

**FOUNDATION INVESTIGATION AND DESIGN REPORTS  
PROPOSED CULVERT REPLACEMENTS  
(C1, C2, C3, C4, C7 & C8)  
HIGHWAY 6 FROM 1.1 KM SOUTH OF  
GREY COUNTY ROAD 9 NORTHERLY TO  
DURHAM SOUTH LIMITS, ONTARIO  
G.W.P. 338-97-00**

**GEOCRES NO. 41A-193**

**Prepared For:**

**UMA/AECOM ENGINEERING LIMITED**

**Prepared by:**

**SHAHEEN & PEAKER LIMITED**

**Project: SPT1174A  
January 24, 2008**



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**FOUNDATION INVESTIGATION REPORT  
PROPOSED CULVERT REPLACEMENTS (C1, C2, C3, C4, C7 & C8)  
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G.W.P. 338-97-00**

**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.

The Highway 6 project includes pavement rehabilitation throughout, vertical grade revisions in some areas, construction of a new northbound (NB) passing lane and replacement extension of several culverts (C1 through C11) within the project limits. 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.

This report presents the findings of the geotechnical investigation for the proposed replacement of six non-structural culverts (C1 through C4, C7 and C8) at the following locations:

<b>Culvert No</b>	<b>Station</b>
C1	21+204
C2	21+809
C3	23+793
C4	24+482
C7	27+065
C8	28+299

The geotechnical investigation results for the replacement of three structural culverts were presented in separate reports under SPT1174C (for Culvert C9), 1174D (for Culvert C10) and 1174E (for culvert C11). The findings of the geotechnical investigation for replacement of the other non-structural culverts (C2A, C3A, C5, C6) will be presented under a separate report (SPT1174B).

## **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 Physiographic Region known as the Horseshoe Moraines. The Horseshoe Moraines Physiographic Region 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.

Geological information indicates that the overburden (glacial drift), in this general area, may be underlain by bedrock at relatively shallow depths. Some areas may be located near the interface of Upper Silurian Salina and Middle Silurian Guelph Formations, which are approximately 420 million years old. The Salina Formation (the younger of the two) consists of dolostone, shale, gypsum and salt while the Guelph Formation consists of dolostone.

## **3. INVESTIGATION PROCEDURES**

In the current geotechnical report, the subsurface conditions for the proposed culvert replacement at six sites (C1 through C4, C7 and C8) were investigated for replacements, as per the original TOR in the RFP document and the S&P proposal.

At each culvert site, three boreholes were drilled, one at each end of the culvert and one at the crest of the embankment for culvert replacement. Therefore, a total of eighteen boreholes were drilled for the replacement of six culverts to different depths (typically a minimum of 6 m below the culvert invert).

The fieldwork was carried out during several periods from August 10 to 22, 2006, September 21-29, 2006, October 2 to 16, 2006, Oct. 16 to 19, 2006, November 8 to 14, and December 5 to 8, 2006

All 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, except for Borehole C2-1 which had to be put down using manual methods (due to inaccessibility with a conventional drill rig). All the boreholes were drilled under the full time supervision of geotechnical engineers from S&P.

Sampling in the boreholes (except Borehole C2-1) 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.

Manual drilling (in Borehole C2-1) consisted of driving a conventional 51 mm O.D. split-spoon sampler into the ground using a 31.8 kg hammer (instead of the conventional 63.6 kg hammer). The number of blows required to advance the sampler into the undisturbed ground was counted and recorded. After 0.6 m penetration, the sampler was withdrawn and sample which was retrieved was examined and logged. The sampler was then put back into the hole and driven another 0.6 m. This was continued until the termination of the borehole or refusal to penetration at 3.0 m below the ground surface. The number of blows of the hammer to drive the sampler by 0.3 m into the ground was divided by two (since the weight of the hammer is one-half of the conventional hammer) in order to obtain a resistance value approximately equivalent to the N-value obtained in the Standard Penetration test. These values are shown on the Record of Borehole as "equivalent" N-values.

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.

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

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, 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 A1 through A6. The locations of the boreholes and the inferred subsurface stratigraphy are also shown in the same Appendices (i.e. Appendix A1 through A6).

The results of the laboratory tests are also presented in Appendices B1 through B6.

#### 4. SUBSURFACE CONDITIONS

The soil conditions at the location of each individual culvert are discussed in the following sections. Details of the stratigraphy encountered in the boreholes are presented on the Record of Borehole Sheets and on the soil strata drawings in Appendix A1 through A6. The following paragraphs are only meant to complement and amplify these data.

##### 4.1 CULVERT REPLACEMENT AT STATION 21+204 (C1)

At this location, the existing culvert is a corrugated steel pipe (CSP) about 0.76 m in diameter and approximately 22 m in length with the culvert invert elevation at 375.99 to 376.16 m.

Three boreholes were drilled for this culvert replacement. Boreholes C1-1 and C1-3 were put down near the existing culvert ends on the left (west) and right (east) sides of highway, respectively, while Borehole C1-2 was advanced on the left shoulder of the highway, as shown on Drawings No. 1A and 1B.

Borehole C1-2 was located on the shoulder of the highway and contacted fill materials which extend to a depth of about 1.5 m below the ground surface, underlain by a 0.3 m thick topsoil layer to El. 376.0 m. Boreholes C1-1 and C1-3, which were put down beyond the bottom of the existing highway embankment, contacted topsoil and organic silt to 0.7 m below the ground surface or to El. 375.4 and 375.8 m, respectively.

In general below the fill and organic soils, the boreholes contacted, a major deposit of sand and gravel, changing to relatively finer granular soils below about 5 m depth or below El. 371-370 m.

##### 4.1.1 GRANULAR FILL

Borehole C1-2, drilled from the left shoulder of the highway, contacted a 0.8 m thick granular shoulder fill which consisted of sand and gravel to a depth of 0.25 m, changing to sand with some gravel below this depth.

##### 4.1.2 SILT AND CLAYEY SILT FILL

The granular shoulder fill in Borehole C1-2 is underlain by a 0.7 m thick fill layer which consists of silt with some sand and traces of gravel. This basically fine-grained granular (i.e. non-cohesive) soil extends to 1.5 m below the ground surface or to El. 376.3 m and is underlain by a 0.3 m thick organic topsoil layer to a depth of 1.8 m (El. 376.0 m). The topsoil is in turn underlain by a 0.4 m cohesive deposit (clayey silt with traces of gravel and organics) which was identified as possible fill.

#### 4.1.3 TOPSOIL AND ORGANIC SILT

In Borehole C1-2, the embankment fill is underlain at 1.5 m depth by a 0.3 m thick topsoil layer.

Boreholes C1-1 and C1-3, which were drilled from the bottom (i.e. beyond the toe) of the highway embankments, contacted a topsoil layer extending to about 0.5 m and 0.2 m, respectively. In these two boreholes, the topsoil is underlain by organic silt (floodplain deposit) to a depth of 0.7 m below the ground surface, or to El. 375.4 m and 375.8 m, respectively.

Standard Penetration tests performed in these organic deposits yielded N-values which are 6 and 7 blows/0.3 m, respectively, indicating a loose condition of this basically granular (non-cohesive) soil.

It should be pointed out that the thickness of topsoil and organic soils can be expected to be variable in between and beyond borehole locations, especially near water courses.

#### 4.1.4 SAND & GRAVEL

Underlying the surficial soils described in the preceding paragraphs, all three boreholes contacted a coarse granular deposit consisting of sand & gravel with some silt and occasional cobbles and boulders. This deposit was contacted at depths 0.7 to 2.2 m below the ground surface or at El. 375.8 to 375.4 m and extended to depths ranging between 5.0 m (El. 371.0 m) in Borehole C1-1 and 6.0 m (El. 370.6 m) in Borehole C1-3. Borehole C1-2 was terminated in this deposit at 6.9 m or at El. 371.0 m. In Borehole C1-3, it attained at El. 370.6 m a somewhat finer texture, changing to sand to sand with some gravel.

The grain-size distribution of three samples from the sand & gravel is presented in Figure B1-1 in Appendix B1. The following grain-size distribution is indicated:

Gravel:	31 – 48%
Sand:	36 - 57%
Silt and clay:	11 - 20%

The measured N-values in the sand & gravel and in the underlying sand deposit range from 28 to in excess of 100 blows/0.3 m, indicating a compact but generally dense to very dense condition. The measured natural moisture contents range from 6 to 17% but generally between 5 and 11%.

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

#### 4.1.5 SILTY SAND TO SANDY SILT TILL

Borehole C1-1 contacted underlying the sand & gravel at 5.2 m depth (El. 371.0 m) relatively finer granular soils ranging from silty sand to sandy silt till to the full depth of the borehole at 7.9 m depth or El. 368.1 m.

N-values recorded in these basically granular soil deposit range from 51 blows/0.3 m to 50 blows/0.08 m which indicate a very dense condition.

#### 4.1.6 SILT TILL

Underlying the sand & gravel and sand in Borehole C1-3, a glacial till deposit was contacted at a depth of 6.8 m (El. 369.7 m). The deposit consists of mainly silt size particles with some sand and clay content. The borehole was terminated at 7.3 m (El. 369.2 m) after penetrating this basically granular soil by a vertical distance of 0.5 m.

The natural moisture content of the sample recovered from this deposit was measured to 9% and based on a recorded N-value of 50 blows/0.15 m, its relative density is described as very dense.

#### 4.1.7 GROUNDWATER CONDITIONS

Groundwater levels in the open boreholes were observed during the drilling and at the completion of each borehole. In addition, a piezometer was installed in Borehole C1-3 to allow ground monitoring over a prolonged period of time, without interference from surface water. 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 C1-1 the soil became wet at 1.1 m and on completion free-standing water was recorded at about 1.2 m or at about El. 374.9 m. In the piezometer installed in Borehole C1-3, water level was recorded at a depth of 0.9 m below the ground surface or at El. 375.6 m. From these observations, the groundwater level at the time of our investigation was at about 1 m below the ground surface or between Elevations 375.6 and 375.0 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.

## 4.2 CULVERT REPLACEMENT AT STATION 21+809 (C2)

The existing culvert at Station 21+807 is a 0.914 m diameter, 25 m long CSP (corrugated steel pipe) culvert, with an invert at El. 382.0 m (on the east side) to 379.7 m (on the west side). The new culvert will be located at Station 21+809.5 m (immediately adjacent to the existing culvert).

The field investigation for the new culvert consisted of three sampled boreholes put down at the locations shown on the Borehole Location Plan, Drawing Nos. 2A and 2B in Appendix A2. Borehole C2-2 was drilled from the left shoulder of the highway, while Boreholes C2-1 and C2-3 were put down from the bottom of the highway embankment immediately adjacent to the toe, from the original ground (o.g.) levels on the left and right sides, respectively. Records of Borehole Sheets are presented in Appendix A2.

Boreholes C2-2 and C2-3 were advanced using truck-mounted and track-mounted drilling rigs, respectively while Borehole C2-1 had to be put down using manual drilling methods due to inaccessibility with a conventional drill rig. Manual drilling consisted of driving a conventional 51 mm O.D. split-spoon sampler into the ground using a 31.8 kg hammer (instead of the conventional 63.56 kg hammer). The number of blows required to advance the sampler into the undisturbed ground was counted and recorded. After 0.6 m penetration, the sampler was withdrawn and sample which was retrieved was examined and logged. The sampler was then put back into the hole and driven another 0.6 m. This was continued until refusal to penetration at 3.0 m below the ground surface. The number of blows of the hammer to drive the sampler by 0.3 m into the ground was divided by two (since the weight of the hammer is one-half of the conventional hammer) in order to obtain a resistance value approximately equivalent to the N-value obtained in the Standard Penetration test. These values are shown on the Record of Borehole C2-1, as equivalent N-values.

Borehole C2-2 which was put down from the shoulder of the highway, contacted a granular embankment fill to a depth of 3.4 m. Between 3.4 and 4.3 m, the material changed to silty sand to sandy silt with clayey silt zones. Due to the presence of some topsoil and wood below about 4.0 m depth, this material was identified as probable fill.

Underlying the fill and material identified as possible fill in Borehole C2-2 and surficial topsoil in Boreholes C2-1 and C2-3, the boreholes contacted glacial till deposits with some silt and gravelly sand layers.

### 4.2.1 EMBANKMENT FILL

Borehole C2-2 was drilled from the shoulder of the highway from near the existing culvert and this borehole encountered a granular fill to a depth of 3.4 m. The granular fill consists of sand & gravel at top and primarily sand with some gravel below. A 0.1 m thick asphaltic

concrete layer/slab was contacted at 0.45 m depth. The presence of occasional topsoil inclusions was also noted below about 3.0 m depth.

Standard Penetration tests, performed in the granular fill deposit below 1.5 m depth, yielded N-values of between 21 and 64 blows for 0.3 m penetration and based on this, the fill appears to have received systematic compaction when it was first placed. The N-values indicate a compact to very dense density.

Underlying the granular fill, in Borehole C2-2, mixed soil conditions were encountered from 3.4 to 4.3 m below the ground surface or between El. 381.1 and 380.2 m, where the soil consists of primarily silty sand to sandy silt with traces of gravel and some clayey silt zones. In addition a topsoil layer/pocket was contacted at 4.0 m depth. From this and from its dark brown to brown colour, the soil in this zone is described as probable fill material. The deposit is considered to be a basically granular soil with cohesive zones. Based on an N-value of 8 blows/0.3 m, it is described as loose to firm. The grain-size distribution of a sample from this deposit is given in Figure B2-1 of Appendix B2.

#### 4.2.2 TOPSOIL

Boreholes C2-1 and C2-3, drilled from the o.g. levels near the toe of the highway embankment, contacted a 0.1 m to 0.3 m thick topsoil layer.

It should be pointed out that in our experience the thickness of topsoil and organic rich soils can be variable in between and beyond the borehole locations, especially near water courses and low-lying areas.

#### 4.2.3 CLAYEY SILT TO SILTY CLAY TILL

In Borehole C2-3, the topsoil is underlain by a 1.6 m thick layer of cohesive glacial deposit, consisting of clayey silt to silty clay till. This deposit was found to extend to 1.7 m depth or to El. 381.3 m. The material consists of a heterogeneous mixture of clayey silt to silty clay with traces to some sand and gravel. The grain-size distribution of a sample from this deposit was determined in the laboratory and the resulting curve is given in Figure B2-2 in Appendix B2. The following grain-size distribution is indicated.

Gravel:	2%
Sand:	12%
Silt:	49%
Clay:	37%

Based on this and a visual examination of the soil samples, the deposit can be expected to be practically impervious. Due to their mode of deposition the presence of cobbles and

boulders can be expected in the glacial deposits. From the recorded N-values of 9 and 14 blows/0.3 m, the consistency of this cohesive soil is described as stiff.

#### 4.2.4 SILT

The cohesive till contacted in Borehole C2-3, described the preceding section of this report, is underlain by a 1.3 m thick silt layer. The silt was encountered at a depth of 1.7 m (El. 381.3 m) and was found to extend to 3.0 m or El. 380.0 m. This deposit is a borderline material between a fine-grained granular soil and a cohesive soil, but more akin to a cohesive material. In addition, it contains occasional very thin clay interbeds. N-values of 10 and 47 blows/0.3 m were recorded and from this the consistency of deposit is described as stiff near the top, changing to hard with increased depth.

#### 4.2.5 SILTY SAND TO SANDY SILT TILL

Underlying the topsoil in Borehole C2-1, embankment fill in C2-2 and clayey till and silt deposits in Borehole C2-3, all three boreholes contacted a glacial deposit consisting of silty sand to sandy silt till, at depths 0.3 m to 4.3 m below the ground surface or below Elevations ranging from 380.2 m to 379.4 m. This deposit extends to the full depth of all three boreholes. The till consists of a heterogeneous mixture of silty sand to sandy silt with some gravel and traces of clay size particles. The presence of cobbles and boulders was also inferred during drilling. In any event, the presence of cobbles and boulders should always be anticipated in the glacial till deposits due to their mode of deposition. The presence of gravelly sand and sand seams/layers was noted. The grain-size distribution of a sample is given in Figure No. B2-3 and B2-4 in Appendix B2.

The deposit is a basically granular (non-cohesive) material. Natural moisture contents measured on samples from the deposit typically range from 6 to 12%.

Standard Penetration tests performed in this deposit in Boreholes C2-2 and C2-3 yielded N-values which ranged from 30 blows/0.3 m to typically in excess of 50 blows/0.15 m penetration. These results indicate a dense to very dense but generally very dense relative density.

In Borehole C2-1 in the upper 2± metres of the deposit the recorded equivalent N-values range from 8 to 28 blows/0.3 m. These values indicate a loose to compact relative density. Below about 2.3 m depth, however, an equivalent N-value of 110 blows/0.3 m was recorded which indicates a very dense condition near the bottom of borehole (i.e. from a depth of about 2.5 m to 3.0 m or between El. 377.2 and 376.7 m). This manually drilled borehole was terminated at 3.0 m depth due to spoon refusal, probably on a cobble or boulder.

#### 4.2.6 GROUNDWATER CONDITIONS

A free-standing water level was recorded in Borehole C2-1 at a depth of 0.8 m (El. 378.9 m) upon completion. In Borehole C2-2 which was drilled from the shoulder of the highway, no free standing water was recorded upon its completion. However, this is a short-term condition and does not represent stabilized conditions. A piezometer was installed in Borehole C2-3 and in this borehole the groundwater was recorded at a depth of 2.4 m below the ground surface or at El. 380.9 m, about six weeks after completion.

Based on these observations, the groundwater level at the site is likely to range from about El. 381. m on the east side to about 379 m on the west side of the road and would be influenced by the level of water in the water course. As well, seasonal fluctuations in the groundwater level can be anticipated, including fluctuations in response to major weather events.

#### 4.3 CULVERT REPLACEMENT AT STATION 23+793 (C3)

Based on the information provided to us by UMA, the existing culvert is a corrugated steel pipe arch (CSPA), approximately 1.5 m wide, 1.2 m high (inside dimensions) and 22.8 m long. The existing culvert invert is at El. 373.41 m (upstream) and at El. 373.32 m (downstream).

The original TOR in the RFP contemplated the replacement of the existing CSPA culvert at Sta. 23+793 with a new culvert. Based on the latest UMA 30% Design Drawings, the new culvert will be significantly larger, 3.0 m wide and 1.8 m high. It will be installed at approximately the same invert elevations as the existing culvert.

For design of the proposed culvert replacement, three boreholes (C3-1, C3-2 and C3-3) were drilled at this site along the existing culvert. Borehole C3-1 was advanced on the left (west) side of Highway 6 near the downstream-end of the existing culvert, as shown on the Site Plan and profile (Drawing Nos. 3A and 3B in Appendix A3). Boreholes C3-2 and C3-3 were drilled on the right (east) side of the highway, on the east shoulder and close to the upstream end of the culvert, respectively.

Details of the subsurface conditions encountered in the boreholes are shown on the Record of Borehole Sheets presented in Appendix A3. The following paragraphs are only meant to complement and amplify these data.

Below the embankment fill and topsoil/organic silt, these boreholes encountered native gravelly sand to silty sand and/or silty sand to sandy silt till with intermittent sand & gravel seam extending to the termination of the boreholes (up to a maximum depth of 9.2 m or El. 366.1 m in Borehole C 3-2).

##### 4.3.1 TOPSOIL/PEATY ORGANIC SILT

At the locations of Borehole C3-1 and C3-3 near downstream and upstream ends of the existing culvert, a topsoil/peaty organic silt layer was contacted at the ground surface. The thickness of this organic layer was about 0.3 and 0.15 m, respectively. In addition, an organic silt layer (about 0.2 m in thickness) was contacted below the embankment fill in Borehole C 3-2.

The natural moisture content of a surficial sample of topsoil/organic silt was measured at 38%.

#### 4.3.2 EMBANKMENT GRANULAR FILL

Borehole C3-2, drilled on the right shoulder of the highway, contacted 2.1 m granular fill material extending to about El. 373.2 m. The embankment fill primarily consist of sand and gravel.

Standard Penetration test performed in the fill material below 1.5 m depth yielded a N-value of 15 blows/0.3 m, indicating compact condition.

The measured moisture contents of the embankment fill material range from 2 to 6%.

#### 4.3.3 GRAVELLY SAND TO SILTY SAND

Underlying the surficial soils (topsoil or embankment fill and organic silt materials) described in the preceding paragraphs, Boreholes C3-2 and C3-3 contacted a granular deposit consisting of gravelly sand to silty sand. This deposit was found to extend to depths of about 2.1 m (El. 371.5 m) and 5.2 m (El. 370.1 m), in Boreholes C3-3 and C3-2, respectively. This deposit was generally grey and moist to wet.

Grain size analysis tests performed on two samples of the upper portion of this deposit (C3-2/SS4 and C3-3/SS2) yielded the following grain-size distribution, as shown in Figure B3-1 in Appendix B3.

Gravel:	28 and 32%
Sand:	70 and 55%
Silt and Clay:	2 and 13%;

Therefore, the tested material is described as gravelly sand, a coarse-grained granular (i.e. non-cohesive) deposit. It may be of interest that the tested sample from Borehole C3-3/SS2 meets the gradation requirements for Granular 'B'.

The measured natural moisture contents of this granular deposit range from 12 to 13%.

Standard Penetration tests performed in this granular deposit yielded N-values ranging from 11 to 34 blows/0.3 m, indicating a compact to dense but generally compact condition.

#### 4.3.4 SILTY SAND TO SANDY SILT TILL

Below surficial topsoil in Borehole C 3-1 and embankment fill and gravelly sand to silty sand deposit in Boreholes C 3-2 and C3-3, a glacial silty sand to sandy silt till deposit with occasional cobbles/boulders was encountered extending to the termination of all three boreholes (i.e., to 7.8 to 9.2 m depth or El. 366.1 to 365.4 m and possibly beyond). The presence of some clayey or silty seams was noted in the upper part of this deposit (e.g., in Borehole C 3-2 and C 3-3 up to about El. 369.5 m).

In addition, occasional wet sand/sand & gravel seams were found in this glacial till deposit in the boreholes. For example, a significant water bearing sand and gravel layer (about 1.9 m in thickness) was found in Borehole C3-1, as described in Section 4.3.5.

Standard penetration tests performed in this granular deposit yielded N-values ranging from 16 blows/0.3 m to 80 blows/0.25 m, indicating a compact to very dense but a typically dense to very dense condition.

The measured natural moisture contents of soil samples recovered from this deposit range from 8 to 21% but generally from 8 to 14%. It should be noted that higher measured natural moisture contents ranging from 17 to 21% generally correspond to more silty/clayey seams.

#### 4.3.5 SAND & GRAVEL

At the location of Borehole C3-1, a water bearing (wet) sand and gravel layer was encountered within the glacial till deposit at about 5.2 m depth (El. 368.3 m) extending to about 7.1 m depth (El. 366.4 m).

Standard penetration tests performed in this deposit yielded N-values of 42 blows/0.3 m and 50 blows/0.14 m, indicating dense to very dense condition.

#### 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, piezometers were installed in Boreholes C3-1 and C3-3 to allow ground monitoring over prolonged period of time. The groundwater observations during our investigation are presented on the individual Record of Borehole sheets in Appendix A3.

The results indicate that at the time of our investigation the groundwater level in sealed piezometers in Boreholes C3-1 and C3-3 (adjacent to the existing culvert) was recorded at 0.4 and 0.5 m below the ground surface, or at El. 373.6 and 373.2 m, respectively. The observed water level during drilling in Borehole C3-2 (through the highway embankment) was found to be lower at about El. 371.6 m. However, this water level does not represent a stabilized condition.

Based on these observations at the time of our investigation, the groundwater level at the site was at about 0.4 to 0.5 m below o.g. levels or at about El. 373.6 to 373.2 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.

#### 4.4 CULVERT REPLACEMENT AT STATION 24+482 (C4)

The existing CSP culvert at Station 24+482 is 914 mm in diameter and about 23 m in length with the culvert invert elevation at 381.86 to 381.90 m.

At this location, three boreholes were drilled for the proposed culvert replacement. Borehole C4-1 was put down near the west-end (downstream) of the existing culvert, while Boreholes C4-2 and C 4-3 were drilled on the west shoulder of the highway and near the east-end (upstream) of the existing culvert, respectively, as shown on Drawing Nos. 4A and 4B in Appendix A4.

Below some granular embankment fill (Borehole C4-2) and surficial topsoil and slightly organic silt, the boreholes show, in general, the presence of sandy silt to silty sand glacial till with some sand layers.

Details of the stratigraphy encountered in the boreholes are given on the Record of Boreholes in Appendix A4. The following paragraphs are only meant to amplify and complement these data.

##### 4.4.1 GRANULAR FILL

Borehole C4-2, which was put down on the left shoulder of Highway 6, contacted a 0.4 m thick layer of sand & gravel pavement fill underlain by sand fill with some gravel to a depth of 2.2 m.

A Standard Penetration test, performed at a depth of 1.5 m below the ground surface, yielded an N-value of 23 blows/0.3 m. Based on this, the relative density of the lower portion of the granular embankment fill is described as compact.

##### 4.4.2 TOPSOIL

Boreholes C4-1 and C4-3, drilled from beyond the toe of the highway embankment (i.e. from the o.g. level), contacted a 0.2 m to 0.13 m thick topsoil layer, respectively.

It should be pointed out that, in our experience, the thickness of topsoil and other organic soils can be expected to be variable, especially in low-lying areas and near water courses.

An approximately 0.2 to 0.3 m thick organic rich layer of soil (possibly original topsoil) was also encountered in Borehole C4-2 below the granular embankment fill at depth of 2.2 m (El. 381.9 m).

#### 4.4.3 SILT

Underneath the topsoil described in the preceding paragraph, Boreholes C4-1 and C4-3 contacted a surficial alluvial silt layer which extended to a depth of 0.7 m below the ground surface at both borehole locations (El. 382.2 and 381.7 m, respectively). From its darkish colour, relatively high natural moisture contents of 22 to 32%, this surficial fine-grained granular deposit is believed to have a slight organic content.

N-values recorded in this surficial unit are 7 and 13 blows/0.3 m which indicates a loose to compact condition.

#### 4.4.4 SAND

Underlying the granular pavement fill and a possible original organic rich soil layer, Borehole C4-2 contacted a sand to silty sand deposit at a depth of about 2.2 m below the ground surface or at about El. 381.9 m. This is a granular soil and was identified as a possible till deposit. Based on the recorded N-values its relative density is described as compact to dense.

In Borehole C4-3, sand with some gravel and traces of silt was encountered underlying glacial till at 7.1 m below the ground surface or below El. 375.3 m. This borehole was terminated in this sand deposit after penetrating it a vertical distance of 0.8 m. An N-value of 50 blows per 8 cm penetration was recorded on this granular (non-cohesive) deposit, indicating a very dense condition.

#### 4.4.5 SANDY SILT TO SILTY SAND TILL

At a depth of 0.7 m in Boreholes C4-1 and C4-3 (at Elevations 382.2 and 381.7 m, respectively) and at 4.0 m depth (El. 380.1 m) all three boreholes contacted a relatively fine-grained granular till deposit which consists of a heterogeneous mixture of sandy silt to silty sand with traces of gravel and clay size particles. This is the predominant soil unit underlying the site and extends to the full depth of Boreholes C4-2 and C4-1 (i.e. to depths of 6.3 and 7.8 m or El. 377.9 and 375.1 m, respectively). In Borehole C4-3, the glacial till extends to 7.1 m depth (El. 375.3 m) and is underlain by a relatively coarser sand deposit to the full depth of the borehole.

The grain-size distribution of two samples from the glacial till deposit is given in Figure B4-1, in Appendix B4. These show the following grain-size distribution:

Gravel:	5 – 12%
Sand:	41-46%
Silt:	34-53%
Clay:	1 – 8%

Due to their mode of deposition, the presence of cobbles and boulders should always be anticipated in the glacial till deposits.

The measured natural moisture contents of the deposit range from 7 to 24% indicating a damp to wet condition. Standard Penetration tests performed in the deposit yielded N-values which range from 7 blows/0.3 m to in excess of 50 blows/0.15 m. These results indicate a loose to very dense material. The relatively low N-values were generally recorded in the upper portions of the deposit, while the lower portions appear to be typically very dense.

#### 4.4.6 GROUNDWATER CONDITIONS

The groundwater level observations and recorded water levels in the open boreholes as well as in the piezometers installed in Boreholes C4-1 and C4-3 are given on the individual Record of Borehole sheets in Appendix A4.

Upon its completion in Borehole C4-3, no free-standing water was recorded in the open hole. Subsequent observations showed no groundwater in the piezometer installed. This shows that the groundwater level in this borehole was below a depth of 7.9 m or below El. 374.4 m. In Borehole C4-1, a water level was recorded at 7.3 m (El. 375.5 m) and water level remained at approximately this level in the piezometer installed. In Borehole C4-2 a free-standing water level was recorded at 4.1 m below the road shoulder level or at El. 380.1 m upon the completion of the borehole.

From these observations, it our opinion that the groundwater level at the time of our investigation was at between El. 375 and 376 m, but from the short-term observations made in Borehole C4-2 and the moisture contents of the samples, it is our opinion that a perched groundwater level existed due to the accumulation of surface water in the relatively more pervious embankment fill and the underlying sandy deposit in Borehole C4-2. Relatively higher natural moisture contents of the near surface samples in the other two boreholes lead us to believe that perched water conditions are likely to have existed in the past at the other borehole locations, as well.

In summary, therefore, in our opinion that at the time of our investigation the groundwater level at the site was between El. 374 and 376 m, but perched water conditions can be expected. In addition, the groundwater table would be subject to seasonal fluctuations and variations in response to major weather events as well as the water levels in the water course.

#### 4.5 CULVERT REPLACEMENT AT STATION 27+065 (C7)

At Station 27+065, the existing culvert is a corrugated steel pipe (CSP) about 1.5 m in diameter and approximately 22 m in length. Its invert is at El. 357.46m at its east end and 357.55 m at its west end.

Three boreholes were drilled for this culvert replacement. Boreholes C7-1 and C7-3 were put down near the existing culvert ends on the left (west) and right (east) sides of highway respectively, while Borehole C7-2 was advanced on the left shoulder of the highway, as shown on Drawing Nos. 7A and 7B, in Appendix A5.

Borehole C7-2 was located on the shoulder of the highway and contacted fill material which extends to a depth of approximately 2.8 m below the ground surface to El. 356.4 m. Boreholes C7-1 and C7-3, which were put down beyond the bottom of the existing highway embankment at the o.g. levels, contacted topsoil which extended 0.3 m and 0.6 m respectively below the ground surface.

In general below the fill and topsoil, the boreholes contacted silty sand to sandy silt till and silty sand to sandy silt deposits.

##### 4.5.1 GRANULAR EMBANKMENT FILL

Borehole C7-2, which was drilled from the left shoulder of the highway, contacted embankment fill which extended to 2.2 m below the top of the shoulder or to El. 357.0 m. The embankment fill at this location was found to consist of sand and gravel with traces to some silt near the top and bottom of the embankment and sand with some gravel and silt within the middle portion.

The grain-size distribution of a sample obtained from the bottom portion of the fill is presented in Figure B7-1, in Appendix B5. The following grain-size distribution is indicated.

Gravel	43%
Sand	40%
Silt and Clay	17%

This particular sample was found to emit a hydrocarbon odour. A Standard Penetration test performed on this bottom section of the embankment fill, yielded an N-value of 9 blows /0.3 m which indicates that the embankment fill at this depth at the borehole location is in a loose condition.

The measured natural moisture contents of the removed samples ranged from 4% near the top and middle to 11% in the lower portion.

From 2.2 m to 2.8 m below the ground surface (i.e. from El. 357.0 to 356.4 m) the soil encountered in Borehole C7-2 was identified as a granular material (i.e. primarily a gravelly sand soil) and as a probable fill.

#### 4.5.2 TOPSOIL

Boreholes C7-1 and C7-3, which were put down from the bottom of the highway embankment, contacted a topsoil layer of a depth approximately 0.3 m and 0.6 m respectively below the ground surface or to El. 357.9 and 357.3m. The topsoil layer in Borehole C7-3 was found to be a peaty material.

#### 4.5.3 SURFICIAL SILTY SAND TO SANDY SILT

The topsoil in Borehole C7-1 is underlain by a 1.2 m thick layer of fine-grained granular soil which consists of fine sand and silt with traces of gravel and organics. Because of its organic content and relatively disturbed condition it was identified as possible fill or an alluvial soil. This layer extends to 1.5 m below the ground surface or to El. 356.7 m.

N-values recorded in this unit are 7 and 9 blows /0.3 m which indicate a loose condition.

#### 4.5.4 SILTY SAND TO SANDY SILT TILL

Underlying the surficial soils encountered in the preceding paragraphs, all three boreholes contacted a glacial deposit which consists of a heterogeneous mixture of sand and silt with some gravel and traces of clay size particles. This deposit was contacted at depths of 0.6 m (Borehole C7-3) to 2.8 m (Borehole C7-2) below the ground surface or at El. 357.3 to 356.4 m and extended to depths of 3.0 to 5.5 m or to El. 354.9 m (Borehole C7-3) to 353.7 m (Boreholes C7-1 and C7-2), where it is underlain an interglacial deposit of silty sand to sandy silt. A lower till layer was contacted in Borehole C7-3 at 6.9 m (El. 351.0 m) and extended to the termination of the borehole at 8.1 m depth.

The grain-size distribution of a sample from the upper zones of this basically granular glacial deposit is given in Figure B7-2 in Appendix B5. The curve indicates the following grain-size distribution.

Gravel	36%
Sand	40%
Silt	20%
Clay	5%

N-values recorded in the deposit range from 4 blows/0.3 m to 50 blows/0.14 m. These results indicate a very loose to very dense but generally compact to dense relative density.

#### 4.5.5 SILTY SAND TO SANDY SILT

Underlying the upper glacial till deposit all three boreholes contacted a fine grained granular interglacial deposit which consists of silty sand to sandy silt. This deposit was contacted at depths ranging from 3.0 to 5.5 m below the ground surface or at El. 354.9 to 353.7 m and extended to the full depth of Boreholes C7-1 and C7-2 (i.e. 8.1 and 9.6 m respectively) and to a depth of 6.9 m (El. 351.0 m in Borehole C7-2, where it is underlain by glacial till).

The grain-size distribution curve for a sample from the deposit is given in Figure B7-3 in Appendix B5, which shows the following particle sizes.

Gravel	2%
Sand	35%
Silt	57%
Clay	6%

The natural moisture contents of the samples from the deposits are typically 15-18% as opposed to the overlying glacial till which are typically 8-10%.

From the recorded N-values which range from 28 blows for 0.3 m penetration to 50 blows for 0.15 m penetration, the relative density of the deposit is described as compact to very dense but generally dense to very dense.

#### 4.5.6 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 C7-1 and C7-3 to allow ground monitoring over a prolonged period of time, without interference from surface water. The observations and recorded values are shown on the individual Record of Boreholes sheets presented in Appendix A5.

The observations indicate that at the completion of Boreholes C7-1 and C7-3 the water level was recorded at 0.5m below the ground surface. Approximately five weeks thereafter the water levels in the piezometers rose to 0.2 m below the ground surface or El. 358.0 m and 357.7m respectively. From these observations, the groundwater level at the time of our investigation was at approximately 0.2 m below the ground surface or between El. 358.0 and 357.7 m.

It should however 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.

#### 4.6 CULVERT REPLACEMENT AT STATION 28+299 (C8)

At this location, the existing culvert is a corrugated steel pipe (CSP) about 0.9 m in diameter and approximately 40 m in length. The invert elevation of the existing culvert is at El. 334.14 m (upstream) and El. 334.13 m (downstream).

For this culvert replacement, three boreholes (C8-1, C8-2 and C8-3) were drilled through the existing embankment. The boreholes were put down on or near the shoulder of the highway both on the left (west) and right (east) sides of highway, as shown on Drawings No. 8A and 8B. Boreholes C8-1 and C8-3 could not be located closer to the inlet and outlet of the existing culvert due to access restrictions.

As shown on the Record of Borehole Sheets in Appendix A6, all three boreholes contacted embankment fill materials extending to depths ranging from about 2.1 to 2.9 m below the ground surface (down to El. 333.4 m in Borehole C8-3). Below the embankment fill, the boreholes contacted native granular deposits consisting of primarily sand and gravel (except for the upper 1.8 m of silty sand in Borehole C8-3) to the termination of all the boreholes.

##### 4.6.1 TOPSOIL

Borehole C8-3 put down beyond the gravel shoulder of the existing highway contacted 0.3 m topsoil at the ground surface to El. 336.0 m.

It should be pointed out that the thickness of topsoil and organic soils can be expected to be variable in between and beyond borehole locations, especially near water courses.

##### 4.6.2 EMBANKMENT FILL

All three boreholes contacted embankment fill materials extending to depths ranging from about 2.1 to 2.9 m below the ground surface or to El. 334.1 and 334.2 m in Boreholes C8-2 and C8-1 and to El. 333.4 m in Borehole C8-3. The fill is essentially granular and its composition at the borehole locations ranges from silty sand to sandy silt with traces of gravel and topsoil inclusions (Borehole C8-3 from 0.3 to 1.4 m), silty sand to sand with traces of gravel, clay and topsoil (BH C8-1 from 1.4 to 2.6 m and BH C8-2 from 0.3 to 2.1 m depth) to sand & gravel (BH C8-1 from ground surface to 1.4 m below and BH C8-3 from 1.4 to 2.9 m). The presence of occasional asphalt inclusions was also noted in the sand & gravel fill in BH C8-3. As well, the material in this borehole was found to have some organic soil mixture.

The grain-size distribution curves for two tested samples of the sand & gravel fill are presented in Figure B8-1 in Appendix B6. The following grain-size distribution is indicated:

Gravel:	47 – 54%
Sand:	45 - 53%
Silt and Clay:	0 – 1%

From the grain-size distribution curves, the sand & gravel fill is considered a relatively pervious material.

Standard Penetration tests performed in the fill materials yielded N-values ranging from 5 to 36 blows/0.3 m, indicating loose to dense but generally loose to compact condition.

#### 4.6.3 SILTY SAND

Borehole C8-3 contacted underlying the sand & gravel fill at 2.9 depth (El. 333.4 m), a natural soil deposit consisting of silty sand with traces of gravel and occasional silt pockets extending to 4.7 m depth or El. 331.6 m.

Standard Penetration tests, performed in this basically granular deposit, yielded N-values of 21 and 35 blows/0.3 m, indicating compact to dense condition.

The measured natural moisture contents of the recovered samples from this deposit were 18 and 21%.

#### 4.6.4 SAND & GRAVEL

Underlying the embankment fill and silty sand (in Borehole C8-3 only) described in the preceding paragraphs, all three boreholes contacted a coarse granular deposit consisting of sand & gravel with occasional cobbles and boulders. This deposit was contacted at depths of 2.1 to 4.7 m below the ground surface or at El. 334.2 to 331.6 m and extended to the termination of all boreholes at depths of 5.0 to 7.9 m or to El. 331.3 to 328.4 m.

The measured N-values in this deposit range from 32 blows/0.3m to 100 blows/0.1 m, indicating a dense to very dense but generally very dense condition.

The measured natural moisture contents of samples from the deposit range from 8 to 18% but generally between 8 and 14%.

This deposit was in a wet condition (i.e. water-bearing) and based on a visual examination of the soil samples, it is considered to be a relatively pervious soil. Boreholes C8-1 and C8-2 were terminated in this deposit at depths/elevation of 5.0 m/331.3 m and 6.3 m/330.5 m due to auger refusal possibly owing to the presence of boulders, while Borehole C8-3 was extended to fill borehole depth of 7.9 m (El. 328.4 m) without encountering refusal to augering.

#### 4.6.5 GROUNDWATER CONDITIONS

Groundwater levels in the open boreholes were observed during the drilling and at the completion of each borehole. In addition, a piezometer was installed in Borehole C8-3 to allow ground monitoring over a prolonged period of time, without interference from surface water. The observations and recorded values are shown on the individual Record of Borehole sheets in Appendix A6.

The results indicate that at the time of our investigation, the soil in the boreholes became wet at about 2 m depth or at about El. 334.0 to 334.5 m. Upon completion of drilling, free-standing water was recorded in the sealed piezometer in Borehole C8-3 at 1.8 m or at El. 334.6 m. Subsequent readings in this piezometer over the following two weeks recorded a water level of 1.7 m below the ground surface, or at El. 334.7 m. From these observations, the groundwater level at the time of our investigation was about 1.7 to 2.0 m below the ground surface, or at about El. 334.5 to El. 334.7 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/hd

## Appendix A1

# Drawings & Record of Borehole Sheets for Culvert C1

# METRIC

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

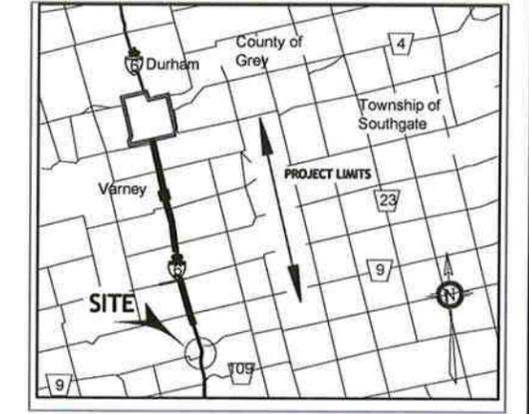
NOTES:  
FOR DETAILED SUBSURFACE CONDITIONS  
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.  
GWP: 338-97-00



Highway 6, Durham  
Culvert C1 @ Sta. 21+204  
BOREHOLE LOCATIONS

## SHAHEEN & PEAKER LIMITED



KEY PLAN  
N.T.S

### LEGEND

No.	ELEV.	CO-ORDINATES	
		NORTH	EAST
C1-1	376.1	4 882 440.1	200 946.4
C1-2	377.8	4 882 441.1	200 953.1
C1-3	376.5	4 882 450.8	200 969.0

### NOTE

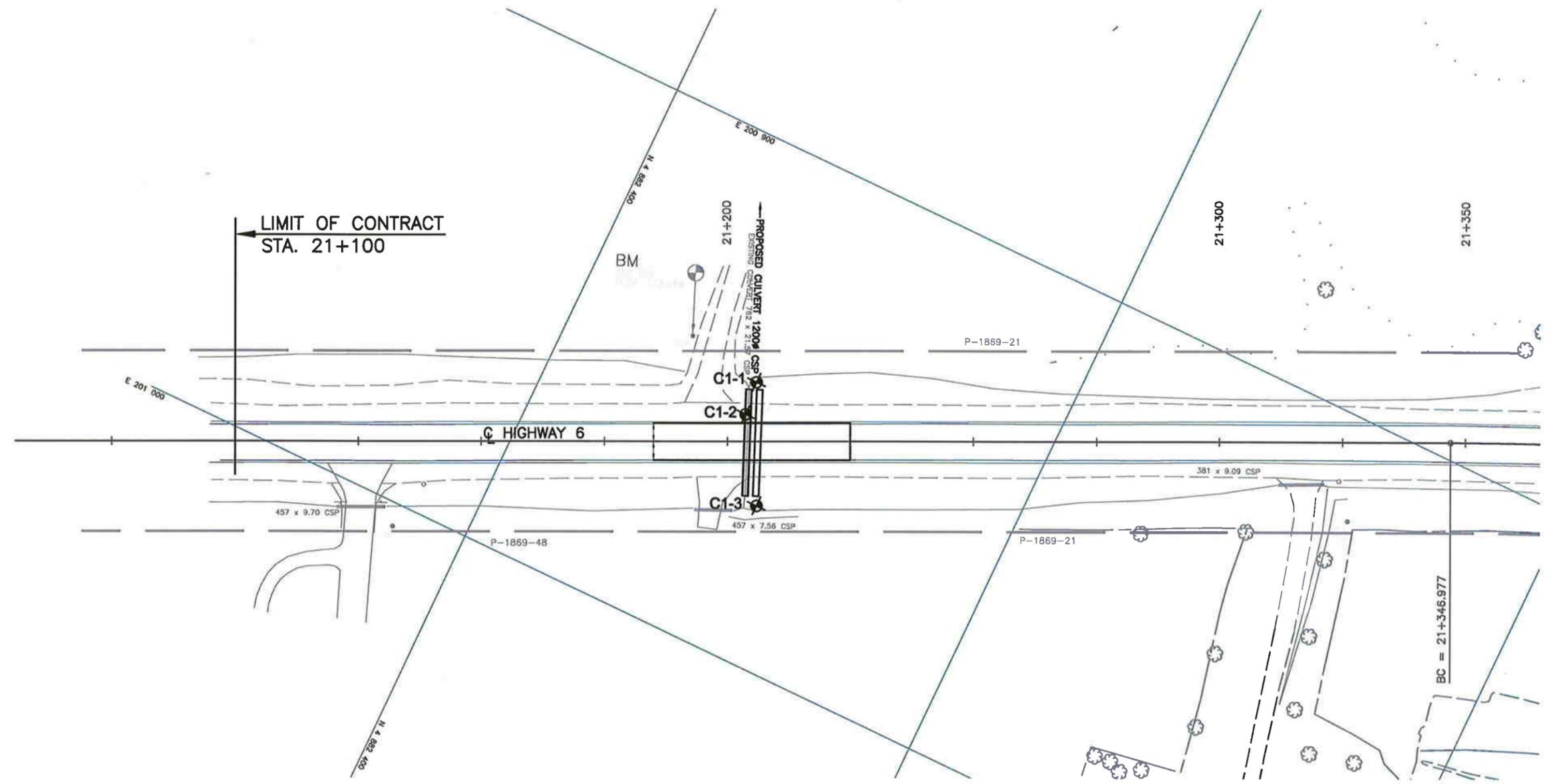
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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-193			
SPT 1174			DIST
SUBM'D	CHECKED	DATE Jan., 2008	SITE
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 1A



PLAN



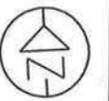
# METRIC

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

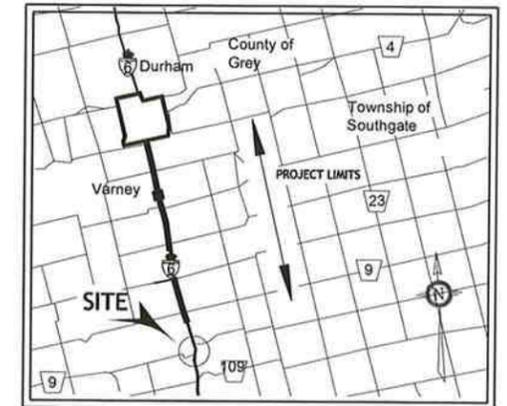
NOTES:  
FOR DETAILED SUBSURFACE CONDITIONS  
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.  
GWP: 338-97-00

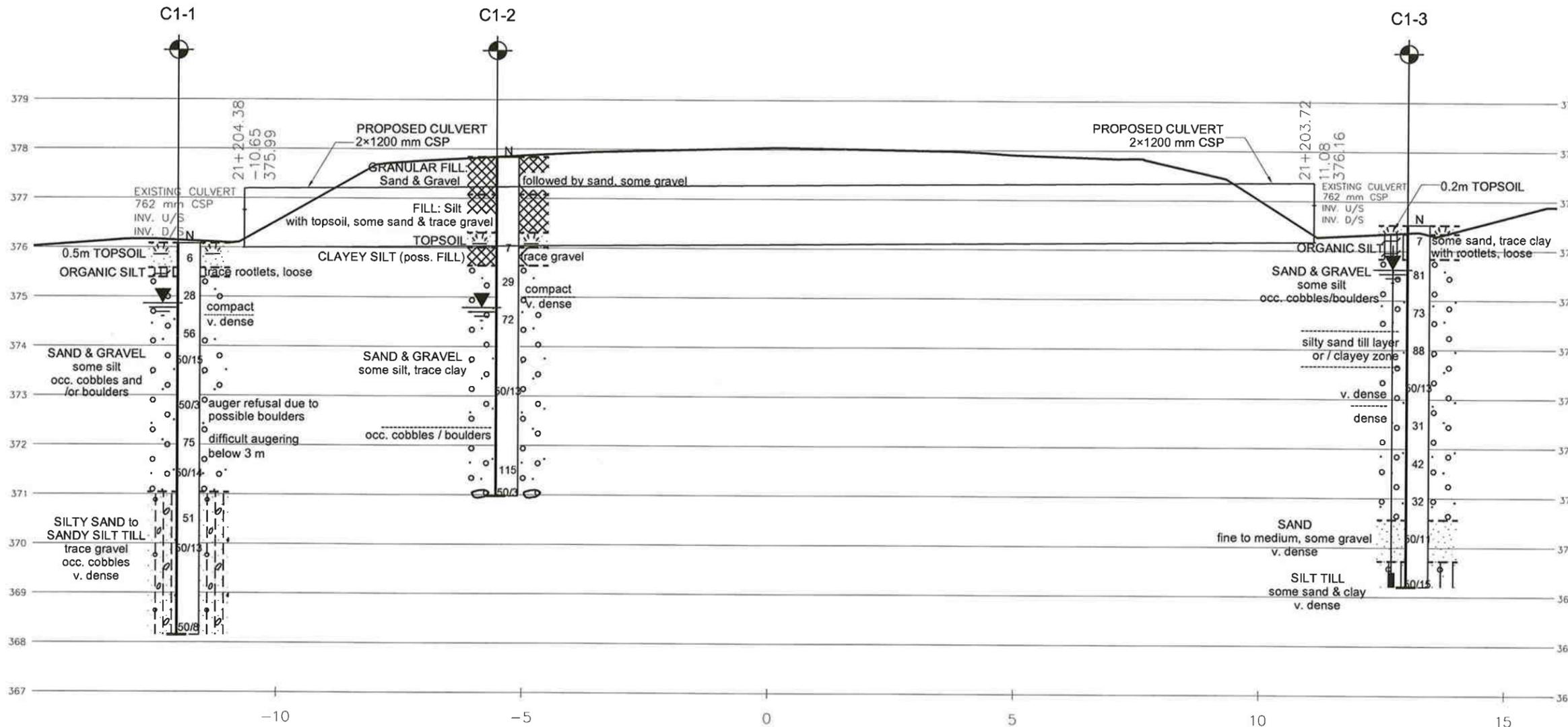
Highway 6, Durham  
Culvert C1 @ Sta. 21+204  
SOIL STRATA



## 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
C1-1	376.1	4 882 440.1	200 946.4
C1-2	377.8	4 882 441.1	200 953.1
C1-3	376.5	4 882 450.8	200 969.0

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

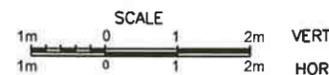
NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

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REV.	DATE	BY	DESCRIPTION

Geocres No. 41A-193

SPT 1174			DIST
SUBM'D	CHECKED	DATE Jan., 2008	SITE
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 1B



STRATIGRAPHIC SECTION ALONG CULVERT C1 @ STA. 21+204



SPT1174

RECORD OF BOREHOLE No C1-1

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 21+206, 12m Lt. C/L ORIGINATED BY JL  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers COMPILED BY HL  
 DATUM Geodetic DATE 10/2/2006 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa							WATER CONTENT (%)						
						20	40	60	80	100	20	40	60	80	100	10	20	30		GR SA SI CL	
376.1 0.0	GROUND SURFACE																				
375.6 0.5	0.5 m TOPSOIL		1	SS	6																
375.4 0.7	ORGANIC SILT trace rootlets, brown, wet to moist, loose		2	SS	28																31 57 (12) wet spoon
	compact		3	SS	56																48 41 (11)
	very dense		4	SS	50/15																
	SAND & GRAVEL some silt occasional cobbles and/or boulders brown, moist to wet		5	SS	50/3																
			6	SS	75																
			7	SS	50/14																
371.0 5.0	SILTY SAND to SANDY SILT TILL trace gravel occasional cobbles brown, moist to wet very dense		8	SS	51																
			9	SS	50/13																
368.1 7.9	End of borehole. * Water level in open borehole at 1.2 m (El. 374.8 m) upon completion (not stabilized). Borehole was relocated by 1m north and redrilled due to possible boulder refusal at 3 m depth.		10	SS	50/8																

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



SPT1174

RECORD OF BOREHOLE No C1-3

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 21+206, 13m Rt. C/L ORIGINATED BY NH  
 DIST          HWY 6 BOREHOLE TYPE Hollow Stem Augers COMPILED BY HL  
 DATUM Geodetic DATE 10/10/2006 CHECKED BY FS

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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	
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
							20	40	60	80	100	PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	
376.5	GROUND SURFACE														
376.0	0.2 m TOPSOIL														
375.8	ORGANIC SILT some sand, trace clay, with rootlets dark brown, loose		1	SS	7										
0.7	SAND & GRAVEL some silt occasional cobbles/boulders brown, wet very dense		2	SS	81										
			3	SS	73										
	silty sand till layer or / clayey zone		4	SS	88										
			5	SS	50/13										
			6	SS	31										
			7	SS	42										
			8	SS	32										
370.6	SAND fine to medium, some gravel brown, wet, very dense		9	SS	50/11										
369.7	SILT TILL some sand & clay, brown, moist, very dense		10	SS	50/15										
369.2															
7.3	End of borehole.  Piezometer installed to depth of 7.3 m. Water level in piezometer: Oct. 10, 2006 ---1.4 m (El. 375.2 m) Nov. 22, 2006 ---0.9 m (El. 375.6 m)														

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

## Appendix A2

# Drawings & Record of Borehole Sheets for Culvert C2

# METRIC

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

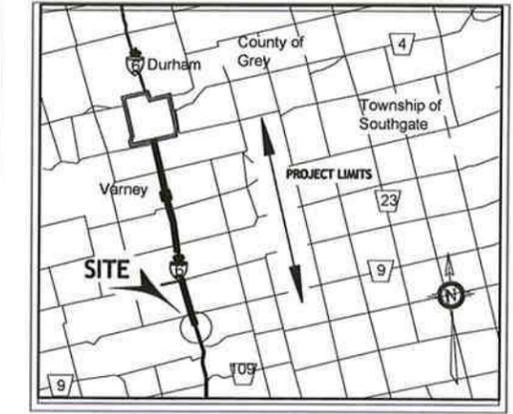
NOTES:  
FOR DETAILED SUBSURFACE CONDITIONS  
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.  
GWP: 338-97-00

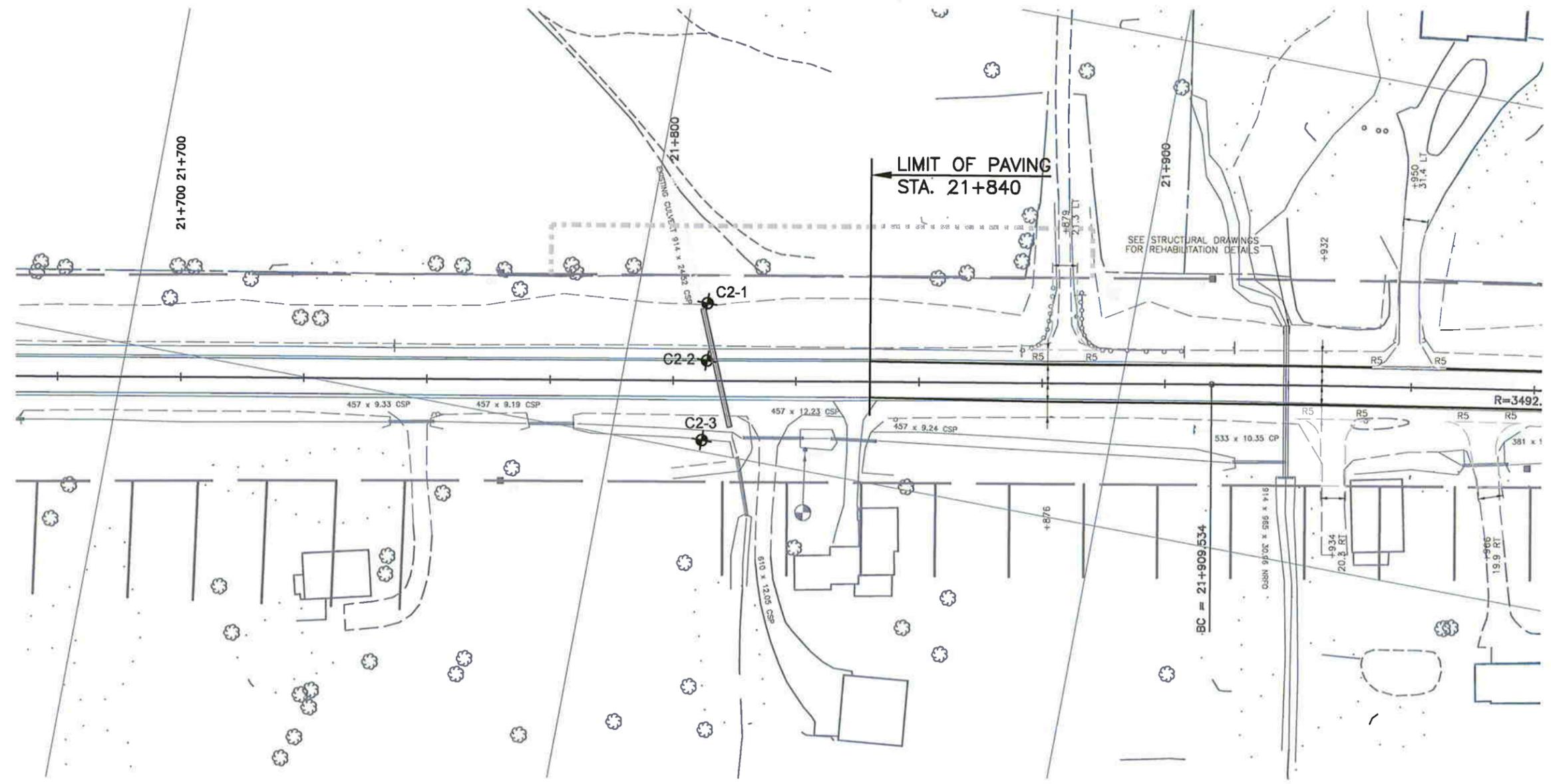
Highway 6, Durham  
Culvert C2 @ Sta. 21+807  
BOREHOLE LOCATIONS



## SHAHEEN & PEAKER LIMITED



KEY PLAN  
N.T.S



### LEGEND

Borehole

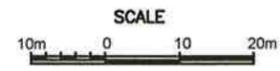
No.	ELEV.	CO-ORDINATES	
		NORTH	EAST
C2-1	379.7	4 883 014.5	200 770.2
C2-2	384.5	4 883 016.5	200 781.6
C2-3	383.0	4 883 018.4	200 797.6

### 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.



PLAN



REV.	DATE	BY	DESCRIPTION

Geocres No. 41A-193			
SPT 1174			DIST
SUBM'D	CHECKED	DATE Jan., 2008	SITE
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 2A

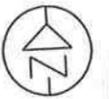
# METRIC

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

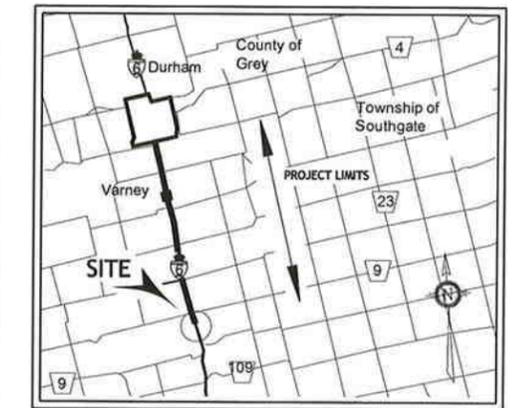
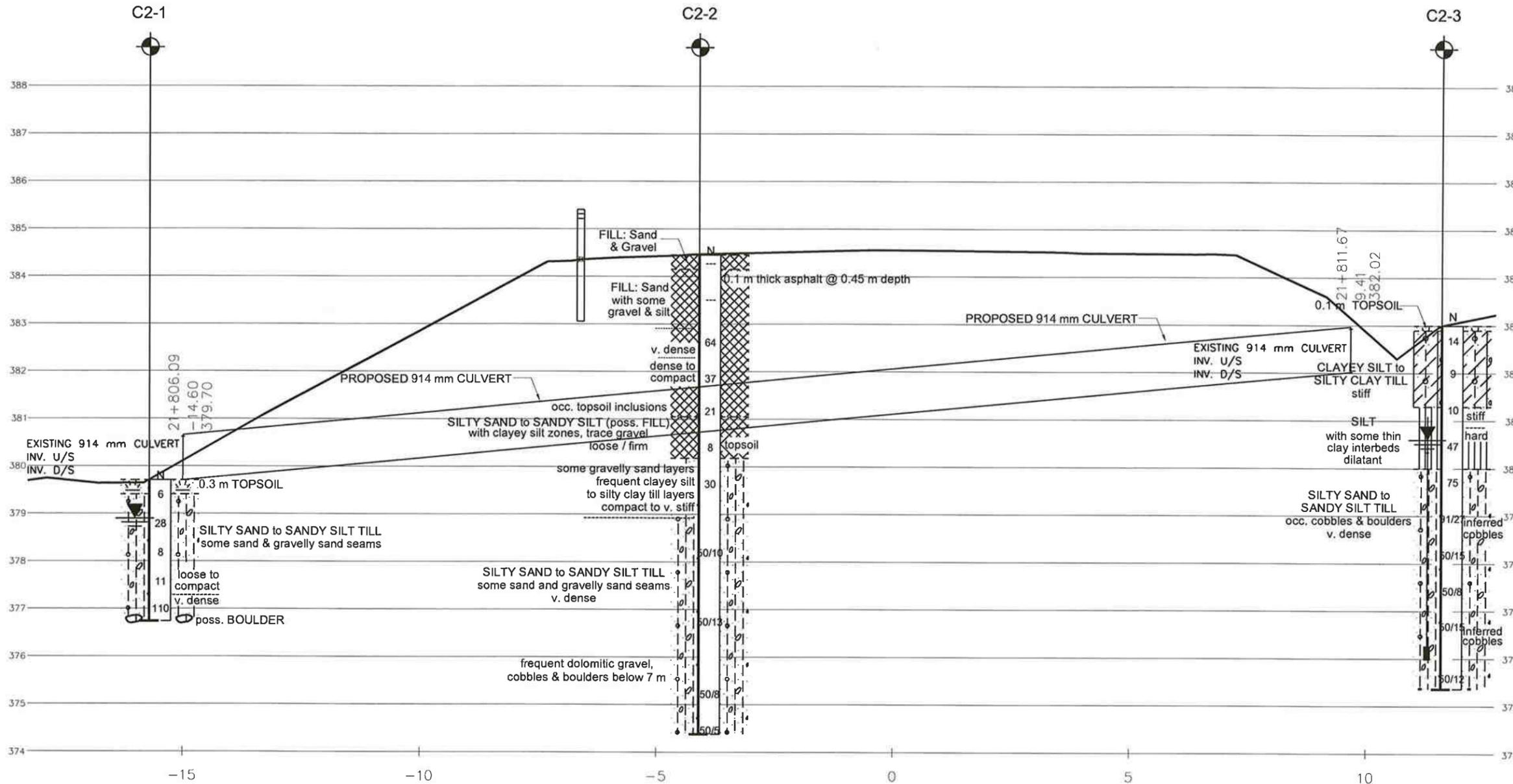
NOTES:  
FOR DETAILED SUBSURFACE CONDITIONS  
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.  
GWP: 338-97-00

Highway 6, Durham  
Culvert C2 @ Sta. 21+807  
SOIL STRATA



## SHAHEEN & PEAKER LIMITED



### 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
C2-1	379.7	4 883 014.5	200 770.2
C2-2	384.5	4 883 016.5	200 781.6
C2-3	383.0	4 883 018.4	200 797.6

**=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.



STRATIGRAPHIC SECTION ALONG CULVERT C2 @ STA. 21+810

REV.	DATE	BY	DESCRIPTION

Geocres No. 41A-193

SPT 1174			DIST
SUBM'D	CHECKED	DATE Jan., 2008	SITE
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 2B

SPT1174

RECORD OF BOREHOLE No C2-1

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 21+807, 15.7m Lt, C/L ORIGINATED BY ZI  
 DIST HWY 6 BOREHOLE TYPE Manual (Hand) Drilling Using 31.8 kg Hammer COMPILED BY XS  
 DATUM Geodetic DATE 12/7/2006 CHECKED BY ZO

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80			100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W
379.7	GROUND SURFACE															
379.2	0.3 m TOPSOIL															
0.3	SILTY SAND to SANDY SILT TILL some sand and gravelly sand seams brown, moist to wet  loose to compact ----- very dense		1	SS	6											
			2	SS	28											20 59 (21)
			3	SS	8											SS3: no recovery
			4	SS	11											
			5	SS	110											
376.7	End of borehole.														spoon refusal @	
3.0	<p>* Water level in open borehole at 0.8 m (El. 378.9 m) upon completion (not stabilized).</p> <p>Borehole caved at 2.3 m depth.</p> <p>** Note: A 31.8 kg hammer was used to obtain N- values. Blow counts were divided by two to obtain an equivalent N- value.</p>															

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

SPT1174

RECORD OF BOREHOLE No C2-2

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 21+807, 4.1m LI, CL  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers  
 DATUM Geodetic DATE 8/24/2006  
 ORIGINATED BY JL  
 COMPILED BY XS  
 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 (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
						20 40 60 80 100	PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>				
							○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE						
384.5	GROUND SURFACE												
384.2	FILL: Sand & Gravel		1	AS	---								
0.3	0.1 m thick asphalt @ 0.45 m depth												
	FILL: Sand with some gravel & silt brown, damp		2	AS	---								
	very dense		3	SS	64								
	dense to compact		4	SS	37								
381.1	occasional topsoil inclusions		5	SS	21								
3.4	SILTY SAND to SANDY SILT (possible FILL) with clayey silt zones, trace gravel brown to dark brown, moist loose / firm		6	SS	8								8 42 37 13
380.2													topsoil @ 4.0 m
4.3	some gravelly sand layers frequent clayey silt to silty clay till layers compact to very stiff		7	SS	30								23 63 (14)
			8	SS	50/10								
	SILTY SAND to SANDY SILT TILL some sand and gravelly sand seams brown, moist to damp very dense		9	SS	50/13								
			10	SS	50/8								
	frequent dolomitic gravel, cobbles & boulders below 7 m												
374.4			11	SS	50/5								
10.1	End of borehole. Borehole dry upon completion.												

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

SPT1174

RECORD OF BOREHOLE No C2-3

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 21+806, 9.5m Rt, C/L ORIGINATED BY NH  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers COMPILED BY HL  
 DATUM Geodetic DATE 10/11/2006 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			20	40	60					
383.0	GROUND SURFACE														
382.6	0.1 m TOPSOIL														
381.3	CLAYEY SILT to SILTY CLAY TILL brown, stiff		1	SS	14										
			2	SS	9									2 12 49 37	
381.3	SILT		3	SS	10										
380.0	with some thin clay interbeds brown, wet, dilatant	stiff hard	4	SS	47										
380.0	SILTY SAND to SANDY SILT TILL occasional cobbles & boulders brown, damp, very dense		5	SS	75										
			6	SS	91/27									inferred cobbles	
			7	SS	50/15										
			8	SS	50/8										
			9	SS	50/15									inferred cobbles	
			10	SS	50/12										
375.4	End of borehole.														
7.6	Piezometer installed to depth of 7.0 m. Water level in piezometer: Oct. 11, 2006 ---4.0 m (El. 379.4 m) Nov. 22, 2006 ---2.4 m (El. 380.9 m)														

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

## Appendix A3

# Drawings & Record of Borehole Sheets for Culvert C3

# METRIC

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

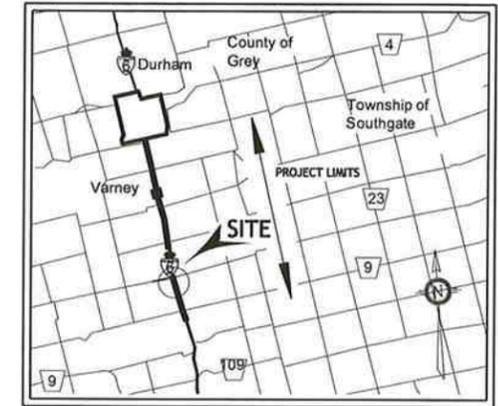
NOTES:  
FOR DETAILED SUBSURFACE CONDITIONS  
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.  
GWP: 338-97-00

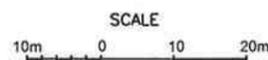
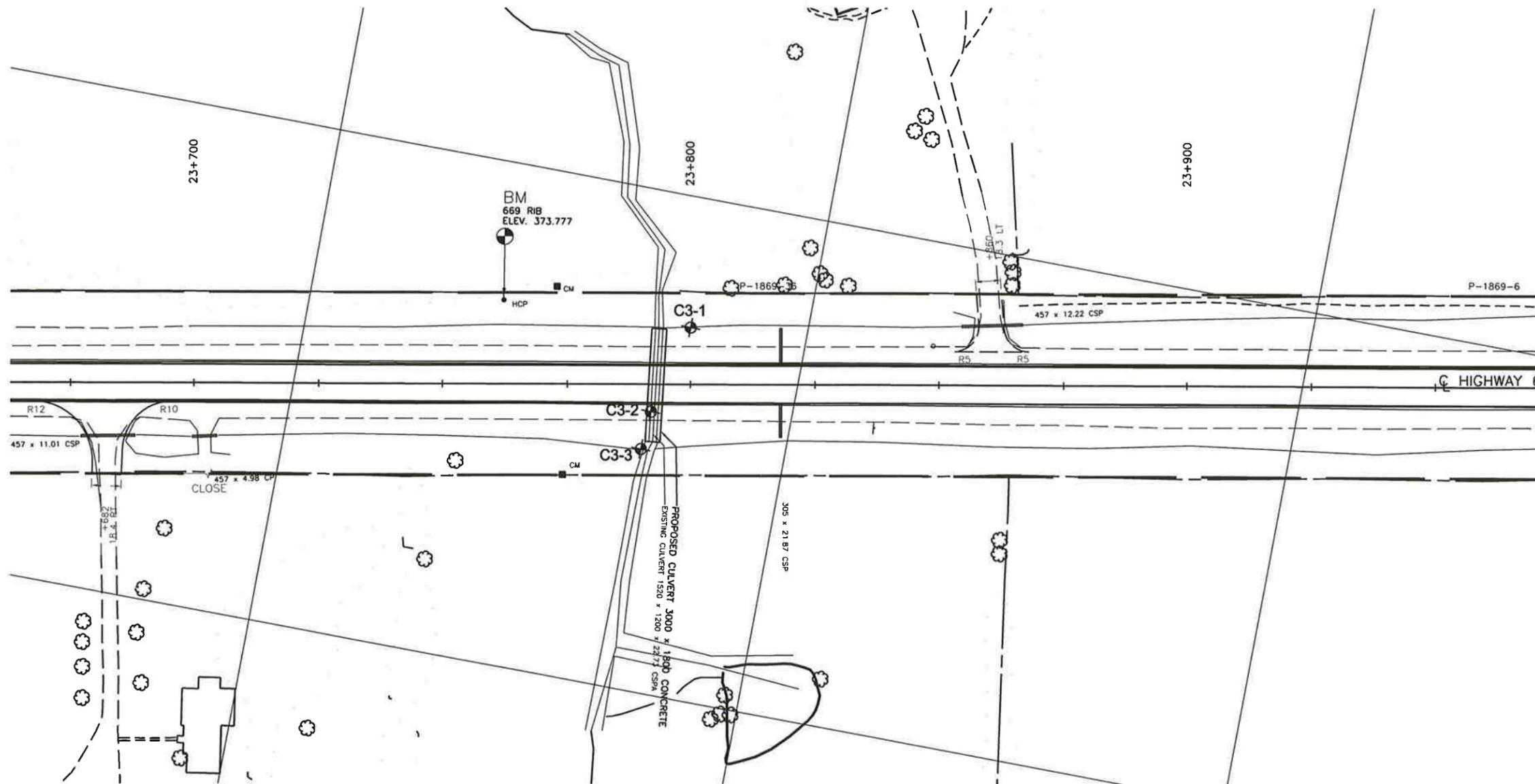
Highway 6, Durham  
Culvert C3 @ Sta. 23+793  
BOREHOLE LOCATIONS



## SHAHEEN & PEAKER LIMITED



KEY PLAN  
N.T.S



PLAN

### LEGEND

Borehole

No.	ELEV.	CO-ORDINATES	
		NORTH	EAST
C3-1	373.5	4 884 976.8	200 426.0
C3-2	375.3	4 884 971.9	200 444.1
C3-3	373.7	4 884 971.3	200 451.8

### 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-193

SPT 1174			DIST
SUBM'D	CHECKED	DATE Jan., 2008	SITE
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 3A

# METRIC

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

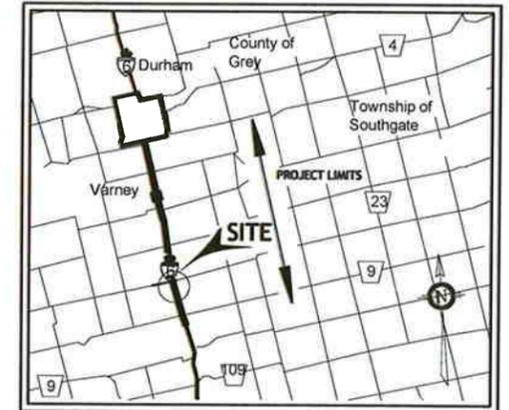
NOTES:  
FOR DETAILED SUBSURFACE CONDITIONS  
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.  
GWP: 338-97-00

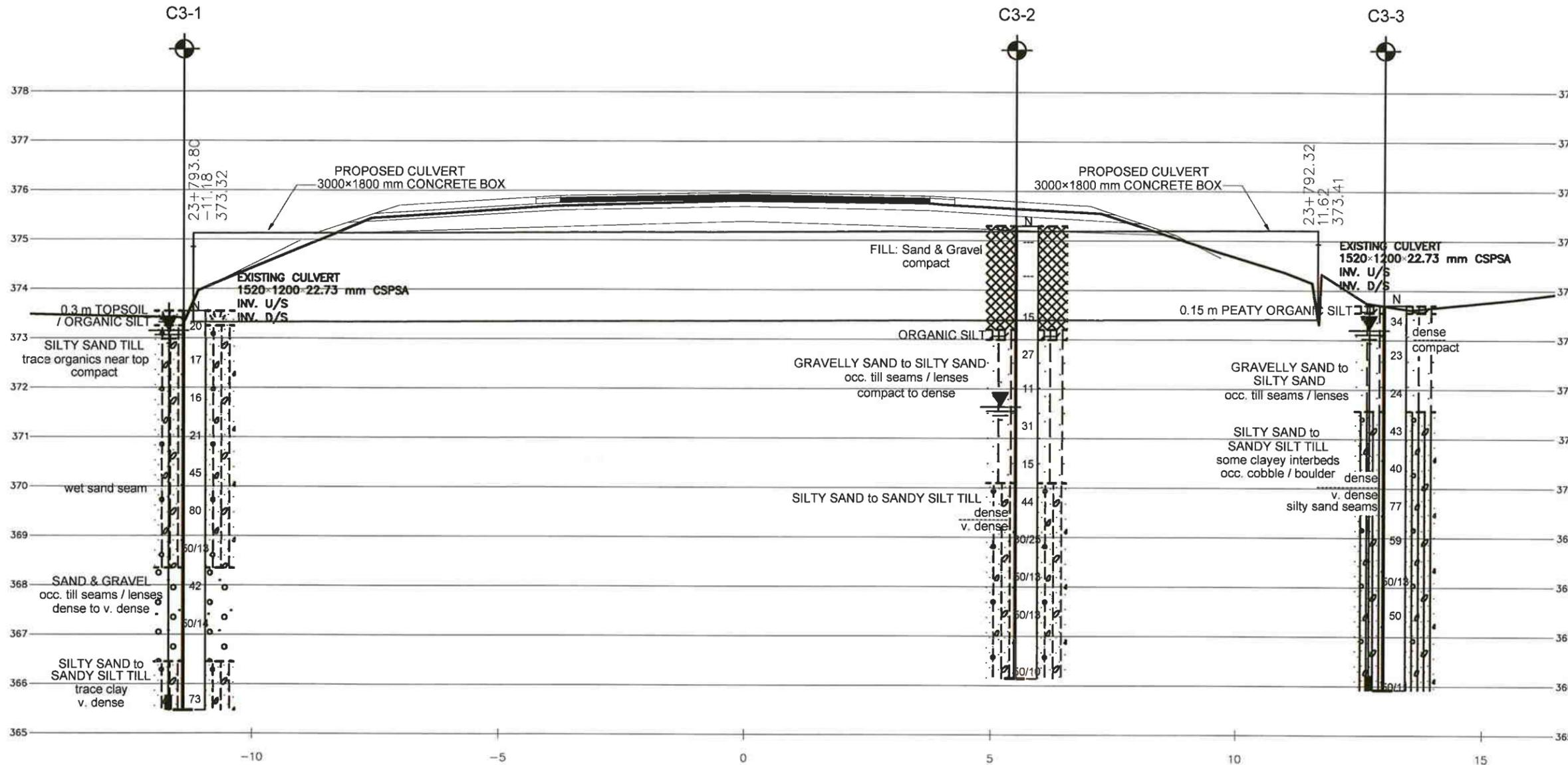
Highway 6, Durham  
Culvert C3 @ Sta. 23+793  
SOIL STRATA



SHAHEEN & PEAKER LIMITED



KEY PLAN  
N.T.S



STRATIGRAPHIC SECTION ALONG CULVERT C3 @ STA. 23+793

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
C3-1	373.5	4 884 976.8	200 426.0
C3-2	375.3	4 884 971.9	200 444.1
C3-3	373.7	4 884 971.3	200 451.8

**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.

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REV.	DATE	BY	DESCRIPTION

Geocres No. 41A-193

SPT 1174			DIST
SUBM'D	CHECKED	DATE Jan., 2008	SITE
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 3B

SPT1174

RECORD OF BOREHOLE No C3-1

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 23+800, 11.4m Lt, C/L  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers  
 DATUM Geodetic DATE 10/12/2006  
 ORIGINATED BY JL  
 COMPILED BY HL  
 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40						60	80
373.5	GROUND SURFACE															
373.2	0.3 m TOPSOIL / ORGANIC SILT															
0.3	SILTY SAND to SANDY SILT TILL trace organics near top dark brown to brown compact		1	SS	20											
			2	SS	17											
			3	SS	16											
		moist	4	SS	21											
		wet	5	SS	45											
	wet sand seam		6	SS	80											
			7	SS	50/13											
368.3	SAND & GRAVEL occasional till seams / lenses brown, wet dense to very dense		8	SS	42											
5.2			9	SS	50/14											
366.4	SILTY SAND to SANDY SILT TILL trace clay brown, wet very dense															
7.1			10	SS	73											
365.5	End of borehole.  Piezometer installed to depth of 7.0 m. Water level in piezometer: Oct. 12, 2006 --6.7 m (El. 367.3 m) Nov. 22, 2006 --0.4 m (El. 373.6 m)															

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

RECORD OF BOREHOLE No C3-2

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 23+792, 5.5m Rt, C/L ORIGINATED BY JL  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers COMPILED BY XS  
 DATUM Geodetic DATE 10/8/2006 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80					
375.3	GROUND SURFACE															
0.0	FILL: Sand & Gravel brown, damp to moist compact	[Cross-hatched]	1	AS	--											
			2	AS	--											
373.2			3	SS	15											
2.1	ORGANIC SILT trace rootlets, black, moist	[Dotted]														
373.0			4	SS	27											
2.3	GRAVELLY SAND to SILTY SAND occasional till seams / lenses grey, compact to dense	[Dotted]														
			5	SS	11											
	moist wet		6	SS	31											
			7	SS	15											
370.1			8	SS	44											
5.2	dense very dense		9	SS	80/25											
			10	SS	50/13											
	SILTY SAND to SANDY SILT TILL grey, wet		11	SS	50/13											
			12	SS	50/10											
366.1	End of borehole.															
9.2	* Water level in open borehole at 3.7 m (El. 371.6 m) upon completion (not stabilized).															



## Appendix A4

# Drawings & Record of Borehole Sheets for Culvert C4

# 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.

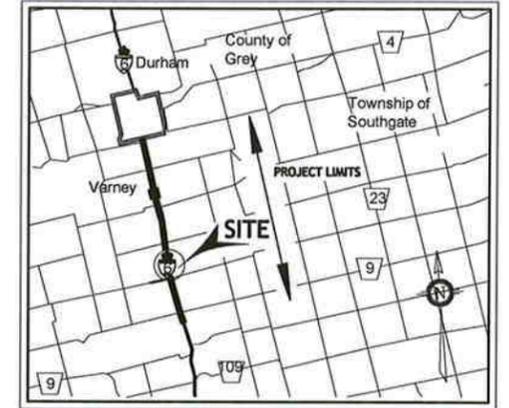
CONT No.

GWP: 338-97-00

Highway 6, Durham  
Culvert C4 @ Sta. 24+482  
BOREHOLE LOCATIONS



## SHAHEEN & PEAKER LIMITED



KEY PLAN  
N.T.S



PLAN

### LEGEND

Borehole

No.	ELEV.	CO-ORDINATES	
		NORTH	EAST
C4-1	382.9	4 885 655.7	200 318.1
C4-2	384.2	4 885 651.4	200 323.9
C4-3	382.4	4 885 651.7	200 341.9

### 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-193

SPT 1174			DIST
SUBM'D	CHECKED	DATE Jan., 2008	SITE
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 4A

# 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.

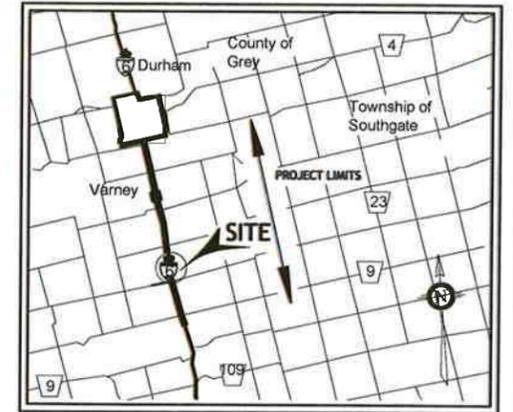
CONT No.

GWP: 338-97-00

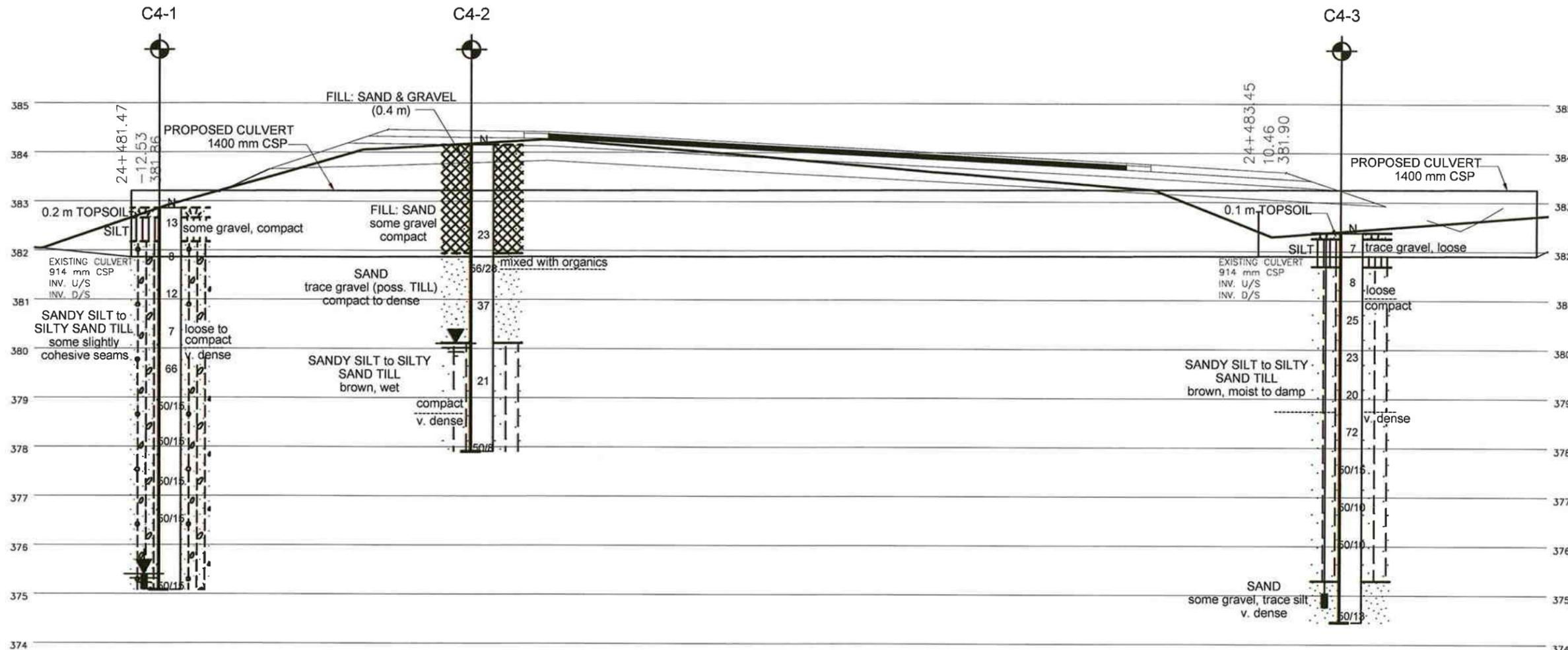
Highway 6, Durham  
Culvert C4 @ Sta. 24+482  
SOIL STRATA



## 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
C4-1	382.9	4 885 655.7	200 318.1
C4-2	384.2	4 885 651.4	200 323.9
C4-3	382.4	4 885 651.7	200 341.9

### 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-193

SPT 1174			DIST
SUBM'D	CHECKED	DATE Jan., 2008	SITE
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 4B



STRATIGRAPHIC SECTION ALONG CULVERT C4 @ STA. 24+482



RECORD OF BOREHOLE No C4-1

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 24+486, 12m Lt C/L  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers ORIGINATED BY NE  
 DATUM Geodetic DATE 10/13/2006 COMPILED BY XS  
 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20	40	60
382.9	GROUND SURFACE																		
382.0	0.2 m TOPSOIL																		
0.2																			
382.2	SILT some gravel, dark brown, damp, compact	1	SS	13															
0.7																			
382.2	SANDY SILT to SILTY SAND TILL some slightly cohesive seams brown, moist to damp	2	SS	8															
0.7																			
		3	SS	12															
		4	SS	7															
	loose to compact very dense	5	SS	66															
		6	SS	50/15															
		7	SS	50/15															
		8	SS	50/15															
		9	SS	50/15															
		10	SS	50/15															
375.1	End of borehole.																		
7.8	Water level @ 7.3 m and hole caved-in @ 7.4 m upon completion. Piezometer installed to depth of 7.8 m. Water level in piezometer: Oct. 13, 2006 ---7.3 m (El. 375.5 m) Nov. 22, 2006 ---7.4 m (El. 375.4 m)																		

SPT1174

RECORD OF BOREHOLE No C4-2

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 24+482, 6m LI, C/L ORIGINATED BY JL  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers COMPILED BY XS  
 DATUM Geodetic DATE 8/22/2006 CHECKED BY FS

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
384.2	GROUND SURFACE													
0.0	FILL: Sand & Gravel (0.4 m) FILL: Sand some gravel brown, damp compact		1	AS			384							
			2	AS			383							
381.9			3	SS	23		382							
2.2	mixed with organics		4	SS	56/28		381							
	SAND trace gravel (possible TILL) brown, moist to wet compact to dense		5	SS	37		380							
380.1							380							
4.0	SANDY SILT to SILTY SAND TILL brown, wet		6	SS	21		379							
	compact very dense						378							
377.9			7	SS	50/8		378							
6.3	End of borehole. * Water level in open borehole at 4.1 m (El. 380.1 m) upon completion (not stabilized).													

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

RECORD OF BOREHOLE No C4-3

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 24+483, 12m RI, C/L  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers ORIGINATED BY NH  
 DATUM Geodetic DATE 10/13/2006 COMPILED BY HL  
 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
382.4	GROUND SURFACE												
382.3	0.1 m TOPSOIL												
381.7	SILT trace gravel, dark brown, damp, loose	1	SS	7									
381.7		2	SS	8								12 46 34 8	
381.7		3	SS	25									
381.7		4	SS	23									
381.7	SANDY SILT to SILTY SAND TILL brown, moist to damp	5	SS	20									
381.7		6	SS	72									
381.7		7	SS	50/15									
381.7		8	SS	50/10									
381.7		9	SS	50/10									
375.3	SAND some gravel, trace silt brown, damp very dense	10	SS	50/13									
374.4	End of borehole.												
374.4	Borehole dry upon completion. Piezometer installed to depth of 7.6 m. Water level in piezometer: Oct. 13, 2006 ---dry. Oct. 18, 2006 ---dry. Nov. 22, 2006 ---dry.												

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

## Appendix A5

# Drawings & Record of Borehole Sheets for Culvert C7

# METRIC

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

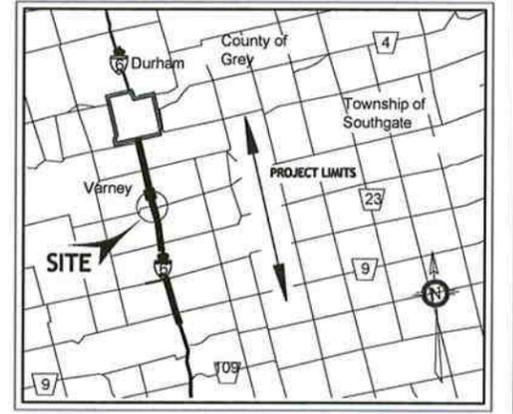
NOTES:  
FOR DETAILED SUBSURFACE CONDITIONS  
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.  
GWP: 338-97-00

Highway 6, Durham  
Culvert C7 @ Sta. 27+065  
BOREHOLE LOCATIONS



## SHAHEEN & PEAKER LIMITED



KEY PLAN  
N.T.S

### LEGEND

Borehole

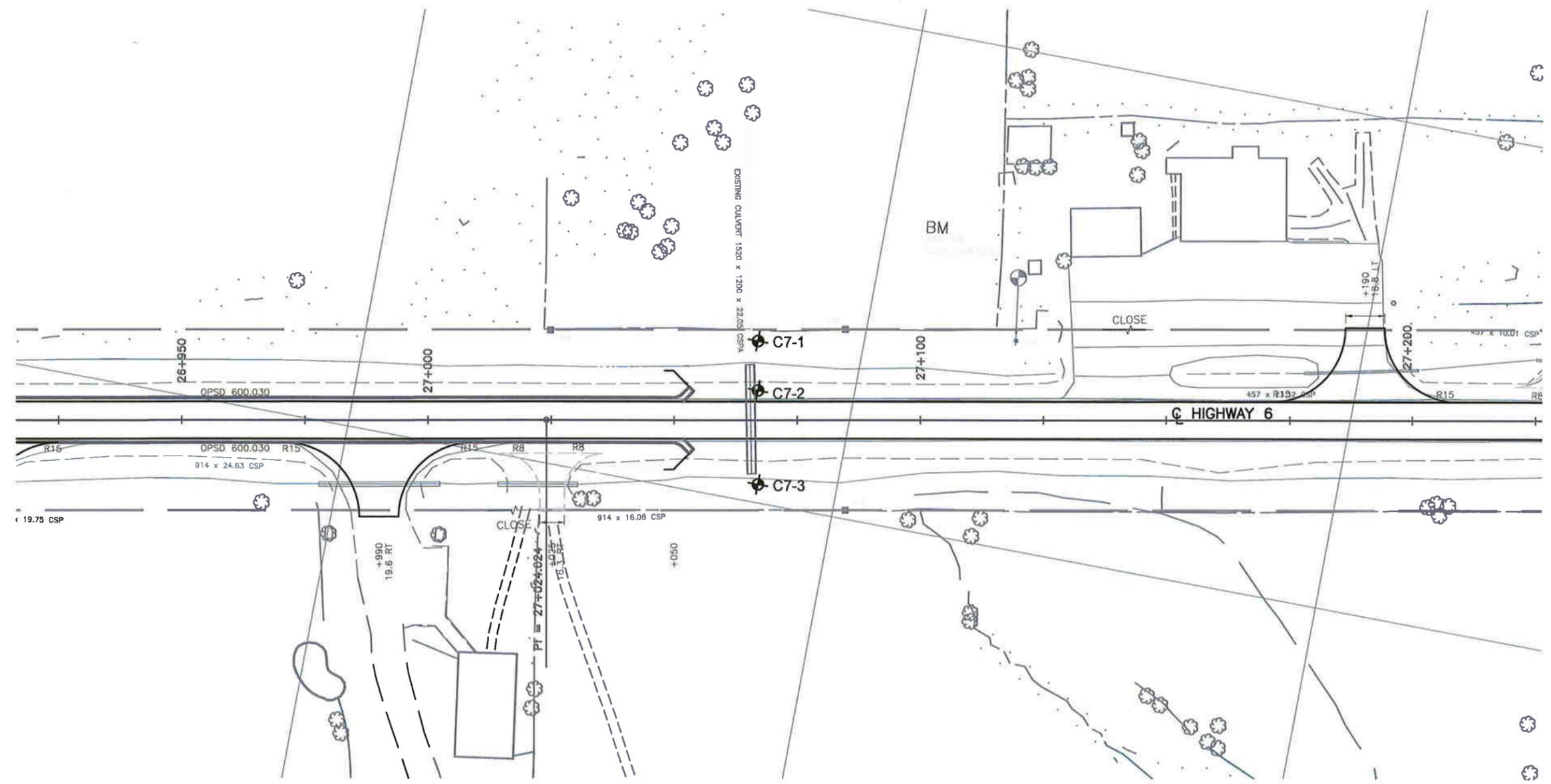
No.	ELEV.	CO-ORDINATES	
		NORTH	EAST
C7-1	358.2	4 888 178.8	200 167.8
C7-2	359.2	4 888 180.6	200 177.7
C7-3	357.9	4 888 184.1	200 196.3

### NOTE

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

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.



SCALE



PLAN



REV.	DATE	BY	DESCRIPTION

Geocres No. 41A-193			
SPT 1174			DIST
SUBM'D	CHECKED	DATE Jan., 2008	SITE
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 7A

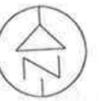
# METRIC

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

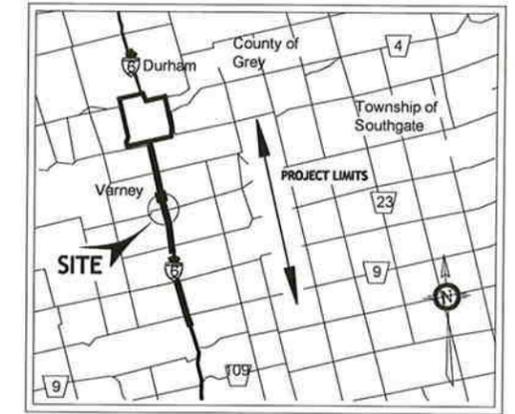
NOTES:  
FOR DETAILED SUBSURFACE CONDITIONS  
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.  
GWP: 338-97-00

Highway 6, Durham  
Culvert C7 @ Sta. 27+065  
SOIL STRATA



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
C7-1	358.2	4 888 178.8	200 167.8
C7-2	359.2	4 888 180.6	200 177.7
C7-3	357.9	4 888 184.1	200 196.3

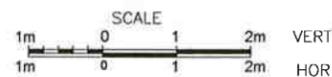
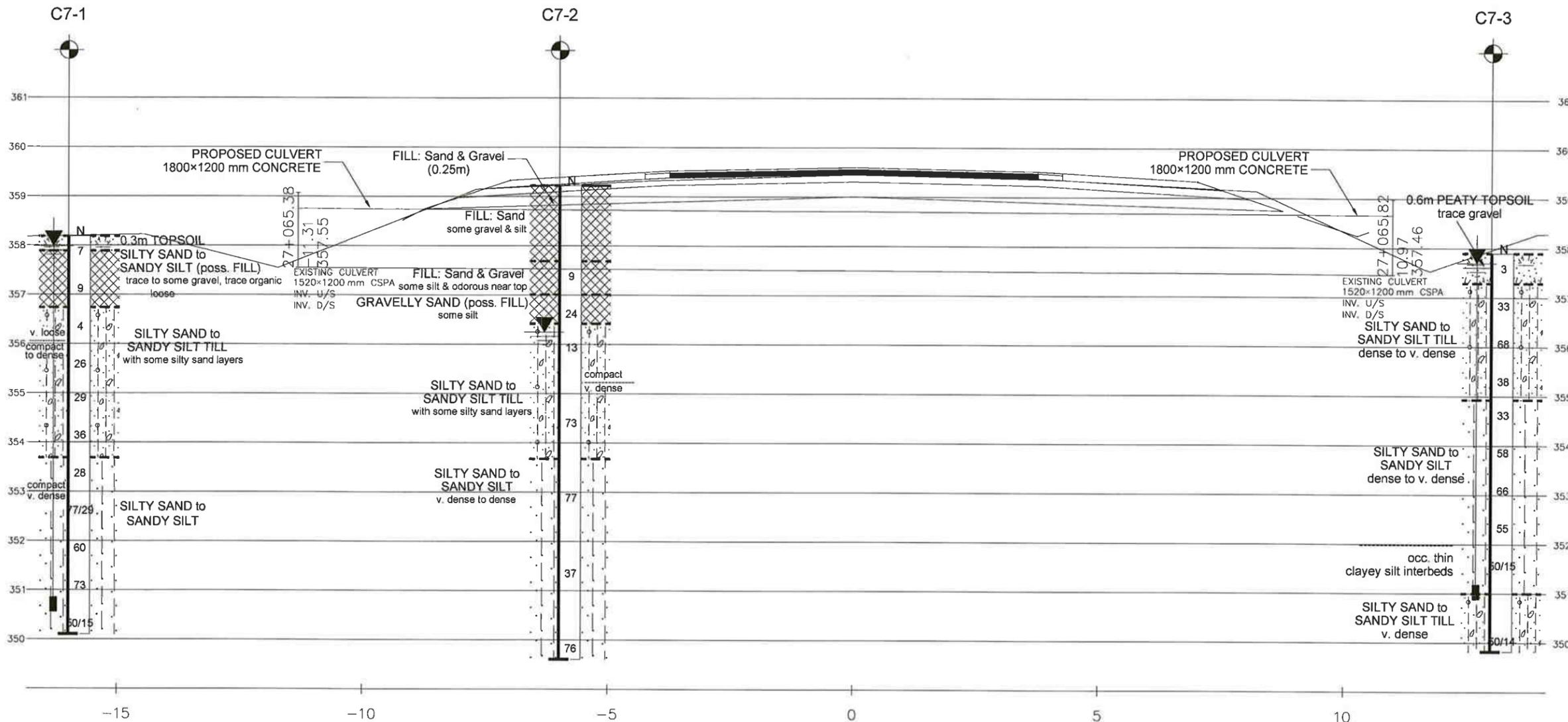
**NOTE**  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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-193			
SPT 1174			
SUBM'D	CHECKED	DATE Jan., 2008	SITE
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 7B



STRATIGRAPHIC SECTION ALONG CULVERT C7 @ STA. 27+065



SPT1174

**RECORD OF BOREHOLE No C7-1**

1 OF 1

**METRIC**

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 27+067, 16m Lt C/L ORIGINATED BY JL  
 DIST \_\_\_\_\_ HWY 6 BOREHOLE TYPE Hollow Stem Augers COMPILED BY XS  
 DATUM Geodetic DATE 10/16/2006 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 Y 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
358.2	GROUND SURFACE																
357.9	0.3 m TOPSOIL, with rootlets																
357.6	SILTY SAND to SANDY SILT (possible FILL) trace some gravel trace organic light brown to grey, moist loose  very loose  compact to dense  SILTY SAND to SANDY SILT TILL with some silty sand layers greyish brown  compact  very dense  SILTY SAND to SANDY SILT greyish brown, wel, dilatant	[Strat Plot Diagram]	1	SS	7												
357.5			2	SS	9												
357.4			3	SS	4												
357.3			4	SS	26												
357.2			5	SS	29												
357.1			6	SS	36												
357.0			7	SS	28												
356.9			8	SS	77/29												
356.8			9	SS	60												
356.7			10	SS	73												
356.6			11	SS	50/15												
350.1	End of borehole. Piezometer installed to depth of 7.6 m. Water level in piezometer: Oct. 16, 2006 ---0.5 m (El. 357.7 m) Nov. 22, 2006 ---0.2 m (El. 358.0 m)																

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

SPT1174

RECORD OF BOREHOLE No C7-2

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 27+067.6m Lt C/L  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers ORIGINATED BY JL  
 DATUM Geodetic DATE 8/21/2006 COMPILED BY XS  
 CHECKED BY FS

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
			NUMBER	TYPE	"N" VALUES			20	40	60					
359.2 0.0	GROUND SURFACE														
	FILL: Sand & Gravel (0.25 m)		1	AS											
	FILL: Sand some gravel & silt brown, moist		2	AS											
357.7 1.5	FILL: Sand & Gravel some silt & odorous near top dark brown to black, wet, loose		3	SS	9										
357.0 2.2	GRAVELLY SAND (possible FILL) some silt grey, wet		4	SS	24										
356.4 2.8	SILTY SAND to SANDY SILT TILL with some silty sand layers greyish brown, wet		5	SS	13										
	compact very dense														
			6	SS	73										
353.7 5.5	SILTY SAND to SANDY SILT greyish brown very dense to dense, wet, dilatant		7	SS	77										
			8	SS	37										
349.6 9.6	End of borehole.		9	SS	76										

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



## Appendix A6

# Drawings & Record of Borehole Sheets for Culvert C8

# METRIC

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

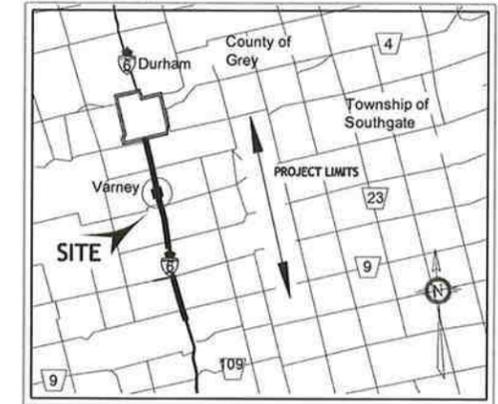
NOTES:  
FOR DETAILED SUBSURFACE CONDITIONS  
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.  
GWP: 338-97-00

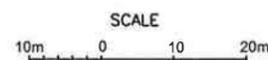
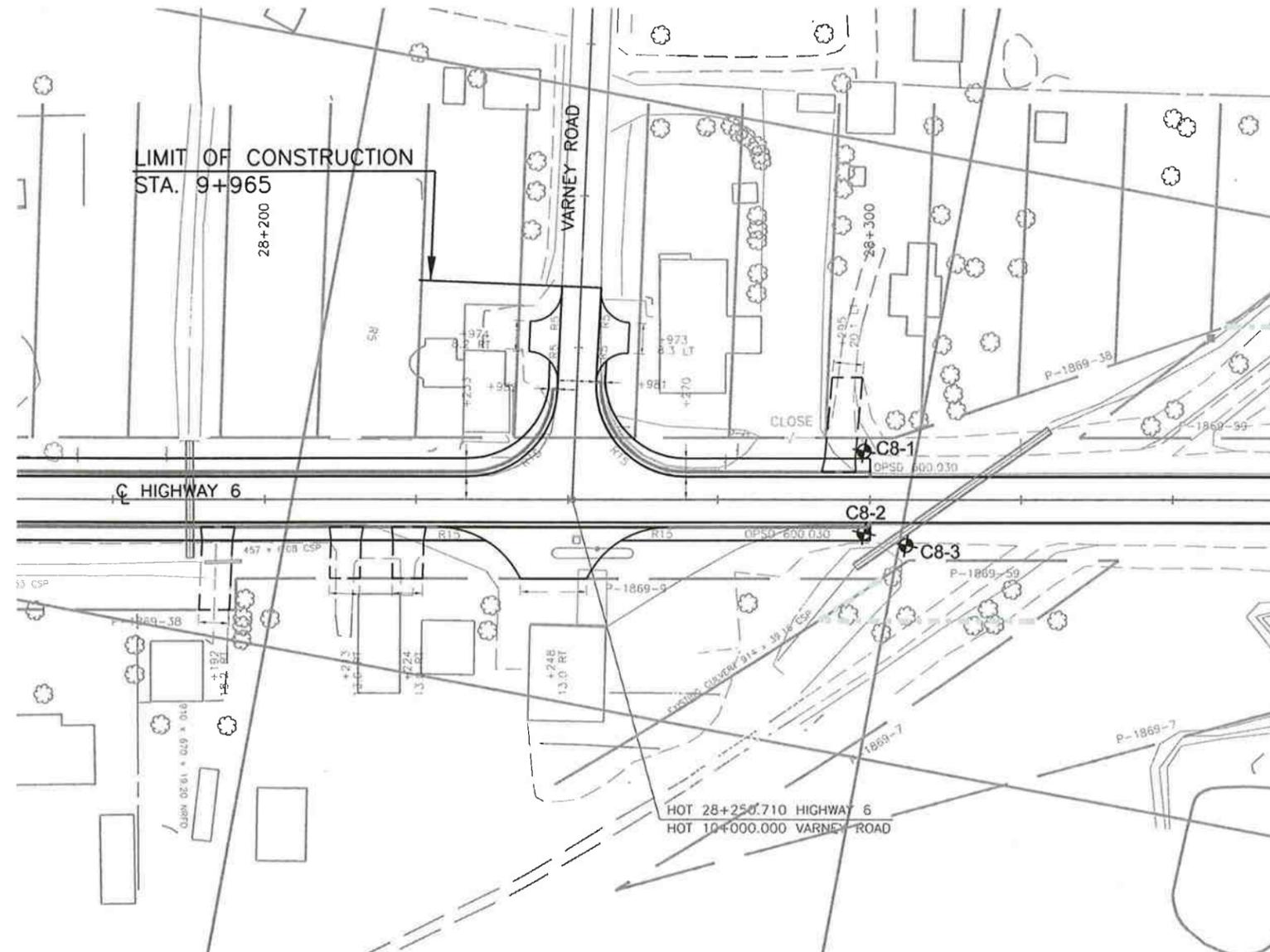
Highway 6, Durham  
Culvert C8 @ Sta. 28+299  
BOREHOLE LOCATIONS



**SHAHEEN & PEAKER LIMITED**



KEY PLAN  
N.T.S



PLAN

**LEGEND**

Borehole

No.	ELEV.	CO-ORDINATES	
		NORTH	EAST
C8-1	336.3	4 889 391.5	199 950.2
C8-2	336.4	4 889 393.9	199 963.5
C8-3	336.3	4 889 401.2	199 964.2

**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-193

SPT 1174			DIST
SUBM'D	CHECKED	DATE Jan., 2008	SITE
DRAWN SM	CHECKED RM	APPROVED ZO	DWG 8A

# METRIC

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

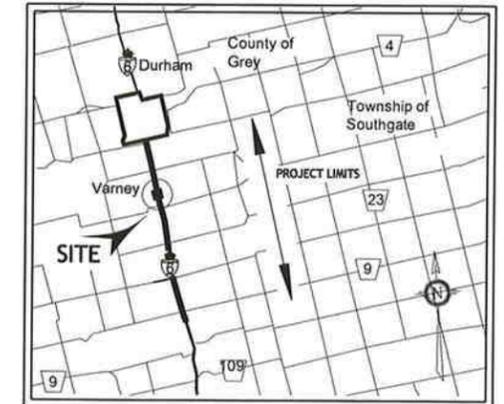
NOTES:  
FOR DETAILED SUBSURFACE CONDITIONS  
REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.  
GWP: 338-97-00

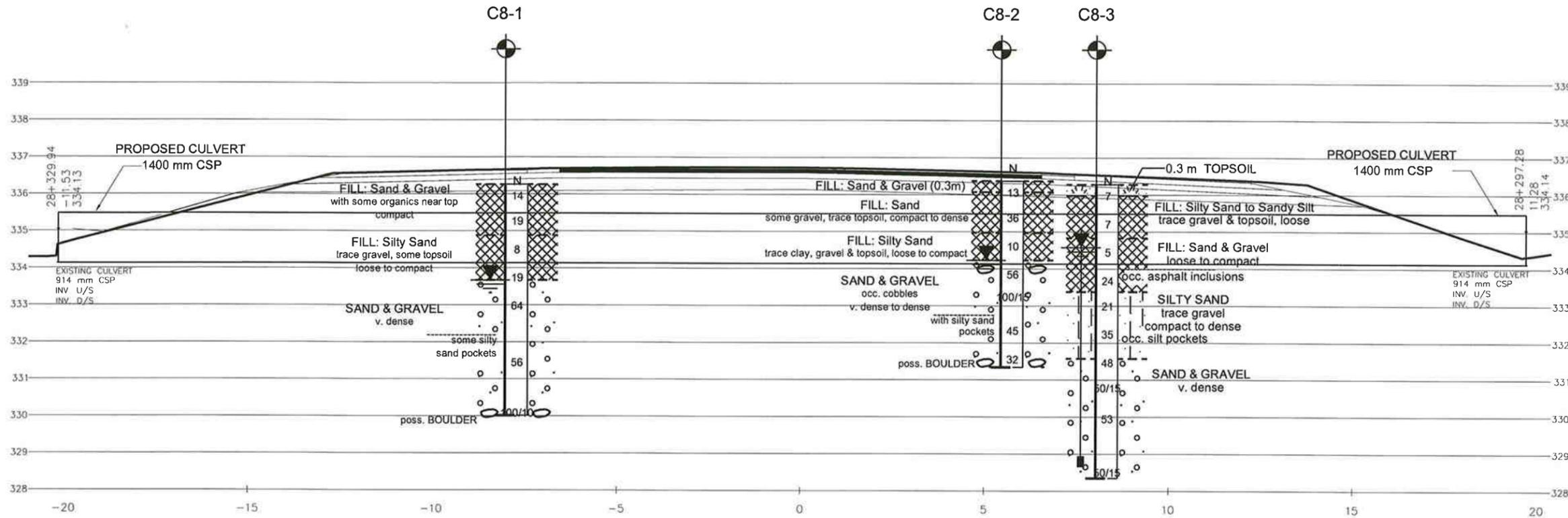
Highway 6, Durham  
Culvert C8 @ Sta. 28+299  
SOIL STRATA



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
C8-1	336.3	4 889 391.5	199 950.2
C8-2	336.4	4 889 393.9	199 963.5
C8-3	336.3	4 889 401.2	199 964.2

NOTE

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

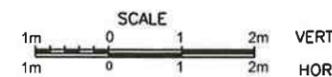
NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

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-193

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



STRATIGRAPHIC SECTION ALONG CULVERT C8 @ STA. 28+299



SPT1174

RECORD OF BOREHOLE No C8-1

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 28+299, 12m Lt, C/L ORIGINATED BY NH  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers COMPILED BY XS  
 DATUM Geodetic DATE 8/16/2006 CHECKED BY FS

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							20	40	60	80	100	10	20	30		GR SA SI CL	
336.7	GROUND SURFACE																
0.0	FILL: Sand & Gravel with some organics near top brown, moist compact	[Cross-hatched]	1	SS	14							○					
335.3			2	SS	19							○				54 45 (1)	
1.4	FILL: Silty Sand trace gravel, some topsoil brown to dark brown, moist to wet loose to compact	[Cross-hatched]	3	SS	8								○				
334.1			4	SS	19									○			
2.6	compact	[Dotted]															
334.1	SAND & GRAVEL greyish brown to brown, wet very dense	[Dotted]	5	SS	64												
	some silty sand pockets	[Dotted]															
332.9			6	SS	56								○				
330.5			7	SS	100/10												
6.3	End of borehole. Auger refusal on a possible boulder or bedrock at 6.3 m. * Water level in open borehole at 2.6 m (El. 332.9 m) upon completion (not stabilized).	[Circle]														possible boulder.	

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

SPT1174

RECORD OF BOREHOLE No C8-2

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 28+299, 5.5m Rt C/L ORIGINATED BY ZI  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers COMPILED BY XS  
 DATUM Geodetic DATE 8/17/2006 CHECKED BY FS

SOIL PROFILE		STRAT PLOT	SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE			"N" VALUES	20 40 60 80 100	PLASTIC LIMIT		
336.4	GROUND SURFACE										
336.1	FILL: Sand & Gravel (0.3 m)	[Hatched]	1	SS	13						
335.0	FILL: Sand some gravel, trace topsoil brown, dry to moist compact to dense	[Hatched]	2	SS	36						
334.2	FILL: Silty Sand trace clay, gravel & topsoil brown, moist loose to compact	[Hatched]	3	SS	10						
334.2	SAND & GRAVEL occasional cobbles brown, wet very dense to dense	[Dotted]	4	SS	56						split spoon bounced on possible cobble
333.3	with silty sand pockets	[Dotted]	5	SS	100/15						
332.3		[Dotted]	6	SS	45						
331.3		[Dotted]	7	SS	32						possible boulder.
331.3	End of borehole. Auger refusal at 5.0 m on possible boulder or bedrock.  * Water level in open borehole at 2.1 m (El. 334.3 m) upon completion (not stabilized).  Hole caved at 2.3 m.										

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

SPT1174

RECORD OF BOREHOLE No C8-3

1 OF 1

METRIC

GWP 338-97-00 LOCATION Hwy 6, Durham - Sta. 28+306, 7.5m Rt C/L  
 DIST HWY 6 BOREHOLE TYPE Hollow Stem Augers  
 DATUM Geodetic DATE 11/8/2006  
 ORIGINATED BY ZI  
 COMPILED BY XS  
 CHECKED BY FS

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20
336.3	GROUND SURFACE																	
336.0	0.3 m TOPSOIL, with rootlets		1	SS	7		336											
334.8	FILL: Silty Sand to Sandy Silt trace gravel & topsoil brown, moist, loose		2	SS	7		335											
333.4	FILL: Sand & Gravel some organic soil black to dark grey, wet loose to compact  occasional asphalt inclusions		3	SS	5		334											
333.4	SILTY SAND trace gravel brown, wet compact to dense  occasional silt pockets		4	SS	24		334											
331.6			5	SS	21		333											
331.6	SAND & GRAVEL greyish brown, wet		6	SS	35		332											
328.4			7	SS	48		331											
328.4			8	SS	50/15		330											
328.4	End of borehole.  Piezometer installed to depth of 7.6 m. Water level in piezometer: Nov. 8, 2006 ---1.8 m (El. 334.6 m) Nov. 14, 2006 ---1.7 m (El. 334.7 m) Nov. 22, 2006 ---1.7 m (El. 334.7 m)		9	SS	53		329											
328.4			10	SS	50/15		329											

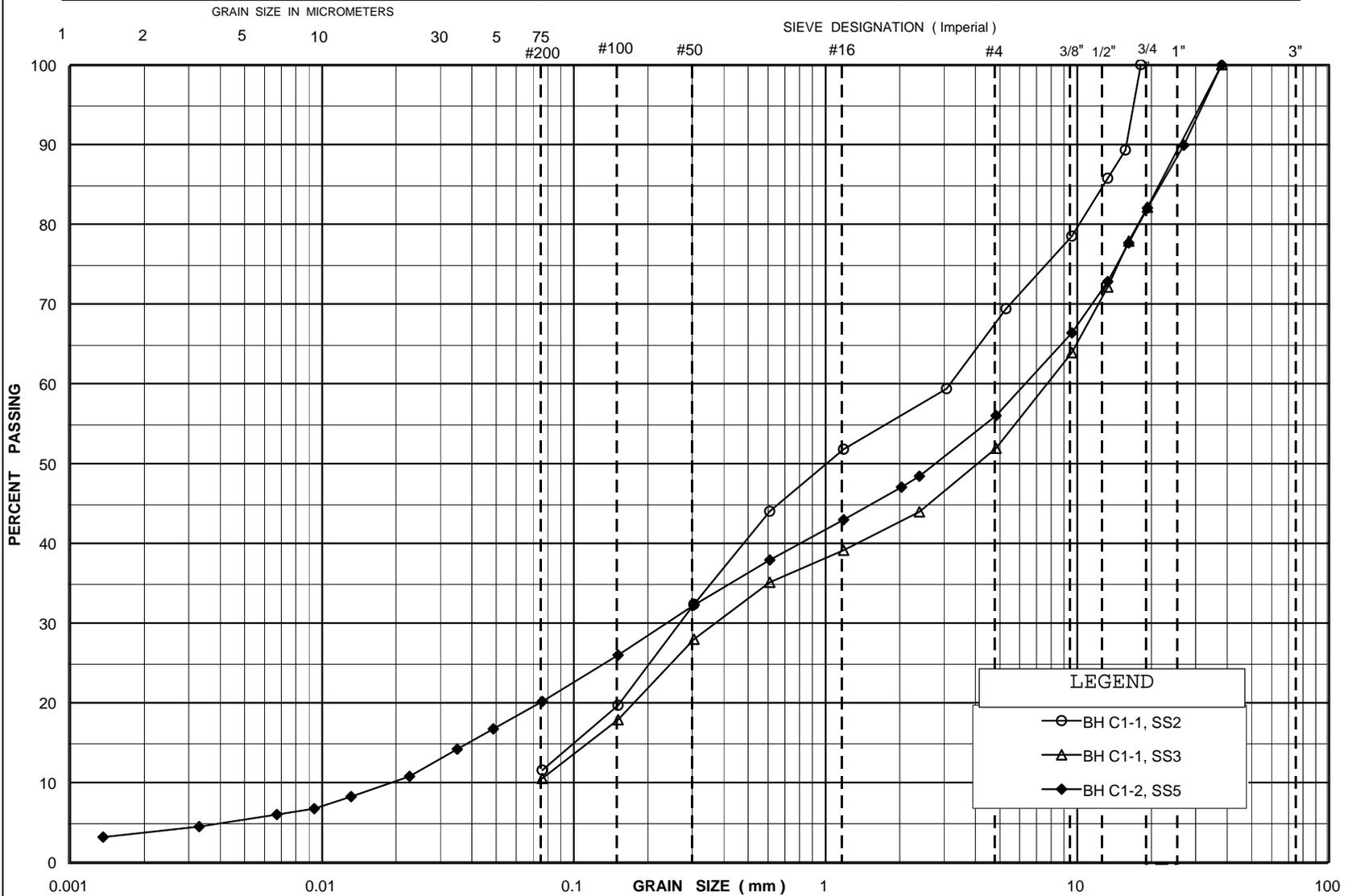
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15 ← 5  
 10  
 (%) STRAIN AT FAILURE

## Appendix B1

# Laboratory Test Results for Culvert C1

**UNIFIED SOIL CLASSIFICATION SYSTEM**

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



LEGEND	
○	BH C1-1, SS2
△	BH C1-1, SS3
◆	BH C1-2, SS5

SHAHEEN & PEAKER LIMITED

**GRAIN SIZE DISTRIBUTION**  
SAND & GRAVEL, some silt

FIGURE No. B1-1

G. W. P. 338-97-00

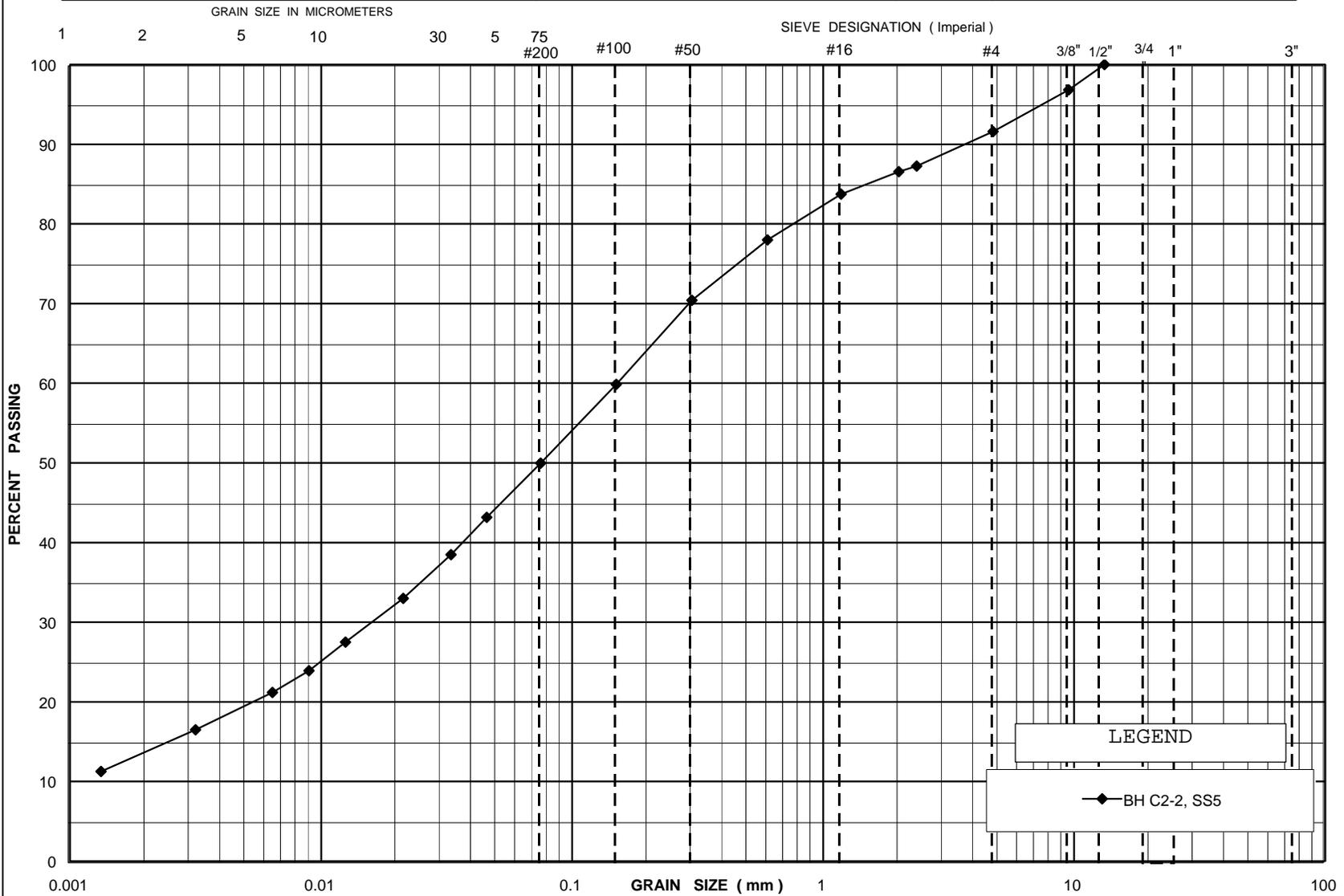
REF. No. SPT 1174

## Appendix B2

# Laboratory Test Results for Culvert C2

**UNIFIED SOIL CLASSIFICATION SYSTEM**

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



**LEGEND**

◆ BH C2-2, SS5

SHAHEEN & PEAKER LIMITED

**GRAIN SIZE DISTRIBUTION**  
 SILTY SAND to SANDY SILT, traces of clay & gravel (possible FILL)

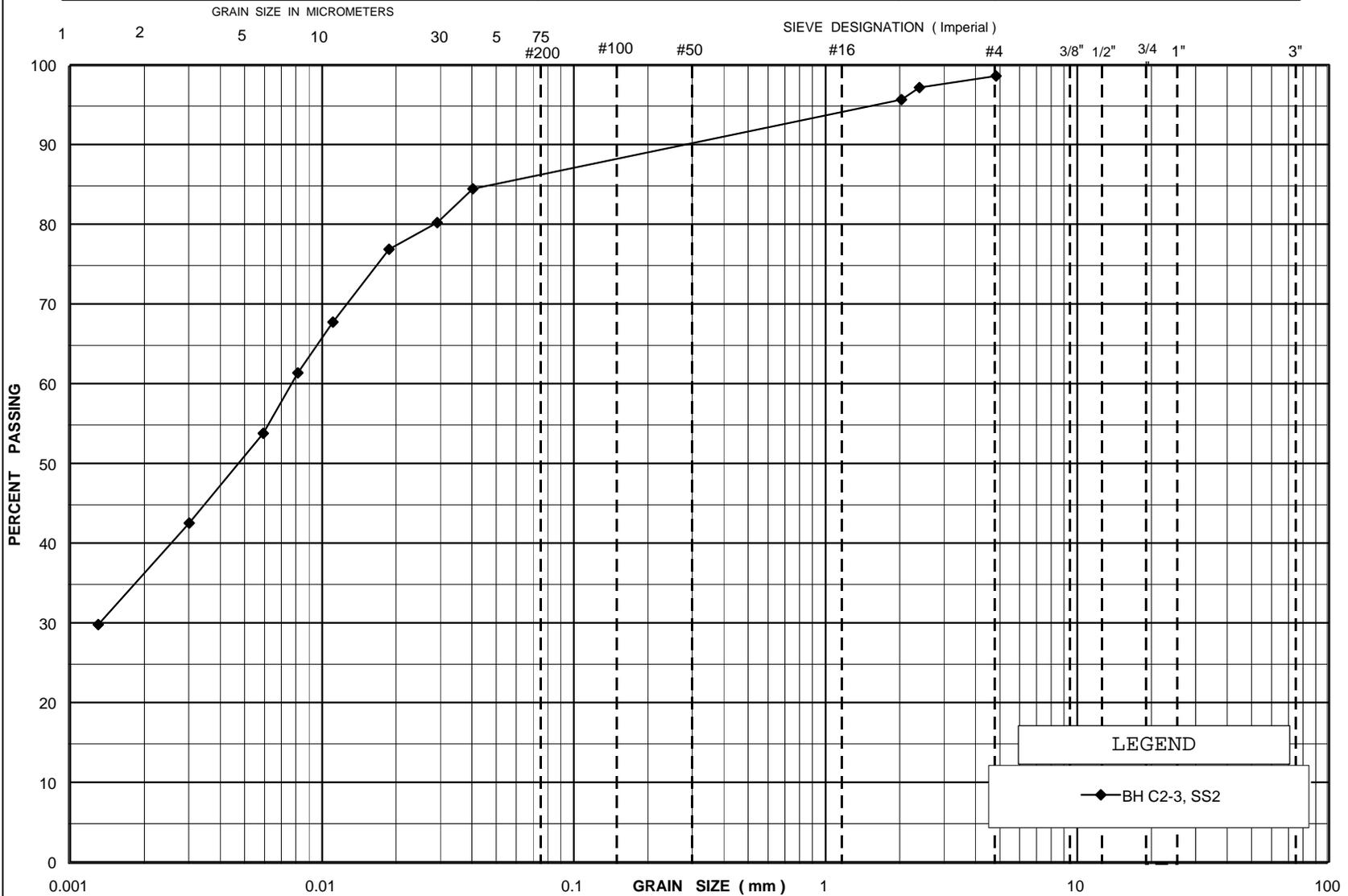
FIGURE No. B2-1

G. W. P. 338-97-00

REF. No. SPT 1174

**UNIFIED SOIL CLASSIFICATION SYSTEM**

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



SHAHEEN & PEAKER LIMITED

**GRAIN SIZE DISTRIBUTION**  
CLAYEY SILT to SILTY CLAY TILL

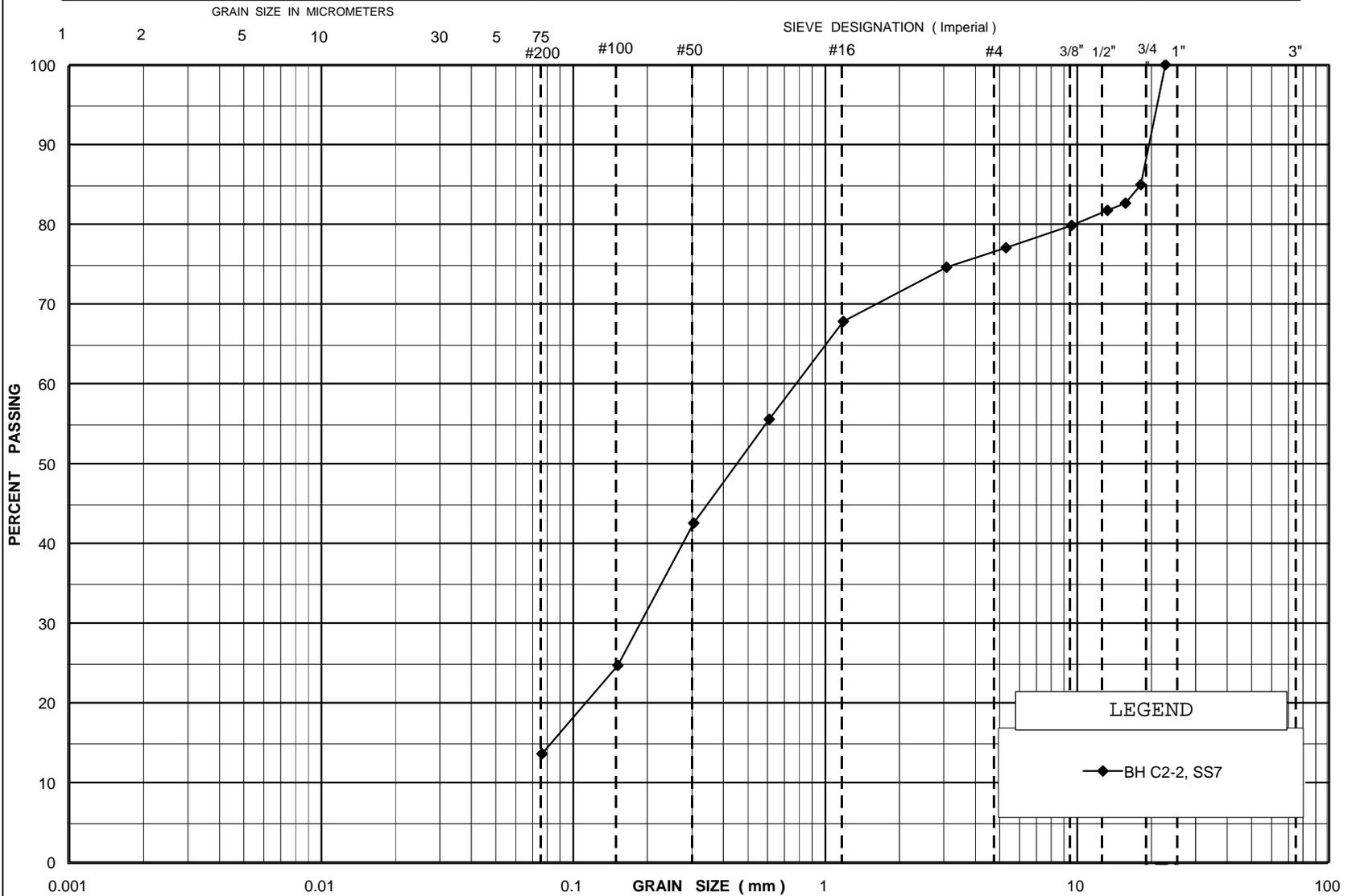
FIGURE No. B2-2

G. W. P. 338-97-00

REF. No. SPT 1174

**UNIFIED SOIL CLASSIFICATION SYSTEM**

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



**LEGEND**

◆ BH C2-2, SS7

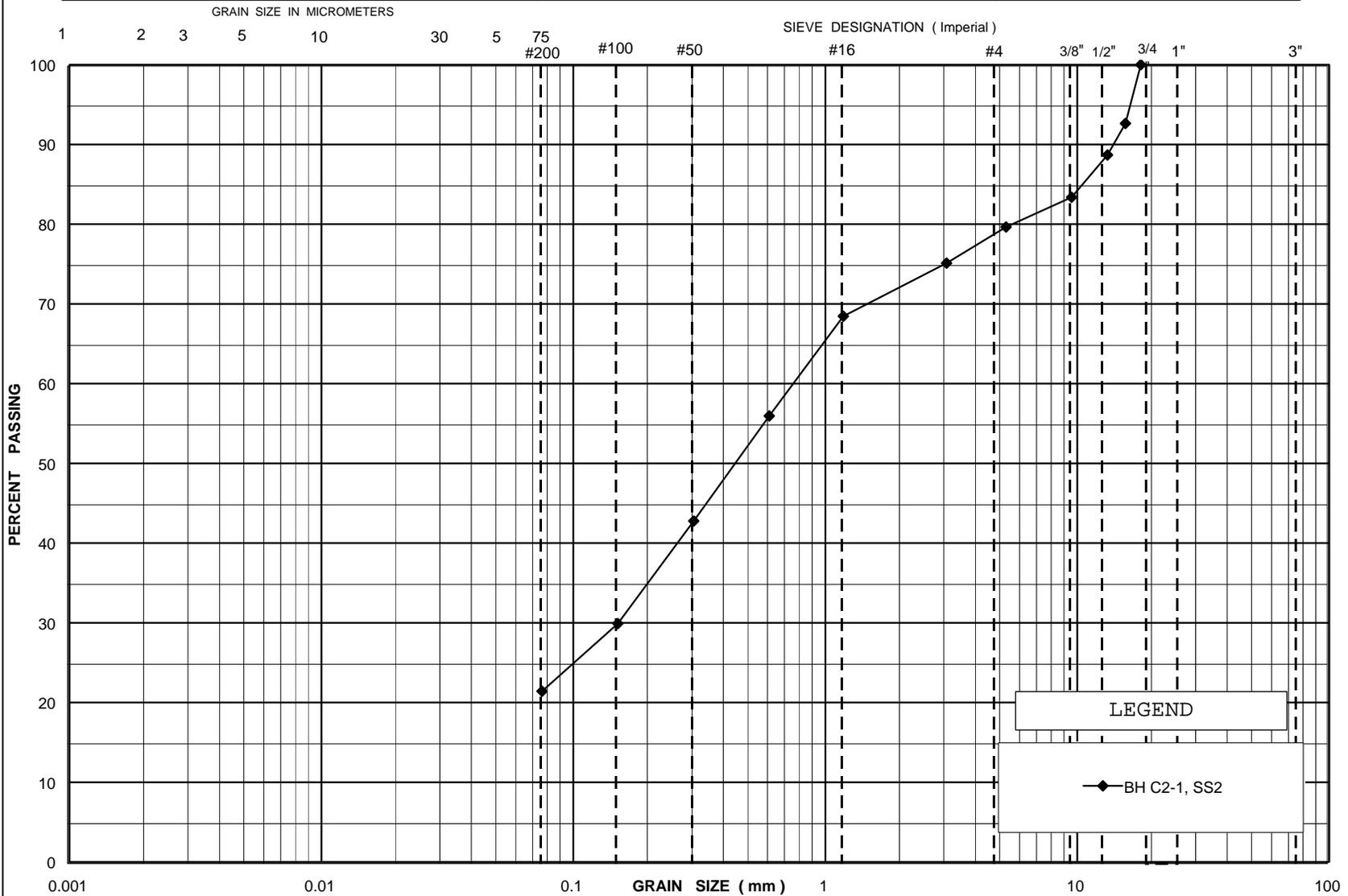
SHAHEEN & PEAKER LIMITED

**GRAIN SIZE DISTRIBUTION**  
SILTY SAND TILL with gravelly sand layers

FIGURE No. B2-3  
G. W. P. 338-97-00  
REF. No. SPT 1174

**UNIFIED SOIL CLASSIFICATION SYSTEM**

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



LEGEND

◆ BH C2-1, SS2

SHAHEEN & PEAKER LIMITED

**GRAIN SIZE DISTRIBUTION**  
GRAVELLY SAND with Silt

FIGURE No. B2-4

G. W. P. 338-97-00

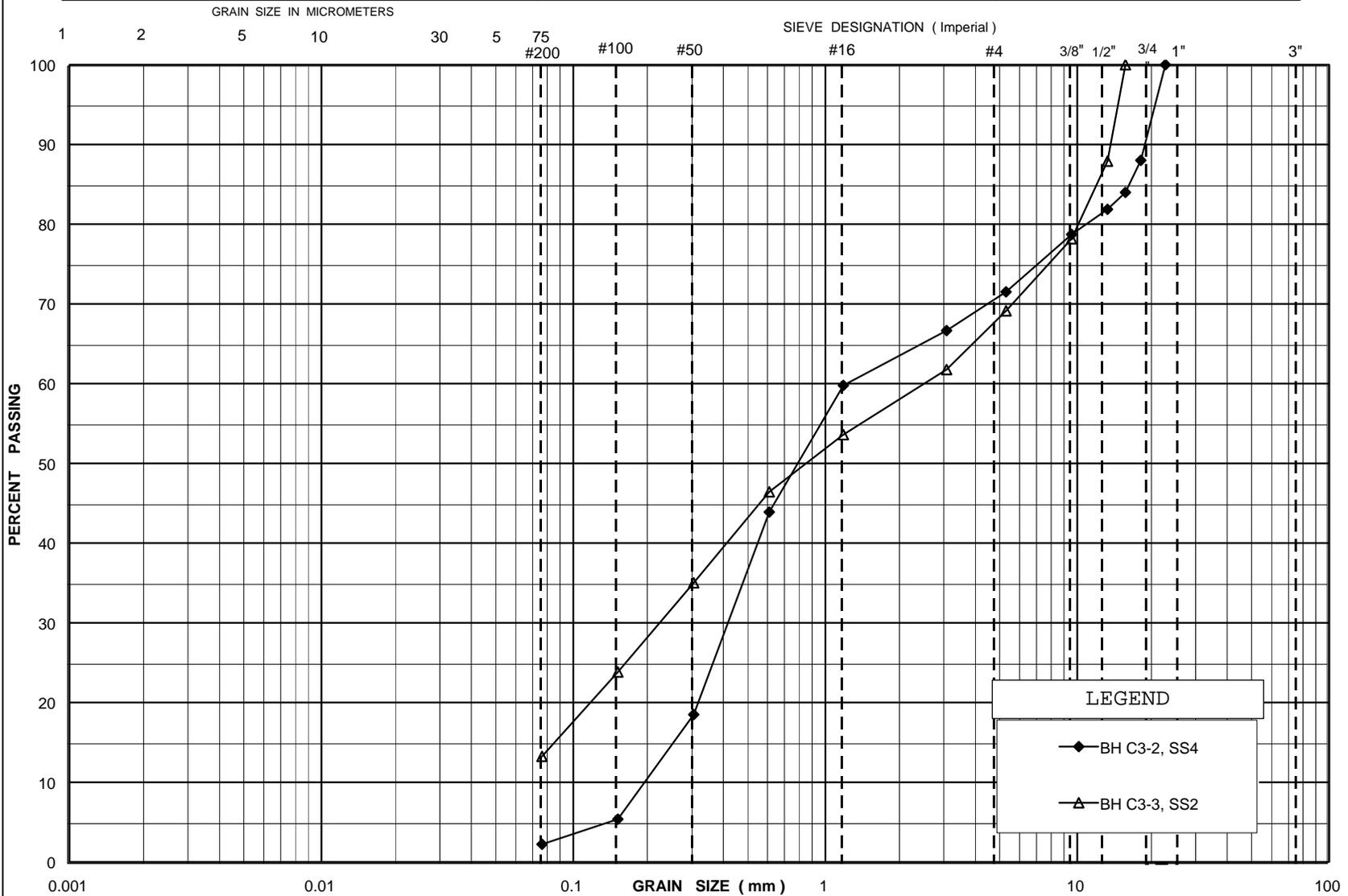
REF. No. SPT 1174

## Appendix B3

# Laboratory Test Results for Culvert C3

**UNIFIED SOIL CLASSIFICATION SYSTEM**

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



LEGEND	
◆	BH C3-2, SS4
▲	BH C3-3, SS2

SHAHEEN & PEAKER LIMITED

**GRAIN SIZE DISTRIBUTION**  
GRAVELLY SAND, trace / some silt

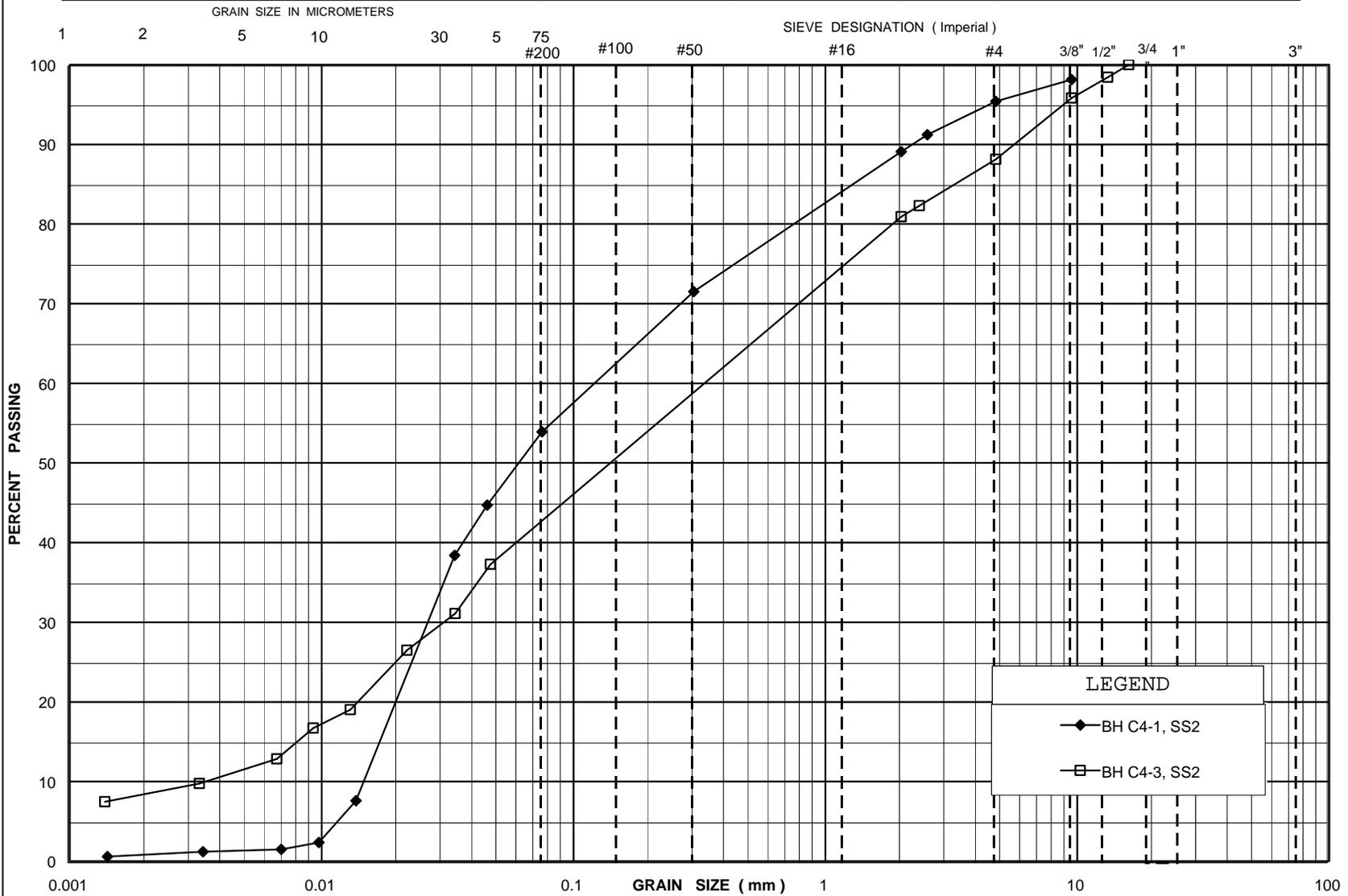
FIGURE No. B3-1  
G. W. P. 338-97-00  
REF. No. SPT 1174

## Appendix B4

# Laboratory Test Results for Culvert C4

**UNIFIED SOIL CLASSIFICATION SYSTEM**

CLAYEY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



SHAHEEN & PEAKER LIMITED

**GRAIN SIZE DISTRIBUTION  
SANDY SILT to SILTY SAND TILL**

FIGURE No. B4-1

G. W. P. 338-97-00

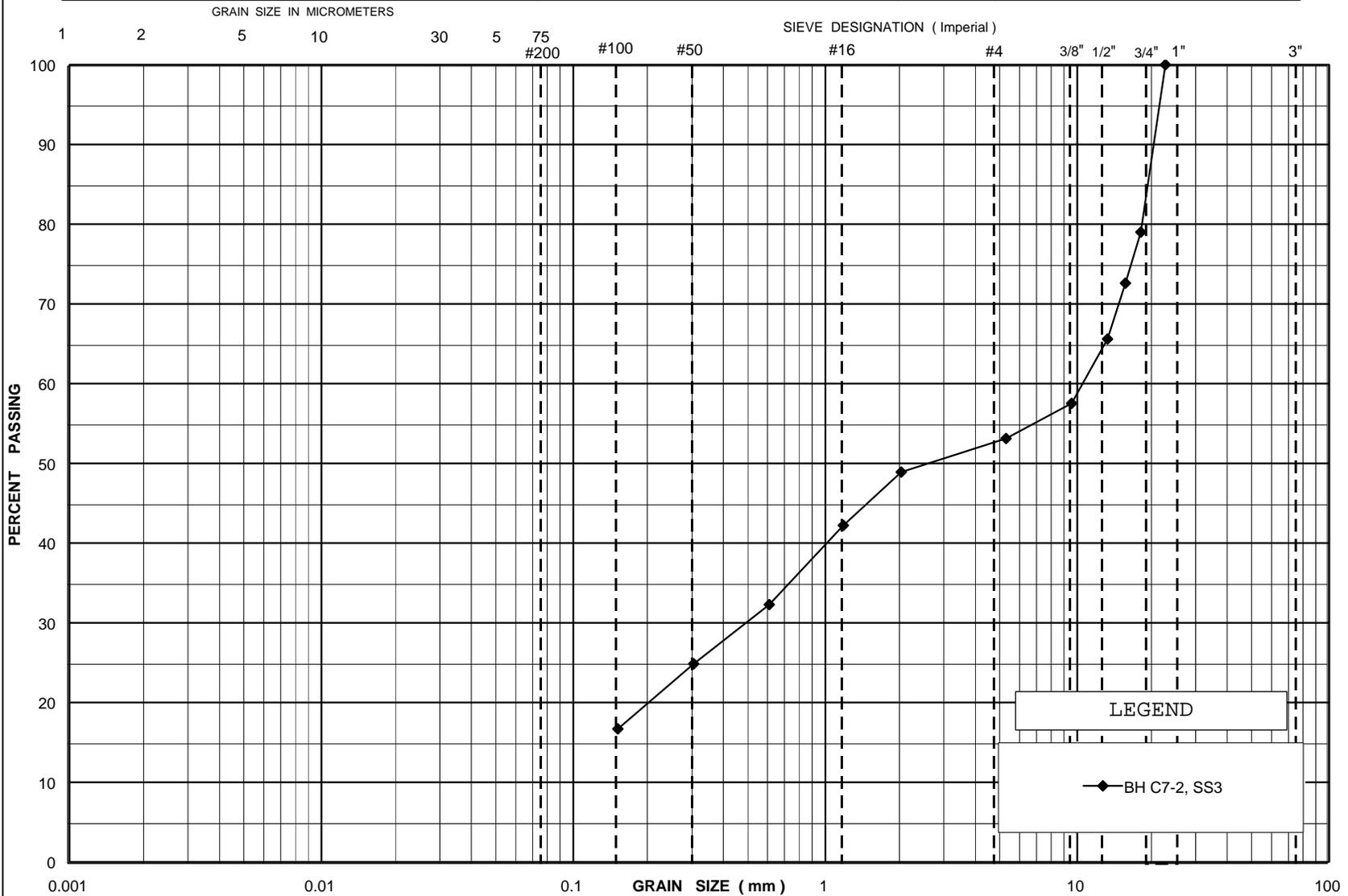
REF. No. SPT 1174

## Appendix B5

# Laboratory Test Results for Culvert C7

**UNIFIED SOIL CLASSIFICATION SYSTEM**

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



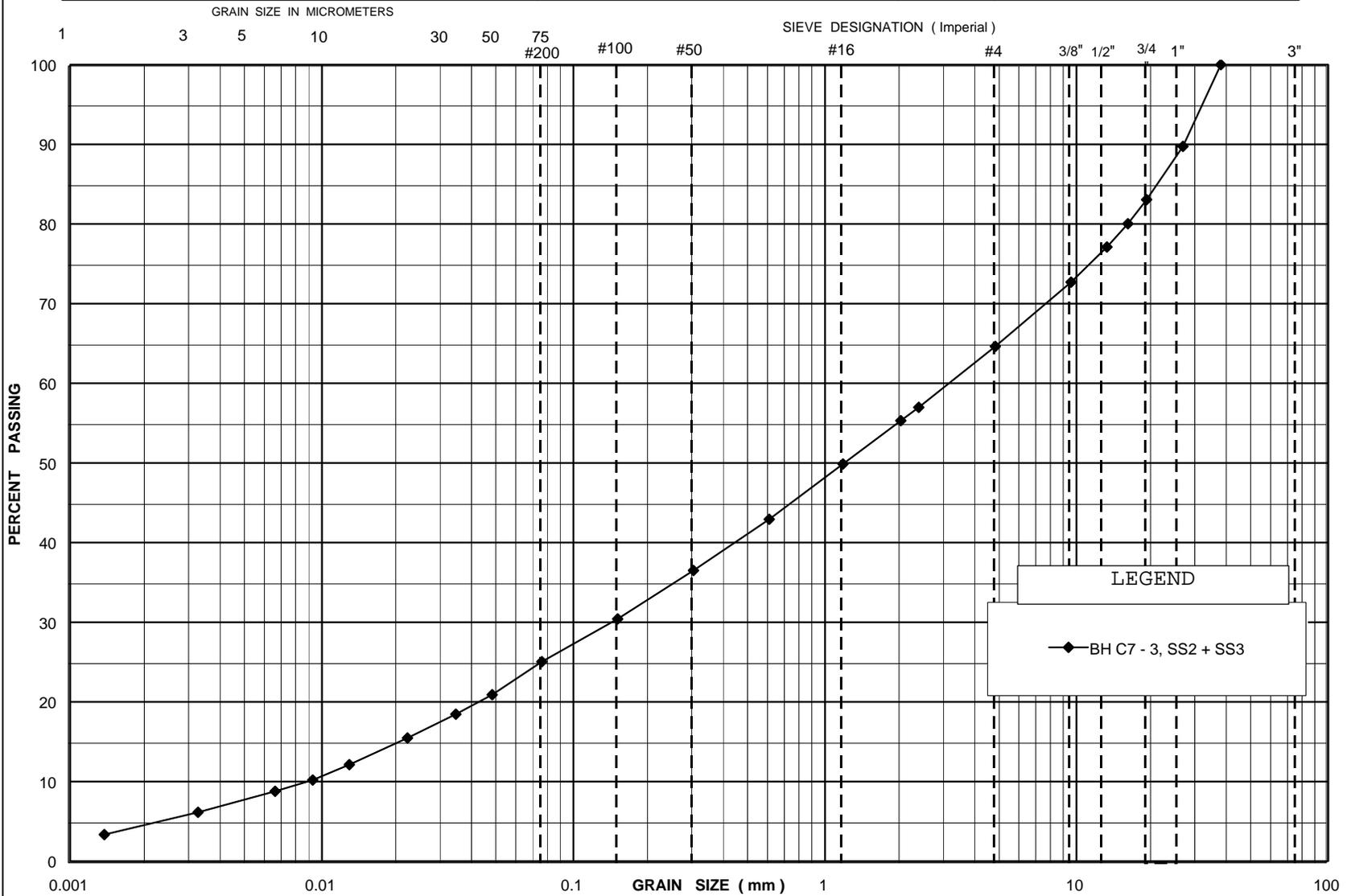
SHAHEEN & PEAKER LIMITED

**GRAIN SIZE DISTRIBUTION**  
FILL: Sand & Gravel, some Silt

FIGURE No. B7-1  
G. W. P. 338-97-00  
REF. No. SPT 1174

**UNIFIED SOIL CLASSIFICATION SYSTEM**

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



SHAHEEN & PEAKER LIMITED

**GRAIN SIZE DISTRIBUTION  
SILTY SAND TILL**

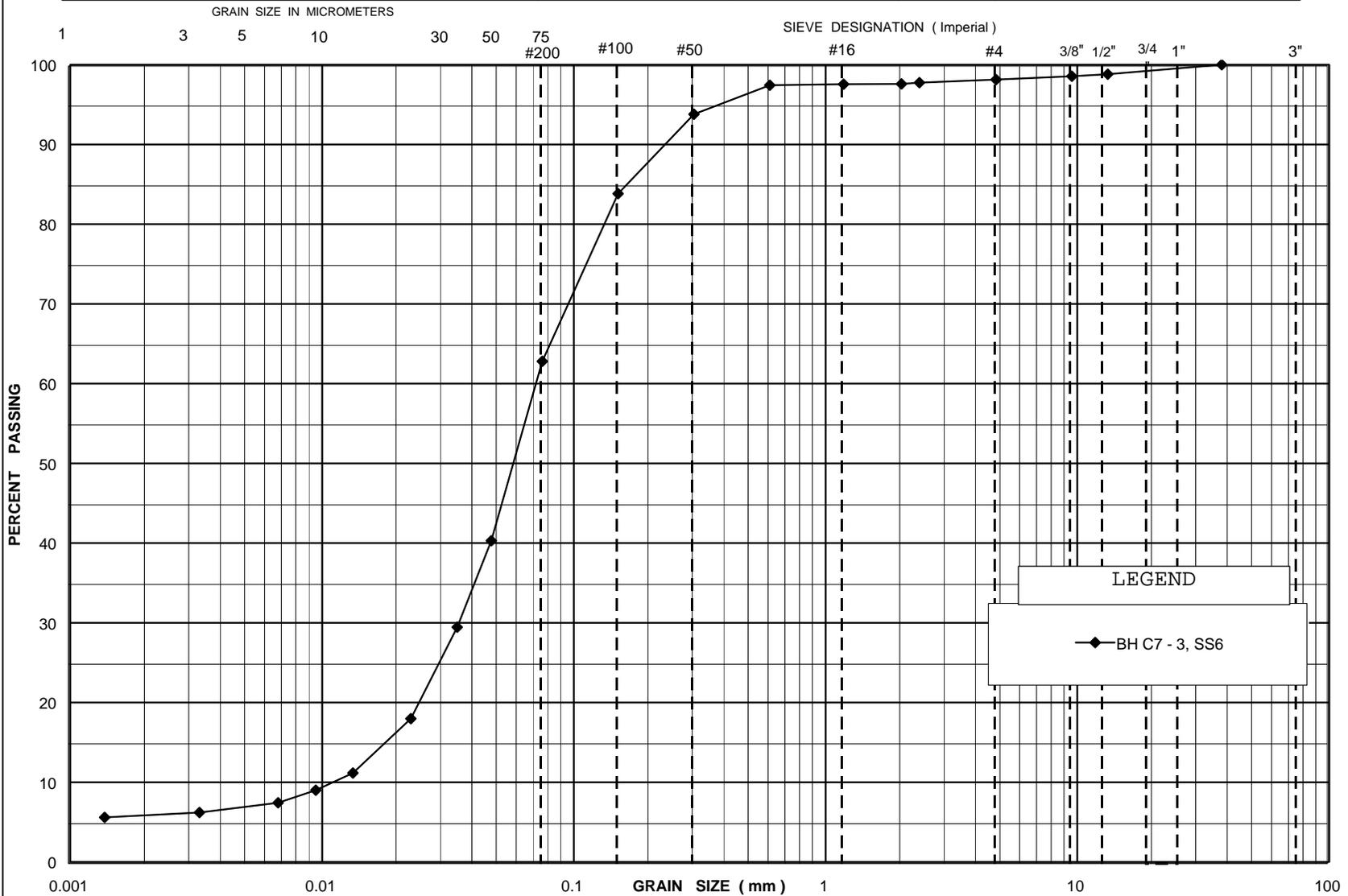
FIGURE No. B7-2

G. W. P. 338-97-00

REF. No. SPT 1174

**UNIFIED SOIL CLASSIFICATION SYSTEM**

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



LEGEND

◆ BH C7 - 3, SS6

SHAHEEN & PEAKER LIMITED

**GRAIN SIZE DISTRIBUTION  
SANDY SILT**

FIGURE No. B7-3

G. W. P. 338-97-00

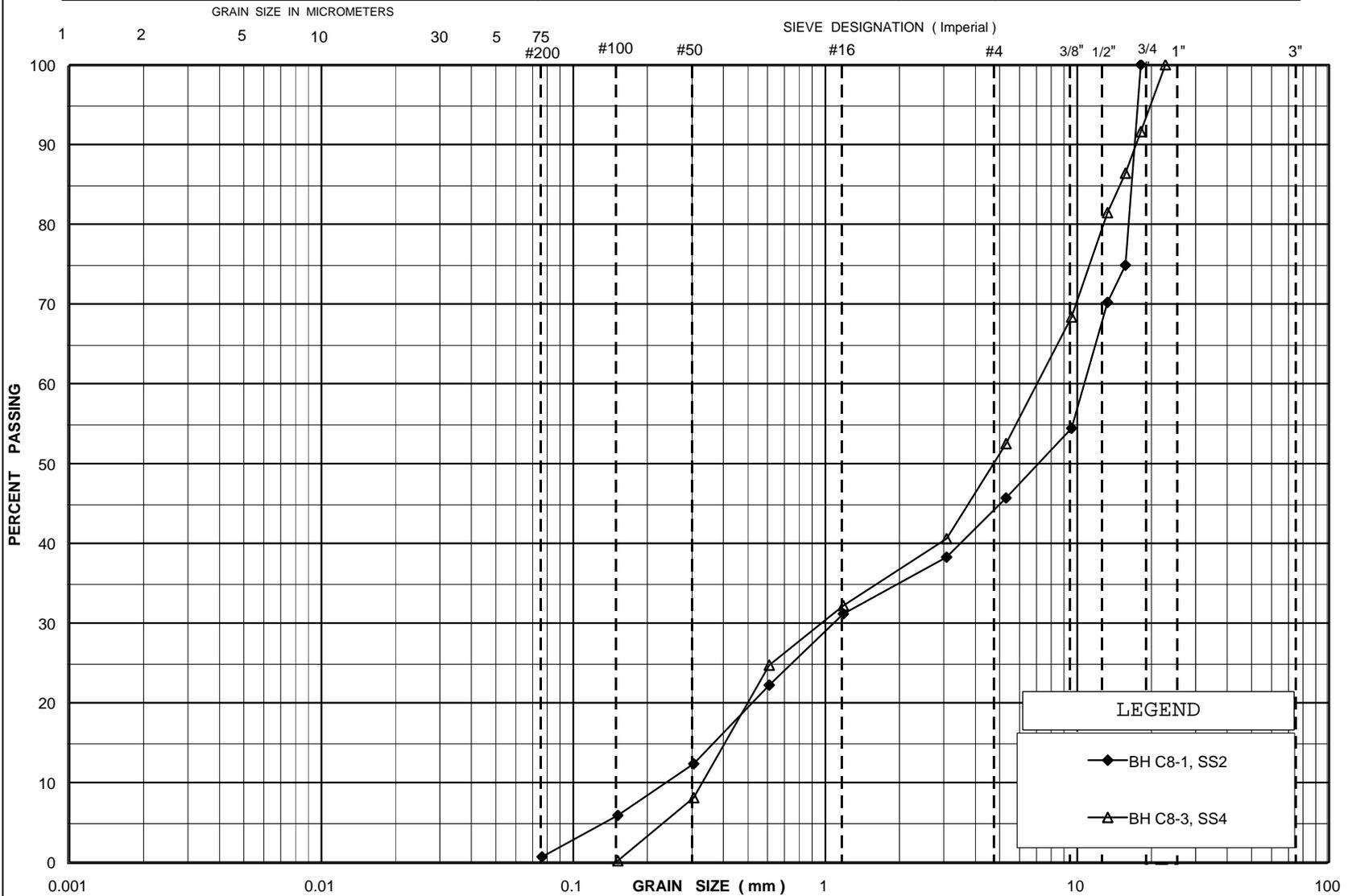
REF. No. SPT 1174

## Appendix B6

# Laboratory Test Results for Culvert C8

**UNIFIED SOIL CLASSIFICATION SYSTEM**

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



SHAHEEN & PEAKER LIMITED

**GRAIN SIZE DISTRIBUTION**  
GRANULAR FILL: Sand & Gravel

FIGURE No. B8-1

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 STRUCTURAL FEATURES AND/OR STRENGTH.

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

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

### MECHANICAL 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
$S_r$	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 = $(W_L - W) / I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
$P'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED 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						