003	0.0	15.2	76.9	7.9

TBT Engineering
Suite 314-101 Syndicate Ave. N
Thunder Bay, ON P7C 3V4
Telephone: (807) 624-5160
Fax: (807) 624-5161

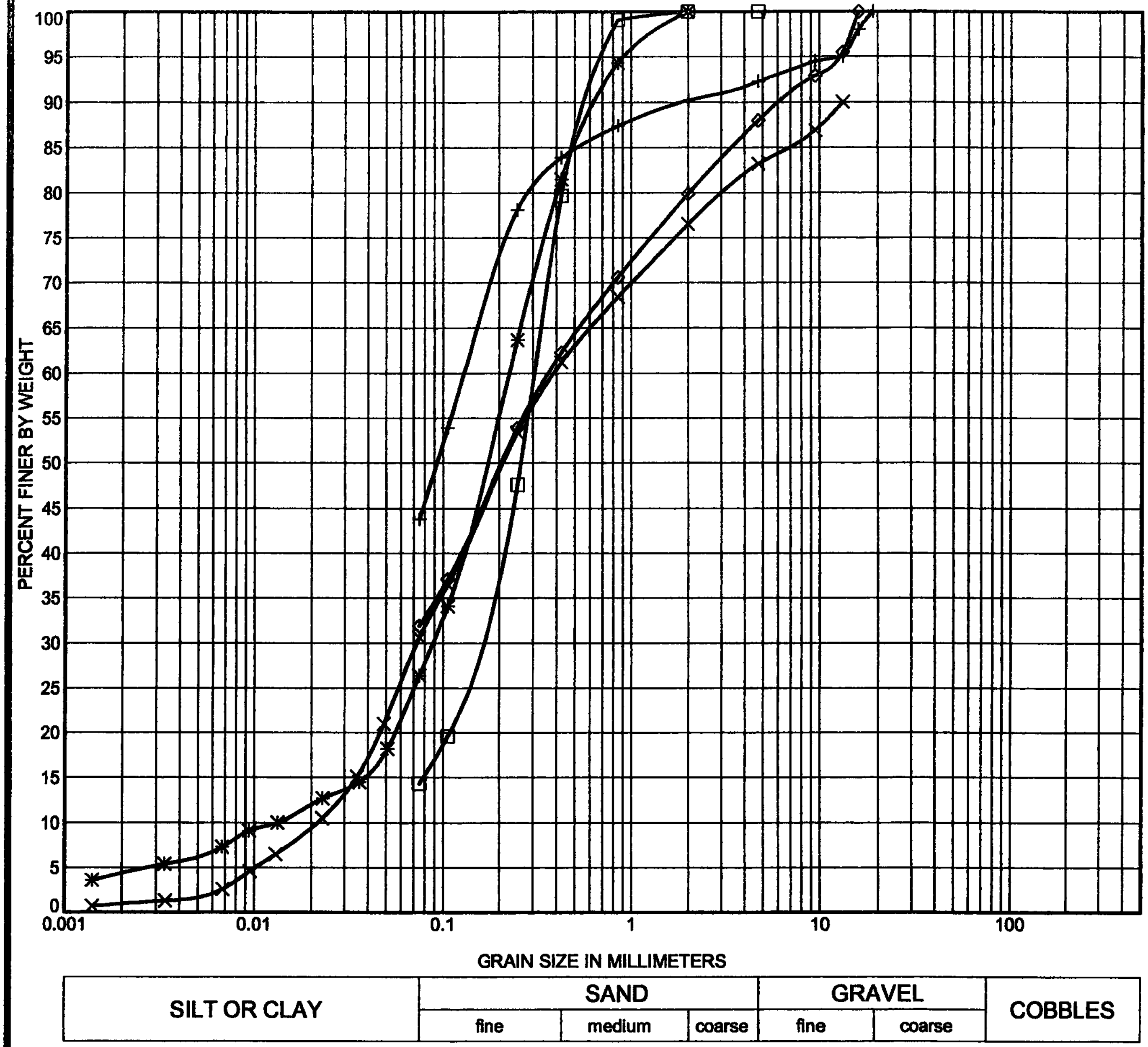
GRAIN SIZE DISTRIBUTION

Project: Little Savanne River Bridge

Location: 17

Number: J03-140

ENCLOSURE 1



Material:

SAND DEPOSIT

Test Hole		Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	1	9.00	4.75	0.307	0.146		0.0	85.7	14.3	
✳	2	14.70	2	0.225	0.088	0.013	0.0	73.6	22.1	4.3
×	3	7.50	13.2	0.392	0.073	0.021	6.8	52.6	29.7	0.9
+	4	10.50	19	0.132			7.7	48.5	43.8	
◇	8	8.10	16	0.368			12.0	56.1	31.9	

TBT Engineering
Suite 314-101 Syndicate Ave. N
Thunder Bay, ON P7C 3V4
Telephone: (807) 624-5160
Fax: (807) 624-5161

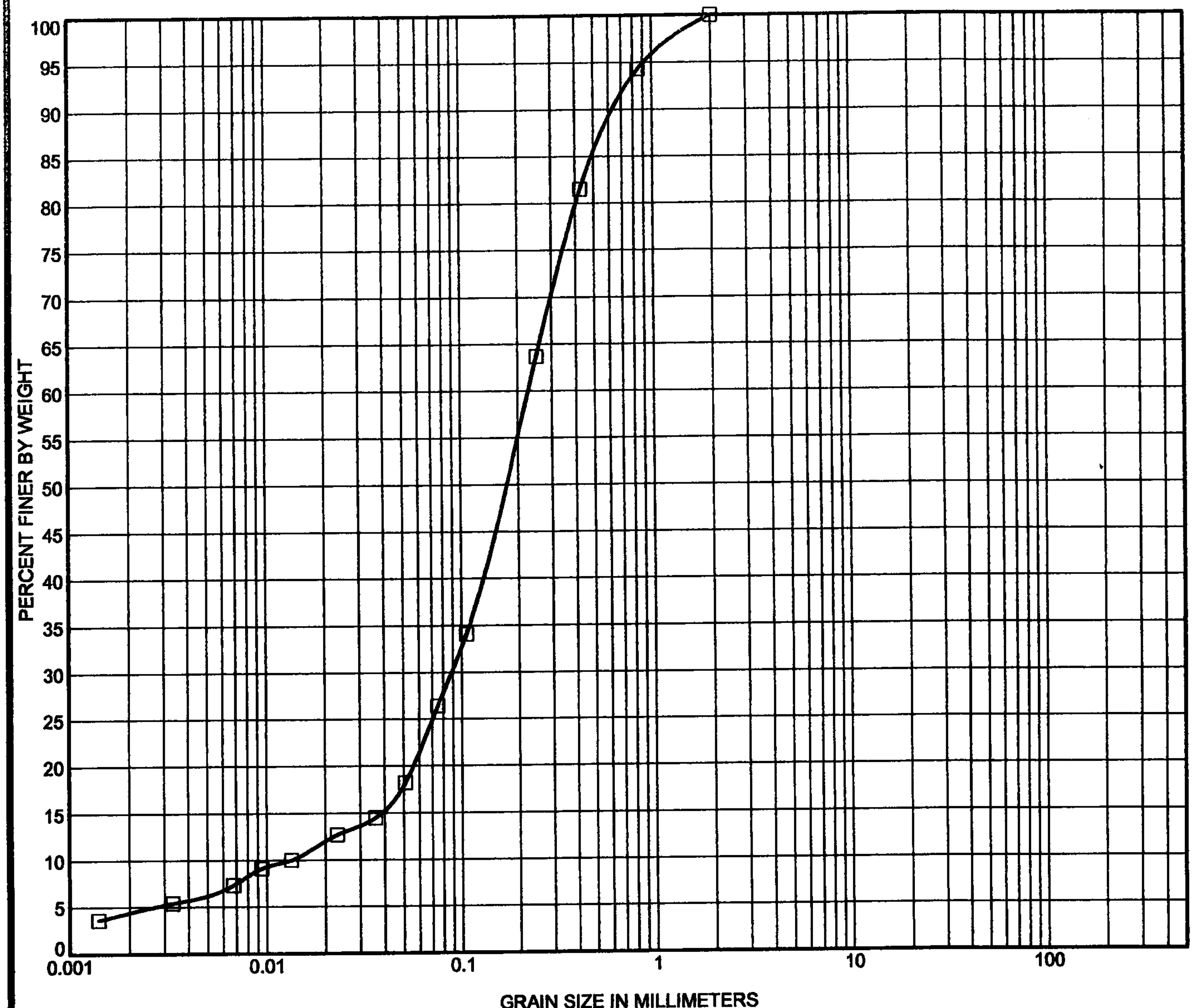
GRAIN SIZE DISTRIBUTION

Project: Little Savanne River Bridge

Location: 17

Number: J03-140

ENCLOSURE 2



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Material:

SAND with COBBLES and BOULDERS (fine fraction only)

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ 2	**14.70**	**2**	**0.225**	**0.088**	**0.013**	**0.0**	**73.6**	**22.1**	**4.3**

MTO_GS_03-140.GPJ CAN_LAB.GDT 1/6/04

TBT Engineering
Suite 314-101 Syndicate Ave. N
Thunder Bay, ON P7C 3V4
Telephone: (807) 624-5160
Fax: (807) 624-5161

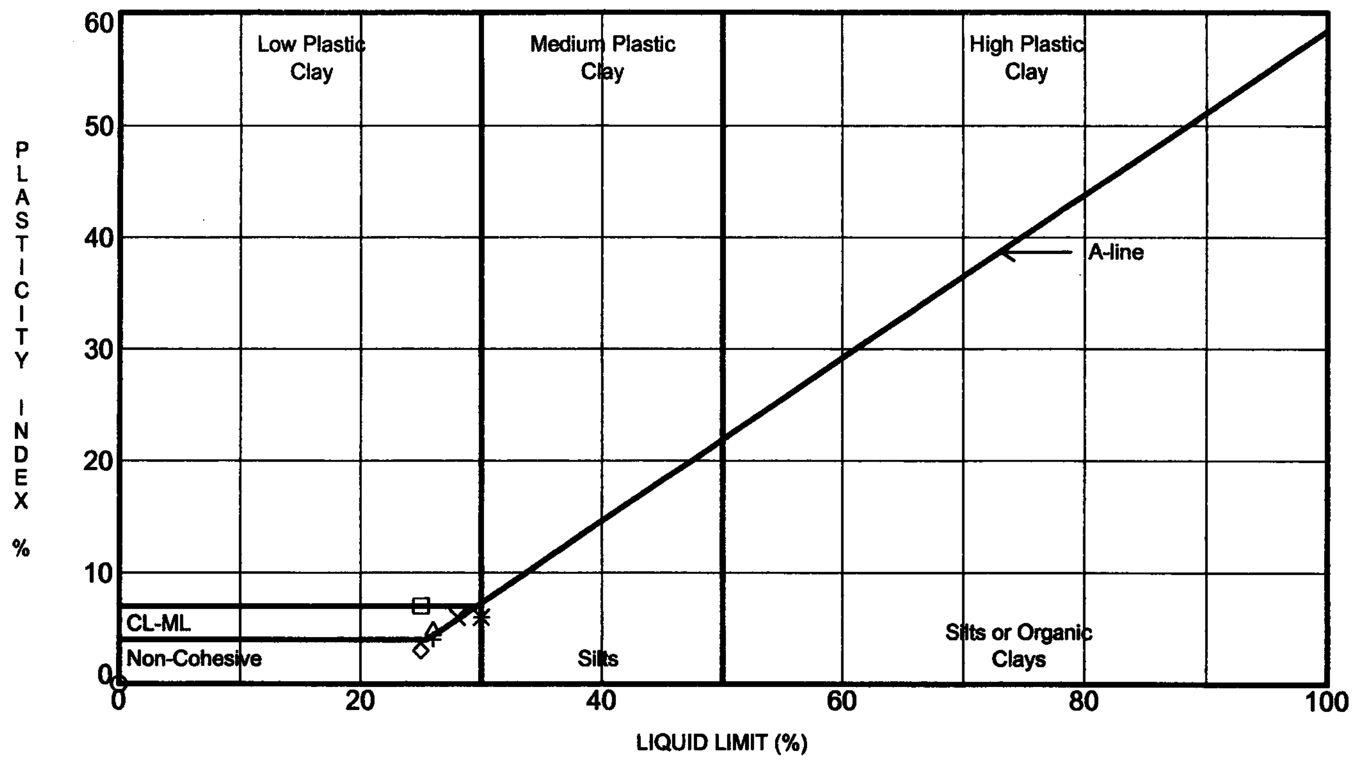
GRAIN SIZE DISTRIBUTION

Project: Little Savanne River Bridge

Location: 17

Number: J03-140

ENCLOSURE 3



Material:

CLAYEY SILT DEPOSIT

	Borehole No.	Sample No.	Depth	LL%	PL%	PI%	M/C%
□	1	2	1.50	25	18	7	38
✳	2	1	0.75	30	24	6	31
×	3	1	1.50	28	22	6	36
+	5	1	1.50	26	22	4	34
◇	6	1	1.50	25	22	3	29
△	7	2	1.20	26	21	5	38
○	8	3	2.40	NP	NP	NP	47

TBT Engineering
Suite 314-101 Syndicate Ave. N
Thunder Bay, ON P7C 3V4
Telephone: (807) 624-5160
Fax: (807) 624-5161

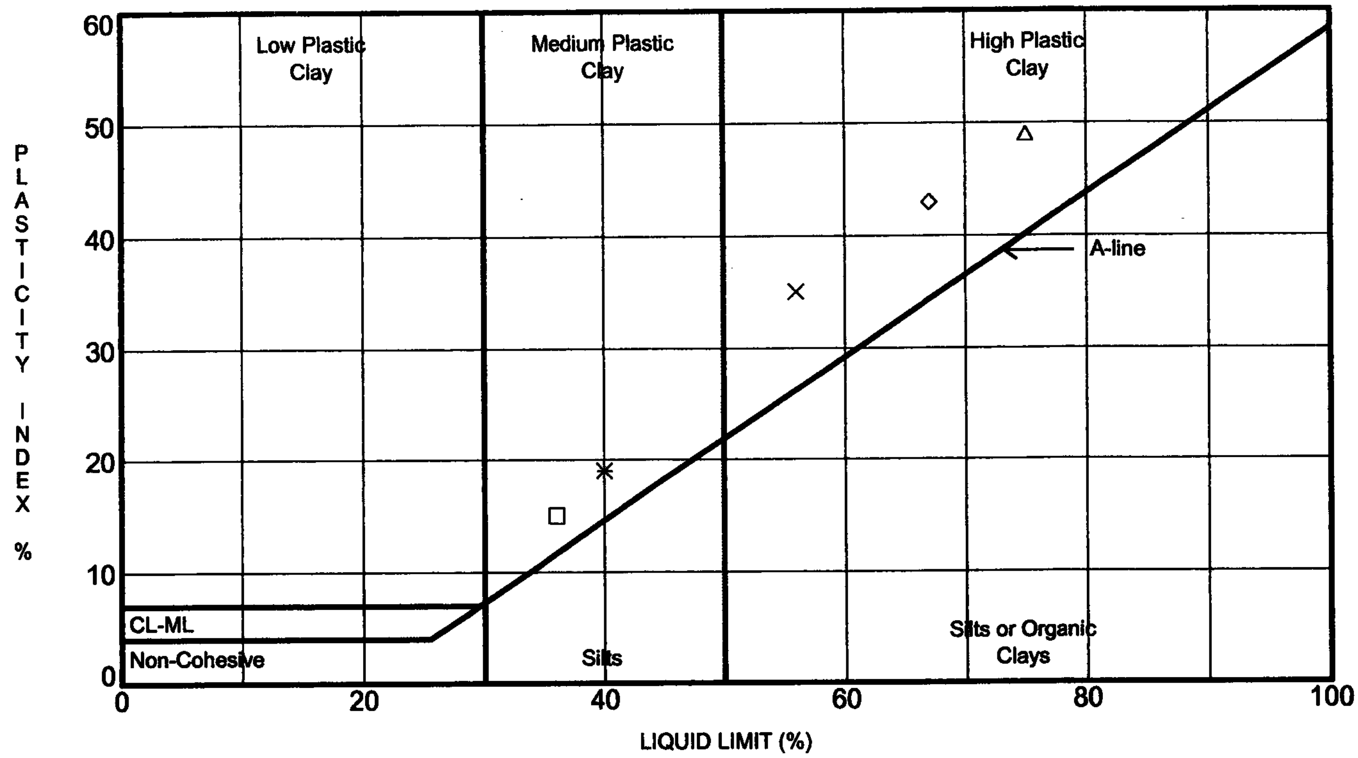
ATTERBERG LIMIT RESULTS

Project: Little Savanne River Bridge

Location: 17

Number: J03-140

ENCLOSURE 4



Material:

CLAY DEPOSIT

	Borehole No.	Sample No.	Depth	LL%	PL%	PI%	M/C%
□	1	3	3.00	36	21	15	58
✳	2	3	3.00	40	21	19	49
×	4	3	4.50	56	21	35	70
+	5	5	7.50	50	20	30	68
◇	6	6	7.50	67	24	43	85
△	7	4	4.20	75	26	49	71

TBT Engineering
Suite 314-101 Syndicate Ave. N
Thunder Bay, ON P7C 3V4
Telephone: (807) 624-5160
Fax: (807) 624-5161

ATTERBERG LIMIT RESULTS

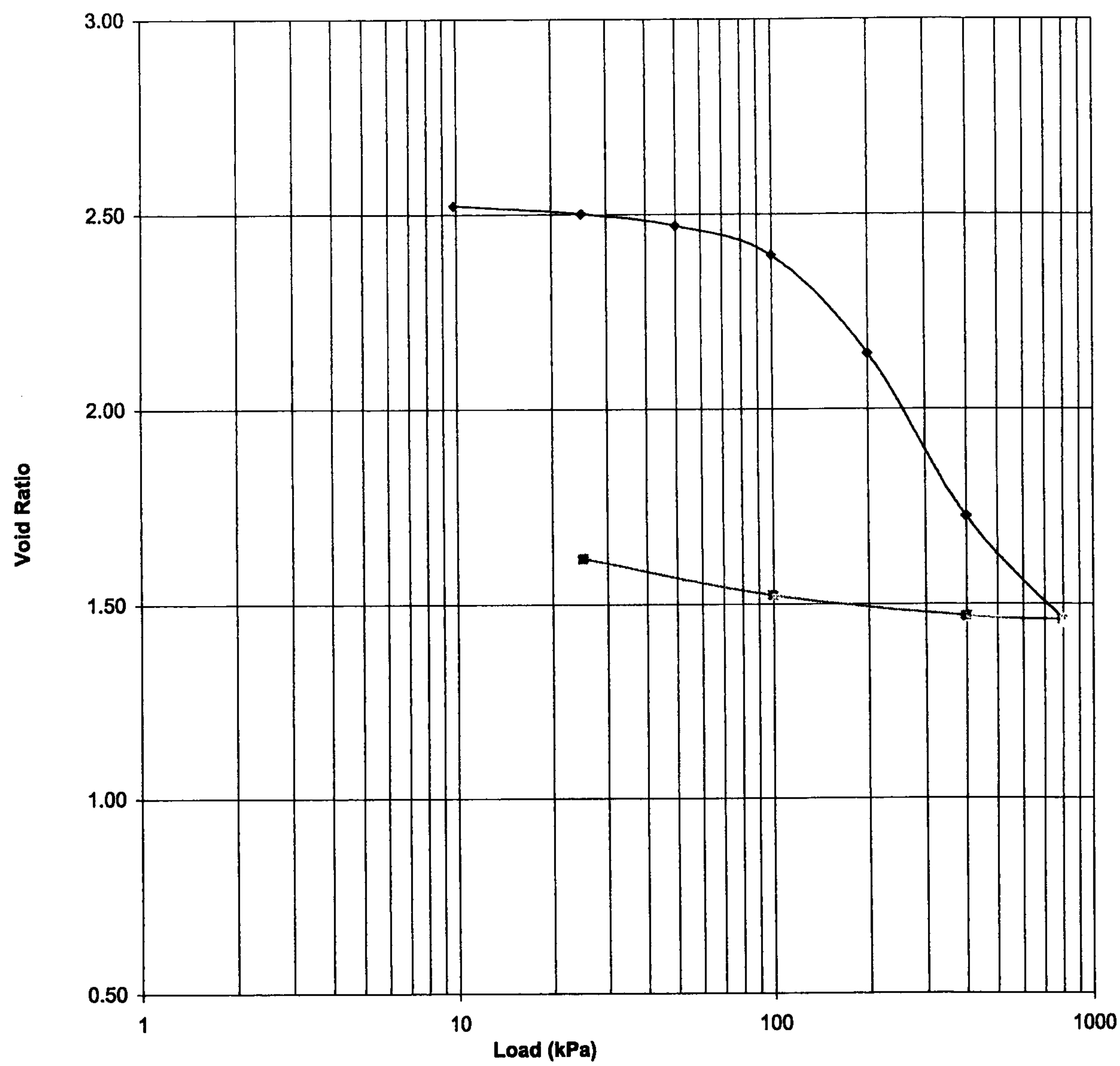
Project: Little Savanne River Bridge

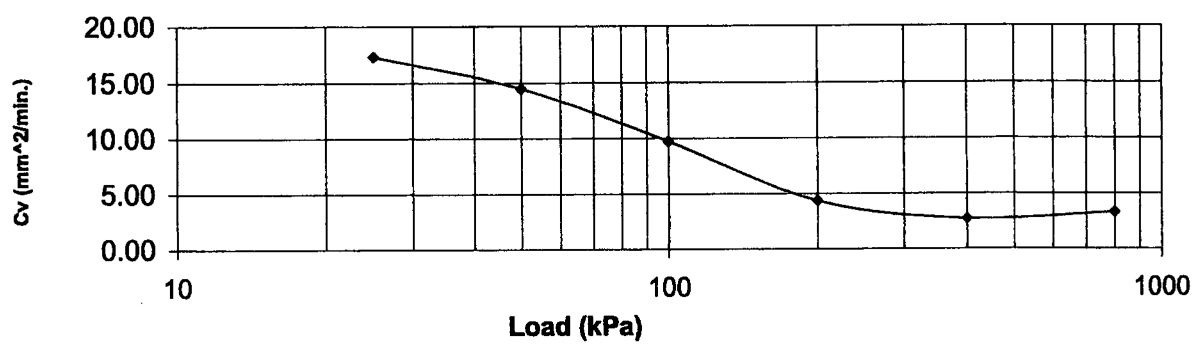
Location: 17

Number: J03-140

ENCLOSURE 5

TBT ATTERBURG MTO 03-140.GPJ CAN LAB.GDT 3/8/04



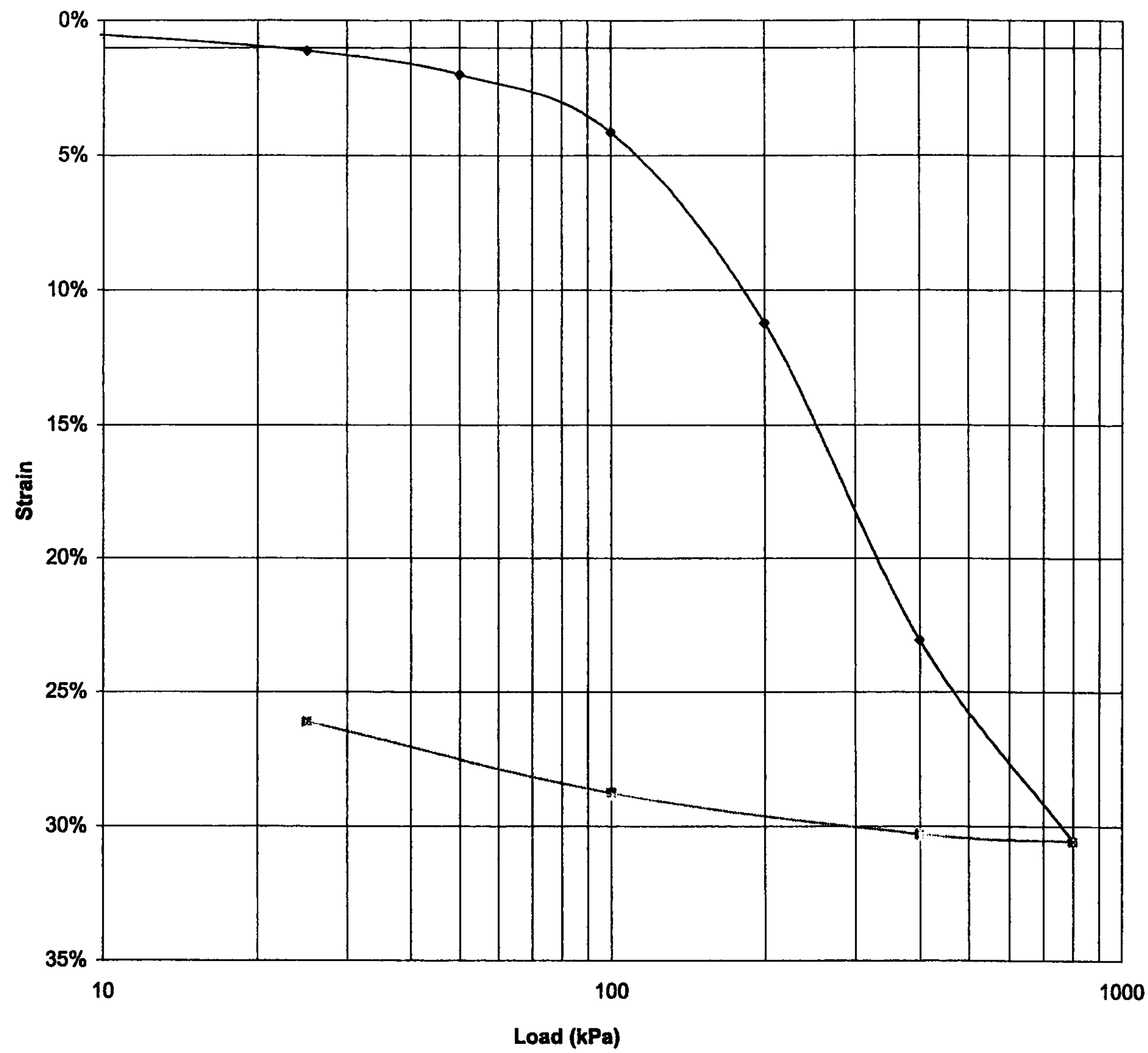


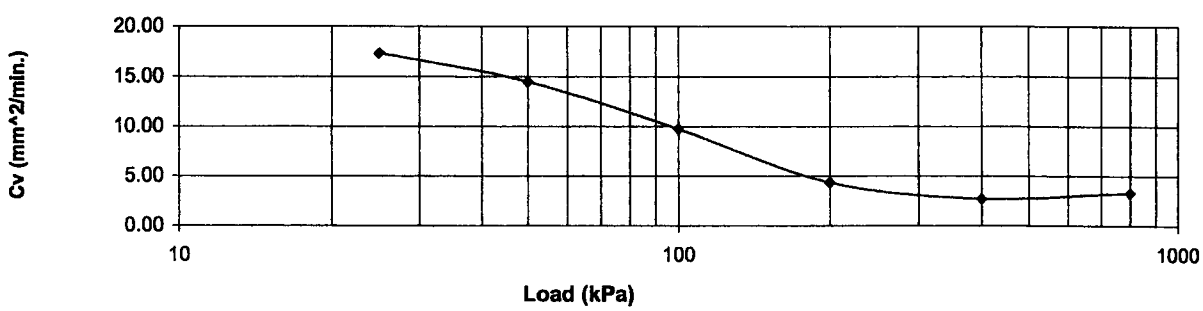
CONSOLIDATION TEST
Little Savanne River

Borehole 1 Depth: 4.9 Lab No. 143

Project No.: 03-140

Enclosure No.C-1



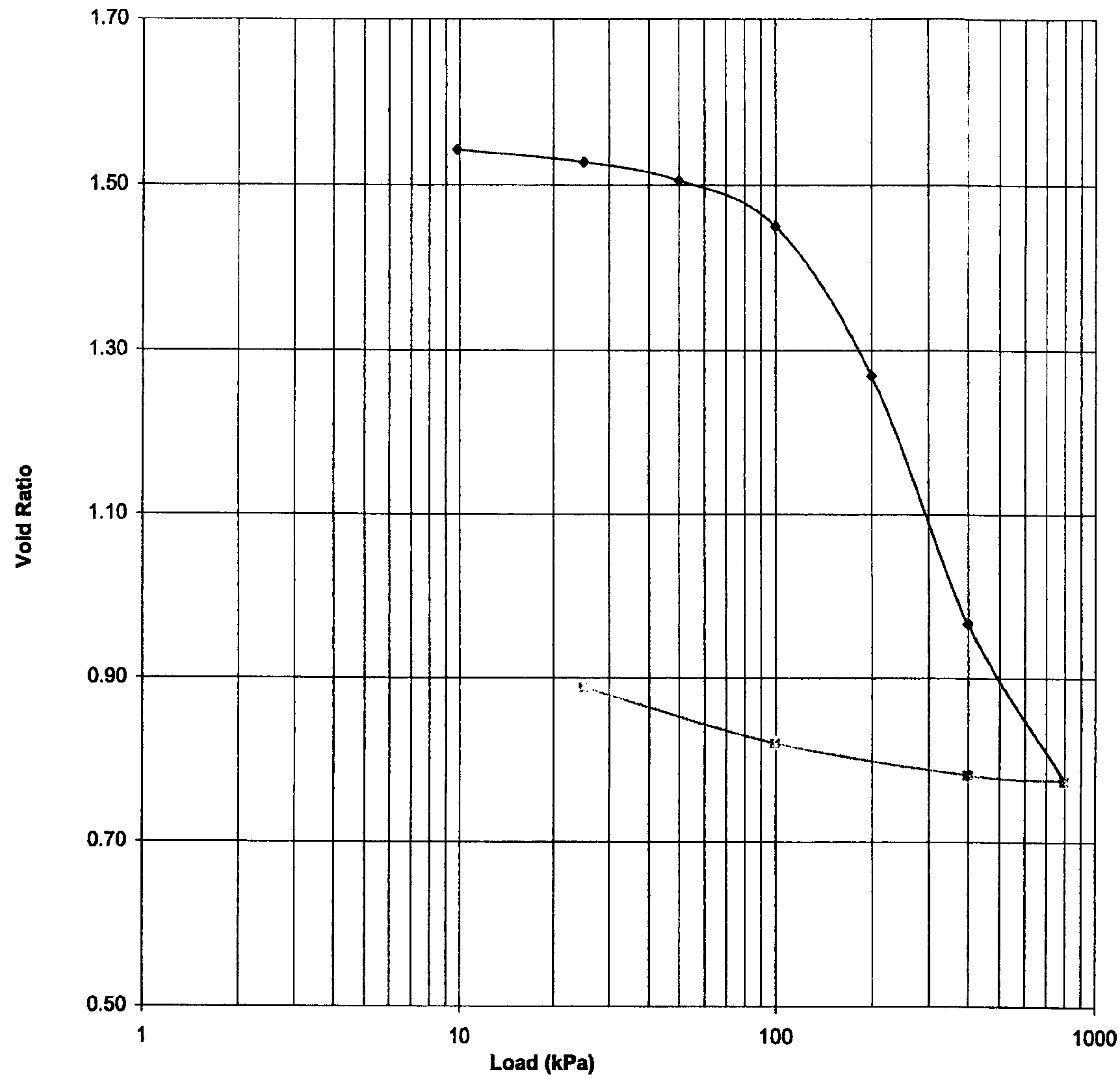


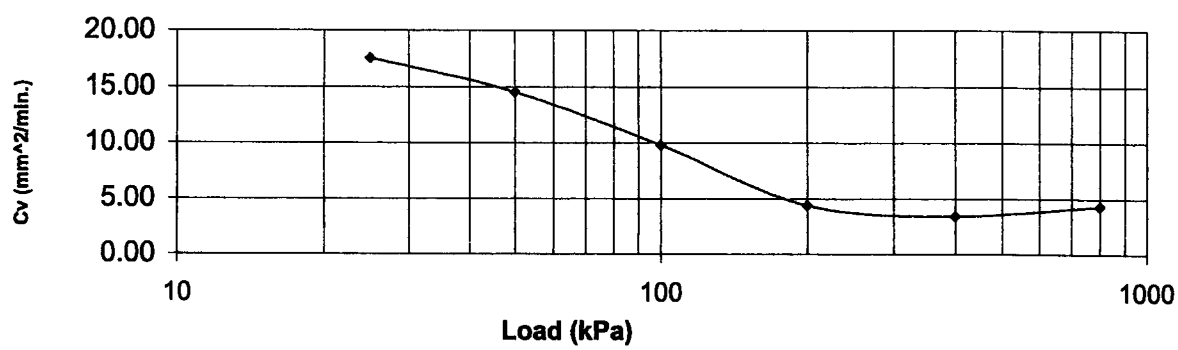
CONSOLIDATION TEST
Little Savanne River

Project No.: 03-140

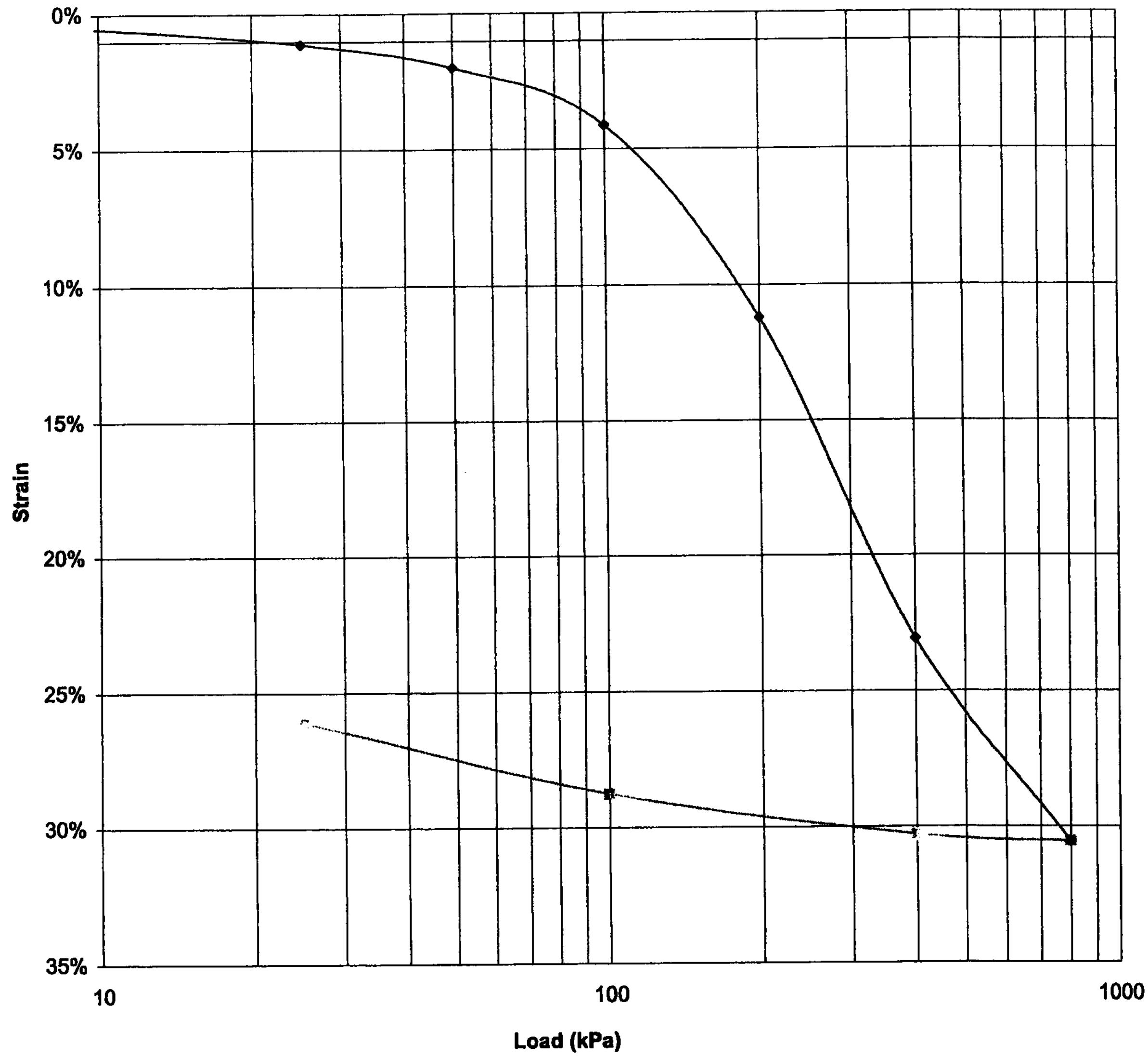
Borehole	1	Depth:	4.9	Lab No.:	143

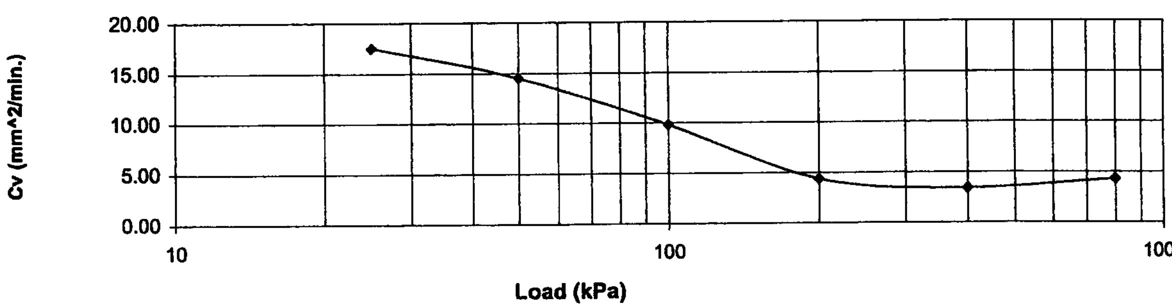
Enclosure No.C-1





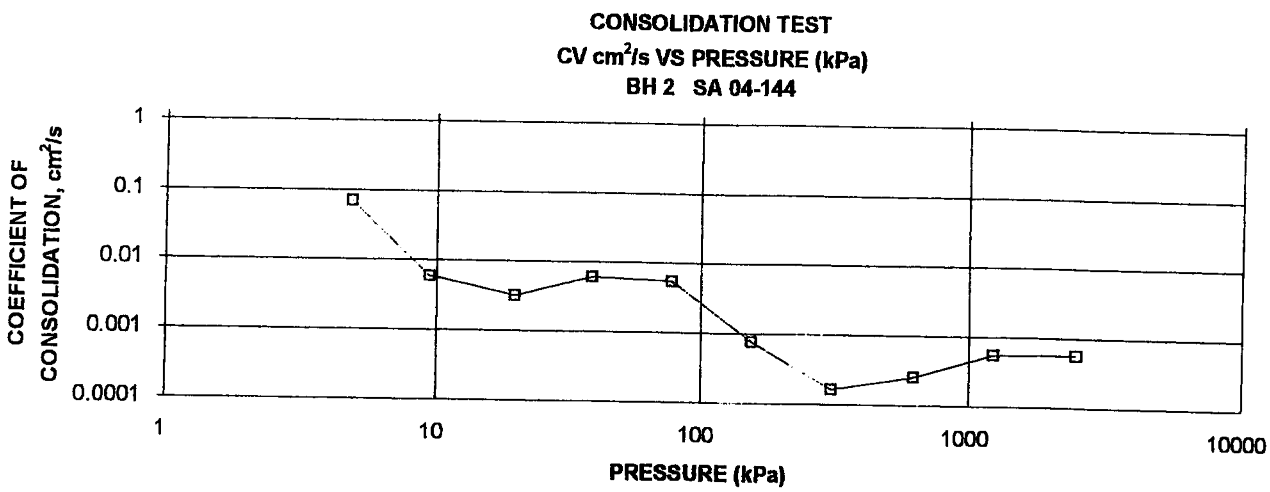
	CONSOLIDATION TEST **Little Savanne River**	Project No.: 03-140
	Borehole 3 Depth: 5.8m Lab No. 122	Enclosure No.C-1

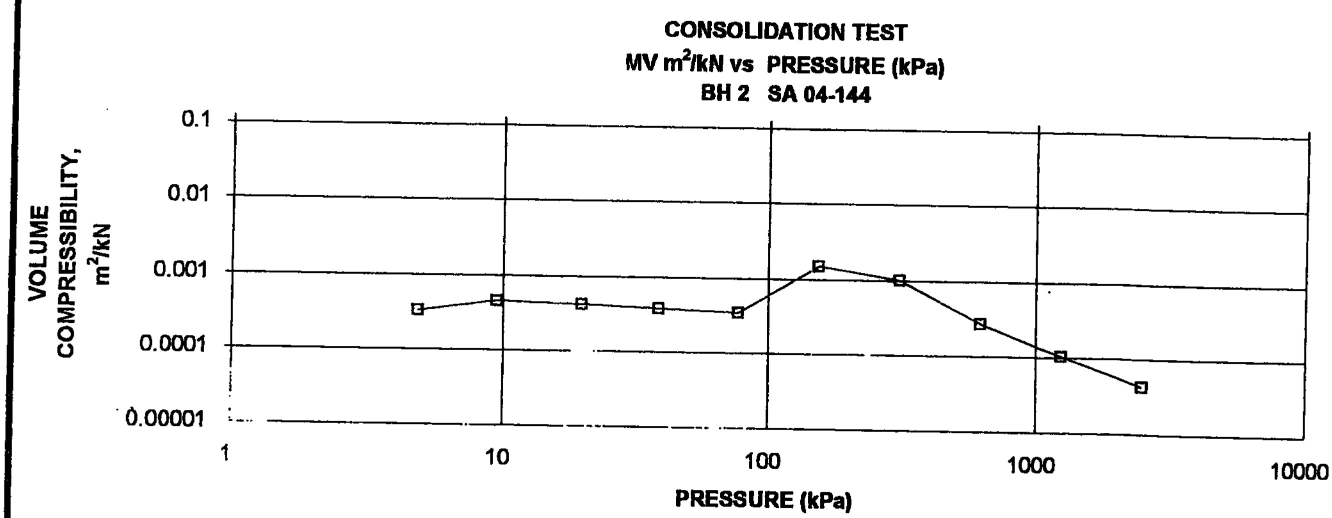


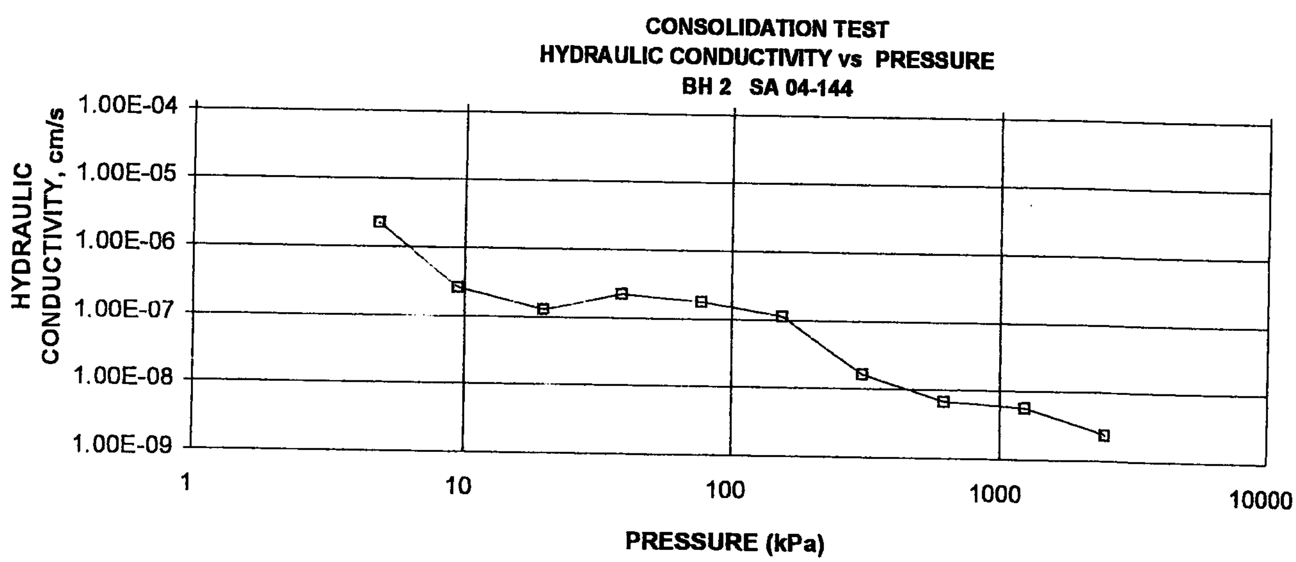


	CONSOLIDATION TEST **Little Savanne River**	Project No.: 03-140
	Borehole 3 Depth: 5.8m Lab No.: 122	Enclosure No.C-1

OEDOMETER CONSOLIDATION SUMMARY





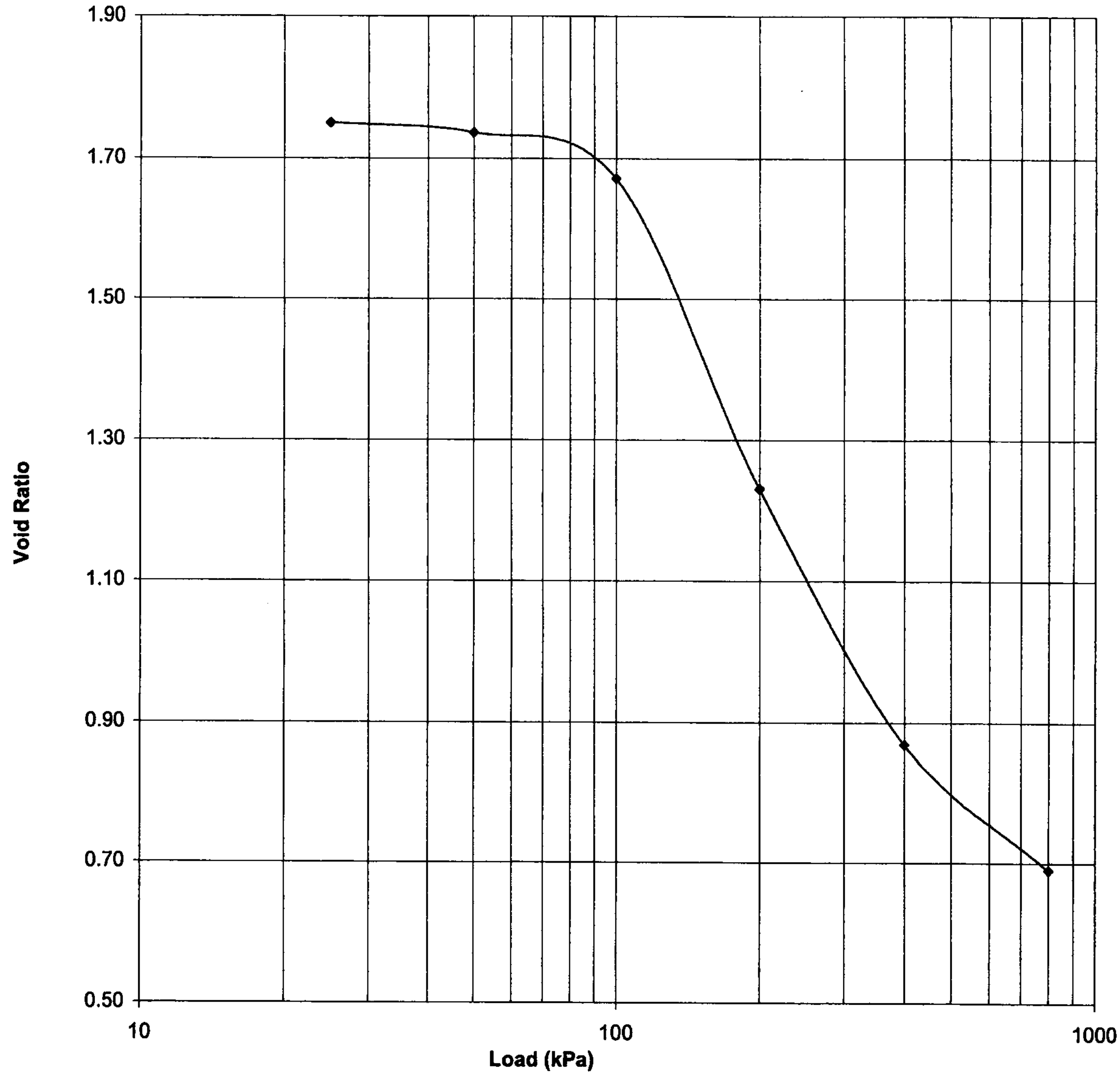


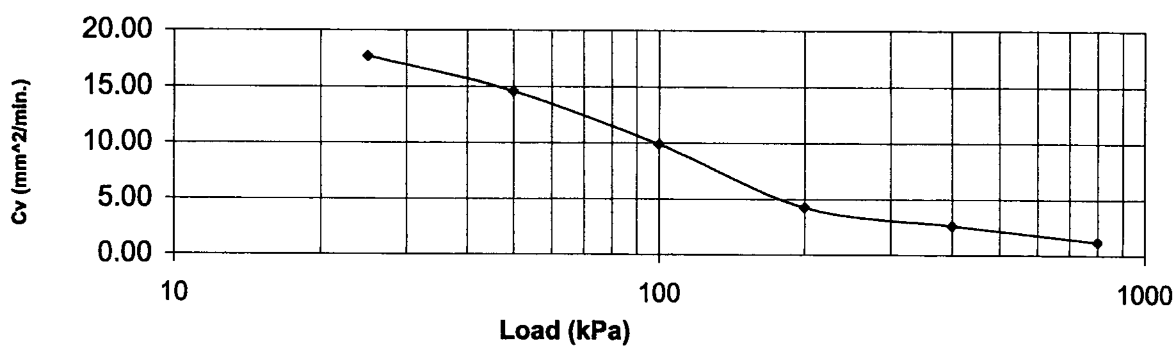
Project No. 04-1116-039

Prepared By: LFG

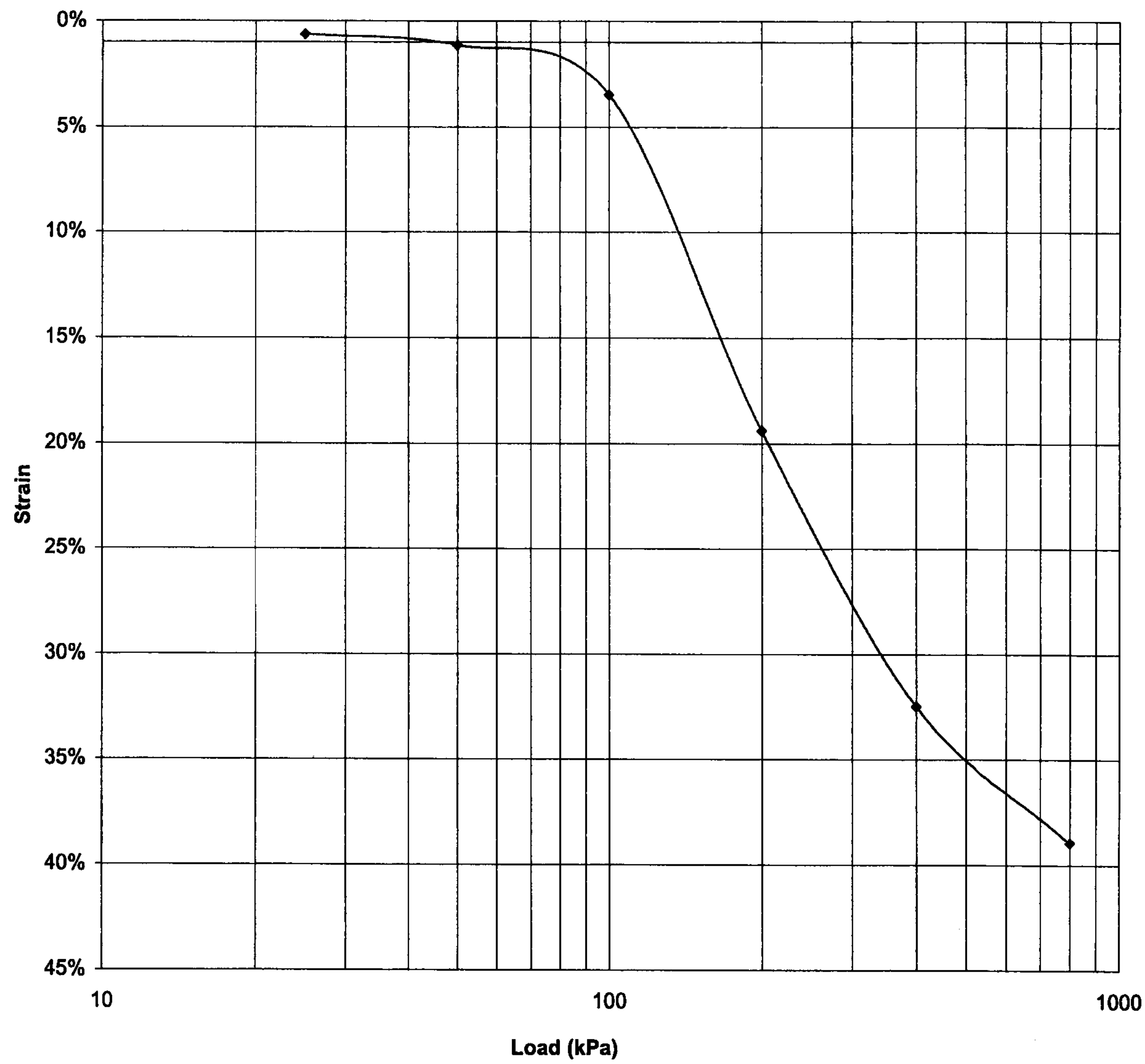
Golder Associates

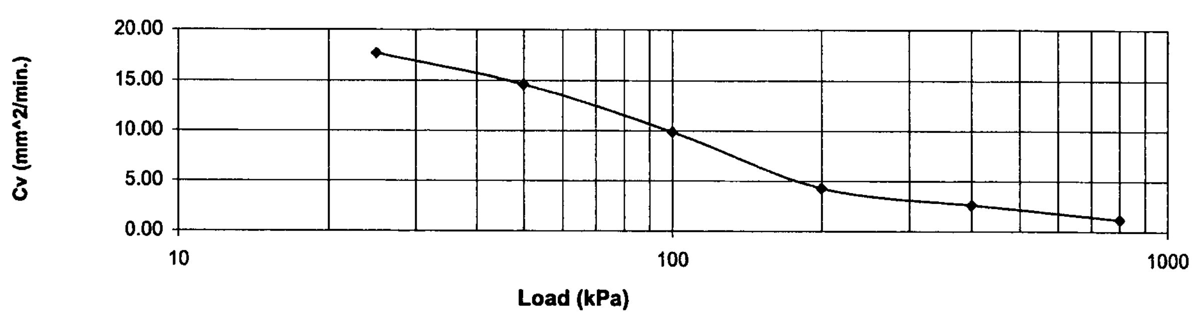
Checkey By: MM





	CONSOLIDATION TEST **Little Savanne River**	Project No.: 03-140
	Borehole 4 Depth: 5.3-5.9 m Lab No. 58	Enclosure No.C-1

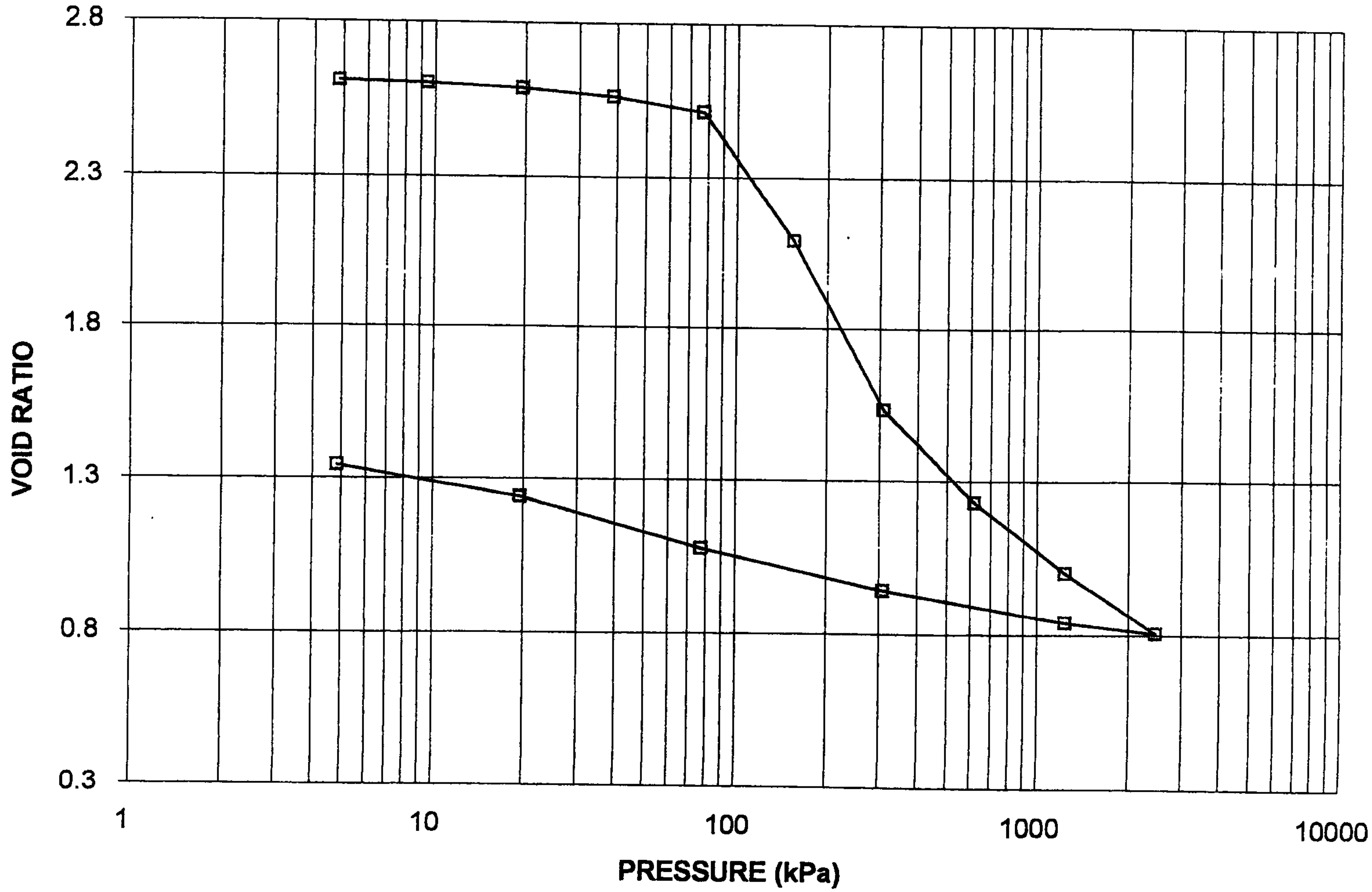




	CONSOLIDATION TEST **Little Savanne River**	Project No.: 03-140
	Borehole 4 Depth: 5.3-5.9 m Lab No.: 58	Enclosure No.C-1

Project No. 04-1116-039
Prepared By: LFG

CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH 2 SA 04-144



Golder Associates

Checked By: MM

CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE

UNCONFINED COMPRESSION TEST (UC)

ASTM D 2166-00

SAMPLE IDENTIFICATION

PROJECT NUMBER	04-1116-039	SAMPLE NUMBER	04-144
BOREHOLE NUMBER	2	SAMPLE DEPTH, m	6.1-6.7

TEST CONDITIONS

MACHINE SPEED, mm/min	1.40	TYPE OF SPECIMEN	
RATE OF AXIAL STRAIN, %/min	1.00	L/D	2.02

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.99	WATER CONTENT, (specimen) %	68.35
SAMPLE DIAMETER, cm	6.94	UNIT WEIGHT, kN/m^3	15.89
SAMPLE AREA, cm^2	37.83	DRY UNIT WT., kN/m^3	9.44
SAMPLE VOLUME, cm^3	529.21	SPECIFIC GRAVITY, measured	2.84
WET WEIGHT, g	857.90	VOID RATIO	0.66
DRY WEIGHT, g	509.59		

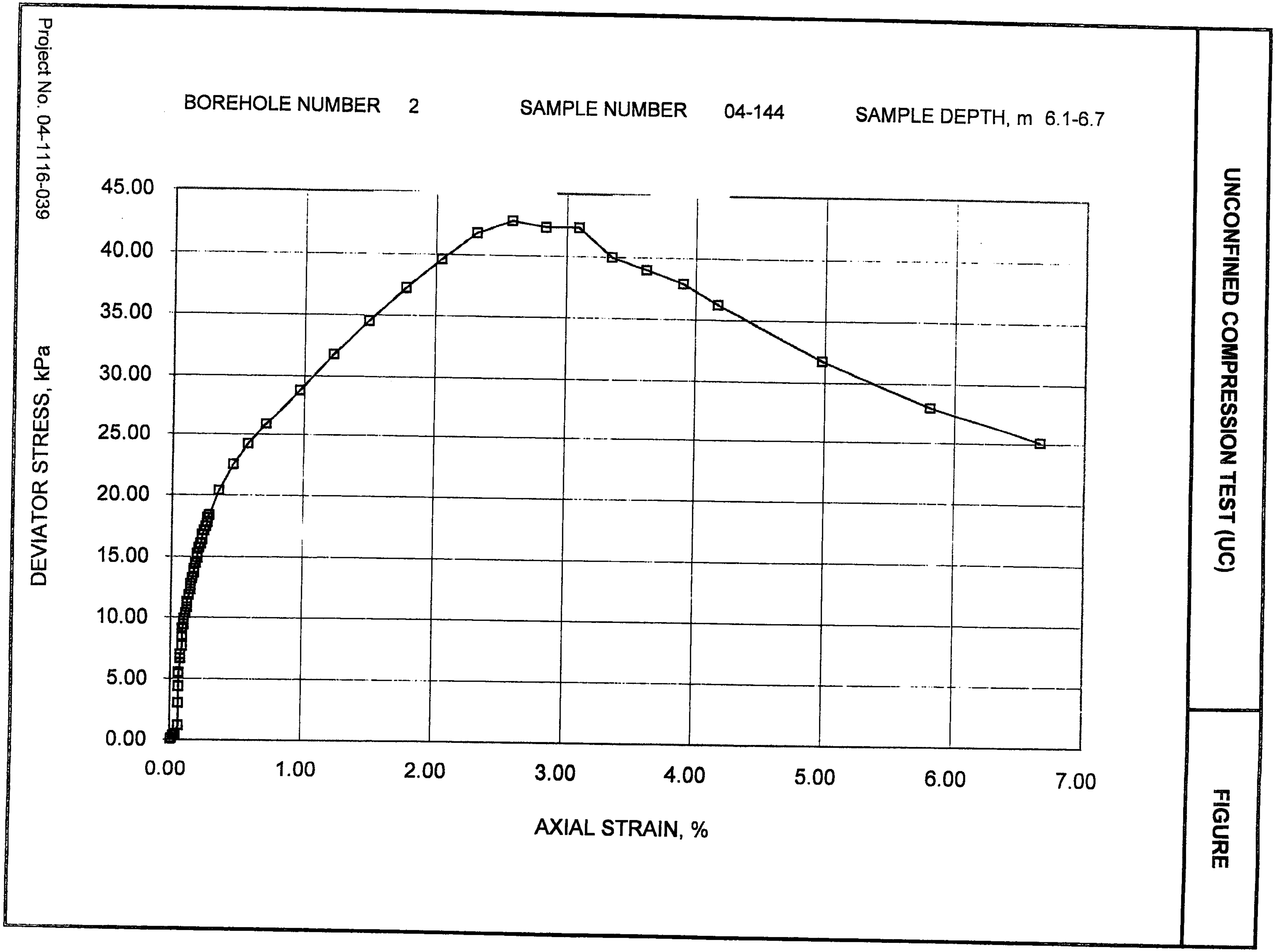
FAILURE SKETCH

TEST RESULTS

STRAIN AT FAILURE, %	2.6	COMPRESSIVE STRESS, kPa	43

REMARKS:		DATE:	5/5/2004
PREPARED BY:	MM	CHECKED BY:	RO

Golder Associates


Project No. 04-1116-039
BOREHOLE NUMBER 2
SAMPLE NUMBER 04-144
SAMPLE DEPTH, m 6.1-6.7
DEVIATOR STRESS, kPa
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
AXIAL STRAIN, %
UNCONFINED COMPRESSION TEST (UC)
FIGURE

UNCONFINED COMPRESSION TEST (UC)

ASTM D 2166-00

SAMPLE IDENTIFICATION

PROJECT NUMBER	04-1116-039	SAMPLE NUMBER	04-068
BOREHOLE NUMBER	4	SAMPLE DEPTH, m	5.3-5.9

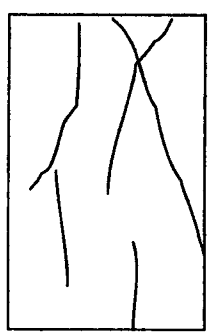
TEST CONDITIONS

MACHINE SPEED, mm/min	1.40	TYPE OF SPECIMEN	
RATE OF AXIAL STRAIN, %/min	1.01	L/D	1.91

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.81	WATER CONTENT, (specimen) %	47.89
SAMPLE DIAMETER, cm	7.24	UNIT WEIGHT, kN/m^3	17.21
SAMPLE AREA, cm^2	41.17	DRY UNIT WT., kN/m^3	11.64
SAMPLE VOLUME, cm^3	568.54	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	998.30	VOID RATIO	0.56
DRY WEIGHT, g	675.03		

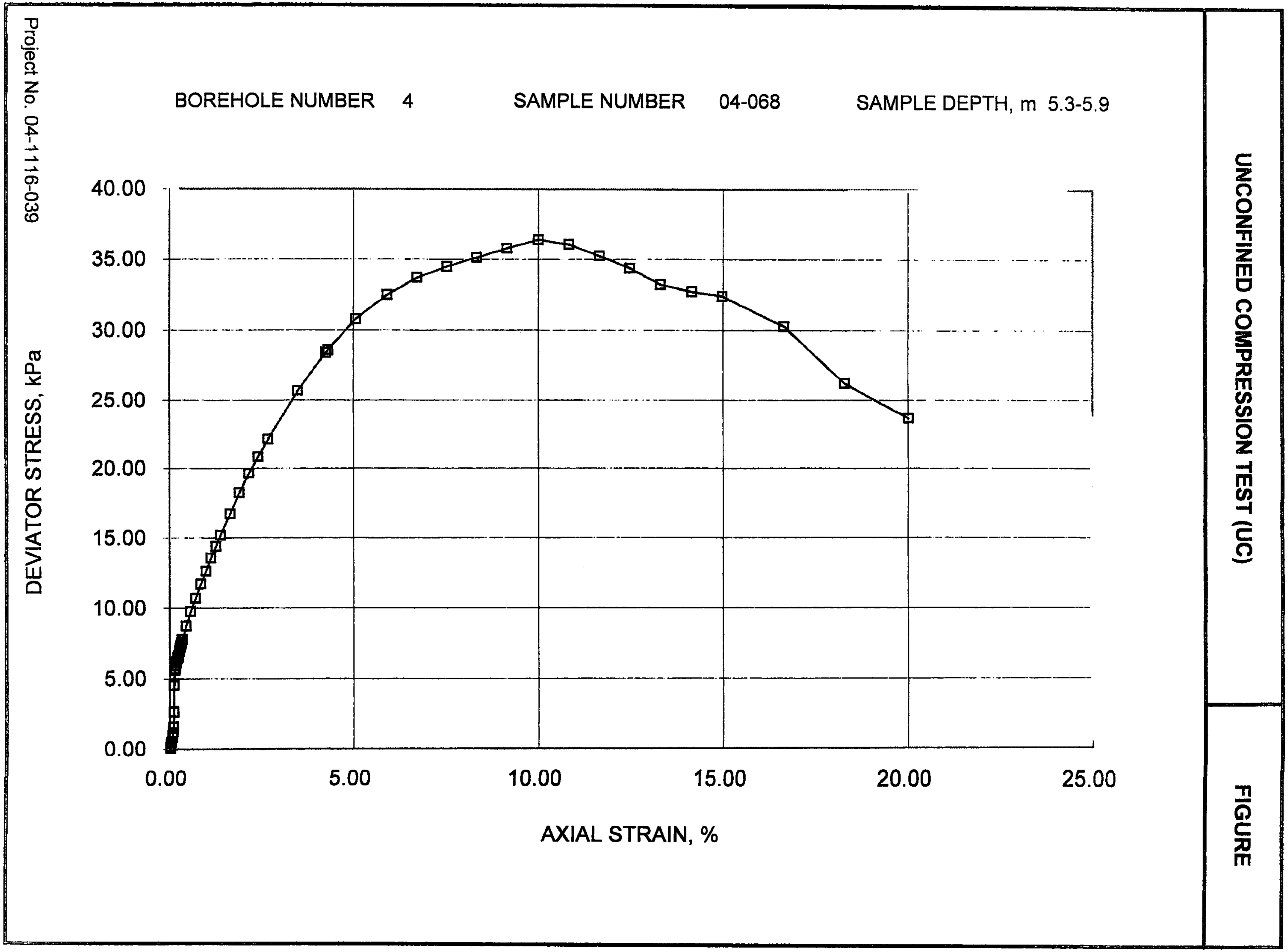
FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	10.0	COMPRESSIVE STRESS, kPa	36

REMARKS:		DATE:	5/5/2004
PREPARED BY:	MM	CHECKED BY:	RO


Project No. 04-1116-039
BOREHOLE NUMBER 4
SAMPLE NUMBER 04-068
SAMPLE DEPTH, m 5.3-5.9
DEVIATOR STRESS, kPa
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
5.00
10.00
15.00
20.00
25.00
AXIAL STRAIN, %
UNCONFINED COMPRESSION TEST (UC)
FIGURE

SPECIFIC GRAVITY TEST RESULTS

ASTM D 854-00 TEST METHOD A

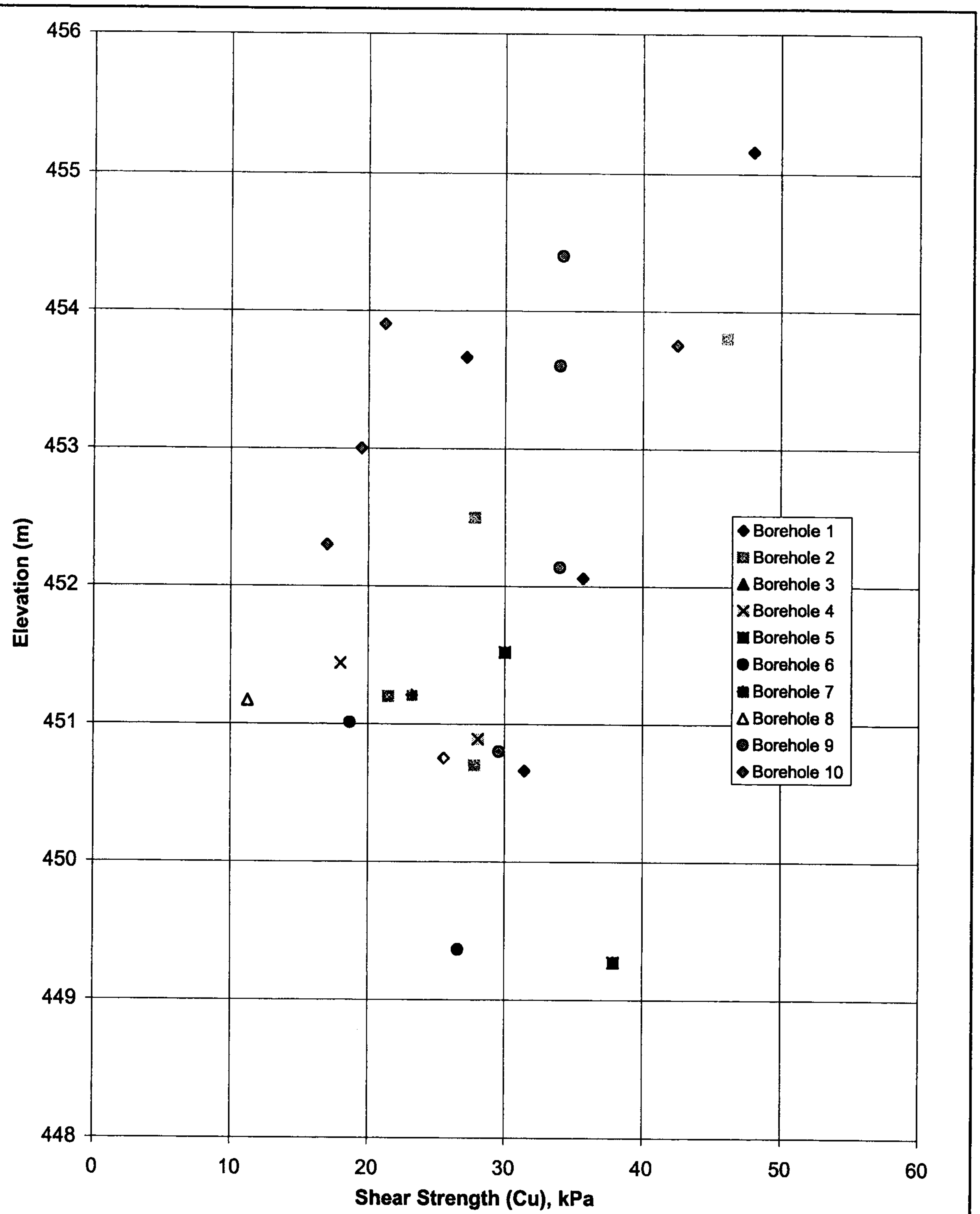
PROJECT NUMBER	04-1116-039
PROJECT NAME	TBT / Lab Testing / P.O. 3438
DATE TESTED	May, 2004

Borehole No.	Sample No.	Specific Gravity
2	04-144	2.84

Note: Test carried out on soil particles <4.75mm using distilled water.

APPENDIX C

Drawings and Figures



Little Savanne River Bridge

Shear Strength Profile - Clay Strata

TBT ENGINEERING

TBTE Ref. No. 03-140

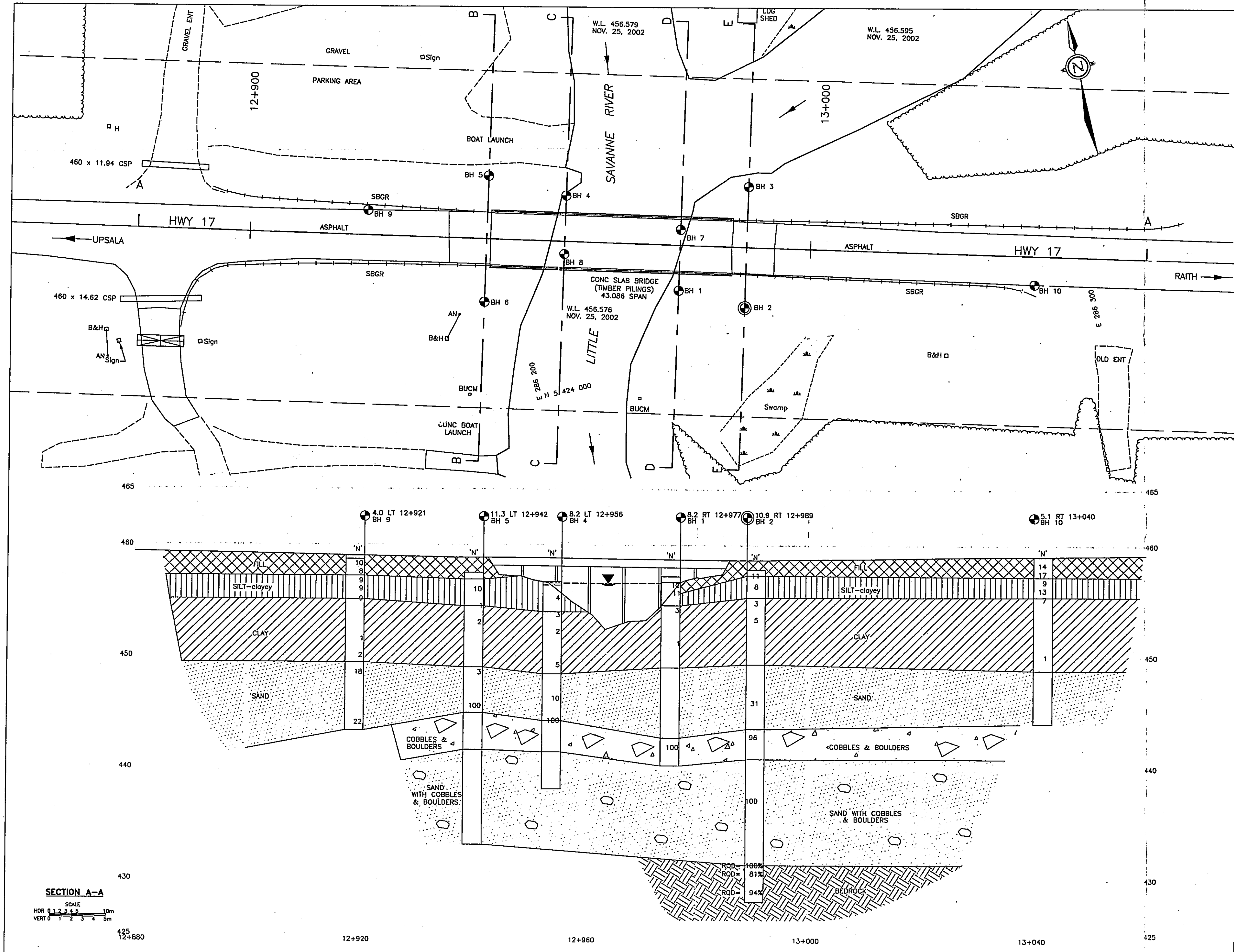
Figure No.1

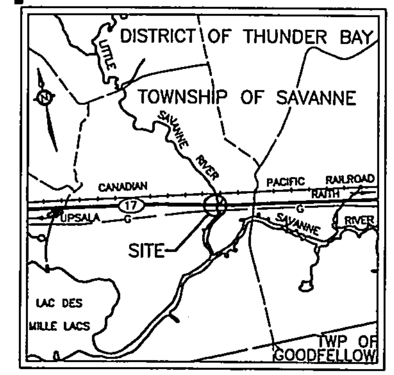
CONT No
WP NO 198-92-00

LITTLE SAVANNE RIVER BRIDGE
HWY 17, Approx. 18.9km East of Upsala
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 1

TBT ENGINEERING





KEY PLAN

1.0 km 0 1.0 km

SOIL STRATA SYMBOLS

SAND
SAND WITH COBBLES
BEDROCK
SILT–clayey
FILL
COBBLES & BOULDERS
CLAY

LEGEND

Borehole
Borehole with Rock Core
'N' Std Pen Test (Blows/0.3m)
WL at time of investigation FEB 2004

No	ELEVATION	BOREHOLE LOCATION STA.	O/S
1	457.2	12+977	8.2 RT
2	457.3	12+989	10.9 RT
3	457.1	12+989	10.9 LT
4	456.7	12+956	8.2 LT
5	457.5	12+942	11.3 LT
6	457.8	12+942	11.4 RT
7	456.8	12+977	2.8 LT
8	456.6	12+956	2.3 RT
9	459.0	12+921	4.0 LT
10	459.0	13+040	5.1 RT

HORIZONTAL DATUM
North American Datum 1983 (NAD83)(CSRS)
3 Degree Modified Transverse Mercator
(MTM Zone 15) Grid Coordinates

VERTICAL DATUM
Canadian Geodetic Vertical Datum
1928 Adjustment, Geodetic Elevations

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

REVISIONS

DRAWING REFERENCED FROM PLAN B&C-1039-17-3, HWY 17, TWP OF SAVANNE 12+698.832 TO 13+410.078, NOV 2002, MINISTRY OF TRANSPORTATION, NORTHWEST REGION

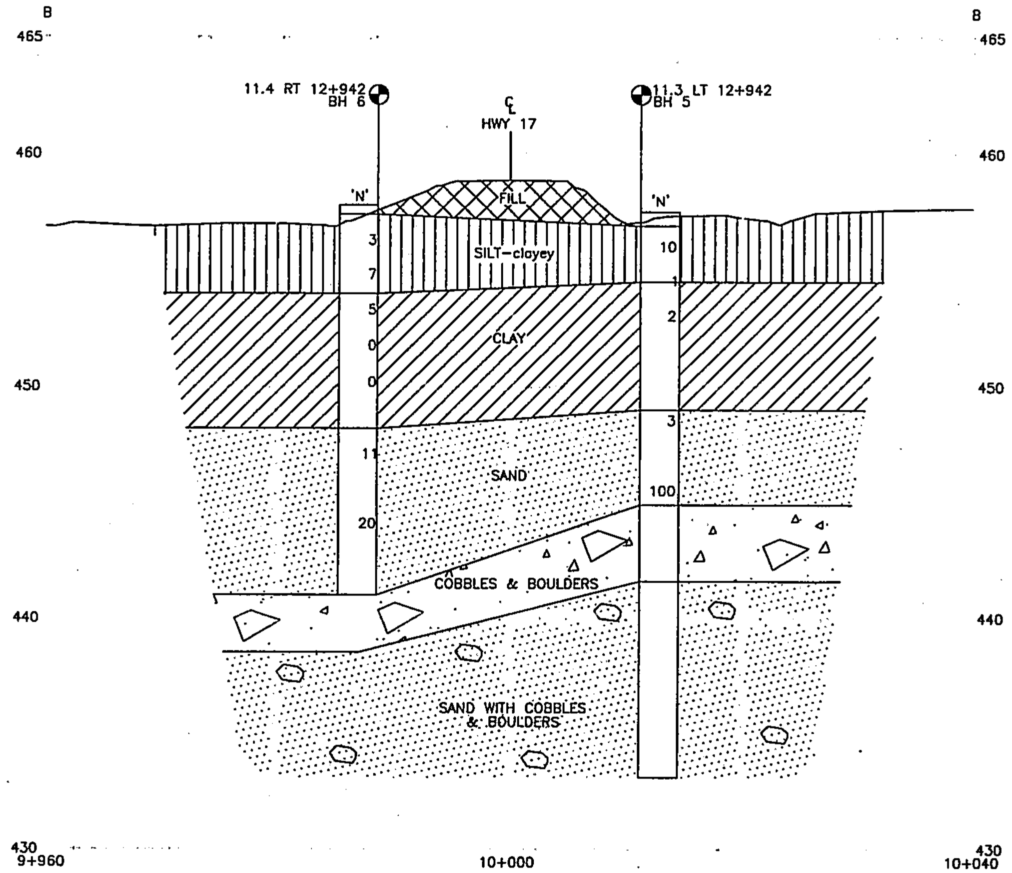
HWY 17 LITTLE SAVANNE RIVER BRIDGE			DIST	THUNDER BAY
SUBM'D WH	CHECKED	DATE JUNE 2004	SITE	
DRAWN CZ	CHECKED	APPROVED	DWG	2

CONT No
WP NO 198-92-00

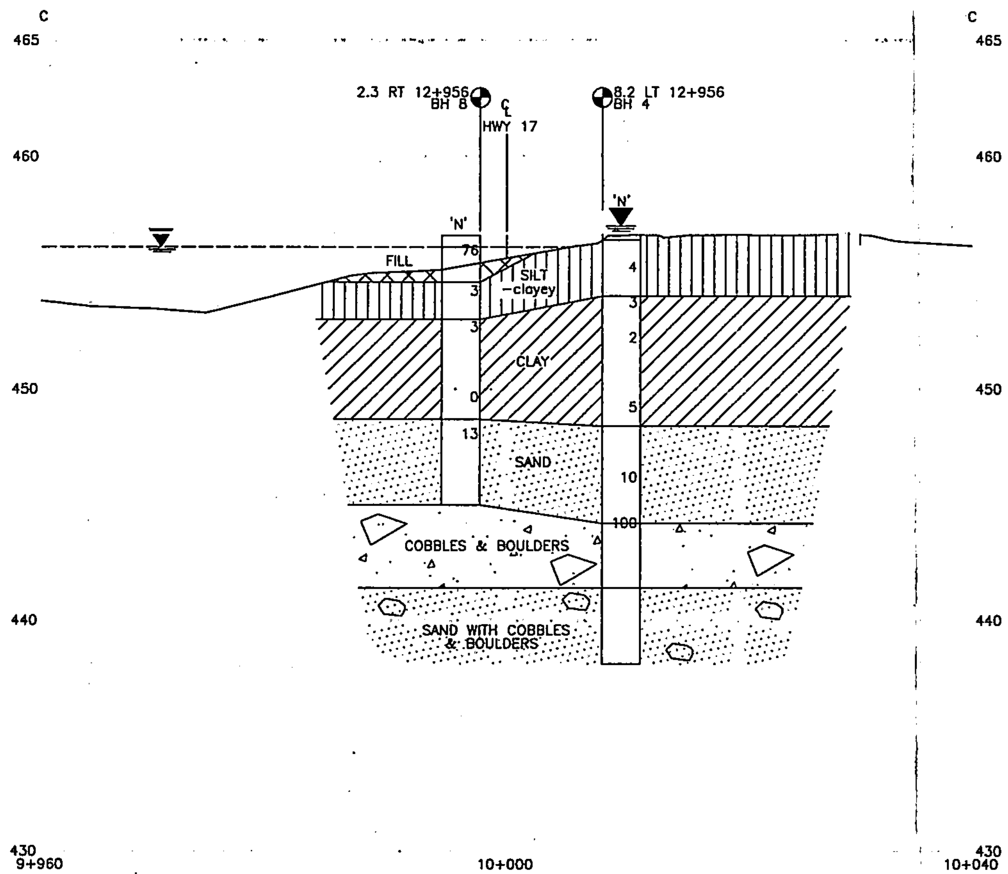
LITTLE SAVANNE RIVER BRIDGE
HWY 17, Approx. 18.9km East of Upsala
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 2

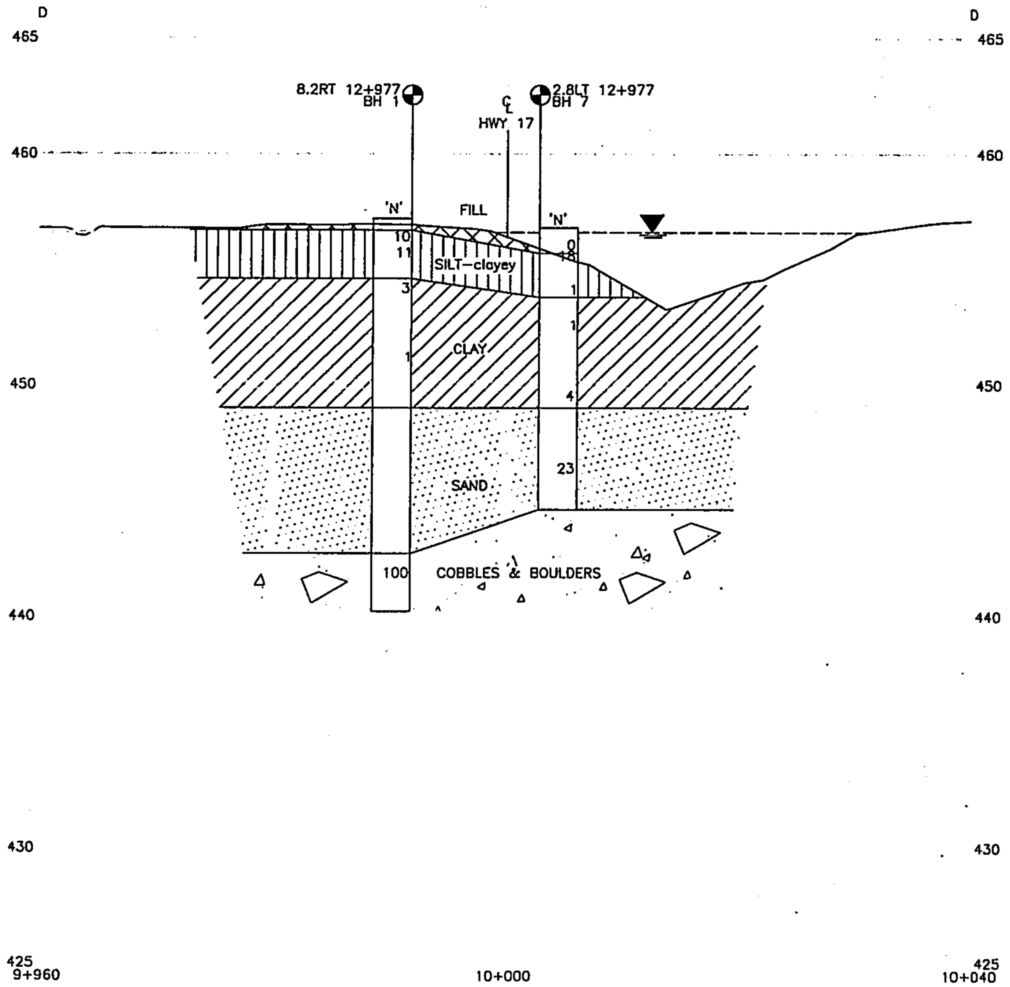
TBT ENGINEERING



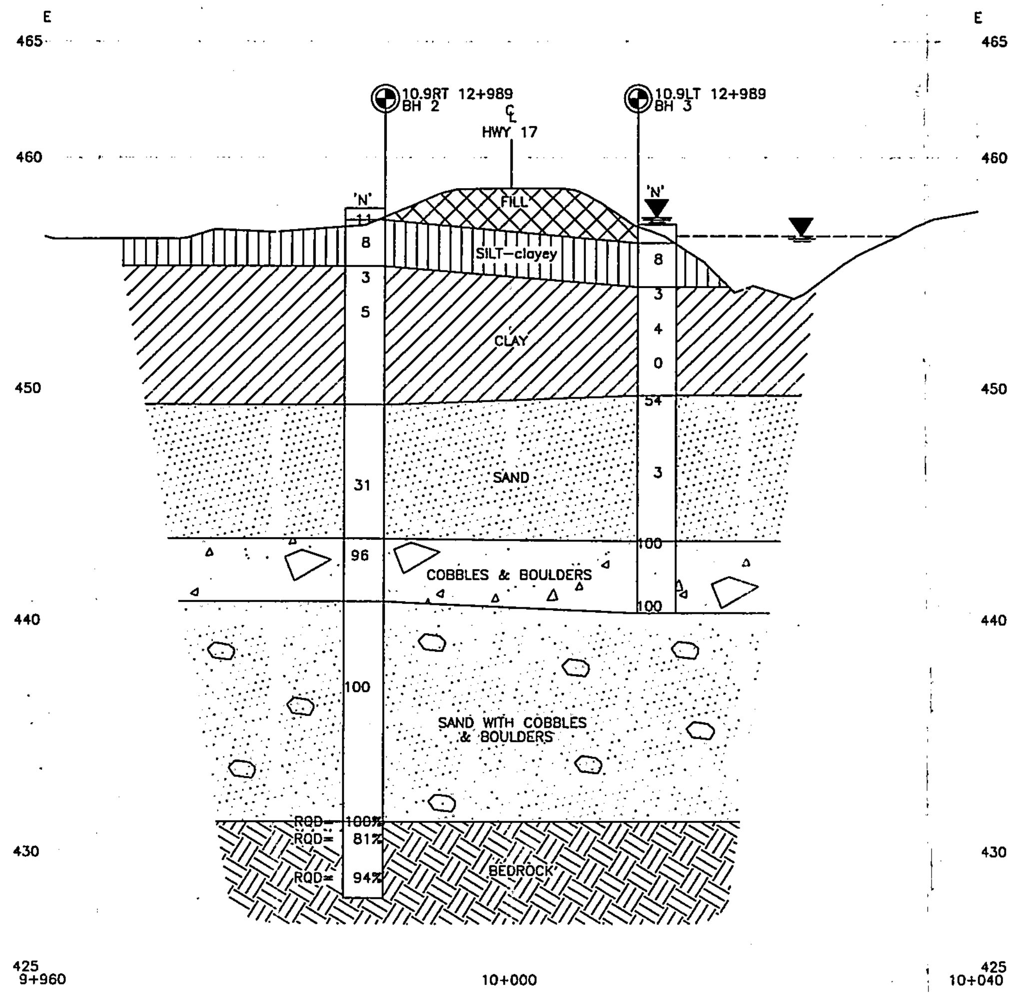
SECTION B-B
10+000 = 12+942.068
SCALE
HOR 0 1 2 3 4 5 10m
VERT 0 1 2 3 4 5m



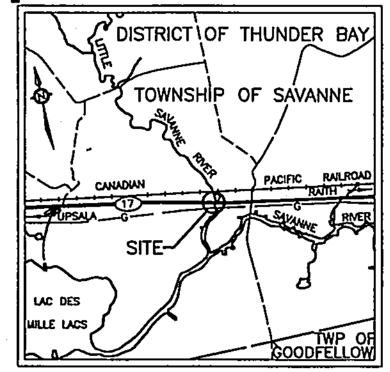
SECTION C-C
10+000 = 12+956.054
SCALE
HOR 0 1 2 3 4 5 10m
VERT 0 1 2 3 4 5m



SECTION D-D
10+000 = 12+976.542
SCALE
HOR 0 1 2 3 4 5 10m
VERT 0 1 2 3 4 5m



SECTION E-E
10+000 = 12+988.540
SCALE
HOR 0 1 2 3 4 5 10m
VERT 0 1 2 3 4 5m



KEY PLAN
1.0 km 0 1.0 km

SOIL STRATA SYMBOLS	
SAND	SAND WITH COBBLES
BEDROCK	SILT-clayey
FILL	COBBLES & BOULDERS
CLAY	

LEGEND

- Borehole
- Borehole with Rock Core
- 'N' Std Pen Test (Blows/0.3m)
- WL at time of investigation FEB 2004

No	ELEVATION	BOREHOLE LOCATION STA.	O/S
1	457.2	12+977	8.2 RT
2	457.3	12+989	10.9 RT
3	457.1	12+989	10.9 LT
4	456.7	12+956	8.2 LT
5	457.5	12+942	11.3 LT
6	457.8	12+942	11.4 RT
7	456.8	12+977	2.8 LT
8	456.6	12+956	2.3 RT
9	459.0	12+921	4.0 LT
10	459.0	13+040	5.1 RT

HORIZONTAL DATUM
North American Datum 1983 (NAD83)(CSRS)
3 Degree Modified Transverse Mercator
(MTM Zone 15) Grid Coordinates

VERTICAL DATUM
Canadian Geodetic Vertical Datum
1928 Adjustment, Geodetic Elevations

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

REVISIONS

DRAWING REFERENCED FROM PLAN B&C-1039-17-3, HWY 17, TWP OF SAVANNE 12+698.832 TO 13+410.078, NOV 2002, MINISTRY OF TRANSPORTATION, NORTHWEST REGION

HWY 17 LITTLE SAVANNE RIVER BRIDGE			DIST THUNDER BAY
SUBM'D WH	CHECKED	DATE JUNE 2004	SITE
DRAWN CZ	CHECKED	APPROVED	DWG 3

TBT ENGINEERING

GEOTECHNICAL ENGINEERING DIVISION

GEOTECHNICAL DESIGN REPORT

G.W.P. NO. 198-92-00

TBTE Ref. No. 03-140

LOCATION:

Highway 17, Little Savanne River Bridge – Site 48W-16

January 11, 2005

INTEROFFICE MEMORANDUM

To: Distribution below

Date: January 31, 2005

Subject: **GWP 198-92-00**
Little Savanne River Bridge
18.9 km E. Upsala E. Limits, Site 48W-16
<u>Highway 17, Thunder Bay District</u>

Attached please find a copy of the Geotechnical Design Report for the above-noted group work project for your information.

L. McLure

L. McLure
Eng. Services Officer
Engineering Office
(for)
P. Makula
Manager, Engineering
Northwestern Region

<u>Distribution:</u>

<u>Head Office</u>	<u>Regional</u>	<u>District</u>
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T.J. Kazmierowski	I. Galloway (2)	
	B. Snell (3)	

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Geotechnical Design Report

GWP 198-92-00 – Little Savanne River Bridge Replacement

1.0 LOCATION

This project includes the replacement of the Little Savanne River Bridge (Site No. 48W-16) located on Highway 17 within the Township of Savanne. The Little Savanne River Bridge structure is located approximately 18.9 km east of the town of Upsala, Ontario.

Little Savanne River Bridge (MTO Site # 48W-16)

Little Savanne River Approaches (MTO Site # 48W-16)

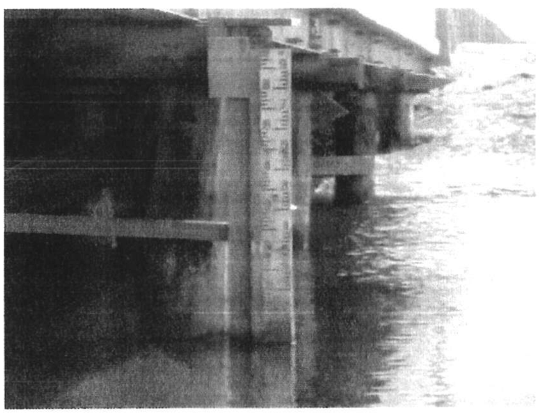
Little Savanne River - East approach looking Westerly

Little Savanne River - West approach looking Easterly

2.0 SCOPE OF WORK

The scope of work, as per Agreement No. 6005-A-000266, consists of the replacement of the Little Savanne River Bridge, rehabilitation of both approaches, and a grade raise of up to 1.2 m. This report covers the geotechnical aspects for approach fill and pavement structure design. A Foundation Report for the structure replacement will be issued under a separate cover. The design project is being carried out under an Agreement between the Ministry of Transportation and Stantec Consulting Ltd. TBT Engineering is providing the geotechnical and foundation engineering services as a sub-consultant to Stantec Consulting Ltd.

Investigations were based on the proposed alignment, gradeline and project limits as supplied by the Prime Consultant, Stantec Consulting Ltd, *(Design Option 3).* The proposed vertical alignment at the structure consisted of a grade raise in the order of approximately 1.0 m. The existing horizontal alignment was to be retained. The two commercial entrances located at station 12+910, servicing a campground to the south and side road to the north, are to be relocated to station 12+803 to accommodate the proposed grade raise and construction operations.



Little Savanne River Bridge – underside of existing structure showing timber pile foundation and water level conditions.

3.0 EXISTING SITE CONDITIONS

The existing Little Savanne River Bridge is a two-lane structure comprised of concrete decking and abutments supported by a deep timber pile foundation system. The bridge deck is surfaced with asphaltic concrete. Both approaches are in a fill condition at the structure. The adjacent sections of Highway 17 were reconstructed in 2002 under Contract 2001-0215 with a treatment of in-place processing and placing 130 mm Hot Mix Asphalt consisting of a 65 mm Heavy Duty Binder Course (HDBC) and a 65 mm HL 4 modified surface course (HL4M). The reconstructed sections of pavement east and west of the structure, within this projects limit, are considered to be in a good condition with no visual evidence of distorting or cracking.

A tourist camp/outfitter is located on the southwest quadrant of the site and a public boat launch facility with parking area is situated upstream from the structure in the northwest quadrant of the site. The Little Savanne River is to remain navigable at the bridge structure.

3.1 Physiography and Soils Data

At this location, Highway 17 runs in a generally east-west direction. The Little Savanne River flows southerly, into the Savanne River and into Lac Des Milles Lacs. The area surrounding the bridge site is rural and generally covered with mixed bush. The terrain in the immediate surrounding area is flat and swampy.

The quaternary geology of the site is mapped (Ministry of Northern Development and Mines, Ontario Geological Survey, Map 2554) as recent fluvial deposits, including gravel, sand, silt and clay deposited on modern flood plains. Directly north of the site, the area is mapped as glaciofluvial outwash deposits, gravel and sand. Bedrock geology in the vicinity is mapped (Ontario Geological Map No. 2199) to include Early Pre-Cambrian felsic igneous and metamorphic rock.

3.1.1 Soil Erodibility

Based on grainsize analyses carried out on representative subgrade soil samples, the native clayey silt material is considered moderately to highly erodible with a 'k' factor ranging between 0.25 and 0.6. Erosion control measures should be taken where subgrade soils are to be exposed.

3.1.2 Frost Penetration

The MTO Pavement Design and Rehabilitation Manual documents a design frost penetration depth of 2.4 m below bare asphalt for the Upsala area.

3.2 Investigations

TBTE conducted a site investigation of the bridge approaches for verification of existing pavement structure, soil and local drainage conditions. Investigations included power auger, hand auger (PEDO) and asphalt pavement coring programs. Utility owners were contacted for clearance prior to the commencement of field investigation activities.

Field investigations were conducted in accordance with the Northwest Region Geotechnical Investigation Minimum Requirements. Asphalt coring investigations included coring with a 150-mm nominal diameter core barrel to verify approach pavement thickness and Granular 'A' depth below the pavement. Boreholes were placed in the shoulders of each approach with sampling of the existing granular base and sub-base courses within the paved shoulders for verification of material gradation. PEDO investigations were conducted for the proposed widening, commercial entrance relocation, and drainage improvements.

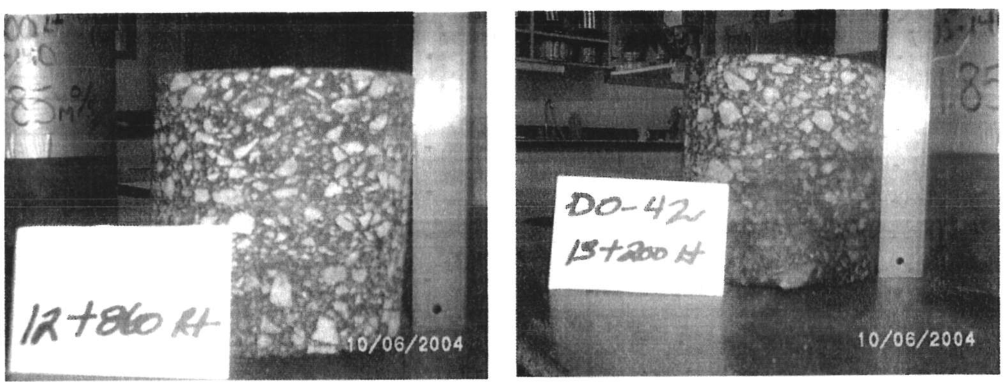
Thirty-eight boreholes were drilled to investigate the pavement structure and subsurface soils for this project. In addition, ten deep foundation boreholes were carried out by TBT Engineering to investigate the sub-surface conditions for the proposed structure replacement. All boreholes were advanced past the interface of the existing fill material and native soils. Station, offset, material types and layer depths were noted for all boreholes. A listing of borehole logs with sampling locations is appended to this report.

3.3 Existing Conditions

Boreholes placed in the existing roadbed indicate that there generally is between 1.0 m and 2.1 m of granular base and sub-base materials overlying native clayey silt with some areas containing organic material. Laboratory testing carried out on representative samples indicate that the existing granular base materials grade fine to acceptable for Granular 'A' and the existing sub-base materials grade fine for Granular 'B' Type III. The silt subgrade becomes more plastic with depth, ranging from soft to firm in consistency and from medium to high in plasticity as it changes to clay. The clay is frequently varved and brownish grey in colour.

3.3.1 Core Results

The asphaltic pavement within the project limits was cored at twelve locations. Station, offset and layer depths were noted for all pavement cores. Asphalt depths generally varied between 110 mm and 150 mm within the main lanes. The paved entrance located 60 m west of the structure, exiting south, has an asphalt thickness of 85 mm. The Granular 'A' depth under the existing roadway was checked at two locations and found to be greater than 100 mm in depth. A summary listing of core data is appended to this report.



150-mm Diameter Asphaltic Pavement Cores

4.0 DESIGN CRITERIA

The existing two-lane structure is to be replaced with a new two-lane, 3 span, integral abutment, composite steel and concrete structure supported by a deep foundation system (i.e.: steel piles). The vertical alignment will be raised approximately 0.8 to 1.2 m at the structure.

Polystyrene may be utilized in the roadbed as lightweight fill to reduce settlement. If designed as such, a minimum pavement granular structure cover of 900 mm over the polystyrene lightweight fill is required to provide adequate pavement structural strength and to reduce the surface effect from the insulation acting as a thermal barrier. The granular portion of the pavement structure should be comprised of 600 mm of Granular 'B'- Type III material (or equivalent) and 300 mm of Granular 'A' material. Granular material placed directly over lightweight fill shall have no particles over 26.5 mm in diameter.

Further recommendations regarding lightweight fill for the proposed bridge structure are discussed in the Foundation Investigation and Design Report prepared by TBT Engineering dated August 2004.

4.1 Traffic Data

Traffic volumes for 2002 and projected year 2012 volume data supplied by MTO – Northwest Region Traffic Section are summarized below:

LOCATION	YEAR	AADT	SADT	DHV	% COMM*	% LT*
Hwy 17, 14.0 km West of Hwy 11 and Hwy 11/17 Junction (Shabaqua Corners)	2002	2500	3600	320	40.5	28.2
	2012	2750	3960	350	40.5	28.2

*Based on 12 day traffic survey -average of weekday and weekend

4.1.1 ESALS (Equivalent 9 Tonne Single Axle Loadings)

Total # of Trucks = 1,170

Total # of Long Trucks = 815

Truck in Design Lane = 1170 x 0.5 = 585

% Long Trucks in Total Truck Population = 70.0 %

Truck Factor (from Graph) = 1.75

Equivalent 9 t Axles per Day = 585 x 1.75 (TF) = 1024

Equivalent 9 t Axles per Year (300 Days) = 1024 x 300 = 307,200

Equivalent 9 t Axles per Year (350 Days) = 1024 x 350 = 358,400

Equivalent 9 t Axles per 20 Year Period (300 days/yr.) = 6,144,000

Based on the traffic data documented above, the Northwest Region Geotechnical Design Guidelines and the calculated ESALS, a pavement thickness design of 130 mm hot mix is desirable.

The adjacent sections of Highway 17 were reconstructed in 2002 under Contract 2001-0215 with a treatment of in-place processing and placing 130 mm Hot Mix Asphalt consisting of a 65 mm Heavy Duty Binder Course (HDBC) and a 65 mm HL 4 modified surface course (HL4M).

4.2 Alternate Pavement Designs

The vertical re-alignment warrants complete pavement removal / treatment to prevent trapping moisture in a thin granular layer causing a reduction in structural strength. Staging options will dictate when and how much asphalt can be removed and when it can be replaced. Based on the above, a conventional flexible pavement design is the most appropriate and, as a result, rigid and composite designs were not considered. Due to nature of the project (new construction) alternate pavement rehabilitation designs were not considered.

4.3 Granular Base Equivalencies (GBE)

The 'Granular Base Equivalency' method of comparing strengths to predict comparative performance reduces each material layer and relates that layer to the load bearing capacity of a standard Granular 'A' base course layer by using layer equivalency factors. Layer equivalency factors are derived from the Ministry of Transportation of Ontario's Pavement Design and Rehabilitation Manual for New Construction and Resurfacing projects.

4.3.1 Equivalency Factors

New Materials

Superpave 12.5 & 19.0	= 2.0
Granular 'A'	= 1.0
Granular 'B'	= 0.67

Resurfacing Projects

Old HL	= 1.25
Old Granular Base	= 0.75
Blended Granular 'A'	= 1.0
In-place Processed Material	= 1.0
Old Granular Sub-base	= 0.5

The typical subgrade soil condition throughout the site can be generalized as consisting of a moist to wet silt with clay, organics present in some areas.

The Northwestern Region Pavement Design Thickness Chart indicates that for calculated *20 year OPAC Loadings* exceeding 4.5×10^6, a wet clay and silt sub-grade type should have 900 mm granular design.

4.3.2 'Target' Granular Base Equivalency

The following is a 'Target' GBE that would be derived from new construction.

130 mm HL	= 130 x 2.0	= 260
150 mm Granular 'A'	= 150 x 1.0	= 150
750 mm Granular 'B'	= 750 x 0.67	= 503
therefore, *'Target' GBE*		= ***913***

4.3.3 Existing GBE's

Using discounted equivalency factors for the existing materials, GBE's can be calculated using an average pavement structure depth of 1.9 m:

130 mm avg. old HL	= 130 x 1.25	= 162.5
150 mm avg. old Granular 'A'	= 150 x 0.75	= 112.5
1.6 m avg. old Granular 'B'	= 1.6 x 0.5	= 800
'Existing' GBE		= ***1075***

Based on the above GBE calculations, the existing pavement structure has sufficient granular thicknesses to accommodate the anticipated wheel loadings.

5.0 RECOMMENDATIONS AND CONSTRUCTION FEATURES

5.1 Pavement Treatment

It is proposed that the existing pavement will be removed full depth from both approaches for the full length of the proposed project. Match points to be confirmed during detailed design.

The binder and surface course thicknesses shall be specified as below. The Northwest Region Geotechnical section has requested the surface course consist of Superpave 12.5 hot mix and the binder course 19.0 mm Superpave hotmix. Each layer shall have a PGAC of 58-34.

a. *Pavement Depths* – The following depths apply to this project:
   i. *Structure Deck*
      – 10 mm waterproofing, 40 mm Superpave 12.5 Binder Course, and 40 mm Superpave 12.5 Surface Course.
   ii. *Approach Slabs*
      – 10 mm waterproofing, 40 mm Superpave 12.5 Binder Course, and 40 mm Superpave 12.5 Surface Course.
   iii. *Approaches (Vertical Revision Area)*
      – 75 mm Superpave 19.0 Binder Course, and 55 mm Superpave 12.5 Surface Course.
   iv. *Paved Shoulders (Full and Partial)*
      – 55 mm Superpave 12.5 Surface Course.
   v. *Entrance (South) (*Relocated to Station 12+803)
      – 55 mm Superpave 12.5 Surface Course.
   vi. *Sideroad (North) (*Relocated to Station 12+803)
      – 55 mm Superpave 12.5 Surface Course.

b. *Pavement Joints* – It is recommended that 'Step Joints' be constructed for each layer at both the east and west limits. Each layer shall be stepped a minimum of 3.0 m. Exact stationing is to be determined during the detailed design phase.

5.2 Temporary Asphalt

Staging - It is recommended that all trafficked *temporary* asphalt required to be placed for less than one season under this project consist of a 40 mm HL 4 Binder Course and a 40 mm HL 4 Surface Course (alternately Superpave 12.5 as available). For very short duration, a single 50 mm surface course may be used. Each layer shall have a PGAC of 52-34, and minimum Marshall stabilities of 8000 Newtons at 60°C (Refer to SP 313F32).

Staging asphalt that is to remain in-place, as part of the final pavement structure shall be as recommended under Recommendation 5.1.

5.3 Full Depth Removal

Full depth pavement removal from the bridge approaches is proposed for the length of the project. Exact stationing is to be determined during the detailed design phase.

5.4 Earth Excavation & Backfill

Several areas will require earth excavation for removal of deleterious material prior to foreslope widenings due to grade raises. All deleterious material (ie. organics, debris) should be removed prior to backfilling these areas as per OPSD 203-020. On widening, it is anticipated that excavations of deleterious organic material will be in the order of 500 mm to 1.0 m.

5.5 Roadbed Widening, Fill Materials

It is recommended that in areas of proposed vertical revision, fill of 300 mm or less be bought up to grade following the pavement removal operations entirely with Granular 'A'.

Areas of fill and widenings in excess of 300 mm in depth should be constructed with Granular 'B' Type III capped with 150 mm of Granular 'A'.

In areas of lighweight fill, a minimum Granular 'A' thickness of 300 mm shall be used.

5.6 Drainage

Drainage is presently handled by open ditch design. It is recommended that positive drainage be maintained where existing ditches are altered.

5.7 Stripping

In areas of roadbed widening, strip existing shoulder rounding and fill slopes, commencing from inner edge of rounding to toe of fill slope. For design purposes assume stripping depth to be 150 mm.

5.8 Benching

It is recommended that (where applicable) the existing fill slope be benched as per OPSD 208.010.

5.9 Erosion Protection

Native soils on this project are generally silts and clays. Where seeding and mulching are included, seeding and mulching mixtures and application rates should conform to the requirements of SP572SO1 using Standard Roadside Mix.

Fill or cut slopes adjacent to watercourses should be armored with rock protection or rip-rap for protection from soil erosion. Slope armoring should extend to at least the high water mark. Rock protection materials shall conform to OPSS 1004.05.06.02, which states that rock protection shall be well graded in sizes ranging from 100 mm to 500 mm. The rock protection and/or rip-rap shall be underlain with a class 2 non-woven geotextile having an FOS of 75-150 um.

5.10 Sideroad and Entrance Relocation

The Prime Consultant has proposed the relocation of entrances, north and south, from 12+907 to 12+803. The commercial entrance on the south services a campground facility located immediately adjacent to Highway 17 and the Little Savanne River. The sideroad entrance north provides access to a public boat launch and for railway operations located to the north of Highway 17. Borehole investigations (PEDO) carried out along the proposed entrance routes indicate that 700 to 900 mm of soft to firm, fibrous organic material is present overlying firm silt with trace clay. Free water at surface was observed during field investigations, November 2004. The native silt subgrade is considered to be moderately to highly sensitive. Recommendations regarding the geotechnical aspects of design for construction of the proposed entrances are as follows:

- Excavate all organic and deleterious material from the proposed entrance footprints;
- Install non-woven geosynthetic filter fabric over undisturbed native silt subgrade (a class 2 non-woven geotextile having an FOS of 75-150 um, as used elsewhere in the contract, shall suffice);
- Place a minimum of 1.0 m of granular sub-base material (Granular 'B' – Type III) or rock fill capped with a minimum of 150 mm of Granular 'B' above the ground water level. Considering the condition and sensitivity of the native subgrade material, it is recommended that static rolling of the lower sub-base fill be carried out;
- Place and compact a minimum of 100 mm of granular base material (Granular 'A') over compacted sub-base;
- Pave entrances with 55 mm of Superpave 12.5 Surface Course with a PGAC of 58-34.

6.0 LIMITATIONS

Conclusions and recommendations presented in this report are based on the information determined at the test hole locations and are intended for the use of the design team only. The design recommendations provided in this report are based on the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation. Subsurface and groundwater conditions between and beyond test locations may differ from those encountered.

The information contained within this report in no way reflects any environmental aspect of the site or soil.

This report has been prepared by
TBT Engineering as sub-consultant to
Stantec Consulting Ltd.
to address the Geotechnical Design component of a Detail Design assignment for the Ministry of Transportation of Ontario's Work Project 198-92-00.

Prepared by:

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Al Clements — Date: Jan 11, 2005
Manager, Geotechnical Services
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Reviewed by:

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Vice-President Engineering,
Thunder Bay Testing & Engineering Limited

APPENDIX A

Asphalt Core Data

Asphalt Core Data

TBTE Project #:	03-140	**Date:**	May 26, & June 2, 2004
Client Ref. #:	W.P. 198-92-00		
Location:	Little Savanne River Bridge	**Remarks:**	

Location		**Hot Mix Depth (mm)**	**Remarks**
Station	**Offset (m)**		
Twp. Savanne			
12+860	2.2 Rt	140	150 mm dia. core - Gran 'A' > 100+ mm
12+875	3.0 Rt	130 (60+70)	
12+885	6.0 Rt	85 (35+50)	Maki Bay Resort Ent
12+890	1.6 Lt	151 (50+59+42)	Ent
12+935	3.2 Lt	116 (62+54)	
12+935	2.0 Rt	110 (60+50)	
13+000	1.2 Lt	133 (36+51+46)	
13+000	1.8 Rt	125 (50+75)	
13+080	3.3 Lt	113 (25+57+31)	
13+135	2.7 Lt	130 (42+33+55)	
13+135	2.0 Rt	150 (50+100)	
13+200	1.9 Lt	146 (64+82)	150 mm dia. core - Gran 'A' = 190 mm (Sample 04-DG-42)

APPENDIX B

Borehole Logs

LITTLE SAVANNE RIVER BRIDGE – TWP. SAVANNE

AGM = Acceptable Granular Material
BLGM = Borderline Granular Material
NAGM = Not Acceptable Granular Material

Station 12+850 4.0 Lt

0	- 25	Asph
25	- 310	Cr Gr
310	- 1.5	Br M-Co Sa with F Gr (Dry)
1.5	- 1.7	Gry Co Sa (Moist-Wet)
1.7	- 2.1	Blk-Br Orgs (Fib) with Cl (Wet & Soft)
2.1	- 4.2	Gry-Blk Si(y) Cl with Orgs (Wet & Soft)

Station 12+890 18.5 Lt (Boat Launch Ent)

0	- 300	Cr Gr
300	- 590	Gry Cr Gr Tr Cl (Dry)
590	- 600	Blk Si(y) Orgs (Moist)
600	- 900	Gry Sa(y) Si Tr Cl
900	- 1.1	Blk Org Sa
1.1	- 2.0	Gry Cl (Moist)

Station 12+890 18.0 Rt (Ent)

0	- 20	Winter Sa
20	- 350	Cr Gr
350	- 1.7	Gry-Br Cr Gr Tr Cl (Dry)
1.7	- 1.9	Dk Br Si with Cl Tr Orgs (Moist)
1.9	- 2.1	Gry Cl (Moist)

Station 12+915 3.2 Lt

0	- 90	Asph
90	- 230	Cr Gr
230	- 1.2	Br F-Co Sa with F Gr (Dry)
1.2	- 2.5	Gry Cl(y) Si Tr Orgs (Moist & Soft)
2.5	- 4.2	Br-Gry Si(y) Cl (Wet & Soft)

Station 12+915 3.0 Rt

0	- 140	Asph
140	- 220	Cr Gr
220	- 1.2	Br M-Co Sa with F Gr (Dry)
1.2	- 2.0	Gry Cl(y) Si Tr Orgs (Moist & Soft)
2.0	- 4.2	Br-Gry Si(y) Cl (Wet & Soft)

Station 12+915 3.0 Rt
Sample No.04-DG-04 (220 – 1.0)

% Passing 4.75 mm	85.1 %
% Passing 75 um	8.3 %
Group Symbol	SW-SM

NAGM – Gran 'B' Type III
. due to fineness of gradation

Station 12+918 16.0 Rt (D-2.5)

0	- 30	Wat
30	- 35	F-Co Sa Tr Orgs (Wet)
35	- 650	Gry Cl (Moist)

Station 12+920 12.0 Lt (D-1.8)

0	- 300	Wat
300	- 600	Br F-M Sa Tr Si, Gr & Orgs (Wet)
600	- 650	Br-Gry Cl with Si Tr Orgs (Wet)
650	- 1.2	Br-Gry Cl (Dry-Moist)

Station 12+921 4.3 Lt

0	- 65	Asph
65	- 300	Cr Gr
300	- 1.8	Br Sa with Gr (Dry)
1.8	- 3.9	Gry-Br Cl(y) Si (Moist)
3.9	- 10.0	Gry-Br Si(y) Cl (Wet & Soft)
10.0	- 15.0	Br-Gry Si(y) F-M Sa Occ Cobs (Wet)

Station 13+000 3.0 Lt

0	- 60	Asph
60	- 250	Cr Gr
250	- 1.2	Br F-Co Sa (Dry)
1.2	- 2.8	Gry Cl(y) Si Tr Orgs (Moist & Soft)
2.8	- 4.2	Br-Gry Si(y) Cl (Wet & Soft)

Station 13+000 3.0 Lt
Sample No.04-DG-01 (65 – 250)

% Passing 4.75 mm	75.4 %
% Passing 75 um	7.5 %
% Crushed	89.9 %

NAGM – Gran 'A' due to fineness of gradation

Station 13+000 3.0 Lt
Sample No.04-DG-02 (250 – 1.2)

% Passing 4.75 mm	96.9 %
% Passing 75 um	7.7 %
FMC @ 1.2	4.8 %
Group Symbol	SP-SM

NAGM – Gran 'B' Type 1 (Mod)
. due to fineness of gradation

Station 13+000 3.0 Lt
Sample No.04-DG-03 (1.2 – 2.2)

% Passing 4.75 mm	99.2 %
% Passing 75 um	73.0 %
FMC @ 2.2	21.4 %
W_L	22 %
W_p	17 %
I_p	5
Group Symbol	CL-ML

Station 13+005 16.0 Lt (D-1.9)

0	-	20	Tps & Surface Debris (Wet)
20	-	500	Br-Gry Cl with Orgs (Moist)
500	-	1.1	Br-Gry Cl (Moist)

Station 13+005 18.0 Rt (D-2.0)

0	-	20	Tps (Fr Wat on Surf)
20	-	470	F-Co Sa Tr Orgs
470	-	850	Blk Cl Tr Si with Orgs
850	-	1.1	Gry Cl (Moist)

Station 13+035 15.5 Rt (D-1.8)

0	-	20	Tps (Moist)
20	-	280	F-Co Sa Tr Orgs (Moist)
280	-	300	Blk Cl Tr Si with Orgs (Moist)
300	-	1.4	Lt Br-Gry Cl (Moist)

Station 13+040 15.0 Lt (D-2.0)

0	-	10	Tps (Moist)
10	-	450	Br Si(y) Sa with Cl & Orgs (Moist)
450	-	1.2	Lt Br-Gry Cl (Moist) (Wat Seep @ 800)

Station 13+041 4.0 Rt

0	-	240	Cr Gr
240	-	1.8	Br F-M Sa with Gr Tr Si (Dry-Moist)
1.8	-	3.6	Gry Cl(y) Si Tr Orgs (Moist & Soft)
3.6	-	10.2	Br-Gry Si(y) Cl (Wet & Soft)
10.2	-	15.0	Br-Gry Si(y) Sa Occ Cob (Wet)

Station 13+060 14.5 Lt (D-2.2)

0	-	540	Br F-M Si(y) Sa Tr Gr & Orgs (Wet)
540	-	1.0	Lt Br-Gry Cl (Moist-Wet)

Station 13+060 14.5 Rt (D-900)

0	-	750	F-Co Sa Tr Orgs (Moist) (Wet from 600)
750	-	1.0	Blk Cl Tr Si with Orgs (Moist)
1.0	-	1.2	Lt Br-Gry Cl (Moist)

Station 13+070 4.0 Lt

0	-	25	Asph
25	-	240	Cr Gr
240	-	1.0	Br F-M Sa with Gr Tr Si (Dry)
1.0	-	2.5	Gry Cl(y) Si Tr Orgs (Moist & Soft)
2.5	-	4.2	Br-Gry Si(y) Cl (Wet & Soft)

Station 13+104 4.0 Rt

0	-	90	Asph
90	-	260	Cr Gr
260	-	2.2	Br F-Co Sa with F Gr (Dry)
2.2	-	2.7	Gry Cl(y) Si with Sa Tr Orgs (Fib) (Moist)
2.7	-	4.2	Gry Cl(y) Si (Moist & Soft)

Station 13+105 14.0 Lt (D-2.2)

0	-	10	Tps (Wet)
10	-	350	Lt Br Sa Tr Gr with Orgs (Wet)
350	-	800	Lt Br F-M Sa with Si Tr Gr & Orgs (Wet)
800	-	1.0	Gry Cl (Moist)

Station 13+105 13.0 Rt (D-2.1)

0	-	150	Wat
150	-	800	Dk Br Sa with Orgs Tr Si (Moist)
800	-	1.2	Gry Cl (Moist)

Station 13+130 4.0 Rt

0	-	25	Asph
25	-	200	Cr Gr
200	-	2.1	Br F Sa with F Gr (Dry)
2.1	-	2.4	Gry Cl(y) Si with Sa (Moist & Soft)
2.4	-	4.2	Br-Gry Si(y) Cl (Moist & Soft)

Station 13+135 14.0 Lt (D-2.2)

0	-	20	Tps (Wet)
20	-	360	Lt Br F-Co Sa Tr Gr with Orgs (Wet)
360	-	1.1	Lt Br Sa with Si Tr Orgs (Wet)
1.1	-	1.2	Gry Cl (Moist)

Station 13+135 13.0 Rt (D-2.5)

0	-	20	Wat
20	-	1.3	Dk Br Sa with Orgs Tr Si (Moist)
1.3	-	1.5	Gry Cl (Moist)

Station 13+190 4.3 Lt

0	-	25	Asph
25	-	240	Cr Gr
240	-	1.9	Br F-M Sa with F Gr (Dry)
1.9	-	2.6	Gry F-Co Sa (Moist)
2.6	-	2.9	Blk-Br Si with Orgs (Fib) (Moist & Soft)
2.9	-	4.2	Gry Si(y) Cl (Moist & Soft)

Station 13+200 1.9 Lt

Sample No.04-DG-42 (150 – 340)

% Passing 4.75 mm	51.7 %
% Passing 75 um	7.6 %
% Crushed	84.2 %

AGM - Gran 'A'

Proposed Entrance Relocations

South Entrance

Station 12+803 14.0 Rt (D-1.8)

0	-	800	Br Org (Wdy) (Rts)(Soft & Wet) (Fr Wat on surf)
800	-	1.2	Gry Si Tr Cl (Firm)(Wet)

Station 12+803 38.0 Rt (D-1.7)

0	-	800	Br Org (Wdy) (Rts)(Soft & Wet) (Fr Wat on surf)
800	-	1.2	Gry Si Tr Cl (Firm)(Wet)

Station 12+820 38.0 Rt (D-1.6)

0	-	700	Br Org (Wdy) (Rts)(Soft & Wet) (Fr Wat on surf)
700	-	1.0	Gry Si Tr Cl (Firm)(Wet)

Station 12+845 38.0 Rt (D-1.6)

0	-	700	Br Org (Wdy) (Rts)(Soft & Wet) (Fr Wat on surf)
700	-	1.0	Gry Si Tr Cl (Firm)(Wet)

Station 12+845 44.0 Rt (D-1.5)

0	-	100	Tps
100	-	300	Gry Br Si with Sa & Gr Mixed (Wet)(Fr Wat @ 150)
300	-	750	Br Org (Fib)(Soft & Wet)
750	-	1.0	Gry Si Tr Cl & F Sa (Firm)(Wet)

Station 12+845 32.0 Rt (D-1.6)

0	-	700	Br Org (Wdy) (Rts)(Soft & Wet) (Fr Wat on surf)
700	-	1.0	Gry Si Tr Cl (Firm)(Wet)

Station 12+870 38.0 Rt (D-1.5)

0	-	30	Br Say Tps with Si
30	-	1.0	Br M - Co Sa & F - M Gr Mixed Tr Si (Wet)(Fr Wat @ 550)
1.0	-	1.2	Blk Org (Fib)(Soft & Wet)
1.2	-	1.5	Gry Si Tr Cl (Firm)(Wet)

North Entrance

Station 12+803 14.0 Lt (D-1.8)

0	- 900	Br Org (Fib) (Rts)(Soft & Wet) (Fr Wat on surf)
900	- 1.3	Gry Si Tr Cl (Firm)(Wet)

Station 12+803 41.0 Lt (D-1.8)

0	- 950	Br Org (Fib) (Rts)(Soft & Wet) (Fr Wat on surf)
950	- 1.2	Gry Si Tr Cl (Firm)(Wet)

Station 12+841 41.0 Lt (D-1.5)

0	- 900	Br Org (Wdy) (Rts)(Soft & Wet) (Fr Wat on surf)
900	- 1.3	Gry Si Tr Cl (Firm)(Wet)

Station 12+861 41.0 Lt (D-1.5)

0	- 800	Br Org (Wdy) (Rts)(Soft & Wet) (Fr Wat on surf)
800	- 1.2	Gry Si Tr Cl (Firm)(Wet)

Station 12+861 35.0 Lt (D-1.5)

0	- 900	Br Org (Fib) (Rts)(Soft & Wet) (Fr Wat on surf)
900	- 1.3	Gry Si Tr Cl (Firm)(Wet)

Station 12+861 47.0 Lt (D-1.5)

0	- 800	Br Org (Fib) (Rts)(Soft & Wet) (Fr Wat on surf)
800	- 1.2	Gry Si Tr Cl (Firm)(Wet)

Station 12+880 41.0 Lt (D-1.3)

0	- 800	Br Org (Fib) (Rts)(Soft & Wet) (Fr Wat on surf)
800	- 1.1	Gry Si Tr Cl (Firm)(Wet)

APPENDIX C

Laboratory Results

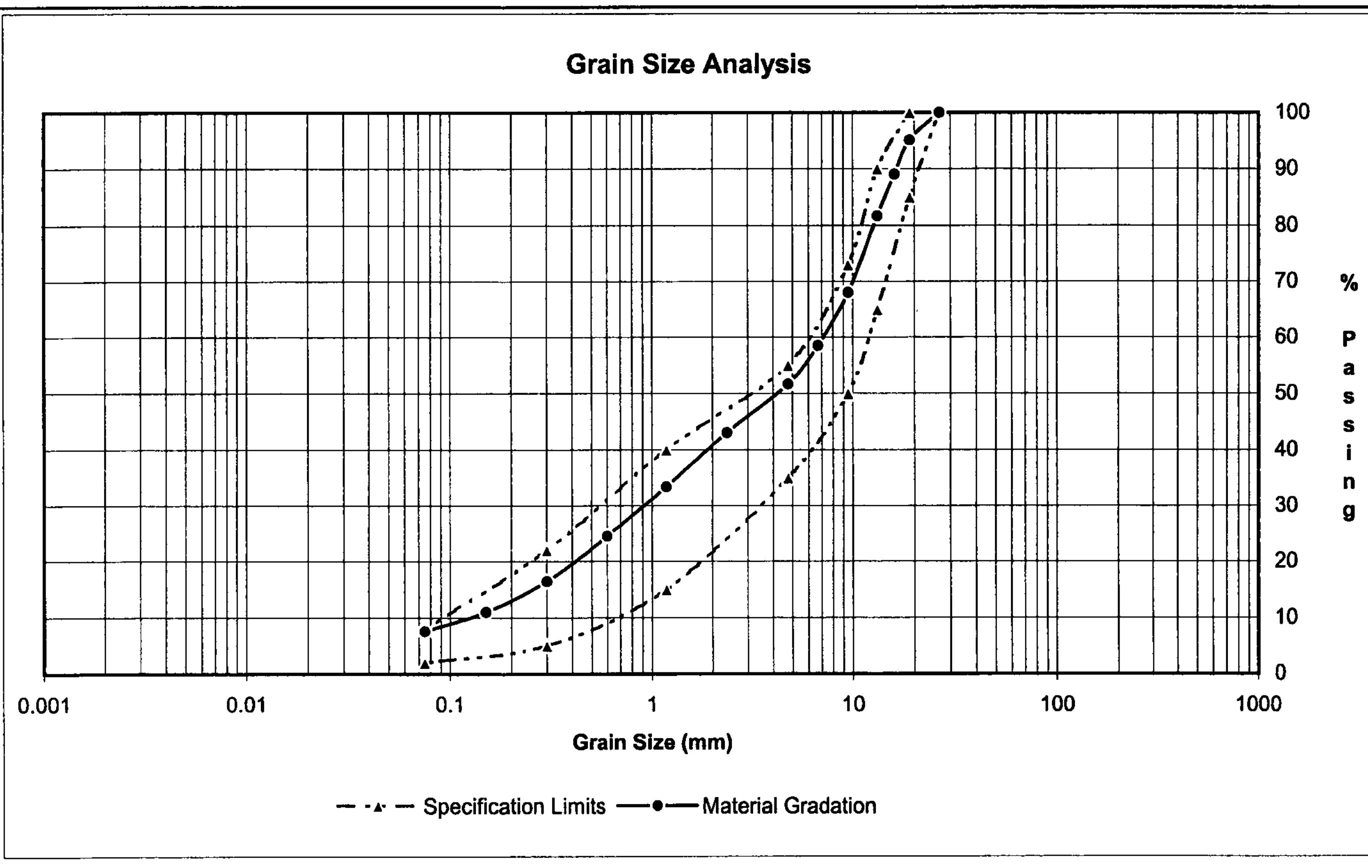
TBT ENGINEERING

Thunder Bay Testing & Engineering Limited
LABORATORY
711 Harold Cres.,Thunder Bay, ON P7C 5H8
PH: (807) 624-5162 FAX: (807) 624-5163
E-Mail: tbte@tbt-engineering.on.ca

Grain Size Analysis - Granular 'A'

Client:	Stantec	TBTE Project No.:	03-140
Client Project No.:		Lab No.:	04-260
Twp.:		Field No.:	04-DO-42
Report To:	Wayne Hurley	Station:	13+200
Location:	Little Savanne River Bridge	Offset:	1.85 m Lt of CL
		Depth:	0 to 146 mm
Sampled By/Date:	D. O'Rourke/May 27, 2004	Tested By/Date:	F. Valela/June 2, 2004
Reported By:	Patricia Cruickshank	Reviewed By:	Tim Fummerton

Sieve Size	Percent Passing	OPSS 1010 Specifications
26.5 mm	100.0	100
19.0 mm	95.1	85 - 100
16.0 mm	89.0	
13.2 mm	81.7	65 - 90
9.5 mm	68.0	50 - 73
6.7 mm	58.5	
4.75 mm	51.7	35 - 55
2.36 mm	43.0	
1.18 mm	33.4	15 - 40
600 um	24.5	
300 um	16.4	5 - 22
150 um	11.0	
75 um	7.6	2 - 8



Remarks: Test Method LS 602,607/ ASTM C136, D5821
Crushed Particles - 84.2 %

Thunder Bay Testing & Engineering Limited
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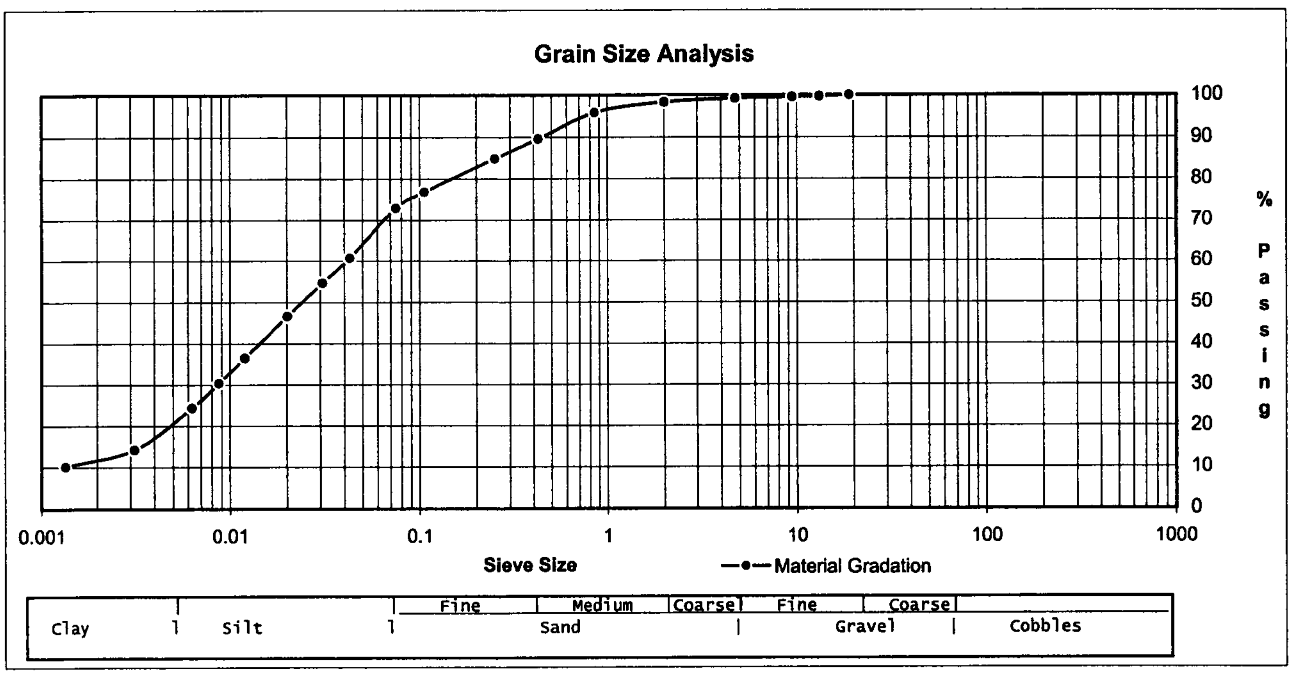
TBT ENGINEERING

Particle Size Analysis of Soils Test Report

Client:	Stantec	TBTE Project No.:	03-140
Client Project No.:		Lab No.:	04-279
Twp.		Field No.	04-DG-03
Report To:	Wayne Hurley	Station:	13+000
Location:	Little Savanne River Bridge	Offset:	3.0 m Lt of CL
		Depth:	1.2 m to 2.2 m
Sampled By/Date:	Dave Gauthier/June 3, 2004	Tested By/Date:	Z. Zawadzki/June 10, 2004
Reported By:	Patricia Cruickshank	Reviewed By:	Tim Fummerton

Sieve Analysis		Hydrometer Analysis	
Sieve	% Passing	Diameter	% Finer
25.0 mm		0.042720	60.8
19.0 mm	100.0	0.030885	54.7
13.2 mm	99.7	0.020091	46.6
9.50 mm	99.5	0.011989	36.5
4.75 mm	99.2	0.008715	30.4
2.00 mm	98.3	0.006275	24.3
0.850 mm	95.9	0.003145	14.2
0.425 mm	89.6	0.001336	10.1
0.250 mm	84.9		
0.106 mm	76.8		
0.075 mm	73.0		



%Gravel	0.8	% Silt	51.9	Moisture Content	21.4	
% Sand	26.2	% Clay	21.1	PI	5	Soil Classification: CL-ML

Remarks: Test Method LS 701, 702, ASTM D2216, D4318

CCIL & CSA Certified

R10501-Rev.0103

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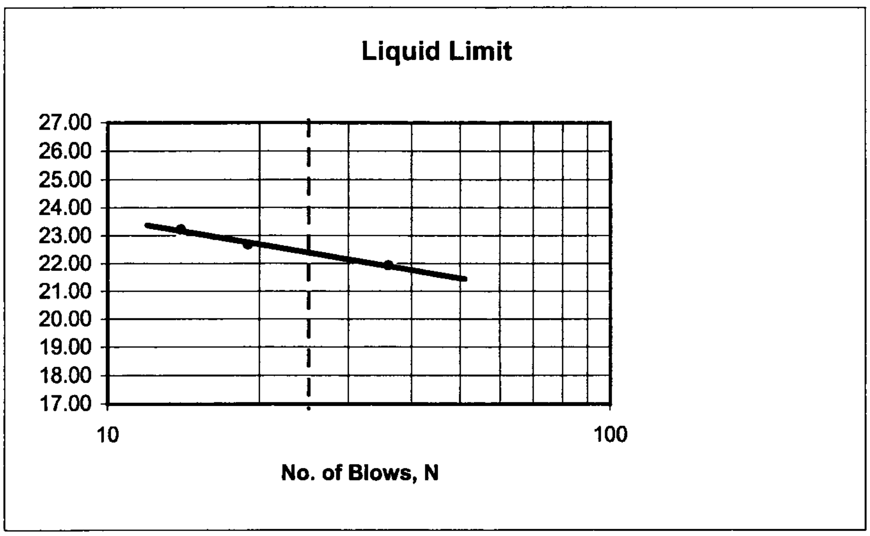
Atterberg Limits

Client:	Stantec	TBTE Project No.:	03-140
Client Project No.:		Lab No.:	04-279
Twp.:		Field No.:	04-DG-03
Report to:	Wayne Hurley	Station:	13+000
Location:	Little Savanne River Bridge	Offset:	3.0 m Lt of CL
		Depth:	1.2 m to 2.2 m
Sampled By/Date:	Dave Gauthier/June 3, 2004	Tested By/Date:	Z. Zawadzki/June 9, 2004
Reported By:	Patricia Cruickshank	Reviewed By:	Tim Fummerton

Liquid Limit Determination					
Dish No.:	236	33	244		Liquid Limit 25 Blows
Wet Soil + Dish:	47.252	50.155	50.799		
Dry Soil + Dish:	42.086	44.966	45.265		
Moisture:	5.166	5.189	5.534		
Dish:	19.836	22.098	20.028		
Dry Soil:	22.25	22.868	25.237		
% Moisture:	23.22	22.69	21.93		
No. of Blows:	14	19	36		
Liquid Limits:	22	22	23		22



Liquid Limit, %:	22
Plastic Limit, %:	17
Plasticity Index:	5

Plastic Limit Determination					Natural Moisture
Dish No.:	226	62			
Wet Soil + Dish:	31.383	33.46			323.1
Dry Soil + Dish:	29.701	31.931			271.7
Moisture:	1.682	1.529			51.4
Dish:	20.071	23.202			31.1
Dry Soil:	9.63	8.729			240.6
% Moisture:	17.47	17.52			21.4
Average:	17				

Test Method : ASTM: D4318, D2216

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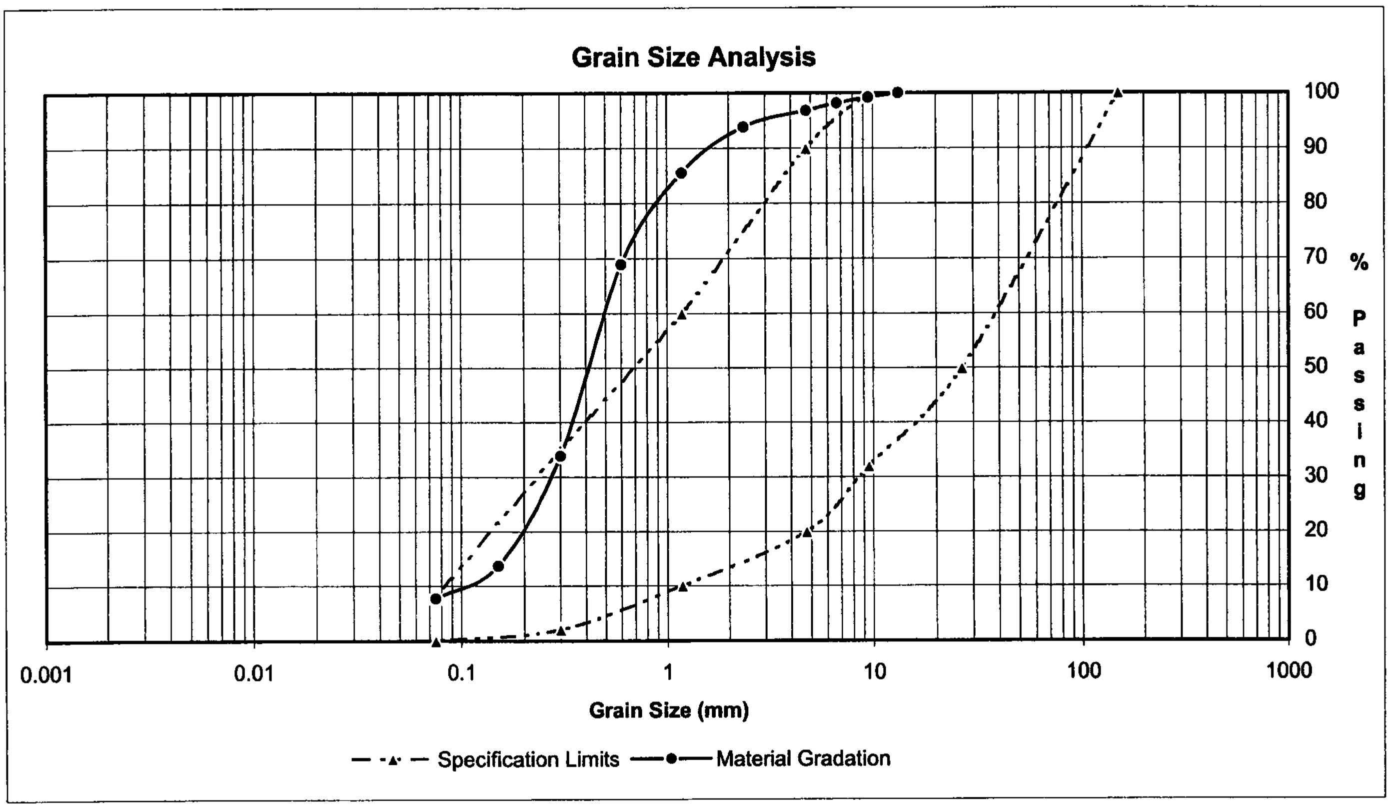
Client:	Stantec	TBTE Project No.:	03-140
Client Project No.:		Lab No.:	04-280
Twp.:		Field No.:	04-DG-02
Report To:	Wayne Hurley	Station:	13+000
Location:	Little Savanne River Bridge	Offset:	3.0 m Lt of CL
		Depth:	250 mm to 1.2 m
Sampled By/Date:	Dave Gauthier/June 3, 2004	Tested By/Date:	F. Valela/June 8, 2004
Reported By:	Patricia Cruickshank	Reviewed By:	Tim Fummerton

Sieve Size	Percent Passing		SP110F13
150 mm			100
26.5 mm			50-100
19.0 mm			
16.0 mm			
13.2 mm	100.0		
9.5 mm	99.2		32-100
6.7 mm	98.2		
4.75 mm	**96.9**	**	20-90
2.36 mm	93.9		
1.18 mm	**85.6**	**	10-60
600 um	69.0		
300 um	33.8		2-35
150 um	13.7		
75 um	7.7		0-8



Remarks: Test Method LS 602, 701/ASTM C136, D2216

Natural Moisture Content 4.8 % @ 1.2 Depth

Soil Classification:SP-SM

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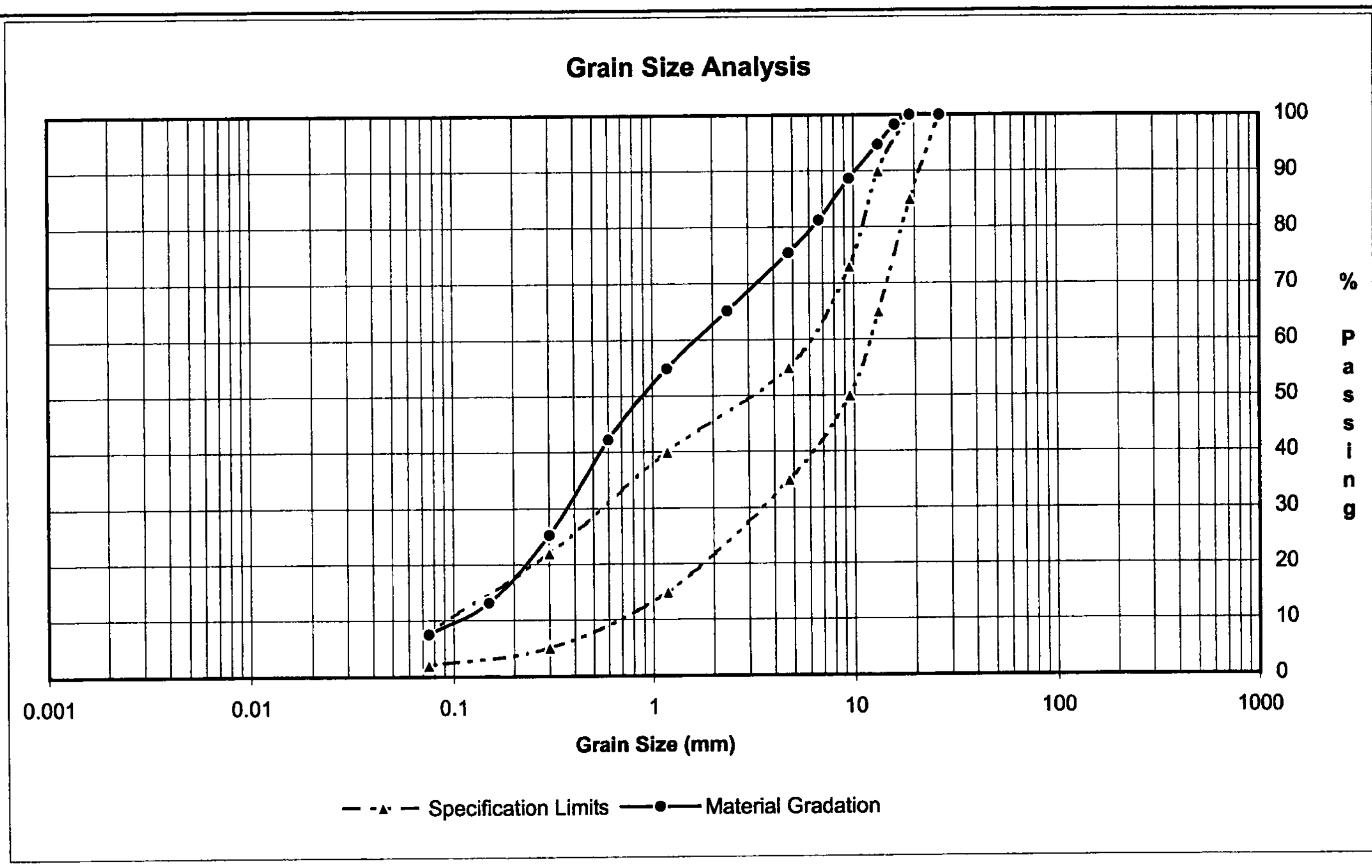
Grain Size Analysis - Granular 'A'

Client:	Stantec	TBTE Project No.:	03-140
Client Project No.:		Lab No.:	04-281
Twp.:		Field No.:	04-DG-01
Report To:	Wayne Hurley	Station:	13+000
Location:	Little Savanne River Bridge	Offset:	3.0 m Lt of CL
		Depth:	65 mm to 250 mm
Sampled By/Date:	Dave Gauthier/June 3, 2004	Tested By/Date:	F. Valela/June 8, 2004
Reported By:	Patricia Cruickshank	Reviewed By:	Tim Fummerton

Sieve Size	Percent Passing		OPSS 1010 Specifications
26.5 mm	100.0		100
19.0 mm	100.0		85 - 100
16.0 mm	98.3		
13.2 mm	**94.7**	**	65 - 90
9.5 mm	**88.6**	**	50 - 73
6.7 mm	81.3		
4.75 mm	**75.4**	**	35 - 55
2.36 mm	65.2		
1.18 mm	**54.9**	**	15 - 40
600 um	42.2		
300 um	**25.3**	**	5 - 22
150 um	13.1		
75 um	7.5		2 - 8



Remarks: Test Method LS 602,607/ ASTM C136, D5821
Crushed Particles - 89.9 %

TBT ENGINEERING

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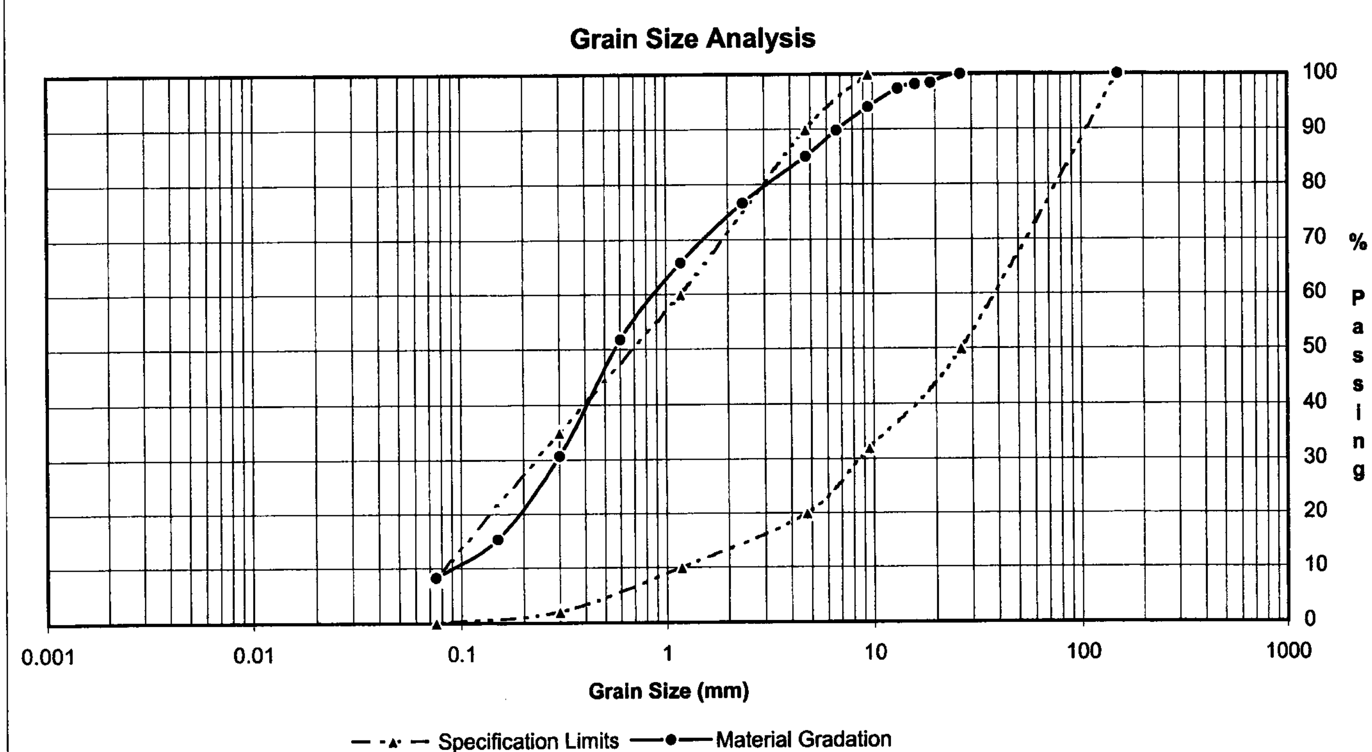
Client:	Stantec	TBTE Project No.:	03-140
Client Project No.:		Lab No.:	04-282
Twp.:		Field No.:	04-DG-04
Report To:	Wayne Hurley	Station:	12+915
Location:	Little Savanne River Bridge	Offset:	3.0 m Rt of CL
		Depth:	220 mm to 1.0 m
Sampled By/Date:	Dave Gauthier/June 3, 2004	Tested By/Date:	F. Valela/June 8, 2004
Reported By:	Patricia Cruickshank	Reviewed By:	Tim Fummerton

Sieve Size	Percent Passing		SP110F13
150 mm	100.0		100
26.5 mm	100.0		50-100
19.0 mm	98.4		
16.0 mm	98.2		
13.2 mm	97.4		
9.5 mm	94.1		32-100
6.7 mm	89.8		
4.75 mm	85.1		20-90
2.36 mm	76.6		
1.18 mm	**65.8**	**	10-60
600 um	51.8		
300 um	30.7		2-35
150 um	15.3		
75 um	**8.3**	**	0-8



Remarks: Test Method LS 602, 701/ASTM C136, D2216

Soil Classification: SW-SM