

**FOUNDATION INVESTIGATION REPORT
FOR
PROPOSED STAR LAKE ROAD OVERPASS, SBL
STRUCTURE SITE NO. 44-392S
DISTRICT 52, HUNTSVILLE
W.P. 469-93-01**

Submitted To:

**Delcan Corporation
133 Wynford Drive
North York, Ontario, M3C 1K1
Canada**

Submitted By:

**AGRA
104 Crockford Blvd.
Scarborough, Ontario, M1R 3C6
Canada**

**August 1999
TT98820C**

August 31, 1999.
Ref. No.: TT98820C

Delcan Corporation
133 Wynford Drive
North York, Ontario, M3C 1K1
Canada

Attention: Mr. Khaled El-Dalati, P. Eng.

Dear Sir:

**Re: FOUNDATION INVESTIGATION REPORT
FOR
PROPOSED STAR LAKE ROAD OVERPASS, SBL
STRUCTURE SITE NO. 44-392S
DISTRICT 52, HUNTSVILLE
W.P. 469-93-01**

We take pleasure in enclosing six (6) copies of our Foundation Investigation Report carried out for the above mentioned project and we will be glad to discuss any questions arising from this work.

Soil samples will be retained for a period of one year, and will thereafter be disposed of unless we are otherwise instructed.

We thank you for giving us this opportunity to be of service to you.

Sincerely,



Z.S. Ozden, P. Eng.,
Principal Engineer.

ZSO/dee

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DWG. NO. 2

1.0 INTRODUCTION

AGRA, Consulting Geotechnical Engineers, was retained by Delcan Corporation to conduct a foundation investigation at the site of a proposed bridge that will carry the proposed realigned southbound lane of Highway 11 over the existing Star Lake Road. The site is located in the Village of Emsdale, about 0.3 km west of the intersection of Star Lake Road and present Highway 11, in the Township of Perry, Lot 14, Concession 11 in MTO District 52 - Huntsville (see Key Plan, Drawing No. 1). The proposed bridge will be an approximately 21 m long, 2-lane, single span structure.

The purpose of the investigation has been to obtain information about the subsurface conditions at the site of the proposed bridge and approach embankments by means of exploratory boreholes, and based on the findings, to provide recommendations for the geotechnical design of the foundations of the proposed structure and approach fills.

2.0 SITE DESCRIPTION AND PHYSIOGRAPHY

The site is located about 0.3 km west of the intersection of Star Lake Road and present Highway 11, in the Village of Emsdale. The ground elevation in the general area of the proposed bridge site falls to the north and the east, ranging in Elevation from about 345 m to 336 m. The surrounding area is wooded with residential properties located about 70 \pm m to the west and the TransCanada PipeLine about 130 \pm m further to the west.

Available geologic information indicates that the site is in an area of ice-contact sediments. Generally, after the last glacial withdrawal, ice-contact sediments (sands and gravels) followed by glaciofluvial sediments (ranging from deltaic and nearshore sands and gravels to prodeltaic and lake bottom silts and clays) were deposited on top of the existing sandy glacial till or Precambrian bedrock. The area was then inundated by glacial Lake Algonquin depositing sands, silts and clays in low lying areas.

Published geological information indicate that the bedrock generally consists of strongly, foliated gneissic to migmatic rocks of the Central Gneiss Belt, which is part of the Grenville Province (a structural subdivision of the Canadian Shield).

3.0 INVESTIGATION PROCEDURES

The fieldwork for this project was performed during the period of February 9, 24, 25, March 24 and April 20, 1999, and consisted of drilling and sampling eight boreholes (Borehole Nos. SL10, 11, 12, 13, 14, 15, 16 and 17) and conducting four dynamic cone penetration tests. The plan locations of the boreholes, along with stratigraphic sections are shown on Drawing No. 1.

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Due to overhead utility cables along the north side of Star Lake Road, and uneven sloping ground along the road cut on the south side of Star Lake Road, the exact proposed abutment locations were not accessible. The boreholes were therefore drilled offset from the actual proposed foundation elements, as close as practicable.

The boreholes were advanced using solid and hollow stem continuous flight augers with a track-mounted power auger drilling rig (CME 75) owned and operated by Canadian Soil Drilling Inc. and a track-mounted power auger drilling rig (BOA 6M) owned and operated by Groundworks Drilling Inc., under the full-time supervision of a soils engineer from AGRA.

Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test Method (SPT), as specified in ASTM Method D 1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter o.d. split barrel (split-spoon) sampler into the ground. The number of blows of the hammer to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the 'N'-value of the soil and this gives an indication of the consistency or the compactness condition of the soil deposit.

Due to the presence of boulders above the bedrock surface, Boreholes SL12 and 14 (i.e. deep boreholes) had to be extended below about 19 m by triconing and/or rock coring methods to the bedrock surface and the bedrock was subsequently cored using NW size casing.

In addition, dynamic cone penetration tests were performed adjacent to four of the boreholes. This test consists of driving a 60° point, 50 mm diameter cone attached to the drill rod continuously, into the undisturbed ground with a driving energy of 475 J (63.5 kg hammer falling freely a distance of 76 cm) per blow. The number of blows for each 30 cm of penetration is recorded and this provides an indication of the relative changes in the soil density with depth.

The borehole locations were established in the field by our engineering staff, in relation to the already staked out centre-line of Highway 11 (by Dearden and Stanton Limited). The borehole geodetic elevations and co-ordinates were later taken by surveyors from Dearden and Stanton Limited.

The soil samples were shipped in sealed containers to our geotechnical laboratory in Toronto (Scarborough) for further examination and classification. A laboratory testing programme, consisting of natural moisture content, Atterberg Limits tests and grain-size analyses, was performed on selected representative soil samples. The results of the laboratory tests are presented on the appropriate Borehole Log Sheets and also in Figure Nos. 1 to 6.

Groundwater conditions in the open boreholes were observed during drilling and the boreholes were left open until the end of each work day to enable us to take additional water level readings. A standpipe piezometer was installed in Borehole SL11 to monitor the groundwater level. The remaining boreholes were grouted on completion, while the piezometer tube in Borehole SL11 was grouted on February 29, 1999.

4.0 SUBSURFACE CONDITIONS

The subsurface conditions were explored at eight borehole locations (Borehole Nos. SL10 to SL17), and were inferred at the locations of four dynamic cone penetration tests. The locations of the boreholes and cone penetration tests are shown on the Plan and Profile Drawing No. 1 and are also indicated on the individual Borehole Log Sheets. Cross sections of inferred subsurface stratigraphy are given on Drawing No. 1.

The ground surface at the proposed site falls to the north and east. The ground elevation at the proposed bridge location generally ranges from about 345 to 336 m.

In general, the boreholes contacted, below a surficial topsoil layer, granular soil deposits ranging from sandy silt to sand & gravel. The relatively finer grained silty sand to sandy silt generally occur near the surface, underlain by fine to medium sand. In several of the boreholes an upper sand & gravel deposit was also contacted near the ground surface. In the majority of the boreholes the fine to medium sand is underlain by a lower sand & gravel deposit, which, in the two deeper boreholes, extends to the surface of the bedrock. In the two deeper boreholes that extended into the bedrock (i.e. Boreholes SL12 and 14), the sand & gravel deposit immediately overlying the bedrock contains frequent cobbles and boulders, which were cored in order to advance the borehole to the bedrock. The bedrock ranges from Precambrian diorite to grano-diorite. The bedrock was cored to a depth of 3.4 to 4.6 m and is generally of fair to excellent quality. The groundwater table at the time of our investigation was encountered at depths of 17 to 19 m below existing grade.

Details of the subsurface conditions encountered in these boreholes are presented on the Borehole Log Sheets. The individual strata are briefly described below.

4.1 TOPSOIL

Topsoil was encountered at the majority of boreholes (except Borehole SL16), ranging in thickness from 0.1 to 0.3 m.

In our experience the thickness of topsoil frequently varies in between and beyond the borehole locations. In addition, at the time of our investigation the ground near the surface was frozen; therefore the soil conditions within the upper several decimeters could not be accurately determined and the descriptions given for this upper zone should be considered approximate only.

4.2 SILTY SAND TO SANDY SILT

Underlying the surficial topsoil at Boreholes SL10, 11 and 12 (in the area of the proposed north abutment) and below the surficial sand in Borehole SL14, a cohesionless deposit ranging in composition from silty sand to sandy silt with traces of clay, was encountered to depths of 2.2 to 4.6 m below existing grade. In addition, a 0.7 m thick layer of fine sandy silt was contacted in Borehole SL12 below a depth of 18.2 m (Elevation 320.3 m). Five grain size analyses were

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conducted on samples from this deposit resulting in the following grain size measurements, which are presented in Figure No. 1:

| | |
|---------|----------|
| Gravel: | 0 - 1% |
| Sand: | 37 - 79% |
| Silt: | 17 - 63% |
| Clay: | 0 - 7% |

Measured 'N'-values within the deposit generally range from 15 to in excess of 50 blows/0.3 m, indicating a generally compact to dense condition, with some low values (4 to 5 blows/0.3 m) recorded at the surface (indicating a very loose surficial condition).

Measured natural moisture contents range from 7 to 16%.

4.3 UPPER SAND & GRAVEL

At depths ranging from 0.3 to 2.6 m below the ground surface, Boreholes SL11, 16, and 17 contacted a surficial sand & gravel deposit. This granular (cohesionless) deposit extended to depths ranging from 2.2 m (Elevation 340.7 - Borehole SL17) to 8.2 m below the existing grade (i.e. full depth of Borehole SL16 or Elevation 328.1 m). Grain size analyses were conducted on five samples from this deposit and the results indicate the following grain size measurements, which are presented as an envelope in Figure No. 2:

| | |
|----------------|----------|
| Gravel: | 24 - 66% |
| Sand: | 30 - 72% |
| Silt and Clay: | 4 - 5% |

Measured 'N'-values within this deposit generally range from 6 to 78 blows/0.3 m, indicating a generally compact to very dense condition with a loose surface layer (i.e. N=6) in Borehole SL17. Measured natural moisture contents range from 1 to 4%.

4.4 SAND

At depths ranging from 0.2 to 5.3 m below the ground surface, all the boreholes contacted a 2.6 m (Borehole SL16) to 14.0 m (Borehole SL12) thick fine to medium sand deposit. This cohesionless deposit extends at the borehole locations to depths ranging from 2.6 m to 18.2 m below the ground surface. Grain size distribution analyses were conducted on fourteen samples and the range of particle sizes are presented in an envelope form in Figure No. 3. The analyses indicate:

| | |
|----------------|----------|
| Gravel: | 0 - 11% |
| Sand: | 69 - 97% |
| Silt and Clay: | 3 - 31% |

It should be pointed out that in general the gravel content ranges from 0 to 1%, except in Sample 7 from Borehole SL15 where 11% gravel was found. Traces of gravel was also noted in Borehole SL16. Similarly, the soil fines (i.e. silt & clay content) generally range from about 3 to 21%, except in Borehole SL17, where they were measured to be 31% (i.e. the soil in this borehole is silty). In addition the deposit contains occasional silt and clay seams in the upper zones of Borehole SL10 and also in Borehole SL16.

Measured 'N'-values in this deposit range from 6 to 51 blows/0.3 m indicating a very loose to dense condition, but generally compact.

Dynamic cone penetration results range from about 17 to 70 blows/0.3 m, but generally 20 to 50 blows/0.3 m.

Measured natural moisture contents range from 3 to 10%.

4.5 SILTY CLAY

Interbedded with the upper sand & gravel deposit in Borehole SL16, a silty clay layer was contacted from 3.8 m (Elevation 332.5 m) to 5.2 m (Elevation 331.1 m) below the existing grade. This cohesive deposit contains occasional sand seams. An 'N'-value of 25 blows/0.3 m was obtained in this deposit indicating a very stiff consistency. A pocket penetrometer test on the recovered split-spoon sample gave an undrained shear strength value of 120 kPa, also indicating a very stiff consistency. A grain size distribution analysis was conducted and the resulting grain size distribution is presented in Figure No. 4.

An Atterberg Limit was conducted on the sample obtained, yielding the following results (presented in Figure No. 6):

| | |
|----------------------|-----|
| Plastic Limit (%) | 19% |
| Liquid Limit (%) | 27% |
| Plasticity Index (%) | 8% |
| Moisture Content (%) | 29% |

These results indicate that the material is a clayey deposit of low plasticity. The natural moisture content is higher than the liquid limit and this indicates that the material could be somewhat weak and compressible.

4.6 LOWER SAND & GRAVEL

Boreholes SL12, 13, 14 and 17 contacted, at depths ranging from 6.8 m (Elevation 337.4 m) to 18.9 m (Elevation 319.6 m) below the ground surface, a lower sand & gravel deposit. Boreholes SL13 and SL17 were terminated within this deposit (Borehole SL13 was terminated due to auger refusal on a boulder) at depths of 15.7 and 12.7 m, respectively while in Boreholes SL12 and 14 the deposit extended to the surface of bedrock at depths of 21.5 and 21.4 m or Elevations 317.0

and 322.1 m, respectively.

Grain size distribution of samples from the deposit are shown in an envelope form in Figure No. 5. The test results indicate 18-47% gravel, 48-63% sand and 4-7% soil fines (silt & clay) size particles except for one sample (i.e. Borehole SL14, Sample 20) where 23% silt size particles was measured. It should also be pointed out that cobbles and boulders were encountered in this deposit. In particular, Borehole SL13 was terminated at 15.7 m (Elevation 328.5 m) due to auger refusal, probably on a boulder. In Borehole SL14 (the deep borehole near the south abutment location) the presence of cobbles was inferred at about 12 m depth. Cobbles and boulders were encountered at 18.6 m (Elevation 324.8 m), causing refusal to augering and below this depth the borehole had to be advanced to the surface of bedrock by washboring methods. The presence of the deposit was inferred in the deep borehole near the north abutment location (i.e. Borehole SL12) below a depth of 18.9 m or Elevation 319.6 m. No soil samples could be obtained from this material by STP, as the borehole had to be advanced by washboring methods through frequent cobbles and boulders to the surface of bedrock at 21.5 m depth of Elevation 317.0 m.

'N'-values recorded in this deposit ranged from 15 to 160 blows/0.3 m, indicating a compact to very dense condition, but generally dense to very dense.

4.7 BEDROCK

Bedrock was encountered and cored in Boreholes SL12 and 14 at depths of 21.5 m (Elevation 317.0m) and 21.4 m (Elevation 322.1 m) below existing ground surface, respectively. At Borehole SL12, the bedrock consists of massive, moderately closely jointed, slightly metamorphosed, Precambrian diorite. The diorite was cored to a depth of 4.6 m and the percentage of core recovery was 100%. A rock quality designation (R.Q.D.) value of 95 to 99% was measured. Based on these values together with a visual examination of the rock cores, the rock is considered to be excellent quality.

At Borehole SL14 the rock was cored to a depth of 3.4 m. It generally consists of massive, moderately closely jointed, Precambrian grano-diorite. The percentage of core recovery within the zone cored was 75 to 100% and a rock quality designation (R.Q.D.) value of 56 to 77% was measured. Based on these and a visual examination of the rock cores, the rock is considered to be fair to good quality, but generally fair.

Based on Boreholes SL12 and 14 drilled for this bridge and Boreholes SL1, 2 and 4, drilled for its twin SBL bridge, the surface of the bedrock generally dips in the north-east direction (following the existing ground surface).

4.8 GROUNDWATER CONDITIONS

Groundwater levels in the open boreholes were observed during the drilling and at the completion of each borehole. To enable us to measure water levels at the site over a prolonged period of time without interference from surface water, a standpipe piezometer was installed in Borehole SL11.

The recorded values, shown on the individual Borehole Log Sheets, indicate that the groundwater levels at the time of the investigation generally ranged from about 17 to 19 m below the ground surface (approximately Elevation 319 to 325 m). It should, however, be pointed out that the groundwater at the site would fluctuate seasonally and can be expected to be somewhat higher during the spring months and in response to heavy rains.

5.0 CLOSURE

The Limitations of Report, as quoted in Appendix A, is an integral part of this report.

Sincerely,



Andrew Drevininkas, P. Eng.

AD/dee



Z.S. Ozden, P. Eng.



APPENDIX A

AGRA
LIMITATIONS OF REPORT

The information contained herein in no way reflects on the environmental aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. AGRA accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

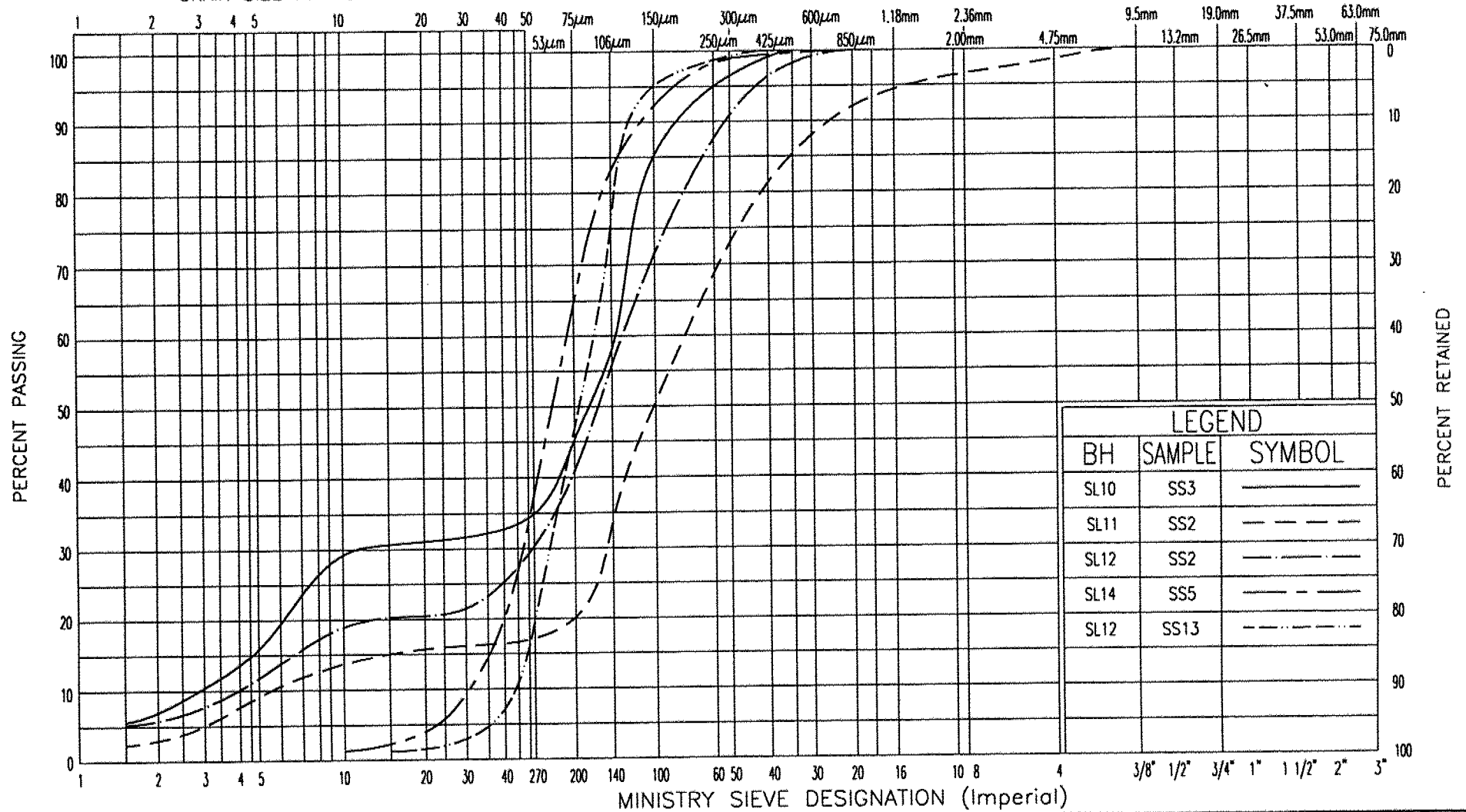
FIGURES

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY & SILT | SAND | | | GRAVEL | |
|-------------|------|--------|--------|--------|--------|
| | Fine | Medium | Coarse | Fine | Coarse |

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



GRAIN SIZE DISTRIBUTION
SILTY SAND to SANDY SILT

FIG No 1

W P 466-93-00

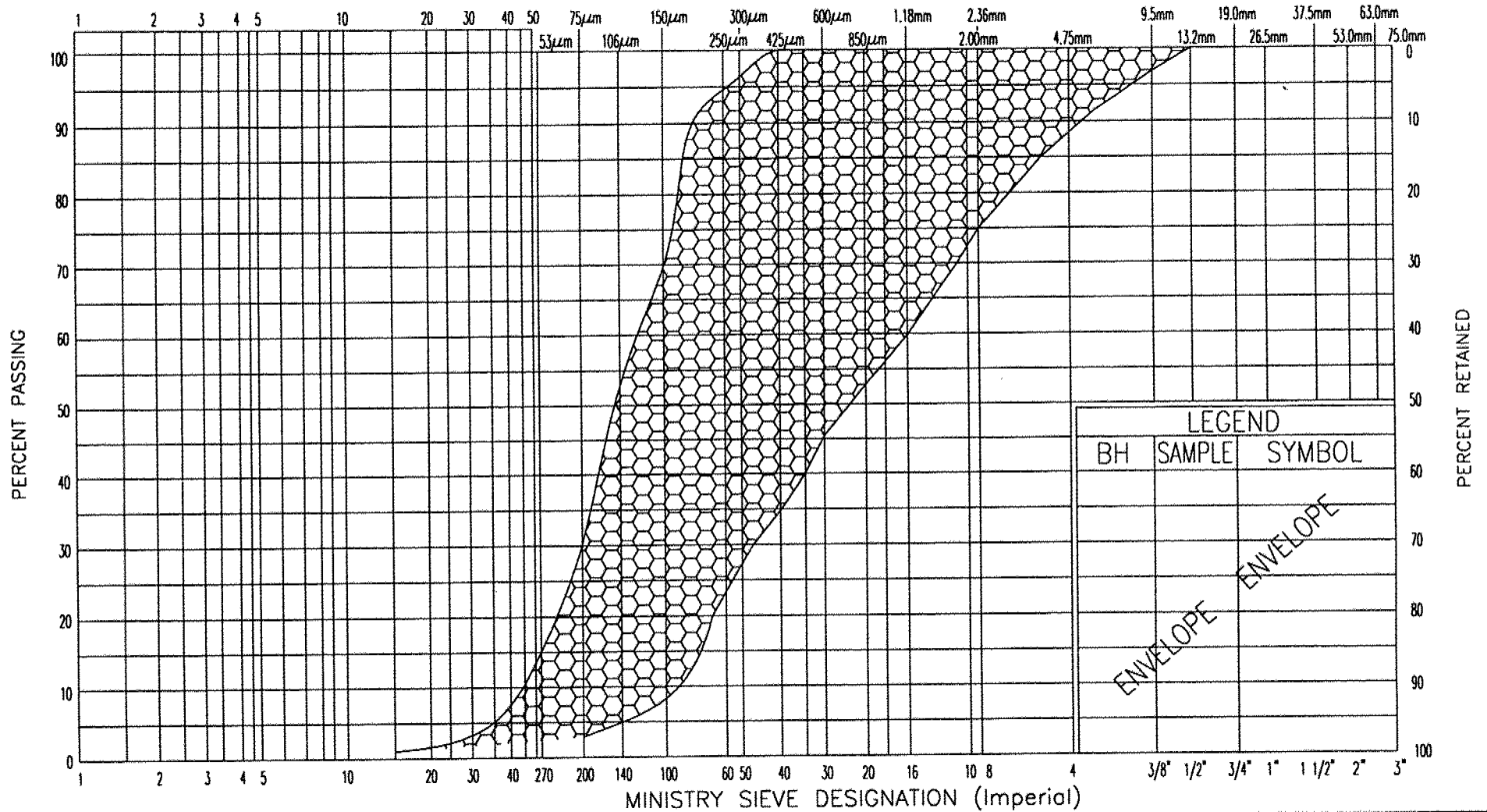


UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY & SILT | SAND | | | GRAVEL | |
|-------------|------|--------|--------|--------|--------|
| | Fine | Medium | Coarse | Fine | Coarse |

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



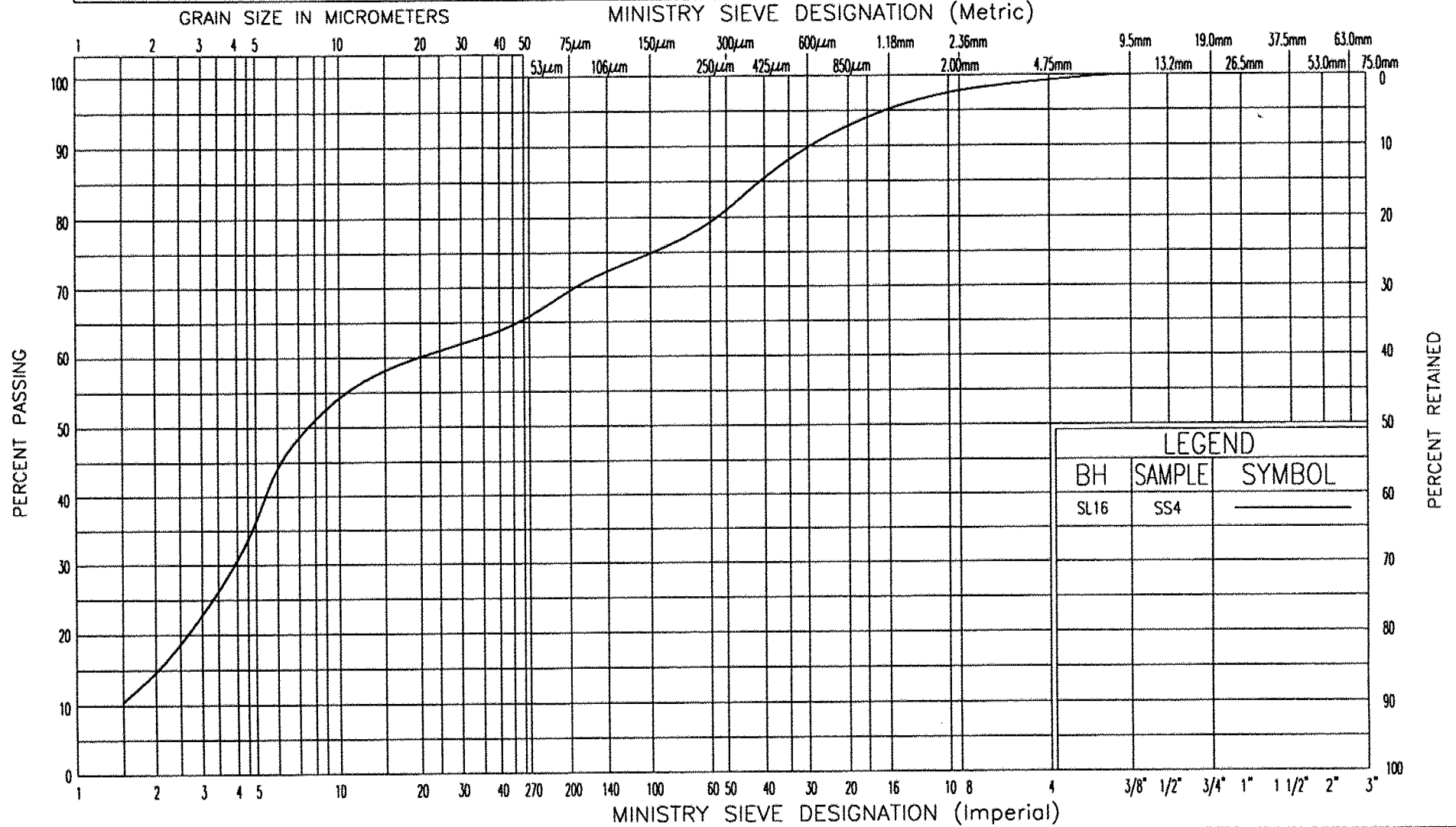
GRAIN SIZE DISTRIBUTION
SAND

FIG No 3

W P 466-93-00

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY & SILT | SAND | | | GRAVEL | |
|-------------|------|--------|--------|--------|--------|
| | Fine | Medium | Coarse | Fine | Coarse |



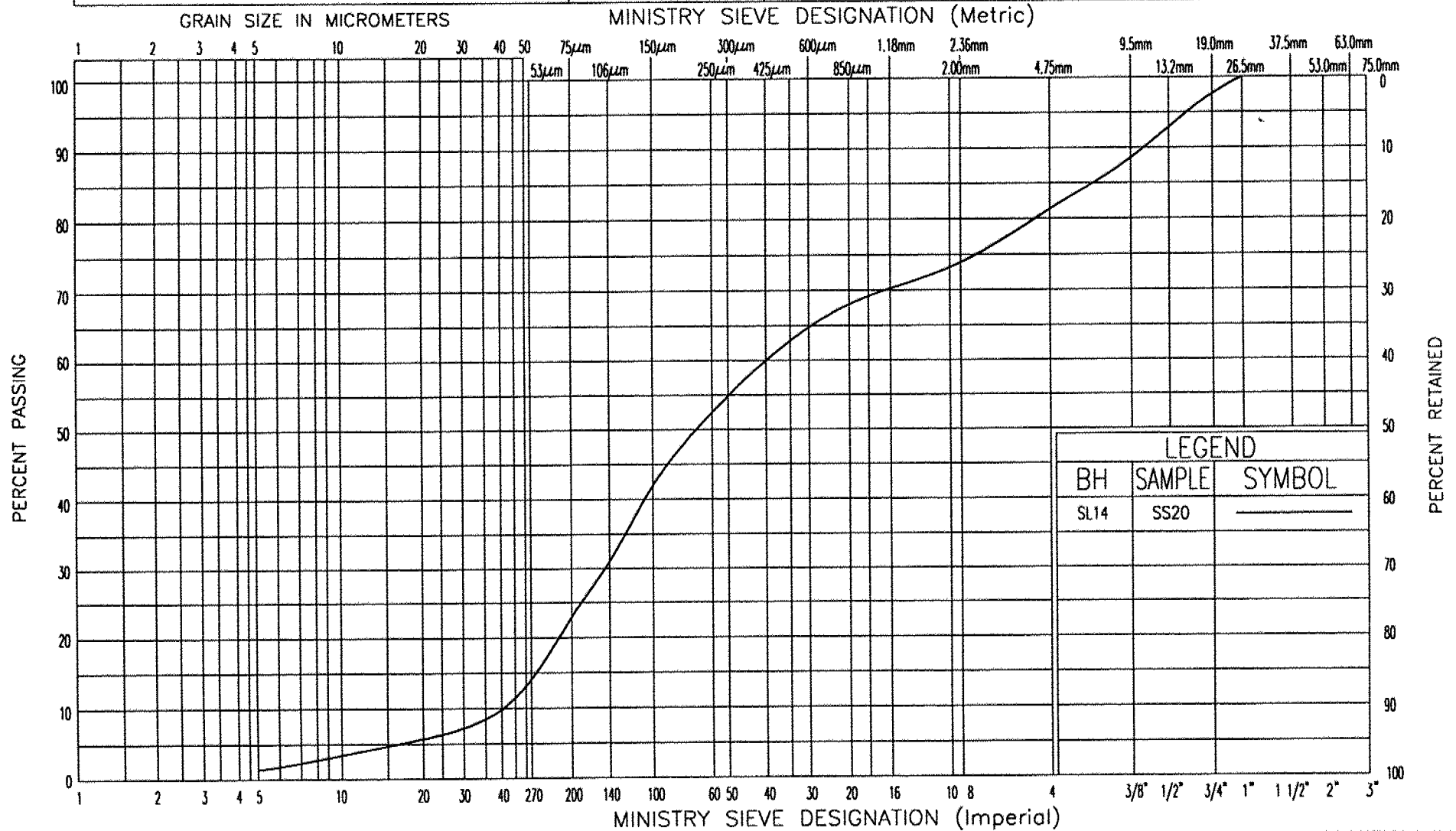
GRAIN SIZE DISTRIBUTION
SILTY CLAY

FIG No 4
W P 466-93-00



UNIFIED SOIL CLASSIFICATION SYSTEM

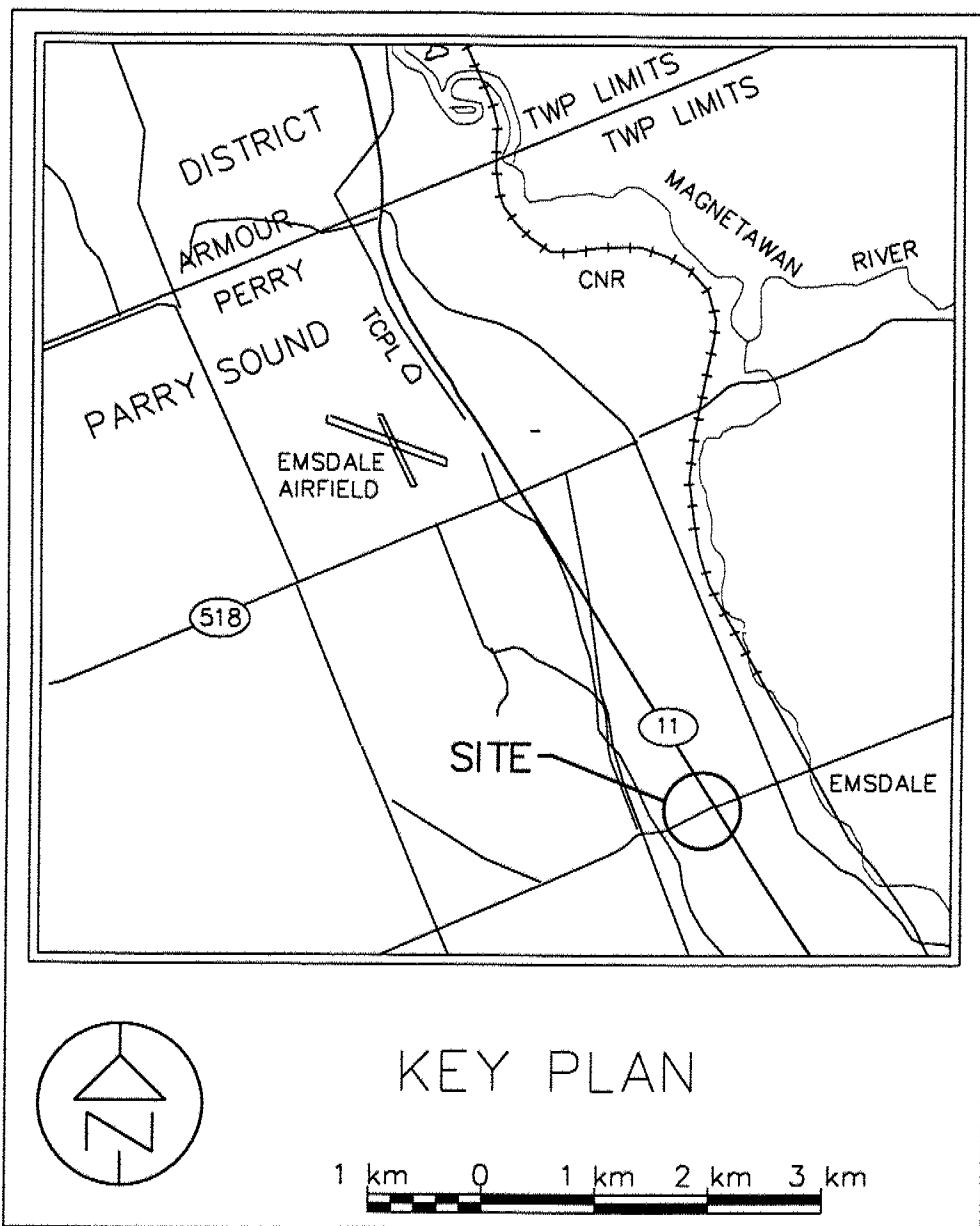
| CLAY & SILT | SAND | | | GRAVEL | |
|-------------|------|--------|--------|--------|--------|
| | Fine | Medium | Coarse | Fine | Coarse |



GRAIN SIZE DISTRIBUTION
LOWER SAND & GRAVEL

FIG No 5
W P 466-93-00

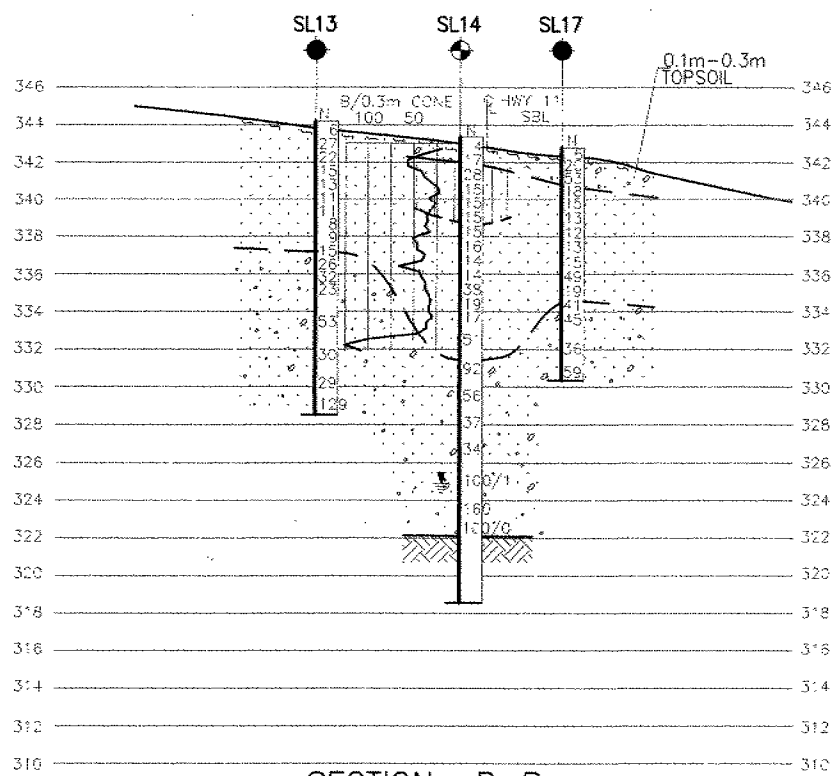
ENCLOSURES



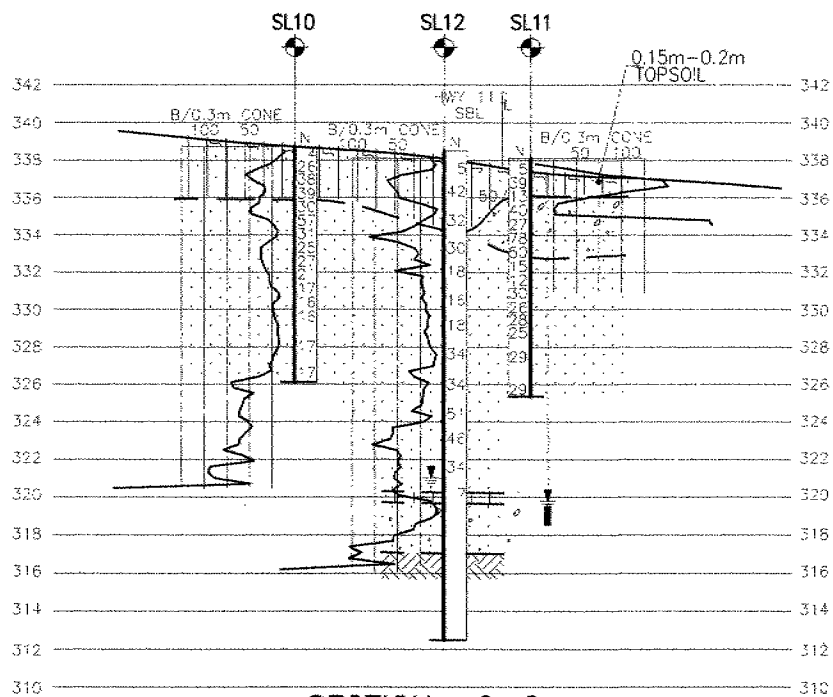
STAR LAKE ROAD OVERPASS (SBL)
KEY PLAN

Dwg. No 1





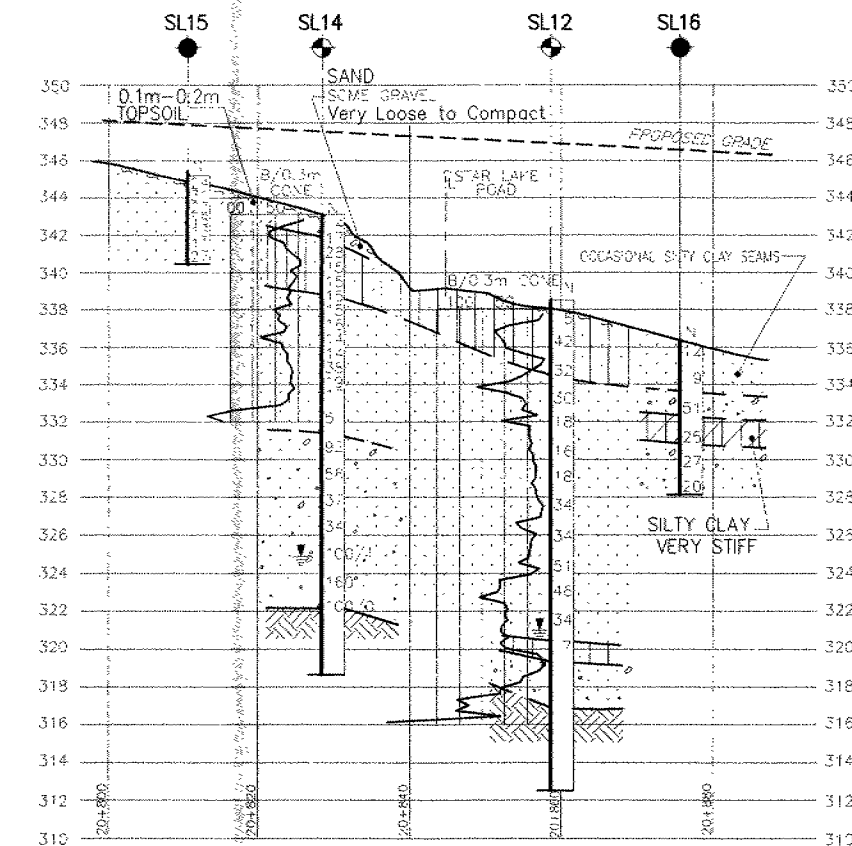
SECTION B-B



SECTION C-C

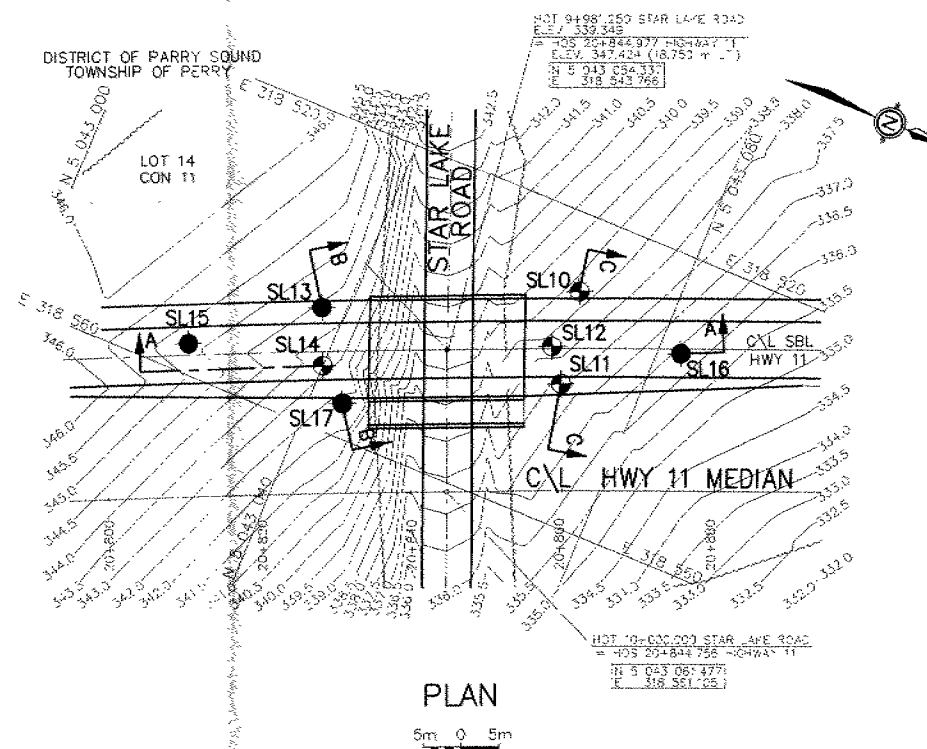
SOIL STRATIGRAPHY LEGEND

| | | | |
|--|--|--|--|
| | SAND Loose to Very Dense | | SILTY SAND to SANDY SILT Compact to Very Dense |
| | SAND & GRAVEL Compact to Very Dense | | GRANODIORITE BEDROCK |



SECTION A-A

5m 0 5m HCR
2m 0 2m VER



PLAN

5m 0 5m



METRIC

MEASUREMENTS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN METRES - METRES.

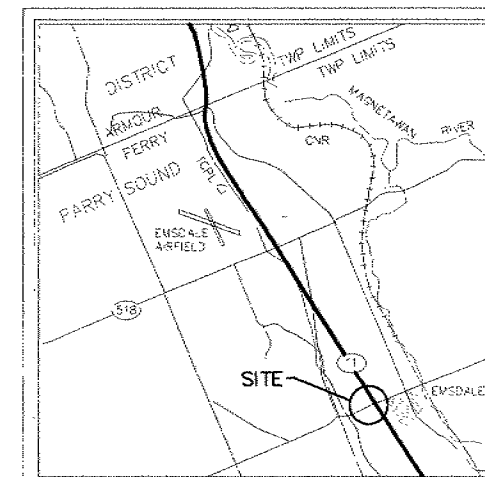
CONT. No.
W.P. No. 469-93-01

STAR LAKE ROAD OVERPASS (SBL)
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

AGRA Earth & Environmental Ltd.



KEY PLAN

1 km 0 2 km 3 km

LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊙ Bore Hole & Cone
- "1" Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60' Cone, 475 J/blow)
- WL at time of investigation Feb. 99
- WL in Piezometer
- Piezometer

| No. | ELEVATION | CO-ORDINATES NORTH | EAST |
|------|-----------|-----------------------|---------|
| SL10 | 338.3 | 5 043 067 | 318 530 |
| SL11 | 338.3 | 5 043 070 | 318 542 |
| SL12 | 338.5 | 5 043 067 | 318 538 |
| SL13 | 344.2 | 5 043 037 | 318 545 |
| SL14 | 343.4 | 5 043 040 | 318 552 |
| SL15 | 345.5 | 5 043 022 | 318 556 |
| SL16 | 336.3 | 5 043 083 | 318 532 |
| SL17 | 342.9 | 5 043 044 | 318 556 |

NOTE

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 20.1 of OPS Gen. Cond.

| REV | DATE | BY | DESCRIPTION |
|-----|------|----|-------------|
|-----|------|----|-------------|

REF. Hwy 11 Bridge Site Plan
Dwg. by M. J. Con. 1999

| | | |
|----------------------|-----------------|--------------------|
| Hwy No 11 | DATE June, 1999 | DIST 52-HUNTSVILLE |
| SUBMIT TO CHECKED AD | APPROVED | SITE 44-392S |
| DRAWN MA | CHECKED | DWG 2 |

RECORD OF BOREHOLE No SL10

1 OF 2

METRIC

W.P. 469-93-01 LOCATION N 5043067.5 E 318529.9 ORIGINATED BY AD
 DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
 DATUM Geodetic DATE 24.2.99 CHECKED BY ZSO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE 20 40 60 80 100 | PLASTIC LIMIT w _p | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|---|------------|---------|------|------------|-------------------------|-----------------|--|---------------------------------|-------------------------------|--------------------------------|---------------------------------------|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | |
| 338.9 0.0 | 0.2m TOPSOIL very loose brown SILTY SAND to SANDY SILT trace clay compact to dense damp | | 1 | SS | 4 | | | | | | | | Station 20 + 862 7.7 Lt SBL C/L |
| | | | 2 | SS | 26 | | 338 | | | | | | |
| | | | 3 | SS | 38 | | 337 | | | | | | 0 53 40 7 |
| | | | 4 | SS | 39 | | | | | | | | |
| 335.9 3.0 | occasional Silt and Clay seams trace Gravel brown SAND fine to medium, compact to very dense damp | | 5 | SS | 30 | | 336 | | | | | | |
| | | | 6 | SS | 57 | | 335 | | | | | | |
| | | | 7 | SS | 31 | | 334 | | | | | | |
| | | | 8 | SS | 25 | | 333 | | | | | | |
| | | | 9 | SS | 27 | | 332 | | | | | | 0 96 (4) |
| | | | 10 | SS | 21 | | 331 | | | | | | |
| | | | 11 | SS | 17 | | 330 | | | | | | |
| | | | 12 | SS | 16 | | 329 | | | | | | |
| | | | 13 | SS | 16 | | 328 | | | | | | |
| | | | 14 | SS | 17 | | 327 | | | | | | |
| | | | 15 | SS | 17 | | 326 | | | | | | |
| 326.1 12.8 | END OF BOREHOLE WL on completion: none | | | | | | 325 | | | | | | |
| | | | | | | | 324 | | | | | | |

Continued Next Page

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

RECORD OF BOREHOLE No SL10

2 OF 2

METRIC

W.P. 489-93-01 LOCATION N 5043067.5 E 318529.9 ORIGINATED BY AD
 DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
 DATUM Geodetic DATE 24.2.99 CHECKED BY ZSO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|--|------------|---------|------|------------|-------------------------|-----------------|--|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | |
| 320.3 | | | | | | | | | | | | | |
| 18.6 | END OF DCPT @ 18.6m Dynamic Cone Penetration Test conducted 2m West of Borehole | | | | | | | | | | | | |

RECORD OF BOREHOLE No SL11

1 OF 2

METRIC

W.P. 488-93-01 LOCATION N 5043070.4 E 318542.2 ORIGINATED BY AD
DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
DATUM Geodetic DATE 24.2.99 CHECKED BY ZSO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE 20 40 60 80 100 | PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|--|------------|---------|------|------------|-------------------------|-----------------|--|---|---------------------------------------|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| 338.3 0.0 | 0.15m TOPSOIL very loose brown SILTY SAND trace Clay dense damp | | 1 | SS | 5 | | 338 | | | | Station 20 + 860 4.8 Rt SBL C/L |
| | | | 2 | SS | 39 | | 337 | | | | 1 79 17 3 |
| | | | 3 | SS | 50/13 | | 336 | | | | |
| 336.1 2.2 | brown SAND & GRAVEL compact to very dense dry | | 4 | SS | 40 | | 335 | | | | 25 71 (4) |
| | | | 5 | SS | 27 | | 334 | | | | 66 30 (4) |
| | | | 6 | SS | 78 | | 333 | | | | SS7: No recovery |
| | | | 7 | SS | 50* | | 332 | | | | |
| 333.0 5.3 | brown SAND fine to medium, trace Silt compact dry | | 8 | SS | 15 | | 331 | | | | 1 89 10 0 |
| | | | 9 | SS | 12 | | 330 | | | | |
| | | | 10 | SS | 30 | | 329 | | | | 0 95 (5) |
| | | | 11 | SS | 26 | | 328 | | | | |
| | | | 12 | SS | 28 | | 327 | | | | |
| | | | 13 | SS | 25 | | 326 | | | | |
| | | | 14 | SS | 29 | | 325 | | | | |
| 325.5 12.8 | END OF BOREHOLE | | 15 | SS | 29 | | 324 | | | | |

Continued Next Page

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

RECORD OF BOREHOLE No SL11

2 OF 2

METRIC

W.P. 469-93-01 LOCATION N 5043070.4 E 318542.2 ORIGINATED BY AD
 DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
 DATUM Geodetic DATE 24.2.99 CHECKED BY ZSO

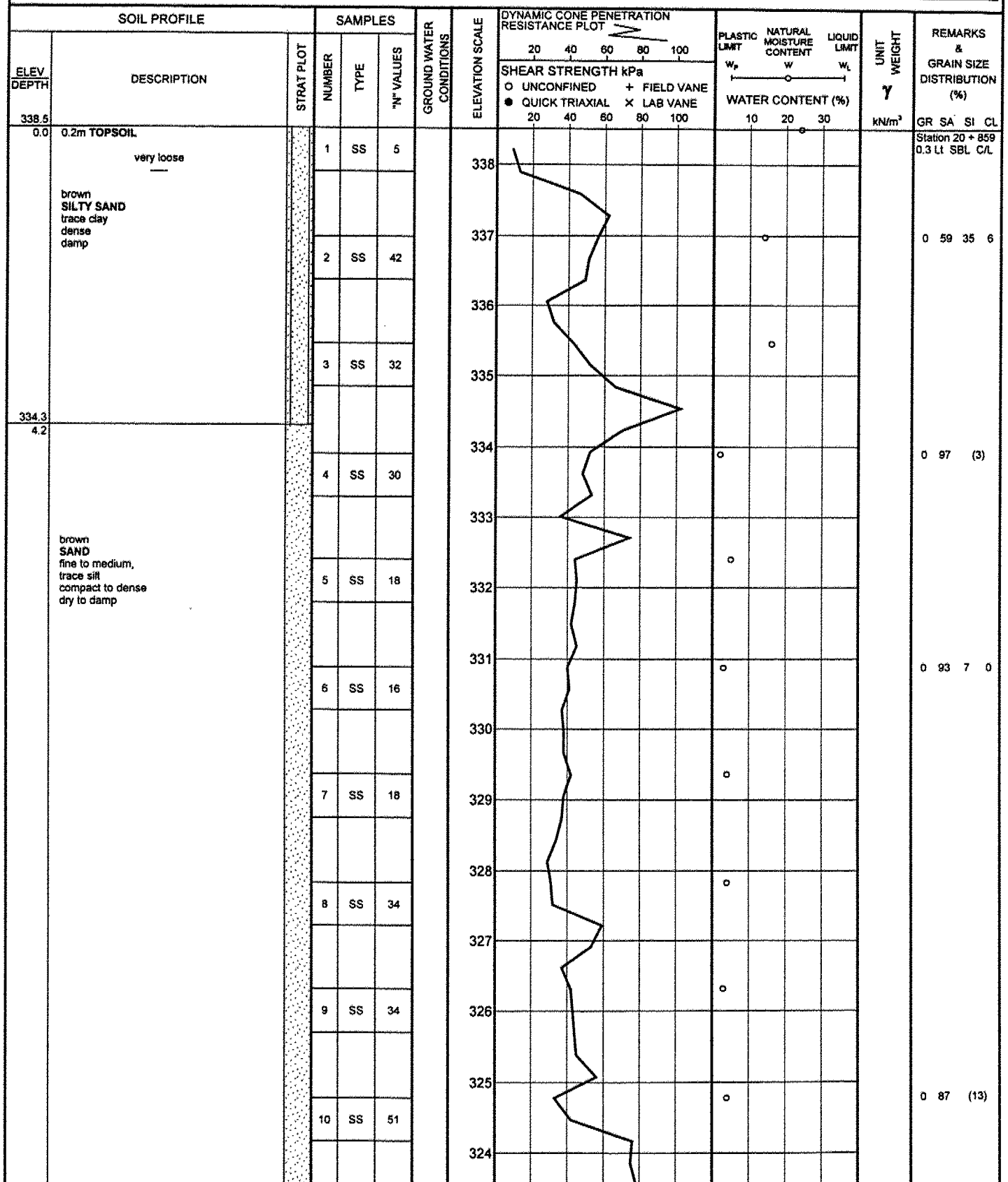
| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT w _p | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w _L | UNIT WEIGHT γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|---|------------|---------|------|------------|-------------------------|-----------------|--|--|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | |
| | | | | | | | | 20 40 60 80 100 | | | | | | |
| | Borehole Extended to 19.8m by straight augering to install standpipe piezometer | | | | | | 323 | | | | | | | |
| | | | | | | | 322 | | | | | | | |
| | | | | | | | 321 | | | | | | | |
| | | | | | | | 320 | | | | | | | |
| | | | | | | | 319 | | | | | | | |
| 318.5 | END OF AUGER PROBE | | | | | | | | | | | | | |
| 19.8 | WL IN PIEZOMETER Feb 25/99: 18.7m Dynamic Cone Penetration Test conducted 2m West of Borehole | | | | | | | | | | | | | |

RECORD OF BOREHOLE No SL12

1 OF 2

METRIC

W.P. 499-93-01 LOCATION N5043067.0 E 318538.1 ORIGINATED BY AD
 DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
 DATUM Geodetic DATE 24.3.99 CHECKED BY ZSO



Continued Next Page

RECORD OF BOREHOLE No SL13

1 OF 2

METRIC

W.P. 489-93-01 LOCATION N 5043036.9 E 318544.9 ORIGINATED BY AD
 DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
 DATUM Geodetic DATE 25.2.99 CHECKED BY ZSO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | PLASTIC LIMIT w _p | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|----|-----|----|----|------------------------------------|-------------------------------------|-----------------------------------|--|---|-------------------|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | | | WATER CONTENT (%) | | |
| | | | | | | | | ○ UNCONFINED + FIELD VANE | | | | | | | | | | ○ | | |
| | | | | | | | | ● QUICK TRIAXIAL × LAB VANE | | | | | | | | | | | | |
| 344.2 | | | | | | 20 | 40 | 60 | 80 | 100 | 10 | 20 | 30 | | GR SA SI CL | | | | | |
| 0.0 | 0.2m TOPSOIL | | 1 | SS | 6 | | | | | | | | | | | Station 20 + 829 | | | | |
| | loose | | | | | | | | | | | | | | | 5.9 Lt SBL C/L | | | | |
| | | | 2 | SS | 27 | | | | | | | | | | | 0 85 15 0 | | | | |
| | brown SAND fine to medium, some Silt damp | | 3 | SS | 22 | | | | | | | | | | | | | | | |
| | | | 4 | SS | 15 | | | | | | | | | | | | | | | |
| | | | 5 | SS | 13 | | | | | | | | | | | | | | | |
| | | | 6 | SS | 11 | | | | | | | | | | | | | | | |
| | compact | | 7 | SS | 11 | | | | | | | | | | | 0 80 20 0 | | | | |
| | loose | | 8 | SS | 8 | | | | | | | | | | | | | | | |
| | | 9 | SS | 9 | | | | | | | | | | | | | | | | |
| 337.4 | | | 10 | SS | 15 | | | | | | | | | | | 40 56 (4) | | | | |
| 6.8 | brown SAND & GRAVEL compact to very dense damp | | 11 | SS | 26 | | | | | | | | | | | | | | | |
| | | | 12 | SS | 32 | | | | | | | | | | | | | | | |
| | | | 13 | SS | 23 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | 14 | SS | 53 | | | | | | | | | | | 34 62 (4) | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | 15 | SS | 30 | | | | | | | | | | | | | | | |
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Continued Next Page

RECORD OF BOREHOLE No SL13

2 OF 2

METRIC

W.P. 489-93-01 LOCATION N 5043036.9 E 318544.9 ORIGINATED BY AD
 DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
 DATUM Geodetic DATE 25.2.99 CHECKED BY ZSO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | PLASTIC LIMIT w _p | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|----------------|---|------------|---------|------|------------|----------------------------|-----------------|---|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV. DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | |
| 328.5 | | | 17 | SS | 129 | | 329 | | | | | | |
| 15.7 | Auger Refusal Probably on Boulder DCPT Refusal WL on completion: none | | | | | | | | | | | | |

METRIC

| | | | | | |
|-------|-----------|----------|------------------------|---------------|-------------|
| W.P. | 469-83-01 | LOCATION | N 5043040.4 E 318552.0 | ORIGINATED BY | AD |
| DIST | 52 | HWY | 11 | BOREHOLE TYPE | Hollow Stem |
| DATUM | Geodetic | DATE | 9.2.99 | COMPILED BY | CK |
| | | | | CHECKED BY | ZSO |

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | SHEAR STRENGTH kPa | | | | | WATER CONTENT (%) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | ○ UNCONFINED | + FIELD VANE | ● QUICK TRIAXIAL | | | | x LAB VANE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 343.4 | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | </ |

Continued Next Page

+3, X3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SL15

1 OF 1

METRIC

W.P. 480-03-01 LOCATION N 5043022.4 E 318556.1 ORIGINATED BY AD
DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
DATUM Geodetic DATE 25.2.99 CHECKED BY ZSO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|--|------------|---------|------|------------|-------------------------|-----------------|--|----------|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | |
| | | | | | | | 20 40 60 80 100 | 20 40 60 80 100 | 10 20 30 | | | | | |
| 345.5 | 0.2m TOPSOIL | | 1 | SS | 24 | | | | | | | | | |
| | brown SAND fine to medium, trace Silt compact to dense damp to dry | | 2 | SS | 31 | | | | | | | | | |
| | | | 3 | SS | 23 | | | | | | | | | |
| | | | 4 | SS | 18 | | | | | | | | | |
| | | | 5 | SS | 13 | | | | | | | | | |
| | | | 6 | SS | 11 | | | | | | | | | |
| 340.5 | trace Gravel | | 7 | SS | 27 | | | | | | | | | |
| 5.0 | END OF BOREHOLE | | | | | | | | | | | | | |
| | WL on completion: none | | | | | | | | | | | | | |

1 OF 1

METRIC

ORIGINATED BY AD

COMPILED BY CK

CHECKED BY ZSO

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

RECORD OF BOREHOLE No SL17

1 OF 1

METRIC

W.P. 489-93-01 LOCATION N 5043044.3 E 318555.6 ORIGINATED BY AD
 DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
 DATUM Geodetic DATE 24.2.99 CHECKED BY ZSO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT w_p | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | |
|--------------|--|------------|---------|------|------------|-------------------------|-----------------|--|----|------------------------|---------------------------------|-----------------------|--|---------------------------------------|----|----|------------------------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 | 40 | | | | | | 60 | 80 | 100 |
| 342.9 | 0.3m TOPSOIL | | 1 | SS | 6 | | | | | | | | | | | | Station 20 + 831 6.6 Rt SBL C/L |
| | loose | | | | | | | | | | | | | | | | |
| | brown SAND & GRAVEL compact to dense damp | | 2 | SS | 20 | | | | | | | | | | | | 24 72 (4) |
| | | | 3 | SS | 53 | | | | | | | | | | | | |
| 340.7 | | | | | | | | | | | | | | | | | |
| 2.2 | brown SAND fine, Silty compact to dense dry | | 4 | SS | 18 | | | | | | | | | | | | |
| | | | 5 | SS | 15 | | | | | | | | | | | | |
| | | | 6 | SS | 13 | | | | | | | | | | | | 0 69 (31) |
| | | | 7 | SS | 12 | | | | | | | | | | | | |
| | | | 8 | SS | 13 | | | | | | | | | | | | |
| | | | 9 | SS | 15 | | | | | | | | | | | | 0 71 (29) |
| | | | 10 | SS | 49 | | | | | | | | | | | | |
| | | | 11 | SS | 19 | | | | | | | | | | | | |
| 334.5 | | | | | | | | | | | | | | | | | |
| 8.4 | brown SAND & GRAVEL dense to very dense damp | | 12 | SS | 41 | | | | | | | | | | | | |
| | | | 13 | SS | 45 | | | | | | | | | | | | 40 55 5 0 |
| | | | | | | | | | | | | | | | | | |
| | | | 14 | SS | 36 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| 330.3 | | | 15 | SS | 59 | | | | | | | | | | | | 47 48 (5) |
| 12.7 | END OF BOREHOLE | | | | | | | | | | | | | | | | |
| | WL on completion: none | | | | | | | | | | | | | | | | |

**FOUNDATION DESIGN REPORT
FOR
PROPOSED STAR LAKE ROAD OVERPASS, SBL
STRUCTURE SITE NO. 44-392S
DISTRICT 52, HUNTSVILLE
W.P. 469-93-01**

Submitted To:

**Delcan Corporation
133 Wynford Drive
North York, Ontario, M3C 1K1
Canada**

Submitted By:

**AGRA
104 Crockford Blvd.
Scarborough, Ontario, M1R 3C6
Canada**

**August 1999
TT98820C**

August 31, 1999.
Ref. No.: TT98820C

Delcan Corporation
133 Wynford Drive
North York, Ontario, M3C 1K1
Canada

Attention: Mr. Khaled El-Dalati, P. Eng.

Dear Sir:

**Re: FOUNDATION DESIGN REPORT
FOR
PROPOSED STAR LAKE ROAD OVERPASS, SBL
STRUCTURE SITE NO. 44-392S
DISTRICT 52, HUNTSVILLE
W.P. 469-93-01**

We take pleasure in enclosing six (6) copies of our Foundation Design Report carried out for the above mentioned project and we will be glad to discuss any questions arising from this work.

Soil samples will be retained for a period of one year, and will thereafter be disposed of unless we are otherwise instructed.

We thank you for giving us this opportunity to be of service to you.

Sincerely,



Z.S. Ozden, P. Eng.,
Principal Engineer.

ZSO/dee

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1.0 INTRODUCTION

AGRA, Consulting Geotechnical Engineers, was retained by Delcan Corporation to conduct a foundation investigation at the site of a proposed bridge that will carry the proposed realigned southbound lane of Highway 11 over the existing Star Lake Road. The site is located in the Village of Emsdale, about 0.3 km west of the intersection of Star Lake Road and present Highway 11, in the Township of Perry, Lot 14, Concession 11 in MTO District 52 - Huntsville (see Key Plan, Drawing No. 1). The proposed bridge will be an approximately 21 m long, 2-lane, single span structure.

The purpose of the investigation has been to obtain information about the subsurface conditions at the site of the proposed bridge and approach embankments by means of exploratory boreholes, and based on the findings, to provide recommendations for the geotechnical design of the foundations of the proposed structure and approach fills.

2.0 SITE DESCRIPTION AND PHYSIOGRAPHY

The site is located about 0.3 km west of the intersection of Star Lake Road and present Highway 11, in the Village of Emsdale. The ground elevation in the general area of the proposed bridge site falls to the north and the east, ranging in Elevation from about 345 m to 336 m. The surrounding area is wooded with residential properties located about 70 \pm m to the west and the TransCanada PipeLine about 130 \pm m further to the west.

Available geologic information indicates that the site is in an area of ice-contact sediments. Generally, after the last glacial withdrawal, ice-contact sediments (sands and gravels) followed by glaciofluvial sediments (ranging from deltaic and nearshore sands and gravels to prodeltaic and lake bottom silts and clays) were deposited on top of the existing sandy glacial till or Precambrian bedrock. The area was then inundated by glacial Lake Algonquin depositing sands, silts and clays in low lying areas.

Published geological information indicate that the bedrock generally consists of strongly, foliated gneissic to migmatic rocks of the Central Gneiss Belt, which is part of the Grenville Province (a structural subdivision of the Canadian Shield).

3.0 INVESTIGATION PROCEDURES

The fieldwork for this project was performed during the period of February 9, 24, 25, March 24 and April 20, 1999, and consisted of drilling and sampling eight boreholes (Borehole Nos. SL10, 11, 12, 13, 14, 15, 16 and 17) and conducting four dynamic cone penetration tests. The plan locations of the boreholes, along with stratigraphic sections are shown on Drawing No. 1.

Due to overhead utility cables along the north side of Star Lake Road, and uneven sloping ground along the road cut on the south side of Star Lake Road, the exact proposed abutment locations were not accessible. The boreholes were therefore drilled offset from the actual proposed foundation elements, as close as practicable.

The boreholes were advanced using solid and hollow stem continuous flight augers with a track-mounted power auger drilling rig (CME 75) owned and operated by Canadian Soil Drilling Inc. and a track-mounted power auger drilling rig (BOA 6M) owned and operated by Groundworks Drilling Inc., under the full-time supervision of a soils engineer from AGRA.

Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test Method (SPT), as specified in ASTM Method D 1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter o.d. split barrel (split-spoon) sampler into the ground. The number of blows of the hammer to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the 'N'-value of the soil and this gives an indication of the consistency or the compactness condition of the soil deposit.

Due to the presence of boulders above the bedrock surface, Boreholes SL12 and 14 (i.e. deep boreholes) had to be extended below about 19 m by triconing and/or rock coring methods to the bedrock surface and the bedrock was subsequently cored using NW size casing.

In addition, dynamic cone penetration tests were performed adjacent to four of the boreholes. This test consists of driving a 60° point, 50 mm diameter cone attached to the drill rod continuously, into the undisturbed ground with a driving energy of 475 J (63.5 kg hammer falling freely a distance of 76 cm) per blow. The number of blows for each 30 cm of penetration is recorded and this provides an indication of the relative changes in the soil density with depth.

The borehole locations were established in the field by our engineering staff, in relation to the already staked out centre-line of Highway 11 (by Dearden and Stanton Limited). The borehole geodetic elevations and co-ordinates were later taken by surveyors from Dearden and Stanton Limited.

The soil samples were shipped in sealed containers to our geotechnical laboratory in Toronto (Scarborough) for further examination and classification. A laboratory testing programme, consisting of natural moisture content, Atterberg Limits tests and grain-size analyses, was performed on selected representative soil samples. The results of the laboratory tests are presented on the appropriate Borehole Log Sheets and also in Figure Nos. 1 to 6.

Groundwater conditions in the open boreholes were observed during drilling and the boreholes were left open until the end of each work day to enable us to take additional water level readings. A standpipe piezometer was installed in Borehole SL11 to monitor the groundwater level. The remaining boreholes were grouted on completion, while the piezometer tube in Borehole SL11 was grouted on February 29, 1999.

.../...

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4.0 SUBSURFACE CONDITIONS

The subsurface conditions were explored at eight borehole locations (Borehole Nos. SL10 to SL17), and were inferred at the locations of four dynamic cone penetration tests. The locations of the boreholes and cone penetration tests are shown on the Plan and Profile Drawing No. 1 and are also indicated on the individual Borehole Log Sheets. Cross sections of inferred subsurface stratigraphy are given on Drawing No. 1.

The ground surface at the proposed site falls to the north and east. The ground elevation at the proposed bridge location generally ranges from about 345 to 336 m.

In general, the boreholes contacted, below a surficial topsoil layer, granular soil deposits ranging from sandy silt to sand & gravel. The relatively finer grained silty sand to sandy silt generally occur near the surface, underlain by fine to medium sand. In several of the boreholes an upper sand & gravel deposit was also contacted near the ground surface. In the majority of the boreholes the fine to medium sand is underlain by a lower sand & gravel deposit, which, in the two deeper boreholes, extends to the surface of the bedrock. In the two deeper boreholes that extended into the bedrock (i.e. Boreholes SL12 and 14), the sand & gravel deposit immediately overlying the bedrock contains frequent cobbles and boulders, which were cored in order to advance the borehole to the bedrock. The bedrock ranges from Precambrian diorite to grano-diorite. The bedrock was cored to a depth of 3.4 to 4.6 m and is generally of fair to excellent quality. The groundwater table at the time of our investigation was encountered at depths of 17 to 19 m below existing grade.

Details of the subsurface conditions encountered in these boreholes are presented on the Borehole Log Sheets. The individual strata are briefly described below.

4.1 TOPSOIL

Topsoil was encountered at the majority of boreholes (except Borehole SL16), ranging in thickness from 0.1 to 0.3 m.

In our experience the thickness of topsoil frequently varies in between and beyond the borehole locations. In addition, at the time of our investigation the ground near the surface was frozen; therefore the soil conditions within the upper several decimeters could not be accurately determined and the descriptions given for this upper zone should be considered approximate only.

4.2 SILTY SAND TO SANDY SILT

Underlying the surficial topsoil at Boreholes SL10, 11 and 12 (in the area of the proposed north abutment) and below the surficial sand in Borehole SL14, a cohesionless deposit ranging in composition from silty sand to sandy silt with traces of clay, was encountered to depths of 2.2 to 4.6 m below existing grade. In addition, a 0.7 m thick layer of fine sandy silt was contacted in Borehole SL12 below a depth of 18.2 m (Elevation 320.3 m). Five grain size analyses were

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conducted on samples from this deposit resulting in the following grain size measurements, which are presented in Figure No. 1:

| | |
|---------|----------|
| Gravel: | 0 - 1% |
| Sand: | 37 - 79% |
| Silt: | 17 - 63% |
| Clay: | 0 - 7% |

Measured 'N'-values within the deposit generally range from 15 to in excess of 50 blows/0.3 m, indicating a generally compact to dense condition, with some low values (4 to 5 blows/0.3 m) recorded at the surface (indicating a very loose surficial condition).

Measured natural moisture contents range from 7 to 16%.

4.3 UPPER SAND & GRAVEL

At depths ranging from 0.3 to 2.6 m below the ground surface, Boreholes SL11, 16, and 17 contacted a surficial sand & gravel deposit. This granular (cohesionless) deposit extended to depths ranging from 2.2 m (Elevation 340.7 - Borehole SL17) to 8.2 m below the existing grade (i.e. full depth of Borehole SL16 or Elevation 328.1 m). Grain size analyses were conducted on five samples from this deposit and the results indicate the following grain size measurements, which are presented as an envelope in Figure No. 2:

| | |
|----------------|----------|
| Gravel: | 24 - 66% |
| Sand: | 30 - 72% |
| Silt and Clay: | 4 - 5% |

Measured 'N'-values within this deposit generally range from 6 to 78 blows/0.3 m, indicating a generally compact to very dense condition with a loose surface layer (i.e. N=6) in Borehole SL17. Measured natural moisture contents range from 1 to 4%.

4.4 SAND

At depths ranging from 0.2 to 5.3 m below the ground surface, all the boreholes contacted a 2.6 m (Borehole SL16) to 14.0 m (Borehole SL12) thick fine to medium sand deposit. This cohesionless deposit extends at the borehole locations to depths ranging from 2.6 m to 18.2 m below the ground surface. Grain size distribution analyses were conducted on fourteen samples and the range of particle sizes are presented in an envelope form in Figure No. 3. The analyses indicate:

| | |
|----------------|----------|
| Gravel: | 0 - 11% |
| Sand: | 69 - 97% |
| Silt and Clay: | 3 - 31% |

It should be pointed out that in general the gravel content ranges from 0 to 1%, except in Sample 7 from Borehole SL15 where 11% gravel was found. Traces of gravel was also noted in Borehole SL16. Similarly, the soil fines (i.e. silt & clay content) generally range from about 3 to 21%, except in Borehole SL17, where they were measured to be 31% (i.e. the soil in this borehole is silty). In addition the deposit contains occasional silt and clay seams in the upper zones of Borehole SL10 and also in Borehole SL16.

Measured 'N'-values in this deposit range from 6 to 51 blows/0.3 m indicating a very loose to dense condition, but generally compact.

Dynamic cone penetration results range from about 17 to 70 blows/0.3 m, but generally 20 to 50 blows/0.3 m.

Measured natural moisture contents range from 3 to 10%.

4.5 SILTY CLAY

Interbedded with the upper sand & gravel deposit in Borehole SL16, a silty clay layer was contacted from 3.8 m (Elevation 332.5 m) to 5.2 m (Elevation 331.1 m) below the existing grade. This cohesive deposit contains occasional sand seams. An 'N'-value of 25 blows/0.3 m was obtained in this deposit indicating a very stiff consistency. A pocket penetrometer test on the recovered split-spoon sample gave an undrained shear strength value of 120 kPa, also indicating a very stiff consistency. A grain size distribution analysis was conducted and the resulting grain size distribution is presented in Figure No. 4.

An Atterberg Limit was conducted on the sample obtained, yielding the following results (presented in Figure No. 6):

| | |
|----------------------|-----|
| Plastic Limit (%) | 19% |
| Liquid Limit (%) | 27% |
| Plasticity Index (%) | 8% |
| Moisture Content (%) | 29% |

These results indicate that the material is a clayey deposit of low plasticity. The natural moisture content is higher than the liquid limit and this indicates that the material could be somewhat weak and compressible.

4.6 LOWER SAND & GRAVEL

Boreholes SL12, 13, 14 and 17 contacted, at depths ranging from 6.8 m (Elevation 337.4 m) to 18.9 m (Elevation 319.6 m) below the ground surface, a lower sand & gravel deposit. Boreholes SL13 and SL17 were terminated within this deposit (Borehole SL13 was terminated due to auger refusal on a boulder) at depths of 15.7 and 12.7 m, respectively while in Boreholes SL12 and 14 the deposit extended to the surface of bedrock at depths of 21.5 and 21.4 m or Elevations 317.0

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and 322.1 m, respectively.

Grain size distribution of samples from the deposit are shown in an envelope form in Figure No. 5. The test results indicate 18-47% gravel, 48-63% sand and 4-7% soil fines (silt & clay) size particles except for one sample (i.e. Borehole SL14, Sample 20) where 23% silt size particles was measured. It should also be pointed out that cobbles and boulders were encountered in this deposit. In particular, Borehole SL13 was terminated at 15.7 m (Elevation 328.5 m) due to auger refusal, probably on a boulder. In Borehole SL14 (the deep borehole near the south abutment location) the presence of cobbles was inferred at about 12 m depth. Cobbles and boulders were encountered at 18.6 m (Elevation 324.8 m), causing refusal to augering and below this depth the borehole had to be advanced to the surface of bedrock by washboring methods. The presence of the deposit was inferred in the deep borehole near the north abutment location (i.e. Borehole SL12) below a depth of 18.9 m or Elevation 319.6 m. No soil samples could be obtained from this material by STP, as the borehole had to be advanced by washboring methods through frequent cobbles and boulders to the surface of bedrock at 21.5 m depth of Elevation 317.0 m.

'N'-values recorded in this deposit ranged from 15 to 160 blows/0.3 m, indicating a compact to very dense condition, but generally dense to very dense.

4.7 BEDROCK

Bedrock was encountered and cored in Boreholes SL12 and 14 at depths of 21.5 m (Elevation 317.0m) and 21.4 m (Elevation 322.1 m) below existing ground surface, respectively. At Borehole SL12, the bedrock consists of massive, moderately closely jointed, slightly metamorphosed, Precambrian diorite. The diorite was cored to a depth of 4.6 m and the percentage of core recovery was 100%. A rock quality designation (R.Q.D.) value of 95 to 99% was measured. Based on these values together with a visual examination of the rock cores, the rock is considered to be excellent quality.

At Borehole SL14 the rock was cored to a depth of 3.4 m. It generally consists of massive, moderately closely jointed, Precambrian grano-diorite. The percentage of core recovery within the zone cored was 75 to 100% and a rock quality designation (R.Q.D.) value of 56 to 77% was measured. Based on these and a visual examination of the rock cores, the rock is considered to be fair to good quality, but generally fair.

Based on Boreholes SL12 and 14 drilled for this bridge and Boreholes SL1, 2 and 4, drilled for its twin SBL bridge, the surface of the bedrock generally dips in the north-east direction (following the existing ground surface).

4.8 GROUNDWATER CONDITIONS

Groundwater levels in the open boreholes were observed during the drilling and at the completion of each borehole. To enable us to measure water levels at the site over a prolonged period of time without interference from surface water, a standpipe piezometer was installed in Borehole SL11.

The recorded values, shown on the individual Borehole Log Sheets, indicate that the groundwater levels at the time of the investigation generally ranged from about 17 to 19 m below the ground surface (approximately Elevation 319 to 325 m). It should, however, be pointed out that the groundwater at the site would fluctuate seasonally and can be expected to be somewhat higher during the spring months and in response to heavy rains.

5.0 DISCUSSION AND RECOMMENDATIONS

The proposed Highway 11 realignment will consist of a four lane divided highway with an approximately 30 m wide median. The proposed bridge will carry the proposed southbound lane of Highway 11 over Star Lake Road. It will be an approximately 21 m long, 2-lane (13 m wide), single span structure. The grade at the bridge site falls to the north-east, the existing ground elevation along the bridge alignment generally being 342 to 338 m. The proposed grade of Highway 11 for the bridge is Elevation $347.5 \pm$ m and therefore the existing grades at the south and north abutments will be raised by about 5.5 to 9.5 m, respectively.

In general, the boreholes have shown beneath a surficial topsoil the presence of cohesionless, granular deposits of compact to very dense sandy silt to sand & gravel to depths of $21.5 \pm$ m (approximately Elevation 322 to 317) where bedrock was encountered. In the two deep boreholes (i.e. Boreholes SL12 and 16), the sand & gravel deposit immediately overlying the bedrock contains frequent cobbles and boulders, which were cored in order to advance the borehole to the bedrock. The bedrock ranges from Precambrian diorite to grano-diorite. It was cored to a depth of 3.4 to 4.6 m and the cores generally indicate fair to excellent quality. The groundwater table at the time of our investigation was encountered at depths of 17 to 19 m below existing grade.

5.1 FOUNDATIONS

It is our understanding that the abutments of the proposed bridge will be of the "integral" type and will be supported on driven steel H-piles. In our opinion, the subsurface conditions are suitable for the use of integral abutments.

The boreholes show that for the prevailing subsurface conditions the use of a low displacement pile, such as a steel H-pile with a heavy section, such as HP310X110 with reinforced tips as per MTO Specifications, would be better suited than other pile types (i.e. steel tube piles, steel H-piles with light section).

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The piles would preferably be driven to the surface of the bedrock where uniformly high resistances can be utilized. In Boreholes SL12 and SL14, drilled near the proposed north and south abutment locations, the surface of the bedrock was contacted at Elevations 317.0 m and 322.1 m, respectively. Experience in the general area however shows that the surface of the bedrock can be uneven and unpredictable. In addition, in both of these boreholes (i.e. SL12 and SL14), frequent cobbles and boulders were encountered in the sand & gravel deposit immediately overlying the bedrock, and the boreholes had to be extended by rock coring methods to reach the bedrock. Because of this it is likely that many of the piles may not reach the surface of the bedrock and will likely terminate in the bouldery sand & gravel overburden above the bedrock surface.

The following table summarizes the approximate average pile tip elevations that may be assumed for design purposes.

TABLE 1

| SUPPORT LOCATION | REFERENCE BOREHOLE | BEDROCK SURFACE ELEVATION (m) | ESTIMATED PILE TIP ELEVATION (m) | ESTIMATED APPROXIMATE AVERAGE PILE TIP ELEVATION (m) |
|------------------|---------------------------------|-------------------------------|--|--|
| North Abutment | SL10* SL11 SL12 SL12** | 317.0 | 320 Below 318.5 319.0+ 316.5+ | 317.5+ |
| South Abutment | SL14 | 322.1 | 324.5+ | 322.5+ |

* Based on dynamic cone penetration test performed adjacent to the borehole.

** Dynamic cone penetration test performed 2 m west of Borehole SL12.

In general the pile tip elevations can be expected to be somewhat higher on the west side of the abutments and somewhat lower towards the east end, following the inferred bedrock surface.

For piles driven to practical refusal within the very dense overburden at or below elevations shown in the above table the following axial resistances may be utilized for HP310X110 steel H-piles.

Factored axial resistance at Ultimate Limit States (U.L.S.) = 1,600 kN
Geotechnical resistance at Serviceability Limit States (S.L.S.) = 1,100 kN

These values were somewhat conservatively selected in view of the fact that some premature refusals may be encountered due to the presence of cobbles and boulders. It is also possible that due to undulations in the surface of the bedrock and the overburden soils immediately overlying it, which are not uncommon in Northern Ontario, the piles may drive several meters below the tip elevations given above. For example, in Borehole SL12 refusal to further augering was encountered at Elevation 319.3 m on a boulder and the borehole had to be advanced by rock coring methods through many boulders to the surface of the bedrock at Elevation 317.0 m. This indicates that at this exact borehole location, refusal to pile driving will likely be encountered at about Elevation 319.3 m, while a dynamic cone penetration test performed 2 m west of this borehole location advanced without encountering any cobbles or boulders to Elevation 316.6 m and the pile will probably penetrate to about this elevation. It is of interest to note that this refusal elevation is below the recorded bedrock elevation in Borehole SL12. We recommend that this aspect be taken into consideration when ordering the piles. The piles should be driven with a suitably heavy hammer capable of delivering a rated capacity of at least 50 kJ/blow. The energy should however be restricted to not more than 60 kJ/blow.

The driving of the piles should be controlled by a recognized pile driving formula, such as the Hiley Formula. The estimated ultimate resistance of the piles (driven to practical refusal in the overburden) by the Hiley Formula is approximately 3200 kN. This value was arrived by dividing the factored axial resistance at U.L.S. by a resistance factor of 0.5 as per MTO current practice. Because of the presence of occasional cobbles or boulders in the overburden (e.g. refusal to augering was encountered in Borehole SL13 at Elevation 328.5; also see Borehole Log SL14, Elevation 331.5± m), the bouldery layer immediately above the surface of the bedrock, and the anticipated hard driving conditions, as mentioned before, the piles should be equipped with reinforced tips as per MTO Standards (OPSD 3301.00).

Oversize materials (e.g. greater than 75 mm nominal diameter) should not be used in the fills through which piles would be driven.

In cohesionless soils the coefficient of horizontal subgrade reaction may be estimated from;

$$k_s = n_h z/d$$

where k_s = coefficient of horizontal subgrade reaction
 z = depth
 d = pile width
 n_h = coefficient related to soil density as given in the table below

Also, presented in the same table are the estimated values for angle of internal friction and bulk unit weights.

TABLE 2

| AREA/REFERENCE BOREHOLE NO. | APPLICABLE DEPTH FROM EXISTING GROUND SURFACE | SOIL TYPE | BULK UNIT WEIGHT (kN/m ³) | ANGLE OF INTERNAL FRICTION (ϕ) DEGREES | RECOMMENDED n_h VALUE (MN/m ³) |
|--------------------------------|---|--|---|---|--|
| North Abutment | | | | | |
| SL10 | 0 - 1 m | v. loose silty sand/sandy silt | 18 | 26 | 2.0 |
| | 1 - 3 m | compact to dense silty sand/sandy silt | 19 | 29 | 9.0 |
| | 3 - 13 m | compact to dense sand | 20 | 32 | 9.0 |
| SL11 | 0 - 1 m | v. loose silty sand | 18 | 26 | 2.0 |
| | 1 - 2 m | dense to v. dense silty sand | 20 | 30 | 15.0 |
| | 2 - 5 m | compact to v. dense sand & gravel | 21 | 34 | 18.0 |
| SL12 | 5 - 13 m | compact sand | 20 | 32 | 7.0 |
| | 0 - 1 m | v. loose silty sand | 18 | 26 | 2.0 |
| | 1 - 4 m | dense silty sand | 20 | 30 | 15.0 |
| | 4 - 18 m | compact to dense sand | 20 | 32 | 9.0 |

TABLE 2 (continued)

| AREA/REFERENCE BOREHOLE NO. | APPLICABLE DEPTH FROM EXISTING GROUND SURFACE | SOIL TYPE | BULK UNIT WEIGHT (kN/m ³) | ANGLE OF INTERNAL FRICTION (ϕ) DEGREES | RECOMMENDED n_h VALUE (MN/m ³) |
|--------------------------------|---|---------------------------------|---|---|--|
| South Abutment | | | | | |
| SL13 | 0 - 1 m | loose sand | 18 | 28 | 2.5 |
| | 1 - 7 m | compact to loose sand | 19 | 30 | 6.0 |
| | 7 - 16 m | compact to dense sand & gravel | 21 | 33 | 15.0 |
| SL14 | 0 - 1.5 m | v. loose to compact sand | 18 | 28 | 2.5 |
| | 1.5 - 5 m | compact silty sand/sandy silt | 19 | 29 | 7.0 |
| | 5 - 12 m | compact to dense sand | 20 | 32 | 9.0 |
| | 12 - 19 m | dense to v. dense sand & gravel | 21 | 34 | 18.0 |
| SL17 | 0 - 1 m | loose sand & gravel | 19 | 29 | 2.5 |
| | 1 - 2 m | compact to dense sand & gravel | 20 | 32 | 9.0 |
| | 2 - 8 m | compact silty sand | 19 | 29 | 7.0 |
| | 8 - 13 m | dense to v. dense sand & gravel | 21 | 34 | 18.0 |

The recommended horizontal resistances for the HP310X110 steel H-piles are as follows:

$$\begin{aligned} \text{Factored Horizontal Resistance at U.L.S.} &= 130\text{kN} \\ \text{Horizontal Resistance at S.L.S} &= 60\text{ kN} \end{aligned}$$

In order to minimize the effect of any downdrag we recommend that the approach embankment fills be placed to their final grade elevation at least three weeks prior to driving the piles.

In accordance with MTO requirements (MTO Structural Office Standard), piles for integral abutments require a 3 m long flex zone. In essence the current MTO standard for the flex zone consists of an annular space in between two consecutive CSP's. One of the CSP's surrounds the H-pile (i.e. has a diameter of about 600 mm surrounding the pile, while the second CSP has a somewhat larger diameter; typically 800 mm for a 310 mm H-pile). The annular space in between

the CSP's is the 3 m long flex zone. After the pile is driven, the space between the H-pile and the inner CSP is filled coarse sand. An NSSP should be included in the contract documents specifying the gradation of the sands as follows.

| <u>Sieve Size</u> | <u>Percentage Passing</u> |
|-------------------|---------------------------|
| 2 mm | 100% |
| 600µm | 80 - 100% |
| 425µm | 40 - 80% |
| 250µm | 4 - 25% |
| 150µm | 0 - 6% |

Depending on the details of the proposed structure (i.e. foundation width, elevation, etc.) spread footing foundations on engineered fill may be feasible at or above Elevation 344 m. The settlements may however be somewhat in excess of the normally accepted value of 25 mm (e.g. 'N'-values of between 8 and 15 blows/0.3 m were recorded between Elevations 342 and 337 m in Borehole SL13). In view of this and the requirement of integral abutments, the use of normal spread footing foundations is not recommended. If however, it is necessary to consider normal spread footing foundations we will be pleased to further look into this aspect.

5.2 LATERAL EARTH PRESSURES

Backfill behind abutments and retaining walls should consist of non-frost susceptible, free draining granular materials in accordance with the Ontario Ministry of Transportation Standards.

Free-draining backfill materials (i.e. Granular 'A' or Granular 'B') and the provision of drain pipes and weep holes, etc., should prevent hydrostatic pressure build-up. Computation of earth pressures should be in accordance with O.H.B.D.C. For design purposes, the following parameters (unfactored) can be used.

Compacted Granular 'A'

Unit Weight = 22 kN/m³

Coefficient of Lateral Earth Pressures:

$$K_a = 0.27$$

$$K_o = 0.43$$

Compacted Granular 'B'

Unit Weight = 21 kN/m³

Coefficient of Lateral Earth Pressures:

$$K_a = 0.31$$

$$K_o = 0.47$$

Rock Fill

Unit Weight = 18 kN/m³

Coefficient of Lateral Earth Pressures:

$$K_a = 0.27$$

$$K_o = 0.43$$

These values are based on the assumption that the backfill behind the retaining structure is free-draining and adequate drainage is provided. As well, it is assumed that the ground behind the retaining structure is level.

The earth pressure coefficient adopted will depend on whether the retaining structure is restrained or movements can be allowed such that the active state of earth pressure can develop. If the abutment is restrained and does not allow lateral yielding, then at rest pressures should be used as per Clause C6-7.1 of the O.H.B.D.C., 3rd Edition. The effect of compaction should also be taken into account in the selection of the appropriate earth pressure coefficients in accordance with Clause 6-7.4.3 of the O.H.B.D.C., 3rd Edition.

Vibratory equipment for use behind abutments and retaining walls should be restricted in size as per current MTO practice.

As an alternative to conventional retaining walls, MTO's Retained Soil System may be used. The following should be included in the Contract Documents:

- identify longitudinal extent in plan of the Retained Soil System.
- identify in plan transverse space constraints (top of wall and bottom of wall)
- identify elevation of top of wall and bottom of wall
- include NSSP for Retained Soil Systems in Contract Documents

The Retained Soil System should be of high performance and moderate to high appearance.

5.3 APPROACH EMBANKMENTS

As the proposed finished bridge deck level is about Elevation 347.5 m, and the existing ground elevations at the immediate approaches are approximately 342 and 338 m, about 5.5 to 9.5 m high embankments will have to be built at the south and north abutment locations, respectively.

Based on the borehole results, no foundation failures are anticipated for the proposed 6 to 10 m high embankments, provided all organic soils, weak or otherwise unsuitable materials are removed as per MTO Standards before placing the fill.

Assuming properly compacted, acceptable inorganic earth fill material, 2 horizontal in 1 vertical side slopes can be used but in accordance with MTO Northern Region Policy, for embankment heights of greater than 6 m, a 2 m wide mid-height berm should be provided to satisfy current

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requirements by MTO. The berm gradient should be sloped (say 1V:20H) to drain away from the embankment. Proper erosion control measures should be implemented both during the construction and permanently. This can be achieved by immediate seeding or sodding (OPSS 572).

All organic and other unsuitable soils should be removed within an envelope given by an imaginary slope not steeper than 1:1 from the toe of the proposed embankment as depicted by the sketch presented in Appendix B. The average thickness of the unsuitable soils to be stripped can be assumed to be about 0.2 m. After stripping, the exposed subgrade should be inspected, approved and properly compacted from the surface under the supervision of a geotechnical engineer who is familiar with the findings of this report and appointed by the Contract Administrator, using a suitably heavy compactor.

Provided that all organic and otherwise unsuitable materials are removed and the subgrade is properly compacted from the surface as detailed above, the settlement of the foundation materials (i.e. not including the settlement of the embankment material under its own weight) should not exceed 30 mm on the south side and 80 mm on the north side and should be substantially completed during the construction and within three weeks of placing the embankment fill to its full height. Such settlements are considered acceptable and will not necessitate preloading or surcharging.

Groundwater levels were recorded at about 17 to 19 m below existing grade and, therefore, we do not anticipate major problems due to groundwater seepage during stripping of the subgrade and backfilling for the construction of the embankments.

The materials used for the construction of the embankment fills should consist of approved, acceptable earth fill (e.g. Select Subgrade Materials - OPSS 1010). The majority of the clean, inorganic in-situ materials (i.e. sands) are considered to be suitable for this purpose. The fills should be placed in lifts not exceeding 300 mm before compaction and each lift should be uniformly compacted to at least 95% of the material's Standard Proctor Maximum Dry Density. The degree of compaction within the top 0.5 m of the fill (i.e. the subgrade immediately beneath the granular sub-base) should be increased to 98%. The selection, placement and compaction of the fill should be carried out under the supervision of a geotechnical engineer who is familiar with the findings of this report and appointed by the Contract Administrator. The settlement of the embankment fills prepared as described above should not exceed 40 and 80 mm, respectively for the south and north approach embankments. The time rate of settlement will depend on the material used for construction and for granular fills it should be mostly elastic (i.e. should be substantially completed during the construction and within a few weeks thereafter) while clayey fills will consolidate over a longer period of time. These quoted settlements would be in addition to the foundation settlements quoted earlier in this section of the report.

For embankment construction rockfill can also be used, if available. Side slopes of 1 1/4H:1V can be maintained for embankments constructed from rockfill. In conformance with MTO Northern Region Practice a 2 m wide mid-height berm should be provided for fill heights greater than 6 m.

Rockfill should not be used in the area of driven piles because this will interfere with the installation of piles. This would also apply to the area of the proposed future widening.

5.4 CONSTRUCTION COMMENTS

Water level measurements in the boreholes indicate groundwater levels approximately between Elevations 325 and 319 m, or at depths of about 17 to 19 m below existing grade. No major problems due to groundwater seepage are therefore foreseen in excavations. Any surface water seepage, or seepage due to a perched water table (i.e. surface water accumulating on top of finer, silty soils) can if necessary, easily be handled by gravity drainage and pumping from open sumps.

5.5 FROST PROTECTION

Design frost penetration for the general area is 1.8 m. Therefore, a permanent soil cover of 1.8 m or its thermal equivalent is required for frost protection of foundations.

6.0 CLOSURE

We recommend that once the details of the structure are finalized, our recommendations should be reviewed for their specific applicability.

The Limitations of Report, as quoted in Appendix A, is an integral part of this report.

Sincerely,


Andrew Drevininkas, P. Eng

AD/dee





Z.S. Ozden, P. Eng.



APPENDIX A

AGRA
LIMITATIONS OF REPORT

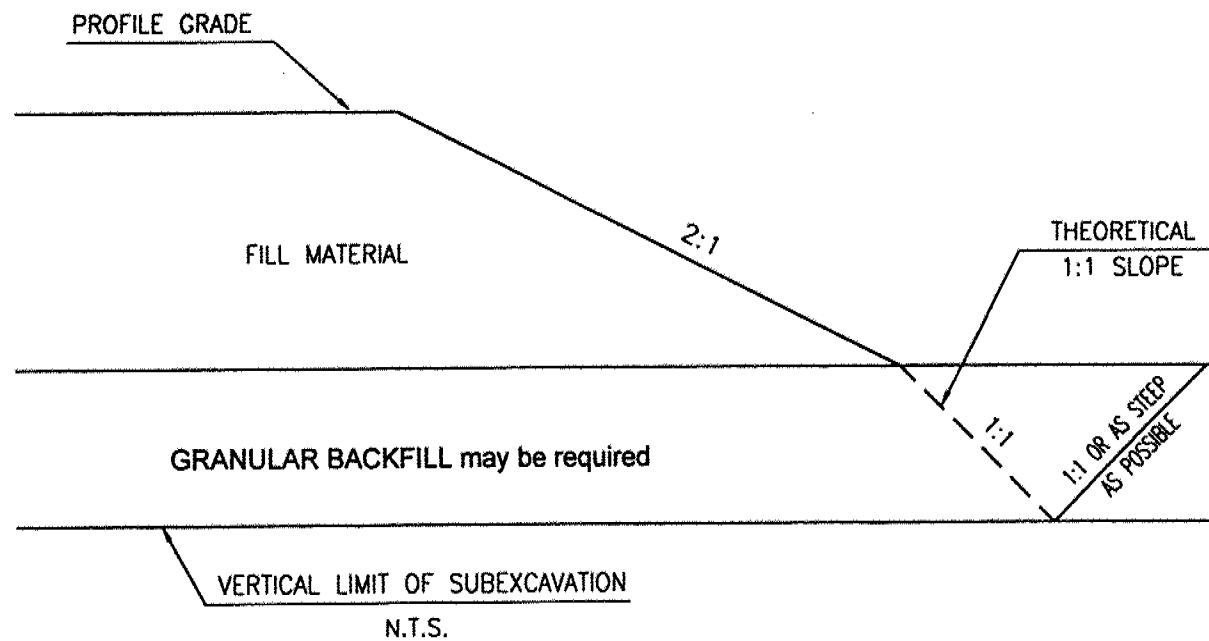
The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environmental aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Geotechnical Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in testholes. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. AGRA accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

APPENDIX B

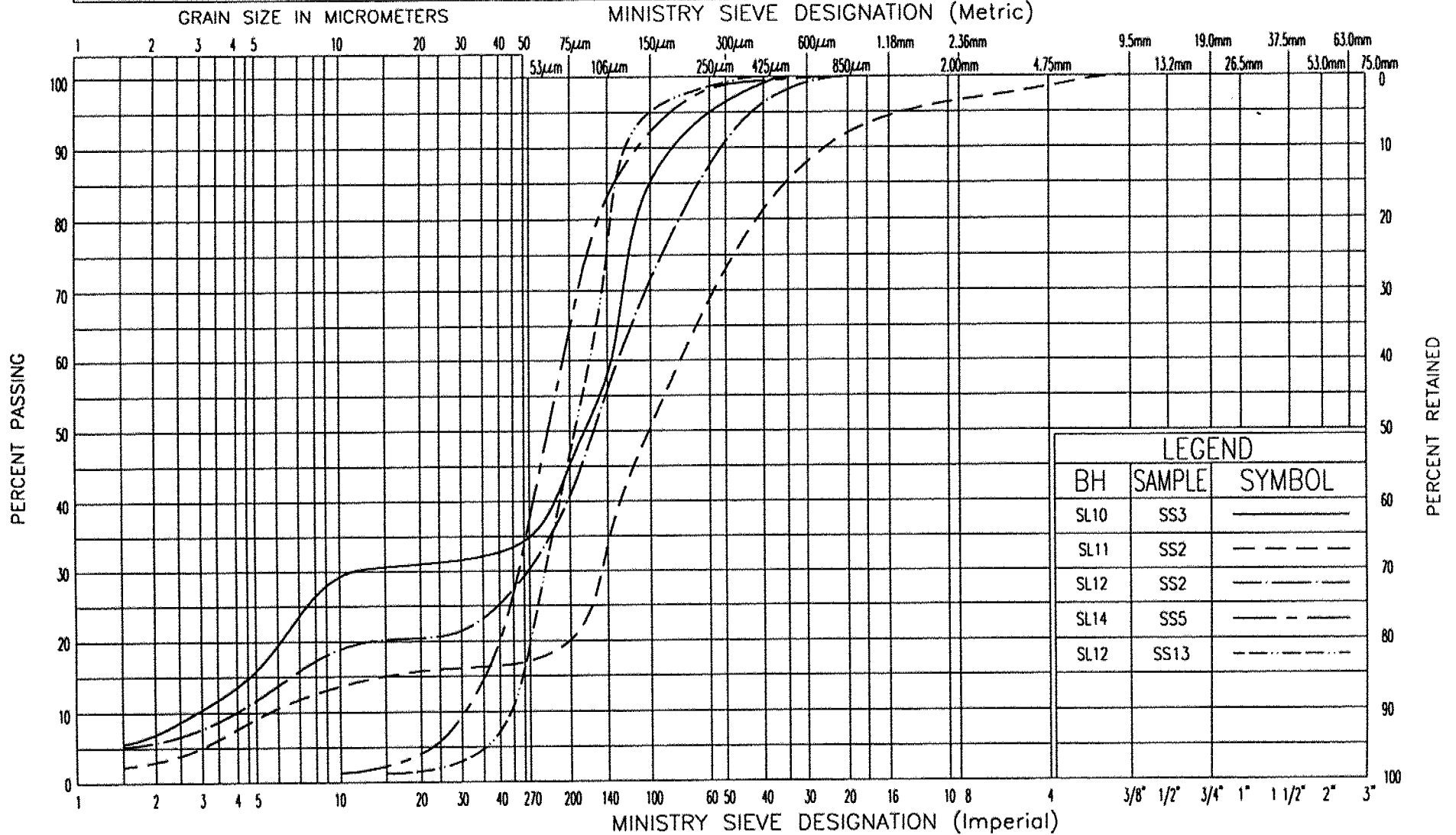


REMOVAL OF UNSUITABLE SOILS
FROM BENEATH APPROACH FILLS
N.T.S.

FIGURES

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY & SILT | SAND | | | GRAVEL | |
|-------------|------|--------|--------|--------|--------|
| | Fine | Medium | Coarse | Fine | Coarse |

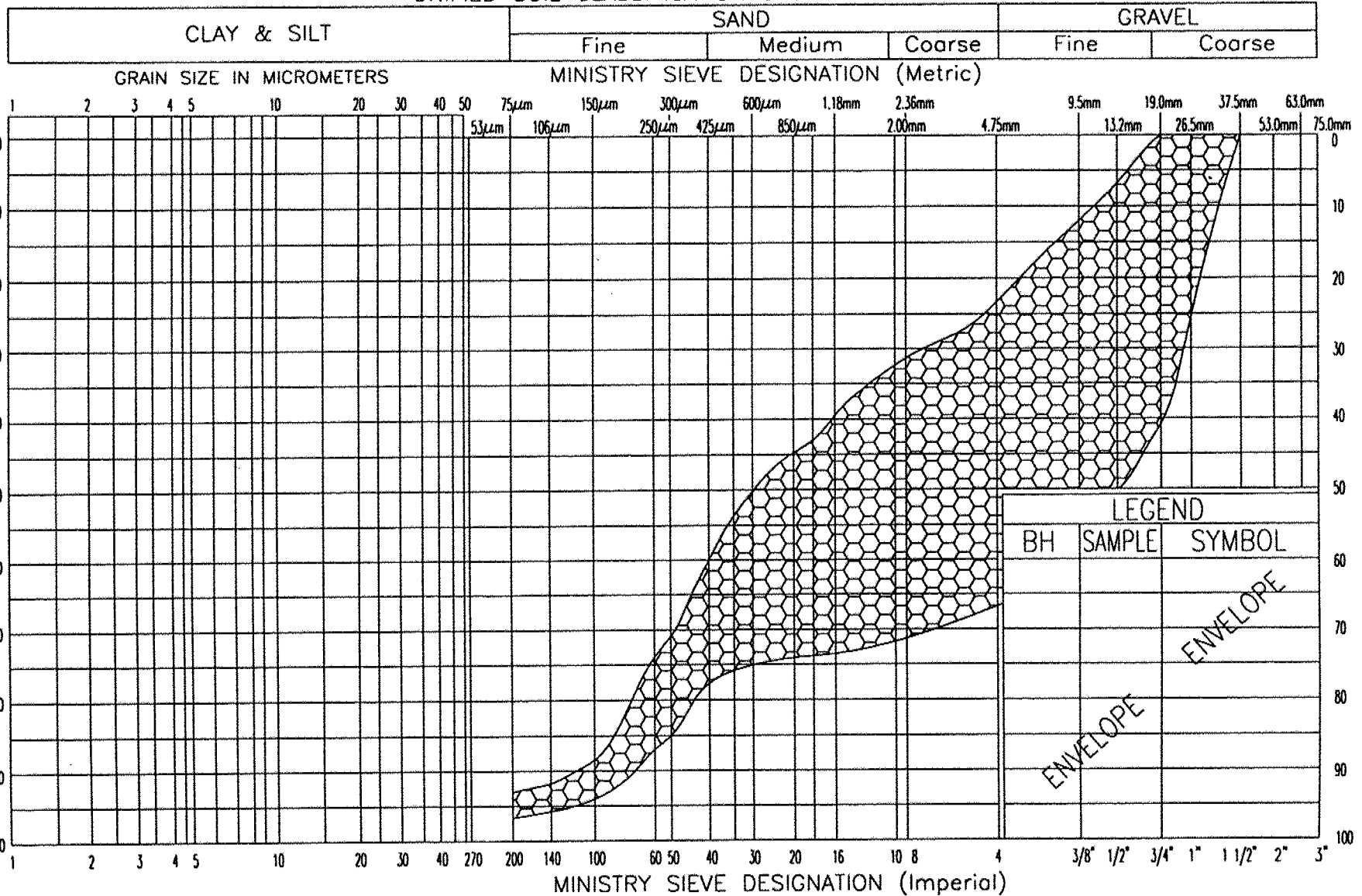


GRAIN SIZE DISTRIBUTION
SILTY SAND to SANDY SILT

FIG No 1

W P 466-93-00

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
UPPER SAND & GRAVEL

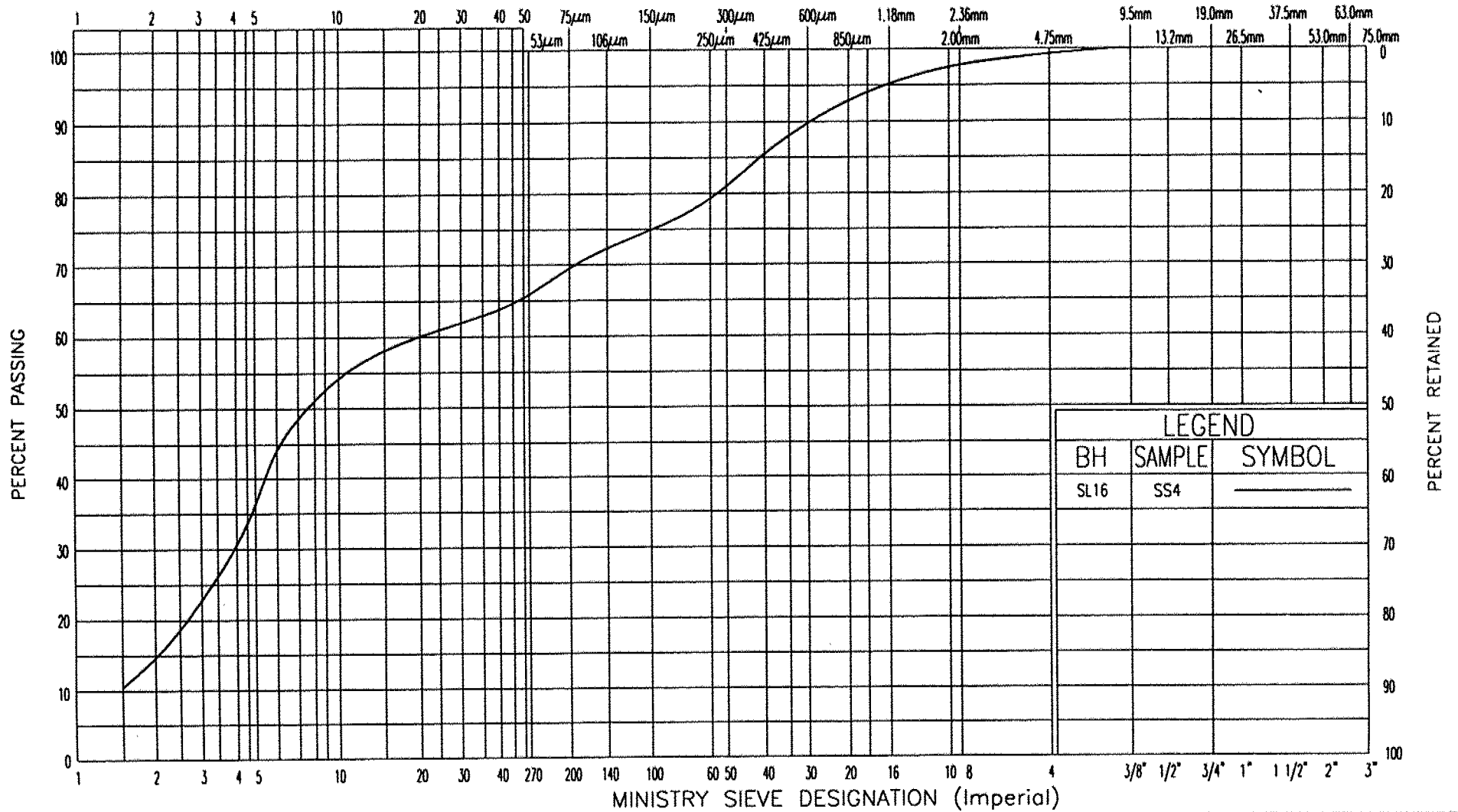
FIG No 2
W P 466-93-00

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY & SILT | SAND | | | GRAVEL | |
|-------------|------|--------|--------|--------|--------|
| | Fine | Medium | Coarse | Fine | Coarse |

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



| LEGEND | | |
|--------|--------|--------|
| BH | SAMPLE | SYMBOL |
| SL16 | SS4 | — |
| | | |
| | | |
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GRAIN SIZE DISTRIBUTION
SILTY CLAY

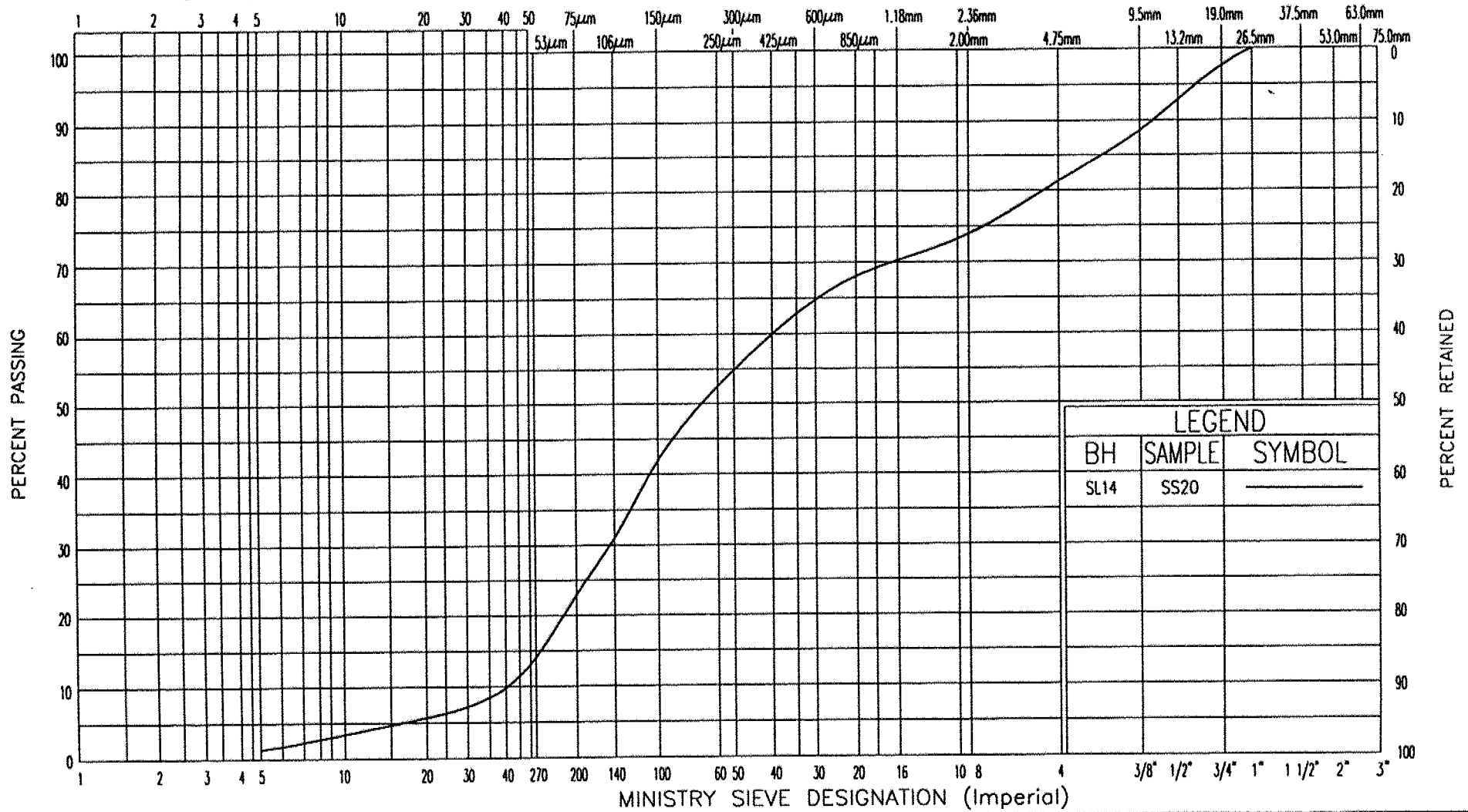
FIG No 4
W P 466-93-00

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY & SILT | SAND | | | GRAVEL | |
|-------------|------|--------|--------|--------|--------|
| | Fine | Medium | Coarse | Fine | Coarse |

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)

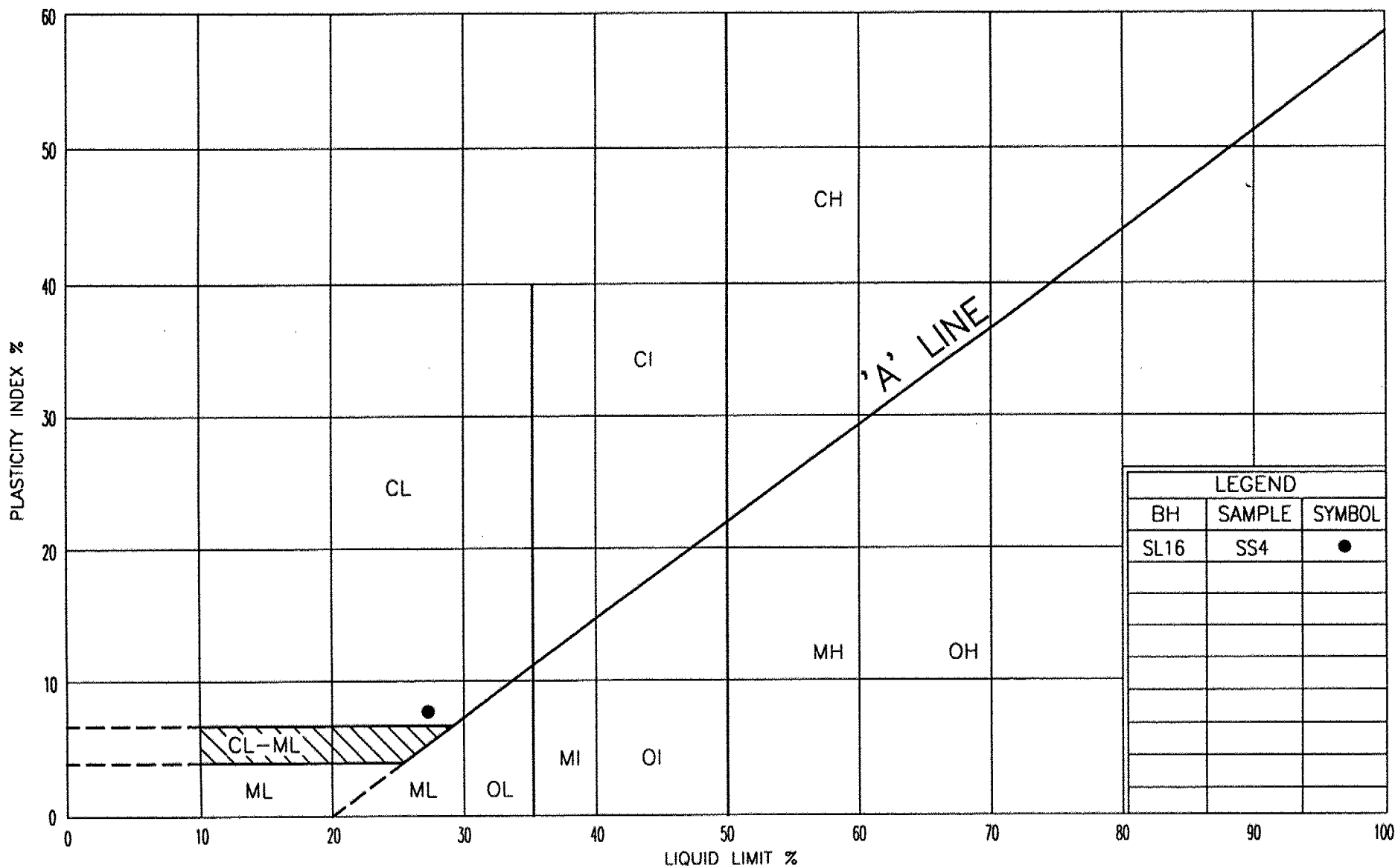


| LEGEND | | |
|--------|--------|--------|
| BH | SAMPLE | SYMBOL |
| SL14 | SS20 | — |
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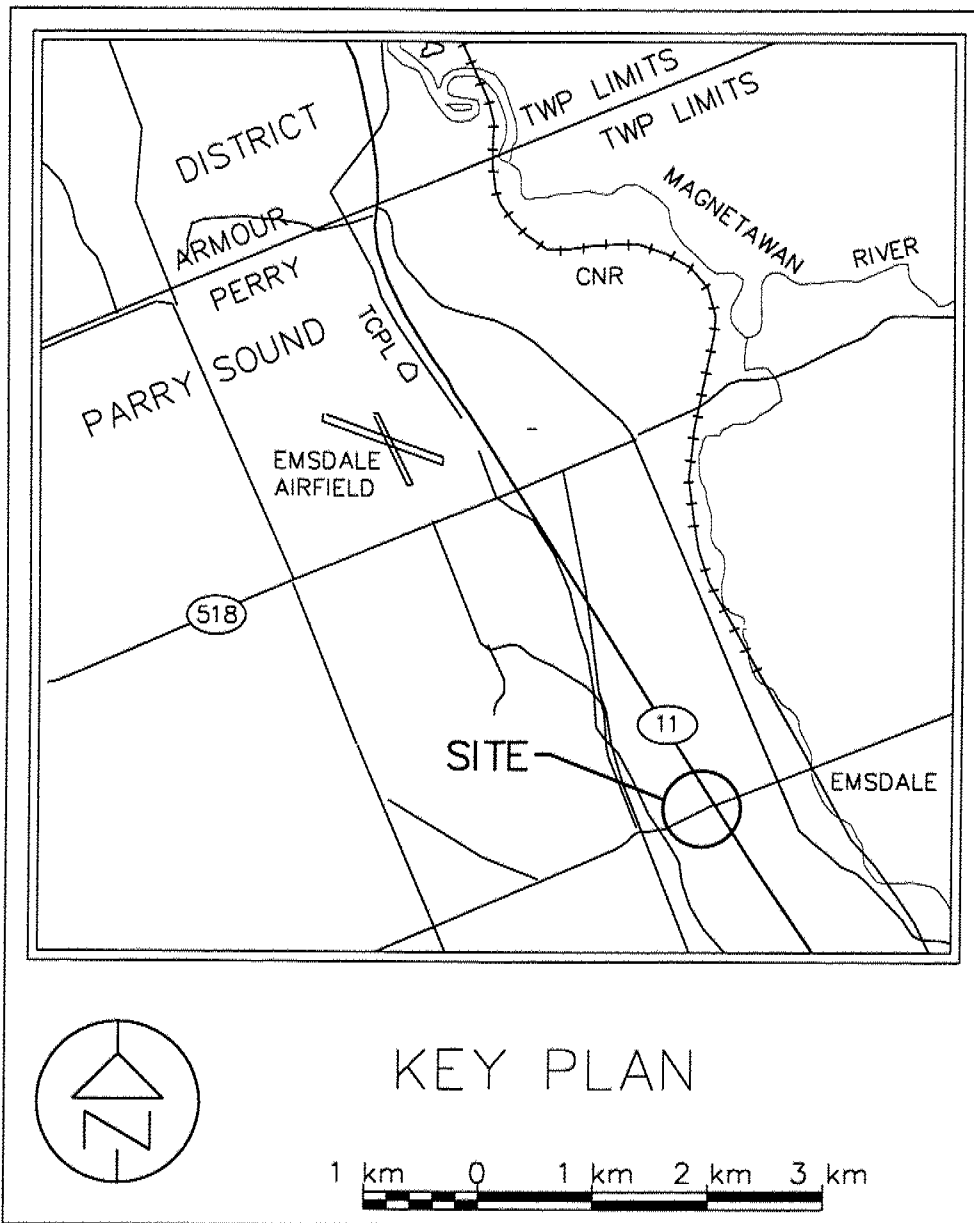


GRAIN SIZE DISTRIBUTION
LOWER SAND & GRAVEL

FIG No 5
W P 466-93-00



ENCLOSURES



STAR LAKE ROAD OVERPASS (SBL)
KEY PLAN

Dwg. No 1



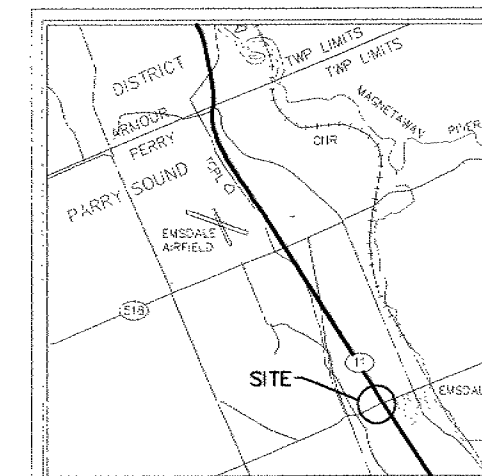


CONT. No.
W.P. No. 469-93-01

STAR LAKE ROAD OVERPASS (SBL)
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

AGRA Earth & Environmental Ltd.

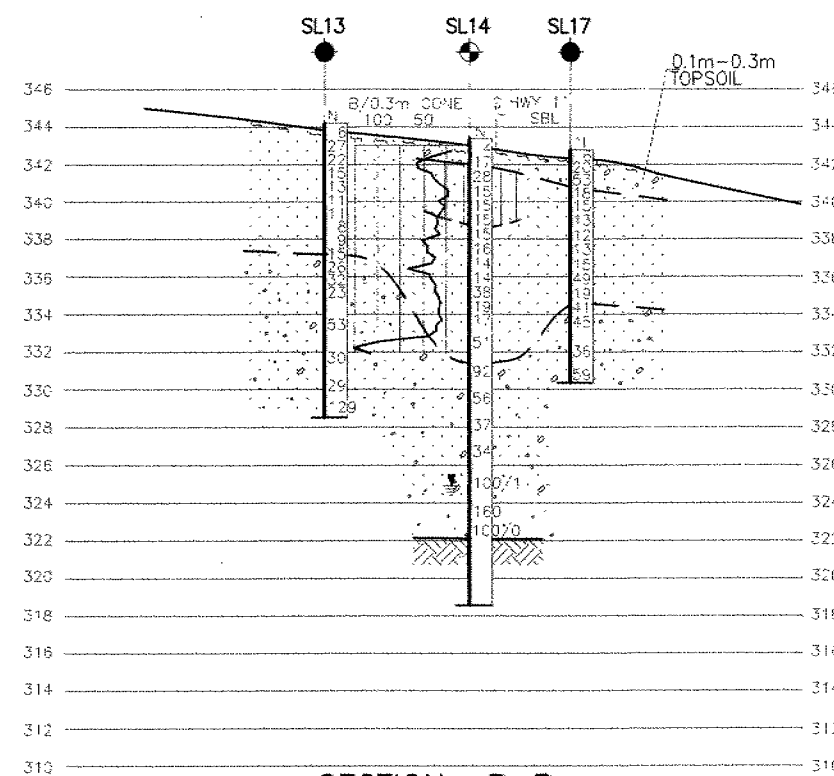


KEY PLAN

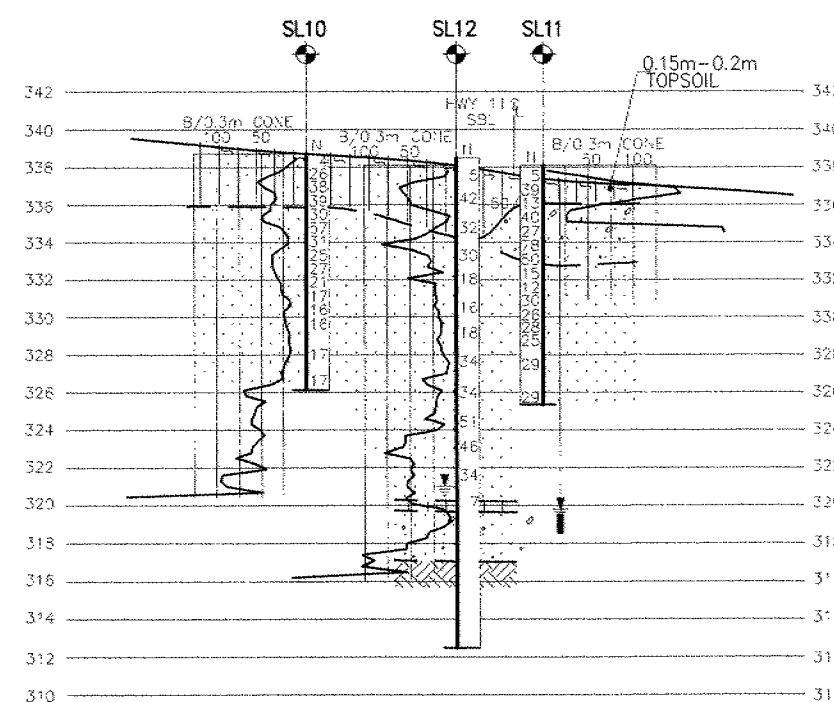
1 km 0 1 km 2 km 3 km



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES - METRES.

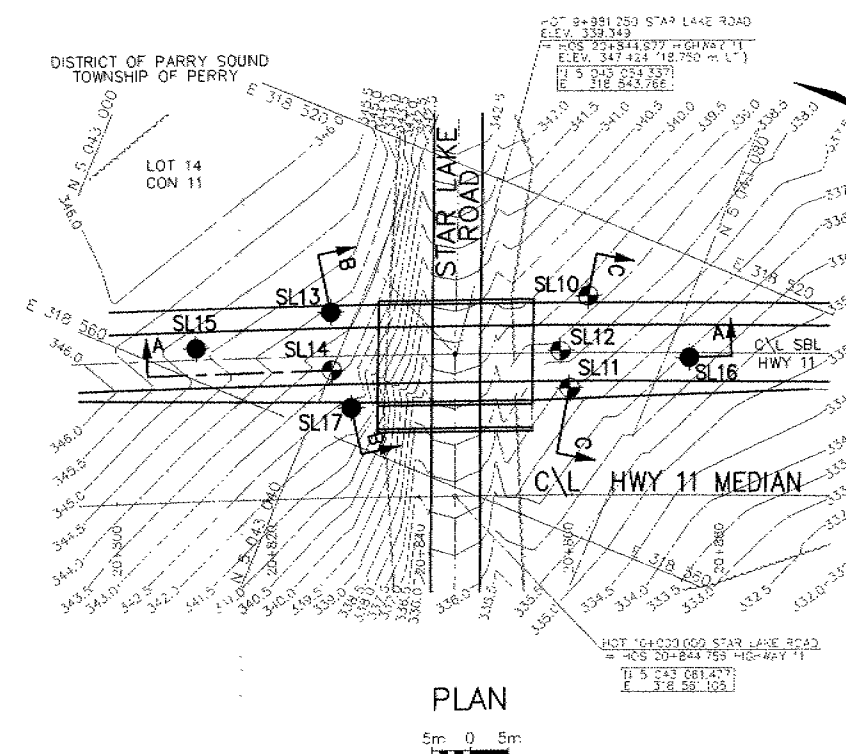
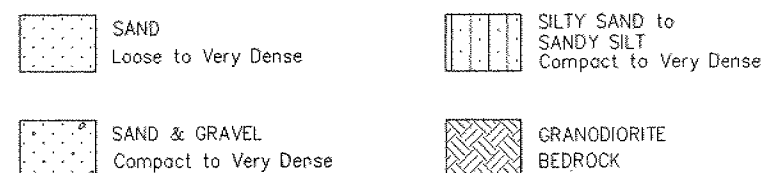


SECTION B-B



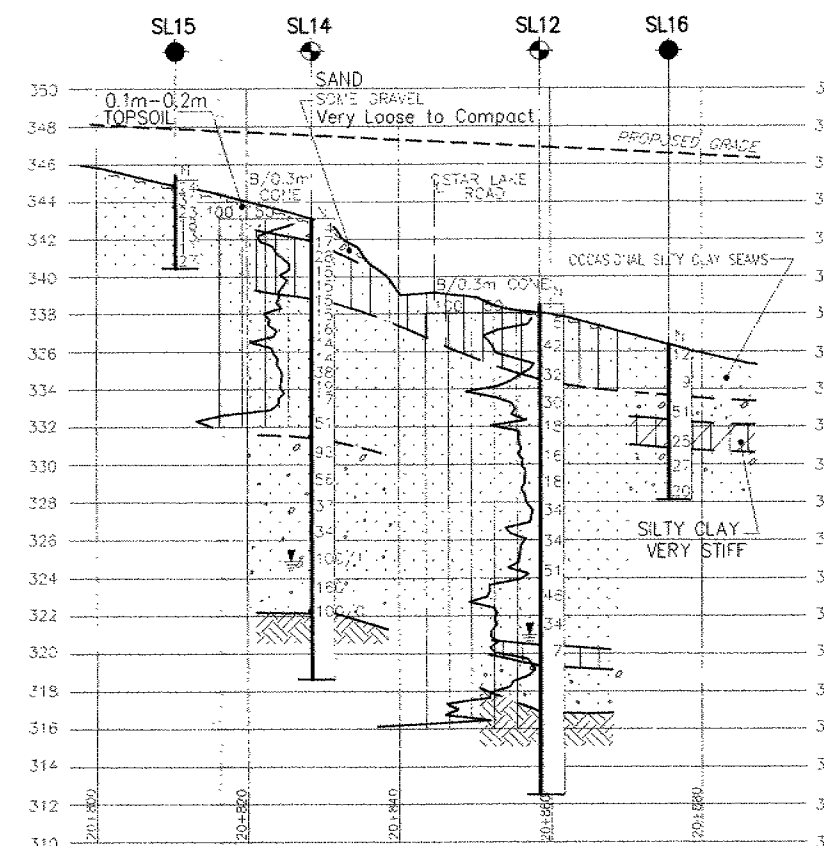
SECTION C-C

SOIL STRATIGRAPHY LEGEND



PLAN

5m 0 5m



SECTION A-A

5m 0 5m HOR
2m 0 2m VER

LEGEND

- Bore Hole
- ⊕ Dynamic Core Penetration Test (Core)
- ⊙ Bore Hole & Cone
- 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60" Cone, 475 J/blow)
- WL at time of investigation Feb. 99
- WL in Piezometer
- Piezometer

| No | ELEVATION | CO-ORDINATES | |
|------|-----------|--------------|---------|
| | | NORTH | EAST |
| SL10 | 338.9 | 5 043 087 | 318 530 |
| SL11 | 338.3 | 5 043 070 | 318 542 |
| SL12 | 338.5 | 5 043 067 | 318 538 |
| SL13 | 344.2 | 5 043 037 | 318 545 |
| SL14 | 343.4 | 5 043 040 | 318 552 |
| SL15 | 345.5 | 5 043 022 | 318 556 |
| SL16 | 336.3 | 5 043 083 | 318 532 |
| SL17 | 342.9 | 5 043 044 | 318 556 |

NOTE

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen Cond

| DATE | BY | DESCRIPTION |
|------|----|-------------|
| | | |

| | |
|--------------------------------------|--------------------|
| HWY No 11 | DIST 52-HUNTSVILLE |
| SUBMIT TO CHECKED AS DATE June, 1999 | SITE 44-3925 |
| DRAWN BY CHECKED APPROVED | DWG 2 |

REF: Hwy 11 Bridge Site Plan
Dwg. by MTO Jan. 1999

RECORD OF BOREHOLE No SL10

1 OF 2

METRIC

W.P. 469-93-01 LOCATION N 5043067.5 E 318529.9 ORIGINATED BY AD
 DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
 DATUM Geodetic DATE 24.2.99 CHECKED BY ZSO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT w_p | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL | |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|--------------|---------------------------|---------------------------------------|--------------------------|---|--|-------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | WATER CONTENT (%) |
| | | | | | | | | ○ UNCONFINED | + FIELD VANE | | | | | | |
| | | | | | | | | ● QUICK TRIAXIAL | × LAB VANE | | | | | | |
| 338.9 | 0.2m TOPSOIL | | | | | | 20 40 60 80 100 | | 10 20 30 | | | | | Station 20 + 862 | |
| 0.0 | very loose | | 1 | SS | 4 | | | | | | | | | 7.7 Lt SBL C/L | |
| | | | 2 | SS | 26 | | | | | | | | | | |
| | brown SILTY SAND to SANDY SILT trace clay compact to dense damp | | 3 | SS | 38 | | | | | | | | | 0 53 40 7 | |
| | | | 4 | SS | 39 | | | | | | | | | | |
| 335.9 | | | 5 | SS | 30 | | | | | | | | | | |
| 3.0 | occasional Silt and Clay seams | | 6 | SS | 57 | | | | | | | | | | |
| | | | 7 | SS | 31 | | | | | | | | | | |
| | trace Gravel | | 8 | SS | 25 | | | | | | | | | | |
| | | | 9 | SS | 27 | | | | | | | | | | |
| | | | 10 | SS | 21 | | | | | | | | | 0 96 (4) | |
| | brown SAND fine to medium, compact to very dense damp | | 11 | SS | 17 | | | | | | | | | | |
| | | | 12 | SS | 16 | | | | | | | | | | |
| | | | 13 | SS | 16 | | | | | | | | | | |
| | | | 14 | SS | 17 | | | | | | | | | | |
| | | | 15 | SS | 17 | | | | | | | | | | |
| 326.1 | | | | | | | | | | | | | | | |
| 12.8 | END OF BOREHOLE | | | | | | | | | | | | | | |
| | WL on completion: none | | | | | | | | | | | | | | |

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

+³, X³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

RECORD OF BOREHOLE No SL11

1 OF 2

METRIC

W.P. 469-93-01 LOCATION N 5043070.4 E 318542.2 ORIGINATED BY AD
DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
DATUM Geodetic DATE 24.2.99 CHECKED BY ZSO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|-----------------|------------------------------------|-------------------------------------|-----------------------------------|--|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | |
| | | | | | | | | ○ UNCONFINED + FIELD VANE | | | | | | |
| | | | | | | | | ● QUICK TRIAXIAL × LAB VANE | | | | | | |
| | | | | | | | | | 20 40 60 80 100 | | | | | |
| | | | | | | | | | 20 40 60 80 100 | | | | | |
| 338.3 | 0.15m TOPSOIL | | | | | | | | | | | | | GR SA SI CL |
| 0.0 | very loose | | 1 | SS | 5 | | 338 | | | | | | | Station 20 + 860 |
| | | | 2 | SS | 39 | | 337 | | | | | | | 4.8 Rl SBL C/L |
| | brown SILTY SAND trace Clay dense damp | | 3 | SS | 50/13 | | 336 | | | | | | | 1 79 17 3 |
| 336.1 | | | 4 | SS | 40 | | 335 | | | | | | | 25 71 (4) |
| 2.2 | brown SAND & GRAVEL compact to very dense dry | | 5 | SS | 27 | | 334 | | | | | | | 66 30 (4) |
| | | | 6 | SS | 78 | | 333 | | | | | | | SS7: No recovery |
| | | | 7 | SS | 50* | | 332 | | | | | | | |
| 333.0 | | | 8 | SS | 15 | | 331 | | | | | | | |
| 5.3 | brown SAND fine to medium, trace Silt compact dry | | 9 | SS | 12 | | 330 | | | | | | | 1 89 10 0 |
| | | | 10 | SS | 30 | | 329 | | | | | | | |
| | | | 11 | SS | 26 | | 328 | | | | | | | |
| | | | 12 | SS | 28 | | 327 | | | | | | | |
| | | | 13 | SS | 25 | | 326 | | | | | | | 0 95 (5) |
| | | | 14 | SS | 29 | | 325 | | | | | | | |
| | | | 15 | SS | 29 | | 324 | | | | | | | |
| 325.5 | | | | | | | | | | | | | | |
| 12.8 | END OF BOREHOLE | | | | | | | | | | | | | |

Continued Next Page

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

RECORD OF BOREHOLE No SL11

2 OF 2

METRIC

W.P. 469-93-01 LOCATION N 5043070.4 E 318542.2 ORIGINATED BY AD
 DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
 DATUM Geodetic DATE 24.2.99 CHECKED BY ZSO

| SOIL PROFILE | | SAMPLES | | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|--|------------|--------|------|------------|----------------------------|-----------------|---|----|----|----|-----|---|---|----------------|---|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 | 40 | 60 | 80 | 100 | W _p | W | W _L | | |
| 318.5 | Borehole Extended to 19.8m by straight augering to install standpipe piezometer ----- wet | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | |
| 19.8 | END OF AUGER PROBE WL IN PIEZOMETER Feb 25/99: 18.7m Dynamic Cone Penetration Test conducted 2m West of Borehole | | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No SL12

1 OF 2

METRIC

W.P. 469-93-01 LOCATION N5043067.0 E 318538.1 ORIGINATED BY AD
 DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
 DATUM Geodetic DATE 24.3.99 CHECKED BY ZSO

| SOIL PROFILE | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | PLASTIC LIMIT w _p | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w _L | UNIT WEIGHT γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|--|------------|--------|------|-------------------------|-----------------|--|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | | | | | | | | |
| 338.5 | 0.2m TOPSOIL | | 1 | SS | 5 | | | | | | | Station 20 + 859 0.3 Lt SBL C/L |
| 0.0 | very loose | | | | | | | | | | | |
| | brown SILTY SAND trace clay dense damp | | 2 | SS | 42 | | | | | | | 0 59 35 6 |
| | | | 3 | SS | 32 | | | | | | | |
| 334.3 | | | 4 | SS | 30 | | | | | | | 0 97 (3) |
| 4.2 | | | 5 | SS | 18 | | | | | | | |
| | brown SAND fine to medium, trace silt compact to dense dry to damp | | 6 | SS | 16 | | | | | | | 0 93 7 0 |
| | | | 7 | SS | 18 | | | | | | | |
| | | | 8 | SS | 34 | | | | | | | |
| | | | 9 | SS | 34 | | | | | | | |
| | | | 10 | SS | 51 | | | | | | | 0 87 (13) |
| | | | | | | | | | | | | |

Continued Next Page

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

2 OF 2

METRIC

ORIGINATED BY AD

COMPILED BY CK

CHECKED BY ZSO

+³, X³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

RECORD OF BOREHOLE No SL13

1 OF 2

METRIC

W.P. 469-93-01 LOCATION N 5043036.9 E 318544.9 ORIGINATED BY AD
DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
DATUM Geodetic DATE 25.2.99 CHECKED BY ZSO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | | | |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|----|----|------------------------------------|-------------------------------------|-----------------------------------|--|---|------------------------------------|--|--|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | WATER CONTENT (%) | | | | |
| | | | | | | | | ○ UNCONFINED + FIELD VANE | | | | | | | | ○ | | | | |
| | | | | | | | | ● QUICK TRIAXIAL × LAB VANE | | | | | | | | | | | | |
| 344.2 | | | | | | | 20 | 40 | 60 | 80 | 100 | 10 | 20 | 30 | GR SA SI CL | | | | | |
| 0.0 | 0.2m TOPSOIL | | 1 | SS | 6 | | | | | | | | | | | Station 20 + 829 5.9 Lt SBL C/L | | | | |
| | loose | | | | | | | | | | | | | | | 0 85 15 0 | | | | |
| | | | 2 | SS | 27 | | | | | | | | | | | | | | | |
| | brown SAND fine to medium, some Silt damp | | | | | | | | | | | | | | | | | | | |
| | | | 3 | SS | 22 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | 4 | SS | 15 | | | | | | | | | | | | | | | |
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| | | | 5 | SS | 13 | | | | | | | | | | | | | | | |
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| | | 6 | SS | 11 | | | | | | | | | | | | | | | | |
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| | | 7 | SS | 11 | | | | | | | | | | | | | | | | |
| | compact | | | | | | | | | | | | | | 0 80 20 0 | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | loose | | 8 | SS | 8 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | 9 | SS | 9 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| 337.4 | | | 10 | SS | 15 | | | | | | | | | | 40 56 (4) | | | | | |
| 6.8 | | | | | | | | | | | | | | | | | | | | |
| | brown SAND & GRAVEL compact to very dense damp | | | | | | | | | | | | | | | | | | | |
| | | | 11 | SS | 26 | | | | | | | | | | | | | | | |
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| | | | 12 | SS | 32 | | | | | | | | | | | | | | | |
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| | | | 13 | SS | 23 | | | | | | | | | | | | | | | |
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Continued Next Page

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

RECORD OF BOREHOLE No SL13

2 OF 2

METRIC

W.P. 469-93-01 LOCATION N 5043036.9 E 318544.9 ORIGINATED BY AD
 DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
 DATUM Geodetic DATE 25.2.99 CHECKED BY ZSO

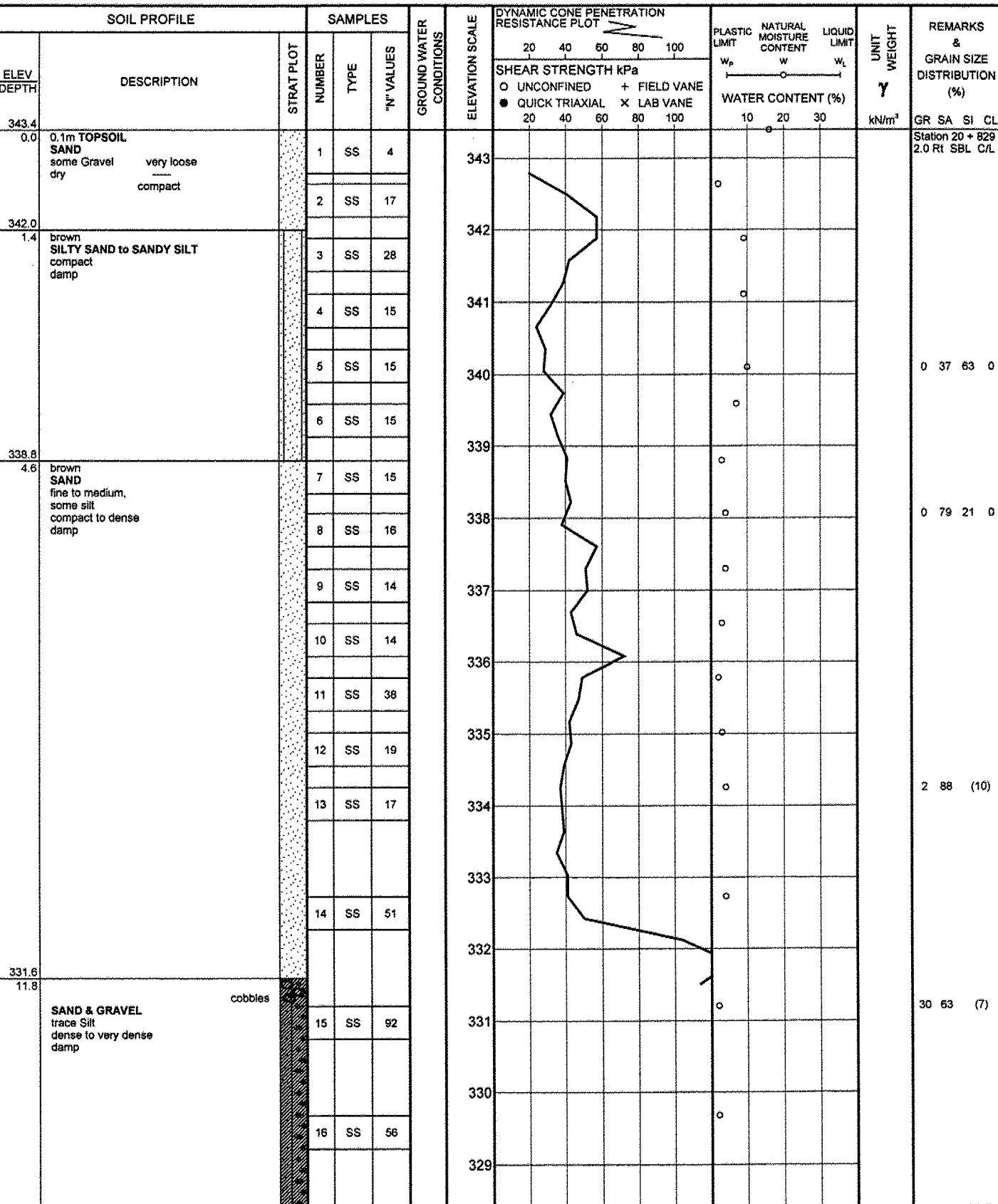
| SOIL PROFILE | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|---|------------|--------|------|----------------------------|-----------------|---|----|----|----|----|---|----------------|---|---|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | | | "N" VALUES | 20 | 40 | 60 | 80 | 100 | W _p | W | | |
| 328.5 | | | 17 | SS | 129 | 329 | | | | | | | | | | |
| 15.7 | Auger Refusal Probably on Boulder DCPT Refusal WL on completion: none | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No SL14

1 OF 2

METRIC

| | | | | | |
|-------|-----------|----------|------------------------|---------------|-------------|
| W.P. | 489-93-01 | LOCATION | N 5043040.4 E 318552.0 | ORIGINATED BY | AD |
| DIST | 52 | HWY | 11 | BOREHOLE TYPE | Hollow Stem |
| DATUM | Geodetic | DATE | 9.2.99 | COMPILED BY | CK |
| | | | | CHECKED BY | ZSO |



Continued Next Page

+3, ×3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SL15

1 OF 1

METRIC

W.P. 489-03-01 LOCATION N 5043022.4 E 318556.1 ORIGINATED BY AD
DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
DATUM Geodetic DATE 25.2.99 CHECKED BY ZSO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL | | | |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|----|--------------|-----|------------------|------------------------------------|-------------------------------------|-----------------------------------|--|--|-------------------|--|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | | | WATER CONTENT (%) | | |
| | | | | | | | | ○ UNCONFINED | | + FIELD VANE | | ● QUICK TRIAXIAL | | | | | | × LAB VANE | | W |
| 345.5 | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | | | | |
| 0.0 | 0.2m TOPSOIL | | 1 | SS | 24 | | | | | | | | | | | | Station 20 + 811 1.5 Lt SBL C/L | | | |
| | brown SAND fine to medium, trace Silt compact to dense damp to dry | | 2 | SS | 31 | | | | | | | | | | | | | | | |
| | | | 3 | SS | 23 | | | | | | | | | | | | | | | |
| | | | 4 | SS | 18 | | | | | | | | | | | | 0 90 (10) | | | |
| | | | 5 | SS | 13 | | | | | | | | | | | | | | | |
| | | | 6 | SS | 11 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | trace Gravel | | 7 | SS | 27 | | | | | | | | | | | | 11 84 (5) | | | |
| 340.5 | END OF BOREHOLE | | | | | | | | | | | | | | | | | | | |
| 5.0 | WL on completion: none | | | | | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No SL16

1 OF 1

METRIC

W.P. 469-93-01 LOCATION N 5043083.0 E 318532.5 ORIGINATED BY AD
DIST 52 HWY 11 BOREHOLE TYPE Solid Stem/Hollow Stem COMPILED BY CK
DATUM Geodetic DATE 20.4.99 CHECKED BY ZSO




| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|--|----------|------------------------------------|-------------------------------------|-----------------------------------|--|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | |
| | | | | | | | | 20 40 60 80 100 | | | | | | | |
| | | | | | | | | ○ UNCONFINED + FIELD VANE | | | | | | | |
| | | | | | | | | ● QUICK TRIAXIAL X LAB VANE | | | | | | | |
| 336.3 | | | | | | | | 20 40 60 80 100 | | 10 20 30 | | | | | GR SA SI CL |
| 0.0 | brown SAND trace Gravel with occasional Silty Clay seams loose to compact damp | | 1 | SS | 12 | | 336 | | | | | | | | Station 20 + 875 0.6 Rt SBL C/L |
| | | | | | | | 335 | | | | | | | | |
| | | | 2 | SS | 9 | | 334 | | | | | | | | |
| 333.7 | | | | | | | | | | | | | | | |
| 2.6 | brown SAND & GRAVEL very dense dry | | 3 | SS | 51 | | 333 | | | | | | | | 36 59 (5) |
| 332.5 | | | | | | | 332 | | | | | | | | |
| 3.8 | brown SILTY CLAY occasional Sand seams very stiff | | 4 | SS | 25 | | | | | | | | | | 1 29 55 15 |
| 331.1 | | | | | | | 331 | | | | | | | | |
| 5.2 | brown SAND & GRAVEL compact dry | | 5 | SS | 27 | | 330 | | | | | | | | |
| | | | | | | | 329 | | | | | | | | 34 62 (4) |
| 328.1 | | | 6 | SS | 20 | | 328 | | | | | | | | |
| 8.2 | END OF BOREHOLE WL on completion: none Borehole drilled by straight augering 2m Rt of SL16 to 12.8m | | | | | | 327 | | | | | | | | |
| | | | | | | | 326 | | | | | | | | |
| | | | | | | | 325 | | | | | | | | |
| | | | | | | | 324 | | | | | | | | |
| 323.6 | | | | | | | | | | | | | | | |
| 12.8 | END OF AUGER PROBE WL on completion: none | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No SL17

1 OF 1

METRIC

W.P. 489-93-01 LOCATION N 5043044.3 E 318555.6 ORIGINATED BY AD
DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem COMPILED BY CK
DATUM Geodetic DATE 24.2.99 CHECKED BY ZSO

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | | | |
|---------------|--|---|---------|------|------------|----------------------------|-----------------|---|----|--------------|-----|------------------|------------------------------------|-------------------------------------|-----------------------------------|---|---|-------------------|------------|--|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | | | WATER CONTENT (%) | | | | |
| | | | | | | | | ○ UNCONFINED | | + FIELD VANE | | ● QUICK TRIAXIAL | | | | | | | × LAB VANE | | | |
| 342.9 | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | | | | | | |
| 0.0 | 0.3m TOPSOIL |  | 1 | SS | 6 | | | | | | | | | | | GR SA SI CL Station 20 + 831 6.6 Rt SBL C/L | | | | | | |
| | loose | | | | | | | | | | | | | | | | | | | | | |
| | brown SAND & GRAVEL compact to dense damp | | 2 | SS | 20 | | | | | | | | | | | | 24 72 (4) | | | | | |
| | | | 3 | SS | 53 | | | | | | | | | | | | | | | | | |
| 340.7 | | | | | | | | | | | | | | | | | | | | | | |
| 2.2 | brown SAND fine, Silty compact to dense dry |  | 4 | SS | 18 | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | 5 | SS | 15 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | 6 | SS | 13 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | 7 | SS | 12 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | 8 | SS | 13 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | 9 | SS | 15 | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | Gravelly Layer | 10 | SS | 49 | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | 11 | SS | 19 | | | | | | | | | | | | | | | | | |
| 334.5 | | | | | | | | | | | | | | | | | | | | | | |
| 8.4 | brown SAND & GRAVEL dense to very dense damp |  | 12 | SS | 41 | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | 13 | SS | 45 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | 14 | SS | 36 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | 15 | SS | 59 | | | | | | | | | | | | | | | | | |
| 330.3 | | | | | | | | | | | | | | | | | | | | | | |
| 12.7 | END OF BOREHOLE | | | | | | | | | | | | | | | | | | | | | |
| | WL on completion: none | | | | | | | | | | | | | | | | | | | | | |