

**FOUNDATION INVESTIGATION & DESIGN REPORTS  
TWO SWAMP CROSSINGS  
PROPOSED WIDENING OF HIGHWAY 7  
FROM 2.6 KM WEST OF MARMORA WEST LIMITS  
AND FROM MARMORA EAST LIMITS TO 6.6 KM  
WEST OF HIGHWAY 62, 12.5 KM  
G.W.P. 251-98-00**

**GEOCRES NO. 31C-173**

**Prepared For:**

**TRANSENCO LIMITED**

**Prepared by:**

**SHAHEEN & PEAKER LIMITED**

**Project: SPT1147  
June 26, 2006**



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**FOUNDATION INVESTIGATION REPORT  
TWO SWAMP CROSSINGS, PROPOSED WIDENING OF HIGHWAY 7  
FROM 2.6 KM WEST OF MARMORA TO MARMORA WEST LIMITS  
AND FROM MARMORA EAST LIMITS TO 6.6 KM WEST OF HIGHWAY 62, 12.5 KM  
G.W.P. 251-98-00**

## **1. INTRODUCTION**

Ministry of Transportation of Ontario (MTO) is planning to widen the existing Highway 7, east of Marmora, Ontario, by one lane at two swamp crossing locations.

The swamp crossings are designated for the purposes of this project as Swamp No. 2 and Swamp No. 3, as follows:

Swamp No. 2 – Station 23+950 to 24+225 (i.e. 275 m long section) in the Township of Marmora

Swamp No. 3 - Station 25+330 to 25+361.245 in the Township of Marmora and Station 10+000 to 10+180 in the Township of Madoc (25+361.245 Marmora Township = 10+000 Madoc Township)

Shaheen & Peaker Limited (S&P) was retained by Transenco Limited (Transenco) to carry out a foundation investigation at the site of two proposed swamp crossing locations along the proposed widening alignments.

The purpose of the investigation was to investigate the subsurface conditions at the site of the proposed swamp crossings by means of boreholes and to determine the relevant engineering characteristics of the subsurface soils by means of field and laboratory tests.

The findings of the investigation are presented in this report.

## **2. SITE DESCRIPTION AND GEOLOGY**

The two swamps are located east of the Town of Marmora in the Townships of Marmora and Madoc, in relatively depressed areas, characterized by poor drainage exacerbated by the presence of the highway embankment which cuts across both sites. Along the swamp crossings, the highway embankment is typically 2.0 to 3.5 m high. The presence of bulrushes and some dead tree trunks indicate the presence of high water table and inundation in areas adjacent to the highway embankment. In fact, at the time of our investigation, both swamp locations were inundated by up to about 1.6 m of water (including

surface ice thickness) at the borehole locations immediately near the north toe of the roadway embankment. Site photos for Swamps 2 and 3 are presented in Appendix E.

Based on the Ontario Geological Survey Map P.2715 (Physiography of Southern Ontario by Putnam & Chapman), the Ontario Geological Survey Map P.2374 (from Ministry of Natural Resources 1980) and the Bedrock Geology of Ontario (Southern Sheet) Ministry of Northern Development and Mines Map 2544, the general area is located near the confluence of the Physiographic Regions known as Dummer Moraines and Peterborough Drumlin Fields. The Township of Marmora is partly covered by the extension of Dummer Moraines which constitute an area of rough stony land bordering the Canadian Shield from Kawartha Lakes eastward. The underlying bedrock are sedimentary limestones, most of the Bobcaygeon and Gull River Formations of the Simcoe Group, but also including some of the underlying Lindsay and Verulam Formations (e.g. basalt is being quarried near Marmora). They form a plain which declines gently southward from an elevation of 240 to 180 m a.s.l.. The limestone terminates on the north in an escarpment 8 to 20 m high, while in a few places the rock face is hidden beneath a morainic mantle. On the south, there is an irregular boundary between the moraines and the drumlinized till plain. Lying on the Canadian Shield, sometimes several kilometers north of the main escarpment, are a number of limestone outliners. In this general area just north of the limestone bedrock, there is some shaley till which is mapped with the morainic area. However, crossing this morainic belt are several streams which are tributary to the Trent or Maira Rivers. Most of them follow preglacial valleys, entrenched up to 30 m in the bedrock. A number of these valleys are blocked by glacial drift, thus creating long narrow lakes or swamps. The Kawartha Lakes (west of Marmora) and Moira Lakes (east of Marmora) are prominent examples of this type.

In the vicinity of the Village of Marmora, Limestone outcrop is clearly present (known as Marmora rock cut along Highway 7). This limestone is of Bobaygen Formation of middle Ordovician age (i.e. approximately 500 million years old). It is generally pale to medium brown, fine to medium grained and bioclastic (Carson, 1980). In some areas, the limestone maybe thinly bedded with the bedding planes between limestone layers often comprised of shale or shaley limestone.

Further east along Highway 7, near the boundary with the Madoc Township is the boundary of these limestones with the primarily igneous rocks, belonging to the Pre-Cambrian Era (i.e. start of the Canadian Shield).

In the area east of the Township and south of Marmora Station and Deloro, the overburden generally consists of intermittent till moraine, shallow till and rock ridges, while, a clay plain may be expected in low-lying areas north of the Marmora Township. Till Moraines of this area are characterized by angular fragments and blocks of limestone with many Precambrian rocks also present. The surface is extremely rough even though most of the

morainic ridges are quite low. Bordering the escarpment, and here and there among the moraines are areas of shallow drift and even bare limestone.

In the low-lying, poorly-drained areas, the presence of clay infill, overlain by organic soils, including peat bogs are not uncommon.

### 3. INVESTIGATION PROCEDURES

The fieldwork for the project was performed first by using a truck-mounted drilling rig on January 11 and 12, 2006. During this period, two boreholes were drilled from the left (north) shoulder of Highway 7 at Swamp No. 3 at Stations 10+000 and 10+100. This was followed by drilling a total of nine boreholes at Swamp No. 2 and another eight boreholes at Swamp No. 3, a short distance beyond the toe of the existing road embankment, as follows:

Swamp No. 2			Swamp No. 3		
Borehole No	Station	Offset	Borehole No.	Station	Offset
2-1	23+962	14.5 m Lt of CL	3-1	25+343	13.0 m Lt of CL
2-2	23+988	14.5 m Lt of CL	3-2	10+007	13.5 m Lt of CL
2-3	24+012	14.0 m Lt of CL	3-3	10+033	13.5 m Lt of CL
2-4	24+038	14.0 m Lt of CL	3-4	10+061	14.0 m Lt of CL
2-5	24+065	12.0 m Lt of CL	3-5	10+087	14.0 m Lt of CL
2-6	24+125	13.0 m Lt of CL	3-6	10+113	14.0 m Lt of CL
2-7	24+169	12.5 m Lt of CL	3-7	10+138	14.5 m Lt of CL
2-8	24+213	16.5 m Lt of CL	3-8	10+165	18.0 m Lt of CL
2-8A	24+213	12.0 m Lt of CL			

These boreholes were drilled from the surface of ice or frozen ground, using a portable, motorized tripod set-up and were extended by wash-boring methods and casing, while the two boreholes drilled from the left shoulder of the highway earlier in January were extended by solid-stem augering (using a truck-mounted drill rig) to refusal on rockfill embankment surface at about 3.6 m below the ground surface, followed by washboring methods and casing advancement.

Walker Drilling of Utopia, Ontario, drilling contractor, carried out the drilling, testing and sampling under the supervision of Geotechnical Engineers from S&P.

Samples in the boreholes were taken at frequent intervals of depth by the Standard Penetration Test Method (SPT), in general accordance with ASTM D1586. The test consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter O.D. split barrel (SS 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 which is indicative of the compactness condition of granular (or cohesionless) soils (gravels, sands and silts) or the consistency of cohesive soils (clays and clayey soils).

In cohesive (clayey) deposits, where the consistency of the soil permitted, relatively undisturbed samples (TW) were also taken with thin-walled (Shelby) tubes which were pushed into the bottom of the borehole by the application of static weight. The undrained shear strength of the soil was also measured in-situ by means of field vane tests where consistency of the clay soils permitted. A small vane (50 mm x 100 mm) was used for this purpose, as the regular MTO vane was not suitable to extend through the casing used for washboring.

Adjacent to or below the bottom of several boreholes (Boreholes 2-3, 2-8, 3-2, 3-5 and 3-8), Dynamic Cone Penetration tests were performed. In Dynamic Cone Penetration Test (DCPT), a 51 mm diameter, 60 deg. apex cone point, screw-attached to the tip of A-size rods, is driven into the ground using the same driving energy as in the SPT method. By recording the number of blows to drive the cone/rod assembly into the soil every 0.3 m, a qualitative record of relative density/consistency is obtained. Although the interpretation of the test results is difficult because no samples are obtained by the DCPT method and the penetration resistances are not necessarily equal to the N-values, useful information is gained by the continuity of the results and by the elimination of unbalanced hydrostatic effects which in many cases affect the SPT values, especially in the fine-grained granular soils. The DCPT was generally terminated when the number of blows to drive the cone/rod assembly 0.3 m exceeded 100.

Groundwater conditions in the boreholes were observed during the drilling in the open boreholes. However, since at most locations the ground was inundated and/or water was used to advance the boreholes the observed water levels do not represent the stabilized groundwater conditions. Upon their completion, the boreholes were grouted using a cement/bentonite mixture as per MTO procedures.

The details of the drilling, sampling, field testing and soil conditions encountered are presented on the Record of Borehole Sheets in Appendix A (Swamp No. 2 location) and Appendix C (Swamp No. 3 location).

A laboratory testing programme, consisting of natural moisture content measurements, Atterberg (liquid and plastic) Limits, grain-size analyses, one-dimensional consolidation (oedometer) and quick triaxial compression (undrained triaxial) and bulk unit weight tests, was performed on selected soil samples. The results of laboratory tests are presented on the appropriate Record of Borehole Sheets and also in Appendix B (Swamp No. 2) and in Appendix D (Swamp No. 3).

## 4. SUBSURFACE CONDITIONS

### 4.1 SWAMP NO. 2

Swamp No. 2 is located between Stations 23+950 and 24+225 (i.e. approximately 275 m long stretch of land) in the Township of Marmora. This section was explored by drilling nine boreholes (numbered through 2-1 through 2-8A) at 24 to 60 m intervals of distance. The boreholes were drilled from near the toe of the existing highway embankment (using a portable drill rig). Boreholes 2-1, 2-2 and 2-3 were drilled from top of an approximately 0.2 m thick ice underlain by between 0.4 and 0.8 m water, whilst others were drilled from the top of frozen ground surface. In general, the boreholes contacted some fill and/or peat and organic silt, underlain by sandy silt to clayey silt which are in turn underlain by another major deposit of silty clay/clayey silt, and finally a thin basal silt deposit immediately above refusal depths to washboring methods (i.e. possible bedrock) at depths ranging from between 7.8 and 12.7 m below the surface of the ice or ground surface.

Details of the sub-surface conditions encountered in the boreholes are presented on the Record of Borehole Sheets in Appendix A, while a stratigraphic profile is given in Drawing No. 1. The various soil strata encountered in the boreholes and their geotechnical properties are briefly described in the following paragraphs. It should be noted that the soil, bedrock and groundwater conditions may vary in between and beyond the borehole locations.

#### 4.1.1 FILL

Boreholes 2-5, 2-6, 2-7, 2-8 and 2-8A contacted a granular fill layer immediately below the ground surface level. This surficial fill was found at the borehole locations to be 0.6, 1.4, 1.4, 0.2 and 1.2 m thick, respectively. The grain-size distribution of a sample from the fill is given in Figure B-1 which indicates the following grain-size distribution:

Gravel:	9%
Sand:	68%
Silt & clay:	23%

In the remaining boreholes, the fill was found to be somewhat coarser, (i.e. more gravelly). At some locations, the fill was noted to be mixed with some organic soil. N-values recorded in the fill ranged from 9 to 70 blows/0.3 m. However, some N-values may not be reliable due to frost in the ground. Possible fill, consisting of sandy silt with occasional peat inclusions was found in Borehole 2-3, below a 0.1 m thick peat layer. This material was found to extend to 0.6 m below the ground surface.

#### 4.1.2 PEAT & ORGANIC SILT

Peat and organic silt were contacted in all the boreholes except for Boreholes 2-6 and 2-8A, as follows:

#### Peat and Organic Silt Depths in the Boreholes

Borehole No.	Depth Below Ground Surface (m)	Thickness of Deposit (m)	Bottom Elevation (m)	Remarks
2-1	zero	0.3	203.8	
2-2	zero	1.2	202.5	
2-3	zero	0.1	203.7	Peat inclusions to 0.6 m in the underlying possible fill deposit
2-4	zero	1.7	202.9	Some sand and gravel, pieces of asphalt penetration into the deposit
2-5	0.6	0.7	203.2/201.8	Encountered underlying granular fill which extends to 0.6 m. Some gravel penetration into the deposit. Peat and organic silt deposit is underlain by a somewhat organic silty clay to clayey silt deposit to 2.7 m depth (i.e. 1.4 m thick)
2-6	-	-	n/a	No organic soil but the granular fill deposit which extends from ground surface to 1.4 m depth has some organic content (i.e. possibly displaced the organic soils)
2-7	1.4	0.2	202.8	Encountered underlying granular fill which extends to 1.4 m depth
2-8	0.2	1.2	203.0	Encountered underlying granular fill which extends to 0.2 m depth
2-8A	-	-	n/a	Trace organics

The measured natural moisture contents on samples recovered range from about 53 to 324%.

N-values recorded in these organic deposits range from 0 to 8 blows/0.3 m penetration but the relatively higher values were recorded due to gravel penetration into the deposit and typical values range from zero to 3 blows/0.3 m. Due to their organic nature, these soils are considered weak and highly compressible. Based on the recorded N-values and a visual and tactile examination of the samples, the consistency of this basically cohesive deposit is considered to be generally very soft.

#### 4.1.3 UPPER SILT

Boreholes 2-1, 2-5, 2-6, 2-7 and 2-8 contacted a surficial silt deposit immediately below the fill or peat and organic silt deposits described in the previous paragraphs.

The silt deposit was encountered at depths/elevations ranging from 0.3 m/203.8 m to 2.7 m/201.8 m below the ground surface and extended to depths/elevations ranging from 2.5 m/202.0 m to 6.1 m/198.3 m.

The grain-size distribution of the material ranges from sandy silt to silt with occasional clayey silt and silty sand seams or zones. The grain-size distribution of three samples from the deposit is given in Figure B-2, Appendix B. This upper silt is a basically fine-grained granular soil which was found to be wet and dilatant. Standard Penetration tests performed in this deposit yielded N-values which ranged from 12 to 30 blows/0.3 m indicating a compact condition, except in the upper zone in Borehole 2-1. In this borehole an N-value of 2 blows/0.3 m indicated a very loose condition. The presence of small sea shell remains was noted in the samples obtained from this very loose zone.

#### 4.1.4 CLAYEY SILT WITH SILT LAYERS

Boreholes 2-2, 2-3 and 2-4 contacted below the surficial fill or organic silt and peat, a basically cohesive clayey silt deposit, rather than the upper silt deposit described in the previous section. Clayey silt was also encountered in Boreholes 2-1, 2-5 and 2-6, immediately underlying the upper silt deposit. This clayey silt deposit is somewhat finer than the silt deposit and exhibits some dilatation.

This unit was contacted at depths (below ground surface)/elevations ranging from 0.6 m/203.2 m at Borehole 2-3 to 3.9 m/200.6 m at Borehole 2-5 and extended to depths/elevations of between 2.2 m/201.6 m at Borehole 2-3 and 7.4 m/196.7 m (Borehole 2-1), with a thickness of between 1.6 and 4.8 m.

This basically cohesive deposit contains some non-cohesive (fine-grained granular) seams and also exhibits some dilatation. The grain-size distribution of four samples from the deposit is given in an envelope form in Figure B-3 in Appendix B.

N-values recorded in the deposit range from 3 to 64 blows/0.3 m indicating a very soft to hard consistency. However, the recorded values are generally in the 11 to 26 blows/0.3 m, indicating a generally stiff to very stiff material, with a very soft zone near the surface of the deposit in Borehole 2-1.



#### 4.1.5 CLAYEY SILT

Underlying the upper silt or clayey silt deposits all the boreholes, except for Boreholes 2-1 and 2-8A, contacted a cohesive deposit consisting of clayey silt.

The deposit was encountered below depths ranging 2.2 m (El. 201.6 m) and 7.3 m (El. 197.2 m) from the ground surface and extended to depths of between 6.3 m (El. 198.3 m) and 12.3 m (El. 192.2 m) below the ground surface. At most boreholes, it is underlain by a lower silt deposit, except at Borehole 2-3 location where the borehole was terminated upon encountering refusal within this deposit but some rock fragments were found in the sample recovered near the refusal depth of 7.3 m (El. 196.5 m). The thickness of the deposit at the location of Boreholes 2-2 through 2-8 ranged from 2.3 to 6.6 m at Boreholes 2-4 and 2-5, respectively.

The deposit contains some thin clay and occasional silt seams. The grain-size distribution of two samples from the deposit is given in Figure B-4 in Appendix B. The following grain-size distribution is indicated:

Gravel:	0%
Sand:	3 - 5%
Silt:	65-69%
Clay:	26-31%

Atterberg Limits tests performed in the laboratory gave the following index values (7 samples), as shown in Figure B-5.

Liquid Limit:	25-28%
Plastic Limit:	15-18%
Plasticity Index:	9-12%

These values are characteristic of clayey soils of low plasticity. The measured natural moisture contents generally range from 20 to 30%.

The relatively high percentage of clay size particles in relation to plasticity indices, as well as somewhat dilatant nature of the soil, in our opinion, indicate that the clay particles in this deposit, including the overlying clayey silt and silt deposits, are relatively inactive and may contain a high percentage of rock flour rather than true clay particles.

N-values recorded in this deposit generally range from 8 to 32 blows/0.3 m. Undrained shear strength, as measured by in-situ shear vane tests, ranged from 40 to 100 kPa, while one quick triaxial compression test yielded an undrained shear strength of 53 kPa. Based on these values, the consistency of the material is described as generally firm to very stiff. Bulk unit weights of 18.5 to 19.3 kN/m<sup>3</sup> were measured.

Consolidation characteristics of the material were investigated by means of one-dimensional consolidation (oedometer) tests (2 tests) and the resulting curves are presented on Figures B-6 and B-7 in Appendix B. As shown on the curves, the deposit appears to be pre-consolidated in excess of existing overburden pressure ( $P_c - P_o$ ) by about 200 to 300 kPa. This is likely to be due to a phenomenon known as aging and possibly some past overburden pressures in excess of the existing overburden pressures.

#### 4.1.6 LOWER SILT

All the boreholes except for Boreholes 2-1, 2-3 and 2-8A contacted a lower silt deposit immediately before encountering refusal to further advance of the boring.

In Borehole 2-1, a sandy silt till deposit was contacted at 7.4 m below the ground surface or at El. 196.7 m. This borehole was terminated upon encountering refusal at 8.6 m (El. 195.5 m) after penetrating the till deposit by 1.2 m. The recorded N-values in this till deposit were 62 and 77 blows/0.3 m which indicates a very dense relative density. In Borehole 2-3, refusal was encountered at 7.3 m (El. 196.5 m) in the silty clay/silty clay deposit discussed in Section 4.1.5 of this report. In Borehole 2-8A, refusal was encountered at 1.2 m (El. 203.2 m) in the granular fill layer.

In Boreholes 2-2 and 2-4 through 2-8, the lower silt deposit was contacted at depths ranging from 6.3 to 12.3 m below the ground surface or at between Elevations 198.3 m and 192.2 m. It was penetrated for a vertical distance of between 0.3 and 1.5 m where the boreholes were terminated due to refusal to further advance by washboring methods.

From the recorded N-values, the compactness condition of the deposit is considered compact to very dense but generally dense to very dense.

This material was noted to be wet and dilatant.

As was mentioned before, refusal was encountered in all the boreholes at depths ranging from 7.3/El. 196.5 m (Borehole 2-3) and 12.6 m/El. 191.9 m (Borehole 2-5). These refusal depths may possibly represent the surface of the bedrock or depths close to it. However, the presence of bedrock was not confirmed by diamond drilling and rock coring, as this was not within our Terms of Reference.

#### 4.1.7 GROUNDWATER CONDITIONS

At the time of our investigation, at many of the borehole locations, the site was inundated and the depth of water (including ice at top) was measured to range from 0.1 to 1.0 m. Because of this and as water was used to advance the boreholes by washboring methods, the measured water levels in the boreholes are unlikely to represent the stabilized groundwater

conditions. It is, however, believed that the groundwater table at the site is high (i.e. at or near the existing ground level and at most times throughout the year free-standing water above ground level similar to the conditions encountered during our fieldwork, will prevail.

It should also be pointed out that groundwater table would be subject to seasonal fluctuations and in response to major weather events.

#### 4.2 SWAMP NO. 3

An approximately 210 m stretch of low-lying land between Stations 25+330 and 10+180, located at the boundary of Townships of Marmora and Madoc, was identified as Swamp No. 3 for the purposes of this project. This area was investigated by drilling eight boreholes in the low lands immediately adjacent to the north toe of the Highway 7 embankment which, in this area, is about 3 m high.

At the time of our investigation, at the location of the boreholes drilled from near the toe, the site was covered by 0.6 to 1.6 m of water (including ice at top). All the boreholes, except for Borehole 3-8, contacted a 1.2 to 3.2 m thick peat layer underlain by organic silts to depths of between 2.7 and 4.6 m below the ground surface. These organic soils are in turn underlain by a weak silty clay deposit which at the borehole locations was found to be 0.5 to 1.8 m thick. At three of the borehole locations, the silty clay deposit is underlain by 0.5 to 1.2 m thick sandy gravel to silty sand deposits followed by refusal to advancing the borehole by washboring methods by portable equipment while at the other locations the refusal was contacted underlying the clay (i.e. gravelly sand was not contacted immediately above the refusal elevations). The refusal depths in Boreholes 3-1 through 3-7 ranged from 3.4 to 6.5 m or elevations ranging 219.9 to 216.8 m.

Borehole 3-8 and DCPT test (Borehole 3-8A), which were located near the east end of the swampy area, at about Station 10+165, contacted fill or suspected fill deposits to refusal depths of 3.1 m and 2.9 m or at Elevations 221.0 m and 221.2 m, respectively.

In addition to boreholes advanced from near the toe, two boreholes were put down from the shoulder of the highway embankment at Stations 10+000 and 10+100. These boreholes contacted, below a granular embankment fill, rock fill or a bouldery fill layer, underlain by peat and organic silt which are in turn underlain by a layer of weak silty clay. The silty clay is followed by competent sandy deposits extending to refusal to further augering at 7.9 to 8.2 m below road grade or at Elevations 218.2 and 218.1 m, respectively. These elevations are similar to refusal elevations encountered in Boreholes 3-2 and 3-6, which are the toe boreholes located closest to Stations 10+000 and 10+100.

Details of the subsurface conditions encountered in the boreholes are given on the Record of Borehole Sheets in Appendix C. A stratigraphic profile is presented in Drawing No. 2, while

inferred cross sections at approximate Stations of 10+000 and 10+100 are given in Drawing No. 3. The following paragraphs are only meant to complement these data. It should be pointed out that the soil, bedrock and groundwater conditions may vary in between and beyond the borehole locations.

#### 4.2.1 FILL

Borehole 3-8, which is located near the easterly boundary of the site, contacted a basically granular fill (i.e. sand and gravel) mixed with some clay and peat to a depth of 0.9 m below the ground surface or to El. 222.6 m. Based on an N-value of 9 blows/0.3 m this material is considered loose. Underlying this, a deposit of clayey silt with gravel, sand and organics was contacted. This deposit, which is likely also fill, was found to extend to the sampled depth of the borehole (i.e. 2.4 m depth or El. 221.7 m). The grain-size distribution of a sample from this material is given in Figure D-1 in Appendix D. A dynamic cone penetration test performed from the bottom of the borehole (i.e. from 2.4 m depth) encountered refusal at 3.1 m depth or at El. 221.0 m. Another dynamic cone penetration test performed 1.2 m west of the borehole contacted refusal at 2.9 m depth or El. 221.2 m, possibly on the surface of bedrock.

Granular embankment fill was contacted in Boreholes 10+000, 5.5 m Lt and 10+100, 5.5 m Lt, which were drilled from the shoulder of the highway embankment. Granular fill was found to extend to depths/elevations of 3.4 m/222.7 m and 3.1 m/223.2 m, respectively. The grain-size distribution of two samples from the fill is given in Figure D-2 (Appendix D). Standard Penetration tests conducted on this granular fill deposit yielded N-values which ranged from 7 to 47 blows/0.3 m which indicate a loose to dense but generally compact to dense condition.

Underlying the granular fill, both boreholes contacted a 0.7 to 1.6 m thick layer of rock fill (or a very coarse fill layer consisting of cobbles and boulders). This layer was found to extend to 4.1 m/El. 222.0 m and 4.7 m/El. 221.6 m in Boreholes 10+000 and 10+100, respectively. In Borehole 10+100, another similar 1.0 m thick layer was contacted from 6.0 to 7.0 m depth. This may consist of a layer of cobbles and boulders of natural occurrence or more likely it may represent rock fill which sank through the overlying organic and weak clay soils.

#### 4.2.2 PEAT

Boreholes 3-1 through 3-7 contacted immediately at the ground surface level a 1.2 to 3.2 m thick peat deposit which extended to elevations ranging from 221.7 m to 219.9 m. The samples recovered from peat indicate a generally well-humified material. The measured natural moisture contents typically range from 400 to 700%.

N-values recorded in the deposit range from 0 to 2 blows/0.3 m (typically zero) indicating a very soft consistency. The peat is considered to be basically cohesive soil. Due to its organic nature, it is likely compressible material which would continue to settle even after any pore pressures generated by the stress increases have dissipated, due to a phenomenon known as 'secondary consolidation.'

Peat was also encountered in Boreholes 10+000 and 10+100, drilled from the top of the highway embankment, at depths/elevations of 4.1 m/222.0 m and 4.7 m/221.6 m, with a thickness of 0.5 and 0.3 m, respectively. It should, however, be realized that these are compressed thicknesses (i.e. after having settled under the weight of the embankment fill for the past 40 to 50 years) as well, some of the peat may have been displaced and/or penetrated by rock fill during the construction of the embankment. Therefore, the peat thickness before the construction of Highway 7 would have been in excess of the values measured in Boreholes 10+000 and 10+100.

#### 4.2.3 ORGANIC SILT

Boreholes 3-1 through 3-7 contacted, underlying the peat, a 0.5 m (Boreholes 3-5 and 3-7) to 3.1 m (Borehole 3-3) thick organic silt layer which extends to depths ranging between 2.7 m and 4.6 m or to between Elevations 220.4 and 218.6 m.

The organic silt is a beige or off-white colored marl-like material and contains small sea shell remains, especially near the surface. Dark grey/blackish non-marl like zones are also common, especially towards the bottom of the deposit. The measured natural moisture contents of samples from the deposit range from 68 to 322%, indicating its organic nature.

N-values recorded in the cohesive deposit ranges from zero to 3 blows/0.3 m but are generally zero, indicating a very soft consistency. A field vane test conducted in this deposit in Borehole 3-3 yielded an undrained in-situ shear strength of 8 kPa.

Similar to the overlying peat deposit, due to its organic nature, the organic silt is considered to be highly compressible material exhibiting long-term 'secondary consolidation' phenomenon.

In the boreholes drilled from the top of the highway embankment, organic silt was also encountered underlying the peat at depth of 4.6 to 5.0 m depths. Its thickness in these two boreholes was found to be 0.7 and 1.7 m and it extended to depths/elevations 5.7 m/220.6 m and 6.3 m/219.8 m. Again, these thicknesses should be considered as compressed thicknesses under the embankment fill stresses.

#### 4.2.4 CLAYEY SILT

Boreholes 3-1 through 3-7 and Boreholes 10+000 and 10+100 contacted, underlying the organic silt, a clayey silt deposit. In Boreholes 3-1 through 3-7, the clayey silt was encountered at depths of 2.7 to 4.6 m below the ground surface or at Elevations of 220.4 to 218.6 m, with a thickness varying from 0.5 m to 1.8 m, but generally about 0.7 m. This cohesive deposit was found to extend to depths ranging from 3.4 m to 5.7 m or to between Elevations 219.9 and 217.5 m.

In Boreholes 10+000 and 10+100 this deposit was encountered at depths/elevations 6.3/219.8 and 5.7/220.6 m and extended to depths/elevations 7.0/219.1 and 6.0/220.3 m, respectively.

The grain-size distribution of three samples from the deposit is given in Figure D-3 (Appendix D). Atterberg limits tests performed in the laboratory from samples recovered from this cohesive deposit, yielded the following index values (eight samples).

Liquid Limit:	27 – 37%
Plastic Limit:	15 – 22%
Plasticity Index:	9 – 17%

As shown on the Plasticity Chart (Figure D-4, Appendix D) these values are characteristic of clayey soils of low plasticity. The measured natural moisture contents are well in excess of the measured liquid limit, indicating a normally consolidated and possibly an under-consolidated deposit.

N-values recorded in the deposit in Boreholes 3-1 through 3-7 yielded N-values generally ranging from zero to 1 blow/0.3 m. The measured in-situ, undrained shear strengths (by means of three field vane tests) ranged from 20 to 40 kPa. Based on these values along with a visual and tactile examination of the soil samples, the consistency of the material is described as very soft to firm, but generally very soft.

One-dimensional consolidation tests were performed on two relatively undisturbed samples from the deposit and the resulting curves are given on Figures D-5 and D-6. The results show no pre-consolidation pressure in excess of existing effective stresses (i.e.  $P_o \cong P_c$ ).

From these results, the material is considered to be highly compressible.

#### 4.2.5 SAND

A basal deposit of sand with variable amount of gravel and silt content (i.e. grain-size distribution varies from silty sand to sand gravel) was contacted in Boreholes 3-2, 3-3 and 3-6 and in the two boreholes drilled from the top of the highway embankment. This granular

deposit was contacted underlying the silty clay deposit at depths of 7.0 m (El. 219.3 - 219.1 m) in the boreholes drilled from the top of the embankment and at depths of 3.6 to 5.7 m (El. 219.1 -217.5 m) in the boreholes put down from near the toe (i.e. Boreholes 3-2, 3-3 and 3-6). The thickness of the deposit at the borehole locations ranged from 0.5 to 1.2 m. All the boreholes drilled at this site were terminated upon encountering refusal beneath the sand or the clay deposits. In most of the boreholes broken rock fragments were found immediately before refusal depths indicating possible bedrock. The bedrock at the site is likely to consist of granitic gneisses of the Pre-cambrian age.

The grain-size distribution of a sample from the deposit is presented in Figure D-7. This shows 54% gravel, 34% sand and 12% soil fines (i.e. silt and clay particles). N-values recorded in this deposit ranged from 33 to in excess of 100 blows/0.3 m which indicate a generally dense to very dense condition.

#### 4.2.6 GROUNDWATER CONDITIONS

At the toe borehole locations, the ground was covered by 0.6 to 1.6 m of water and ice. As well, water was used to facilitate advancing the boreholes. For this reason, the groundwater levels in the boreholes could not be identified. We believe that the groundwater table would be at or near the ground surface. We also understand that free-standing water (above ground surface levels) prevails throughout much of the year or throughout the entire time.

It should also be pointed out that the groundwater table would be subject to seasonal fluctuations and fluctuations in response to major weather events.

#### SHAHEEN & PEAKER LIMITED



  
Ramon Miranda, P.Eng.

ZO:tr/idrive



Z.S. Ozden, M.A.Sc., M.Eng., P.Eng.



*Project: SPT1147  
Transenco Limited*

*Foundation Investigation Report  
Two Swamp Crossings, Proposed Widening of Highway 7  
From 2.6 km West of Marmora to Marmora West Limits  
And from Marmora East Limits to 6.6 km West of Highway 62, 12.5 km  
G.W.P. 251-98-00*

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# Drawings



CONT No.  
GWP: 251-98-00

HIGHWAY 7 (MARMORA)  
SWAMP NO.2  
BORE HOLE LOCATIONS & SOIL STRATA



SHAHEEN & PEAKER LIMITED



KEY PLAN  
N.T.S.

**METRIC**

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

**LEGEND**

- Bore Hole
- ⊕ Bore Hole & Core
- N Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation

No.	ELEV.	STATION	OFFSET
BH2-1	204.7	23+962	14.5m Lt C/L
BH2-2	204.7	23+968	14.5m Lt C/L
BH2-3	204.6	24+012	14.0m Lt C/L
BH2-4	204.6	24+038	14.0m Lt C/L
BH2-5	204.6	24+065	12.0m Lt C/L
BH2-6	204.5	24+125	13.0m Lt C/L
BH2-7	204.4	24+169	12.5m Lt C/L
BH2-8	204.4	24+213	16.5m Lt C/L
BH2-8A	204.4	24+213	12.0m Lt C/L
BH2-8B	204.4	24+214.1	12.0m Lt C/L

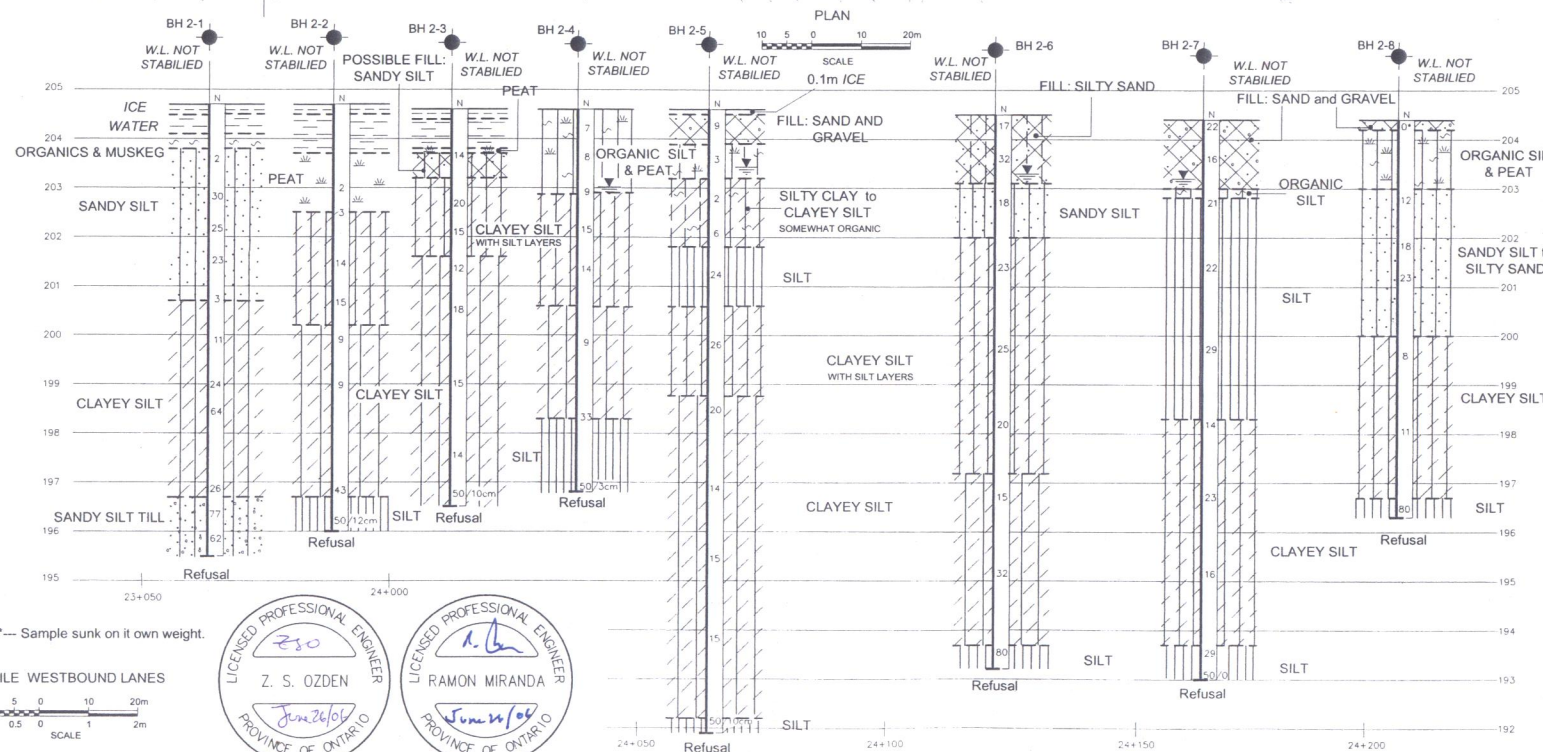
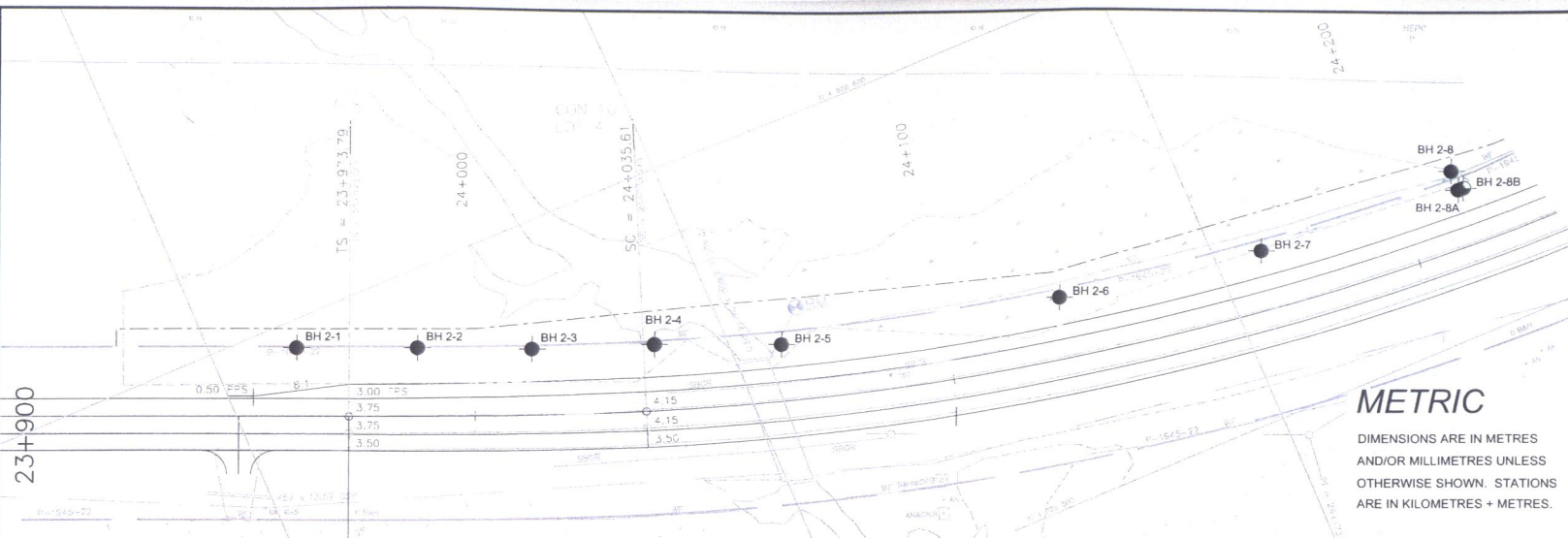
**=NOTE=**  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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

DATE	BY	DESCRIPTION

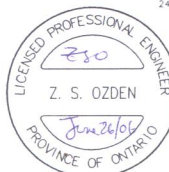
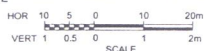
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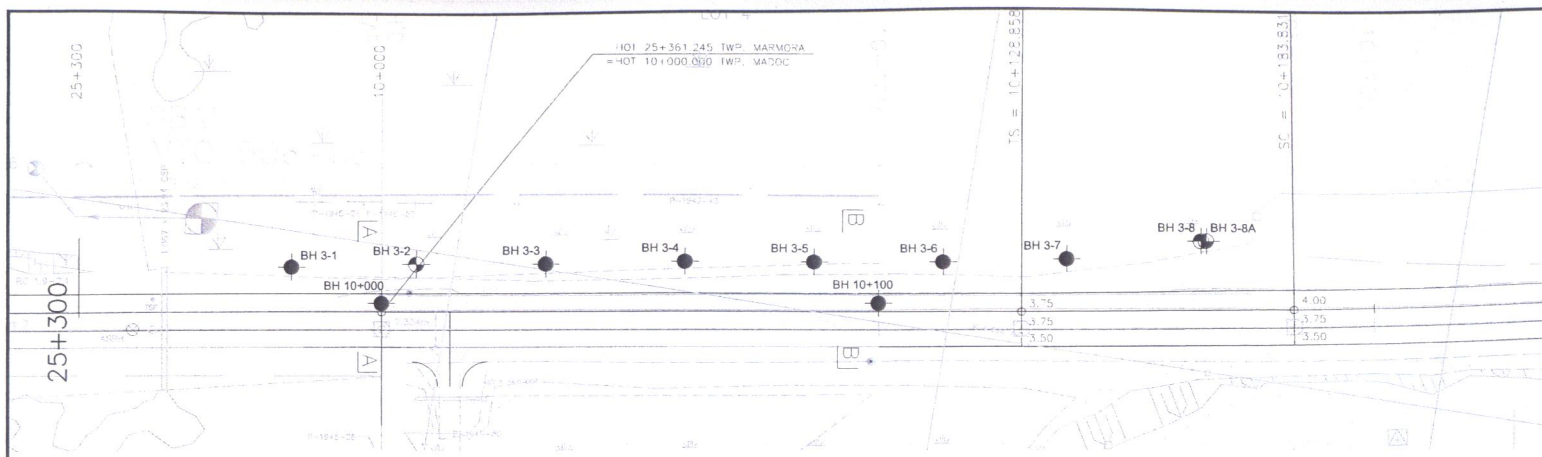
HWY No. 7		DIST
SUBM'D ZO	CHECKED ZO	DATE June, 2006
DRAWN JZ	CHECKED ZO	APPROVED ZO
		DWG 1



NOTE: 0"--- Sample sunk on it own weight.

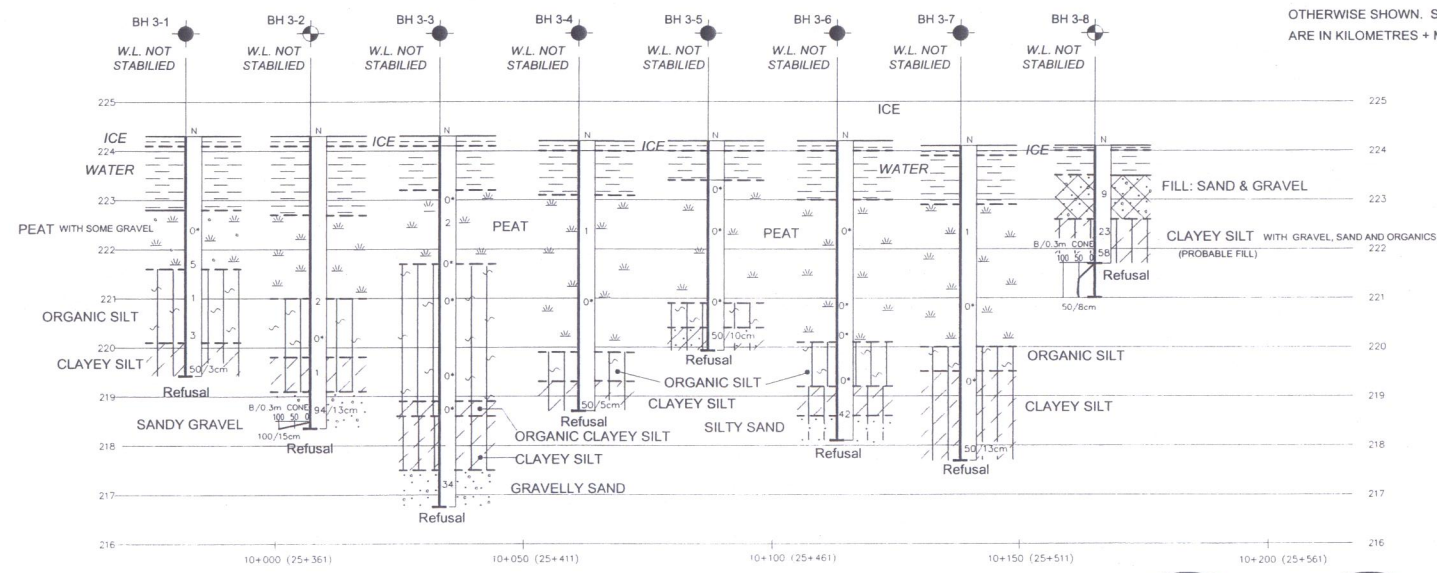
Q PROFILE WESTBOUND LANES



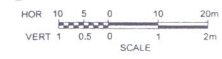


# METRIC

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



PROFILE WESTBOUND LANES



NOTE: 0\* --- Sampler sunk on its own weight

CONT No.  
GWP: 251-98-00  
HIGHWAY 7 (MARMORA)  
SWAMP NO. 3  
BORE HOLE LOCATIONS & SOIL STRATA

## SHAHEEN & PEAKER LIMITED



KEY PLAN  
N.T.S

## LEGEND

- Bore Hole
- Bore Hole & Core
- Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation

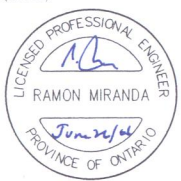
No.	ELEV.	STATION	OFFSET
BH3-1	224.3	25+343 (Marmora)	13.0m Lt C/L
BH3-2	224.3	10+007 (Marmora)	13.5m Lt C/L
BH3-3	224.3	10+033 (Marmora)	13.5m Lt C/L
BH3-4	224.2	10+061	14.0m Lt C/L
BH3-5	224.2	10+087	14.0m Lt C/L
BH3-6	224.2	10+113	14.0m Lt C/L
BH3-7	224.1	10+138	14.5m Lt C/L
BH3-8	224.1	10+165	18.0m Lt C/L
BH3-8A	224.1	10+164	18.0m Lt C/L

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

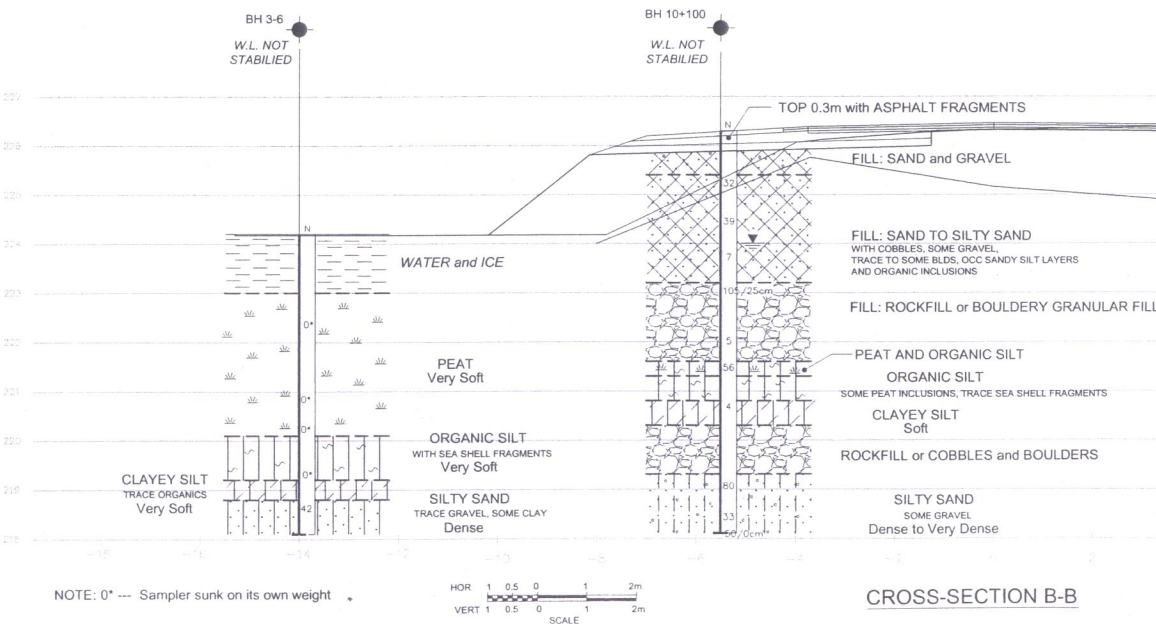
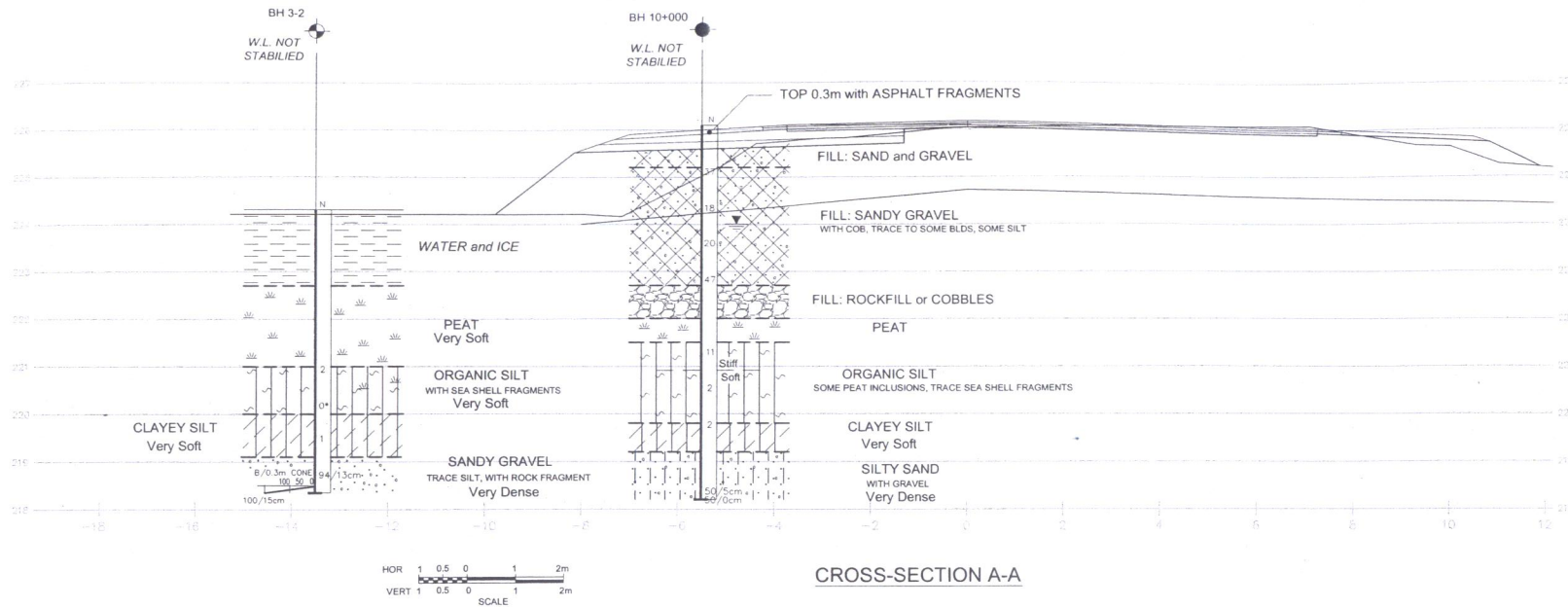
NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents are specifically excluded in accordance with the conditions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

REV.	DATE	BY	DESCRIPTION

Geocres No. 31C-173			
HWY No. 7			DIST
SUBMD ZO	CHECKED ZO	DATE June, 2006	SITE
DRAWN JZ	CHECKED ZO	APPROVED ZO	DWG 2







CONT No.  
GWP: 251-98-00

HIGHWAY 7 (MARMORA)  
SWAMP NO. 3  
BORE HOLE LOCATIONS & SOIL STRATA

SHAHEEN & PEAKER LIMITED



#### LEGEND

- Bore Hole
- Bore Hole & Core
- N Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation

No.	ELEV.	STATION	OFFSET
BH3-2	224.3	10+007 (Modoc)	13.5m Lt C/L
BH3-6	224.2	10+113	14.0m Lt C/L
BH10+000	226.1	10+000	5.5m Lt C/L
BH10+100	226.3	10+100	5.5m Lt C/L

#### NOTE

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

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

REV.			
	DATE	BY	DESCRIPTION

Geocres No. 31C-173

HWY No. 7			DIST
SUBMD ZO	CHECKED ZO	DATE June, 2006	SITE
DRAWN JZ	CHECKED ZO	APPROVED ZO	DWG 3



# Appendix A

## Record of Borehole Sheets (Swamp No. 2)

SPT1147

# RECORD OF BOREHOLE No 2-1

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 23+962 (Marmora), 14.5 m Lt C/L, Highway 7 ORIGINATED BY N.H.  
DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
DATUM Geodetic DATE 3/10/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
204.7 0.0	Ice Surface						20 40 60 80 100						
204.1 0.6	ICE (0.2m) and WATER						○ UNCONFINED + FIELD VANE						
203.8 0.9	ORGANICS & MUSKEG						● POCKET PENETR. × LAB VANE						
	very loose		1	SS	2								
	compact		2	SS	30								0 5 74 21
	SANDY SILT with Silty Sand and silt zones, traces of sea shells & organics brown to grey, wet		3	SS	25								
			4	SS	23								
200.7 4.0			5	SS	3								
	soft to firm		6	SS	11								0 2 60 38
	stiff												
	very stiff		7	SS	24								
	CLAYEY SILT some silt and silty clay zones		8	SS	64								
	hard to v. stiff reddish grey												
196.7 8.0			9	SS	26								
	SANDY SILT TILL grey, wet very dense		10	SS	77								
195.5 9.2			11	SS	62								
	End of borehole. Wash boring refusal at 9.2 m on possible bedrock.												
	Ground water level can not be determined since the area is below water.												

SPT1147

# RECORD OF BOREHOLE No 2-2

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 23+988 (Marmora), 14.5 m Lt C/L, Highway 7 ORIGINATED BY N.H.  
 DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
 DATUM Geodetic DATE 3/10/2006 CHECKED BY R.M.

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						
204.7 0.0	Ice Surface												kN/m <sup>3</sup>	GR SA SI CL
203.7 1.0	ICE (0.2) and WATER						204							
202.5 2.2	PEAT black, very soft		1	SS	2		203						152.2	
200.2 4.5	CLAYEY SILT with silt layers grey, wet very soft to stiff, dilatant	mostly silt	2	SS	3		202						324.2	
			3	SS	14		201							
			4	SS	15		200							
	CLAYEY SILT with thin clay seams firm to stiff		5	SS	9		199							0 5 69 26
			6	SS	9		198							Consolidation Test
196.7 8.0	SILT reddish grey, wet, dense, dilatant trace rock fragment	hard	7	TW	PH		197						18.5 19.1	
196.0 8.7	End of borehole. Wash boring refusal at 8.7 m on possible bedrock.  Water level could not be determined since borehole location in below water level.		8	SS	43									
			9	SS	50/12									

+ 3 . × 3 : Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE



SPT1147

RECORD OF BOREHOLE No 2-3

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 24+012 (Marmora), 14 m Lt C/L, Highway 7 ORIGINATED BY N.H.  
DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
DATUM Geodetic DATE 3/10/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● POCKET PENETR.    × LAB VANE						WATER CONTENT (%) w P                      w                      w L
204.6 0.0	Ice Surface													
	ICE (0.2m) and WATER													
203.8 0.8							204							
203.7 0.9	PEAT POSSIBLE FILL: SANDY SILT some clay, trace gravel, occ. peat inclusions		1	SS	14									
203.2 1.4	greenish gray wet, compact													
	CLAYEY SILT with silt layers grey, wet, stiff, dilatant		2	SS	20		203							0 15 67 18
			3	SS	15		202							
201.6 3.0			4	SS	12		201							0 3 65 31
	CLAYEY SILT some thin clay seams grey, wet, stiff		5	SS	18		200							
			6	SS	15		199							
							198							
			7	SS	14									
			8	SS	50/10		197							
196.5 8.1	trace gravel													
	End of borehole. Wash boring refusal at 8.1 m on possible bedrock.  Drove DCPT from 8.0 to 8.1m. (108 blows/2.5cm)  Water level could not be determined since the area is below water.													

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

SPT1147

# RECORD OF BOREHOLE No 2-4

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 24+038 (Marmora), 14 m Lt C/L, Highway 7 ORIGINATED BY N.H.  
DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
DATUM Geodetic DATE 3/11/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL							
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)						
								○ UNCONFINED	+ FIELD VANE	● POCKET PENETR.			× LAB VANE	W <sub>p</sub>	W	W <sub>L</sub>			
204.6 0.0	Ground Surface						20	40	60	80	100								
202.9 1.7	ORGANIC SILT & PEAT mixed with sand & gravel, occ. asphalt pieces dark brown, wet, loose		1	SS	7		204												
			2	SS	8														
200.6 4.0	CLAYEY SILT with silt layers grey, wet, stiff, dilatent		3	SS	9		203												
			4	SS	15														
198.3 6.3	CLAYEY SILT some thin clay seams grey, stiff		5	SS	14		202												
196.8 7.8	SILT with clayey silt seams reddish grey, wet dilatent, dense to v. dense		6	SS	9	201													
			7	SS	33	200													
			8	SS	50/3	199													
						</													

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



SPT1147

# RECORD OF BOREHOLE No 2-5

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 24+065 (Marmora), 12 m Lt C/L, Highway 7 ORIGINATED BY N.H.  
DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
DATUM Geodetic DATE 3/11/2006 CHECKED BY R.M.

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				
204.6	Ice Surface						20 40 60 80 100	20 40 60 100	20 40 60	0 14 68 180		
0.0	ICE (0.1m) FILL: Sand & Gravel with organics dark grey, wet, loose		1	SS	9		○ UNCONFINED + FIELD VANE ● POCKET PENETR. x LAB VANE	20 40 60 80 100	20 40 60			
203.9												
0.7	PEAT & ORGANIC SILT with some gravel black to dark grey, wet, very loose		2	SS	3							
203.2												
1.4	SILTY CLAY to CLAYEY SILT somewhat organic dark grey, wet, very soft to firm		3	SS	2							
201.8			4	SS	6							
2.8	SILT grey, wet, compact, dilatent		5	SS	24							
200.6												
4.0	CLAYEY SILT with silt layers grey, wet, very stiff, dilatent		6	SS	26							
198.8												
5.8			7	SS	20							
	CLAYEY SILT with thin clay seams grey, stiff											
			8	SS	14							
			9	SS	15							
			10	SS	15							
192.2												
12.4	SILT reddish, wet, very dense		11	SS	50/10							
12.7	End of borehole. Wash boring refusal at 12.7 m on possible bedrock.											
12.7	Water level @ 0.9m below ground surface upon completion (not stabilized).											

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

SPT1147

# RECORD OF BOREHOLE No 2-6

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 24+125 (Marmora), 13 m Lt C/L, Highway 7 ORIGINATED BY N.H.  
DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
DATUM Geodetic DATE 3/12/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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	LIQUID LIMIT w <sub>L</sub>	
204.5 0.0	Ground Surface											
	<b>FILL: SILTY SAND</b> some gravel, some organics dark brown, wet, compact		1	SS	17		204					
			2	SS	32							
203.1 1.4	<b>SANDY SILT</b> grey, wet, compact, dilatent		3	SS	18		203					
202.0 2.5	<b>CLAYEY SILT</b> with Silt Layers grey, wet, very stiff, dilatent		4	SS	23		202					
			5	SS	25		201					
			6	SS	20		200					
			7	SS	15		199					
197.2 7.3	<b>CLAYEY SILT</b> with thin clay seams grey, stiff to very stiff		8	SS	32		198					
			9	SS	80		197					
193.7 10.8	<b>SILT</b> reddish grey, wet, very dense, dilatent						196					
193.2 11.3	End of borehole. Wash boring refusal at 11.3 m on possible bedrock.  Water level @1.2m upon completion ( not stabilized).						195					
							194					

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

SPT1147

# RECORD OF BOREHOLE No 2-7

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 24+169 (Marmora), 12.5 m Lt C/L, Highway 7 ORIGINATED BY N.H.  
DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
DATUM Geodetic DATE 3/12/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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	LIQUID LIMIT w <sub>L</sub>	
204.4 0.0	Ground Surface											
	FILL: GRAVEL & SAND trace silt, trace rootlets		1	SS	22		204					
			2	SS	16							
203.0 1.4	ORGANIC SILT, dark grey						203					
202.8 1.6	trace rootlets		3	SS	21							
	SILT with some clayey silt and sandy silt seams grey, wet, compact, dilatent						202					
			4	SS	22		201					0 5 63 32
							200					
			5	SS	29							
							199					
198.3 6.1	CLAYEY SILT grey, wet, stiff to very stiff		6	SS	14		198					
							197					
			7	SS	23							
							196					
			8	SS	16		195					
							194					
193.7 10.7	SILT reddish grey, wet, compact, dilatent		9	SS	29							
193.0 11.4	End of borehole. Wash boring refusal at 11.4 m on possible bedrock.  Water level @ 1.2m upon completion (not stabilized)				50/0		193					

+ 3, X 3: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE



SPT1147

# RECORD OF BOREHOLE No 2-8

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 24+213 (Madoc), 16.5m Lt C/L, Highway 7 ORIGINATED BY N.H.  
 DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
 DATUM Geodetic DATE 3/13/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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	LIQUID LIMIT w <sub>L</sub>	
204.4	Ground Surface											
204.2	FILL: SAND and GRAVEL some silt		1	SS	0*		204					
0.2	ORGANIC SILT & PEAT dark grey to black, very soft											
203.0							203					
1.4	SANDY SILT to SILTY SAND wet, compact		2	SS	12							
			3	SS	18		202					
			4	SS	23		201					
200.0							200					
4.4	CLAYEY SILT some silt and thin clay seams grey, wet, stiff		5	SS	8		199					
			6	TW	PH							
			7	SS	11		198					
196.7							197					
7.7	SILT reddish grey, wet, very dense		8	SS	80							
196.3												
8.1	End of borehole. Wash boring refusal at 8.1 m on possible bedrock. Try Dynamic Cone Penetration Test @ 8.0m; 100 blows for 0.15m penetration, then refusal.  * Sampler sunk on it own weight.  Water level @ 0.65m upon completion ( not stabilized).											

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

SPT1147

# RECORD OF BOREHOLE No 2-8A

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 24+213 (Madoc), 12.0m Lt C/L, Highway 7 ORIGINATED BY N.H.  
 DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
 DATUM Geodetic DATE 3/12/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. x LAB VANE		WATER CONTENT (%) w P w w L				
204.4 0.0	Ground Surface													
	FILL:SAND and GRAVEL trace organics brown, damp		1	SS	70		204							
203.2 1.2			2	SS	40									
	End of borehole. Wash boring refusal at 1.2m possible on rockfill.													


SPT1147

RECORD OF BOREHOLE No 2-8B

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 24+214.1 (Madoc), 12.0m Lt C/L, Highway 7  
DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod  
DATUM Geodetic DATE 3/12/2006  
ORIGINATED BY N.H.  
COMPILED BY J.Z.  
CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● POCKET PENETR.    × LAB VANE				
204.4 0.0	Ground Surface  Dynamic Core Penetration Test (DCPT) perform from surface to 1.4m.						204					
203.0 1.4	End of DCPT on 1.4m. possible on rockfill.							56 15				

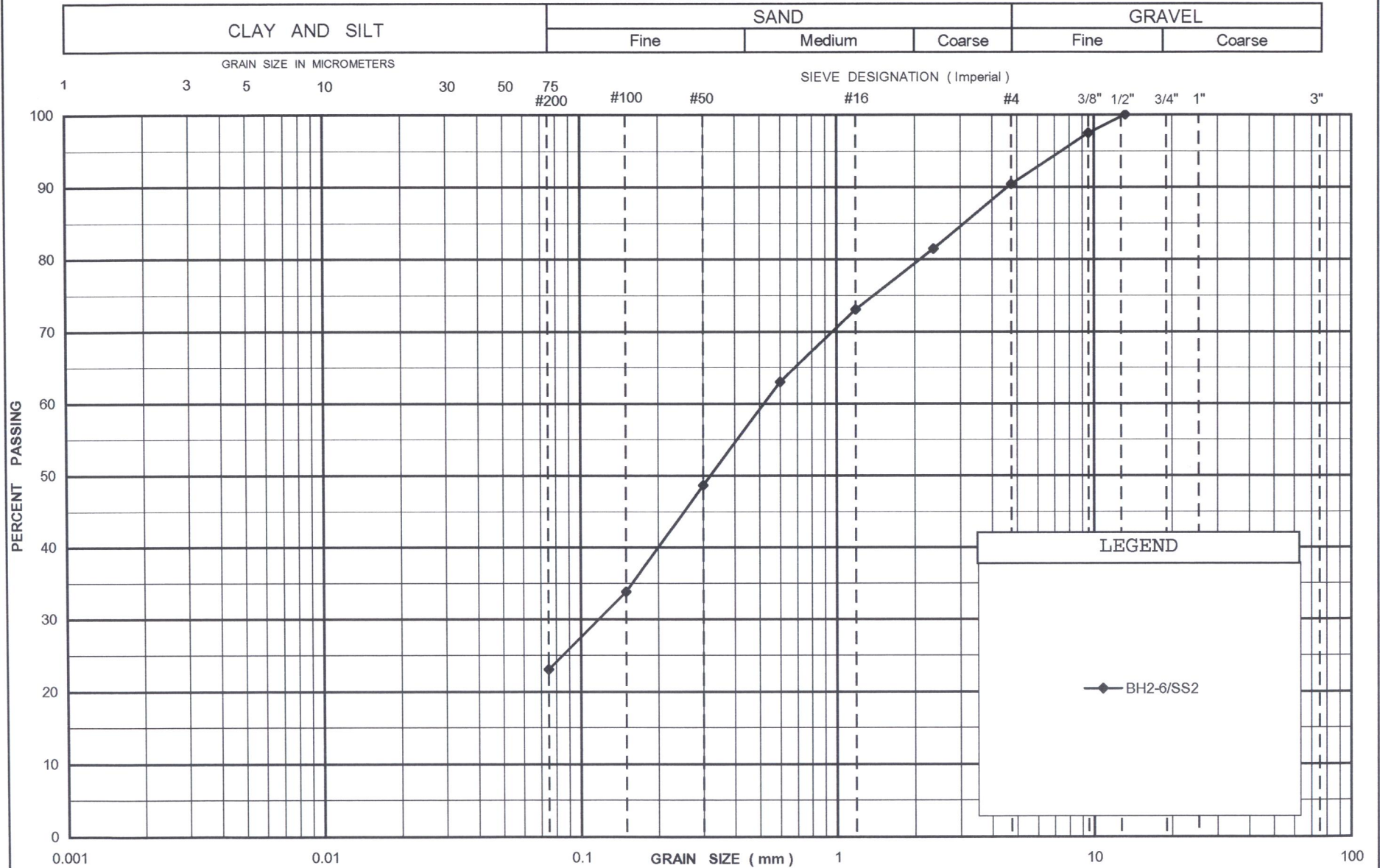
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
20  
15  
10  
(%) STRAIN AT FAILURE

# Appendix B

## Laboratory Results (Swamp No. 2)



# UNIFIED SOIL CLASSIFICATION SYSTEM



SHAHEEN & PEAKER LIMITED

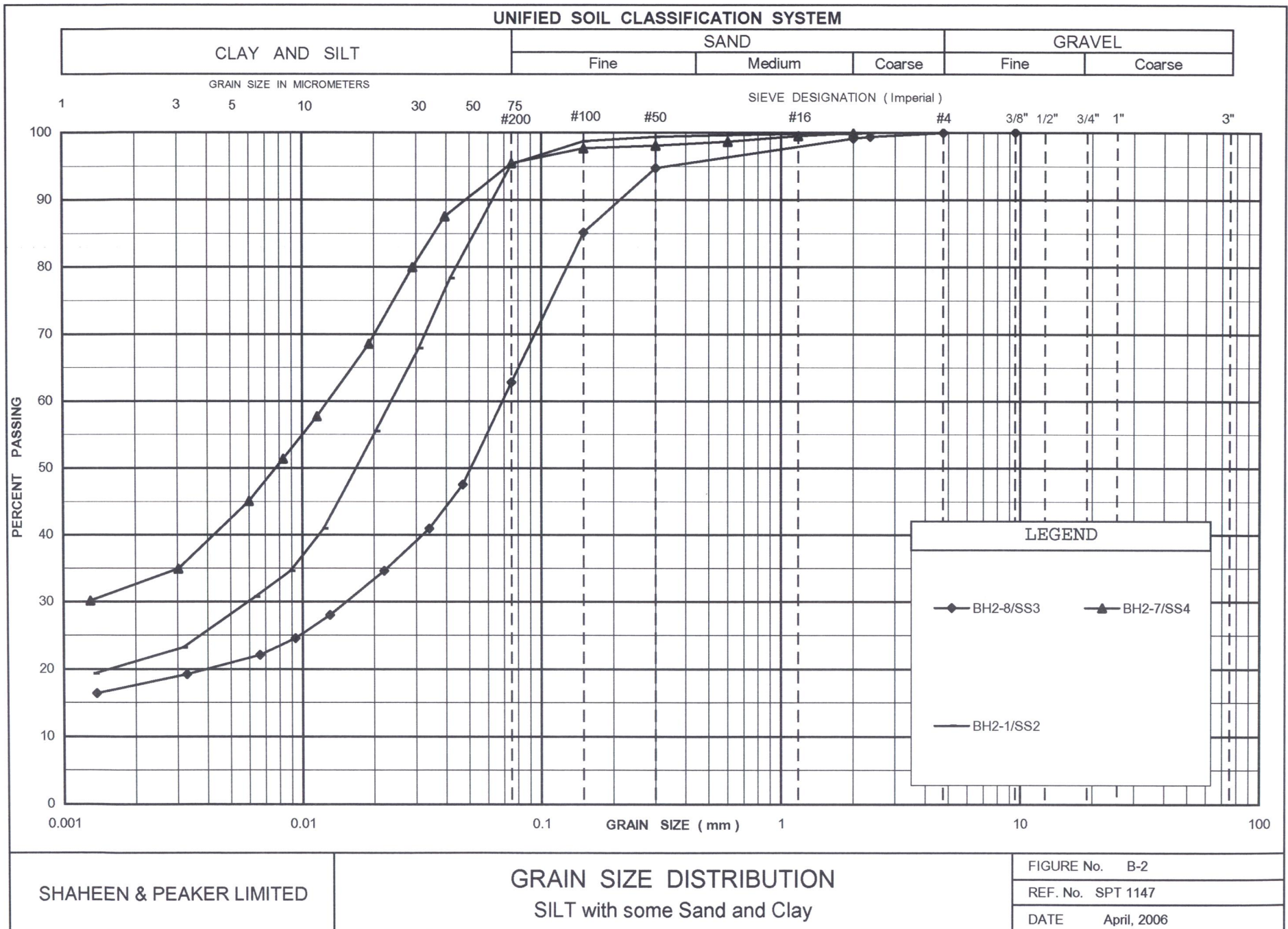
GRAIN SIZE DISTRIBUTION  
FILL: SILTY SAND, some Gravel

FIGURE No. B-1

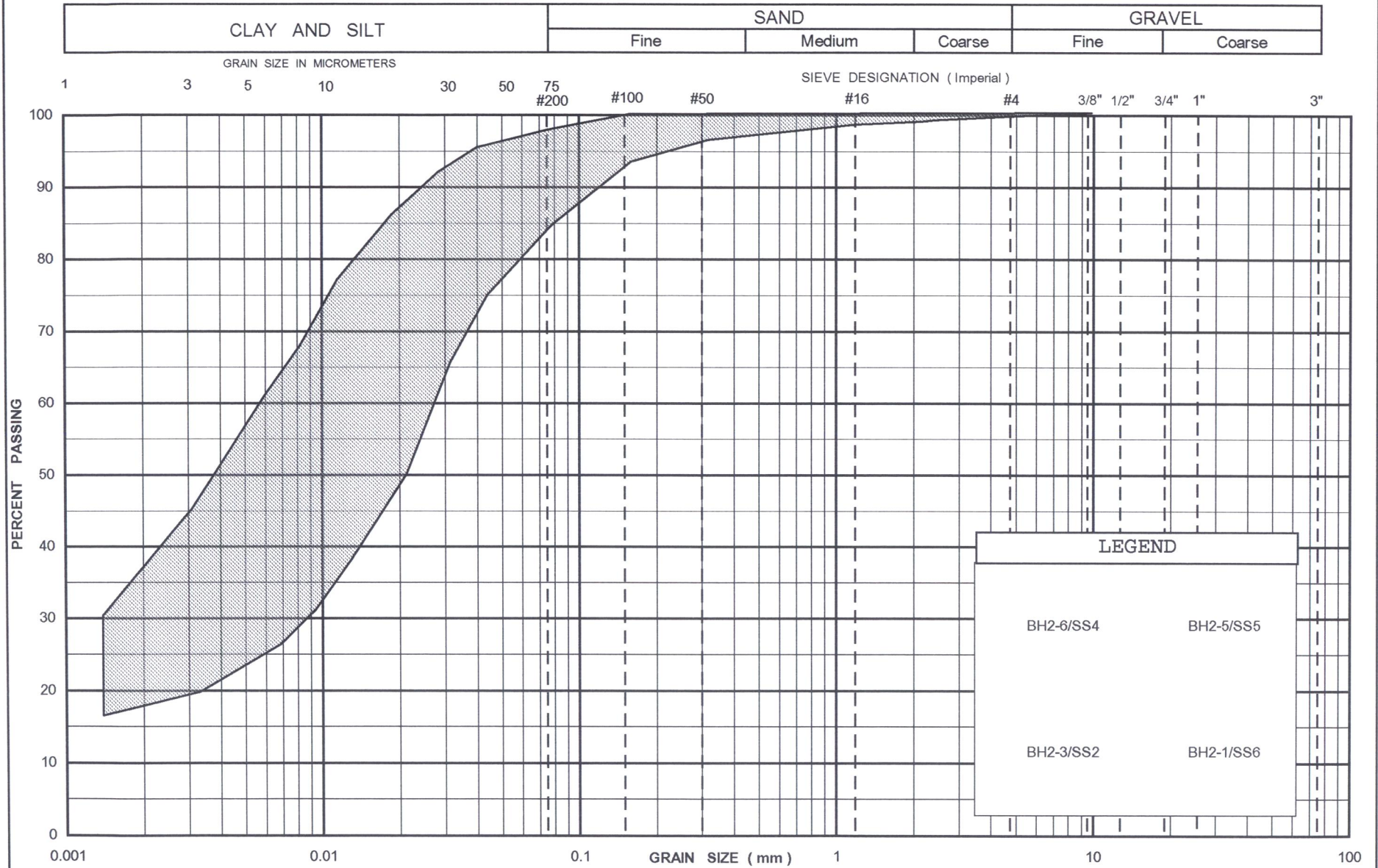
REF. No. SPT 1147

DATE April, 2006





# UNIFIED SOIL CLASSIFICATION SYSTEM



SHAHEEN & PEAKER LIMITED

**GRAIN SIZE DISTRIBUTION**  
CLAYEY SILT with Silt Layers

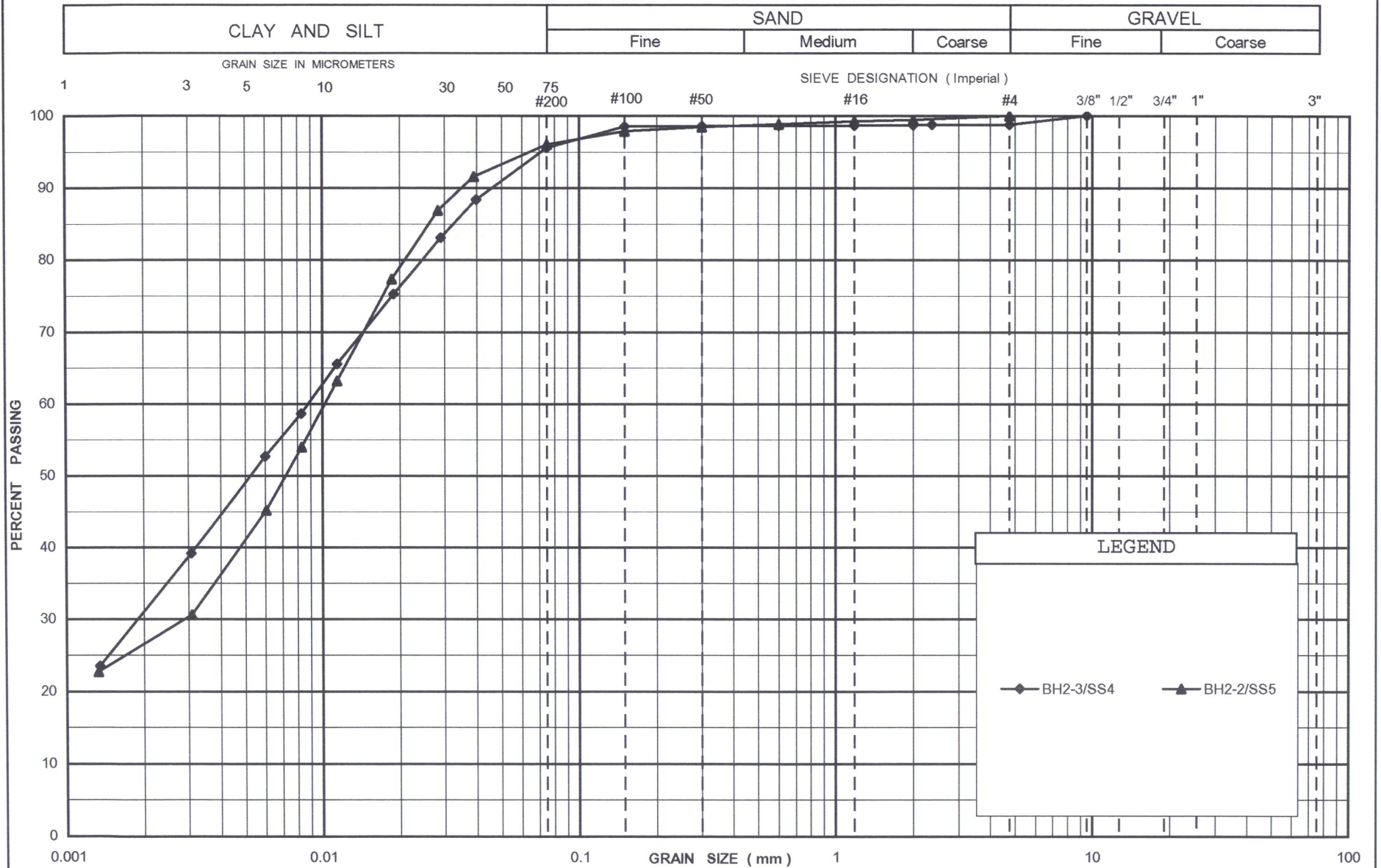
FIGURE No. B-3

REF. No. SPT 1147

DATE April, 2006



# UNIFIED SOIL CLASSIFICATION SYSTEM



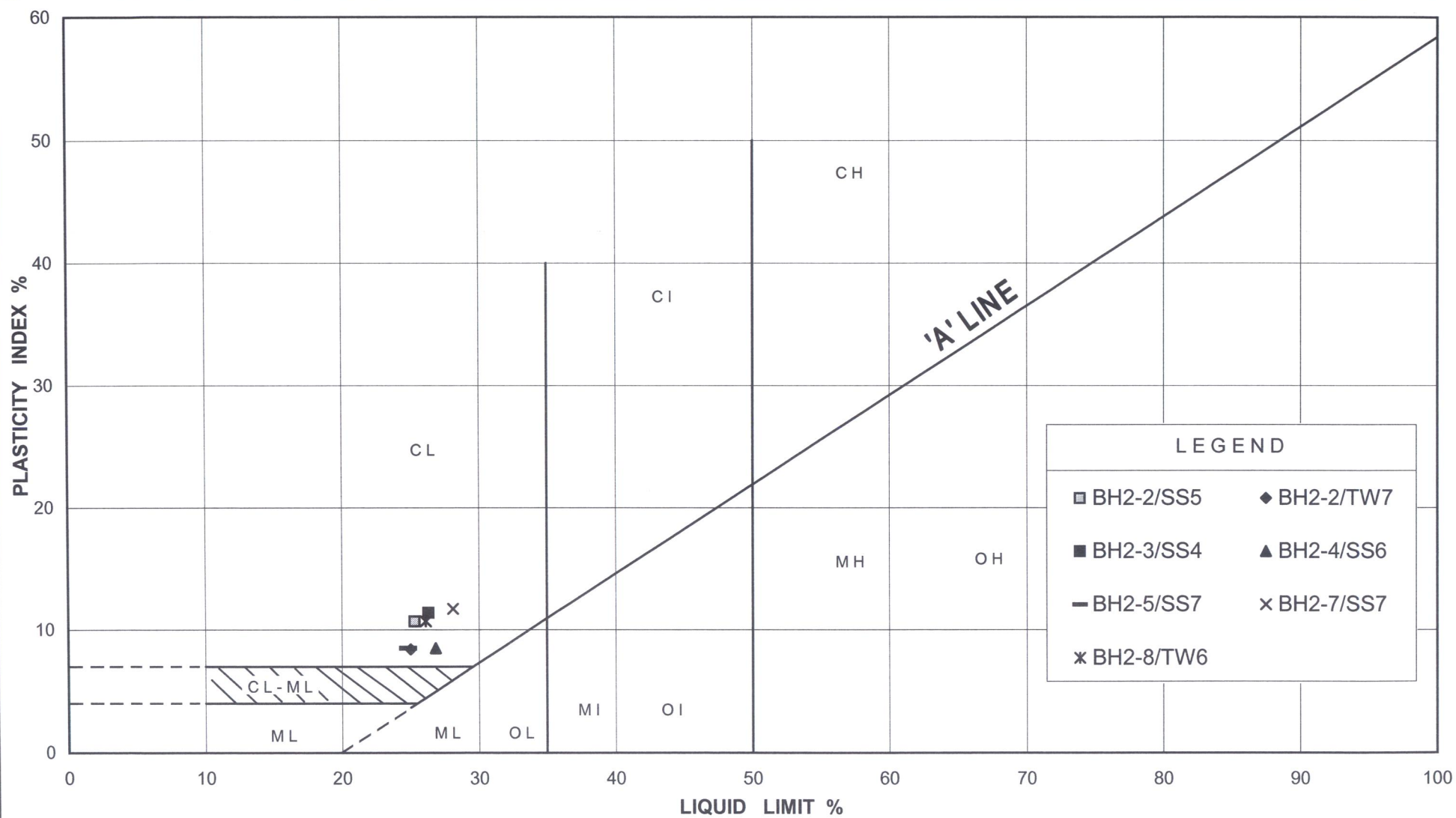
SHAHEEN & PEAKER LIMITED

GRAIN SIZE DISTRIBUTION  
CLAYEY SILT

FIGURE No. B-4

REF. No. SPT 1147

DATE April, 2006



SHAHEEN & PEAKER LIMITED

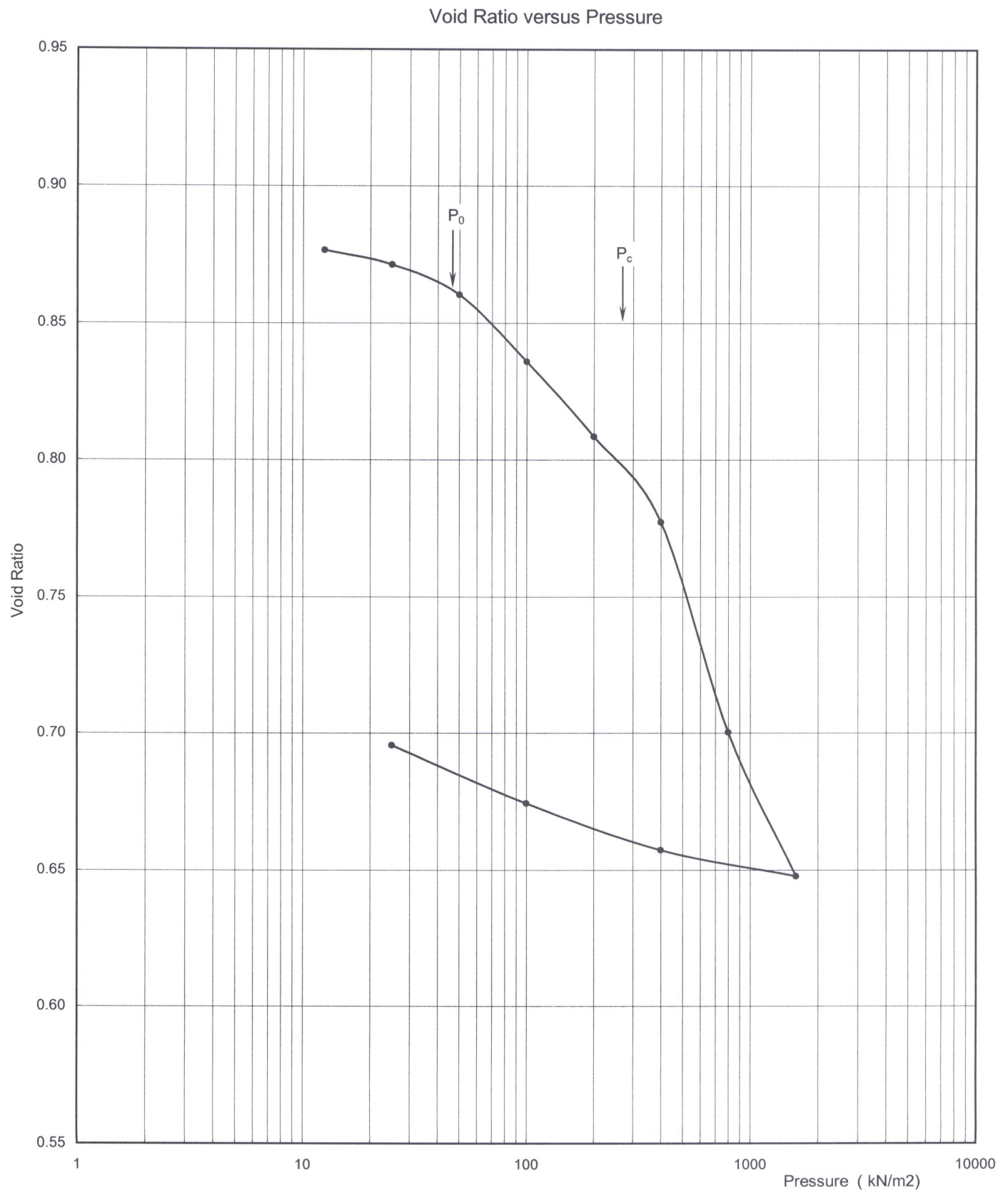
PLASTICITY CHART

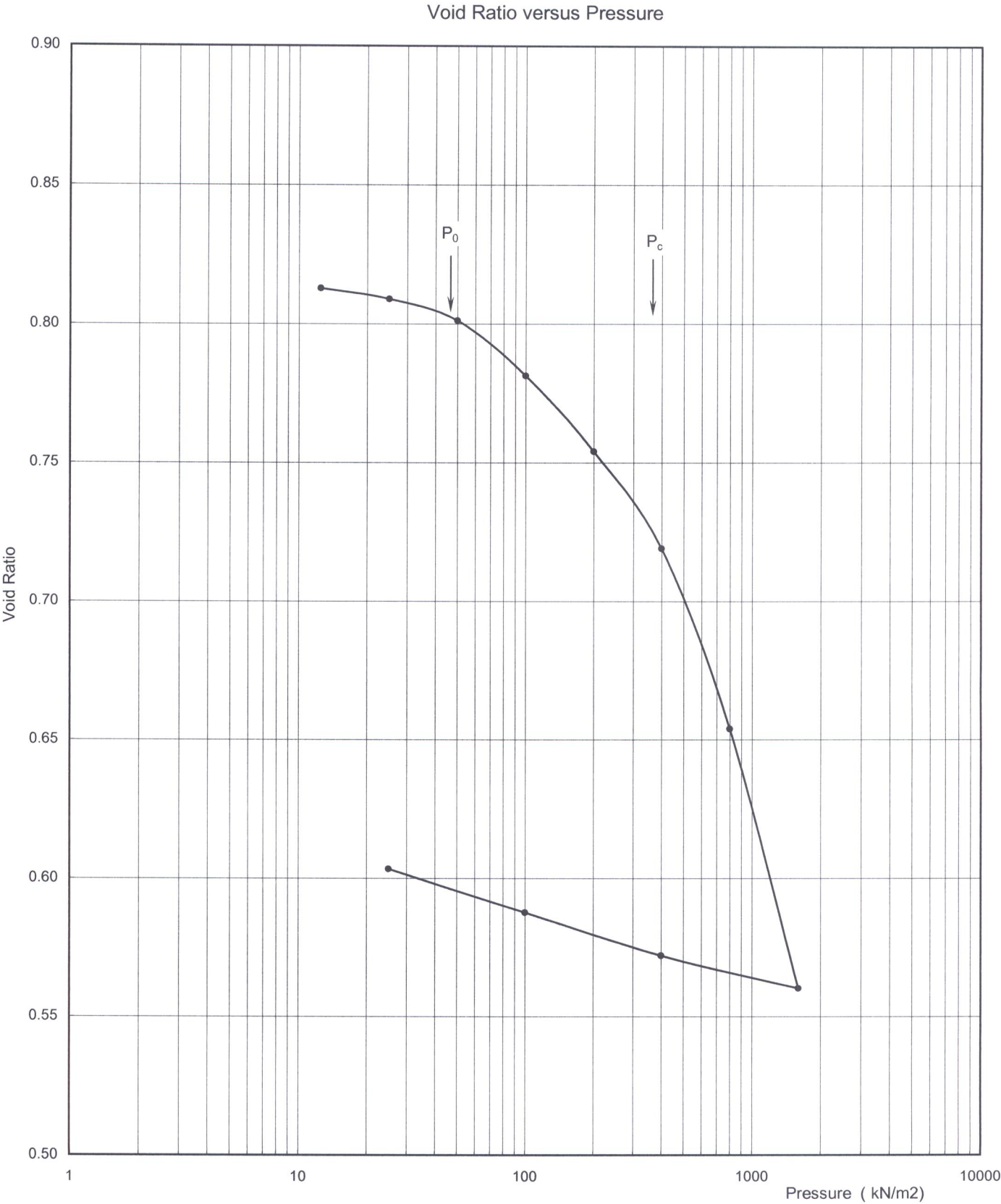
CLAYEY SILT

FIG No B-5

G.W.P. 251-98-00

REF No SPT 1147





# Appendix C

## Record of Borehole Sheets (Swamp No. 3)



SPT1147

RECORD OF BOREHOLE No 3-1

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 25+343 (Marmora), 13m Lt C/L ORIGINATED BY N.H.  
DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
DATUM Geodetic DATE 3/13/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● POCKET PENETR.    × LAB VANE					WATER CONTENT (%) PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT W P                      W                      W L		
224.3 0.0	Ice Surface						224								
222.8 1.5	ICE (0.2m) and WATER						223								
	PEAT with some gravel infill black, v. soft		1	SS	0*		222								
221.6 2.7			2	SS	5										
	ORGANIC SILT with sea shell fragments beige, wet, very soft (marl)		3	SS	1		221								
220.1 4.2			4	SS	3										
219.4 4.9	CLAYEY SILT grey, very soft crushed rock pieces @ 4.8m		5	SS	50/3	220									
	End of borehole. Wash boring refusal at 4.9 m on possible bedrock.  Water level at 0.3 m (not stabilized) and hole open to 4.1 m on completion.  *Sampler sunk on its own weight.														



SPT1147

# RECORD OF BOREHOLE No 3-2

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 10+007 (Madoc), 13.5m Lt C/L ORIGINATED BY N.H.  
DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
DATUM Geodetic DATE 3/13/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● POCKET PENETR.    × LAB VANE					WATER CONTENT (%) w <sub>p</sub> w    w <sub>L</sub>
224.3	Ice Surface												
0.0	ICE (0.2m) and WATER						224						
222.7							223						
1.6	PEAT black, very soft						222						
221.1			1	SS	2		221					377.5 285	
3.3	ORGANIC SILT some sea shell fragments, beige to 4.2m, grey and clayey below, v. soft (marl)		2	SS	0*		220						
219.8													
4.5	CLAYEY SILT grey, very soft		3	SS	1						96	0 6 66 28	
219.1													
5.2	SANDY GRAVEL trace silt, with rock fragments grey, wet, very dense		4	SS	94/13		219					54 34 (12)	
218.4													
6.0	End of borehole. Wash boring refusal at 6.0 m on possible bedrock.  Water level at 0.3m (not stabilized) and hole open to 5.2 m on completion.  *Sampler sunk under its own weight.  Drove DCPT from 5.8m to 6.0m.												















SPT1147

RECORD OF BOREHOLE No 3-3

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 10+033 (Madoc), 13.5m Lt C/L ORIGINATED BY N.H.  
DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
DATUM Geodetic DATE 3/14/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
224.3 0.0	Ice Surface						20 40 60 80 100						
	ICE (0.2m) and WATER												
223.2 1.1	PEAT very soft		1	SS	0*						377.2	Remoulded value of vane test is 0	
			2	SS	2						400.5		
													
221.7 2.6	ORGANIC SILT with shell fragments beige, wet, very soft (marl)		3	SS	0*						322.1		Consolidation Test
			4	SS	0*						281.5		
													
		5	SS	0*						224.4			
218.9 5.4	ORGANIC CLAYEY SILT dark grey, v. soft		6	SS	0*						264.6		
218.6 5.7	CLAYEY SILT grey									Q <sub>133.1</sub>			
			7	TW	PH								
217.5 6.8	GRAVELLY SAND, with rock fragments grey, wet, dense		8	SS	34**								
216.8 7.6	End of borehole. Wash boring refusal at 7.6 m on possible bedrock.  Water level at 1.2 m (not stabilized) and hole open to 6.8 m on completion.  *Sampler sunk on its own weight.  **Little sample - rock fragments only.												

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

SPT1147

RECORD OF BOREHOLE No 3-4

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 10+061 (Madoc), 14m Lt C/L ORIGINATED BY N.H.  
DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
DATUM Geodetic DATE 3/14/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● POCKET PENETR.    × LAB VANE					WATER CONTENT (%) PLASTIC LIMIT    NATURAL MOISTURE CONTENT    LIQUID LIMIT w <sub>p</sub> w    w <sub>L</sub>			
224.2 0.0	Ice Surface						224									
223.1 1.1	ICE (~0.2 m) and WATER						223									
			1	SS	1		222									
							221									
			2	SS	0*		220									
							219									
219.9 4.3	ORGANIC SILT dark grey to black, change to beige (marl) @ 4.7m, very soft															
219.3 4.9			3	SS	-											
218.7 5.5	CLAYEY SILT grey, v. soft rock fragments @ 5.4m		4	SS	50/5											
End of borehole. Wash boring refusal at 5.5 m on possible bedrock.																
Water level at 0.3 m (not stabilized) and hole open to 5.2 m on completion.																
*Sampler sunk on its own weight.																



SPT1147

# RECORD OF BOREHOLE No 3-5

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 10+087 (Madoc), 14m Lt C/L ORIGINATED BY N.H.  
 DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
 DATUM Geodetic DATE 3/14/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT		UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● POCKET PENETR.      × LAB VANE		WATER CONTENT (%) w <sub>p</sub> w      w <sub>L</sub>				
224.2 0.0	Ice Surface						224							Vane Test attempted at 3.6m, but no measurable shea strength.
223.4 0.8	ICE (~0.2 m) and WATER						223							
							222							
							221							
							220							
	PEAT black, very soft		1	SS	0*							474.1		
			2	SS	0*							426.5		
220.9 3.3	ORGANIC SILT with sea shell fragments beige, v. soft (marl)		3	SS	0*									
220.4 3.8	CLAYEY SILT somewhat organic, grey, v. soft rock fragments below 4.0m		4	SS	50/10									
219.9 4.3														
	End of borehole. Wash boring refusal at 4.3 m on possible bedrock.  Dynamic Cone Penetration Test (DCPT) attempted from the bottom of borehole @ 4.3m but no penetration.  Water level at 0.15 m (not stabilized) and hole open to 4.0 m on completion.  *Sampler sunk on its own weight.													

SPT1147

# RECORD OF BOREHOLE No 3-6

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 10+113 (Madoc), 14m Lt C/L ORIGINATED BY N.H.  
DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
DATUM Geodetic DATE 3/15/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)		
								○ UNCONFINED      + FIELD VANE	W P      W      W L						
						● POCKET PENETR.    × LAB VANE									
224.2 0.0	Ice Surface						20 40 60 80 100	20 40 60 80 100	20 40 60 80 100						
223.0 1.2	ICE (~0.2 m) and WATER						224								
							223								
							222								
							221								
220.1 4.1	PEAT black, very soft		1	SS	0*						613.3				
			2	SS	0*						375.1				
			3	SS	0*						224.2				
219.2 5.0	ORGANIC SILT with sea shell fragments beige, wet, very soft (marl)														
218.6 5.6	CLAYEY SILT, trace organics grey, very soft		4	SS	0*										
218.1 6.1	SILTY SAND, trace gravel, some clay grey, wet, dense		5	SS	42										
	End of borehole. Wash boring refusal at 6.1 m on possible bedrock.														
	Water level at 0.15 m (not stabilized) and hole open to 6.0 m on completion.														
	*Sampler sunk on its own weight.														

SPT1147

# RECORD OF BOREHOLE No 3-7

1 OF 1

**METRIC**

GWP 251-98-00 LOCATION Station 10+138 (Madoc), 14.5m Lt C/L ORIGINATED BY N.H.  
 DIST        HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
 DATUM Geodetic DATE 3/15/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE							
224.1 0.0	Ice Surface  ICE (~0.2 m) and WATER						224								
222.9 1.2	PEAT black, very soft						223								
		1	SS	1			222								
							221								
		2	SS	0*			220								
							219								
220.0 4.1	ORGANIC SILT beige, wet, very soft (marl)						220								
219.5 4.6	CLAYEY SILT some organic zones grey, v. soft		3	SS	0*		219								
			4	TW	PH		218								
			5	SS	50/13										
217.7 6.4	rock fragments below 6.1m														
	End of borehole. Wash boring refusal at 6.4 m on possible bedrock.  Water level at 0.15 m (not stabilized).  *Sampler sunk on its own weight.														



SPT1147

# RECORD OF BOREHOLE No 3-8

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 10+165 (Madoc), 18m Lt C/L ORIGINATED BY N.H.  
 DIST HWY 7 BOREHOLE TYPE Wash boring / Tripod COMPILED BY J.Z.  
 DATUM Geodetic DATE 3/15/2006 CHECKED BY R.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● POCKET PENETR.      × LAB VANE		WATER CONTENT (%) w <sub>p</sub> w      w <sub>L</sub>								
224.1 0.0	Ice Surface																	
223.5 0.6	ICE (~0.1 m) and WATER																	
222.6 1.5	FILL: Sand and Gravel some clay, fragments of wood, some peat grey, wet, loose		1	SS	9													
221.7	CLAYEY SILT with gravel, sand and organics grey, wet (probable fill)		2	SS	23													
221.0 3.1	CLAYEY SILT with gravel, sand and organics grey, wet (probable fill)		3	SS	58													
2.4	End of borehole. Dynamic Cone Penetration Test performed from 2.4 m to 3.1 m.												23   22   39   16					
221.0 3.1	End of Dynamic Cone Penetration Test.  D.C.P.T. refusal at 3.1 m probably on bedrock.  Water level at 0.3 m (not stabilized) and hole open to full depth on completion.																	

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

20  
15 10 5  
(%) STRAIN AT FAILURE

SPT1147

# RECORD OF BOREHOLE No 3-8A

1 OF 1

METRIC

GWP 251-98-00 LOCATION Station 10+164 (Madoc), 18m Lt C/L ORIGINATED BY N.H.  
 DIST HWY 7 BOREHOLE TYPE D.C.P.T. COMPILED BY J.Z.  
 DATUM Geodetic DATE 3/15/2006 CHECKED BY R.M.

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							
224.1 0.0	Ice Surface						224							kN/m <sup>3</sup>	GR SA SI CL
223.5 0.6	ICE and WATER						223								
221.2 2.9	Dynamic Cone Penetration Test (DCPT) performed from 0.9 m to 2.9 m.						222								
	End of DCPT.  DCPT was performed 1.2m west of Borehole 3-8. Refusal at 2.9m, possibly on bedrock.														

SPT1147

RECORD OF BOREHOLE No 10+000; 5.5 m Lt 1 OF 1

METRIC

GWP 251-98-00 LOCATION Swamp Section #3, Mamora, On ORIGINATED BY YL  
DIST HWY 7 BOREHOLE TYPE Solid Stem Augers, Casing & Rock Coring COMPILED BY YL  
DATUM Geodetic DATE 1/11/2006 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● POCKET PENETR.			
226.1 0.0	Ground Surface						20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT			
225.2 0.9	Top 0.3 m with Asphalt Fragments												
	FILL: Sand and Gravel brown, moist		1	SS	37							24 55 (21)	
	FILL: Sandy Gravel with cobbles, trace to some boulders, some silt, brown compact to dense		2	SS	18								
			3	SS	20								
			4	SS	47								
222.7 3.4	FILL: Rock Fill or Cobbles		5	HQ	Rec.							Switch to casing and rock coring	
222.0 4.1	PEAT black, wet		6	RC	30%								
221.5 4.6	ORGANIC SILT some peat inclusions, trace sea shell fragments, laminated, beige, wet (marl)		7	SS	11								
			8	SS	2								
219.8 6.3	CLAYEY SILT grey, very soft		9	SS	2								
219.1 7.0	SILTY SAND with GRAVEL grey, wet												
218.2 7.9	End of Borehole. Wash-boring terminated on possible bedrock.  Water level at 2.1 m and hole open to 4.0 m on completion.		11	SS	50/0								




SPT1147

RECORD OF BOREHOLE No 10+100; 5.5 m Lt 1 OF 1

METRIC

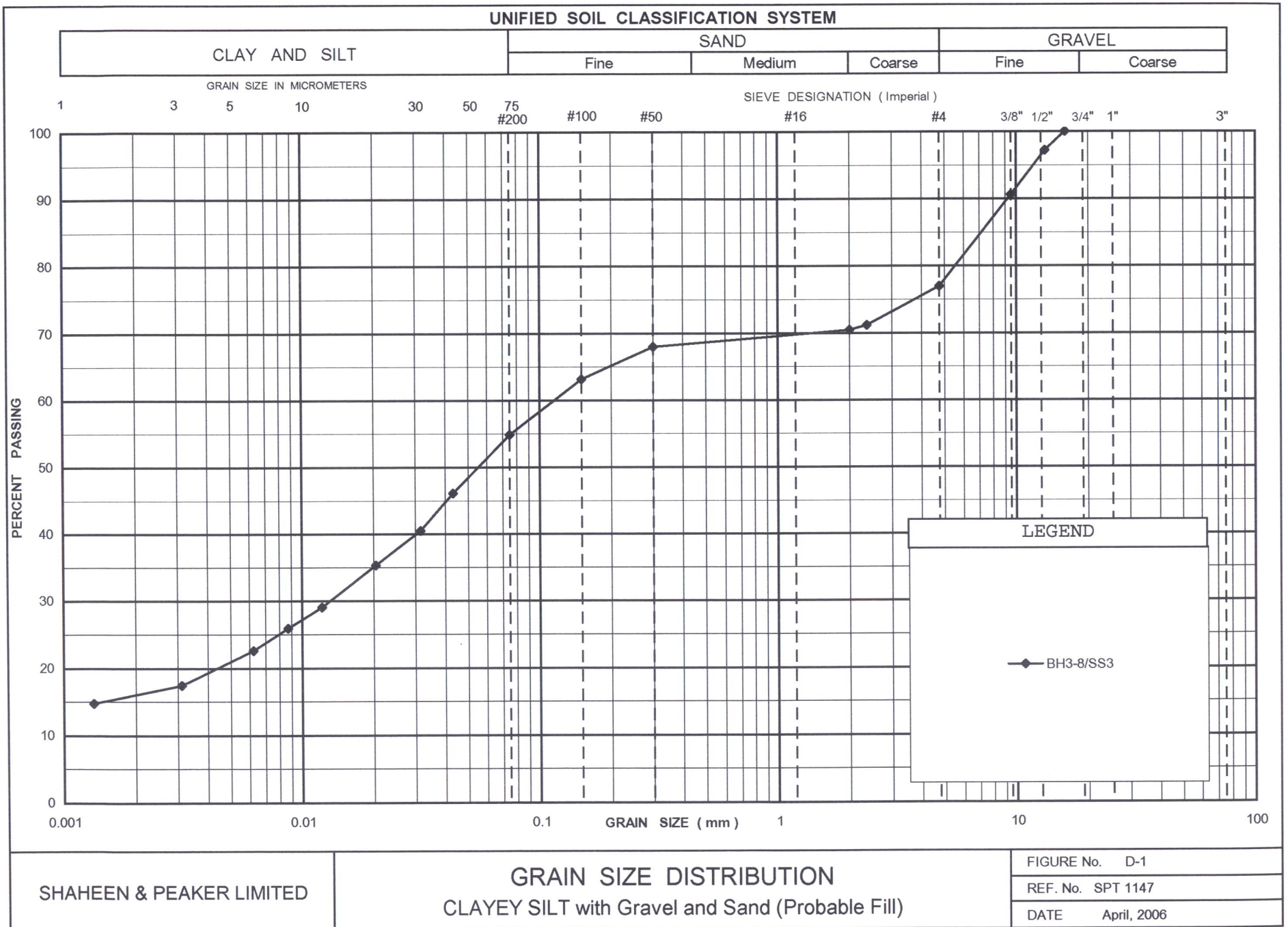
GWP 251-98-00 LOCATION Swamp Section #3, Mamora, On ORIGINATED BY YL  
DIST HWY 7 BOREHOLE TYPE Solid Stem Augers, Casing & Rock Coring COMPILED BY YL  
DATUM Geodetic DATE 1/12/2006 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● POCKET PENETR.    × LAB VANE					WATER CONTENT (%) W P                      W                      W L
226.3 0.0	Ground Surface  Top 0.3 m with Asphalt Fragments  FILL: Sand and Gravel brown, moist												
225.4 0.9	FILL: Sand to Silty Sand with cobbles, some gravel, trace to some boulders, occasional sandy silt layers and organic inclusions, brown to grey		1	SS	32								18 56 (26)
			2	SS	39								
			3	SS	7								
223.2 3.1	FILL: Rock fill or Bouldery Granular Fill		4	SS	105/25								Switch to casing and rock coring
			5	SS	5*								* No recovery
221.6 4.7	PEAT and ORGANIC SILT black, wet		6	SS	56								
221.3 5.0	ORGANIC SILT some peat inclusions, trace sea shell fragments, laminated, beige, (marl) wet, soft		7	SS	4								
220.6 5.7	CLAYEY SILT grey, soft												
220.3 6.0	ROCK FILL or COBBLES and BOULDERS		8	HQ RC	Rec. 30%								
219.3 7.0	SILTY SAND some gravel grey, wet, dense to v. dense		9	SS	80								
		10	SS	33									
218.1 8.2	crushed rock fragments @8.0m  End of Borehole. Wash-boring terminated on possible bedrock.  Water level at 2.3 m and hole open to 6.1 m on completion.	11	SS	50/0									

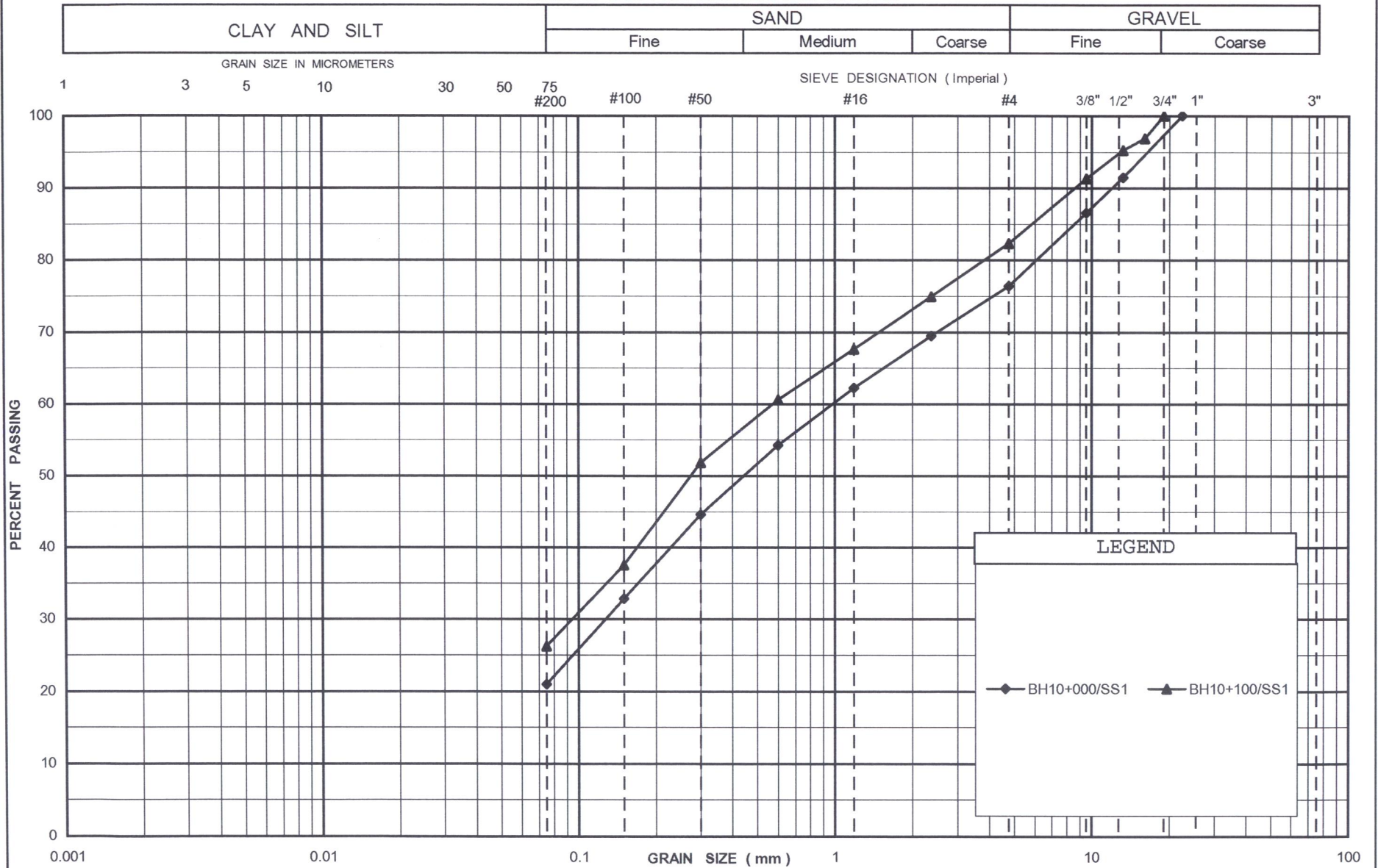
## Appendix D

### Laboratory Results (Swamp No. 3)





# UNIFIED SOIL CLASSIFICATION SYSTEM



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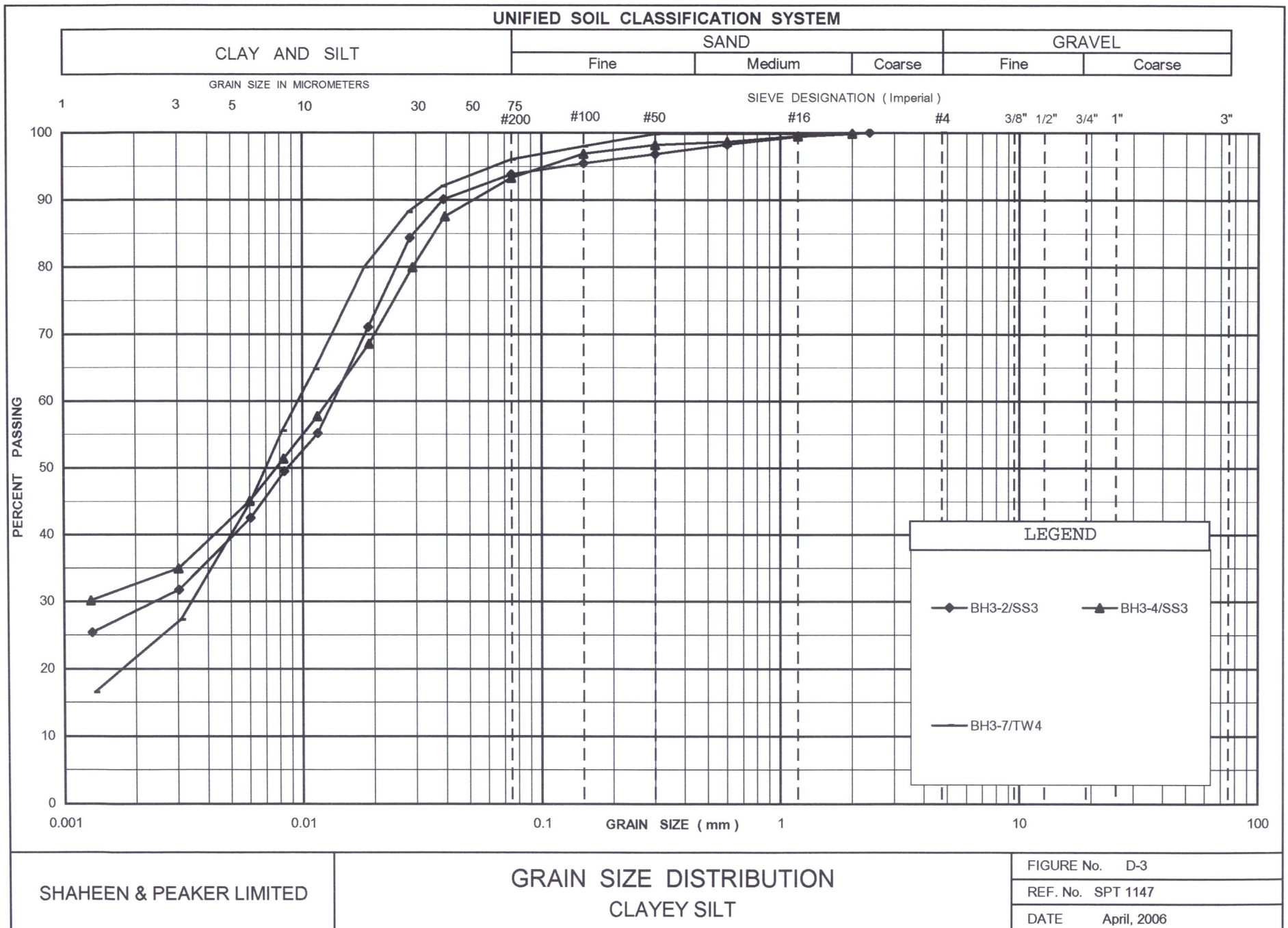
GRAIN SIZE DISTRIBUTION  
GRANULAR EMBANKMENT FILL

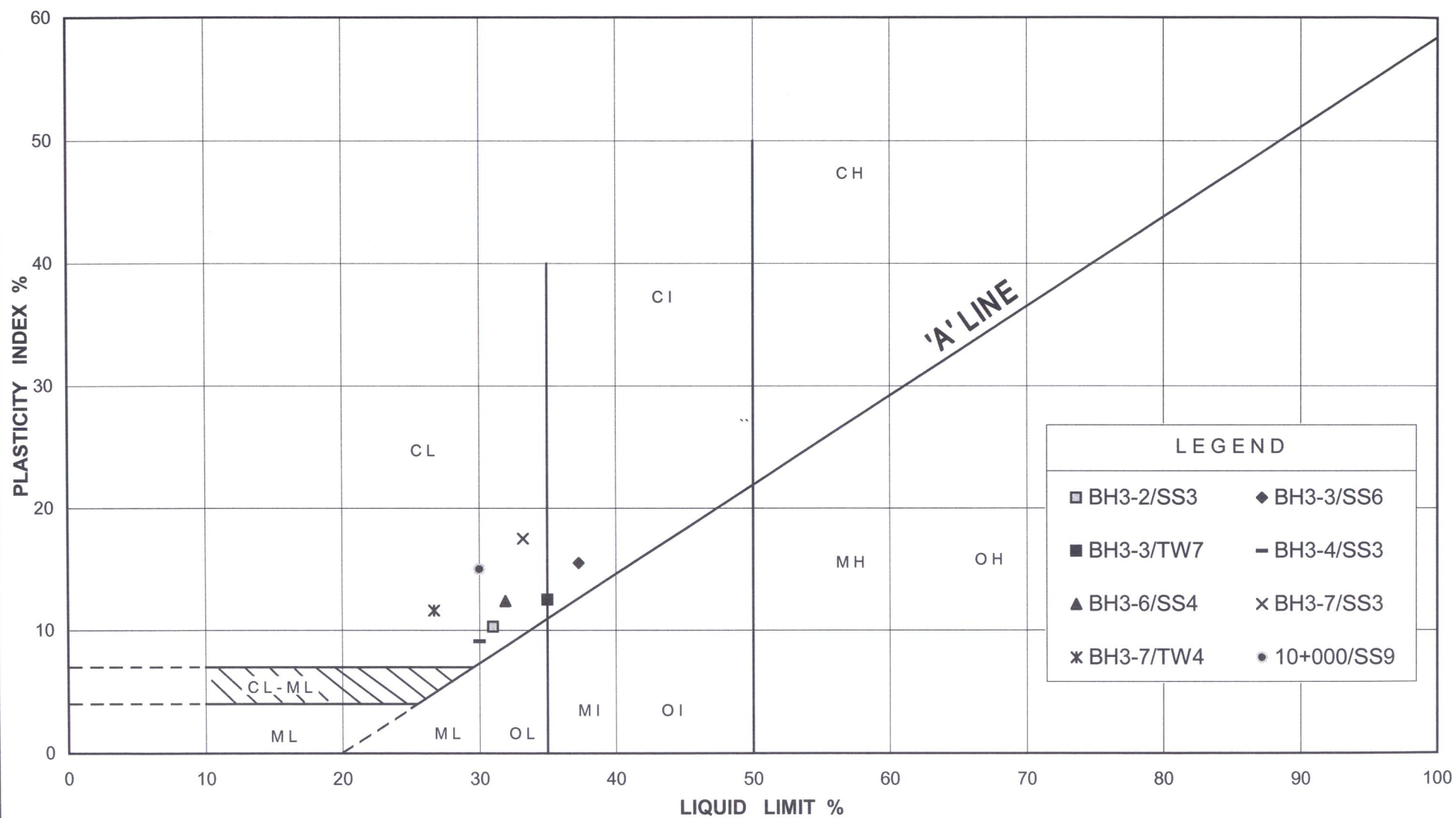
FIGURE No. D-2

REF. No. SPT 1147

DATE April, 2006







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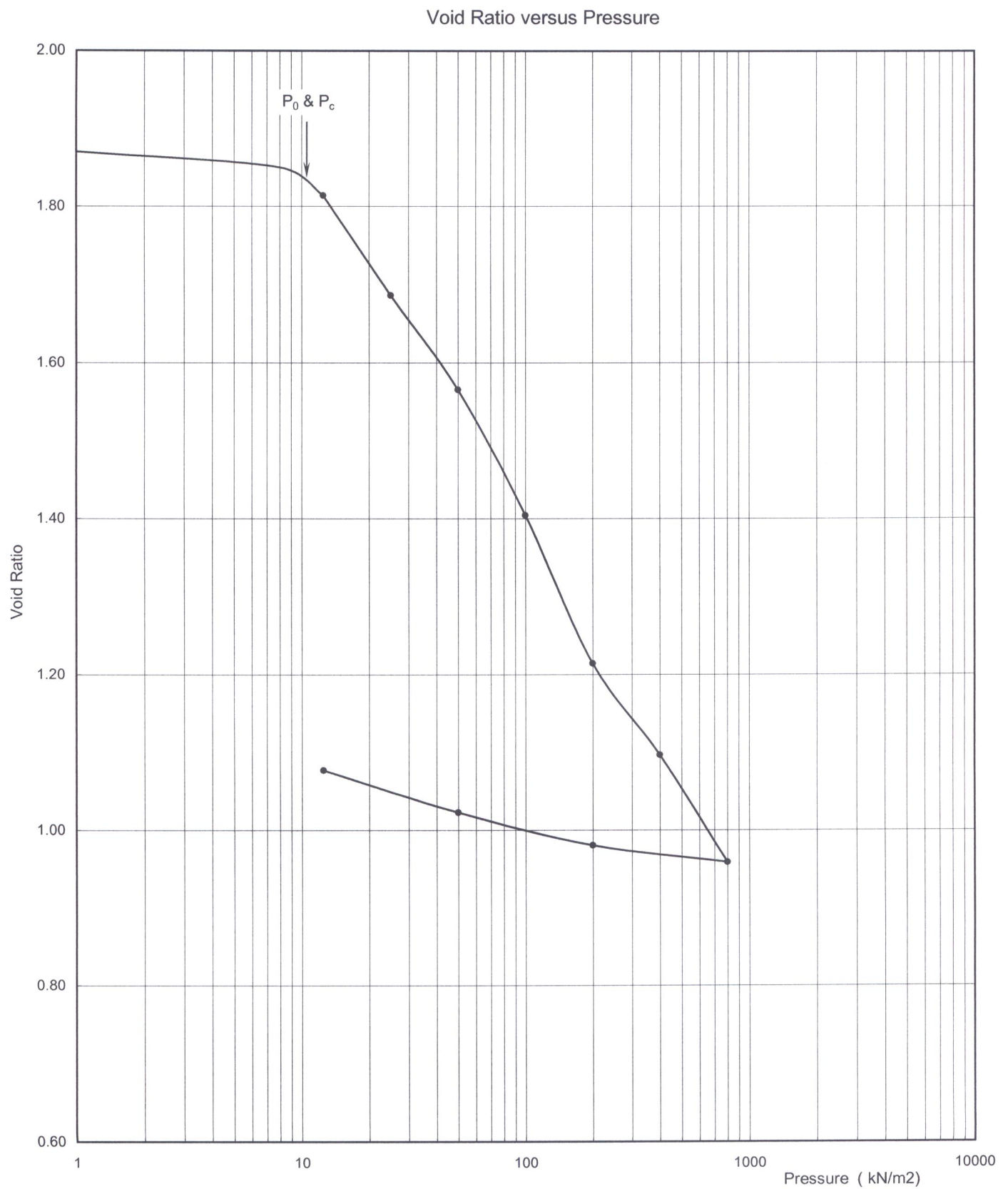
PLASTICITY CHART

CLAYEY SILT

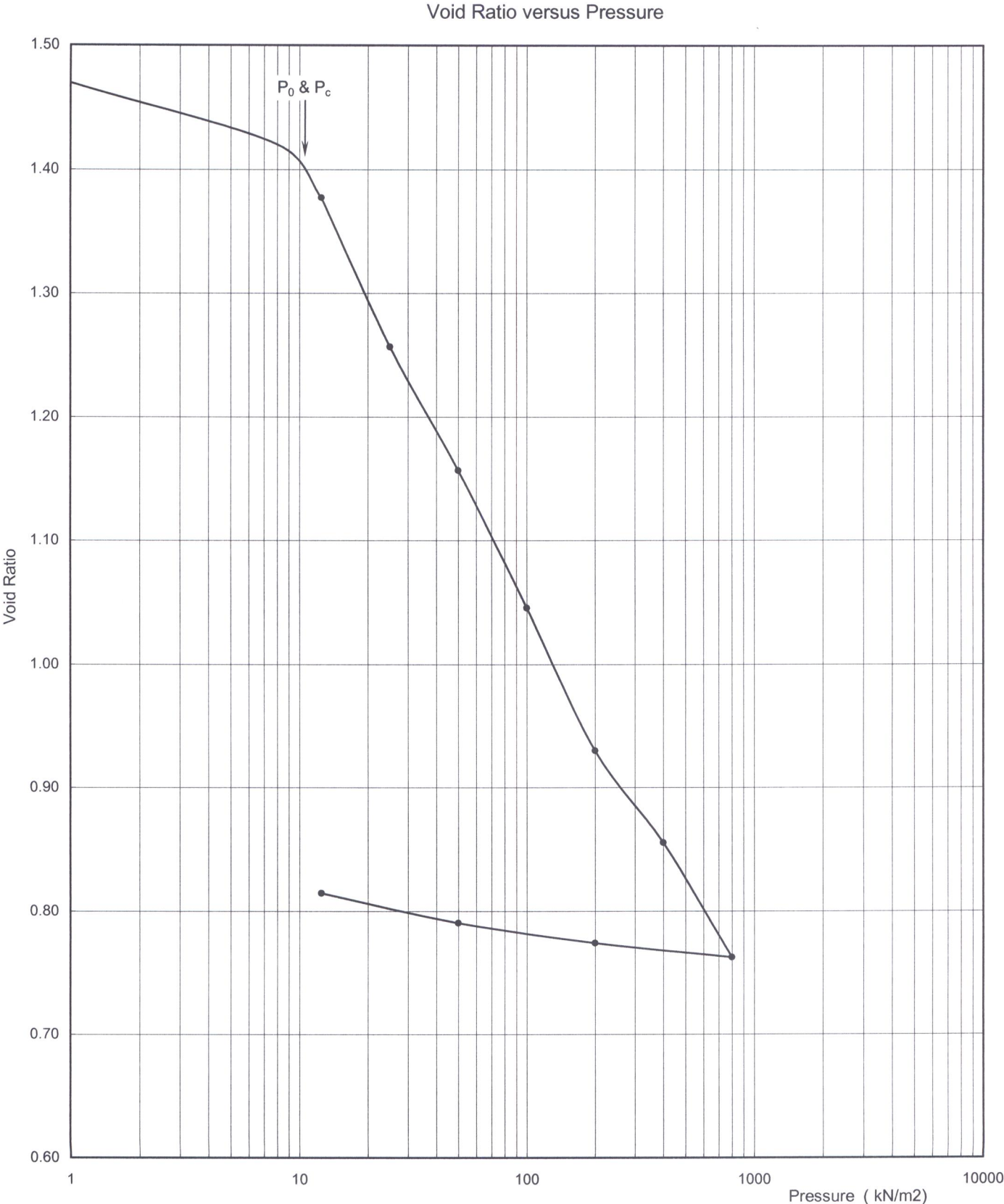
FIG No D-4

G.W.P. 251-98-00

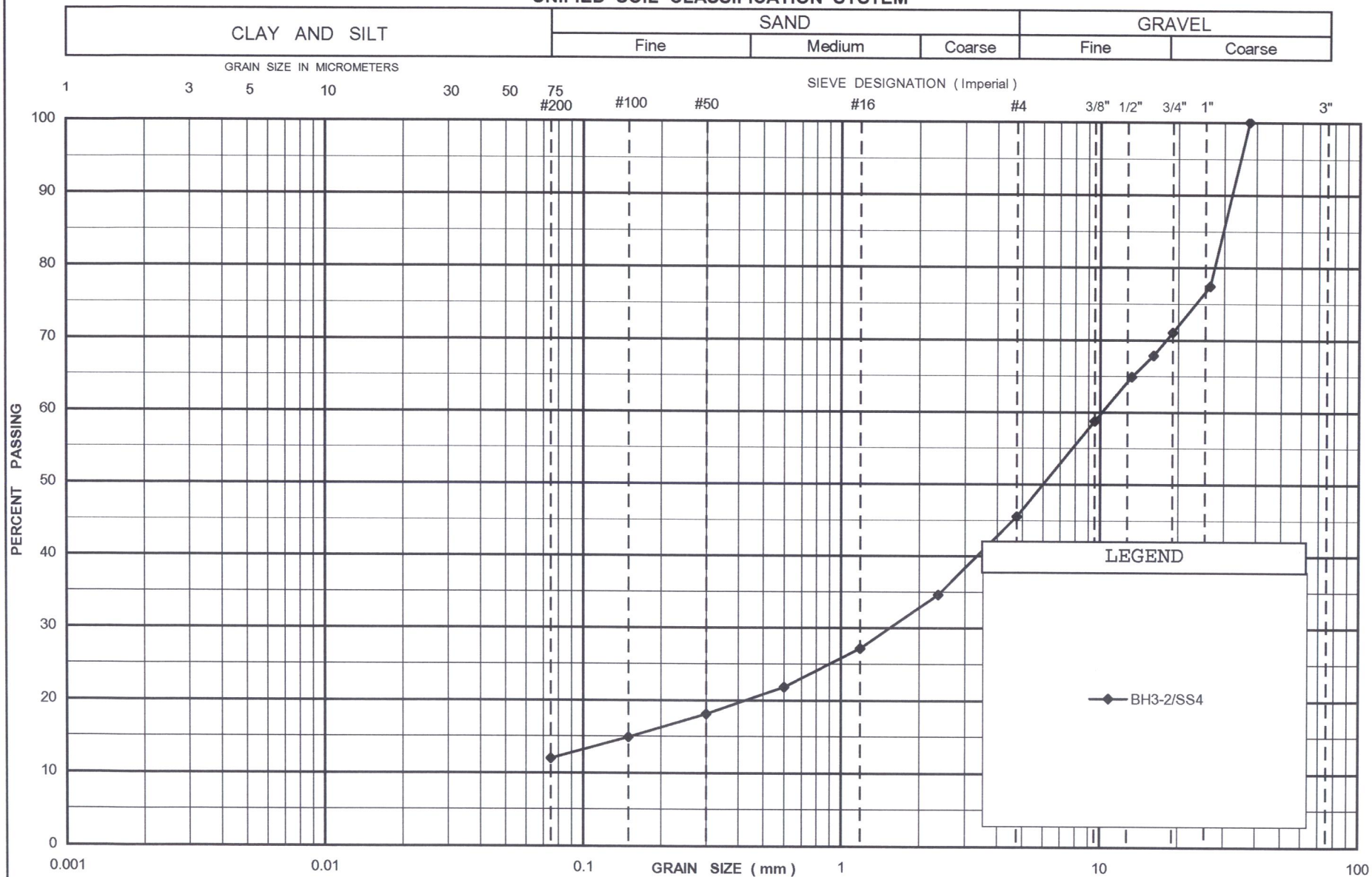
REF No SPT 1147







# UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION  
SAND and GRAVEL, trace Silt

FIGURE No. D-7

REF. No. SPT 1147

DATE April, 2006

# Appendix E

## Site Photographs





Photograph 1 – Swamp 2 Looking West.



Photograph 2 – Swamp 2 Looking East.





Photograph 3 –Swamp 2 Winter Drilling.



Photograph 4 – Swamp 2 Winter Drilling.





Photograph 5 –Swamp 3 Looking East.



Photograph 6 – Swamp 3 Looking West.





Photograph 7 – Swamp 3 Winter Drilling.



Photograph 8 – Swamp 3 (West Side) Winter Drilling.

## Appendix F

# Explanation of Terms Used on Report

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINT AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

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

### MECHANICALL PROPERTIES OF SOIL

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

## PHYSICAL PROPERTIES OF SOIL

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

**FOUNDATION DESIGN REPORT  
TWO SWAMP CROSSINGS  
PROPOSED WIDENING OF HIGHWAY 7  
FROM 2.6 KM WEST OF MARMORA WEST LIMITS  
AND FROM MARMORA EAST LIMITS TO 6.6 KM  
WEST OF HIGHWAY 62, 12.5 KM  
G.W.P. 251-98-00**

**GEOCRES NO. 31C-173**

**Prepared For:**

**TRANSENCO LIMITED**

**Prepared by:**

**SHAHEEN & PEAKER LIMITED**

**Project: SPT1147  
June 26, 2006**



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### APPENDICES

APPENDIX G: TYPICAL CROSS-SECTIONS

APPENDIX H: TYPICAL MTO SPECIFICATIONS

APPENDIX I: LIMITATIONS OF REPORT

**FOUNDATION DESIGN REPORT  
TWO SWAMP CROSSINGS, PROPOSED WIDENING OF HIGHWAY 7  
FROM 2.6 KM WEST OF MARMORA TO MARMORA WEST LIMITS  
AND FROM MARMORA EAST LIMITS TO 6.6 KM WEST OF HIGHWAY 62, 12.5 KM  
G.W.P. 251-98-00**

## **5. DISCUSSION AND RECOMMENDATIONS**

We understand that an additional (truck climbing) lane is required on the south (right) side of the existing Highway 7, immediately east of Marmora. However, due to the presence of underground pipe on the south side, the widening will take place on the north (left) side and therefore, the centerline of the highway will have to be shifted to the left. It is planned to pulverize the existing asphaltic concrete and to repave the existing road, which at the swamp crossings in Swamp No. 3, is in poor condition (probably due to differential settlements). The repaving of the road may require between 0.1 and 0.2 m of grade raise, in relation to existing grades.

### **5.1 SWAMP NO. 2**

Swamp No. 2 is located between Stations 23+950 and 24+225 in the Marmora Township, east of the Town of Marmora. As mentioned above, a new lane will be constructed on the north (left) side and a minimal grade raise (0.1 to 0.2 m) is presently being planned for the existing road surface. However, in order to effect the proposed widening, the grade will be raised above the existing grade in the swamp immediately beyond the toe of the existing embankments. Typical grade raise cross-sections at Stations 23+980, 24+065 and 24+175 are presented as Drawing No. G-1 in Appendix G, as an example, while the anticipated maximum grade raises along the widened sections are given in Table 5.1.1, utilizing information given to us by Transenco.

Table 5.1.1  
Proposed Grade Raises at Swamp No. 2

Station	Approximate Top of Shoulder Elevation (m)	Existing Grade at Toe (m)	Approximate Maximum Grade Raise over the Existing Toe Grade (m)	Nearest Borehole Elevation & Station (m)
23+940	206.5	204.0	2.5	
23+960	206.5	204.0	2.5	Borehole 2-1; 204.1/23+962
23+980	206.3	203.7	2.6	Borehole 2-2; 203.7/23+988
24+000	206.2	203.7	2.5	
24+020	206.0	203.7	2.3	Borehole 2-3; 203.8/24+012

Station	Approximate Top of Shoulder Elevation (m)	Existing Grade at Toe (m)	Approximate Maximum Grade Raise over the Existing Toe Grade (m)	Nearest Borehole Elevation & Station (m)
24+040	205.9	203.7	2.2	Borehole 2-4; 204.6/24+038
24+060	205.8	203.7	2.1	Borehole 2-5; 204.1/24+065
24+080	205.7	204.1	1.6	
24+100	205.5	203.7	1.8	
24+120	205.6	203.8	1.8	Borehole 2-6; 204.5/24+125
25+140	205.6	203.7	1.9	
25+160	205.7	203.7	2.0	Borehole 2-7; 204.4/24+169
25+180	205.8	203.7	2.1	
25+200	206.0	203.8	2.2	
25+220	206.3	204.3	2.0	Borehole 2-8; 204.4/24+213
25+240	207.0	205.0	2.0	

From the above table, it is noted that the proposed grade raises under the widened section are generally between 2.0 and 2.5 m.

The boreholes show the presence of organic, weak or otherwise unsuitable soils to the following depths at each borehole location.

Table 5.1.2

Borehole No./ Station	Ground Surface Elevation at Borehole Location (m)	Depth of Organic/Weak Soils (m)	Corresponding Elevation (m)	Comments
2-1 23+962	204.1	0.8	203.3	0.3 m of Muskeg followed by very loose sandy silt with sea shells and organics to 0.8 m
2-2 23+988	203.7	1.7	202.0	1.2 m of Peat followed by very soft silt/clayey silt to 1.7 m
2-3 24+012	203.8	0.6	203.2	0.1 m of Peat followed by sandy silt with some clay, trace clay and peat inclusions to 0.6 m
2-4 24+038	204.6	1.7	202.9	Organic silt and peat mixed with some gravel occasional asphalt pieces (probably organic soils infiltrated by granular soils, traces of asphalt pieces)
2-5 24+065	204.5	2.7	201.8	Granular fill mixed with organics to 0.6 m underlain by peat and organic silt with some gravel inclusions (probably due to gravel inclusion from the overlying granular fill) to 1.3 m which is in turn underlain by somewhat organic and weak silty clay to clayey silt to 2.7 m

Borehole No./ Station	Ground Surface Elevation at Borehole Location (m)	Depth of Organic/Weak Soils (m)	Corresponding Elevation (m)	Comments
2-6 24+125	204.5	1.4	203.1*	Silty sand with some gravel (Fill) mixed with some organics (probably fill displaced and mixed with existing organic soils). Relatively high N-values of 17 and 32 blows/0.3 m were recorded in the fill.
2-7 24+169	204.4	1.6	202.8*	1.4 m of gravel and sand fill with traces of silt and organics underlain by a 0.2 m thick organic silt layer.*
2-8 24+213	204.4	1.4	203.0	0.2 m thick sand and gravel fill underlain by 1.2 m thick organic silt and peat.

\*organic soils to these elevations and possibly deeper can probably be expected immediately north of the borehole location.

It should be noted that conditions may vary in between and beyond the borehole locations both in the longitudinal and transverse directions.

These unsuitable materials are underlain by silt soils changing to clayey silt and eventually to silty clay to clayey silt deposits of firm to hard but generally stiff to very stiff consistency. Refusal to washboring was contacted immediately underlying the silty clay to clayey silt or beneath a thin silt layer at depths/elevations ranging from 7.3 m/196.5 m to 12.6 m/191.9 m, possibly in the surface of bedrock or some other hard/dense surface.

While normally the removal of all or most of the unsuitable soils are desirable for the long-term performance of the widened road, the following are the possible options.

Table 5.1.3  
Summary of Alternatives for Swamp No. 2

Method	Treatment Type	Comments	Advantages	Disadvantages	Recommendations
1	Backfill over existing grades	Raise grade without effecting any stripping of existing materials	Inexpensive	High settlements which would continue over many years, lateral yield of foundation soils; possible localized foundation slope failures where organic soils are relatively thick (e.g. Boreholes 2-4 and 2-5)	Not recommended due to unreliability.



Method	Treatment Type	Comments	Advantages	Disadvantages	Recommendations
2	Complete removal of all unsuitable soils and backfilling with granular backfill	Remove all unsuitable soils in short sections and backfill immediately with granular backfill	-	Expensive due to material removal and replacement costs as well as cost of hauling excavated materials offsite. The use of granular soils not suitable due to very high water table which prevails at the site, unless major dewatering can be effected.	Not recommended due to unreliability
3	Complete removal of all unsuitable soils and backfilling with Rock Fill	Remove all unsuitable soils in short sections and backfill immediately with rock fill	More reliable and easy to construct in high water level conditions; rock fill will penetrate into very soft soils (i.e. self correcting to some extent)	Expensive due to material removal and replacement costs, as well as cost of hauling excavated materials offsite.*	Recommended based on reliability and less aggressive dewatering need (in comparison with use of granular backfill).
3a	Complete removal of all unsuitable soils and backfilling with rock fill with surcharge or preload	Remove all unsuitable soils in short sections and backfill immediately with rock fill	More reliable and easy to construct in high water level conditions; rock fill will penetrate into very soft soils (i.e. self correcting to some extent)	Expensive due to material removal and replacement costs, as well as cost of hauling excavated materials offsite.*	Recommended based on reliability and less aggressive dewatering need and will cause less settlements than Method 3 and is, therefore, preferable.
4	Soil Displacement by Rock Fill	Displacement of prevailing unsuitable (i.e. organic and/or very soft soils) by rock fill after the removal of all existing fills as well as the surface mat of muskeg	Relatively inexpensive	Less reliability than complete removal by Method 3. High risk of post-construction settlements.	Can be considered if risks are acceptable in terms of future settlements. Not recommended due to unreliability.

Method	Treatment Type	Comments	Advantages	Disadvantages	Recommendations
5	Partial Removal and Backfilling with Rock Fill	Where the unsuitable soils are less than 1.2 m thick remove all unsuitable soils in short sections and backfill with rock fill. Where unsuitable soils are more than 1.2 m thick, remove to 1.2 m and backfill with rock fill.	Reduces amount of excavation and offsite hauling to some extent, in comparison with Method 3 and is therefore more cost effective. More reliable than Methods 1, 2 and 4.	Some long-term settlements may occur.	Can be considered as the best alternative to Method 3, provided that some risk of settlements would be acceptable in areas where the thickness of unsuitable soils is greater than 1.2 m (this risk can be somewhat reduced by preloading/surcharging).

\*We understand that the use of rock fill may not be more expensive than the use of granular soils since rock removal is required within the contract (i.e. re-use of on-site blasted rock).

Option 3a (i.e. complete removal all/most unsuitable soils and backfilling with rock fill and preload/surcharge), which is the recommended option, and Option 5 (i.e. partial removal and backfilling with rock fill) will be discussed as feasible options.

#### 5.1.1 COMPLETE REMOVAL OF UNSUITABLE SOILS

The recommended unsuitable soil removal depths at each borehole location are given in Table 5.1.1.1 below

Table 5.1.1.1  
Recommended Unsuitable Soil Removal Depths

Borehole No.	Station	Offset From Existing Road C/L	Existing Ground Elevation at Borehole Location (m)	Recommended Sub-excavation Depth From Existing Ground (Bottom of Water), (m)	Recommended Sub-excavation Elevation (m)
2-1	23+962	14.5 Lt	204.1	0.8	203.3
2-2	23+988	14.5 Lt	203.7	1.7	202.0
2-3	24+012	14.0 Lt	203.8	0.6	203.2
2-4	24+038	14.0 Lt	204.6	1.7	202.9
2-5	24+065	12.0 Lt	204.5	2.7	201.8
2-6	24+125	13.0 Lt	204.5	1.4	203.1
2-7	24+169	12.5 Lt	204.4	1.6	202.8
2-8	24+213	16.5 Lt	204.4	1.4	203.0

Based on the table above, a station to station removal depth table has been prepared as given in Table 5.1.1.2, assuming that rock fill will be used for backfill to at least the high water level in the swamp.

Table 5.1.1.2  
Anticipated Unsuitable Soil Removal Depths

Station to Station	Average Anticipated Unsuitable Soil Removal Depths (m)	Elevation (m)
23+950 to 23+970	0.8	203.3
23+970 to 24+005	1.7	202.0
24+005 to 24+020	0.6	203.2
24+020 to 24+050	1.7	202.9
24+050 to 24+115	2.7	201.8
24+115 to 24+150	1.4	203.1
24+150 to 24+180	1.6	202.8
24+180 to 24+225	1.4	203.0

It should be pointed out that the depths of unsuitable soils both in the longitudinal and transverse (i.e. in the northerly direction) directions may be different from those encountered in the boreholes, as the depths of organic soils are likely to be variable in the bog. As well, granular fill encountered in some of the boreholes (e.g. Boreholes 2-6 and 2-7) may not be present further north or in between borehole locations. It should also be realized that the spacing of boreholes east of Station 24+065 (i.e. east of Borehole 2-5) is somewhat greater than the west side of the bog. These aspects should be taken into consideration when estimating quantities, as well as excavation depths.

Rock fill will penetrate the underlying soil, as well may displace some of the soil in the northerly direction (away from the embankment). For estimating, therefore, an allowance should be made for this purpose. A figure of 0.2 m can be used for preliminary estimating purposes. The actual depths of sub-excavation and quantities should be confirmed in the field and it must be ensured that all the organic soils are removed. We recommend a Geotechnical Specialist retained through the Contract Administrator (CA) to verify this aspect.

Special care is required when digging adjacent to the existing embankment. The sub-excavation should be carried out in short strips of narrow bands (no wider than about 4 m widths in the perpendicular direction to the existing embankment) and should be backfilled with rock fill immediately. This is necessary to prevent a failure or excessive yield of the existing roadway embankment during construction.

It is suggested that the sub-excavation be started from one end (where access is relatively easier) of the swamp section at the toe of embankment, carry out the excavation in narrow

widths and short sections and backfill with rock fill immediately, working towards the centre. The backfilled portion could be used as platform for the equipment and trucks. We recommend that the excavator and heavy trucks (especially the rock trucks) should maintain a safe distance from the edge of the excavation to prevent instability of the excavation, which may jeopardize the safety of personnel and equipment. We recommend that end-dumping at the edge of the excavation should not be carried out. In other words, rock trucks should not be allowed to back to the edge of the excavation to dump rock fill but rather the rock fill should be pushed with a dozer maintaining a safe distance (or if this is found to be unsafe an alternative method should be suggested by the contractor). An NSSP should be provided in the Contract Documents to warn the contractor of the special excavation treatment in this section. It is recommended that the outer extent of the excavation and rock backfill be determined by projecting a 1¼ H:1V imaginary line from the toe of the proposed final 1¼H:1V embankment slope below the swamp grade to the bottom of the excavation and then daylighting this imaginary line back to the swamp grade at 1:1.

The existing slopes should be cut to 1:1 configuration immediately before excavating each strip (steepening of the slopes in wider sections along the existing embankment may lead to instability), as per OPSD-203.020 (see Appendix H).

The face of the existing embankment which was cut to 1:1 will need to be flattened to 2H:1V for stability (i.e. 1:1 slopes with granular fill in the existing embankment may not be stable for long period of time). We recommend that to flatten the slope (from about 0.3 m above the ground surface level in the swamp to the subgrade level of the road) a 200 mm graded rock fill be used (similar to a riprap). This will provide a filter between the existing granular road embankment fill and the adjacent rock fill which would be used to construct the additional lane (in addition to stabilizing the slope until the rock fill is placed. In this manner, the remaining rock fill can be placed any time (e.g. after finishing the sub-excavation and backfilling portion for the entire swamp).

Alternatively, if the placement of a graded rock filter is considered too costly and the risk of some settlements due to possible loss of soil fines is acceptable, then the graded rock filter can be omitted. In this case, however, since the existing granular embankment will not be stable at 1H:1V side slopes, the rock fill to widen the embankment will need to be placed to the proposed rock subgrade level almost immediately and this may be impractical.

According to our information, the grade raises under the widened section of the road are about 2 m above the existing grades (for typical sections see Appendix G). The estimated foundation settlements for this option using rock fill as backfill ranges from about 15 to 30 mm, assuming that all the organic and weak soils under the footprint of the embankment were removed as per OPSD-203.020. In our opinion, these figures are within tolerable limits for this project. It should, however, be pointed out these figures do not include lateral yield



(which is primarily dependent on the construction procedures) and any vertical movements due to shifting of the rock fill (under its own weight and vibrations generated by the highway traffic). These latter movements can be reduced by preloading (or preferably surcharging by approximately 0.5 m, if possible) the site by about eight weeks. It is recommended that the paving of the road be delayed for at least 3 months (or as long as possible) after the embankment is built.

It should be pointed out that if during its construction the organic soils beneath the existing highway were not fully removed (when the existing highway was first constructed), some on-going settlements may occur, in spite of the fact that the existing highway was probably constructed some 50 years ago. This is due to the fact that organic soils continue to settle even after the completion of the primary consolidation (i.e. after the dissipation of excess, pore-pressures). These settlements termed as 'secondary consolidation' settlements continue to take place even after many years. The magnitude of these settlements under the existing roadway would depend on the thickness of the organic soils left in place, if any, and whether any grade raise will take place which will generate additional stresses. Since there are no foundation boreholes from the top of the embankment, we are unable to comment on this aspect, we understand there are no visible signs of excessive differential settlements of the existing road pavement. To avoid excessive settlements, however, we recommend that grade raise of the existing road be avoided. If this is not possible (e.g. cross-fall requirements from the centerline, line of sight considerations, etc) the grade raise at the center should not exceed 0.3 m.

#### 5.1.2 PARTIAL REMOVAL AND BACKFILLING WITH ROCK FILL

Partial sub-excavation option is similar to full sub-excavation option, as discussed in the previous section of this report, except that the maximum depth of sub-excavation would be limited to removing the top  $1.2 \pm$  m of the peat and organic soil. From Table 5.1.1.1 it can be seen that at some of the borehole locations the required depths of removal is less than 1.2 m and as such excavation depths at these borehole locations remain the same as were previously recommended. For example, at Borehole 2-1 and 2-3 locations, the recommended excavation depths are 0.8 m and 0.6 m and thus 0.8 m and 0.6 m, respectively of excavation is required at these locations for this option as well. However, at Borehole Locations 2-2, 2-4, 2-6, 2-7 and 2-8, where the recommended excavation depths range between 1.4 and 1.7 m, the sub-excavation depths will be limited to only 1.2 m, and thus some (i.e. between 0.2 and 0.5 m) unsuitable soil will be left in place. At Borehole 2-5 location, the organic soils are overlain by a 0.6 m thick fill layer and therefore, the excavation will be extended to 1.8 m below the ground surface in order to remove a minimum of 1.2 m of organic soil (i.e.  $0.6 + 1.2 = 1.8$  m or El. 202.7 m). At this location, an approximately 0.9 m of organic/weak soil will be left in place.

The obvious advantages of this method are the relative ease of construction, somewhat less rock backfill quantities and less waste soil to be hauled away. The latter is important because the hauling and disposal of the excavated very wet soils will be difficult and probably a good portion of the spoil will flow out from hauling trucks, creating environmental concerns.

Disadvantages are additional settlements which will occur. Assuming that borehole information is representative of the site, reference to Table 5.1.2 shows that at Boreholes 2-2, 2-4, 2-7, 2-8 and probably at Borehole 2-6 location the thickness of organic soils ranges between 1.4 and 1.7 m. These are not considered excessive depths since between only 0.2 and 0.5 m of organic soil will be left in place after the removal of 1.2 m of organic soil and rock fill will probably penetrate fully or mostly into these deposits. At Borehole 25, however, and in the general area represented by this borehole, 0.9 m of unsuitable soil will be left in place after the removal of the existing fill (0.6 m) and 1.2 m of the underlying organic soils to El. 202.7 m (i.e. organic/weak soils in this borehole extend to El. 201.8 m). In this case, assuming an average 0.3 penetration of rock fill into underlying soil a 0.6 m thick compressible soil will be left in place and this could lead to about 60 mm additional settlements bringing the total settlements to about 80 to 100 mm which is not considered excessive, especially if an at least 6 week (if possible more) preload or surcharge period is allowed. In this case, allowance should be made for platform widening in the design (e.g.  $4 \times 100 = 400$  mm).

Table 5.1.2.1 below lists recommended organic/unsuitable soil removal elevations station to station by this method, inferred from borehole data.

Table 5.1.2.1  
Soil Removal Elevations by Partial Sub-Excavation Method

Station to Station	Anticipated Excavation Elevation (m)
23+950 to 23+970	203.6
23+970 to 24+005	202.5
24+005 to 24+020	203.2
24+020 to 24+050	203.4
24+050 to 24+115	202.7
24+115 to 24+225	203.2

A rock fill penetration of 0.4 m can be assumed into the subgrade during backfilling for preliminary estimating of rock fill quantities.

Similar construction concerns should be taken into consideration as discussed in the previous section, when carrying out the construction.

## 5.2 SWAMP NO. 3

Swamp No. 3, located further east of Swamp No. 2, at the boundary of Marmora and Madoc Townships, is a 210 m long, low-lying, swampy stretch of land, between Stations 25+330 and 10+180. The roadway will be widened by one lane on the north side.

We understand that there will be little (i.e. up to 0.2 m) or no grade raises of the existing road, as shown on some typical cross-sections of the proposed widening, in Appendix G. Table 5.2.1 summarizes the approximate grade raises which are proposed above the existing swamp grade level (immediately beyond the north toe level) in order to effect the proposed widening (based on nearest borehole location).

Table 5.2.1  
Proposed Grade Raises at Swamp No. 3

Borehole No.	Station	Existing Grade at Borehole Location (m)	Approximate Elevation of the Proposed Shoulder of the Road (m)	Approximate Grade Raise (m)
3-1	25+343	222.8	226.2	3.4
3-2	10+007	222.7	225.9	3.2
3-3	10+033	223.2	225.9	2.7
3-4	10+061	223.1	225.9	2.8
3-5	10+087	223.4	226.1	2.7
3-6	10+113	223.0	226.5	3.5
3-7	10+135	222.9	226.8	3.9
3-8	10+165	223.5	227.2	3.7

The figures in the table which are based on borehole elevations indicate grade raises which range between 2.7 and 3.9 m, but are typically about 3.0 to 3.5 m.

The boreholes show the presence of organic and weak soils to the following depths at each borehole location.

Table 5.2.2  
Depths of Organic/Weak Soils at Borehole Locations

Borehole No./ Station	Ground Surface Elevation at Borehole Location (m)	Depth of Organic/Weak Soils (m)	Corresponding Elevation (m)	Comments
3-1 25+343	222.8	3.3	219.5	1.2 m of peat followed by organic silt to 2.7 m and weak silty clay to 3.3 m

Borehole No./ Station	Ground Surface Elevation at Borehole Location (m)	Depth of Organic/Weak Soils (m)	Corresponding Elevation (m)	Comments
10+000 (road shoulder)	226.1	7.0	219.1	Underlying embankment fill, 0.5 m of peat followed by 1.7 m of organic silt and 0.7 m of weak clay.
3-2 10+007	222.7	3.6	219.1	1.7 m peat followed by organic silt to 2.9 m and weak silty clay to 3.6 m.
3-3 10+033	223.2	5.7	217.5	1.5 m of peat followed by organic silt to 4.6 m and weak silty clay to 5.7 m.
3-4 10+061	223.1	4.3	218.8	3.2 m of peat followed by organic silt to 3.8 m and weak silty clay to 4.3 m
3-5 10+087	223.4	3.2	220.2	2.5 m of peat followed by organic silt to 3.0 and weak silty clay to 3.2 m.
11+000 (road shoulder)	226.3	6.0	220.3	0.3 m of peat and organic silt with rock fill penetration followed by 0.7 m of organic silt and 0.3 m of weak silty clay underlain by 1.0 m of rock fill or cobbles and boulders.
3-6 10+113	223.0	4.4	218.6	2.9 m of peat followed by organic silt to 3.8 m and weak silty clay to 4.4 m.
3-7 10+138	222.9	5.1	217.8	2.9 m of peat followed by organic silt to 3.4 m and weak silty clay to 5.1 m.
3-8 10+165	223.5	2.3*	221.2*	1.8 m fill and probable fill mixed with organics followed by dynamic cone test refusal at 2.5 m.

\*probable unsuitable soil elevation adjacent to the borehole.

It should be noted that conditions may vary between and beyond the borehole locations both in the longitudinal and transverse directions.

The unsuitable soils summarized in Table 5.2.2 appear to be underlain by competent soils and/or bedrock either immediately or a short distance below the recorded unsuitable soils, as evidenced by refusal to washboring.

As was mentioned before in Section 5.1 of this report (i.e. for Swamp No. 2), the removal of all or most of the unsuitable soils is desirable from a technical or reliability point of view for slope stability and for the long-term performance of the widened portion of the roadway. However, the following table summarizes some of other possible options, as well.

Table 5.2.3  
Summary of Alternatives for Swamp No. 3

Method	Treatment Type	Comments	Advantages	Disadvantages	Recommendations
1	Backfill over existing grades	Raise grade without effecting any stripping of existing materials	Inexpensive	High settlements which would continue over many years, lateral yield of foundation soils; foundation slope failures are likely.	Not recommended due to unreliability.
2	Soil Displacement by Rock Fill	Displacement of prevailing unsuitable (i.e. organic and/or very soft) soils by rock fill after the removal of all existing fills as well as the surface mat of muskeg	Relatively inexpensive	Technically not reliable.	Can be considered if risks are acceptable in terms of foundation movements and/or slope failures and future settlements. Not recommended due to unreliability
3	Complete removal of all unsuitable soils and backfilling with Granular Backfill	Remove all unsuitable soils in short sections and backfill immediately with granular backfill	-	Expensive due to material removal and replacement costs as well as cost of hauling excavated materials offsite. The use of granular soils not suitable due to very high water table which prevails at the site, unless major dewatering can be effected.	Not recommended due to unreliability and/or cost.
4	Complete Removal of all unsuitable soils and backfilling with rock fill	Remove all unsuitable soils in short sections and backfill immediately with rock fill	More reliable and easy to construct in high water level conditions; rock fill will penetrate into very soft soils (i.e. self correcting to some extent)	Expensive due to material removal and replacement costs, as well as cost of hauling excavated materials offsite.*	Recommended based on reliability and limited dewatering need (in comparison with use of granular backfill).



Method	Treatment Type	Comments	Advantages	Disadvantages	Recommendations
4a	Complete Removal of all unsuitable soils and backfilling with rock fill with surcharge or preload	Remove all unsuitable soils in short sections and backfill immediately with rock fill	More reliable and easy to construct in high water level conditions; rock fill will penetrate into very soft soils (i.e. self correcting to some extent	Expensive due to material removal and replacement costs, as well as cost of hauling excavated materials offsite.	Recommended based on reliability and less aggressive dewatering need and will cause less settlements than Method 4 and is, therefore, preferable.
5	Partial Removal and Backfilling with Rock Fill	Where the unsuitable soils are less than 4.0 m thick remove all unsuitable soils in short sections and backfill with rock fill. Where unsuitable soils are more than 4.0 m thick, remove to 4.0 m and backfill with rock fill.	Reduces amount of excavation and offsite hauling to some extent, in comparison with Method 4 and is therefore more cost effective.	Some long-term settlements as well as slope foundation failures may occur.	Not recommended due to unreliability (i.e. possible foundation/slope failures as well as settlement).

\*We understand that the use of rock fill may not be more expensive than the use of granular soils for this project, since rock removal is required across the contract (i.e. re-use of on-site blasted rock).

Option 4a which is the recommended option is discussed in some detail in Section 5.2.1 of this report. Option 5 (partial sub-excavation and replacement with rock fill) is also discussed in Section 5.2.2 of this report.

#### 5.2.1 COMPLETE REMOVAL OF ALL UNSUITABLE SOILS AND BACKFILLING WITH ROCK FILL

The recommended unsuitable soil removal depths at each borehole location are given in Table 5.2.1.1.

Table 5.2.1.1  
Recommended Unsuitable Soil Removal Depths

Borehole No.	Station	Offset from Existing Road C/L	Existing Ground Elevation at Borehole Location (m)	Recommended Sub-excavation Depth from Existing Ground (Bottom of Water) m	Recommended Sub-excavation Elevation (m)
3-1	25+343	13.0	222.8	3.3	219.5
3-2	10+007	13.5	222.7	3.6	219.1
3-3	10+033	13.5	223.2	5.7	217.5
3-4	10+061	14.0	223.1	4.3	218.8
3-5	10+087	14.0	223.4	3.2	220.2
3-6	11+113	14.0	223.0	4.4	218.6
3-7	11+138	14.5	222.9	5.1	217.8
3-8	11+165	18.0	223.5	2.5*	221.0*

\*There is no need to remove the soil at borehole location. However, based on the dynamic cone penetration test, soil removal will likely be necessary in areas adjacent to the borehole.

Based on the above table, a station to station anticipated unsuitable soil removal depth table has been prepared as given in Table 5.2.1.2, assuming that rock fill will be used for backfilling the excavations to at least the high water level in the swamp.

Table 5.2.1.2  
Anticipated Unsuitable Soil Removal Depths

Station to Station	Average Anticipated Unsuitable Soil Removal Depths (m)	Elevation (m)
25+330-25+350	3.3	219.5
25+350-10+015	3.6	219.1
10+015-10+055	5.7	217.5
10+055-10+080	4.3	218.8
10+080-10+095	3.2	220.2
10+095-11+120	4.4	218.6
11+120-11+160	5.1	217.8
11+160-11+180	2.5	221.0

The depths of unsuitable soils in the transverse direction (i.e. in the northerly direction) as well as in the longitudinal direction may be different than those encountered in the boreholes, as the depths of organic soils in the bog are likely to be variable. As well, the surficial fill encountered in Borehole 3-8 may not be present elsewhere. You may wish to take these aspects into consideration for estimating quantities. It is recommend that the actual required excavation depths be verified in the field by a Geotechnical Specialist retained by the Contract Administrator during the construction to ensure that all unsuitable soils have been

removed and that the excavations do not extend to excessive (unnecessary) depths (i.e. the removal of sufficiently competent inorganic soils should be minimized).

The rock fill may penetrate into the underlying soil as well as displacing some of the weak soils in the northerly direction at the perimeter of the excavation. You may wish to make an allowance in estimating for this effect. A figure of 0.3 m penetration can be used for preliminary estimating purposes.

Special care is required when digging in the swamp (i.e. adjacent to the existing embankment). The sub-excavation should be carried out in short strips of narrow bands (no wider than about 3 m widths in the perpendicular direction to the existing embankment) and no more than about 4 to 5 m lengths at a time. The excavation should immediately be backfilled with rock fill. This is necessary to prevent a failure or excessive yield of the existing roadway embankment and the caving-in of the walls of the excavation.

As was discussed in Section 5.1.1 of this report for Swamp No. 2, it is recommended that the sub-excavation be started from one end at the toe of the existing embankment where access may be relatively easier and carry out the excavation in narrow widths and short sections and backfill with rock fill immediately, working towards the centre. The backfilled portion could be used as platform for the equipment and trucks. As was recommended before, the excavator and heavy trucks (especially the rock trucks) should maintain a safe distance from the edge of the excavation to prevent instability of the excavation, which may jeopardize the safety of personnel and equipment. We recommend that end-dumping at the edge of the excavation should not be carried out. In other words, rock trucks should not be allowed to back to the edge of the excavation to dump the rock (i.e. should discharge the rock fill a safe distance away). The rock fill can then be pushed into the excavation if this proves to be unsafe on alternate method can be suggested by the contractor. An NSSP should be provided in the Contract Documents to warn the contractor of the special excavation treatment in this section.

Carrying out the excavation by drag line may also be possible provided that the contractor is able to demonstrate this is feasible and safe. Normal MTO practice for widening slopes as per OPSD-203.020 is to excavate vertically from the toe of the 1:1 slope (see Appendix H). In this case, however, this may be risky as the marl-like organic soils appear to be extremely weak (based on a visual examination of the soil samples and field tests during drilling. As well, there is little information about their behaviour under these circumstances (i.e. embankment widening situations) as such soils are extremely rare. For this reason to reduce risks of failures during construction, a flatter slope may be specified say  $\frac{1}{4}$  or  $\frac{1}{2}$  H:1V or even flatter if necessary, keeping in mind this will increase future settlements of the embankments due to unsuitable soils left in place. The feasible slope below grade may be determined in the field by trial and error.

It is recommended that the final widened embankment be 2H:1V. In this instance, the outer extent of the excavation and rock fill be set by projecting an imaginary line from the toe of the final embankment configuration at a slope of 1H:1V below the o.g. and then daylighting at 1H:1V to the swamp surface (o.g.). Alternatively, for the normal 1.25H:1V rockfill embankment slope, similar to Swamp No. 2, the outer extent of the excavation could be determined by projecting a 1.25H:1V imaginary line from the toe of the embankment slope below the swamp grade to the bottom of the excavation and daylighting back to the swamp grade at 1:1.

It should further be pointed out that because of the extremely soft nature of the marl-like organic silt some failures during construction are possible due to its caving-in or yielding. As mentioned before, to minimize the risk and extent of such failures, the width and length of excavation should be kept to a minimum (e.g. maximum 3 m wide excavations in perpendicular direction to the embankment, as well say as 4 to 5 m lengths) in the transverse direction. However, MTO and the contractor should be made to understand such risks. A test section may also be considered.

It is recommended that the existing slopes be cut to 1:1 configuration immediately before excavating each strip (steepening of the slopes in wider sections along the existing embankment may lead to instability), as per OPSD-203.020.

After backfilling the sub-excavated strips to about 0.3 m above the swamp grade, the 1:1 side slope above grade will unlikely be stable since most of the existing embankment appears to be constructed of granular soils above the original grades (o.g.). We recommend that the slope be flattened to 2H:1V as soon as possible. It is recommended that a 200 mm graded rock fill be used (similar to a riprap) to flatten the slope to 2H:1V. This is because a filter is required between the granular soils of the existing embankment and the rock fill to be placed to widen the embankment. A riprap type rock fill will present a compromise solution, since regular chinking or placing of geotextile for separation against steep slopes is in our opinion impractical. After the flattening to 2H:1V there would no time restriction to widen the embankment, as 2H:1V side slopes would be stable.

Alternatively, if the placement of a graded rock filter is considered too costly and the risk of some settlements due to loss of soil fines is acceptable, then the graded rock filter (recommended in the previous paragraph) can be omitted. In this instance, however, since the existing granular embankment will not be stable at 1H:1V construction side slopes, the flattening should be implemented almost immediately. This may present some logistical problems (i.e. difficult access for construction equipment and trucks during construction of the widening).

Table 5.2.1 shows that the anticipated grade raises for the widening (above the swamp ground elevation) will generally be between 2.7 and 3.8 m (for typical sections see Drawing

G-2 in Appendix G). From the borehole results, it can be anticipated that either all or most overburden will be removed or the overburden remaining will be relatively competent. Therefore, the settlement due to stresses caused by grade raise and soil replacement (i.e. removal of light weight soil in the bog and replacing with heavier rock fill) should not exceed 25 mm (assuming all organic soils, including the marl-like material have been removed), which is well within tolerable limits. However, additional movements could occur due to the lateral yield of the weak soils at the northern perimeter of the excavation, as well as the shifting of the rock fill in time, due to traffic vibrations, loads and the amount of organic soils left in place unremoved near the toe of the existing embankment. These can be reduced by preloading (or preferably by surcharging about 0.6 m). Obviously, the longer the time period for preloading/surcharging, the better but for practical purposes a period of about three months is considered acceptable.

#### 5.2.2 FUTURE SETTLEMENTS OF THE EXISTING EMBANKMENT

Boreholes drilled from the shoulder of the highway at Stations 10+000 and 10+100 (see Record of Borehole Sheets for Boreholes 10+000, 5.5 m Lt and 10+100, 5.5 m Lt) show the presence of 2.2 m of organic soil (followed by 0.7 m of very soft silty clay) at Station 10+000 and 1.0 m of organic soil (i.e. peat and organic silt) and 0.3 m soft silty clay, respectively. From this, it can be concluded that further settlements will take place under the weight of the existing embankment (i.e. to the south of the widened section) but this settlement will take place over many years, due to secondary consolidation. Based on Borehole 10+000 results, a settlement of about 50 mm can be expected during the course of the next 20 years. If, however, the grade is raised even by a small amount, additional settlements will likely take place, some of which will take place within the first year of construction and some over many years. It is, therefore, recommended that even small amounts of grade raises be avoided. For example, if the grade is raised by 0.3 m, an additional settlement (i.e. in addition to the estimated 50 mm settlement without grade raise) of 90 mm can be expected over the next 20 years, due to the grade raise. Such settlements, may lead to differential settlements between the existing roadway and the widened section, as well as, causing differential settlements within the existing roadway area due to differences in the thickness of the organic soils under the roadway and/or the extent of rock penetration during the original construction of the highway. If settlements of this magnitude are not acceptable, then other measures such as a complete reconstruction of the highway with or without the use of lightweight fill and surcharging the roadway can be considered. However, such measures are likely be impractical and very costly. We will, however, be pleased to further discuss this, if you wish us to do so. Under these circumstances, the practical solution appears to be avoiding any grade raises.



To avoid a grade raise after the road centerline is shifted to the north, due to chosen rehabilitation strategy (pulverization and pave), we recommend that the road grade be lowered by about 0.3 m by removing the pulverized material (up to 0.3 m depth) within the swamp area. In this case, with the placement of 140 mm of new hot mix and about 160 mm of grade raise at the centerline due to alignment shift, the highest final road elevation will be the same as the road elevation before construction (i.e. no net grade raise).

### 5.2.3 PARTIAL REMOVAL AND BACKFILLING WITH ROCK FILL

Partial sub-excavation option, along with its advantages and disadvantages were discussed, in Section 5.1.2 of this report and will not be repeated here for the sake of brevity.

A reasonable depth of maximum sub-excavation for Swamp No. 3 can be set at 4.0 m to 4.5 m. A comparison of a figure of 4.0 m with those presented in Table 5.2.2 show that at the location of Boreholes 3-1, 3-2, 3-5 and 3-8, the recorded depth of unsuitable soils is less than 4.0 m. This means all the unsuitable soils will be removed at these borehole locations. At Boreholes 3-4 and 3-6, the unsuitable soil depths are 4.3 and 4.4 m, respectively. This means that only minor amounts of unsuitable soils will be left in-place at Borehole 3-4 and 3-6 locations (which will probably be fully penetrated by rock fill). At Boreholes 3-3 and 3-7 the thickness of soil which will be left unexcavated is 1.7 m and 1.1 m, respectively. Assuming that about 0.6 m of rock fill penetration will take place into the subgrade below 4.0 m depth, the anticipated settlements would be about 150 mm. This can be reduced by preloading/surcharging to more reasonable figures.

In spite of the fact that settlements are likely to be manageable with preloading/surcharging, this approach is not recommended due to the concern that foundation slope failures, which may endanger the existing highway embankment, are possible.

## 5.3 CONSTRUCTION COMMENTS

Excavations should be carried out in accordance with the Safety Regulations of the Province (i.e. Occupational Health and Safety Act O. Reg 213/91) as well as the following specifications:

OPSD-203.020	Embankments Over Swamps
OPSS-209	Construction Specification for Embankments over Swamps
SP206S03	Earth Excavation, Grading
	Excavation for Pavement Widening
	Rock Excavation, Grading
	Rock Face
	Rock Embankment

The widening of the embankment should be carried out in accordance with OPSS and established MTO practices. Benching should be as per OPSD 208.01. The new rock fill should be “keyed into” any existing rock fill embankment by removing any soil or deleterious materials (e.g. topsoil or vegetation) on the surface of the existing rock fill and should be compacted by overlapping track prints of the construction equipment. Depending on the size and type of equipment used, generally six to eight passes along each path should suffice.

It is recommended that the rock fill should extend to at least the high water line in the swamps. It can be higher, but since the existing embankments pavements appear to be of granular construction (i.e. at least 900 mm granular pavement fill) a minimum granular pavement fill of 500 mm is recommended (rather than the normal MTO practice of 300 mm granular over rock fill) for compatible performance between the widened and the existing road portion.

As per SP 206S03 (see Appendix H), the maximum lift thickness for rock fill embankments is 1.5 m, prior to compaction and typically the maximum rock size is 2/3 of the lift thickness. This is considered acceptable for embankments to about 0.6 m above the existing grade in the swamp but above this level we recommend that the rock fill thickness be limited to 1.0 m with maximum rock size limited to 2/3 of this figure.

As per SP206S03 “voids of the top surface of the embankment shall be minimized to prevent migration of the roadway sub-base and base into the rock fill embankment by chinking the top surface of the rock fragments and spalls to form the sub-base prior to the placement of the roadway sub-base” (see page 12 of SP206S03, Item 206.07.08). Chinking is also recommended between the existing granular roadway embankment and the new rock fill embankment for the same reason. This will be particularly difficult below existing swamp ground surface level and as such the use of a relatively well-graded rock fill may be considered immediately against the existing embankment. Above ground surface where this will be somewhat more feasible, consideration may be given to placing a graded rock fill layer immediately against the face of the embankment, as was discussed before. The use of a geotextile can be considered but in our experience this does not work well against slopes steeper than 2.5H:1V.

As was mentioned before, it is extremely important to work safely in the swamp to prevent caving-in of the excavation, causing hazard to personnel, equipment and the existing roadway embankment. The contractor should be asked to present a well planned procedure, including digging in short strips and narrow bands, as was detailed before and backfill immediately. An NSSP should be provided in the contract for this requirement. A trial section may be considered at the start of construction.

At the time of our investigation at the borehole locations up to 1.6 m of water depth was recorded above the existing grade. We understand that this is not a seasonal or temporary condition but rather the site is below water throughout the year. Furthermore, the site is an environmentally sensitive area. Under these circumstances and with the prevailing subsurface conditions, it will be very difficult and costly to lower the groundwater at the site to any significant distance below the prevailing ground surface. The recommended construction method was chosen with these conditions in mind. With the method recommended (i.e. excavation in short strips and narrow bands and backfilling immediately with rock fill) dewatering below the ground surface level is not necessary. It is, however, recommended that the standing water at the site be lowered to the existing ground surface level or if this is too costly, to about 0.3 m above the ground surface in the swamp. The acceptable water height above ground is more of a construction issue. The method to lower the standing water level in this environmentally sensitive area is beyond the scope of this report. In any event, to come up with a scheme acceptable to various agencies and to MTO should, in our opinion be best left to the contractor. For example, a temporary cofferdam construction can be considered where the water is pumped from inside the cofferdam and discharged to the outside of the cofferdam. The use of on-site excavated materials for the construction of the cofferdam will probably not be possible due to environmental concerns in this area, underlain by very soft soils. A combination of sand bags and bladder type temporary cofferdams can be considered. If sand bagging is considered, the very soft nature of the peat/inorganic silt in the bog should be taken into consideration (i.e. bearing capacity failures) as well as the safety of the personnel.

Bladder type cofferdams are normally used to block water courses but may possibly work here, in conjunction with sand bagging in corner or difficult to block areas. If this is a consideration, it can be discussed with a supplier or an experienced contractor. One commercially available bladder type system is 'Aqua Dam' by Layfield.

#### 5.4 MISCELLANEOUS

As was mentioned before, differential settlements between the newly constructed lane and the existing portion of the roadway may occur due to the anticipated continuing settlements of the existing embankments (due to organic soils left in place under the existing embankment). The magnitude of such potential settlements under the existing embankment can be reduced by avoiding (or if this is not possible by minimizing) any grade raises.

## 6. CLOSURE

The Limitations of Report, as quoted in Appendix I, are an integral part of this report.

### SHAHEEN & PEAKER LIMITED

  
Ramon Miranda, P.Eng.



ZO:tr/idrive

Z.S. Ozden, M.A.Sc., M.Eng., P.Eng.



# Appendix G

## Typical Cross-Sections



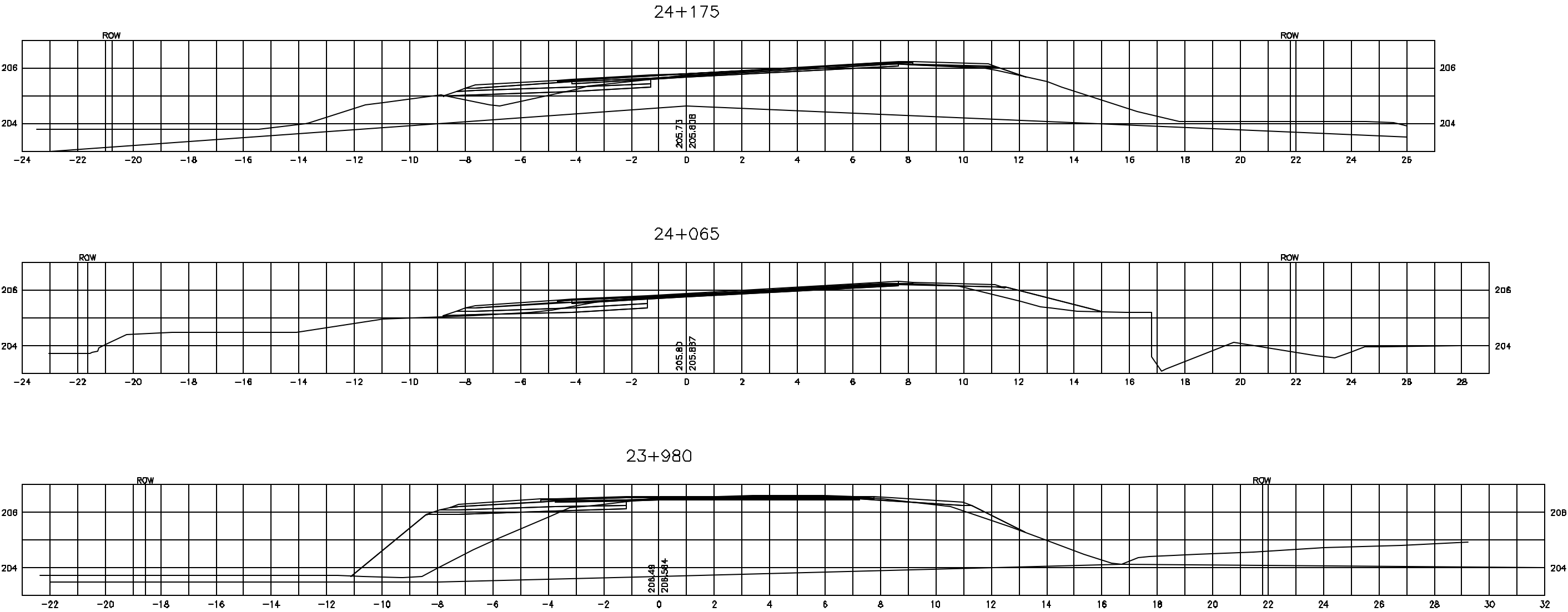


FIGURE G-1 Typical Proposed Cross-Sections for Swamp No. 2

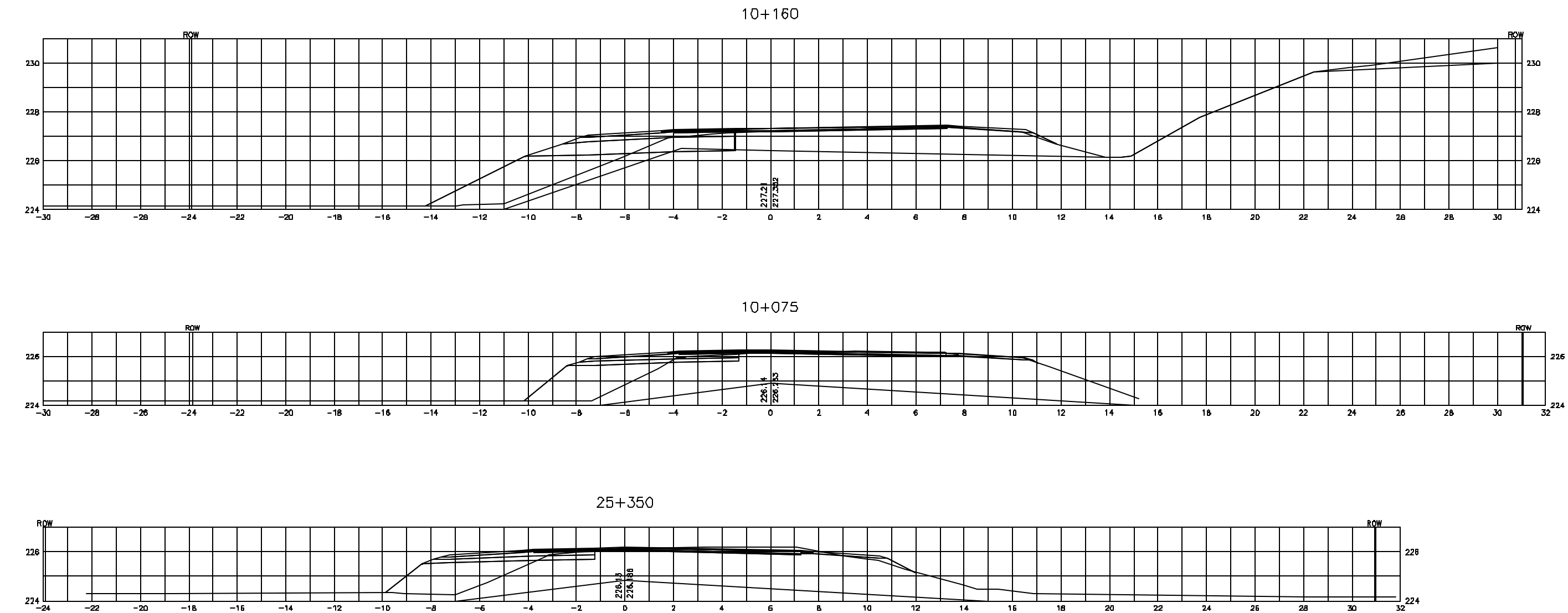
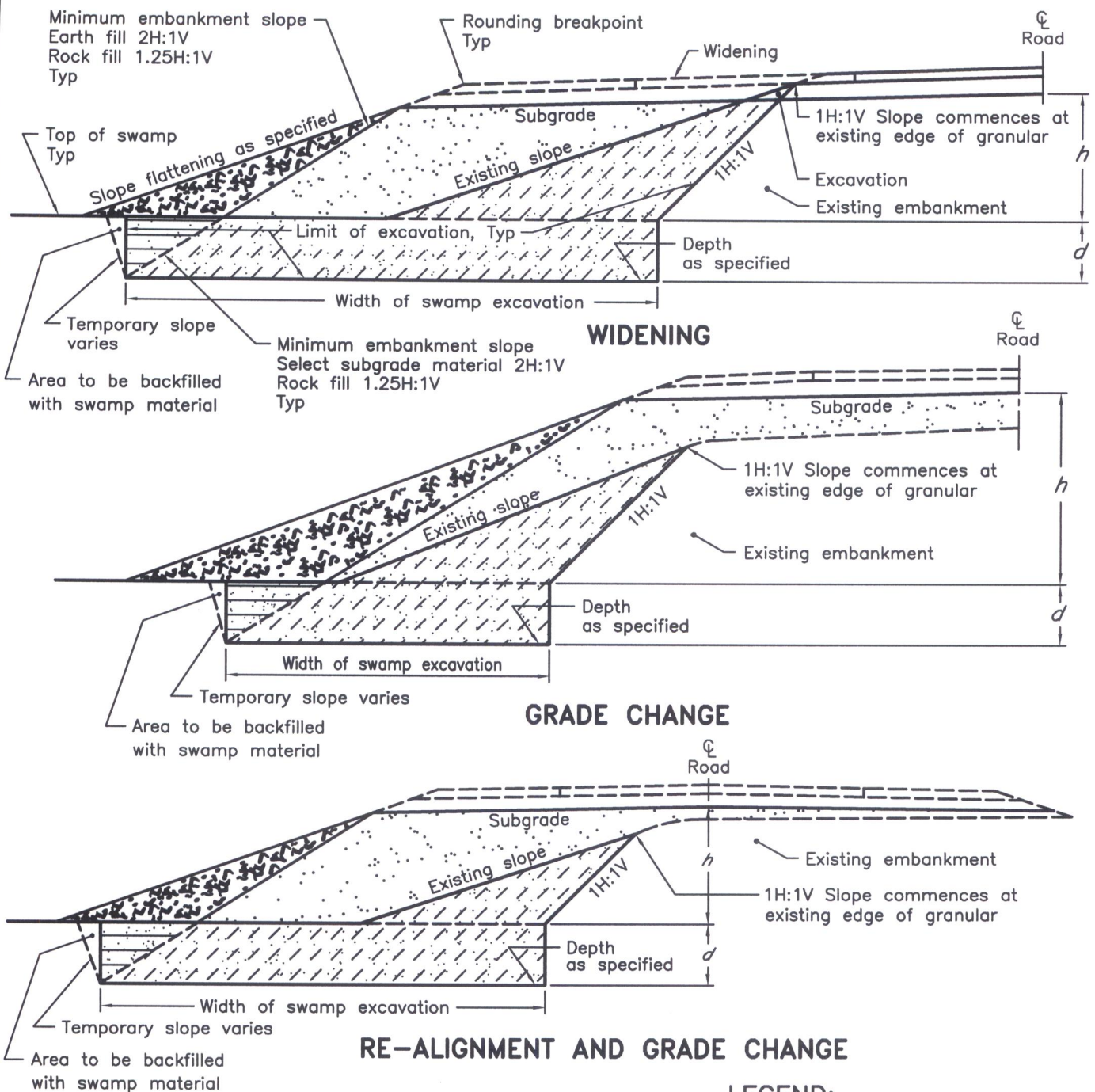


FIGURE G-2 Typical Proposed Cross-Sections for Swamp No. 3

# Appendix H

## Typical MTO Specifications



#### NOTES:

- For this OPSD to apply,  $h$  must be  $\leq 4.5\text{m}$  and  $d$  must be  $\leq 6.0\text{m}$ .
- Height of fill is the vertical difference between top of subgrade and top of swamp elevation measured at new road centreline.
- Widening of existing earth embankments shall be benched according to OPSD-208.010.
- All dimensions are in millimetres unless otherwise shown.

#### LEGEND:

- $h$  - Height of fill  
 $d$  - Depth of sub-excavation
- |  |   |
|--|---|
|  | Embankment materials as specified         |
|  | Excavated swamp material                  |
|  | Excavate and backfill as specified        |
|  | Excavate and backfill with swamp material |

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## EMBANKMENTS OVER SWAMP

EXISTING SLOPE EXCAVATED TO 1H:1V



OPSD - 203.020



## **CONSTRUCTION SPECIFICATION FOR EMBANKMENTS OVER SWAMPS**

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### **APPENDICES**

<b>209-A</b>	<b>Commentary</b>
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### **209.01 SCOPE**

This specification covers the requirements for the construction of embankments over swamps.

#### **209.01.01 Significance and Use of Appendices**

Appendices are not a mandatory part of this specification unless invoked by the Owner.

**Appendix 209-A** is a commentary appendix to provide designers with information on the use of the specification in a Contract.



## 209.02

## REFERENCES

This specification refers to the following standards, specifications, or publications:

### Ontario Provincial Standard Specifications, Construction

OPSS 201	Clearing, Close Cut Clearing, Grubbing, and Removal of Surface and Piled Boulders
OPSS 206	Grading
OPSS 212	Borrow

### Ontario Provincial Standard Specifications, Material

OPSS 1010	Aggregates - Base, Subbase, Select Subgrade, and Backfill Material
OPSS 1860	Geotextiles

## 209.03

## DEFINITIONS

For the purpose of this specification, the following definitions apply:

**Displacement** means to build the embankment directly on the swamp displacing as much of the underlying swamp material as possible.

**Floatation** means to build the embankment directly on the swamp minimizing the displacement of the swamp material.

**Swamp Material** means the material within the swamp excavation, floatation, or displacement limits, except rock, masonry, natural wood, and manufactured products. Wood that has decomposed and breaks down readily upon handling shall be considered swamp material.

**Swamp Wave** means the swamp material that is displaced as a result of placement of embankment material.

## 209.05

## MATERIALS

### 209.05.01

### Embankment Material

Embankment material shall consist of earth, rock, select subgrade material, or other material specified in the Contract Documents.

#### 209.05.01.01

#### Earth or Rock

Earth or rock shall be according to OPSS 206.

#### 209.05.01.02

#### Earth Borrow or Rock Borrow

Earth borrow or rock borrow shall be according to OPSS 212.

#### 209.05.01.03

#### Select Subgrade Material

Select subgrade material shall be according to OPSS 1010.

### 209.05.02

### Geotextiles

Geotextiles shall be according to OPSS 1860 and be of the type, Class, and filtration opening size (FOS) range specified in the Contract Documents.

## **209.06 EQUIPMENT**

### **209.06.01 Swamp Excavator**

When the rental of swamp excavation equipment item is used, the minimum size of a swamp excavator shall be a 26,500 kg hydraulic excavator with a minimum 12 m reach and a 1 m<sup>3</sup> bucket.

### **209.06.02 Spreading, Levelling, and Compacting Equipment**

When the floatation method is used, spreading, levelling, and compacting equipment shall be restricted to a gross weight that, in the opinion of the Contract Administrator, is not detrimental to the structural integrity of the root mat.

## **209.07 CONSTRUCTION**

### **209.07.01 General**

The work of embankment construction shall be carried out using one or more of the following methods specified in the Contract Documents:

- a) Excavation Method
- b) Floatation Method
- c) Displacement Method

### **209.07.02 Clearing and Close Cut Clearing**

Prior to beginning embankment construction, the required clearing and close cut clearing shall be completed according to OPSS 201.

### **209.07.03 Excavation Method**

The work shall include the excavation of all material, except rock from within the designated limits and the handling, placing, shaping, trimming, and hauling of excavated material.

Excavated material shall be placed clear of the sides of the embankment limits and any drainage facilities. The operations of excavating and backfilling shall be carried out simultaneously, except when excavation results in a relatively stable trench. In such cases, the excavating and backfilling may be carried out as separate operations with prior written approval by the Contract Administrator.

### **209.07.03.01 Embankment Construction and Backfill**

Backfill shall be placed according to OPSS 206. However, when wet conditions exist, backfill material may be placed up to 600 mm above water level without compaction.

Embankment material placed subsequent to the backfill material shall be placed according to OPSS 206.

### **209.07.04 Floatation Method**

The work shall consist of controlled placement of embankment material, removal of surcharges as designated from above the subgrade, and hauling and incorporating of this material into the work according to OPSS 206.

#### **209.07.04.01                      Swamp Waves**

Swamp waves shall not be excavated or otherwise disturbed.

#### **209.07.04.02                      Embankment Construction**

The embankment shall be constructed according to OPSS 206, except that vibratory compaction equipment shall not be used within 1.0 m of the original surface of the swamp.

Each layer shall be built using an outside to inside sequence by keeping the outer one-third portions of the layer at least 30 m ahead of the centre portion.

#### **209.07.04.03                      Geotextile**

When geotextile is to be placed, the area designated for geotextile shall be close cut cleared and cleared of objects that may damage the geotextile. Close cut clearing shall be carried out in such a manner as not to damage the structural integrity of the root mat.

Adjacent sections of the geotextile shall be overlapped a minimum of 500 mm or shall be sewn together according to OPSS 1860.

Should the geotextile be damaged, it shall be repaired by placing a piece of geotextile large enough to cover the damaged section and shall meet the above requirements.

The placement operation shall be such that the geotextile is not exposed to daylight for more than 3 Days.

If the geotextile is damaged due to the Contractor's operation during embankment construction, the embankment material shall be removed from the geotextile.

#### **209.07.05                          Displacement Method**

The work shall consist of controlled placement of the embankment material, excavation of swamp waves and displaced material, removal of surcharges, and hauling and incorporating of this material into the work according to OPSS 206.

#### **209.07.05.01                      Embankment Construction**

The embankment shall be built in such a manner as to displace as much of the material underlying the embankment as possible. An inside to outside construction sequence shall be used, keeping the inside one-third portion 30 m ahead of the outside portions.

When a stable platform has been established, embankment material placed 300 mm above original ground shall be placed according to OPSS 206.

#### **209.07.06                          Management of Excess Material**

Management of excess material shall be according to the Contract Documents.

Manufactured products are not to be used in the right-of-way.

Excavated swamp material shall be used as much as possible within the right-of-way adjacent to an embankment and conforming to standard right-of-way offset. This shall be done by widening embankments, flattening side slopes, and constructing modified cross-sections as specified in the Contract Documents. Such material shall be trimmed to provide smooth contours and to provide drainage.

The maximum volume of excavated material that may be used within the Contract limits or designated areas shall be as specified in the Contract Documents.



**209.09 MEASUREMENT FOR PAYMENT**

**209.09.01 Actual Measurement**

**209.09.01.01 Excavation**

Measurement for excavation shall be made in cubic metres by the method of average end areas. The quantity for payment shall be the lesser of the following:

- a) Actual excavation.
- b) Excavation to the length, width, and depth as specified in the Contract Documents.

**209.09.01.02 Rental of Swamp Excavation Equipment**

Measurement for payment of rental equipment shall be by the number of hours that the equipment is actually engaged in the work.

When the excavated material has been placed in a location that will not interfere with subsequent excavation, measurement shall not be made for the handling required in grading, leveling, and trimming of such material.

**209.09.01.03 Select Subgrade Material**

Select subgrade material shall be measured by mass in tonnes or by volume in cubic metres as specified in the Contract Documents.

**209.09.01.03.01 Cubic Metre Measurement**

When measurement of select subgrade material is in cubic metres, one of the following methods, as specified in the Contract Documents, shall be used to calculate the volume of the material:

- a) End Area Method

Volume of material shall be measured in their original location and computed in cubic metres by the method of average end areas.

Original cross-sections shall be taken after the area has been cleared, grubbed, and stripped of unsuitable surface material. These operations shall be completed a minimum of 3 Working Days in advance of excavation to allow for the required cross-sectioning.

- b) Truck Box Method

Material shall be measured in cubic metres, loose, by predetermined truck box capacities. The predetermined capacity of each truck shall be that computed from its box dimensions.

Each truck shall be uniquely and readily identifiable.

**209.09.01.04 Geotextile**

Geotextile shall be measured in square metres in place, with no allowance for overlaps.

**209.09.02 Plan Quantity Measurement**

When measurement is by Plan Quantity, such measurement is based on the units shown in the clauses under Actual Measurement.

**209.10 BASIS OF PAYMENT**

**209.10.01 Excavation**

Payment for swamp excavation shall be at the Contract price for the item Earth Excavation, Grading, according to OPSS 206.

Payment shall not be made for the removal of materials that slide or slough inside the excavation limits.

**209.10.02 Rental of Swamp Excavation Equipment - Item**

Payment at the Contract price for the above item shall be full compensation for furnishing and operating the minimum size equipment specified, including mats when necessary, for the excavation and for the management of the material adjacent to the excavation. When the Contract Administrator approves the use of larger equipment, the Contract price per hour will be adjusted by adding to the Contract price the difference between the rate set out in The 127 Rates for the minimum size equipment specified and the rate set out in The 127 Rates for the larger equipment to be employed.

**209.10.03 Floatation and Displacement Method**

Payment shall not be made for material displaced by floatation or displacement.

**209.10.04 Select Subgrade Material - Item  
Geotextile - Item**

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.

Repairs to geotextile damaged by the Contractor's operation shall be at no additional cost to the Owner.

**209.10.05 Management of Swamp Material Excavated by Equipment Rental**

The management of material that cannot be accommodated adjacent to the excavation shall be paid as Extra Work and shall include:

- a) Loading and hauling when the excavated material has been piled on the right-of-way and could not have been loaded when originally excavated.
- b) Only hauling when the excavated material is loaded directly into trucks from the excavation.
- c) Unloading and grading the material to smooth contours.



## **Appendix 209-A, Commentary for OPSS 209, November 2004**

**Note:** This appendix does not form part of the standard specification. It is intended to provide information to the designer on the use of this specification in the Contract.

### **Designer Action/Considerations**

The designer should specify the following in the Contract Documents:

- Alternative materials allowed in embankment construction, e.g., expanded polystyrene, wood chips, bark, and granular blast furnace slag. (209.05.01)
- One or more of the methods of embankment construction. (209.07.01)
- Woven or non-woven, class of fabric, FOS, and thickness of material for geotextile. (209.05.02)
- Maximum volume and locations of excavated material to be placed within the Contract limits. (209.07.06)
- Method of measurement for select subgrade material. (209.09.01.03)
- Method of calculation for cubic metre measurement, if required. (209.09.01.03.01)

The designer should include the rental of swamp excavation equipment item when cross-sections are not practical due to wet material.

The designer should ensure that the Ontario Provincial Standards General Conditions of Contract and the 100 Series General Specifications are included in the Contract Documents.

### **Related Ontario Provincial Standards Drawings**

OPSD 203.010	Embankments Over Swamp, New Construction
OPSD 203.020	Embankments Over Swamp, Existing Slopes Excavated to 1H:1V
OPSD 203.030	Embankments Over Swamp, Existing Slopes Maintained
OPSD 203.040	Embankments Over Swamp at Pipe Culverts $\leq 1500$ mm

**EARTH EXCAVATION, GRADING – Item No.**  
**EXCAVATION FOR PAVEMENT WIDENING -Item No.**  
**ROCK EXCAVATION,GRADING -Item No.**  
**ROCK FACE-Item No.**  
**ROCK EMBANKMENT -Item No.**

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Special Provision 206S03

January 2004

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**Amendment to OPSS 206, December 1993**

OPSS 206, Construction Specification for Grading is deleted in its entirety and replaced with the following:

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<b>206.04</b>	<b>SUBMISSIONS AND DESIGN REQUIREMENTS</b>
<b>206.05</b>	<b>Not Used</b>
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<b>206.07</b>	<b>CONSTRUCTION</b>
<b>206.08</b>	<b>QUALITY ASSURANCE/QUALITY CONTROL</b>
<b>206.09</b>	<b>MEASUREMENT FOR PAYMENT</b>
<b>206.10</b>	<b>BASIS OF PAYMENT</b>

**206.01 SCOPE**

This special provision covers the requirements for grading, including earth and Rock excavation and embankment construction, ditching, wall control blasting, and the management of surplus and unsuitable material.

Included in this special provision are the requirements for the construction and compaction of Rock fill embankments to minimize and control settlements within the Rock fill.

**206.02 REFERENCES**

This special provision refers to the following standards, specifications, or publications:

## **Ontario Provincial Standards Specification, General:**

OPSS 180 Management and Disposal of Excess Material

## **Ontario Provincial Standard Specifications, Construction:**

OPSS 209 Embankment Over Swamps  
OPSS 212 Borrow  
OPSS 501 Compacting  
OPSS 511 Rip-Rap, Rock Protection and Gravel Sheetting  
OPSS 570 Topsoil  
OPSS 572 Seeding and Mulching, Temporary Cover, and Erosion Control Blanket

### **206.03 DEFINITIONS**

For the purposes of this special provision, the following definitions apply:

**Angle of Repose:** means the maximum angle, measured from the horizontal, at which Rock fill will remain stable.

**Backslope:** means the slope in a cut between the invert of the roadside ditch and the point where the slope intersects original ground.

**Benching:** means the keying of new fill slopes into existing earth slopes by excavating horizontal planes in the existing slopes and backfilling the benches and placing the fill simultaneously. Benching also means the stepping of cut slopes at intermediate levels in deep cuts.

**Berm:** means an extension of an embankment, constructed to a lower height, designed to provide road embankment stability.

**Bulking Factor:** means the ratio of the volume of material insitu to the expanded volume of that same material after transport and placement in embankment. The factor is determined by dividing the expanded material volume by the insitu volume.

**Cushion Blasting:** means a wall control blasting technique involving the placing of a single row of closely spaced holes along the excavation limits, loading them with light, well distributed charges, completely stemmed, and firing them simultaneously to remove the Rock left in place after blasting inside the cut limits.

**Ditching:** means the excavation in earth or in Rock for all water courses. The term shall include roadside ditches, all excavation lying beyond the end of drainage structures, and stream and watercourse diversions and corrections.

**Earth:** means all soils except those defined as Rock, and excludes stone masonry, concrete and other manufactured materials.

**Embankment:** means the limit of the materials placed within the sideslopes, below the top of Subgrade and above the original ground or excavated base as applicable, as specified in the Contract Documents. Widening, flattening or other placement of material adjacent to or on top of sideslopes beyond that specified in the Contract Documents is excluded from this definition.



**Existing Rock Surface:** means the Rock surface after removal of overburden.

**Frontslope:** means the slope in a cut section between the edge of shoulder and the invert of the roadside ditch.

**Line Drilling:** means a wall control blasting technique involving the placing of a single row of very closely spaced unloaded holes along the excavation limits.

**Mucking:** means the picking up of broken Rock prior to haulage.

**Overbreak:** means the portion of any Rock or broken Rock which is excavated, displaced, or loosened outside and beyond the designated excavation limits, regardless of whether it has been excavated, displaced or loosened due to the inherent character of the Rock formation or due to any other cause.

**Pre-Shearing:** means a wall control blasting technique involving the placing of a single row of closely spaced holes, placed along the excavation limits, lightly loading and firing them simultaneously before and independently of the main excavation blast. Preshearing is sometimes referred to as presplitting.

**Roadside Ditch:** means a ditch with one of its sideslopes coincident with the road frontslope.

**Rock:** means natural beds or massive fragments, of the hard, stable, cemented part of the earth's crust, igneous, metamorphic, or sedimentary in origin, which may or may not be weathered, and includes boulders having a volume of 1 cubic m or greater.

**Rock Face:** means the vertical face between the top of the existing Rock surface and the designated Rock ditch grade line.

**Scaling:** means the removal of loose broken Rock fragments, from the vertical or sloped Rock cut limits, that remain in place after the Rock cut has been blasted and mucked.

**Shale:** means a finegrained, low strength, sedimentary Rock that undergoes rapid deterioration on exposure.

**Shatter:** means "in-situ" fractured Rock broken by the use of explosives.

**Sideslope:** means the slope in a fill between the edge of shoulder and the point where the slope intersects original ground.

**Smooth Wall Blasting:** means a wall control blasting technique involving the placing of a single row of closely spaced holes along the excavation limits, lightly loading and firing them along with but moments in advance of the main excavation blast.

**Spall:** means a small Rock fragment, chip or splinter from a Rock surface and created by weathering and/or blasting.

**Stripping:** means the excavation of the organic topsoil and other material specified.

**Tolerance - Minus:** a construction working tolerance only which:

- a. means narrower than the contract standard pertaining to horizontal dimensions as measured from centre line; and

- b. means lower in elevation than the contract standard pertaining to vertical dimensions.

**Tolerance - Plus:** a construction working tolerance only which:

- a. means wider than the contract standard pertaining to horizontal dimensions as measured from centre line; and
- b. means higher in elevation than the contract standard pertaining to vertical dimensions.

**Wall Control Blasting:** means blasting using one of the techniques of either cushion blasting, pre-shearing, smooth wall blasting, or line drilling. Wall control blasting is to produce maintenance free Rock face with a minimum of blast induced fractures; generally it is characterized by noticeable drill hole traces over the majority of the Rock face.

## **206.04 SUBMISSION AND DESIGN REQUIREMENTS**

### **206.04.01 Rock Material Management Plan**

Five business days prior to undertaking the work of Rock excavation or Rock embankment, the contractor shall submit to the Contract Administrator the following information;

- a) A management plan for Rock excavation corresponding to the station intervals shown in the Quantity Sheets identifying:
  - i) the solid, unblasted excavation quantity,
  - ii) the quantity of excavated Rock from the Rock excavation item to be placed in Rock embankment,
  - iii) the quantity of excavated Rock from the Rock excavation item to be processed into granular material and the crushing location,
  - iv) the quantity of excavated Rock from the Rock excavation item to be used for other purposes in completing the contract Work and the type and location of that Work,
  - v) the quantity of excavated Rock from the Rock excavation item to be disposed of or not incorporated into the contract Work, including widening and flattening of embankments, etcetera, and identifying the location and use of the material,
  - vi) any assumptions for Rock excavation overbreak quantities plus the use and location of assumed overbreak
- b) A management plan for construction of embankments identifying locations where embankment material is supplied from corresponding to the station intervals in the Quantity Sheets,
- c) the assumed various Bulking Factor(s) for Rock materials, included in the above.
- d) Additional source locations where applicable, and quantities for Rock embankment and granular materials to meet contract quantity requirements.

The contractor shall update the plan monthly to reflect changes to the plan.

The contractor shall be solely responsible for the reasonableness of the submitted plan or the contractors assumptions.



The contractor shall not be permitted to start work on Rock excavation or Rock embankment until the Rock Materials Management Plan conforming to the above requirements is submitted.

## **206.06 EQUIPMENT**

Tractor bulldozers crawler type used for compaction of Rock fills shall have a minimum net flywheel power of 200kw.

## **206.07 CONSTRUCTION**

### **206.07.01 General**

#### **206.07.01.01 Removal of Ice and Snow**

All ice and snow shall be removed from any portion of the work.

#### **206.07.01.02 Embankments**

Only materials approved by the Contract Administrator shall be used. Frozen earth materials shall not be incorporated into embankments. Materials shall not be placed over either frozen earth or ice surface

Reclaimed asphalt pavement (RAP) used in embankments shall be surplus to the recycling requirements of the contract.

For the purposes of compaction, RAP and reclaimed Portland cement concrete included in the embankment shall be treated as earth or Rock corresponding to the embankment being constructed.

The Contractor shall ensure that the RAP and reclaimed Portland cement concrete are suitable for embankment construction and conform to the dimension requirements as specified in clauses 206.07.07.02, 206.07.07.03, and clause 206.07.07.04.

#### **206.07.01.03 Compaction**

Compaction of materials shall be according to OPSS 501.

#### **206.07.01.04 Management of Surplus and/or Unsuitable Excavated Material**

As much of the excavated materials as possible shall be used within the contract limits where the material is suitable for embankment construction.

Excavated materials may be used where the material is suitable for other contract Work.

Excavated material and excess material shall be managed as specified in OPSS 180.

#### **206.07.01.05 Earth Borrow**

When Earth Borrow is required to complete embankments or backfill requirements, earth borrow shall be provided according to OPSS 212.

## **206.07.01.06                      Tolerances – General**

In the event of a conflict between meeting horizontal grading tolerances and meeting vertical grading tolerances, the vertical grading tolerances shall take precedence.

## **206.07.01.07                      Tolerances for Earth**

All earth grade surfaces shall, on completion be shaped to the specified grades and cross sections within the following tolerances, excluding swamp excavations:

- a.        Vertical grading tolerances of the finished earth subgrade within the limit of the roadway:
  - +        30 mm
  - 30 mm
- b.        Horizontal grading tolerances for the vertical faces of excavations to be backfilled:
  - +        100 mm
  - 0 mm
- c.        Horizontal grading tolerances for the backslopes in earth cut sections:
  - +        300 mm
  - 300 mm

Backslopes beyond the plus tolerance may be accepted by the Contract Administrator where not detrimental to the work.

- d.        Horizontal grading tolerances for ditching slopes in earth excluding roadside ditches in earth cut sections:
  - +        300 mm
  - 0 mm

Sideslopes beyond the plus tolerance may be accepted by the Contract Administrator where not detrimental to the work.

- e.        Vertical grading tolerances for all ditching in earth:
  - +        30 mm
  - 30 mm
- f.        Horizontal grading tolerances for each sideslope in earth embankment construction:
  - +        300 mm
  - 0 mm
- g.        Horizontal grading tolerances for roadside ditch frontslopes:
  - +        0 mm
  - 0 mm

Irrespective of compliance with the above tolerances, the completed slopes shall present a uniform appearance.

**206.07.01.08****Tolerances for Rock**

Rock grade surfaces shall, on completion, be shaped to the specified grades and cross sections within the following tolerances:

- a. Vertical grading tolerances for the finished Rock subgrade within the limits of the roadway:
  - + 30 mm
  - 100 mm

Excavation below the minus tolerance may be accepted by the Contract Administrator where it is not detrimental to the work and is brought up to grade according to clause 206.07.05.01.

- b. Horizontal grading tolerances for vertical Rock face cut limits:
  - + 0 mm
  - 300 mm

Final faces beyond the designated face, in the plus direction, may be accepted by the Contract Administrator where not detrimental to the work.

- c. Horizontal grading tolerances for sloped wall backslopes in Rock cuts:
  - + 300 mm
  - 300 mm
- d. Horizontal grading tolerances for ditching slopes in Rock, excluding roadside ditches:
  - + 300 mm
  - 0 mm

Excavation beyond the plus tolerance may be accepted by the Contract Administrator where not detrimental to the work.

- e. Vertical grading tolerances for all ditching in Rock cuts:
  - + 30 mm
  - 30 mm

Excavation below the minus tolerance may be accepted by the Contract Administrator where not detrimental to the work.

- f. Horizontal grading tolerances at the top of each sideslope of Rock embankment construction:
  - + 300 mm
  - 0 mm

The slope shall be that obtained when built in accordance with the Contract requirements.

**206.07.02****Drainage**

Excavation operations shall be performed in such a manner as to avoid water saturation of embankment material and roadway foundation material, and to avoid leaving undrained pockets in excavations, by providing effective drainage during all stages of the work.

In excavations below subgrade and in stripping operations where provision for surface drainage is impracticable, backfill materials shall be placed as soon as practical following the excavation work.



Ditching required to provide for drainage of an embankment shall be completed in advance of the embankment construction. Ditches in roadway cuts shall be constructed as soon as possible to provide drainage from the cuts. Ditches located above and beyond roadway cuts shall be constructed prior to excavating adjacent cuts. Where pipe subdrainage is required in the bases of roadway cuts, such work shall be carried out at the time that the roadside ditches are being constructed.

**206.07.03                      Earth Excavation, Grading**

**206.07.03.01                  General**

The work to be done under the item Earth Excavation, Grading shall include excavating, hauling, handling and placing, shaping, compacting, and trimming, of earth and excess materials and the management of excess materials as specified in OPSS 180.

Suitable and non surplus earth excavated from roadway cuts, ditching and from other associated sites shall be used in embankment construction unless otherwise specified in the Contract.

**206.07.03.02                  Provision for Temporary Cover**

Mulching for temporary cover shall be applied according to OPSS 572 to those areas specified in the Contract.

**206.07.03.03                  Excavation Below Subgrade**

Unsuitable materials, other than material excavated from swamps, shall be removed below the subgrade to the lengths, widths and depths specified in the Contract. The resulting excavation shall be backfilled with acceptable material that shall be compacted.

**206.07.03.04                  Backfilling of Over-excavated Areas**

Where over-excavation occurs, it shall be backfilled with acceptable material and the backfill compacted. With the exception of frontslopes and where boulders are encountered in the excavation slopes, backfilling shall not be permitted to obtain required slopes for excavations. When boulders are encountered in the excavation slopes, the boulders shall be removed when directed by the Contract Administrator and any resulting cavities shall be backfilled with acceptable material and the backfill shall be compacted.

**206.07.03.05                  Over-excavation of Cut Slopes**

The material from over-excavations of cut slopes, where suitable and where required, shall be used in embankment construction. Where the material is surplus or is unsuitable, it shall be managed as specified in OPSS 180.

**206.07.03.06                  Swamp Excavation**

Swamp material shall be excavated according to OPSS 209.

#### **206.07.03.07 Stripping**

Except where swamp treatment is required, the original ground under embankments of 1.2 m or less in height shall be stripped as specified in the Contract. The height of embankment for this purpose shall be measured from original ground to profile grade.

Topsoil shall be removed from the original surface over the entire width of all excavations.

#### **206.07.03.08 Stockpiling of Topsoil**

When excavating acceptable topsoil material during any grading operation, topsoil shall be stockpiled according to OPSS 570. Material removed in the stripping operation which is unsuitable for use as topsoil, or which is surplus to the amount of topsoil required for the contract, shall be managed as specified in OPSS 180.

#### **206.07.03.09 Excavation for Widening**

Excavation that is adjacent to the travelled portion of the roadway shall at no time be in advance of the backfilling operation by a distance greater than the length specified in the Contract. Any such excavation shall be backfilled with the specified material, and shall be compacted prior to closing down operations each day.

#### **206.07.04 Excavation for Pavement Widening**

The work to be done under the item Excavation for Pavement Widening shall include excavating a trench adjacent to the existing pavement, to the widths and depths specified in the Contract. Excavated material shall be spread on the adjacent shoulders and slopes.

#### **206.07.05 Rock Excavation, Grading**

##### **206.07.05.01 General**

The work to be done under the item Rock Excavation, Grading shall include drilling and blasting to obtain the required Rock excavation and shatter, mucking, and bringing to Rock grade any excavation taken below Rock grade. Hauling is only part of the work when the excavated material is not used for any contract items. Whenever a Rock face item is not included in the contract, Rock scaling and the removing of all overbreak and scaled materials shall be included in the Rock excavation item.

The contractor shall not drill or blast beyond the specified Rock face.

Where Rock is to be excavated, all overlying stumps, roots, and vegetation shall be managed as specified in OPSS 180. Where earth overlies the Rock to be excavated, the earth shall be removed. This work shall be performed sufficiently in advance of Rock excavation operations to allow Rock cross sections to be taken before blasting.

Scaling shall be done during or immediately after mucking. All Rock, boulders, and Rock fragments, either on or outside the excavated areas, and liable to slide or roll down the Rock cuts, shall be removed. Cut ditches shall be excavated at the same time as the main excavation.

Excavation below grade in Rock cuts shall be brought to grade within the specified tolerances with spalls or approved material.



Rock in roadway cuts shall be shattered to a uniform minimum depth of 0.30 m below the theoretical Rock grade for the full width of the cut, including the ditch.

#### **206.07.05.02                      Shale**

The method of excavating shale shall be decided by the Contractor according to site conditions. The Rock face item shall not apply to slopes in shale. Side slopes in shale shall be as specified in the Contract. Shatter is not required in the shale subgrade

#### **206.07.05.03                      Drilling**

Drilling shall not be performed outside, or extend beyond, the theoretical lines, except as noted below.

All holes shall be drilled to a vertical limit that will provide shatter as specified and provide drainage of the shatter

#### **206.07.06                              Rock Face**

The work to be done under the item Rock Face shall include drilling and blasting using one or more of the wall control blasting techniques to produce the Rock face where required in the Contract, scaling, removing all overbreak and scaled Rock. Hauling is only part of the work when the excavated material is not used for any contract items. Trial sections to determine optimum explosive loads and drill and blast patterns for different Rock conditions shall be used. The contractor shall not drill or blast beyond the specified Rock face.

Holes for wall control blasting shall be a maximum diameter of 100 mm and shall be located accurately and consistently along the excavation limits.

The spacing of wall control blasting holes shall be decided by the Contractor, but shall not exceed 0.75 m centre to centre. The spacing shall be adjusted where necessary to ensure a uniform shear face between holes.

The Contractor shall accurately position and load the adjacent line of production holes, located inside the controlled blasting limits, in such a manner as to produce the required Rock face by wall control blasting. The first line of production holes, located inside cut limits, shall be drilled such that no portion of the hole is within 0.75 m of the line of the wall control blasting holes.

#### **206.07.07                              Earth Embankments**

##### **206.07.07.01                      General**

Embankment materials shall be deposited and spread in uniform layers for the full width of the embankment except as otherwise permitted for berms, and each layer shall be compacted before the succeeding layer is placed. For side hill or sloping sections, the lower portion shall be constructed as above until a full width surface of the specified cross section is obtained. The embankment shall be completed thereafter with full width layers or as stage construction allows.

The construction of a core through the embankment and the subsequent completion of the embankment are prohibited except where core construction is permitted in swamps as specified in OPSS 209. The use

of surplus material and the placing of material in difficult locations by side dumping, subject to the approval of the Contract Administrator, may be permitted.

Embankment berms may be constructed separately, but shall be completed before the road embankment is built to a level higher than the berm.

#### **206.07.07.02 Layer Compaction Method**

Except as provided in 206.07.07.03 and unless otherwise specified in the Contract, all earth embankments shall be built using a layer compaction method. The embankment material shall be spread in uniform full width layers not more than 0.30 m in depth prior to compaction. Each layer shall be shaped and compacted to the line and cross section specified before the succeeding layer is placed. All boulders, cobbles, fragments of Rock, RAP, and reclaimed Portland cement concrete greater than the fully compacted layer depth shall be removed.

Material in each layer shall be compacted at moisture content determined by the Contract Administrator to be suitable for obtaining the required density and be compacted according to OPSS 501.

Where the ground cannot support construction equipment using this method initially, then the first layer may be increased conforming to the modified layer compaction method.

#### **206.07.07.03 Modified Layer Compaction Method**

When it is deemed practical to construct an earth embankment or portion of an embankment in deeper lifts than specified in clause 206.07.07.02, permission may be requested to do so by supplying full details of the proposed method. Apart from the depth of material, placement of embankment material shall conform to clause 206.07.07.02 except that the maximum size of boulders, cobbles, fragments of Rock, RAP, and reclaimed Portland cement concrete shall not exceed the compacted modified layer depth or 0.30 m, whichever is less.

The Contractor shall prove that the specified compaction can be achieved throughout the layer.

The Contractor shall do all necessary excavation for establishing the compaction results throughout each compacted layer.

Boulders, cobbles, fragments of Rock, RAP, and reclaimed Portland cement concrete over 0.15 m in their maximum dimension shall not be placed within 0.30m of the surface of the earth grade.

#### **206.07.07.04 Boulders and Fragments**

Boulders, cobbles, fragments of Rock, RAP and reclaimed Portland cement concrete up to 0.5m<sup>3</sup> may be incorporated into an embankment provided:

- (a) they are placed only in the bottom layer of the embankment;
- (b) the maximum dimension of the largest particle shall not exceed 0.80m;
- (c) they are not located within 0.3 m of the final embankment side slopes; and
- (d) they are not located within 1.0 m of the surface of the earth grade.



The work to be done under the item Rock Embankment shall include the supply, hauling, placement and compaction of broken Rock. The broken Rock material shall be supplied by the contractor from Rock material excavated on this contract or from other sources as necessary to meet the contract requirements.

Compaction of Rock materials shall conform to the method and equipment requirements of this special provision. Each Rock fill layer shall be compacted with the equipment specified. The minimum number of complete passes is six(6) and the maximum number of passes is eight(8). A complete pass is defined as 100 percent areal coverage of the layer. The maximum speed of the equipment during each pass shall be 3.2 km/h.

Construction of embankments using shale shall be carried out conforming to shale embankment requirements.

Embankments to be constructed of excavated Rock other than shale shall be constructed by placing embankment materials full width in successive, uniform layers. Layers shall not exceed 1.5 m thickness prior to compaction. Material in each layer shall be fully compacted before the succeeding layer is placed.

Materials shall be placed in final position by blading. End dumping or depositing of Rock over the end of any layer by hauling equipment is not permitted, except as otherwise noted below. Each layer shall be levelled in place and compacted to minimize voids and bridging of large Rock fragments within the embankment.

Rocks exceeding 1 metre in size shall be well distributed throughout the embankment. Rock fragments up to a maximum size of 3 metres in size may be incorporated into the embankment provided that the Rock fragments are less than two-thirds the remaining embankment height and are sufficiently spaced to allow free access of the specified equipment to compact the intervening fill. The remaining height shall be defined as the distance between the bottom of the oversized Rock fragment at point of placement to the top of the Rock fill embankment.

Placement in layers and compaction is not required for Rock to be placed under water. Rock placed underwater may be placed by end dumping. End dumping shall only be used to an elevation of 1.0 m above the water level after which Rock embankments shall be constructed using the equipment and method specified in this special provision. The Rock used for end dumping shall be deposited on the surface of the embankment and pushed forward by blading or dozing over the edge of the embankment. The materials shall be well distributed to form a solid embankment constructed to full width as the work progresses, or as stage construction allows.

Where Rock fill is placed in a wet area (such as swamps with full, partial or no excavation), the direction of the Rock fill placement shall be such that mud waves generated by the Rock fill placement would move away from the embankment. Mud waves shall be displaced or removed to prevent its entrapment below or within the embankment.

Voids on the top surface of the embankment shall be minimized to prevent migration of the roadway subbase and base into the Rock fill embankment by chinking the top surface with Rock fragments and spalls to form the subgrade prior to the placement of the roadway subbase.

Care shall be taken to avoid large boulders and Rock fragments protruding above the average embankment surface within a distance of 3 m beyond the edge of the shoulder for future roadside safety.

Dumping over the sides of embankments is permitted only after the Rock embankments have been completed. Dumping over the sides of embankments shall be restricted to standard offset and right of way limits unless otherwise specified in the Contract Documents. The Contractor shall receive written approval from the Contract Administrator before commencing the above operations.

#### **206.07.08.01                      Shale Embankments**

Shale embankment materials shall be deposited and spread in uniform layers for the full width of the embankment. Layers shall not exceed 0.45 m in depth prior to compaction. Compaction of each layer shall be in two stages. In the first stage, a minimum of two passes shall be made with an 18-tonne static sheepsfoot, packall, padfoot, or tamping foot type roller. In the second stage, a minimum of two passes shall be made with a 9-tonne vibratory steel drum or pneumatic-tired roller. Maximum speed of rollers shall not exceed 10 km/hr. Where harder Rock types, such as limestone, are present as an integral part of the shale formation, no such pieces greater than 0.15 m measured vertical to the embankment layer, nor greater than 0.60 m measured parallel to layers shall be placed in the embankment.

#### **206.07.09                      Rock Backfill to Structure**

When Rock backfill to structures is specified, the Rock shall be clean, free from contaminants, and no larger than 0.25 m in its greatest dimension.

End dumping of Rock backfill against a structure shall not be permitted. Rock backfill shall be placed in such a manner that the structure is not damaged.

### **206.08                      QUALITY ASSURANCE / QUALITY CONTROL**

#### **206.08.01                      General**

The Contractor is responsible for carrying out all Quality Control (QC) grade checks required to ensure that horizontal and vertical grading tolerances are met. The Owner may conduct random Quality Assurance (QA) grade checks to verify the Contractor's ability to ensure that grading tolerances are met.

#### **206.08.02                      Quality Control**

The Contractor shall provide a competent Survey Crew to carry out grade checks on all finished earth and Rock grade surfaces. QC of earth excavation grading and Rock excavation grading shall be based on horizontal and vertical grading tolerances as given in 206.07.01.07 and 206.07.01.08. The grade shall be certified at the stations and offsets shown in the Construction Grading Report. Minimum frequency requirements are given in Table GC7.02 of the MTO General Conditions.

#### **206.08.03                      Submission of Grade Checks**

All Contractor grade checks relating to horizontal and vertical grading tolerances, including all non-compliances, shall be copied to the Contract Administrator within 2 business days following completion of each grade check.

Where grading templates are available, the Contractor shall sign and certify on the grading template that the component(s) of the work indicated on the grading template have been correctly constructed as to the specified line and grade tolerances. If no template is available, the Contractor shall complete, sign and submit the Form PH-CC-820 to the Contract Administrator.



**206.08.04                      Finished Grades Outside Specification**

Where the finished grade or cross-section does not meet the acceptance criteria, the earth or Rock grade surface shall be brought to grade within the specified tolerances.

**206.08.05                      Quality Assurance**

The Owner may conduct random QA grade checks to verify horizontal and vertical grading tolerances. Providing that the Owner's grade checks conform to those determined by the Contractor, no action will be taken. If discrepancies between QA and QC grade checks occur, the Owner may conduct additional QA grade checks.

If the finished grade or cross-section is found to be outside the specification limits allowed under 206.07.01.07 and 206.07.01.08, the Contractor shall be required to bring the earth or Rock grade surface to grade within the specified tolerances. The Contractor shall be charged \$250 per station for finished grade outside of specification limits for each QA grade check. All grading carried out by the Contractor as a result of QA grade checks to ensure minimum tolerances will be completed at no additional charge to the Owner.

**206.09                              MEASUREMENT FOR PAYMENT**

**206.09.01                      Earth Excavation, Grading**

**206.09.01.01                      Actual Measurement**

Measurement shall be by volume in cubic metres measured in its original position and based on cross-sections taken prior to grubbing.

**206.09.01.02                      Plan Quantity Measurement**

Measurement shall be by Plan Quantity as may be revised by Adjusted Plan Quantity, of the volume in cubic metres.

**206.09.01.03                      Overbuilding, Earth**

The Contract Administrator shall be notified when the earth embankment has been completed, and before placing any surplus and unsuitable material and top soil on the embankment slopes.

The Contract Administrator may check the embankment for conformity to the requirements of clause 206.07.01.07 after notification by the Contractor that the embankment has been completed. When such checking is undertaken, the Contract Administrator shall notify the Contractor of any overbuilding.

Where the contract requires borrow, the quantity of material placed beyond the earth grading tolerance shall be deducted from the measured quantity of borrow on a cubic metre for cubic metre basis, with no correction for changes in density of the material.



**206.09.02                      Excavation for Pavement Widening**

**206.09.02.01                  Plan Quantity Measurement**

Measurement shall be by Plan Quantity, as may be revised by Adjusted Plan Quantity, of the horizontal length in metres along each edge of existing pavement where widening is specified.

**206.09.03                      Rock Excavation, Grading**

**206.09.03.01                  General**

The volume of Rock excavation shall include all shatter as specified in the Contract. The quantity of Rock shattered beyond that specified in the Contract, and as ordered by the Contract Administrator in writing, shall be included in the Rock excavation computation.

**206.09.03.02                  Actual Measurement**

Measurement shall be by volume in cubic metres computed from field measurement of cross sections taken by the Contract Administrator of the original Rock line after earth overburden has been removed and shall be based on the theoretical Rock Face and bottom limits designated in the Contract. The theoretical bottom of the cut shall be the shatter line, which shall be 0.30 m below the Rock grade.

**206.09.03.03                  Plan Quantity Measurement**

Measurement shall be by Plan Quantity, as may be revised by Adjusted Plan Quantity, of the volume in cubic metres below the existing Rock surface and above the theoretical bottom of cut, and within the designated faces of the cut. The theoretical bottom of the cut shall be the shatter line, which shall be 0.3 m below the Rock grade.

**206.09.03.04                  Rip-Rap and Rock Protection**

Deductions shall not be made from the Rock excavation quantity for any material conforming to OPSS 511 and used as rip-rap or Rock protection.

**206.09.03.05                  Boulders**

The volume of boulders classified as Rock shall be determined on the basis of 'actual Rock measurement' of the three maximum rectilinear dimensions.

**206.09.04                      Rock Face**

**206.09.04.01                  Plan Quantity Measurement**

Measurement shall be by Plan Quantity, as may be revised by Adjusted Plan Quantity, of the area in square metres of the Rock face.

**206.09.05                      Rock Embankment**

**206.09.05.01                  Plan Quantity Measurement**

Measurement shall be by Plan Quantity, as may be revised by Adjusted Plan Quantity of the volume in cubic metres of the Rock Embankment. Adjustments to the Plan Quantity shall be limited to those which are supported with topographic survey information.

For Rock Embankments in swamp, the theoretical pay line below the top of swamp line, shall be a 1:1 slope from the intersection of the Rock Embankment slope above the top of swamp line and the theoretical top of swamp, to the theoretical firm bottom or as specified.

In the event that the Rock Embankment construction required by the contract is outside the theoretical pay lines, the supply, haulage and placement of such additional rock required to fulfil the contract requirements, shall be deemed to be included in the contract price for Rock Embankment.

The Contract Administrator shall be notified when the Rock embankment has been completed, and before placing any surplus and unsuitable material on the embankment slopes.

The Contract Administrator may check the embankment for conformity to the requirements of clause 206.07.01.08 after notification by the Contractor that the embankment has been completed. When such checking is undertaken, the Contract Administrator shall notify the Contractor of any overbuilding.

**206.10                          BASIS OF PAYMENT**

**206.10.01                      Earth Excavation, Grading - Item**

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

Payment for earth grade checks, including provision of all labour, equipment and materials to conduct Quality Control testing, shall be included in the contract price as part of the work of earth excavation, grading.

**206.10.01.01                  Benching**

Where benching is required to key new fills into existing slopes, materials excavated as a part of this operation shall not be included for measurement or payment.

**206.10.02                      Excavation for Pavement Widening - Item**

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

Where the Contract Administrator directs that material excavated under this item is to be handled other than as specified in subsection 206.07.04, then such handling shall conform to OPSS 180 and shall be treated as Extra Work.

Material used to backfill the excavation shall be paid for at the contract price for the material used.

**206.10.03                      Backfill for Over-excavation**

Payment shall not be made for backfill for any over-excavation in excess of the specified tolerances.

**206.10.04                      Backfill for Subexcavation**

Material used to backfill subexcavations, and transitions or grade point treatments shall be paid for at the contract price for the material used.

**206.10.05                      Rock Excavation, Grading – Item**

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

Where excavated Rock is to be used for other contract item work, including Rock embankment, granular, rip rap, etcetera the hauling costs are deemed to be included in payment for the work associated with the appropriate pay item. Where excavated Rock is not to be used for other contract items work, the hauling costs are deemed to be included in payment for the work under the item of Rock Excavation, Grading.

Payment for Rock grade checks, including provision of all labour, equipment and materials to conduct Quality Control testing, shall be included in the contract price as part of the work of Rock excavation, grading.

Where drilling, blasting and mucking are required as a part of the work for this item, the following progress payments shall be made: 33 percent of the progress volume for drilling, and 33 percent of the progress volume for blasting.

**206.10.06                      Rock Face - Item**

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

On completion of drilling and blasting, a progress payment of 50 percent of the above item shall be made.

On completion of mucking, a progress payment of 75 percent shall be made.

**206.10.07                      Rock Embankment - Item**

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

# Appendix I

## Limitations of Report

## **LIMITATIONS OF REPORT**

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to Shaheen & Peaker Limited at the time of preparation. Unless otherwise agreed in writing by Shaheen & Peaker Limited, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

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

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

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



*Project: SPT1147  
Transenco Limited*

*Foundation Design Report  
Two Swamp Crossings, Proposed Widening of Highway 7  
From 2.6 km West of Marmora to Marmora West Limits  
And from Marmora East Limits to 6.6 km West of Highway 62, 12.5 km  
G.W.P. 251-98-00*

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