

**FOUNDATION INVESTIGATION AND DESIGN REPORTS  
PROPOSED KEMP CREEK CULVERT (C11)  
REPLACEMENT AT STATION 11+737 ON  
HIGHWAY 6 SOUTH OF DURHAM  
SOUTH OF TOWN LIMITS AND  
NORTH OF GREY COUNTY ROAD 9, ONTARIO  
G.W.P. 338-97-00  
SITE NO. 8-450/C**

**GEOCRES NO. 41A-196**

**Prepared For:**

**UMA/AECOM ENGINEERING LIMITED**

**Prepared by:**

**SHAHEEN & PEAKER LIMITED**

**Project: SPT1174E  
January 15, 2008**



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PROPOSED KEMP CREEK CULVERT (C11) REPLACEMENT  
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## **1. INTRODUCTION**

Shaheen & Peaker Limited (S&P) was retained by UMA/AECOM Engineering Limited (UMA) to conduct a foundation investigation for detail design of the proposed culvert replacements on Highway 6 from 1.1 km south of Grey County Road 9 (North Junction) at Station 21+100 northerly through the Village of Varney to Township of Durham South Limits at Station 11+887 in Grey County, Ontario.

As part of the detail design for the proposed improvements on Highway 6, a foundation investigation was required for the detail design of Kemp Creek concrete culvert structure and the associated retaining/wing walls and possible construction of a detour lane during construction.

The Terms of Reference (TOR) for this investigation was outlined in the Request for Proposals (RFP) by the Ministry of Transportation (MTO) under Purchase Order Number 3004-E-0042 dated January 2005 and subsequent S&P proposal P07413. The work was performed in accordance with Consultant Agreement No. 3004-E-0042.

The purpose of this investigation was to obtain subsurface information at the site by means of exploratory boreholes. This report presents the findings of the geotechnical investigation at this site, as well as general comments and recommendations for design and construction of the proposed replacement of Kemp Creek culvert with a larger open bottom concrete culvert and construction of new retaining/wing walls and possible construction of a detour embankment.

## **2. PHYSIOGRAPHY**

According to the Physiography of Southern Ontario (by Putnam & Chapman) and the Ontario Geological Survey Map P.2715, the study area lies in the area known as the Horseshoe Moraines. The Horseshoe Moraines has two main distinguishing features; i.e., irregular sand and gravel knobs and ridges (sand plain and kame moraine), and gravel or swamp-covered valleys. These granular deposits constitute aquifers associated primarily with kame deposits at or near the ground surface within a larger more extensive regional till plain. The existing gravel pit in Durham is part of the moraine spillway.

Existing subsurface information from Geocres database indicates that the overburden in this area primarily consisted of sand and gravel. However, south of the CPR Railway (which runs east-west) and east of CNR Railway limestone bedrock was encountered at about El. 1127 ft (343.7 m) during earlier geotechnical investigations.

According to Ontario Department of Mines Map 2039, entitled distribution of Limestone, Dolomite and Precambrian Pebbles in Gravels of Southern Ontario, the overburden (glacial drift), in this general area, is underlain by bedrock of predominately Guelph-Lockport-Amabel Formations with occasional Ancaster Chert beds. The bedrock composition generally consists of 90% dolomite, 3% limestone and 6% Pre-Cambrian rock. However, some shale and occasional gypsum and salt inclusions may also be found in the surrounding area.

Within the project limits, the grade of Highway 6 generally rises from about El. 377.4 m at Station 21+100 to about El. 386.2 m at Station 24+175, then it drops down to El. 383.7 m at Station 24+440 and generally rolls up to about El. 390.2 m at Station 24+700 and down to about El. 348.6 m at Station 10+700, and up to about El. 353.0 m at Station 10+870 (northern limit of contract), and up to El. 356.2 m at Station 11+175.

### **3. INVESTIGATION PROCEDURES**

Based on the scope of work outlined in RFP document and our proposal, the foundation field investigation for Kemp Creek culvert (C11) consisted of a total of 11 boreholes to evaluate the subsurface conditions in the areas of the proposed culvert replacement, retaining/wing walls and a detour construction.

The field investigation at this site was carried out during several periods from August 21 to December 6, 2006. The field investigation consisted of drilling and sampling of 3 boreholes (Boreholes C11-1, C11-2 and C11-3) for the culvert replacement, 4 boreholes (Boreholes C11-RW1, C11-RW2, C11-RW3 and C11-RW4) for the associated retaining/wing walls, and 4 boreholes (Boreholes C11-D1, C11-D2, C11-D3 and C11-D4) for possible highway detour (around the culvert as discussed in the following sections of this report). As mentioned before, for the proposed culvert replacement, 3 boreholes (Boreholes C11-1, C11-2 and C11-3) were drilled, one at each end of the culvert and one at the crest of the embankment for culvert replacement to a maximum of 10.2 m below the ground surface.

Based on the information provided to us by UMA, four new wing walls are proposed, at the location of culvert C11, on both sides and both ends of the new culvert. The proposed retaining/wing walls will have individual lengths much less than 50 m. Therefore, four boreholes (C11-RW1 through C11-RW4) were put down. Boreholes were generally drilled on the flatter part of the slope or toe of the embankment near the ends of the retaining/wing walls to different depths ranging from 4.7 m to a maximum of 6.6 m, or refusal.

In addition, four boreholes were put down along the proposed detour near Kemp Creek culvert (C11-D1 through C11-D4) to a maximum of 5.5 m depth below the ground surface.

The majority of the boreholes were advanced using solid stem, or hollow stem augers run by truck and track mounted drill rigs owned and operated by Walker Drilling Limited. However, at some borehole locations (e.g., C11-D1 and C11-D2), where steep slopes and difficult access did not allow utilization of a track mounted drilling rig, the boreholes were advanced by manual soil sampling methods using a standard split spoon and a tripod operated by K. J. Beamish Construction Co. Limited. All the boreholes were drilled under the full time supervision of geotechnical engineers from S&P.

Sampling in the boreholes was conducted at frequent intervals of depth by the Standard Penetration Test (SPT) method, as specified in ASTM D1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm O.D. split-barrel (split-spoon) sampler into the ground. The number of blows of the hammer required 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. Refusal was generally defined by reaching competent material for which the resistance measured by the Standard Penetration Test exceeds 100 blows per 0.3 m of penetration.

At Boreholes C11-D1, C11-D2 locations, the boreholes were advanced by manual methods, using light portable equipment. Sampling was effected using a standard split-spoon sampler driven by 31.8 kg hammer (rather than a 63.5 kg hammer, as required by the SPT method). The number of blows of the hammer to drive the sampler was divided by two to obtain equivalent N-values.

At the completion of drilling, all boreholes drilled were grouted and sealed using a cement/bentonite mixture. The boreholes installed with piezometer were sealed with bentonite seal and grout above the slotted portion of the pipes and at ground surface.

Water level observations in the open boreholes were made during drilling and at the completion of each borehole. In addition, piezometers were installed in selected boreholes. These piezometers allow monitoring of groundwater levels over time without undue interference/impact from surface water.

The borehole locations were measured approximately by S&P field staff with reference to the local features, which were converted to station and offset measurements. The corresponding geodetic elevations and coordinates for all the borehole were provided to us by UMA.

A laboratory testing program, consisting of natural moisture content, Atterberg Limits tests, grain-size analyses (sieve and hydrometer), was performed on selected soil samples.

The results of drilling, in-situ testing and water level measurements, as well as laboratory soil testing are summarized on the Record of Borehole Sheets in Appendix A.

The results of the laboratory tests are also presented separately in Appendix B.

#### **4. SUBSURFACE CONDITIONS**

The soil conditions at the location of the culvert are discussed in the following sections. Details of the stratigraphy encountered in the boreholes are presented on the Record of Borehole Sheets in Appendix A and on the soil strata drawings in Drawing No. 11B. The following paragraphs are only meant to complement and amplify these data.

From the information provided to us by UMA, the existing Kemp Creek culvert (C11) is located at Sta. 11+736 and it is a 20.6 m long open bottom concrete structure, about 3.5 m wide and 1.2 m high. The invert elevation of the existing culvert is at 334.95 m (upstream) to 334.77 m (downstream).

Based on the design drawing (Sheet S 03 dated December 2006) provided by UMA, a new larger open bottom concrete culvert is proposed at Sta. 11+736. The proposed highway realignment in this area include a maximum grade raise of 0.5 m.

Three boreholes were drilled for this culvert replacement. Borehole C11-1 was advanced on the west (left) side of Highway 6 near the downstream-end of the existing culvert. Boreholes C11-2 and C11-3 were put down on the east (right) side of Highway 6 on the gravel shoulder and adjacent to the east-end (upstream-end) of the existing culvert, respectively, as shown on the Site Plan and Profile Drawings 11A and 11B.

In general below some fill and original topsoil, all three boreholes contacted a major deposit of sand and gravel, with occasional cobbles and possible boulders, to the termination of the boreholes (to a maximum depth of 10.2 m, or about El. 324.7 m in Borehole C11-3).

##### **4.1 KEMP CREEK CULVERT (CULVERT C11)**

###### **4.1.1 GRANULAR FILL**

Boreholes C11-1 and C11-2 (on the left and right shoulders of the highway) contacted gravelly sand fill extending to a depth of about 2.2 and 1.5 m below the ground surface, or to El 334.3 m and 335.4 m, respectively.

The grain-size distribution of a sample of this deposit (C11-2/AS2) is presented in Figure B11-1 in Appendix B. The following grain-size distribution is indicated:

Gravel:	48%
Sand:	49%
Silt and Clay:	3%

It is noted that the grain size distribution of the sample tested meets that of a Granular 'B' material.

The measured natural moisture contents of the granular fill range from 5 to 11%.

Standard Penetration tests performed in the granular fill yielded N-values ranging from 14 to 6 blows/0.3 m, indicating compact to loose condition.

#### 4.1.2 SANDY SILT FILL

The gravelly sand fill in Borehole C11-2 and the surficial topsoil layer in Borehole C11-3 are underlain by another fill deposit which consists of sandy silt. At Borehole C11-2 and C11-3 locations, this fill deposit was found to extend to a depth of about 2.2 and 1.2 m, or El. 334.7 and 333.7 m, respectively. This deposit is basically a fine-grained granular (i.e. non-cohesive) material.

The measured natural moisture contents of the sandy silt fill material range from 14 to 16%.

Standard Penetration tests performed in this fill deposit yielded N-values ranging from 4 to 12 blows/0.3 m, indicating loose to compact condition.

#### 4.1.3 TOPSOIL AND ORGANIC SILT

Borehole C11-3, which was put down beyond the bottom of the existing highway embankment on the right side, contacted topsoil layer at ground surface to about 0.3 m below grade, or to El. 334.6 m.

In Boreholes C11-2 and C11-3, the fill is underlain by a 0.5 to 0.3 m thick topsoil and peaty organic silt (floodplain deposit) layer to a depth of 2.7 m (El. 334.2 m) and 1.5 m (El. 333.4 m), respectively.

Standard Penetration tests performed in these organic deposits yielded N-values of 8 and 4 blows/0.3 m, respectively, indicating loose to very loose conditions.

#### 4.1.4 SILTY FINE SAND

In Borehole C11-2, the topsoil and organic silt layer is underlain by a 0.3 m thick native silty fine sand deposit.



This fine-grained cohesionless deposit is grey, wet and from the Standard Penetration test results, it is inferred to be loose.

#### 4.1.5 GRAVELLY SAND

Underlying the surficial soils described in the preceding paragraphs, all three boreholes contacted a coarse granular deposit consisting of gravelly sand with traces of silt and occasional cobbles and boulders. The presence of more silty seams is also noted in the deposit (e.g., Borehole C11-3 between 3 and 7 m depths). This deposit was contacted at the borehole locations at depths ranging from 1.5 to 3.0 m below the ground surface or at El. 334.3 to 333.4 m and extended to the termination depths of all three boreholes or 4.6 to 10.2 m or to El. 332.0 to 324.7 m and possibly beyond.

The grain-size distribution of a sample of this deposit (C11-1/SS6) is presented in Figure B11-2 in Appendix B. The following grain-size distribution is indicated:

Gravel:	39%
Sand:	56%
Silt and Clay:	5%

It is of interest to note that the grain-size distribution of the sample tested meets that of a Granular 'B' material, OPSD Form 1010.

The measured N-values in the gravelly sand range from 21 to 74 blows/0.3 m, indicating a compact to very dense but generally dense to very dense condition. The measured natural moisture contents range from 7 to 22% but generally between 7 and 16%. Higher range of moisture contents up to 22% generally correspond to more silty seams.

From the grain-size distribution curve, the deposit is considered to be a relatively pervious deposit.

#### 4.1.6 GROUNDWATER CONDITIONS

Groundwater levels in the open boreholes were observed during the drilling and at the completion of each borehole. In addition, piezometers were installed in Boreholes C11-1 and C11-3 to allow ground monitoring over a prolonged period of time. The observations and recorded values are shown on the individual Record of Borehole sheets.

The results indicate that at the time of our investigation, in Borehole C11-1 the soil became wet at about 1.1 m (El. 335.5 m) during drilling, where free-standing water was subsequently recorded in the piezometer (one week later) at the same El. 335.5 m. In the piezometer installed in Borehole C11-3, water level was recorded at a depth of 0.3 m below the ground surface or at El. 334.6 m. From these observations, the groundwater level at the time of our

investigation ranged between El. 335.5 and 334.6 m. Slightly lower water level at El. 333.8 m was encountered in C11-2 during field drilling, but this may not represent the stabilized water level and the stabilized water level could be at higher elevation.

It should also be pointed out that the groundwater is subject to seasonal fluctuations and fluctuations in response to major weather events. In addition, the water table at the site will be influenced by the water level in the water course.

#### 4.2 RETAINING WALLS/WING WALLS AT BOTH ENDS OF CULVERT C11

In addition to the culvert Boreholes C11-1 through C11-3 (described above), four boreholes (C11-RW1 through C11-RW4) were drilled near the existing Kemp Creek floodplain at the locations shown on the Site Plan Drawing 11A. These boreholes were extended to a maximum of 6.6 m depth to evaluate the subsurface conditions in the area of the proposed retaining/wing walls. It is our understanding that these walls are expected to be less than 3 m high.

These boreholes primarily encountered surficial topsoil and granular fill underlain by some fine sand/silty sand and sand & gravel deposit extending to the termination of the boreholes.

##### 4.2.1 TOPSOIL

A topsoil layer was encountered in all four boreholes near the existing floodplain at ground surface ranging in thickness from about 0.1 to 0.3 m. The insitu moisture content for this material was measured at about 9%.

##### 4.2.2 GRANULAR FILL AND POSSIBLE FILL

At the location of Boreholes C11-RW1 and C11-RW4 on the west side of the existing Culvert C11 (near the existing snowmobile trail), sand and gravel fill and similar material identified as possible fill were encountered extending to about 2.0 and 1.5 m depth (or to El. 335.0 m and 335.4 m) in Boreholes C11-RW1 and C11-RW4, respectively. The natural moisture contents of this granular fill were measured at about 4%. Standard Penetration tests performed in these granular fill and suggested fill materials yielded N-values ranging from 9 to 47 blows/0.3 m, indicating variable, loose to dense, condition.

##### 4.2.3 SILTY SAND/FINE SAND/GRAVELLY SAND FILL (POSSIBLE FILL)

The sand and gravel fill in Borehole C11-RW4 on the left side of the highway was underlain by silt sand to fine sand (possible fill) to about 2.1 m depth (El. 334.7 m). Similarly, at the location of Boreholes C11-RW2 and C11-RW3 on the right side of the highway, silty sand to fine sand and gravelly sand fill/possible fill was encountered extending to about 2.2 and 2.4 m depth (to El. 334.3 m). The measured natural moisture contents of this material range from

7 to 18%. Standard Penetration tests performed in this material yielded N-values ranging from 10 to 23 blows/0.3 m, indicating a compact condition. This is a basically granular (i.e. non-cohesive) material.

#### 4.2.4 FINE SAND TO SILTY SAND

In Borehole C11-RW2 at 2.2 m depth, the silty sand to gravelly sand (possible fill) is underlain by a 1.5 m thick layer of native fine sand to silty sand extending to about El. 332.8 m. Standard penetration tests performed in these basically granular (cohesionless) material yielded N-values of 4 and 24 blows/0.3 m, indicating loose to compact condition.

The measured natural moisture contents of this deposit range from 9 to 15%.

#### 4.2.5 SAND AND GRAVEL

Below the granular fill materials in most boreholes (C11-RW1, C11-RW3, C11-RW4, C11-1 and C11-3) and/or native sand to silty sand in C11-RW2, a coarse granular deposit of sand and gravel was contacted with traces of silt and occasional cobbles and boulders. This deposit was found at depths ranging from 2.0 m (El. 335.0 m in Borehole C11-RW1) on the left side of the highway to 3.7 m (El. 332.8 in Borehole C11-RW2) on the right side of the highway. This deposit extended to the termination of all the boreholes or up to about 10.2 m depth (El. 324.7 m) in Borehole C11-3.

Grain-size analysis tests were performed on three representative samples of this deposit. The results are presented in the following table and in an envelope form in Figure B11-3, in Appendix B.

Table 4.2.5  
Results of Grain Size Analyses

Borehole/Sample	Depth (m)	Mid-El. (m)	Gravel %	Sand %	Silt & Clay %
C11-RW1/SS4 & SS5	3.0	334.0	55	40	5
C11-RW3/SS5 & SS6	3.7	333.0	59	35	6
C11-RW4/SS6	4.1	332.8	45	49	6

The measured N-values in this deposit range from 15 blows/0.3 m to 50 blows/0.08 m, indicating a compact to very dense but generally dense to very dense condition.

The measured natural moisture contents range from 7 to 22% but generally between 8 and 13%.

#### 4.2.6 GROUNDWATER CONDITIONS

Groundwater levels in the open boreholes were observed during the drilling and at the completion of each borehole. In addition, as noted earlier, piezometers were installed in the culvert Boreholes C11-1 and C11-3 to allow ground monitoring over time. The observations and recorded values are shown on the individual Record of Borehole sheets.

The results indicate that at the time of our investigation, the soil became wet at depths ranging from about 1.5 m (El. 335.5 m) in Borehole C11-RW1 to about 2.0 m (El. 334.5 m) in Borehole C11-RW2 during drilling. In addition, water level in the piezometer installed in Borehole C11-3 was reported earlier at a depth of 0.3 m below the ground surface or at El. 334.6 m, which is close to the observed water level in Borehole C11-RW2. From these observations, the groundwater level at the time of our investigation generally ranged between El. 335.5 and 334.5 m.

It should also be pointed out that the groundwater is subject to seasonal fluctuations and fluctuations in response to major weather events. In addition, the water table at the site will be influenced by the water level in the water course.

#### 4.3 PROPOSED DETOUR IN THE VICINITY OF CULVERT C11

In addition to the culvert and retaining wall boreholes (described in Sections 4.1 and 4.2), four detour boreholes C11-D1, C11-D2, C11-D3 and C11-D4 were drilled on the right side of the highway beyond the toe of the existing embankment at the locations shown on Drawing 11A. These boreholes, in addition to Borehole C11-3, put down between Sta 11+625 and Sta 11+825 to evaluate the subsurface conditions along the proposed detour. Based on the base drawing provided by UMA, Boreholes C11-D1, C11-D2 and C11-D3 appear to be located in the Kemp Creek floodplain and near existing wetlands. In particular, Borehole C11-D3 is located between the existing creek and the highway embankment.

Boreholes C11-D3 and C11-D4 were drilled using a regular drilling machine mounted on a truck (Bombardier) type vehicle. These boreholes were extended to depths of 5.5 and 4.6 m. Boreholes C11-D1 and C11-D2, however, had to be advanced using manual methods, due to limited access with a vehicle, as noted earlier in Section 3 of this report. These boreholes were put down by driving a conventional 51 mm O.D., split-spoon sampler into the ground using a 31.8 kg, however, instead of the conventional 63.6 kg hammer. The number of blows of the hammer required to drive the sampler into the undisturbed ground was recorded. After 0.6 m penetration, the sampler was withdrawn and the soil sample inside the sampler was visually examined and logged. The sampler was then put back into the hole and driven in the same manner another 0.6 m. This was continued until 2.4 m depth below the ground surface when the hole was terminated. The number of blows to drive the sampler by 0.3 m into the ground was divided by two to obtain a resistance value which is approximately equivalent to the value which would be obtained by the Standard Penetration test. Dividing by

two was implemented because the weight of the hammer was half of the standard one while the fall was same as in Standard Penetration test.

In general, these boreholes encountered surficial peaty topsoil, some granular fill and organic silt underlain by alluvial silt and fine sand, followed by sand & gravel deposit extending to the termination of all the boreholes.

#### 4.3.1 TOPSOIL/PEATY TOPSOIL

A layer of topsoil/peaty topsoil was found at ground surface in Boreholes C11-D1 through C11-D4 drilled near the toe of the existing highway embankment. The thickness of this material ranges from about 0.15 m in Borehole C11-D4 to 0.8 m in Borehole C11-D1.

#### 4.3.2 SURFICIAL SAND & GRAVEL (POSSIBLE FILL)

Below topsoil, a 0.3 to 0.5 m thick sand and gravel layer was contacted in Boreholes C11-D3 and C11-D4 extending to depths of about 0.6 and 0.7 m (El. 336.1 and 337.0 m), respectively. This material was identified as 'possible fill.'

Standard Penetration tests performed in this surficial granular soil encountered in Boreholes C11-D3 and C11-D4 yielded N-values ranging of 8 and 18 blows/0.3 m, indicating a loose to compact condition, respectively.

#### 4.3.3 PEATY ORGANIC SILT

Below topsoil and some granular fill in C11-D3, a peaty organic silt deposit was found extending to about 2.2 m depth (El. 334.5 m).

Standard Penetration tests performed in this organic deposit yielded N-values of 5 and 8 blows/0.3 m, indicating a loose condition.

#### 4.3.4 ALLUVIAL SILT & FINE SAND

Below surficial soils described above, a 0.4 to 1.0 m thick alluvial silt and fine sand deposit was contacted in Boreholes C11-D1 through C11-D3 extending to about 1.2 m depth in Boreholes C11-D1 and C11-D2 (El. 335.2 m and El. 334.7 m, respectively) and 3.0 m depth in Borehole C11-D3 (El. 333.7 m). This fine-grained, generally cohesionless deposit contains trace organics and rootlets. It is brown to grey and wet.

Standard Penetration tests performed in this deposit yielded N-values ranging from 2 to 17 blows/0.3 m, indicating a very loose to compact condition.

The measured moisture content for this material ranges from 16 to 36%.

#### 4.3.5 SAND & GRAVEL

Underlying the surficial soils described in the preceding paragraphs, all four detour boreholes contacted a coarse granular deposit consisting of sand & gravel with traces to some silt and occasional cobbles and boulders.

This deposit was contacted in all borehole locations at depths ranging from 0.7 to 3.0 m below the ground surface or at El. 337.0 to 333.7 m and extended to the termination of all the four boreholes at depths ranging from 2.4 to 5.5 m below the ground surface or to El. 333.9 to 331.2 m and likely beyond. The refusal of sampling spoon in Borehole C11-D4, at about 4.6 m depth which led to the termination of this borehole at El. 333.1 m, indicates possible presence of cobbles/boulders in this deposit.

Grain-size analysis tests were performed on two representative samples of this deposit. The results are presented in the following table and in Figures B11-4 in Appendix B.

Table 4.3.5  
Results of Grain Size Analyses

Borehole/Sample	Depth (m)	Mid-El. (m)	Gravel %	Sand %	Silt & Clay %
C11-D1/SS3	1.5	334.9	29	51	20
C11-D4/SS2	3.7	333.0	57	34	9

Therefore, the tested materials can be described as gravelly sand to sandy gravel, (or in general sand & gravel) with traces to some silt.

The measured N-values in the deposit range from 17 blows/0.3 m to 50 blows/0.13 m, indicating a compact to very dense but generally dense to very dense condition.

The measured natural moisture contents range from 5 to 16 but generally between 5 and 12%. A higher range of moisture contents in this deposit from 12 to 16% generally correspond to more silty seams below the groundwater table. This cohesionless (granular) deposit is generally considered to be a relatively pervious material.

#### 4.3.6 GROUNDWATER CONDITIONS

Groundwater levels in the open boreholes were observed during the drilling and at the completion of each borehole. In addition, as noted in Sections 4.1.6 and 4.2.6, a piezometer was installed in Borehole C11-3 (on the right side of the highway and between Boreholes C11-D2 and C11-D3) to allow ground monitoring over time. The observations and recorded values are shown on the individual Record of Borehole sheets.

The results indicate that at the time of our investigation, water was found in open boreholes at different depths ranging from a depth of about 0.2 m (El. 336.2 m) in Borehole C11-D1 to about 2.2 m (El. 334.5 m) in Borehole C11-D3. In the piezometer installed in Borehole C11-3, water level was recorded at a depth of 0.3 m below the ground surface or at El. 334.6 m, which is very close to the water level observed in Borehole C11-D3 during drilling. From these observations, the groundwater level at the time of our investigation generally ranged between El. 336 and 335 m.

It should also be pointed out that the groundwater is subject to seasonal fluctuations and fluctuations in response to major weather events. In addition, the water table at the site will be influenced by the water level in the water course.

**SHAHEEN & PEAKER LIMITED**

  
Ramon Miranda, P.Eng.



  
Z.S. Ozden, P.Eng.



ZO:tr/idrive

# Drawings

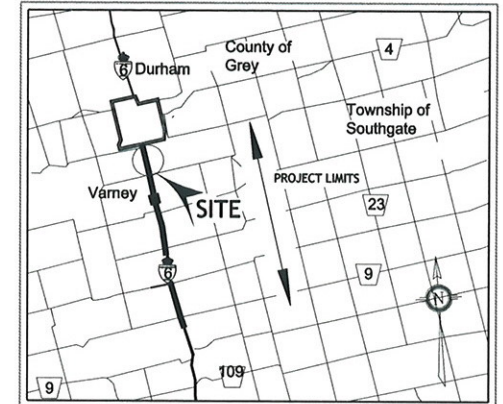


TOWNSHIP OF BENTINCK

**METRIC**DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
ARE IN KILOMETRES + METRES.NOTES:  
FOR DETAILED SUBSURFACE CONDITIONS  
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.

GWP: 338-97-00

Highway 6, Durham  
Kemp Creek Culvert (C11) @ Sta. 11+736  
BORE HOLE LOCATIONS**SHAHEEN & PEAKER LIMITED**KEY PLAN  
N.T.S**LEGEND**

- Borehole
- Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation  
Aug./ Nov., 2006 (Not Stabilized)
- Water Level in Piezometer
- Piezometer

No.	ELEV.	CO-ORDINATES	
		NORTH	EAST
C11-1	336.6	4,892,473.2	199,439.8
C11-2	336.9	4,892,470.7	199,454.2
C11-3	334.9	4,892,469.6	199,460.6
C11-D1	336.4	4,892,359.4	199,451.4
C11-D2	335.9	4,892,408.9	199,450.6
C11-D3	336.7	4,892,507.8	199,462.6
C11-D4	337.7	4,892,556.8	199,472.7
C11-RW1	337.0	4,892,465.9	199,440.6
C11-RW2	336.5	4,892,463.3	199,456.0
C11-RW3	336.7	4,892,478.3	199,457.5
C11-RW4	336.9	4,892,480.7	199,443.6

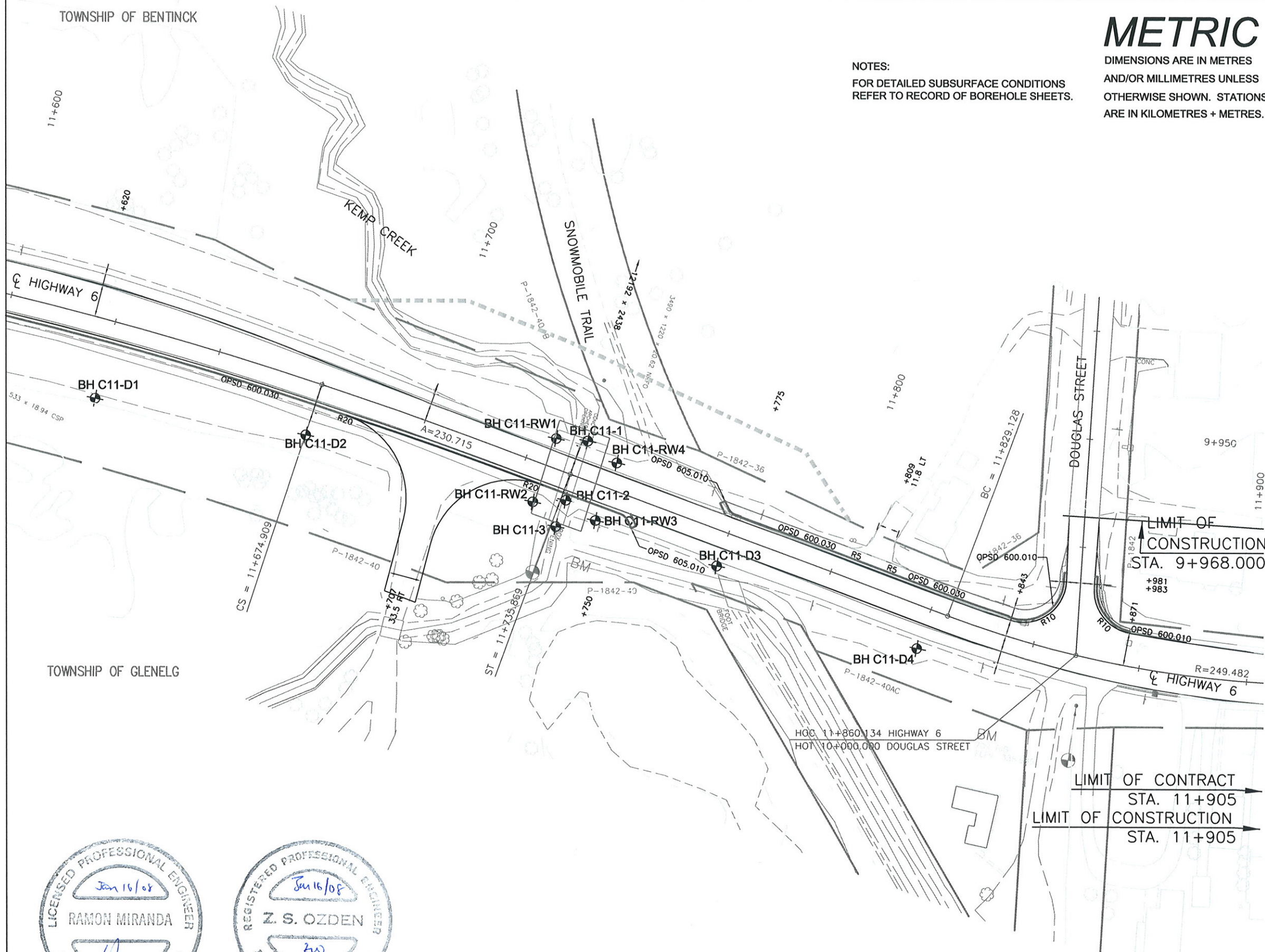
**NOTE**

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 Materials Engineering and Research Office, Downsview. Information contained in this report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REV.	DATE	BY	DESCRIPTION
Geocres No. 41A-196			
SPT 1174, CURVERT C11			DIST
SUBM'D ZO	CHECKED RM	DATE Jan 07, 08	SITE 8-450/C
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 11 A



TOWNSHIP OF GLENELG

SCALES  
PLAN

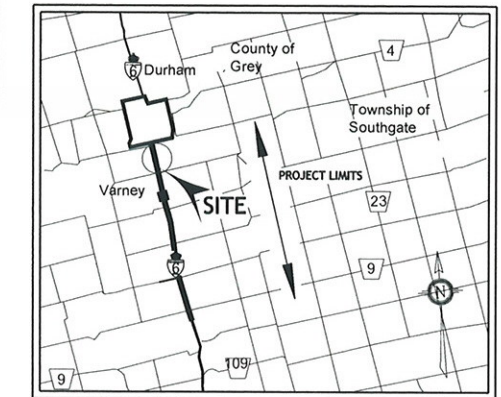


CONT No.  
GWP: 338-97-00



Highway 6, Durham  
Kemp Creek Culvert (C11) @ Sta. 11+736  
PROFILE & SOIL STRATIGRAPHY

SHAHEEN & PEAKER LIMITED



KEY PLAN  
N.T.S.

LEGEND

- Borehole
- Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer

No.	ELEV.	CO-ORDINATES	
		NORTH	EAST
C11-1	336.6	4 892 465.3	199 438.5
C11-2	336.9	4 892 470.7	199 454.2
C11-3	334.9	4 892 469.6	199 460.6

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

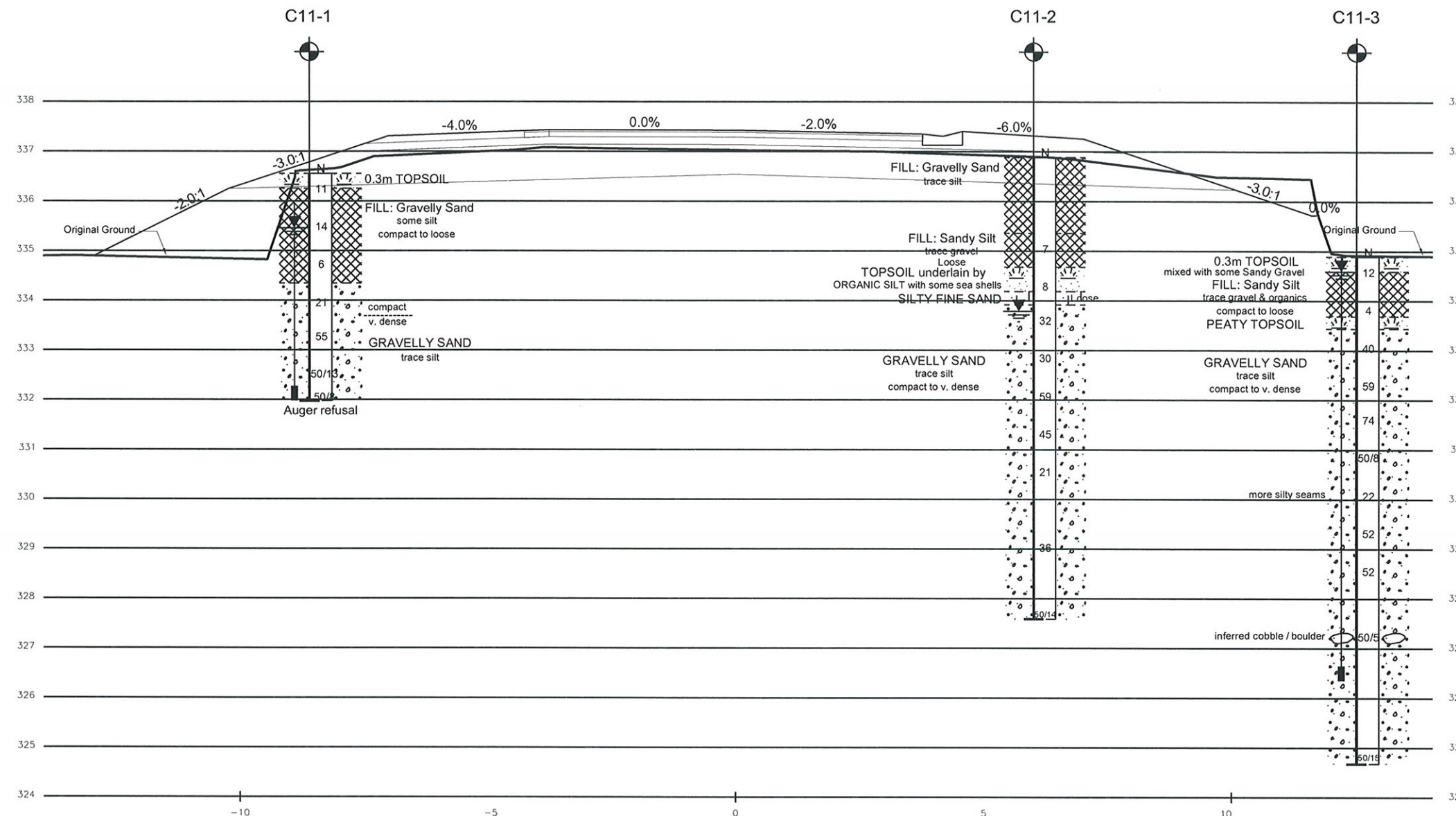
NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

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

REV.	DATE	BY	DESCRIPTION

Geocres No. 41A-196

SPT 1174			DIST
SUBM'D	CHECKED	DATE Jan., 2008	SITE 8-450/C
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 11B



SCALES  
1m 0 1 2m VERT  
1m 0 1 2m HOR

PROFILE ALONG C11 @ STA. 11+736

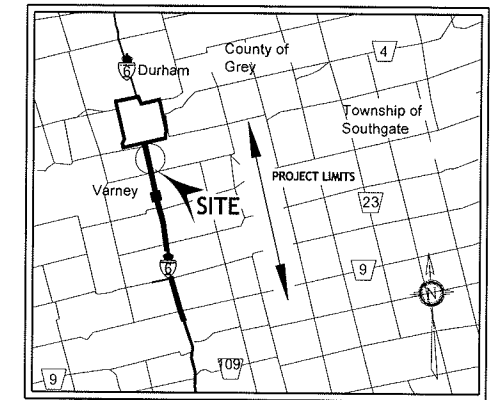


CONT No.  
GWP: 338-97-00



Highway 6, Durham  
Kemp Creek Culvert (C11) @ Sta. 11+736  
PROFILE & SOIL STRATIGRAPHY

SHAHEEN & PEAKER LIMITED



KEY PLAN  
N.T.S

LEGEND

- Borehole
- Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer

No.	ELEV.	CO-ORDINATES	
		NORTH	EAST
C11-D1	336.4	4 892 359.4	199 451.4
C11-D2	335.9	4 892 408.9	199 450.6
C11-3	334.9	4 892 469.6	199 460.6
C11-D3	336.7	4 892 507.8	199 462.6
C11-D4	337.7	4 892 556.8	199 472.7

=NOTE=

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

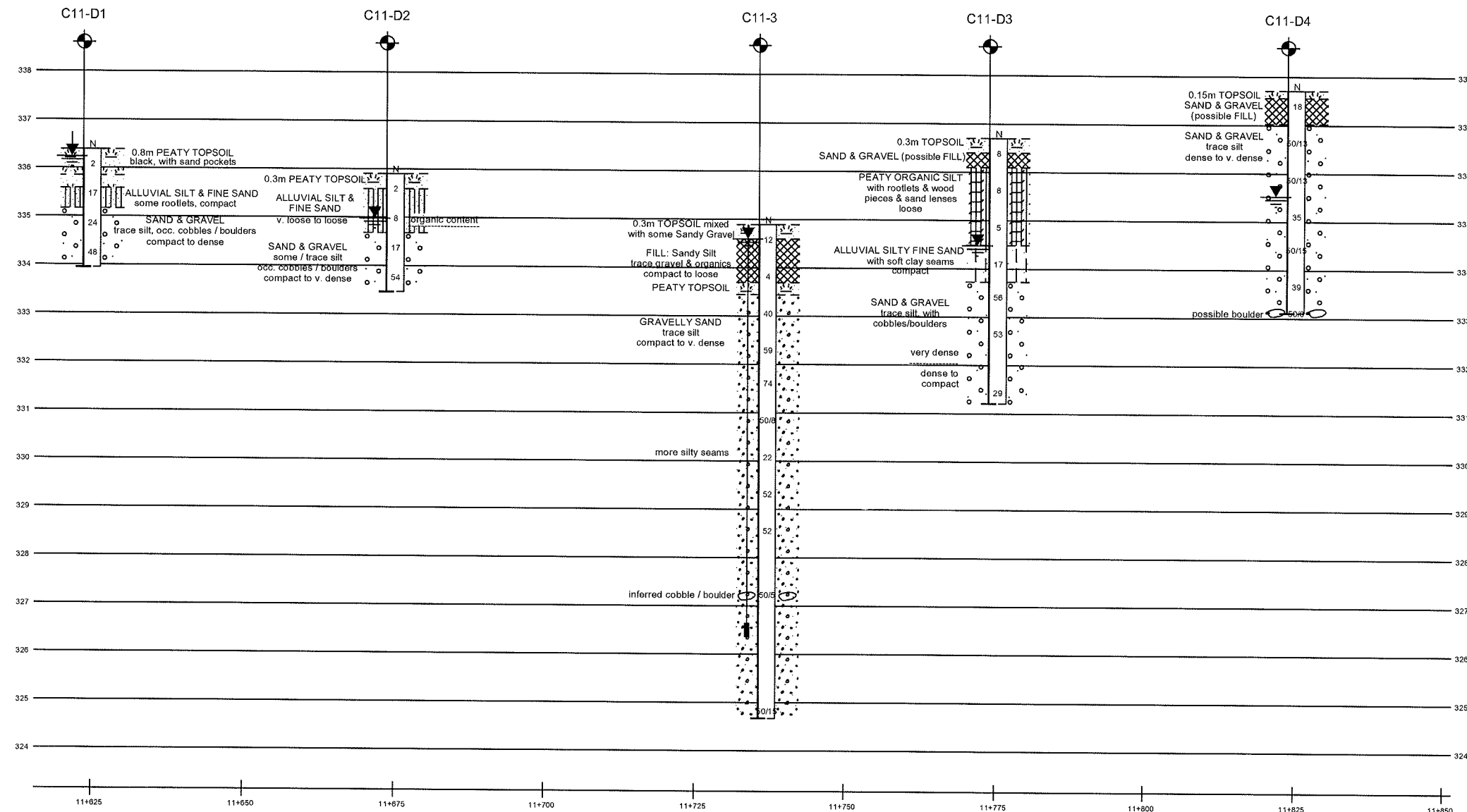
NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

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

REV.	DATE	BY	DESCRIPTION

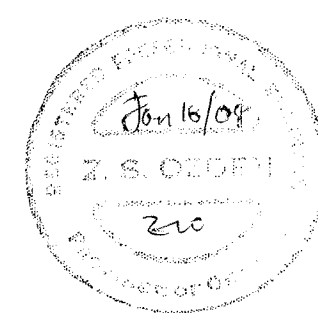
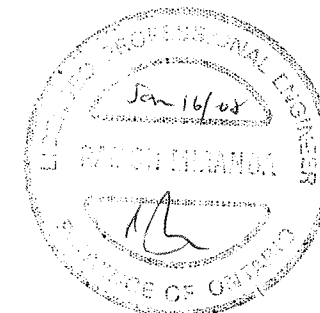
Geocres No. 41A-196

SPT 1174			DIST
SUBM'D	CHECKED	DATE Jan 07, 2008	SITE 8-450/C
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 11C



SCALES  
1m 0 1 2m VERT  
8m 0 8 16m HOR

PROFILE ALONG PROPOSED DETOUR



# Appendix A

## Record of Borehole Sheets

SPT1174

# RECORD OF BOREHOLE No C11-1

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 11+737, 8.6m Lt, C/L ORIGINATED BY NH  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers COMPILED BY XS  
 DATUM Geodetic DATE 11/13/2006 CHECKED BY FS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
336.6														
0.0 336.3	0.3 m TOPSOIL		1	SS	11		336							
0.3	FILL: Gravelly Sand some silt brownish grey compact to loose	damp wet	2	SS	14		335							wet spoon
334.3			3	SS	6		334							
2.2	GRAVELLY SAND	compact very dense	4	SS	21		333							
	trace silt greyish brown to brownish grey, wet		5	SS	55		332							
332.0			6	SS	50/13									39 56 (5)
4.6	End of borehole.		7	SS	50/8									auger refusal
	Piezometer installed to depth of 13.8 m. Water level in piezometer: Nov. 14, 2006 ---2.9 m (El. 333.7 m) Nov. 21, 2006 ---1.1 m (El. 335.5 m)													

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 5 10 15 20 (%) STRAIN AT FAILURE

SPT1174

## 1 OF 1

METRIC

GWP	338-97-00	LOCATION	Hwy 6, Durham - Sta. 11+737, 6m Rt, C/L	ORIGINATED BY	JL
DIST		HWY	6	BOREHOLE TYPE	Hollow Stem Augers
DATUM	Geodetic	DATE	8/21/2006	CHECKED BY	FS

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity



SPT1174

# RECORD OF BOREHOLE No C11-3

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 11+737, 12.5m Rt, C/L ORIGINATED BY ZI  
DIST          HWY 6 BOREHOLE TYPE Hollow Stem Augers COMPILED BY HL  
DATUM Geodetic DATE 11/9/2006 CHECKED BY RM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
334.9														
0.0 334.8	0.3m TOPSOIL mixed with some Sandy Gravel		1	SS	12									
0.3	FILL: Sandy Silt trace gravel & organics brown to grey, wet compact to loose													
333.7			2	SS	4		334							
1.2	PEATY TOPSOIL dark grey, wet													
333.4														
1.5	GRAVELLY SAND trace silt brownish grey, wet compact to very dense		3	SS	40		333							
			4	SS	59		332							
			5	SS	74		331							
			6	SS	50/8		330							
	more silty seams		7	SS	22		329							
			8	SS	52		328							
			9	SS	52		327							
			10	SS	50/6		326							
							325							
324.7			11	SS	50/15									
10.2	End of borehole.  Piezometer installed to depth of 8.5 m. Water level in piezometer: Nov. 14, 2006 ---0.4 m (El. 334.5 m) Nov. 21, 2006 ---0.3 m (El. 334.6 m)													

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 5 10 15 20 (%) STRAIN AT FAILURE

SPT1174

RECORD OF BOREHOLE No C11-RW1 1 OF 1										METRIC					
GWP 338-97-00		LOCATION Hwy 6, Durham - Sta. 11+730, 6.6m Lt, C/L					ORIGINATED BY NH								
DIST HWY 6		BOREHOLE TYPE Hollow Stem Augers					COMPILED BY XS								
DATUM Geodetic		DATE 11/10/2006					CHECKED BY FS								
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa							
337.0							20	40	60	80	100				
336.8	0.15 m TOPSOIL		1	SS	13										
0.2	SAND & GRAVEL (possible FILL) trace silt occasional rootlets near top and bottom brown to dark brown and grey, damp compact to dense		2	SS	47										
335.0			3	SS	29										
2.0	SAND & GRAVEL trace silt grey to greyish brown, wet dense to very dense		4	SS	59										
			5	SS	34										
			6	SS	79										
			7	SS	42										
332.0	End of borehole.  * Water level in open borehole at 1.5 m (El. 335.5 m) upon completion (not stabilized).														
5.0															



SPT1174

RECORD OF BOREHOLE No C11-RW2 1 OF 1										METRIC						
GWP 338-97-00		LOCATION Hwy 6, Durham - Sta. 11+730, 9m Rt C/L					ORIGINATED BY NH									
DIST _____ HWY 6		BOREHOLE TYPE Hollow Stem Augers					COMPILED BY XS									
DATUM Geodetic		DATE 11/10/2006					CHECKED BY FS									
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
336.5							20	40	60	80	100					
0.0 336.2	0.3 m TOPSOIL		1	SS	7											
0.3	FILL: Silty Sand to Fine Sand trace to some gravel dark brown to grey loose		2	SS	10											
335.1																
1.4	SILTY SAND to GRAVELLY SAND (possible FILL) brown, moist, compact		3	SS	10											
334.3																
2.2	FINE SAND to SILTY SAND some gravel, grey, wet		4	SS	4											
	loose															
	compact		5	SS	24											
332.8																
3.7	SAND & GRAVEL trace silt, wet		6	SS	29											
	compact															
	very dense		7	SS	50/15											
331.8																
4.7	End of borehole.  * Water level in open borehole at 2.0 m (El. 334.5m) upon completion (not stabilized).  Borehole caved at 4.3 m upon completion.															

SPT1174

RECORD OF BOREHOLE No C11-RW3 1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 11+745, 8m Rt C/L ORIGINATED BY NH  
DIST HWY 6 BOREHOLE TYPE Solid Stem Augers & Hollow Stem Augers COMPILED BY XS  
DATUM Geodetic DATE 11/10/2006 CHECKED BY FS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
336.7														
0.0 336.4	0.3 m TOPSOIL		1	SS	12									
0.3	FILL: Silty Sand to Fine Sand some gravel, trace clay dark brown to greyish brown compact		2	SS	21									
	moist													
	wet		3	SS	14									
334.3	trace topsoil													
2.4	SAND & GRAVEL some to trace silt, greyish brown, wet compact to very dense		4	SS	15									
			5	SS	26									
			6	SS	34									
			7	SS	23									
			8	SS	84									
330.2			9	SS	40									
6.6	End of borehole.  * Water level in open borehole at 1.5 m (El. 335.2 m) upon completion (not stabilized).  Borehole caved at 4.7 m.													

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 5 10 15 20 (%) STRAIN AT FAILURE

SPT1174

<b>RECORD OF BOREHOLE No C11-RW4    1 OF 1    METRIC</b>																
GWP <u>338-97-00</u>		LOCATION <u>Hwy 6, Durham - Sta. 11+745, 6.2m Lt C/L</u>				ORIGINATED BY <u>JL</u>										
DIST <u>          </u> HWY <u>6</u>		BOREHOLE TYPE <u>Hollow Stem Augers</u>				COMPILED BY <u>XS</u>										
DATUM <u>Geodetic</u>		DATE <u>11/13/2006</u>				CHECKED BY <u>FS</u>										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT    NATURAL MOISTURE CONTENT    LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
							20   40   60   80   100 ○ UNCONFINED    + FIELD VANE ● POCKET PENETR.    × LAB VANE					w <sub>p</sub> w    w <sub>L</sub>				
336.9	0.1 m TOPSOIL	X	1	SS	25											
	FILL: Sand & Gravel	X	2	SS	9											
335.4	greyish brown, damp	X														
334.7	SILTY SAND to FINE SAND (possible FILL) some gravel, grey, wet, compact	X	3	SS	23											
334.7	SAND & GRAVEL	X	4	SS	31											
	trace silt greyish brown, wet	X	5	SS	40											
	medium sand interlayer	X	6	SS	42											
	dense	X	7	SS	21											
	compact	X	8	SS	50/10											
	very dense	X	9	SS	50/8											
330.8	End of borehole.	X														
6.0	* Water level in open borehole at 1.7 m (El. 335.2 m) upon completion (not stabilized).															

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity    20 15 10 5 0 (%) STRAIN AT FAILURE



SPT1174

RECORD OF BOREHOLE No C11-D1										1 OF 1		METRIC					
GWP		338-97-00		LOCATION		Hwy 6, Durham - Sta. 11+625, 18.3m Rt, C/L				ORIGINATED BY		ZI					
DIST		HWY		6		BOREHOLE TYPE		Hand Drilling				COMPILED BY		XS			
DATUM		Geodetic		DATE		12/6/2006				CHECKED BY		FS					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE					WATER CONTENT (%) w <sub>p</sub> w w <sub>L</sub>				
336.4							20	40	60	80	100						
0.0	0.8 m PEATY TOPSOIL black, with sand pockets		1	SS	2											spoon wet	
335.6																	
0.8	ALLUVIAL SILT & FINE SAND some rootlets		2	SS	17												
335.2																	
1.2	brown to grey, wet, compact		3	SS	24												
	SAND & GRAVEL trace to some silt occasional cobbles / boulders brown, oxidised, wet, compact to dense		4	SS	48											29 51 (20)	
333.9																	
2.4	End of Borehole.  *Water level at 0.2 m (El. 336.2 m, not stabilized) and hole open to full depth upon completion.  **Equivalent N- value																



SPT1174

RECORD OF BOREHOLE No C11-D2										1 OF 1		METRIC					
GWP		338-97-00		LOCATION		Hwy 6, Durham - Sta. 11+675, 14.5m Rt, C/L				ORIGINATED BY		ZI					
DIST		HWY 6		BOREHOLE TYPE		Hand Drilling				COMPILED BY		XS					
DATUM		Geodetic		DATE		12/5/2006				CHECKED BY		FS					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE									
335.9																	
0.0 335.6	0.3 m PEATY TOPSOIL		1	SS	2												
0.3	ALLUVIAL SILT & FINE SAND organic content brown to grey, wet, very loose to loose		2	SS	8												spoon wet
334.7																	
1.2	SAND & GRAVEL some / trace silt occasional cobbles / boulders oxidised brown, wet compact to very dense		3	SS	17												
333.5																	
2.4	End of Borehole.  *Water level at 0.9 m (El. 335.0 m, not stabilized) and hole open to full depth upon completion.  **Equivalent N- value																

SPT1174

RECORD OF BOREHOLE No C11-D3										1 OF 1		METRIC				
GWP <u>338-97-00</u>		LOCATION <u>Hwy 6, Durham - Sta. 11+775, 8m Rt, C/L</u>						ORIGINATED BY <u>ZI</u>								
DIST <u>          </u> HWY <u>6</u>		BOREHOLE TYPE <u>Solid Stem Augers</u>						COMPILED BY <u>HL</u>								
DATUM <u>Geodetic</u>		DATE <u>11/9/2006</u>						CHECKED BY <u>FS</u>								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
336.7																
0.0 336.4	0.3 m TOPSOIL		1	SS	8											
0.3 336.1	SAND & GRAVEL (possible FILL)															
0.6 334.5	PEATY ORGANIC SILT with rootlets, wood pieces & sand lenses black to greyish brown, wet loose		2	SS	8											
			3	SS	5											
334.5 2.2	ALLUVIAL SILTY FINE SAND with soft clay seams greyish brown, wet compact		4	SS	17											
333.7 3.0	SAND & GRAVEL trace silt, with cobbles/boulders brown, wet		5	SS	56											
			6	SS	53											
	very dense dense to compact															
331.2 5.5	End of Borehole.  * Water level at 2.2 m (El. 334.5 m) and hole open to full depth upon completion (not stabilized).		7	SS	29											



SPT1174

RECORD OF BOREHOLE No C11-D4										1 OF 1		METRIC					
GWP		338-97-00		LOCATION		Hwy 6, Durham - Sta. 11+825, 9.6m Rt, C/L				ORIGINATED BY		ZI					
DIST		HWY 6		BOREHOLE TYPE		Hollow Stem Augers				COMPILED BY		XS					
DATUM		Geodetic		DATE		11/13/2006				CHECKED BY		FS					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE					WATER CONTENT (%) w <sub>p</sub> w w <sub>L</sub>				
337.7							20	40	60	80	100						
337.6	0.15 m TOPSOIL		1	SS	18												
0.2	SAND & GRAVEL (possible FILL)																
337.0																	
0.7	SAND & GRAVEL trace silt brown to greyish brown, wet dense to very dense		2	SS	50/13												
			3	SS	50/13												
			4	SS	35												
			5	SS	50/15												
			6	SS	39												
333.1			7	SS	50/0												
4.6	End of Borehole.  * Water level at 2.2 m (El. 335.5 m, not stabilized) and hole open to full depth upon completion.																

# Appendix B

## Laboratory Test Results



# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT

SAND

GRAVEL

Fine

Medium

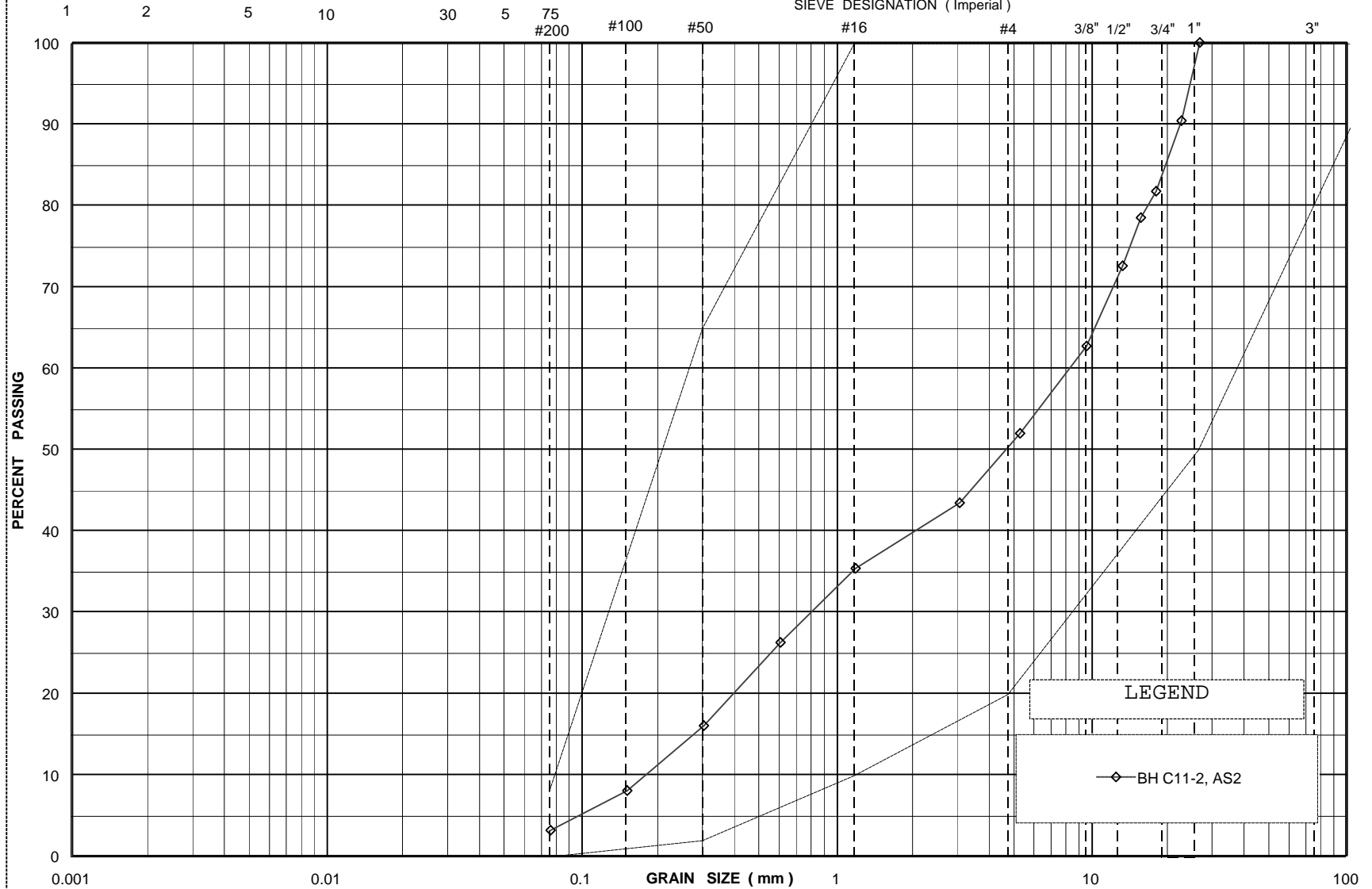
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION ( Imperial )



LEGEND

—◇— BH C11-2, AS2

SHAHEEN & PEAKER LIMITED

GRAIN SIZE DISTRIBUTION

FILL: Gravelly Sand

FIGURE No. B11-1

G. W. P. 338-97-00

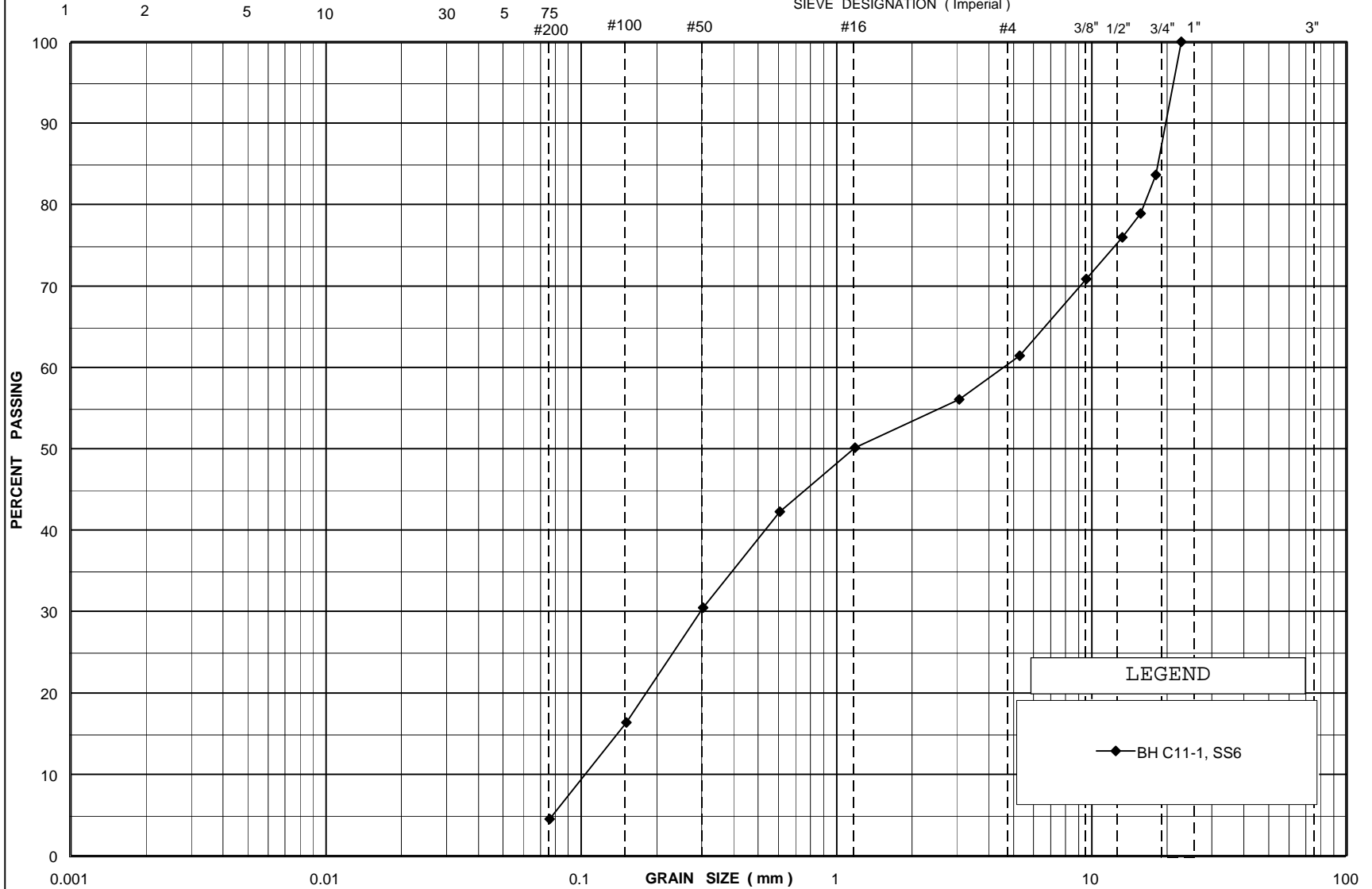
REF. No. SPT 1174

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION ( Imperial )



## LEGEND

—◆— BH C11-1, SS6

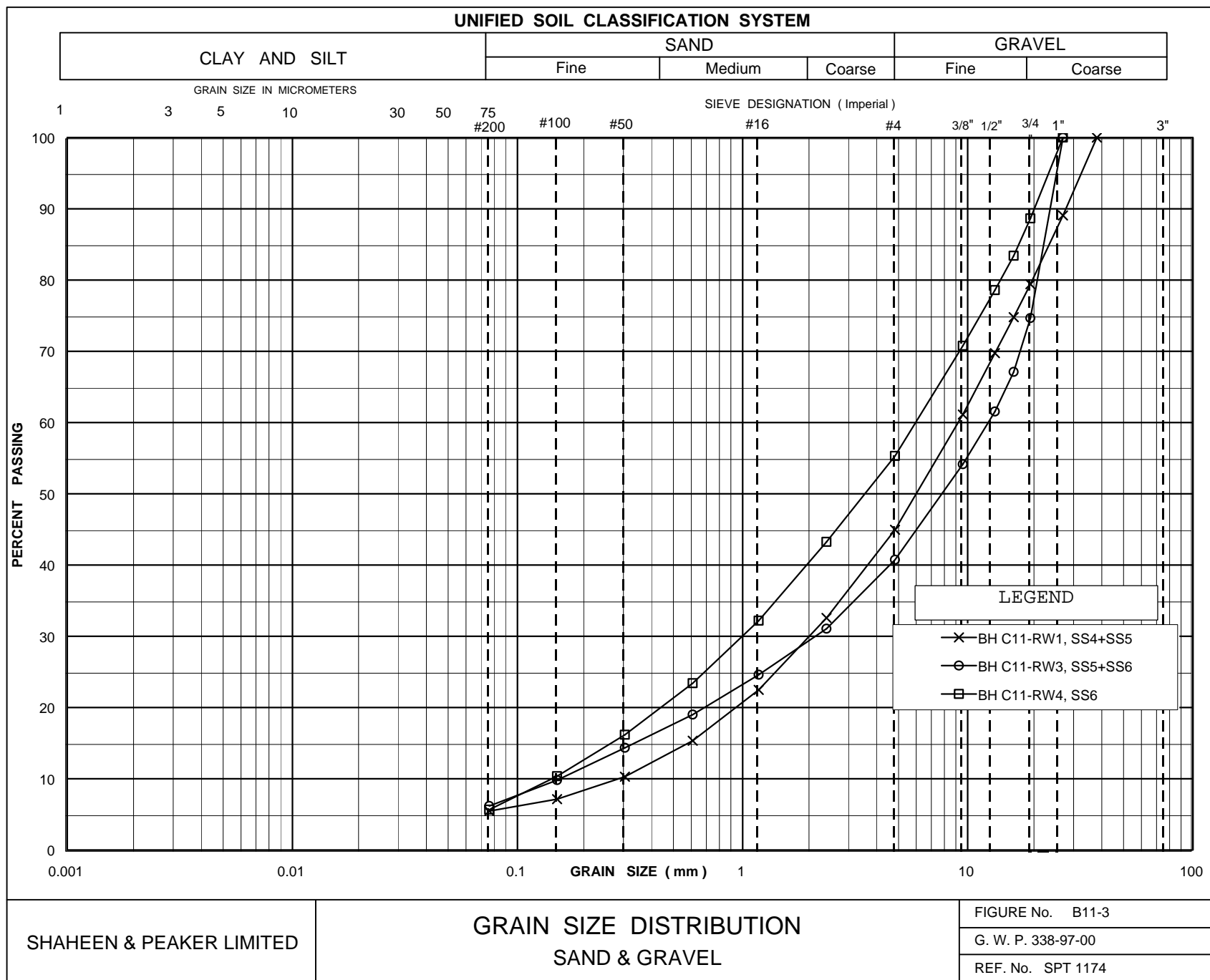
SHAHEEN & PEAKER LIMITED

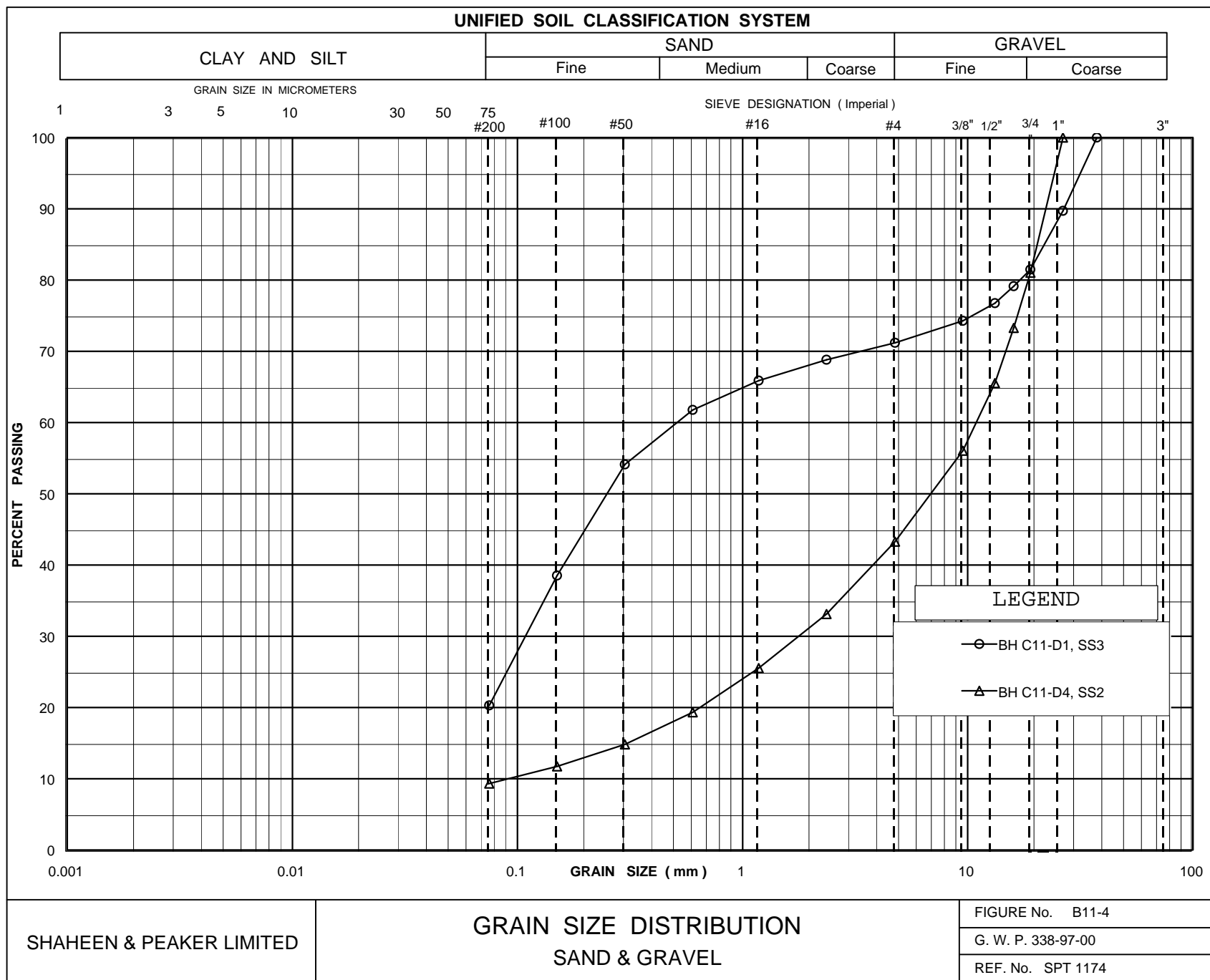
GRAIN SIZE DISTRIBUTION  
Gravelly Sand

FIGURE No. B11-2

G. W. P. 338-97-00

REF. No. SPT 1174





## Appendix C

# Explanation of Terms Used in Report

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

$C_u$ (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

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

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

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

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

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

**JOINT AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

### STRESS AND STRAIN

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

### MECHANICALL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$c_c$	1	COMPRESSION INDEX
$c_s$	1	SWELLING INDEX
$c_a$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $c_u / \tau_r$

## PHYSICAL PROPERTIES OF SOIL

$P_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$j_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$P_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$j_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$s_r$	%	DEGREE OF SATURATION	$D_n$	mm	N PERCENT – DIAMETER
$P$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$j$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$P_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	m <sup>3</sup> /s	RATE OF DISCHARGE
$j_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $(W_L - W_p) / I_p$	v	m/s	DISCHARGE VELOCITY
$P_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $(W - W_p) / I_p$	i	1	HYDAULIC GRADIENT
$j_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_c$	1	CONSISTENCY INDEX = $(W_L - W) / 1_p$	k	m/s	HYDRAULIC CONDUCTIVITY
$P'$	kg/m <sup>3</sup>	DENSITY OF SUBMERED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m <sup>3</sup>	SEEPAGE FORCE
$j'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

# Appendix D

## Site Photographs

**Foundation Investigation Report of Culvert C11 on Highway 6: GWP 338-97-00**



Photo (1): Culvert C11 at Station 11+736 on Highway 6, East End



Photo (2): Highway 6 at Station 11+736 (Culvert C11), Facing North