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REPORT ON

**SUPPLEMENTAL FOUNDATION INVESTIGATION
AND DESIGN
SWAMP CROSSING HWY 60
STATION 13+470 TO 13+700
TOWNSHIP OF WILBERFORCE, ONTARIO
W.P. 263-98-00**

Submitted to:

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PART A

**SUPPLEMENTAL FOUNDATION INVESTIGATION
SWAMP CROSSING HIGHWAY 60
STATION 13+470 TO 13+700
TOWNSHIP OF WILBERFORCE, ONTARIO
W.P. 263-98-00**

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Ltd. (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a supplemental foundation investigation as part of the detailed design for the upgrading of Highway 60 between the Towns of Eganville and Douglas, Ontario.

The terms of reference for the scope of work are outlined in Golder's proposal P31-2045, dated June 2003, that forms part of the Consultant's Agreement (Number P.O.4005-A-000317) for this project. This report addresses the swamp crossing between Station 13+470 and 13+700 along Highway 60 about 5 kilometres west of Kelly's Corner, see Drawing 1. The work was carried out in accordance with the Quality Control Plan for this project dated October 2003.

2.0 SITE DESCRIPTION

Highway 60 from the east limits of Eganville easterly to the east limit of Douglas is presently a two lane, undivided rural highway. This project involves the Detail Design of operational improvements to this 15.1 km section of Highway 60, including rehabilitation of the pavement. This section of Highway 60 is located in the Townships of North Algona/Wilberforce and Admaston/Bromley, in the County of Renfrew.

Within the limits of this supplemental swamp investigation, Station 13+470 to 13+700, Highway 60 forms a sag which is substandard based on current design standards. The sag traverses a swampy area. This section of highway has recently (within the last 4 years), been rehabilitated in the form of an overlay. Nonetheless, the surface of the pavement through this section exhibits some slight distortion. To correct the sag, a grade raise of about 600 millimetres maximum is proposed crossing the swamp. Contract drawings, obtained from the Ministry archives of Contract No. 75-18 , W.P. 265-63-02 indicate that swamp treatment had been carried out as part of that contract. The drawings indicate that swamp excavation was to be carried out as shown in Appendix A. The excavated muskeg material was to be replaced with un-compacted acceptable earth fill. Rock fill was to be placed over the un-compacted earth fill and the pavement constructed on top of the rock fill.

Geotechnical hand augerholes (HA's) completed along the toe-of-slopes as part of the Pavement Design Report indicate ± 0.5 to 4.0 m of organic matter (peat, muckamoor), underlain by sand, silty sand and/or sandy silt. The average thickness of the organic matter is about 1 m but at Station 13+500, 10.6 m Rt., 4.4 m of organic matter was encountered. At several locations the organic matter is underlain by inferred rock fill at depths of 1.5 to 1.8 m below the present ground surface.

Power auger borings (PA's) through the pavement structure encountered auger refusal on or within rock fill at depths ranging from 1.5 to 1.7 metres. The pavement structure is comprised of hot mix asphaltic concrete (120 millimetres thick) over a base consisting of either pulverized asphalt or crushed sand and gravel (170 to 450 millimetres thick) over a predominantly sand subbase. This pavement structure is placed over rock fill. Rock fill is visible along the shoulders.

The existing embankments are overgrown, however rock fill is exposed along the toe of the embankment slopes. The pavement structure appears to be constructed on top of the rock fill. The side slopes of the shoulders vary from about 1.5 to 2.0 horizontal to 1 vertical. The rock fill extends beyond the toe of the shoulder embankments. The existing shoulders are stable with no evidence of erosion or settlement. The surface of the rock fill is irregular. It cannot be determined based on a visual examination if settlement of the rock fill has occurred or is still occurring.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

Five boreholes numbered 04-1 to 04-5 were put down within the limit of the swampy area between October 7 and 13, 2004. These boreholes were advanced to depths varying from 8.2 to 12.3 metres below the existing pavement structure using a truck mounted hollow stem auger machine owned and operated by Marathon Drilling Co. Limited of Ottawa, Ontario. The boreholes were advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers. Where required, rotary drilling techniques were used to advance HQ casing through the rock fill. Once rotary drilling started, the borehole was then advanced full depth using rotary drilling methods. Soil samples were obtained within the rock fill where there was a decrease in augering or drilling resistance. Below the rock fill, samples of the subsoil were obtained near continuously but on occasions were spaced at 0.75 m to 1.5 m intervals of depth using a 50 mm outer diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures. A 75 mm nominal diameter thin walled Shelby tube sample was obtained from a layer of organic silt encountered in borehole 04-4.

The water levels within the boreholes were determined from the opened boreholes at the time of drilling.

The boreholes were backfilled in accordance with MOE Reg. 903 with bentonite pellets, mixed with native soils, and the site conditions restored following completion of work.

The excavation of the test pits was delayed until October 22, 2004 although several attempts were made between October 15 and October 22, 2004. The field work was cancelled on October 15 and 18 because of the forecasted all day rain on those days which would preclude the backhoe from working on the wet pavement platform. The test pit investigation was then rescheduled for October 22, 2004 because of other commitments of the excavating subcontractor on October 18 to 21, 2004.

On October 22, 2004 three test pits were excavated along the shoulders of the highway within the swampy area. The test pits were excavated using a track mounted 320 Caterpillar hydraulic backhoe owned and operated by a local subcontractor. At each test pit location, the rock fill and surficial muskeg was carefully removed in layers to expose the lateral location of the earth fill used in place of the excavated muskeg. The test pit was deepened within the muskeg beyond the earth fill to confirm the lateral limit of the earth fill. Care was also taken to prevent loss of the shoulder of the highway into the excavation. Water inflow and the potential of loss of the shoulder prevented excavation of the test pits beyond depths of about 2.5 metres.

The field work was supervised throughout by members of our engineering and technical staff, who located the boreholes and test pits, arranged for the clearance of underground services, supervised the drilling, sampling and in-situ testing operations, logged the boreholes and test pits, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Ottawa geotechnical laboratory where the samples underwent further detailed visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards as appropriate.

Traffic control was carried out as outlined in the traffic control plan submitted September 29, 2003 in conjunction with the pavement design report investigation for Highway 60 and revised for this project. The traffic control consisted of flagmen, cones and traffic signs as per MTO temporary Conditions Manual , Book 7, Field Edition, March 2001.

The borehole and test pit locations were initially selected by Golder in consultation with MTO. The boreholes and test pits were then surveyed in relation to existing site features as well as roadway stationing painted along the edge of the pavement as part of the geotechnical investigation. The co-ordinates of the boreholes and test pits were obtained by using the digital mapping provided to us by MH. The elevation noted for the ground surface at the test pits is the elevation at the edge of pavement at the station of the test pit. The borehole and test pit elevations were surveyed by Golder in relation to a geodetic benchmark number TSP 503 located along Highway 60 west of the site. The details regarding this benchmark were provided by MH and indicate an elevation of 179.42 metres as reference to Geodetic datum.

The borehole locations, including northing and easting coordinates, and ground surface elevations referenced to geodetic datum are summarized in the following table and are shown on Drawing 1.

Borehole Number	Borehole Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)
04-1	Station 13+500 3.6 m Rt.	5045472.95	260840.10	178.71
04-2	Station 13+600, 3.6 m Rt	5045461.37	260939.43	178.61
04-3	Station 13+675, 3.6 m Rt.	5045452.85	260913.94	179.52
04-4	Station 13+550, 3.6 m Lt.	5045473.92	260890.54	178.83
04-5	Station 13+650, 3.6 m Lt.	5045462.66	260989.90	178.49

Test Pit Number	Test Pit Location	Northing (m)	Easting (m)	Ground surface Elevation (m)
04-6	Station 13+510 4.5 Rt.	5045471.23	260849.96	178.70
04-7	Station 13+570, 4.5 Rt.	5045463.34	260918.51	178.65
04-8	Station 13+630 4.5 Lt.	5045465.45	260970.09	178.60

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The site lies near the boundary between the Ottawa-St. Lawrence Lowlands and the Canadian Shield, as delineated in *The Physiography of Southern Ontario*¹. Shallow Precambrian bedrock of the Canadian Shield lies to the south and west, and is mapped as generally being metasedimentary or gneissic in composition. To the north and east, the terrain is mapped as being part of the minor physiographic region known as the Ottawa Valley Clay Plain, which is part of the Ottawa-St. Lawrence Lowlands. The Ottawa Valley Clay Plain region is characterized by relatively thick deposits of sensitive marine clay, silt, and silty clay that were deposited within the Champlain Sea basin. These deposits, known as the Champlain Sea clay or Leda clay, overlie relatively thin, commonly reworked glacial till and glaciofluvial deposits, that in turn overlie bedrock.¹ Most of this minor physiographic region is underlain by a series of sedimentary rocks, consisting of sandstones, dolostones, limestones and shales that are, in turn, underlain by igneous and metamorphic bedrock of the Precambrian Shield.

Consistent with the physiographic mapping of this area, the lands to the south and west, towards the Town of Eganville, are quite undulating, consisting of a series of bedrock knolls separated by often poorly drained valleys. The terrain to the north and east, towards the towns of Cobden and Douglas, has gentler relief and thicker soil cover.

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets and on Figures 1 to 7. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress, excavation of test pits, and the results of Standard Penetration Tests (SPTs). These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

In general, the subsoils underlying the pavement platform across this swamp consist of approximately 0.6 to 1.2 m of pavement granular material underlain by rock fill that varies in thickness from about 1.4 to 3.4 m, the rock fill is in turn underlain by the earth fill used to replace the excavated muskeg. The earth fill varies in thickness from about 2.1 to 5.4 m.

¹ Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*, Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.

The earth fill is underlain by either layered clayey silt and sandy silt, a thin layer peat, marl and sand, or organic silt.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections, and stratigraphic profiles and sections of this site are shown on Drawing 1.

4.2.1 Existing Roadway Granular Base, Subbase

The existing base and subbase as encountered within the boreholes consists of predominantly sand and gravel. The thickness varies from about 0.6 to 1.2 m. Further details of the roadway granular materials are provided in the Pavement Design Report number 03-1181-129 dated August 27, 2004.

4.2.2 Rock Fill

Rock fill was encountered underlying the shoulder granular materials and is exposed on the side slopes of the highway embankment. The exposed rock fill consists of rock fragments ranging from about 0.2 to 0.6 m in nominal size. The thickness of the rock fill varies from about 1.4 to 3.4 m. Standard penetration tests carried out where possible within the rock fill indicate the rock fill is at least partially infilled with sand and gravel or sandy silt. Portions of the rock fill required rotary drilling methods to penetrate.

4.2.3 Swamp Treatment (Earth Fill – Silty Sand, Sand, Silty Sand and Gravel)

Boreholes 04-1 to 04-5 are all located along the left or right edge of pavement between the limits of the swamp crossing. The pavement shoulder granular material and the rock fill described above are underlain by the earth fill used to replace the excavated muskeg. The thickness of the earth fill varied from about 2.3 to 5.4 m. The gradation of the earth fill varies, consisting predominantly of silty sand trace gravel, but also contains zones of predominantly sand or sand and gravel. Gradations of selected samples of the silty sand and sand and gravel earth fill encountered are shown on Figures 4 to 6. A summary of the results of the grain size analysis testing is provided in the following table.

Soil Type	% Gravel Range (100 to 4.75 mm)	% Sand Range (4.75 mm to 75 µm)	% Silt Range (75 – 5 µm)	% Clay Range (< 5 µm)	Water Content (%)
Silty Sand	7 - 9	53 – 61	26 – 33	4 - 8	13 - 17
Silty Sand and Gravel	31	47	22	-	24

The water content of the earth fill ranged from about 13 to 24 percent. Standard penetration test N values that range from weight hammer to 14 blows per 0.3 m of penetration indicate a very loose to compact state of packing, however the vast majority of the N values are in the 1 to 6 blows per 0.3 m of penetration range which indicates a very loose to loose state of packing.

The intent of the test pits excavated at the shoulders was to determine the lateral extent of the earth fill. The inflow of water into the test pits and the concern for the road stability, limited the depth of excavation of the test pits to slightly below the rock fill. In any case, the lateral extent of the earth fill was determined in each of the test excavations and is summarized as follows:

Test Pit Number	Station, Offset	Distance to Edge of Swamp Treatment from Centreline
04-6	13+510, 8 m Rt.	7.65 m Right
04-7	13+579, 8 m Rt.	9.25 m Right
04-8	13+630, 8 m Lt.	10.85 m Left

Schematic representation of our interpretation of the subsurface information obtained from the boreholes and test pit pits are provided on Figures 1 to 3 for test pits 04-6 (Station 13+510, 8m Rt.), 04-7 (Station 13+579, 8m Rt.) and 04-8 (Station 13+630, 8 m Lt.) respectively. The subsurface conditions under the roadway are inferred from boreholes 04-1 (Station 13+500, 3.6 Rt.), 04-2 (Station 13+600, 3.6 m Rt.) and 04-2 and 04-5 (Stations 13+600, 3.6 Rt. and 13+650, 3.6 m Lt. respectively).

4.2.4 Organic Matter (Organic Silt, Peat, Marl)

In addition to the muskeg (peat) encountered within the swamp on both sides of the Highway, other organic matter was also encountered underlying the earth fill muskeg replacement material. The organic matter was encountered in boreholes 04-4 (Station 13+500), 04-2 (Station (13+600) and 04-3 (Station 13+675). The thickness of the organic matter was 2.2, 0.4 and 0.2 m at boreholes 04-4, 04-2 and 04-3 respectively.

At borehole 04-4, organic silt was encountered. Standard penetration test N values of 2 blows per 0.3 m indicate a very loose state of packing. The water content of one sample of the organic silt measured 80 percent and the organic content was 4.2 percent.

At borehole 04-2, a thin layer of peat, marl and sand was encountered. The water content of this layer was 277 percent and the organic content was 14.2 percent.

At borehole 04-3, the organic layer consists of predominantly clayey silt. The water content of this layer was 36 percent.

4.2.5 Silty Clay and Clayey Silt

The earth fill and organic matter (where encountered) are underlain by a layered sequence of clayey silt and sandy silt with occasional sand layers. All of the boreholes with the exception of boreholes 04-3 were terminated within this soil stratum at depths ranging from 8.7 to 12.3 m. Standard penetration test N values of weight hammer to 6 blows per 0.3 m of penetration indicate a very loose to loose state of packing. The moisture content of two samples was 22 and 24 percent. Atterberg Limit testing on one combined sample of the clayey silt and silty clay gave a plasticity index value of only 2 percent, and a liquid limit of 17 percent. This result is summarized on the Plasticity Chart, Figure 7 and indicates the clayey silt is of low plasticity. The measured water content of two samples of the clayey silt was 22 and 24 percent which is above the measured liquid limit.

4.2.6 Sand

At borehole 04-3, near the east limit of the swamp crossing, the earth fill used for the muskeg replacement and a thin layer of organic silt are underlain by fine to medium sand. A standard penetration test N value of 2 blows per 0.3 m of penetration indicates a very loose state of packing. Borehole 04-3 was terminated in the sand deposit at a depth of 8.2 m (a penetration into the sand of 0.5 m).

4.2.7 Groundwater

The water levels in the open boreholes were measured at the time of the investigation during the very short period that these boreholes were left open. Because of the location of the rockfill with respect to the swamp, the borehole water level reflects that of the swamp. The water levels are summarized in the table below:

Borehole	Ground Surface Elevation (m)	Water Level Depth (m)	Water Level Elevation (m)	Date
04-1	178.7	2.44	176.26	October 6, 2004
04-4	178.8	2.60	176.20	October 12, 2004
04-2	178.6	2.38	176.22	October 7, 2004
04-5	178.5	2.10	176.40	October 13, 2004
04-3	179.5	3.30	176.20	October 7, 2004

The levels indicate a groundwater table consistent with the water level in the swamp. It should be noted that groundwater levels in the area are subject to fluctuations both seasonally and with precipitation events.

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PART B

**SUPPLEMENTAL FOUNDATION INVESTIGATION AND DESIGN
SWAMP CROSSING HIGHWAY 60
STATION 13+470 TO 13+700
TOWNSHIP OF WILBERFORCE, ONTARIO
W.P. 263-98-00**

5.0 ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides foundation design recommendations for the swamp crossing between Station 13+470 and 13+700 along Highway 60 about 5 kilometres west of Kelly's Corner, see Drawing 1. The recommendations are based on interpretation of the factual data obtained from the boreholes and test pits advanced during the subsurface investigation at this site. The interpretation and recommendations provided are intended only to provide the designers with sufficient information to assess the feasible alternatives and to design the proposed grade raise. As such, where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

5.2 Existing Crossing Distress

The boreholes and test pits put down at the site as part of the present investigation suggest that, for the most part, the swamp treatment was carried out as per Contract No. 75-18 , W.P. 265-63-02 as shown in Appendix A. The borings indicate, however, that not all of the organic matter was removed at that time and that at Station 13+600 and 13+675, near the east limit of the swamp treatment, some 400 and 200 mm of organic matter was not removed. Also, at about Station 13+550, where the depth of the organic matter appears to be the greatest, some 2.2 m of organic clayey silt was left under the pavement. It is possible that the reach of the excavator was limited to about 8 metres and could not remove the full depth of the organic clayey silt which at Station 13+550 extends to a depth of about 10.4 m.

The field investigation also indicates that the lateral extent of muskeg treatment, based on the three test pits, was an apparent minimum of 7.7 m and an apparent maximum of about 10.8 m from the existing centreline of Highway 60. The earth fill used for the muskeg replacement generally consists of silty sand, although zones of predominantly sand or sand and gravel were also encountered. This earth fill is overlain with rock fill which supports the pavement structure across the swamp. The rock fill varies in thickness from 1.4 to 3.4 metres. The pavement structure consists of sand and gravel base and subbase supporting asphaltic concrete which, based on the Pavement Design Report, is some 110 to 120 mm thick.

Settlement of the highway crossing the swamp would result from two mechanisms; one being consolidation (compaction) of the fill materials used including the sand swamp treatment fill, rock fill and pavement structure and the other being settlement of the underlying soil below the peat.

Settlement within the fill materials (swamp replacement fill, rock fill and pavement structure) would occur after being deposited into the excavation and as the road is constructed over it. This settlement, however, would have occurred shortly after construction and would likely be relatively uniform across the width and length of the excavated area. At the present, any such time dependant settlement would be negligible.

Although this swamp crossing has exhibited distortions since Contract No. 75-18, it does not appear that ongoing settlement of the embankment has been a significant problem based on the lack of maintenance documentation for this area. The limited settlement is likely because the highly compressible muskeg has been removed from under most of the road platform. The remaining small thickness of compressible peat, would not add significantly to long term settlement. Also, although 2.2 m of organic silt exists at about Station 13+550, the organic content is only about 4 percent and therefore it is not as compressible as the muskeg and the resulting settlement would be limited and within acceptable limits.

Based on the above, it is concluded that the proposed grade raise of 400 to 600 millimetres will induce some settlement over the swamp, due to the remaining organic matter underlying the highway, however, because the organic layers are either of limited thickness or are of limited organic content, the settlement will be within acceptable limits, i.e. less than about 25 mm much of which will occur during construction.

Surface distortions aside from settlement appears to be the main form of distress within the swamp crossing. The sand and gravel infilling of the rock fill underlying the pavement structure suggests that some construction and post construction loss of sand and gravel from the pavement structure into the rock fill might be responsible for at least some of the pavement distortion. Unless corrected by blinding or providing a filter (granular or geotextile) above the existing rock fill prior to constructing the proposed grade raise, loss of pavement granular into the rock fill will continue, causing future pavement distortion.

5.3 Rehabilitation Options

The proposed design consists of 3.5 m wide lanes, 2.5 m wide shoulders and 1.0 m rounding if a Steel Beam Guard Rail is provided. The existing swamp treatment width, based on the test pits, is at least 7.7 m and up to 10.8 m from the centreline of the highway or about 1.3 m wider than the above platform width. The performance of part of the shoulders and the side slopes will likely be different from that of the main traffic platform because of the edge effects along the swamp treatment. To address the probable different performance of these components, alternative remediation options have been investigated as follows:

5.3.1 Sideslope Options

Schematic representations of the sideslope treatment options are shown on Figure 8.

Option S1: Excavate muskeg to accommodate 2H:1V sideslopes.

The proposed design includes 2H:1V sideslopes. The existing swamp treatment may not be of sufficient width to accommodate these sideslopes along the entire crossing. The swamp treatment could be extended on both or one side in order to accommodate the proposed design. If carried out on one side, the horizontal alignment of the highway will have to be realigned over the treatment. A Class II non-woven geotextile fabric would be required where granular materials abut rock fill which should be used for the sideslopes.

Option S2: Steepen the side slopes to 1.25H:1V

Rock fill sideslope can be constructed at 1.25H:1V which, as shown on Figure 8, would allow construction of the sideslopes within the limits of the existing swamp treatment as indicated by the test pits except at the minimum treatment width encountered. Removal of the existing sideslope granular material will be required to prevent lateral movement of the rock fill into the swamp as a result of sliding along and down a granular slope. A Class II non-woven geotextile fabric would be required where granular materials abut rock fill. The rock fill should be placed along the side slope (i.e. the contractor follows good construction practice) as is indicated the report "Task Force #25 (AASHTO-ABC-ARBTA) Specifications for Geotextiles". This report indicates that large size rip rap (rock fill) should be placed from a height of no more than 300 millimetres. For survivability a geotextile having the following properties should be specified:

Grab Strength	-	1200 N
Puncture Strength	-	490 N
Burst Strength	-	2000 kN/ m ²
Trapezoidal Tear	-	30 N

The F.O.S. should be within the range of 75 to 150 microns.

The overall stability of the above rock fill embankment is acceptable from a rotational stability viewpoint. Some subsidence of the rock fill over time should be expected, however, this settlement should not adversely affect the performance of the pavement.

Option S3: Construct new shoulders and sideslopes on a reinforced geogrid mat.

Reinforced geogrid mats have been shown to successfully support loads over swampy ground. To enable the design sideslopes of 2H:1V to be constructed a reinforced geogrid mat could be designed and used as support over the swampy ground without the need for excavation of muskeg. To provide anchorage of the mat against lateral movement towards the swamp the existing shoulder should also be supported on the reinforced geogrid mat. A Class II non-woven geotextile fabric would be required above the mat to prevent the loss of granular into the mat.

Option S4: Do Nothing

This should be considered with Option P4. Although not shown in Figure 8, the do nothing option might be considered. The subsurface investigation indicates that swamp treatment has been carried out under the existing pavement. Settlement and movement resulting from the swamp treatment is likely complete and the only other form of distress appears to be the result of loss of pavement granular into the underlying rock fill. This distortion will be gradual and continue in the long term, however, based on the past performance of the highway across this swamp, periodic maintenance might be acceptable provided the substandard sag is acceptable to MTO.

5.3.2 Pavement Options

The maximum grade raise across the swamp will be about 600 mm. To accommodate this grade raise three pavement remediation options have been considered. Schematic representations of the pavement treatment options are shown on Figure 9.

Option P1: In-place process and construct grade raise:

The existing asphaltic concrete varies from 110 to 120 mm thick. Within the limits of the swamp treatment, in-place process the asphaltic concrete to a depth of 250 mm prior to constructing the grade raise. This treatment is consistent with that given in the pavement design report for fill less than 700 mm. The grade raise should be constructed using Granular B Type III subbase to underside of base, 150 mm Granular A base and 100 mm hot mix. Note that where granular material used in this treatment abut rock fill used as the shoulder/sideslope treatment, a Class II non-woven geotextile should be provided as a separation.

Option P2: Excavate existing pavement to rock fill, provide additional rock fill and new pavement.

At least some of the ongoing distortion problems within this swamp crossing are likely the result of loss of the existing pavement granulars into the rock fill. This is evident by the presence of sand and gravel encountered within the rock fill. To eliminate the potential for future loss of pavement granular into the rock fill, the existing pavement structure could be removed to the top of the rock fill, additional rock fill added and then a new pavement structure consisting of 300 Granular A and 100 mm hot mix, could be provided. A Class II non-woven geotextile will be required where the pavement granular material abut rock fill.

Option P3: Excavate existing pavement to rock fill, construct grade raise and pavement using Granular B Type II.

This options is a variation of Option P2. In lieu of using rock fill for the grade raise, however, Granular B Type II could be substituted. Provided the Granular B Type II is 150 mm minus material, it will provide adequate chinking of the rock fill. The entire grade raise could then be constructed using the Granular B Type II, 150 mm Granular A base and 100 mm hot mix. This option eliminates the need for the geotextile under the pavement and the sideslopes provided chinking is carried out using Granular B Type II.

Option P4 : Do nothing.

This should be considered with Option S4. Although not shown in Figure 9, the do nothing option might be considered. The subsurface investigation indicates that swamp treatment has been carried out under the existing pavement. Settlement and movement resulting from the swamp treatment is likely complete and the only other form of distress appears to be the result of loss of pavement granular into the underlying rock fill. This distortion will be gradual and continue in the long term, however, based on the past performance of the highway across this swamp, periodic maintenance might be acceptable provided the substandard sag is acceptable to MTO.

Option P5 : Excavate All Organic Matter from Below Pavement.

The section on Drawing 1 indicates the presence of organic clayey silt, marl and peat underlying the pavement at Boreholes 04-2, 04-3 and 04-4. These organic layers could be contributing to the long term distortions that have been experienced within this area. Removal of the organic matter will reduce the address the issue of long term settlement mitigation.

5.4 Evaluation of Options

An evaluation of the shoulder/sideslopes and the pavement options is provided in Table 1. The following provides a brief summary of the evaluation of the options.

5.4.1 Sideslopes

Of the sideslope/shoulder options, S1 has the greatest negative impact on the swamp habitat. This option would also require elaborate shoring to prevent loss of the existing pavement when excavating muskeg below the water level and is very high risk. Given the constructability issues associated with installing a shoring system, working in the swamp and staging traffic, option S1 is probably not a feasible option.

Option S2 allows construction of the highway at the proposed grade raise without any appreciable increase in the overall footprint across the swamp. If steel beam guard rails are incorporated into the design of the highway across the swamp, the steepened side slopes will not decrease the overall safety of traffic along the swamp crossing. In addition, the cost of this option would be considerably less than required for either of options S1 and S3. There is some potential however, that settlement will occur in isolated areas where the new toe of slope will coincide with the existing swamp treatment. This will result in some long term periodic maintenance to restore the sideslope which will, however, not adversely affect the performance of the pavement surface.

Option S3 provides an innovative solution to cross the swamp without having to extend the swamp treatment. The use of the reinforced geogrid mat might also assist in construction staging because the reinforced mat could be used to support traffic. The excavation of the sideslope and shoulder to the swamp level can be carried out off the mat as the construction progresses allowing construction traffic to use one of the traffic lanes for hauling purposes. This option however, is more time consuming than option S2 and more expensive.

Option S4 results in a substandard road geometry and section. Maintenance will continue to be required periodically as granular is lost into the rock fill.

Of the above options, S2 would be the preferred option because of the minimal impact on the swamp and the overall cost associated with option S3.

5.4.2 Pavement

Option P1 is more cost effective than either of options P2 and P3. The grade raise strategy used here is the same as that being proposed for the other fill areas in this contract. Construction staging is simplified because the existing pavement structure is left in place. As such, from a safety and constructability point of view, this option is better than either P2 or P3.

The biggest disadvantage is that this option does not address the problem of future loss of pavement granular material into the underlying rock fill which had contributed to at least some of the pavement distortions that require maintenance.

Options P2 and P3 are quite similar. P2 uses rock fill to construct the grade raise fill and Option P3 uses a coarse Granular B Type II. From a constructability point of view option P2 is slightly easier than P3 in that the rock fill construction of the raised embankment is probably faster than that using Granular B Type II. An embankment constructed with Granular B Type II requires thinner lift thickness and more rigorous compaction than rock fill. The Granular B Type II, however, will effectively chink the rock fill such that a geotextile is not required. Both of these options, eliminate the potential for future loss of pavement granular into the rock fill and therefore the maintenance costs are lower. Both options, however, also increase the safety hazard risk during construction in that near vertical cuts into the existing pavement structure in the order of 600 to 1200 mm are required.

Option P5, for the same reasons a Option S1 would not be considered feasible.

Based on the above, option P1 would be the preferred option. The increased maintenance costs associated with the repair of distortions caused by loss of granular into the rock fill do not appear, based on the performance of this section of highway to have been excessive.

5.5 Staging

Staging will require that traffic temporarily use at least a portion of the existing shoulders. The existing shoulders are constructed of sand and gravel. These shoulders should be suitable for carrying short term traffic acknowledging that some grading will be required.

5.6 Construction Considerations

5.6.1 Groundwater and Surface Water Control

Based on the water levels measured in the open boreholes and in the test pits any excavation into the swamp will require excavation below the water level. Pumping of this water to maintain a dry excavation would require high capacity pumps and, as such, construction techniques for working in the wet should be implemented, if muskeg excavation is necessary such as at the culvert extensions.

5.6.2 Excavations

Temporary excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities. The soils at the site are classified as Type 4 soils, according to the OHSA and excavations should be made with side slopes no steeper than 3 horizontal to 1 vertical from the base of the excavation.

5.6.3 Compaction Requirements

Adequate compaction of all granular and earth material is essential for an acceptable level of pavement performance. Compaction should be carried out in accordance with the procedures outlined in OPSS 501.

GOLDER ASSOCIATES LTD.

Terry J. Nicholas, P.Eng.
Principal



F.J. Heffernan, P. Eng.
MTO Designated Contact



TJN/FJH/cr

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TABLE 1
EVALUATION OF SIDESLOPE REMEDIATION OPTIONS
SWAMP CROSSING STATION 13+470 TO 13+700, HIGHWAY 60 TWP OF WILBERFORCE

Option	Description	Advantages	Disadvantages	Feasibility / Comparative Costs	Risks/Consequences
S1	Excavate peat to accommodate 2H:1V sideslope: <ul style="list-style-type: none">Extend the muskeg treatment on both sides or one side of the highway to provide support for proposed 2H:1 V shoulders.	<ul style="list-style-type: none">Provides proposed design shoulder configuration.	<ul style="list-style-type: none">Cannot be done without extensive shoring of road;Cannot stage construction;Negative impact on sensitive swamp habitat;Expensive compared to other options.	<ul style="list-style-type: none">Constructability is an issue;Not feasible;Most Expensive, Cost Prohibitive.	<ul style="list-style-type: none">High risk for loss of pavement/ highway closure.
S2	Use rock fill for sideslopes: <ul style="list-style-type: none">Remove existing sideslopes;Construct rock fill sideslopes at 1.25H:1V.	<ul style="list-style-type: none">Minimal impact on sensitive swamp habitat;Rock fill allows steeper sideslopes 1.25H:1V;Work can be easily staged;Most cost effective side slope treatment.	<ul style="list-style-type: none">Steep sideslopes increase safety hazard;Potential for future settlement of sideslopes because of poor lateral support swamp support;Occasional maintenance costs to reslope sideslopes will be required over long term.	<ul style="list-style-type: none">Feasible;Most cost effective of grade raise options.	<ul style="list-style-type: none">Some periodic long term maintenance of sideslope settlement / periodic maintenance costs to reshape sideslopes.
S3	Construct geogrid reinforced granular mat into swamp to support new shoulders and sideslopes: <ul style="list-style-type: none">Excavate shoulder granular and rock fill to top of swamp grade;Construct reinforced geogrid rock fill extending onto swamp;Provide Class II woven geotextile over reinforced geogrid matt;Provide Class II non-woven geotextile on near vertical cut at shoulder adjacent to traffic lane;Construct new shoulders to design standard using Granular B Type III and Granular A.	<ul style="list-style-type: none">No swamp excavation required;Provides proposed design sideslope configuration;Construction staging might be simplified because reinforced mat can be used for staging in the short term;Innovative solution to support shoulder and side slope allowing proposed design standard.	<ul style="list-style-type: none">Geogrid reinforced mat covers portion of swamp therefore some negative impact on sensitive swamp habitat;Not a standard treatment.	<ul style="list-style-type: none">FeasibleSignificant cost increase compared to Option S2.	<ul style="list-style-type: none">Some future subsidence of shoulder and side slope / maintenance costs increased.
S4	Do Nothing with Sideslopes	<ul style="list-style-type: none">No impact on sensitive swamp habitat;No change in existing settlement.	<ul style="list-style-type: none">Existing shoulders are sloughed;Substandard shoulder condition.	<ul style="list-style-type: none">FeasibleLeast cost of all Options.	<ul style="list-style-type: none">Substandard Highway/ Could lead to increased frequency of accidents.

TABLE 1 (cont'd)

EVALUATION OF PAVEMENT REMEDIATION OPTIONS

SWAMP CROSSING STATION 13+470 TO 13+700, HIGHWAY 60 TWP OF WILBERFORCE

Option	Description	Advantages	Disadvantages	Feasibility / Comparative Costs	Risks/Consequences
P1	Construct grade raise on top of existing platform, <ul style="list-style-type: none">• In-place process existing asphalt pavement to 250 mm depth;• Provide Class II non-woven geotextile on near vertical cut adjacent to shoulder or traffic lane;• Construct grade raise using Granular B Type III and Granular A;• Provide hot mix asphalt.	<ul style="list-style-type: none">• Construction staging simplified;• Makes use of existing pavement;• Pulverizing provides downward drainage.	<ul style="list-style-type: none">• Does not address concern of loss of pavement granular into rock fill.	<ul style="list-style-type: none">• Feasible;• Most cost effective of grade raise options.	<ul style="list-style-type: none">• Long term loss of existing pavement granular into rock fill / Uneven pavement surface, Maintenance costs to repair distortions and uneven pavement similar to normal maintenance based on past performance.
P2	Remove existing pavement to rock fill, grade raise using rock fill: <ul style="list-style-type: none">• Remove existing pavement to top of rock fill, (600 to 1,200 mm) depth;• Provide rock fill to bottom of base;• Provide Class II non-woven geotextile;• Provide Granular A;• Provide hot mix asphalt.	<ul style="list-style-type: none">• Future long term loss of pavement granular into rock fill is eliminated.	<ul style="list-style-type: none">• Construction staging is more difficult because of vertical cut adjacent to traffic lane;• Traffic hazard increased because of vertical cut adjacent to operating traffic lane;• Poor reuse of existing pavement material which is wasted;• Requires increased attention to safety during construction.	<ul style="list-style-type: none">• Feasible;• Significant increased cost compared to Option P1.	<ul style="list-style-type: none">• Traffic hazards increased during construction / Increased accident risk to contractor and public.
P3	Remove existing pavement to rock fill, grade raise using Granular B Type II: <ul style="list-style-type: none">• Remove existing pavement structure to rock fill, (600 to 1200 mm);• Provide Granular B Type II (150 mm minus) to underside of base;• Provide Granular A base;• Provide hot mix asphalt	<ul style="list-style-type: none">• Future long term loss of pavement granular into rock fill is eliminated.	<ul style="list-style-type: none">• Construction staging is more difficult because of vertical cut adjacent to traffic lane;• Traffic hazard increased because of vertical cut adjacent to operating traffic lane;• Poor reuse of existing pavement material which is wasted;• Requires increased attention to safety during construction;• Introduces another granular type into contract	<ul style="list-style-type: none">• Feasible;• Similar costs as Option P2.	<ul style="list-style-type: none">• Traffic hazards increased during construction / Increased accident risk to contractor and public.
P4	Do Nothing (Other than in-place process and pave)	<ul style="list-style-type: none">• No impact on sensitive swamp habitat.	<ul style="list-style-type: none">• Does not address concern of loss of pavement granular into rock fill;• Substandard geometry not corrected.	<ul style="list-style-type: none">• Feasible;• Least cost of all options.	<ul style="list-style-type: none">• Substandard Highway/ Could lead to increased frequency of accidents
P5	Excavate Organic Silt between Station 13+500 and 13+600	<ul style="list-style-type: none">• Eliminates potential for future long term settlement.	<ul style="list-style-type: none">• Cannot be done without extensive shoring of road;• Cannot stage construction;• Negative impact on sensitive swamp habitat;• Expensive compared to other options.	<ul style="list-style-type: none">• Not Feasible;• Cost prohibitive.	<ul style="list-style-type: none">• High risk for loss of pavement/ highway closure.

ABBREVIATIONS FOR BORING AND TEST DATA

Accep	Acceptable	Gry	Grey	Psty	Polystyrene
Agg	Aggregate	H	Heavy	Poss	Possible
Amor	Amorphous	Hi	Highly	PST	Prime and Surface Treated
Asph	Asphalt	HP	High Plasticity	Quant	Quantity
BR	Bedrock	HM	Hot Mix	Reinf	Reinforced
Blk	Black	Lt	Light	RSS	Remoulded Shear Strength
Bl	Blue	Liq	Liquid	RF	Rock Fill
BH	Borehole	WL	Liquid Limit	Sa	Sand
Bld (y)	Boulder (y)	Lo	Loam	Sat	Saturated
Blds	Boulders	L	Loose	SH	Shale
BU	Break Up	Mrl	Marl	St	Sensitivity
Br	Brown	Matl	Material	SSM	Select Subgrade Material
CF	Channel Face	Max	Maximum	Sh Rk	Shot Rock
Cl	Clay	MDD	Maximum Dry Density	Si (y)	Silt (y)
Co	Coarse	MWD	Maximum Wet Density	SI (y)	Slight (ly)
Cob	Cobbles	Med	Medium	SP	Slight Plasticity
Comp	Compact	MP	Medium Plasticity	Stn (y)	Stoney
Conc	Concrete	Mod	Moderate	DR	Relative Density
Contam	Contaminated	Mott	Mottled	Stks	Streaks
Cord	Corduroy	Mul	Mulch	Surf	Surface
Cr	Crushed	NFP	No Further Progress	Temp	Temperature
Dk	Dark	NFP (Blds)	No Further Progress (Boulders)	TH	Test Hole
Decomp	Decomposed	Num	Numerous	TP	Test Pit
D	Dense	OCC	Occasional	Topsoil	Trace
E	Earth	Wopt	Optimum Moisture Content	Trace	Undisturbed Shear Strength
Fib	Fibrous	Ora	Orange	Unrein	Unreinforced
w	Field Moisture Content	Org	Organic	Varv	Varved
F	Fine	Org M	Organic Matter	VF	Very Fine
Fr Wat	Free Water	Ob	Overburden	WT	Water Table
FB	Frost Boil	Pavt	Pavement	Weath	Weathered
FH	Frost Heave	Pedo	Pedological	W	With
Gran	Granular	Pen Mac	Penetration Macadam	Wd (y)	Wood (y)
Gr	Gravel (ly)	Wp	Plastic Limit	Yel	Yellow
Grn	Green	Ip	Plasticity Index		

ONTARIO PROVINCIAL STANDARD DRAWING		Date	1986 07 18	Rev
<h2>ABBREVIATIONS</h2> <h3>GEOTECHNICAL</h3>		Date		
		<div>OPSD - 100.06</div>		

SUSCEPTIBILITY TO FROST HEAVING

HSFH - High
MSFH - Medium
LSFH - Low

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering

Faintly Weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very thickly bedded	>2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	<6 mm

JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	>3 m
Wide	1 – 3 m
Moderately close	0.3 – 1 m
Close	50 – 300 mm
Very close	<50 mm

GRAIN SIZE

<u>Term</u>	<u>Size*</u>
Very Coarse Grained	>60 mm
Coarse Grained	2 – 60 mm
Medium Grained	60 microns - 2mm
Fine Grained	2 – 60 microns
Very Fine Grained	<2 microns

Note: *Grains >60 microns diameter are visible to the naked eye.

O:\ Templates\Rock Description Terminology

CORE CONDITION

Total Core Recovery

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

B -	Bedding	Ca-	Calcite
FO-	Foliation/Schistosity	P-	Polished
CL -	Cleavage	S-	Slickensided
SH -	Shear Plane/Zone	SM-	Smooth
VN-	Vein	R-	Ridged/Rough
F -	Fault	ST-	Stepped
CO-	Contact	PL-	Planar
J -	Joint	FL-	Flexured
FR-	Fracture	UE-	Uneven
MF -	Mechanical	W-	Wavy
A-	Angular	C-	Curved
BP-	Bedding Plane	H-	Hackly
BL-	Blast Induced	SL-	Sludge Coated
	Parallel To	TCA-	To Core Axis
	Perpendicular To	STR-	Stress Induced

PROJECT 04-1120-169-6000			RECORD OF BOREHOLE No 04-1			1 OF 1			METRIC									
W.P. 263-98-00			LOCATION STA. 13+500, 3.6 m RI			ORIGINATED BY D.J.S.												
DIST HWY 60			BOREHOLE TYPE Power Auger 108mm I.D. Hollow Stem Auger			COMPILED BY T.J.N.												
DATUM Geodetic			DATE Oct. 6, 2004			CHECKED BY T.J.N.												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X REMOULDED					W _p W W _L			γ	GR SA SI CL	
178.7 0.0	GROUND SURFACE Sand and gravel (SHOULDER GRANULARS) Brown							20 40 60 80 100										
178.1 0.6	ROCKFILL with sandy silt infilling Dark brown and grey Wet						178											
			1	RC	DD		177											
			2	SS	DD		176											
175.7 3.1	Silty sand, trace gravel and organic matter (FILL) Very loose to compact Brown Wet		3	RC	DD		175											
			4	SS	WH		174											
			5	SS	11		173											
			6	SS	7		172											
			7	SS	2		171											
172.6 6.1	Clayey SILT and Sandy SILT with occ silty sand seam Very loose to loose Grey Wet		8	SS	6													
			9	SS	5													
			10	SS	2													
			11	SS	2													
170.0 8.7	End of Borehole Note: Water level in open hole at 2.44m depth below ground surface upon completion of drilling.																	

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PROJECT <u>04-1120-169-6000</u>		RECORD OF BOREHOLE No 04-2		1 OF 1	METRIC
W.P. <u>263-98-00</u>	LOCATION <u>STA. 13+600, 3.6 m Rt</u>	ORIGINATED BY <u>D.J.S.</u>			
DIST <u> </u> HWY <u>60</u>	BOREHOLE TYPE <u>Power Auger 108mm I.D. Hollow Stem Auger</u>	COMPILED BY <u>T.J.N.</u>			
DATUM <u>Geodetic</u>	DATE <u>Oct. 7, 2004</u>	CHECKED BY <u>T.J.N.</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x REMOULDED						
178.6	GROUND SURFACE													
0.0	Sand and gravel (SHOULDER GRANULARS) Brown													
178.0	ROCKFILL with some sand and gravel infilling Moist													
0.6														
176.6			1	SS	17									
2.0	Fine to coarse SAND, some silt, trace gravel (FILL) Very loose to loose Brown		2	SS	2									
			3	SS	4									
			4	SS	4									
			5	SS	2									
			6	SS	3									
			7	SS	1									
171.4	PEAT, MARL and SAND		8	SS	3									
171.1	Clayey SILT and Sandy SILT, occasional silty clay seam Very loose Grey		9	SS	WH									
7.5			10	SS	2									
169.8	End of Borehole													
8.8	Note: Water level in open hole at 2.38 m depth below ground surface upon completion of drilling.													

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PROJECT		04-1120-169-6000		RECORD OF BOREHOLE No 04-3		1 OF 1		METRIC	
W.P.		263-98-00		LOCATION		STA. 13+675, 3.6 m Rt		ORIGINATED BY	
DIST		HWY 60		BOREHOLE TYPE		Power Auger 108mm I.D. Hollow Stem Auger		COMPILED BY	
DATUM		Geodetic		DATE		Oct. 7, 2004		CHECKED BY	
ELEV		DEPTH		SOIL PROFILE		SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT	
				STRAT PLOT		NUMBER		SHEAR STRENGTH kPa	
				TYPE		'N' VALUES		20 40 60 80 100	
				GROUND WATER CONDITIONS		ELEVATION SCALE		20 40 60 80 100	
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	
								W _p W W _L	
								WATER CONTENT (%)	
								25 50 75	
								UNIT WEIGHT	
								γ	
								kN/m ³	
								REMARKS & GRAIN SIZE DISTRIBUTION (%)	
								GR SA SI CL	
179.5	0.0	GROUND SURFACE							
		Sand and gravel (SHOULDER GRANULARS)							
		Brown Moist							
178.6	0.9	ROCKFILL with sand and gravel infilling		1	SS	>50			
		Brown Moist to wet							
				2	SS	14			
				3	SS	>50			
				4	SS	13			
176.0	3.5	Sandy silt, some gravel (FILL)							
		Loose							
175.5	4.0	Dark brown Wet		5	SS	2			
		Silty sand, some gravel (FILL)							
		Very loose to loose							
		Brown		6	SS	WH			
				7	SS	5			
173.9	5.6	Silty sand, trace gravel, scattered trace peat and fine roots (FILL)							
		Loose							
		Brown		8	SS	5			
		Wet		9	SS	5			
172.0	7.7	Organic Clayey SILT							
		Brown							
		Wet		10	SS	2			
171.3	8.2	Fine to medium SAND							
		Very loose							
		Grey							
		Wet							
		End of Borehole							
		Note:							
		Water level in open hole at 3.30 m depth below ground surface upon completion of drilling.							

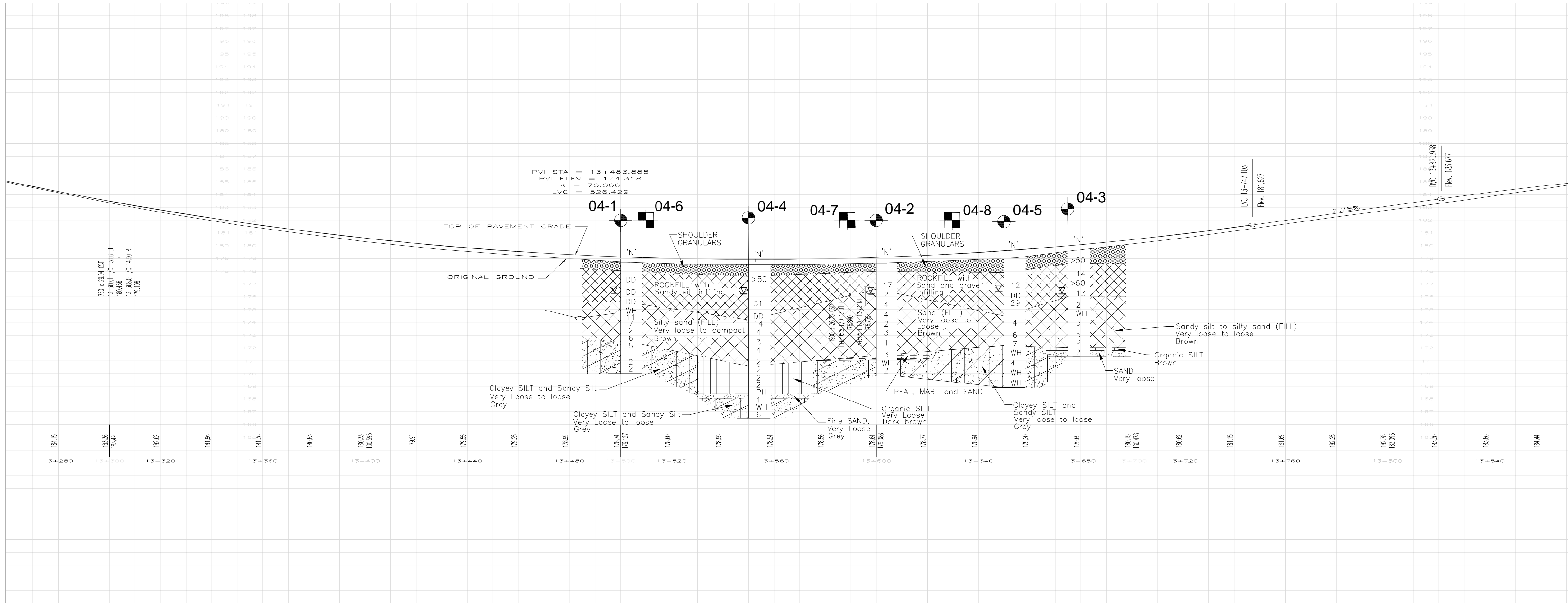
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PROJECT 04-1120-169-6000		RECORD OF BOREHOLE No 04-4		1 OF 1		METRIC												
W.P. 263-98-00		LOCATION STA. 13+550, 3.6 m Rt		ORIGINATED BY D.J.S.														
DIST _____ HWY 60		BOREHOLE TYPE Power Auger 108mm I.D. Hollow Stem Auger		COMPILED BY T.J.N.														
DATUM Geodetic		DATE Oct. 8-12, 2004		CHECKED BY T.J.N.														
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X REMOULDED			WATER CONTENT (%) W _p — W — W _L			UNIT WEIGHT γ	GR SA SI CL			
178.8 0.0	GROUND SURFACE Sand and gravel (SHOULDER GRANULARS) Brown						178											
177.6 1.2	ROCKFILL with sand and gravel infilling Wet		1	SS	>50		177											
			2	SS	31		176											
			3	RC	DD		175											
174.2 4.6	Fine to coarse sand, some silt, trace gravel (FILL) Loose to compact Brown Wet		4	SS	14		174											
			5	SS	4		173											
172.7 6.1	Silty sand, trace gravel (FILL) Very loose Brown Wet		6	SS	3		172											
			7	SS	4		171											
			8	SS	2		170											
170.6 8.2	Organic SILT Very loose Dark brown Wet		9	SS	2		169											
			10	SS	2		168											
			11	SS	2		167											
168.4 10.7	Fine SAND, trace silt Very loose Grey Wet Clayey SILT and Sandy SILT, occ. fine sand layer with depth Very loose Grey Wet		12	TO	PH													
			13	SS	1													
			14	SS	WH													
			15	SS	6													
166.5 12.3	End of Borehole Note: Water level in open hole at 2.6 m depth below ground surface upon completion of drilling.																	

MISS_MTO 041120169-6000.GPJ ON MOT.GDT 23/11/04

PROJECT 04-1120-169-6000				RECORD OF BOREHOLE No 04-5				1 OF 1		METRIC					
W.P. 263-98-00				LOCATION STA. 13+650, 3.6 m Rt				ORIGINATED BY D.J.S.							
DIST HWY 60				BOREHOLE TYPE Power Auger 108mm I.D. Hollow Stem Auger				COMPILED BY T.J.N.							
DATUM Geodetic				DATE Oct. 13, 2004				CHECKED BY T.J.N.							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED							
178.5	GROUND SURFACE														
0.0	Sand and gravel (SHOULDER GRANULARS) Brown														
177.9	ROCKFILL with some sand and gravel infilling														
0.6			1	SS	12										
			2	RC	DD										
			3	SS	29										
174.5															
4.0	Silty sand, with gravel and dark brown organic matter (FILL) Loose Brown		4	SS	4										
			5	SS	6										
			6	SS	7										
172.3															
6.3	Layered Clayey SILT and Sandy SILT with occ. fine to coarse sand seams and layer Very loose to loose Grey Wet		7	SS	WH										
			8	SS	4										
			9	SS	WH										
			10	SS	WH										
168.9															
9.6	End of Borehole Note: Water level in open hole at 2.1 m depth below ground surface upon completion of drilling.														

MISS_MTO_041120169-6000.GPJ ON MOT.GDT 23/11/04.

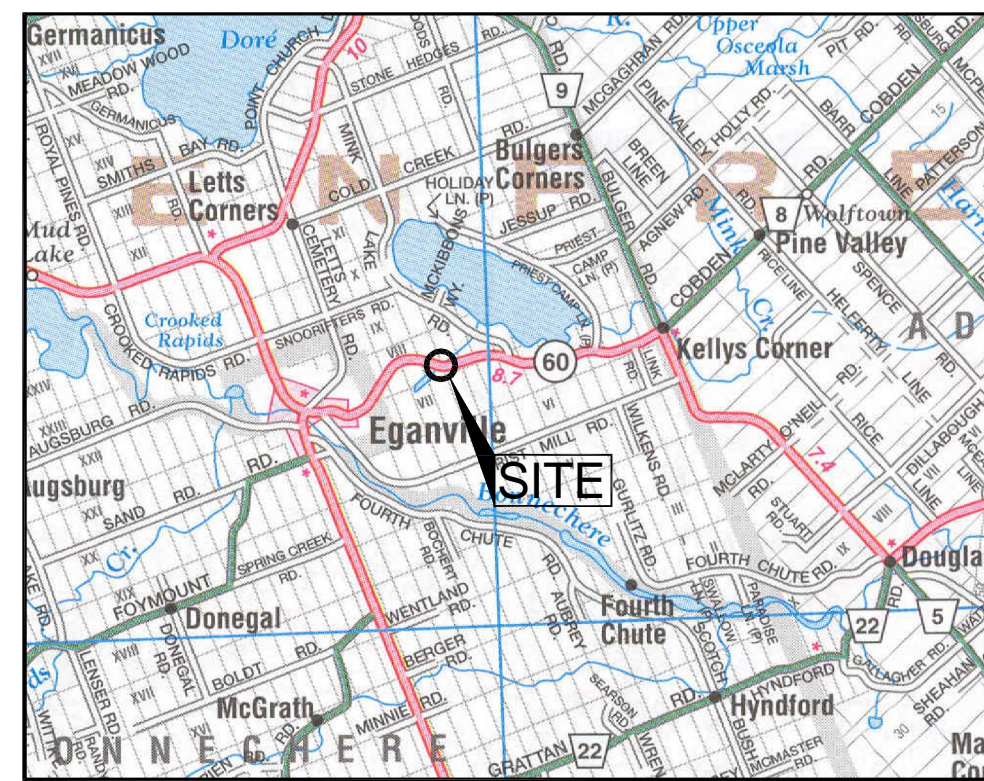


CONT No.
WP No. 263-98-00

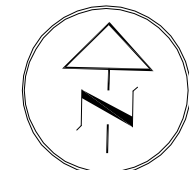
SWAMP CROSSING — HWY 60
BOREHOLE LOCATIONS &
SOIL STRATA



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN



LEGEND

- Borehole
- Seal
- Piezometer
- N Standard Penetration Test value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL upon completion of drilling

No.	ELEVATION	LOCATION	
		NORTHING	EASTING
04-1	178.7	5045472.95	260840.10
04-2	178.6	5045461.37	260939.43
04-3	179.5	5045452.85	260013.94
04-4	178.8	5045473.92	260890.54
04-5	178.5	5045462.66	260989.90
04-6	178.7	5045479.33	260850.97
04-7	178.7	5045471.61	260919.28
04-8	178.6	5045457.58	260969.51

NOTES

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

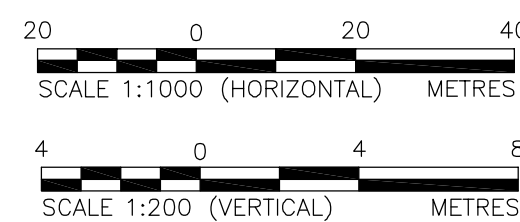
The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

For subsurface information only.

Base plan provided in electronic format by Morrison Hershfield Limited

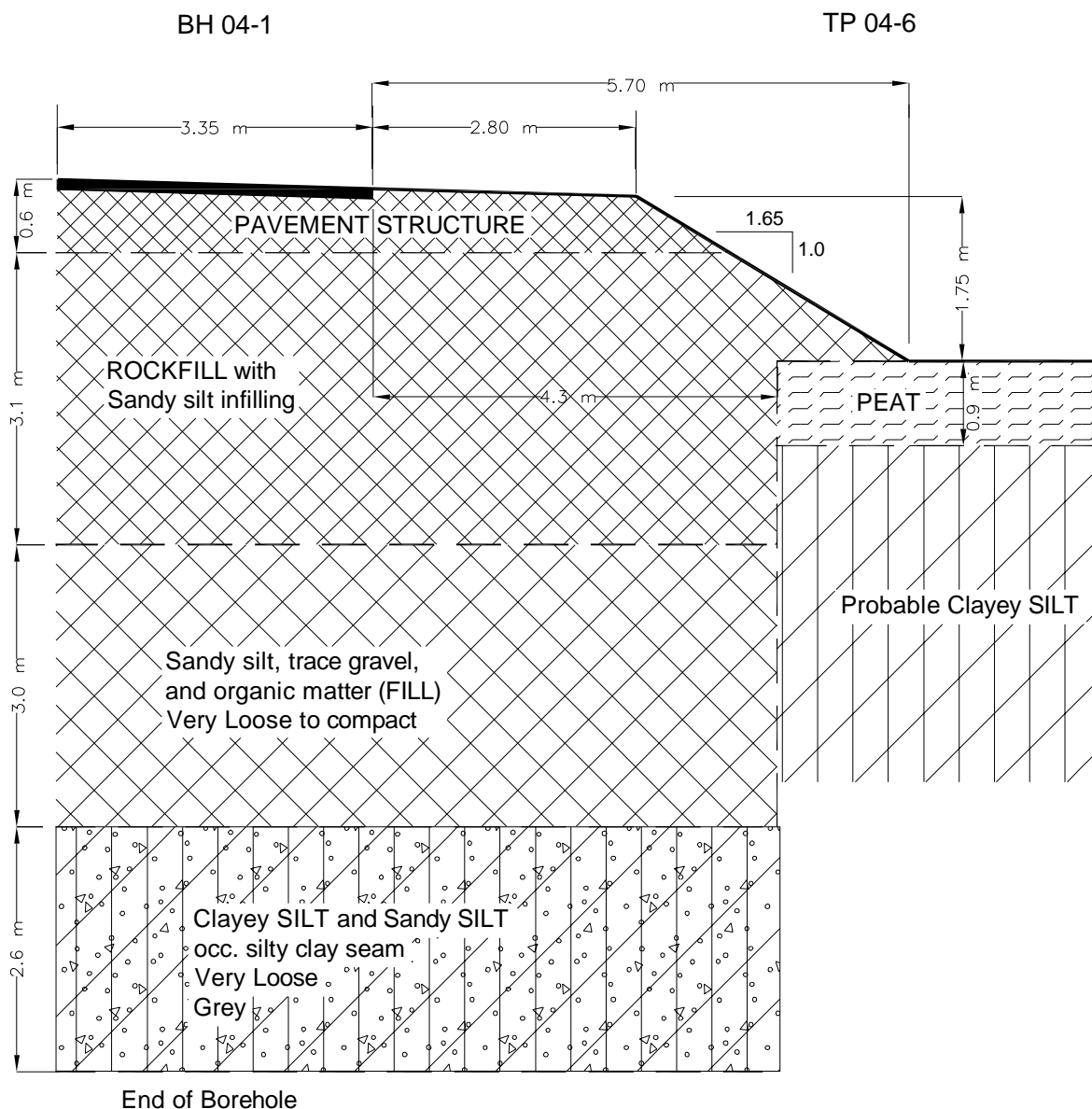
METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



NO.	DATE	BY	REVISION
Geocres No.			
HWY. 60		PROJECT NO. 04-1120-169-6000	DIST.
SUBM'D.	CHKD. T.J.N.	DATE: November 2004	SITE:
DRAWN: S.L.	CHKD.	APPD.	DWG. 1

Drawing file: 041120169-6000-TPSECT.dwg Jan 06, 2005 - 9:37am



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CADD S.L.

TITLE

SCHEMATIC SECTION STATION 13+510

FILE No. 041120169-6000-TP6

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PROJECT No. 04-1120-169 REV.

REVIEW

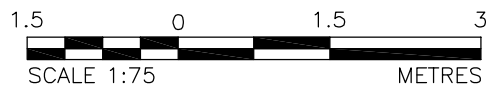
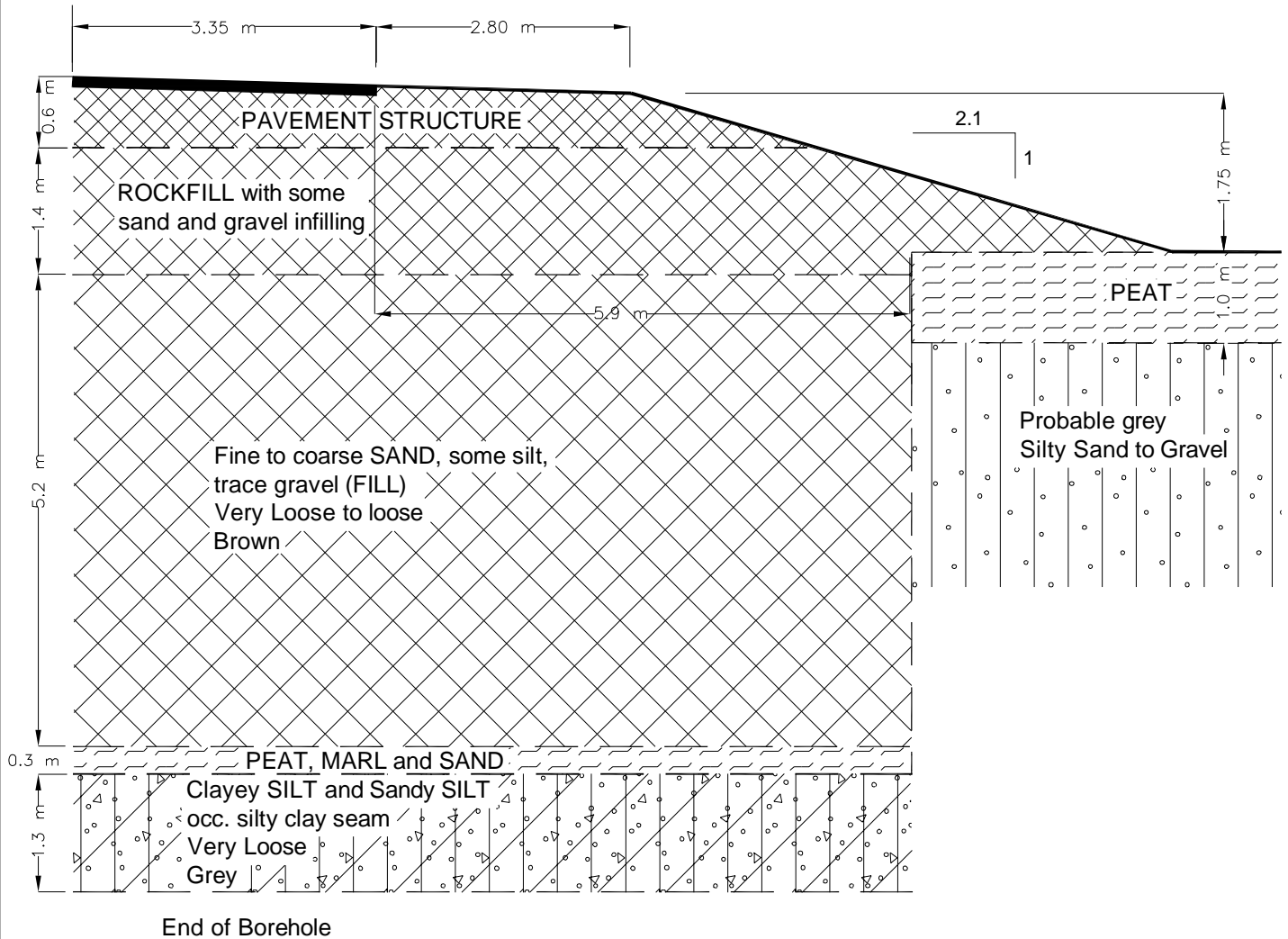
SWAMP CROSSING - HWY 60

FIGURE

1

BH 04-2

TP 04-7



SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT



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DATE NOV. 2004
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TITLE

SCHEMATIC SECTION STATION 13+580

FILE No. 041120169-6000-TPSECT

PROJECT No. 04-1120-169 REV.

CHECK

REVIEW

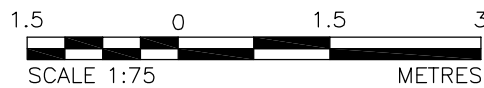
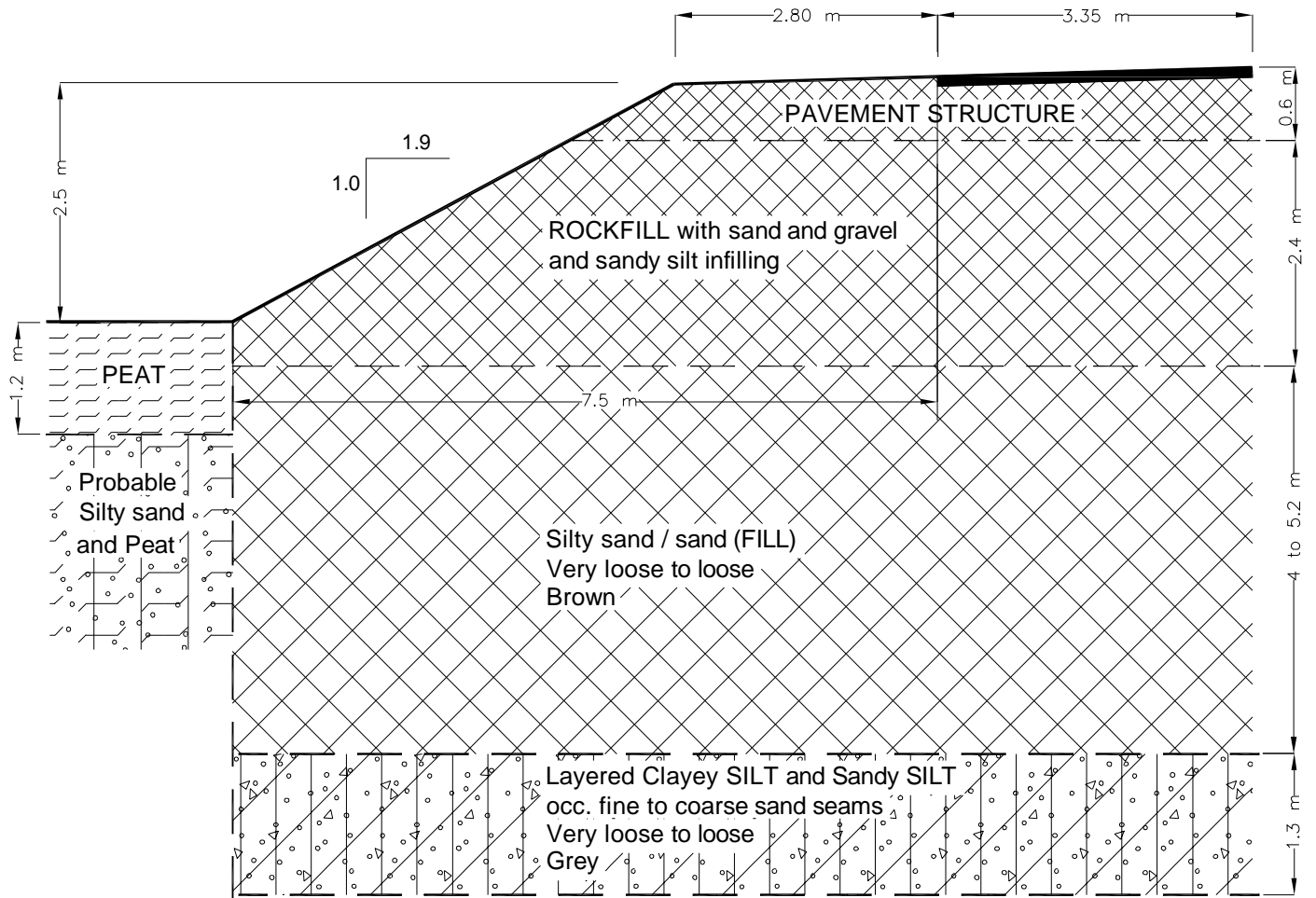
SWAMP CROSSING - HWY 60

FIGURE

2

TP 04-8

BH 04-2 AND BH 04-5



SPECIAL NOTE
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WITH ACCOMPANYING REPORT



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DATE	NOV. 2004
DESIGN	T.J.N.
CADD	S.L.
CHECK	
REVIEW	

TITLE

SCHEMATIC SECTION STATION 13+630

FILE No. 041120169-6000-TPSECT

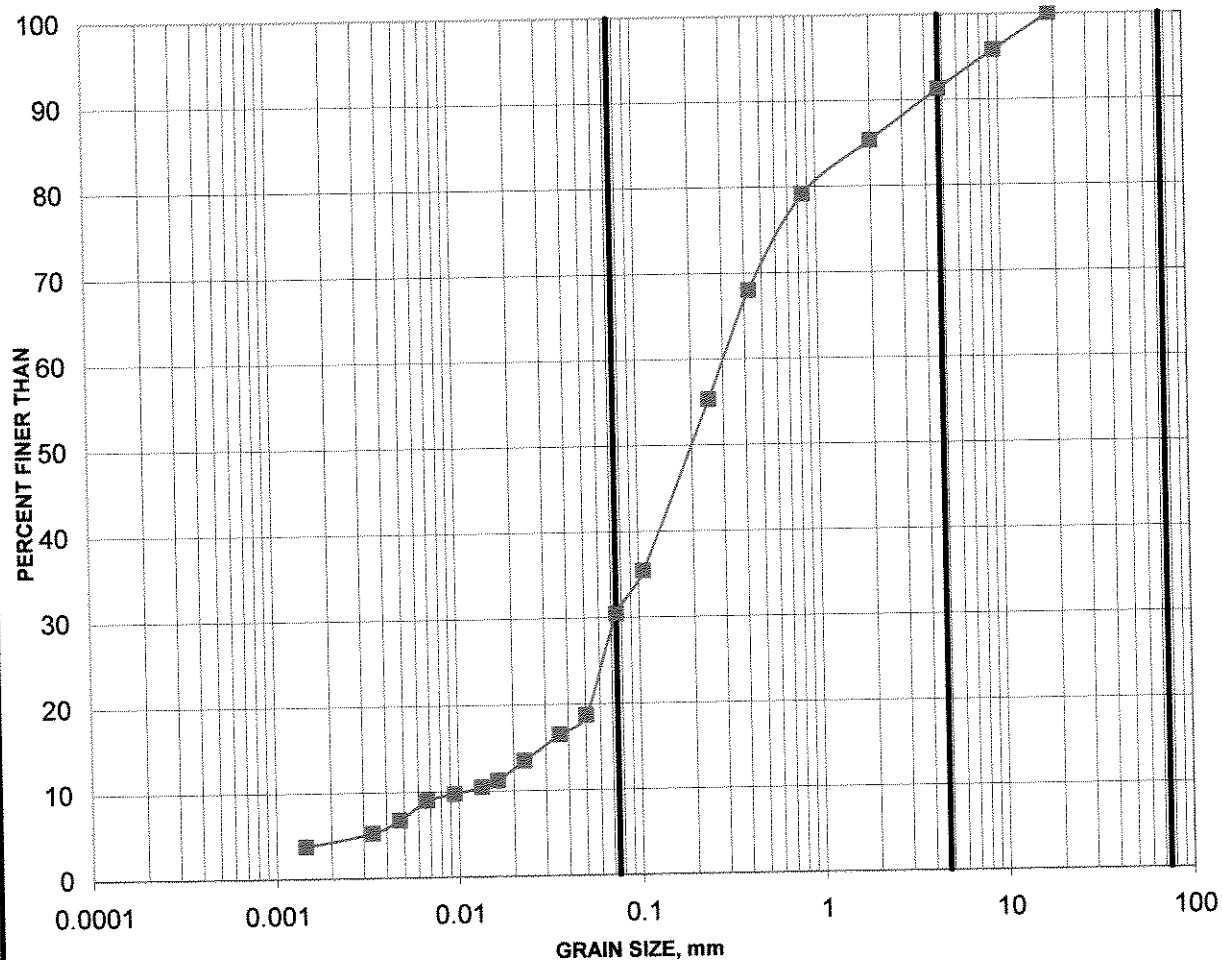
PROJECT No. 04-1120-169 REV.

SWAMP CROSSING - HWY 60

FIGURE

3

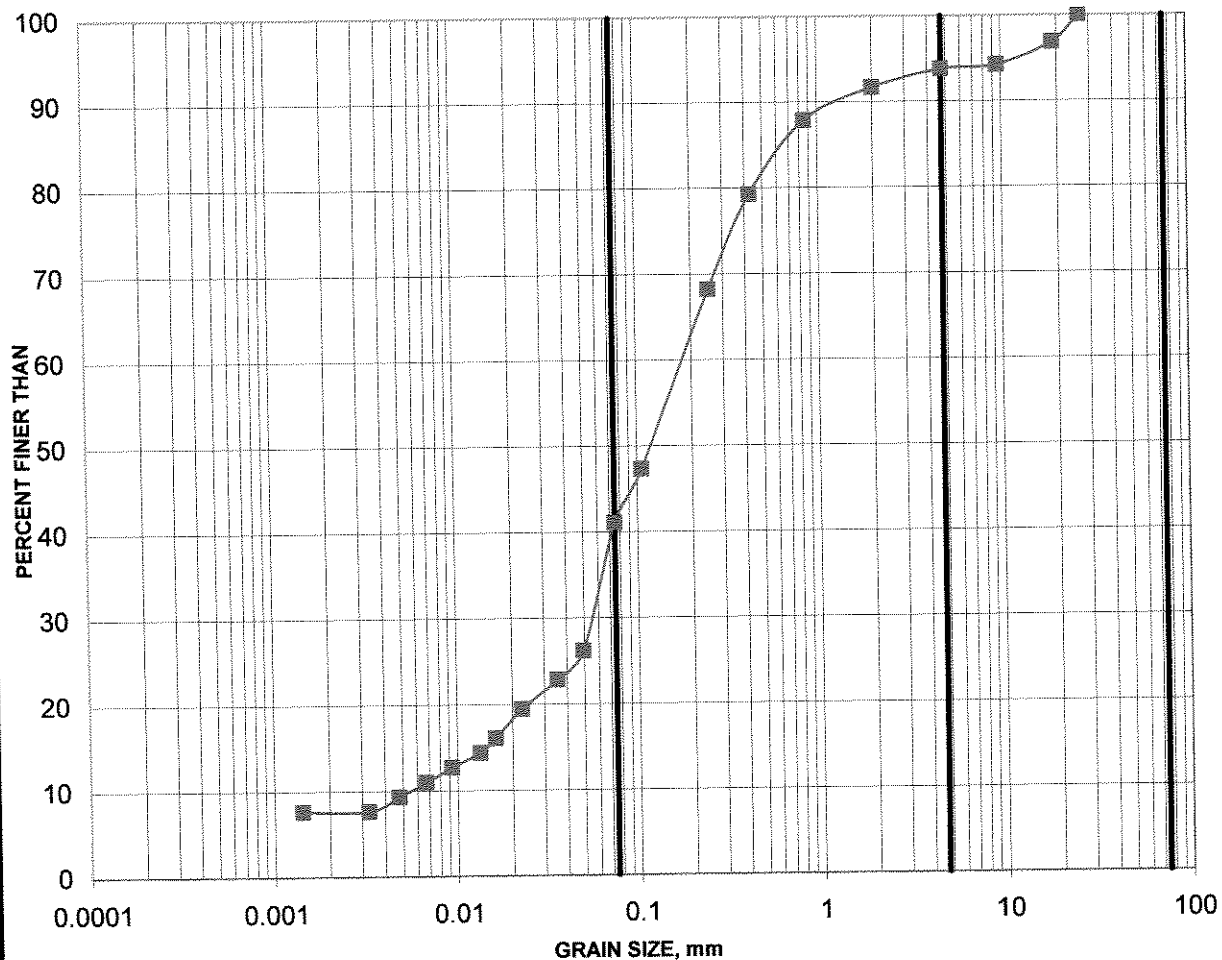
SILTY SAND TRACE GRAVEL
(FILL)



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
04-3	6	4.6-5.2

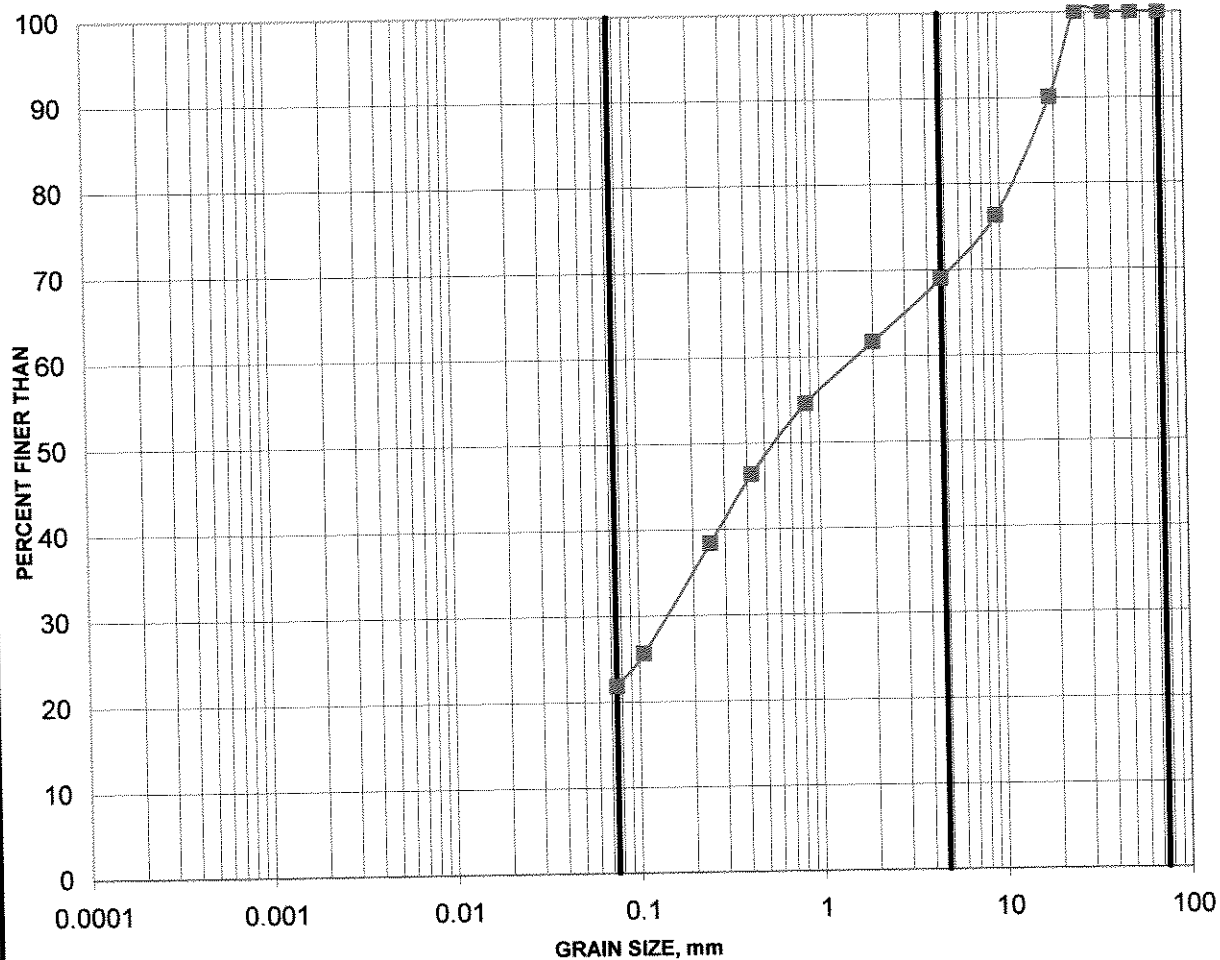
**SILTY SAND TRACE GRAVEL
(FILL)**



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
—■— 04-1	6	4.6-5.2

SILTY SAND AND GRAVEL (FILL)



SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
04-5	5	5.2-5.8

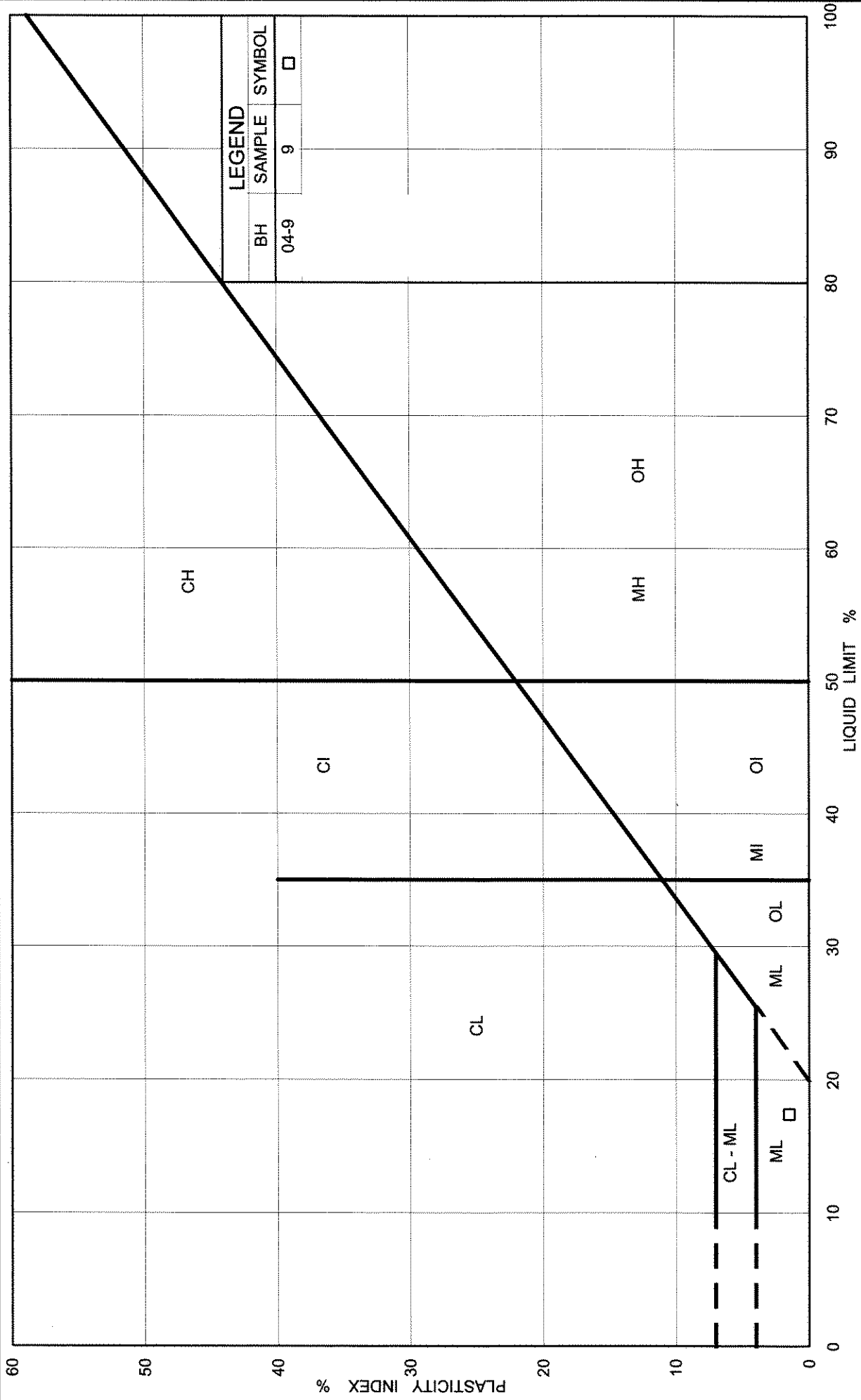
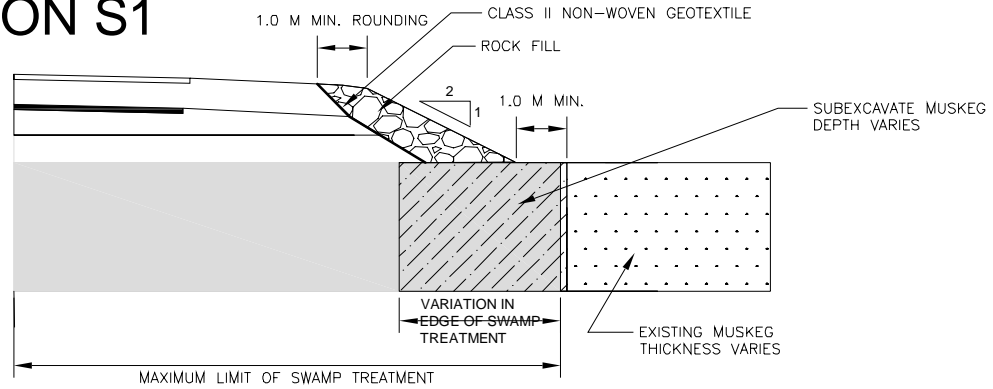


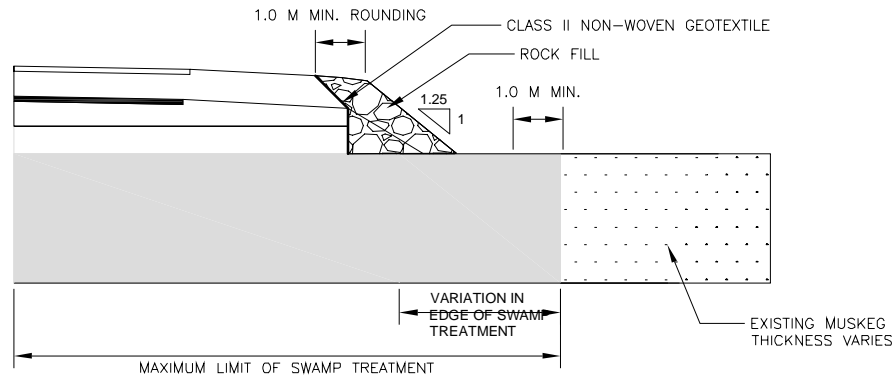
FIG No. 7

PLASTICITY CHART
SILTY CLAY AND CLAYEY SILT

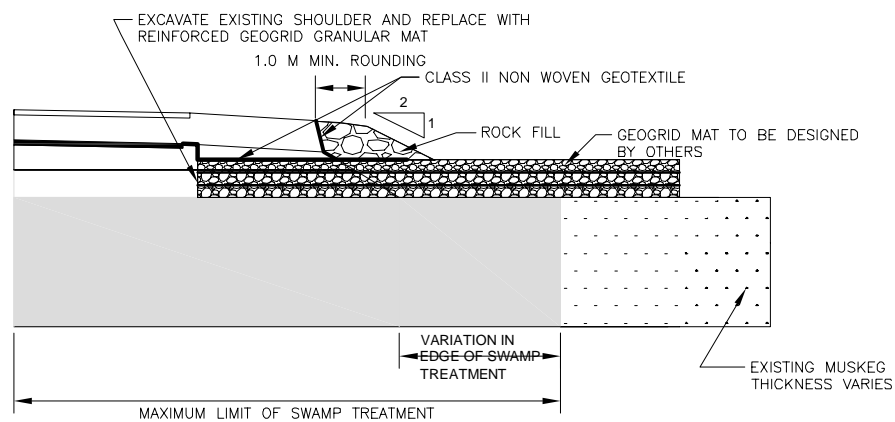
OPTION S1



OPTION S2



OPTION S3



SCALE 1:150
DATE NOV. 2004
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CADD S.L.

TITLE

**SHOULDER / SIDESLOPE OPTIONS
SWAMP STATION 13+470 TO 13+700**

FILE No. 041120169-8000-08.dwg

PROJECT No. 04-1120-169

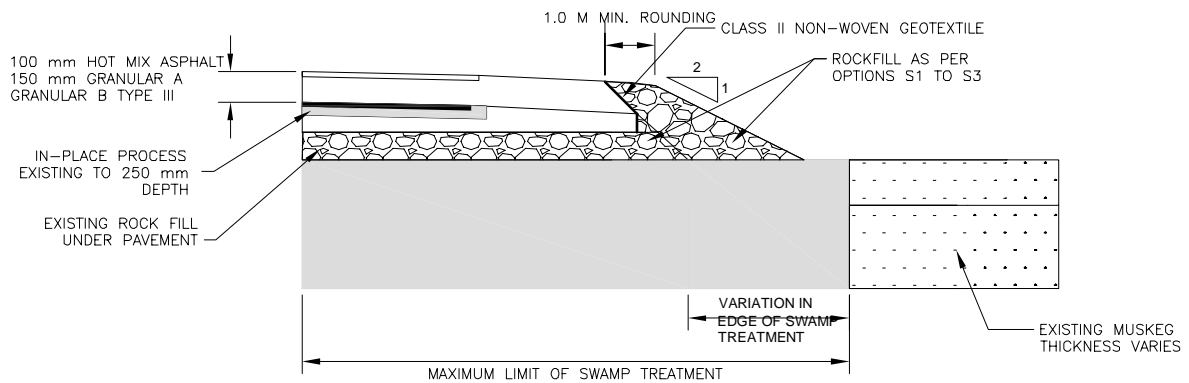
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REVIEW

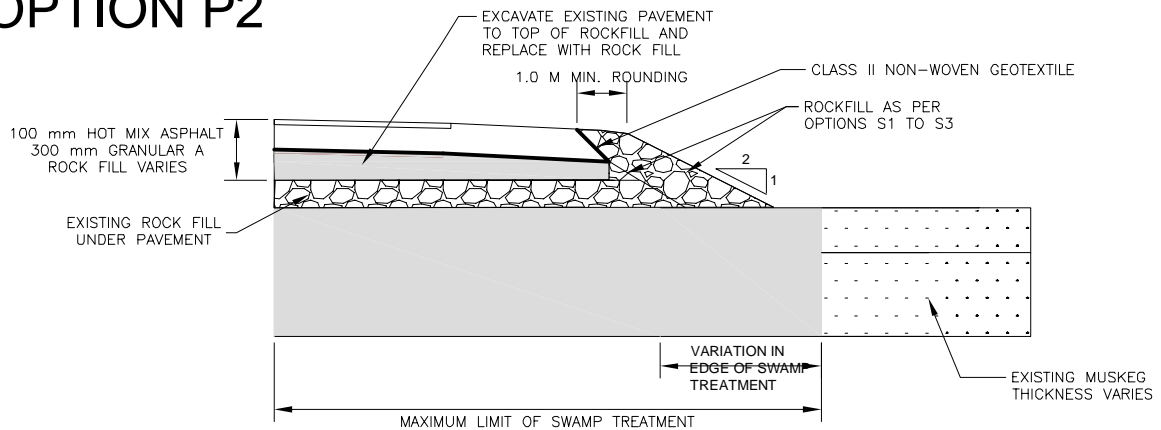
FIGURE

8

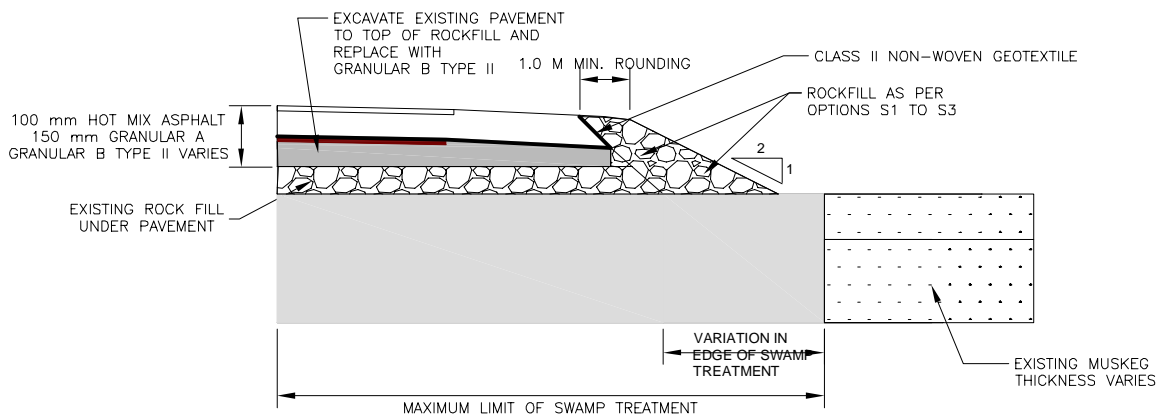
OPTION P1



OPTION P2



OPTION P3



SCALE 1:150
DATE NOV. 2004
DESIGN T.J.N.
CADD S.L.

TITLE

PAVEMENT OPTIONS SWAMP STATION 13+470 TO 13+700

FILE No. 041120169-8000-09.dwg

CHECK

PROJECT No. 04-1120-169

REV.

REVIEW

FIGURE

9

APPENDIX A

CONTRACT 75-18 SWAMP TREATMENT DETAIL

CONT. No. 75-18
W. P. No. 265-63-02

SHEET
22

