GEOCRES No:
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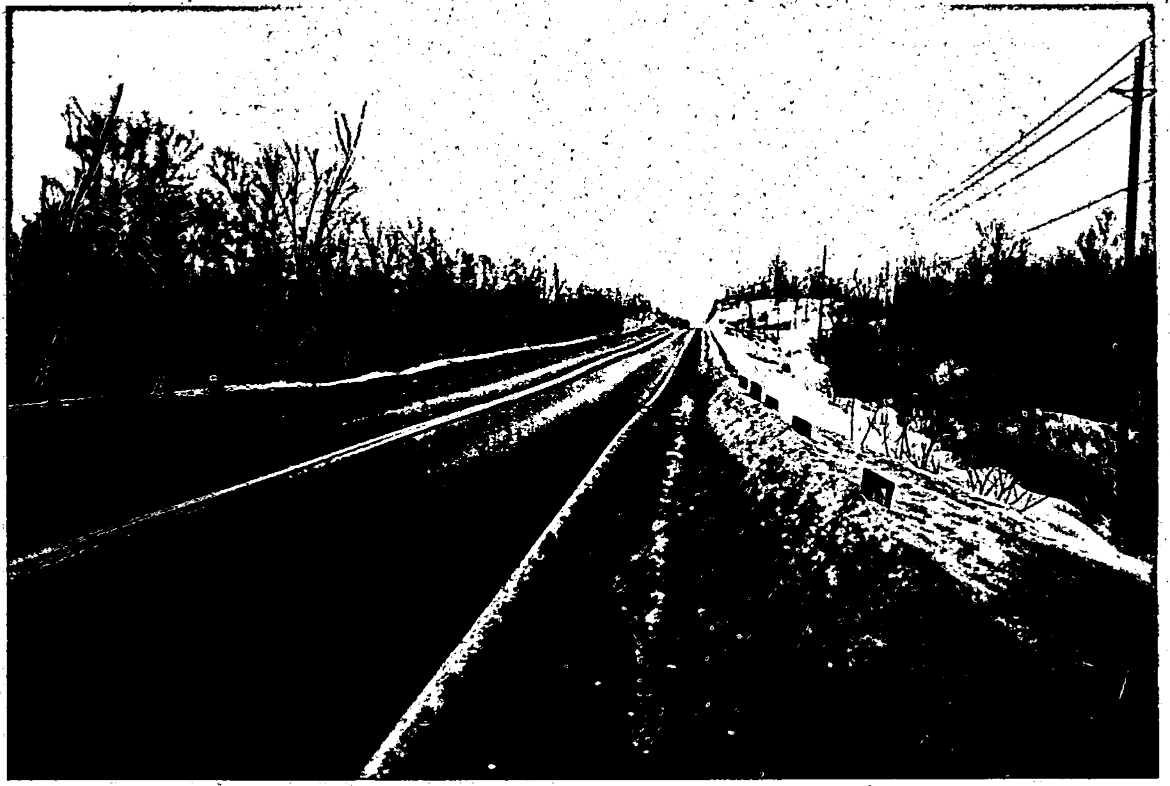
STANLEY CONSULTING GROUP LIMITED

DRAFT FOUNDATION REPORT

W.P. 48-83-01
FILL EMBANKMENT IN SETTLEMENT AREAS
HIGHWAY 15 (NORTH OF PORTLAND)

STA. 22+590 TO STA. 22+630, TOWNSHIP OF BASTARD
STA. 22+800 TO STA. 22+950, TOWNSHIP OF BASTARD
STA. 10+200 TO STA. 10+400, TOWNSHIP OF SOUTH ELMSLEY

DISTRICT 41, KINGSTON
MINISTRY OF TRANSPORTATION ONTARIO



PROJECT NO. 11108

DRAFT FOUNDATION REPORT

TO

STANLEY CONSULTING GROUP LIMITED

ON

W.P. 48-83-01
FILL EMBANKMENT IN SETTLEMENT AREAS
HIGHWAY 15 (NORTH OF PORTLAND)

STA. 22+590 TO Sta. 22+630, TOWNSHIP OF BASTARD
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DISTRICT 41, KINGSTON
MINISTRY OF TRANSPORTATION ONTARIO

Jacques Whitford Limited
2781 Lancaster Road, Suite 200
Ottawa, ON K1B 1A7
Tel:(613)738-0708
Fax:(613)738-0721

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District 41, Kingston

1.0 INTRODUCTION

This report presents the results of a foundation investigation carried out for the fill embankment settlement area problems encountered along Highway 15, north of Portland, Ontario.

The work was carried out under Agreement No. 9740-7411-4242 and in general accordance with our proposal dated January 29, 1999. Authorization to proceed was provided by Mr. Brian Rogers, P.Eng., of Stanley Consulting Group Limited (Stanley).

This report contains the factual information obtained from this investigation as well as discussion and recommendations pertaining to the subsurface conditions, embankment foundation soils and related earthworks.

embankment design

2.0 SITE DESCRIPTION AND GEOLOGY

The project site is located on Highway 15 within the townships of Bastard and South Elmsley. Two of the three investigation locations are located at Station 22+590 to Station 22+630 and at Station 22+800 to Station 22+950 in the Township of Bastard. The third investigation location is on the east side of Otter Lake between the towns of Portland and Lombardy, Ontario within the Township of South Elmsley between Station 10+200 and Station 10+400. The site location is shown on the Key Plan portion of Drawing No. 11108-FE1 in Appendix 2.

This area is in the physiographic region identified by Chapman and Putnam (1984) as the Smith Falls Limestone Plain where overburden generally consists of sandy soils over bedrock (MTO PDR Report, October 1997). Soils are generally thin with the exception of a few small areas of deep deposits. Bedrock underlying the site generally consists of grey limestone, magnesium limestone, blue-grey dolostone and some calcareous sandstone.

2.1 Station 22+590 to 22+630 and Station 22+800 to 22+950, Township of Bastard

The roadway at the site between Station 22+590 and Station 22+630 and between Station 22+800 and Station 22+950 in the Township of Bastard is constructed as a fill with a maximum height of approximately 1.8 m and 1.0 m, respectively within these two poor performing areas. Boreholes from previous investigations indicate peat on either side of the roadway, and organics below the roadway as well as the presence of a layer of buried asphalt. Acquisition of additional field information was deemed warranted at these two poor performing locations in order to provide dig out recommendations if required.

2.2 Station 10+200 to 10+400, Township of South Elmsley

The roadway at the site between Station 10+200 and Station 10+400 in the Township of South Elmsley is a previously reported poor performing area. The roadway is constructed as a fill with the grade rising from the south end adjacent to Otter Lake, to a rock cut at the north end. The maximum height of fill is approximately 4.3 m. Offset boreholes from previous investigations indicate variable conditions within this section from bedrock to peat. Boreholes in the roadway reportedly indicate very thick asphalt (up to 1.4 m) in some locations, two layers of asphalt in other locations, sandy earth borrow and rock fill subgrade. Surface distress includes a bump over the culvert at 10+210 and a dip at approximate Station 10+240. A patch is present from 10+203 to 10+475.

A previously identified poor performing area (PPA) by the MTO in a Pavement Design Report (PDR) dated 1997 within the investigated area reported that the cause of the dip at 10+240 and past patching within this section of highway may be due to settlement of organics underlying the roadway therefore warranting the present investigation. Additional discussion on site with Messrs Ted Phillips and Dave Stinson of the MTO Eastern Region Geotechnical Group on January 21, 1999 concluded that bump at culvert was likely due to minimal culvert cover and the transition between the culvert founded on bedrock and sandy earth borrow.

The existing highway embankment slopes are covered with large pieces of shot rock fill. Short and tall grasses in wet marshy areas were partially visible at the bottom of the roadway embankment fill slope as the ground surface was covered with snow and ice at the time of this investigation. The existing highway section including the riding surface and shoulders within the problem area is approximately 10 m wide.

It is noted that an overhead hydro electric pole line is present along the toe of the embankment slope on the right (east) side of Highway 15. A CNR railway embankment is present further to the east.

Drainage in the immediate area is provided by a cross culvert near Station 10+200 which directs water towards Otter Lake to the west of Highway 15.

3.0 INVESTIGATION PROCEDURES

3.1 Field Program

The field work for this investigation was carried out between February 23 and March 5, 1999. The subsurface conditions were investigated through a borehole drilling investigation and laboratory testing. A total of eleven (11) boreholes numbered 99-1 to 99-11, were advanced in the poor performing area between Station 10+200 and Station 10+400, Township of South Elmsley to depths ranging from 3.7 to 16.8 m below the existing ground surface. Five boreholes (99-1 to 99-5) were drilled in the roadway embankment while the other six boreholes (99-6 to 99-11) were drilled at the bottom of the roadway embankment fill. In addition, one borehole was drilled in each of the other two reported poor performing areas. Borehole 99-12 was drilled between Station 22+590 and 22+630, Township of Bastard while Borehole 99-13 was drilled between Station 22+800 and 22+950, Township of Bastard.

All boreholes were drilled using a CME 55 power auger drill suitably equipped for soil and bedrock sampling. Hollow stem auger equipment was used to advance the boreholes in the overburden. Wash-bore casing technique was used to advance Borehole 99-4 as cobbles and boulders were encountered which could not be displaced by the augers. Subsoil samples were generally retrieved at 0.75 m intervals by a split spoon sampler in both cohesionless and cohesive soils in accordance with the Standard Penetration Test (ASTM D1586). The sampling program was modified for the boreholes drilled at the toe of the roadway embankment slope to establish the thickness of the organic layer within the muskeg areas to a firm stratum. The SPT carried out with the drilling equipment was performed using a standard 64 kg hammer with a 760 mm drop. Shear vane testing and pocket penetrometer testing was carried out in the cohesive deposits, where encountered, in order to estimate the undrained shear strength of the cohesive material. Further advancement of one borehole (99-7) was performed using a steel cone placed at the bottom of drilling rods to probe down to a firm stratum. Bedrock was inferred within four of the boreholes drilled for this investigation.

The subsurface conditions are described in detail in the Borehole Records presented in Appendix 1. All soil and bedrock samples recovered were identified in the field, stored in moisture proof containers and were returned to our laboratory for detailed classification and testing.

Groundwater levels were recorded in the open boreholes throughout the duration of the investigation. Prior to completing the investigation, the boreholes were backfilled.

Borehole locations were established in the field by Jacques Whitford personnel at station locations which would adequately identify limits to the anticipated organic/muskeg areas, relative to the existing chainages painted on the Highway 15 centreline. The ground surface elevations at the borehole locations were referenced to the top of the existing Highway centreline at Station 10+275, Township of South Elemsley. A temporary Geodetic datum of elevation 128.14 m was used in the field when surveying the borehole elevations. A base plan drawing showing the roadway and embankment plan with metric chainages was provided by Stanley in order to establish the location of each borehole.

3.2 Laboratory Testing

All samples returned to the laboratory were subjected to detailed visual classification by a geotechnical engineer. Selected samples were tested for moisture content, Atterberg Limits and grain size distribution testing including hydrometer analysis. All soil samples will be stored for a period of twelve months after issuance of the final report. Unless otherwise directed, the stored samples will be disposed of after this period.

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Profile Sta. 22+590 to 22+630 & Sta. 22+800 to 22+950 Bastard Twp

The subsurface conditions observed in Boreholes 99-12 and 99-13 within the these two areas of reported poor performance are presented in detail on the Borehole Records provided in Appendix 1. A borehole location plan for the roadway embankment investigation area from Station 22+590 to 22+630 and from Station 22+800 to 22+950, Township of Bastard is shown on Drawing No. 11108-FE1.

Within the investigated area between Station 22+590 and 22+630, Highway 15 is in a fill section as high as 1.8 m while between Station 22+800 and 22+950, Highway 15 is in a fill section as high as 1.0 m based on cross-sections provided by Stanley.

In Borehole 99-12 drilled at Station 22+600, a 165 mm layer of asphalt with granular pavement fills and earth fills to a depth of 2.6 m were observed over a 0.6 m layer of woody organic peat. The peat was underlain by a 1.7 m cohesive layer of silt to silty clay followed by a heterogeneous mixture of sand, silt and gravel identified as glacial till. Borehole 99-12 was ended within the glacial till stratum at a depth of 6.1 m below existing ground surface. The natural moisture content of one fill sample and one peat sample tested was 9.4% and 23%, respectively.

In Borehole 99-13 drilled at Station 22+925, a 140 mm layer of asphalt with granular pavement fills and earth fills to a depth of 1.4 m were observed over a 0.4 m layer of woody organic peat. The peat was underlain by a 1.2 m layer consisting of a heterogeneous mixture of sand, silt and gravel identified as glacial till. Auger refusal on inferred bedrock was encountered at a depth of 3.0 m in Borehole 99-13. The natural moisture content of one peat sample tested was 42% while two glacial till samples tested had moisture contents of 9% and 10%.

It is noted that samples of the peat from Boreholes 99-12 and 99-13 had inclusions of sand and gravel hence significantly reducing the moisture content.

4.2 Subsurface Profile Between Sta. 10+200 to 10+400 South Elmsley Twp

The subsurface conditions observed in Boreholes 99-1 through 99-11 within this section are presented in detail on the Borehole Records provided in Appendix 1. An explanation of the symbols and terms used to describe the Borehole Records is also provided. A borehole location plan for the roadway embankment investigation area between Station 10+200 and 10+400 is shown on Drawing No. 11108-FE1. Within the investigated area between Station 10+200 and 10+400, Highway 15 is in a 3 to 4.3 metre high fill section. The boreholes in the roadway embankment indicate it is generally constructed with asphalt over granular fill to a depth of approximately 1 m. Then, fills including earth borrow, cobbles, boulders, rockfill and miscellaneous granular materials make up the remaining fill for the roadway embankment.

A thin layer of topsoil/rootmat is present at ground surface at the bottom of the existing roadway embankment. Native organic peat to organic silt soils extend to as much as 9.1 m below the existing grades at the proposed toe of embankment slope within the narrow widening areas. Underlying these organic soils is a deposit of clayey silt to silty clay, generally cohesive in nature, followed by a heterogeneous mixture of sandy silt, trace gravel (Glacial Till) and bedrock.

Geology information reported in a previous PDR by MTO in 1997 indicates that the site to be underlain by bedrock consisting of grey limestone, magnesium limestone, blue-grey dolostone and some calcareous sandstone.

A detailed description of the subsurface conditions encountered between Station 10+200 and Station 10+400 is given below.

4.2.1 Asphalt, Rootmat (Surficial Material)

A layer of asphalt was encountered at the top of the Highway 15 pavement structure at Boreholes 99-1 through 99-5. The asphalt layer ranged from 200 mm to 1015 mm in thickness at these locations. Boreholes put down and reported in the 1997 MTO PDR indicate as much as 1.4 m of asphalt. A rootmat layer measuring approximately 100 mm was encountered below the tall grass covered surface at Boreholes 99-6 to 99-11.

4.2.2 Sand with Varying Amounts of Gravel and Silt (Fill Material)

Fill was observed below the surficial asphalt layer in Boreholes 99-1 to 99-5. The fill layer extended to depths ranging from 3.5 m to 14.0 m below existing highway pavement surface. The fill consisted generally of an upper layer of sand with gravel and traces of silt providing a pavement structure for the existing Highway 15 platform followed by lower random earth fills consisting of sand with varying amounts of gravel, silt, pieces of asphalt, cobbles, boulders and or rockfill for the construction of the existing highway embankment.

The upper pavement structure fill layer extended to depths ranging from 0.4 m to 2.4 m below existing pavement surface while the lower random embankment fill layer extended to depths ranging from 3.5 m to 14.0 m below existing ground surface.

Standard Penetration tests in the fill revealed ‘N’ values ranging from 7 blows/0.3 m to over 100 blows/0.3 m indicating that the fill ranges in density from loose to very dense. In general the unit can be categorized as compact. The natural moisture content of eighteen samples tested ranged from 3% to 23% with an average of 13%. Two wash sieve, grain-size distribution analyses carried out on representative samples of the fill indicated that it contained 34% to 41% gravel, 51% to 53% sand, and 8% to 13% silt and clay sized particles.

4.2.3 Peat

Organic, fine fibrous to amorphous peat was encountered below the surficial rootmat at 99-6 to 99-11 and below the fill at Borehole 99-2. The brown to dark brown peat layer extended to depths ranging from 2.1 m to 15.3 m below the existing ground surface corresponding to Geodetic elevations of 121.9 m and 112.5 m, respectively. The thickness of the peat ranged from 1.3 m in Borehole 99-2 (below the existing roadway) to as thick as 7.7 m in Borehole 99-6 (below the toe of the existing roadway embankment). The peat was observed to contain small shells in Boreholes 99-6 and 99-7. The natural moisture content of the peat layers ranges from 338% to 655% with an average of 512% for the ten samples tested. The SPT N-values ranged from 1 blows/0.3 m to 3 blows/0.3 m indicating that the peat layers, where sampled, are very loose in relative density.

4.2.4 Organic Silt

Beige colored organic silt with varying minor amounts of clay and sand was observed inferred below the organic peat at Boreholes 99-6, 99-7 and 99-9 to 99-11. The organic silt layer ranged from 1.3 m to 3.7 m in thickness extending to depths ranging from 6.0 m to 9.1 m below existing ground surface. The organic silt was observed to contain numerous, small friable shells in all samples retrieved. The natural moisture content of the organic silt layers ranges from 119% to 420% with an average of 207% for the seven samples tested. The SPT N-values ranged from 1 blows/0.3 m to 2 blows/0.3 m indicating that the organic silt layers, where sampled, are very soft in consistency. A grain-size hydrometer analysis carried out on one sample of this deposit indicated that it contained 0% gravel, 8% sand, 72% silt and 20% clay sized particles (see Grain Size Distribution curve on Figure 1, Appendix 1). The results of Atterberg Limits testing carried out on one representative sample of this deposit indicated a liquid limit (w_L) of 150% and plastic limit (w_P) of 89% (see the Plasticity Chart on Figure 2 in Appendix 1). This deposit at the site can therefore be classified as an organic silt of extremely high plasticity.

4.2.5 Clayey Silt to Silty Clay

A native grey deposit of clayey silt to silty clay was encountered below the above described soil layers in Boreholes 99-2, 99-6 and 99-9 to 99-11. It is noted that this deposit was inferred in Borehole 99-7 through the probing resistance monitored with a cone penetrometer. The thickness of the deposit was determined in Boreholes 99-6 and 99-8 to 99-11 to range from 0.2 m to 4.9 m. Borehole 99-7 was ended on inferred glacial till at a depth of 13.1 m below existing ground surface based on the monitored resistance to the penetration of a cone pushed beyond the layer of peat.

The deposit is generally cohesive in behavior. The natural moisture content of seven samples tested ranged from 38% to 66% with an average of 46%. The SPT N-values ranged from 1 blows/0.3 m to 2 blows/0.3 m. Based on these SPT blow counts and on estimated undrained shear strength measurements (c_u) obtained by conducting field vane tests and pocket penetrometer tests, it is considered that the deposit has generally **a soft consistency**. It is noted that the sensitivity of these deposits may typically range from 4 to 6 which would indicate a sensitive soil.

c_u values ( ) ←

The results of Atterberg Limits testing carried out on two representative sample of this deposit indicated a liquid limit (w_L) of 38% and 57% and plastic limit (w_P) of 18% and 24% (see the Plasticity Chart on Figure 2 in Appendix 1). The clayey silt to silty clay deposit at the site can therefore be classified as a clay of intermediate plasticity (CI).

4.2.6 Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)

Underlying the above noted soils, a heterogeneous mixture of silt, sand and gravel identified as glacial till was encountered in Boreholes 99-6, 99-8 to 99-11 and inferred in Borehole 99-7. It is noted that cobbles and boulders are characteristic components of deposits of this origin and hence may exist in this deposit. The thickness of the glacial till ranged from 0.1 m to 0.2 m at Boreholes 99-9 and 99-11, respectively where auger refusal or split spoon sampler refusal was encountered on inferred bedrock. Boreholes 99-6 to 99-8 and 99-10 were ended within or on the glacial till stratum at depths ranging from 3.7 m to 13.4 m below the existing ground surface.

The SPT tests carried out in this deposit revealed N-values ranging from 5 blows/0.3 m to 14 blows/0.3 m and as high as 100 blows/0.3 m where refusal of the split spoon sampler was reached indicating that the deposit ranges in denseness from compact to very dense. In general, the deposit can be categorized as compact. The natural moisture content of two samples tested was 16% and 25%. A grain-size sieve and hydrometer analysis carried out on one sample of this deposit indicated that it contained 18% gravel, 35% sand, 24% silt and 23% clay sized particles (see Grain Size Distribution curve on Figure 1, Appendix 1).

4.2.7 Inferred Bedrock

Auger refusal on inferred bedrock was encountered at Boreholes 99-2 , 99-5, 99-9 and 99-11 at depths ranging from 5.6 m to 20.3 m below existing ground surface (i.e. Elevation 107.5 to 124.3 m Geodetic datum). Cobbles and/or boulders were inferred at Borehole 99-4 where coring equipment was used to advance the borehole as the augers could not displace the soils at a depth of about 7.4 m below the top of the existing roadway.

Borehole Location	Borehole	Bedrock Elevation (m)
Station 10+250 1.5 LT C/L	99-2	107.5
Station 10+375 1.5 RT C/L	99-5	124.3
Station 10+225 12.5 LT C/L	99-9	118.7
Station 10+325 12.5 LT C/L	99-11	114.9

4.3 Groundwater Conditions

Groundwater levels were estimated based on observations made during the drilling operations at the time of this foundation investigation between February 23 and March 5, 1999.

The groundwater levels at the affected roadway embankment fill areas are generally close to that of the toe of embankment slope. The estimated groundwater level in Borehole 99-12 drilled in the poor performing area between Station 22+590 and 22+630, Township of Bastard, was approximately 2.0 m below the existing pavement surface. The estimated groundwater level in Borehole 99-13 drilled in the poor performing area between Station 22+800 and 22+950, Township of Bastard, was approximately 1 m. The estimated groundwater level in Boreholes 99-1 through 99-11 drilled in the poor performing area between Station 10+200 and 10+400 on the days of drilling ranged from Geodetic elevation 122.3 m to 124.7 m and depths ranging from 1.0 m to 5.2 m below the existing ground surface in Boreholes 99-6 and 99-5, respectively.

Fluctuations in the groundwater level due to seasonal variations or in response to a particular precipitation event should be anticipated.

DRAFT FOUNDATION INVESTIGATION REPORT

For

Fill Embankment in Settlement Areas
North of Portland, Ontario
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Sta. 22+800 to Sta. 22+950, Township of Bastard
Sta. 10+200 to Sta. 10+400, Township of South Elmsley
District 41, Kingston

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 Proposed Development

It is understood that the Ministry of Transportation of Ontario (MTO) plans to widen Highway 15 and perform a general rehabilitation of the existing pavement structure. Typically, the asphalt surface is to be widened by 0.4 m on each side. Three previously identified poor performing areas associated with organic soil and muskeg deposits within the rehabilitation project limits will need to be treated separately from the general roadway rehabilitation work.

The highway widening will cause a grade increase in the form of a wedge over the existing embankment fill slopes and toe of slopes. In addition, a general grade raise of 50 mm will result from the selected rehabilitation over the existing Highway 15 profile while a 200 mm grade raise in the profile is being considered in the poor performing area between Station 10+200 to Station 10+400, Township of South Elmsley.

The proposed grade raise and embankment loading will result in increased stresses in the soil beneath and immediately surrounding the roadway embankment. Additional settlement is anticipated at the location of the narrow embankment widening on each side of the present highway embankment.

An overhead hydroelectric line is presently located parallel to the existing highway and at the toe of the embankment fill along the poor performing area between Station 10+200 and 10+400, Township of South Elmsley.

In addition, it is noted that an old CNR spur line embankment is located almost parallel to the existing highway approximately 30 to 40 m right of the roadway centreline along this same poor performing area. The location of these site features should be considered if deep excavations from deep organic material removals are anticipated for the treatment of the affected poor performing area described herein.

5.2 Options for Treatment of Poor Performing Areas

Borehole results indicate peat on either side and below the roadway at the three poor performing areas. Based on the existing condition of the road and the borehole records it is believed that the swamp material may have been partially excavated or pushed out of the way by the placement of the present roadway embankment fills.

5.2.1 Station 22+590 to 22+630, Township of Bastard

The borehole records and the condition of the roadway suggests that not all of the swamp material was excavated below the roadway between 22+590 to 22+630. Borehole 99-12 indicates that a 600 mm peat layer is present below the existing roadway. Firm bottom was encountered at a depth of 3.2 m below the existing ground surface at that location. The poor performance at this location is attributed to settlement of the underlying soils. Several options have been considered for the design of the widening and treatment of the poor performing area at this location. Sketches of the viable options are presented in Appendix 3. Cost estimates are also provided in Appendix 3.

1) No swamp removal and preloading. Given that as much as 0.9 m of fill is to be placed in the widening, it is expected that settlement in the order of 30 mm beneath the roadway and 300 mm beneath the widening would occur and that the settlement would continue for a number of years. This option is not recommended due to the continued maintenance costs of elevating the grades with granulars and asphalt in the ongoing settlement areas.

2) Full depth organic/muskeg removal across the entire road cross-section. This would need to be done in two stages on a temporarily lowered roadway. This option would successfully treat the poor performing area and result in a superior widened roadway although it requires significant excavation. Daytime traffic would be restricted to only one lane controlled by traffic control persons using stop/slow signalisation. A cost estimate of $45,290 has been generated for this option ignoring paving costs and assuming that shoring will be unnecessary.

3) Excavation of swamp material for widening as per OPSD 203.02 and partial embankment removal beneath the existing roadway and replacement with lightweight fill. This option includes removing the upper most 1050 mm of the existing roadway and reconstructing the roadway and widening with air cooled slag fill placed over a non-woven geotextile surfaced with 630 mm of granulars and asphalt. Rockfill may be used to backfill the swamp excavation.

   The result is that no net increase in load occurs on the underlying materials and consequently no load induced settlements will occur below the existing roadway. No shoring would be required because of the limited depth of excavation. Although this option would be disruptive to daytime traffic as only one lane of traffic controlled by traffic control persons would be maintained using stop/slow signalisation, it would be less disruptive than that of option 2 because construction would be quicker due to shallower excavations. A cost estimate of $31,219 has been generated for this option ignoring paving costs and grade raises.

Although option 2 described above is moderately more expensive than option 3, it is the recommended option as there is a reduced level of risk by removing the source of the problem. Furthermore, option 2 will accommodate future grade and alignment changes more readily.

Reconstruction should consist of 130 mm of asphalt over 200 mm of OPSS Granular A over a minimum of 300 mm of OPSS Granular B Type I over rock fill or OPSS Select Subgrade Material. Should rock fill be utilized, it is recommended that a non-woven geotextile be placed over it to prevent loss of fines from the granular layer.

5.2.2 Station 22+800 to 22+950, Township of Bastard

The borehole records and the condition of the roadway suggests that not all of the swamp material was excavated below the roadway between 22+800 to 22+950. Borehole 99-13 indicates that a 400 mm peat layer is present below the existing roadway. Firm bottom was encountered at a depth of 1.8 m below the existing ground surface at that location. The poor performance at this location is attributed to settlement of the underlying soils. Several options have been considered for the design of the widening and treatment of the poor performing area at this location. Sketches of the viable options are presented in Appendix 3 with cost estimates.

1) No swamp removal and preloading. Given that as much as 0.5 m of fill is to be placed in the widening, it is expected that settlement in the order of 20 mm beneath the roadway and 200 mm beneath the widening would occur and that the settlement would continue for a number of years. This option is not recommended due to the continued maintenance costs of elevating the grades with granulars and asphalt in the ongoing settlement areas.

2) Full depth organic/muskeg removal across the entire road cross-section. This would need to be done in two stages but would not require the use of shoring. This option would successfully treat the poor performing area and result in a superior widened roadway although it requires significant excavation. Daytime traffic would be restricted to one lane controlled by traffic control persons using stop/slow signalisation. A cost estimate of $99,090 has been generated for this option ignoring paving costs and assuming that shoring will be unnecessary.

3) Excavation of swamp material for widening as per OPSD 203.02 and partial embankment removal beneath the existing roadway and replacement with lightweight fill. This option includes removing the upper most 950 mm of the existing roadway and constructing the roadway and widening with air cooled slag fill placed over a non-woven geotextile surfaced with 630 mm of granulars and asphalt. Rockfill may be used to backfill the swamp excavation. The result is that no net increase in load occurs on the underlying materials and consequently no load induced settlements will occur below the existing roadway. No shoring would be required because of the limited depth of excavation. Although this option would be disruptive to daytime traffic as only one lane of traffic controlled by traffic control persons would be maintained using stop/slow signalisation, it would be less disruptive than that of option 2 because construction would be quicker due to the shallower excavations. A cost estimate of $87,210 has been generated for this option ignoring paving costs and grade raises.

Option 2 is the recommended treatment method even though it is moderately more expensive than option 3. Option 2 involves a reduced level of risk by removing the source of the problem. Furthermore, option 2 will accommodate grade and alignment changes more readily.

Reconstruction should consist of 130 mm of asphalt over 200 mm of OPSS Granular A over a minimum of 300 mm of OPSS Granular B Type I over rock fill or OPSS Select Subgrade Material. Should rock fill be utilized, it is recommended that a non-woven geotextile be placed over it to prevent loss of fines from the granular layer.

5.2.3 Station 10+200 to 10+400, Township of South Elmsley

The borehole records and the condition of the roadway suggests that not all of the swamp material was excavated below the roadway between 10+200 to 10+400. Borehole 99-2 indicates that a 1.3 m peat layer is present below the existing roadway. Firm bottom was encountered at a depth of 15.3 m below the existing ground surface at that location. The poor performance of the road manifested as a dip in the road is attributed to settlement of the soils underlying the embankment. A 200 mm grade raise is being considered within this section in order to increase the cover on the culvert at Station 10+210.

Five options have been considered for the design of the widening and treatment of the poor performing area at this location.

1) Full depth organic/muskeg removal across the entire road cross-section. This would need to be done in two stages and would require the use of shoring. Although, this option would successfully treat the poor performing area and result in a superior widened roadway, it requires significant excavation, would encounter potential shoring problems and be disruptive to traffic as only one lane of traffic controlled by traffic control persons would be maintained using stop/slow signalisation. It is noted that this option would also affect the integrity of an existing overhead hydro line located along the east side as well as an existing old railway embankment located approximately 30 m away from the highway centreline and running parallel to the highway. A cost estimate of $2,319,980 has been generated for this option.

2) Removal of existing asphalt fill and resurfacing. Given the grade raise of 200 mm in this area, it is expected that total settlement in the order of 125 mm would occur and that the settlement would continue for a number of years. This option is not recommended due to the continued maintenance costs of elevating the grades with granulars and asphalt in the ongoing settlement areas.

3) Lowering the grade. There is already insufficient cover over an existing cross-culvert present near Station 10+200. This option is not recommended.

water

4) Partial embankment removal beneath the existing roadway and replacement with lightweight fill. This option includes replacing the upper most 1730 mm of the existing roadway with air-cooled slag fill placed over a non-woven geotextile surfaced with the 630 mm pavement structure. The result is that no net increase in load occurs on the underlying materials and consequently no load induced settlements will occur below the existing roadway. Even with no increase in load, it is anticipated that secondary compression will occur. It is estimated that settlement of between 10 and 20 mm will occur at the new edge of pavement over a 10 year period. No shoring would be required because of the limited depth of excavation

   Although this option would be disruptive to traffic as only one lane of traffic controlled by traffic control persons would be maintained using stop/slow signalisation, it would be less disruptive than that of option 1 because construction would be much quicker due to shallower excavations and because no shoring is required. A cost estimate of $275,939 has been generated for this option ignoring paving costs and grade raises.

5) Full depth organic/muskeg removal beyond the existing edge of shoulder only to the limits indicated on OPSD 203.04. This would need to be done in two stages and would require the use of shoring. Although, this option would remove all of the organic material below the proposed widening locations, a 1.3 m layer of peat would remain in place below the roadway. The 200 mm grade raise would induce additional primary and secondary settlements (125 mm). This option would also encounter potential shoring problems and be disruptive to traffic as only one lane of traffic controlled by traffic control persons would be maintained using stop/slow signalisation. It is noted that, as in option 1, this option would also affect the integrity of an existing overhead hydro line located along the east side as well as an existing old railway embankment located approximately 30 m away from the highway centreline and running parallel to the highway. A cost estimate of $1,359,280 has been generated for this option ignoring paving costs and grade raises.

Based on the estimated construction costs and the satisfactory performance anticipated, it is recommended that option 4 described above be selected for the area between Sta. 10+200 and 10+400, ie. slag lightweight fill balance treatment. The excavation should be approached in short increments.

Reconstruction should consist of 130 mm of asphalt over 200 mm of OPSS Granular A over a minimum of 300 mm of OPSS Granular B Type I over 1100 mm of air-cooled slag placed over a non-woven geotextile. It is recommended that paving of this section be delayed for as long as possible to minimize the effects of the possible settlement of the existing roadway embankment due to widening induced stresses at the edges of the slag balance treatment and therefore minimize differential settlements.

5.3 Stability of Embankment

The existing Highway 15 embankment slopes in the three poor performing areas investigated appear to be in stable condition. No signs of recent or past slope failures or earth movements were observed along the highway embankments.

Although site observations indicate that slope stability concerns are not warranted, redevelopment of the highway with narrow widenings and a grade increase must include consideration of slope stability due to the increase in loading associated with such fill placement.

As part of this investigation, slope stability analyses were carried out for one section of Highway 15 between Station 10+200 and Station 10+400, Township of South Elmsley based on combined information from surveyed cross sections provided by Stanley, from subsurface stratigraphy encountered at the borehole locations and from field observations made at the time of the investigation.

The use of lightweight fill in the form of air-cooled slag will create a balance such that no additional stresses are induced to the underlying soils. Therefore, the stability condition of the future embankment should be no worse than that of the present highway embankment - only 200 mm higher in elevation. Nonetheless, the stability of the highway embankment at this location was analyzed utilizing Bishop's Modified Method. Potential slope failure surfaces lying within the overburden were considered, together with estimated values for the shear strength parameters and unit weight of the various materials comprising the highway embankment. An embankment sideslope of 2:1 was utilized in the analysis.

The analyses yielded safety factors above 1.4 which is considered an appropriate minimum factor of safety for the static loading of a roadway embankment. Seismic loading conditions applied to the analysis yielded safety factors above 1.1 which is also considered appropriate for a roadway embankment.

Based on the above, no global stability problems are anticipated between Station 10+200 and 10+400, Township of South Elmsley. As this length of highway is a more critical embankment section than that observed and encountered at the other two poor performing areas, no global stability problems are anticipated for the highway embankment between Station 22+590 and 22+630 and between Station 22+800 and 22+950 in the Township of Bastard.

5.4 Erosion Protection

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the highway embankment slopes. Although the roadway embankment and slopes will include slag and granular fills, slope vegetation should however be established in accordance with MTO standards as soon as possible after completion of the embankment in order to control surficial erosion. It is recommended that sedimentation control measures be installed near the culvert (near Station 10+210) during the widening/embankment construction of the poor performing area between Station 10+200 and Station 10+400 in accordance with OPSD 219 series in order to prevent sediment laden water from entering Otter Lake or any of its tributaries.

5.5 General Construction Recommendations

Site Grading and Preparation

All organic soils, and other deleterious materials on the existing embankment side slopes between 10+200 and 10+400, Township of South Elmsley, must be removed to allow for the proposed roadway widening. Excavation at stations 22+590 to 22+630 and 22+800 to 22+950, Township of Bastard, should be in accordance with OPSD 203.02.

Stripping of deleterious materials and the exposed native firm subgrade surface should be inspected by geotechnical personnel to ensure that all unsuitable materials are removed prior to placement of backfill.

Excavation

Earth excavation should be carried out in accordance with OPSS-206.07.03. A depth of frost treatment, *f*, of 1.5 m should be used at this site. Side slopes for open cut excavations should conform to Occupational Health and Safety Act regulations.

A shoring system will be required if other options are selected for the treatment of the poor performing areas described herein and should be designed to temporarily support the existing roadway and embankment. The shoring should be monitored to ensure the stability of the affected roadway during excavation and backfilling. Shoring design, if required, should be carried out by the contractor and reviewed by the geotechnical engineer.

Dewatering

It is the responsibility of the contractor to control the groundwater table below the excavation base. As anticipated bottom of excavation elevations within the organic removal areas place the work at or below the water table, dewatering will likely be required during construction. The use of sump pumps and coffer dams may be used during organic removal and widening construction of the roadway embankment. Dewatering from inside shored excavations must account for potential basal heave.

Adjacent Hydroelectric Line and Old Railway Embankment

It is understood that the overhead hydroelectric line presently located parallel to the existing highway and at the toe of the embankment fill will be in the affected work area between Station 10+200 and Station10+400, Township of South Elmsley. The existing old railway embankment is located on the east side of the highway running parallel to it at a distance of about 30 m to 40 m from centreline. However, as organic material removal excavations are not being recommended, the adjacent hydroelectric line and old railway embankment are not expected to be affected by the lightweight fill treatment option. Should other options be considered, it is likely that the associated anticipated deep excavations will require that the existing hydroelectric line be temporarily relocated and that the old railway embankment be supported until excavation and backfilling work is complete. It is recommended that this work occur prior to the onset of organic material excavation should those options be considered.

Staging

Excavations should be backfilled to the top of the base material prior to being subjected to vehicular traffic.

Construction staging could be carried out in order to minimize stop/slow signalisation and maximize two way traffic. Two lanes of traffic can be maintained on gravel surface by lowering the grade of the existing roadway full width, and pushing traffic to the opposite side of the roadway prior to carrying out the treatment excavations and roadway widening.

6.0 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

A foundation investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and groundwater conditions, as well as the history of the site reflecting natural, construction, and other activities. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information and its effects on the above conclusions.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Yours very truly,

JACQUES, WHITFORD LIMITED

Jean L. Lemire, B.A.Sc., P.Eng.

Fred J. Griffiths, Ph.D., P.Eng.

P:\1999\10000\11108\FillEmbankmentSettlementRep.wpd

APPENDIX 1

- Explanation of Terms Used in Report
-Borehole Records
- Grain Size Sieve Curves (Figure 1)
- Plasticity Chart (Figure 2)

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 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

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

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

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

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

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

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING 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

S S	SPLIT SPOON
W S	WASH SAMPLE
S T	SLOTTED TUBE SAMPLE
B S	BLOCK SAMPLE
C S	CHUNK SAMPLE
T W	THINWALL OPEN
T P	THINWALL PISTON
O S	OSTERBERG SAMPLE
R C	ROCK CORE
P H	T W ADVANCED HYDRAULICALLY
P M	T W ADVANCED MANUALLY
F S	FOIL SAMPLE

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX $= w_L - w_P$
I_L	1	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 99-1

1 OF 1 **METRIC**

W.P. 48-83-01
LOCATION Highway 15, South Elmsley Township, Station 10+225 1.5 RT C/L
ORIGINATED BY D.F.
DIST 41 HWY 15
BOREHOLE TYPE HS augers, split spoons
COMPILED BY J.L.L.
DATUM Assumed
DATE 99.02.23 &
CHECKED BY F.J.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED ✖ FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
127.6	Ground Surface										
127.4 0.0	250 mm Asphalt										
0.3											
127.2 0.4	Sand with gravel, trace silt (Fill Material) Compact, brown						127				
			1	SS	40						
126.1 1.5	Sand, some gravel, trace silt, trace woody organics (Fill Material)						126				
			2	SS	14						
125.6 2.1	Dense, brown										
	- Gravelly sand, trace silt with a presence of marl (Fill Material) Compact, white and brown		3	SS	12		125				
						∇					
			4	SS	10						
123.8	Gravelly sand, trace silt (Fill Material)						124				
3.8	Compact, light brown		5	SS	15						
	Gravelly sand, some silt (Fill Material) Compact, brownish grey						123				
			6	SS	11						
122.4 5.2	Gravel, some silt to sandy gravel, trace silt (Fill Material) Dense to loose, grey		7	SS	40		122				
			8	SS	31						
							121				
			9	SS	9						
							120				
			10	SS	17						
119.4 8.2	End of Borehole (Estimated water level @ 3.0 m 99-02-23)										

$✖^3$, $\times^3$: Numbers refer to Sensitivity

$15\text{-}\oplus\text{-}5$ (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 99-2

1 OF 2

METRIC

W.P. 48-83-01

LOCATION Highway 15, South Elmsley Township, Station 10+250 1.5 LT C/L

ORIGINATED BY D.F.

DIST 41 HWY 15

BOREHOLE TYPE HS augers, split spoons

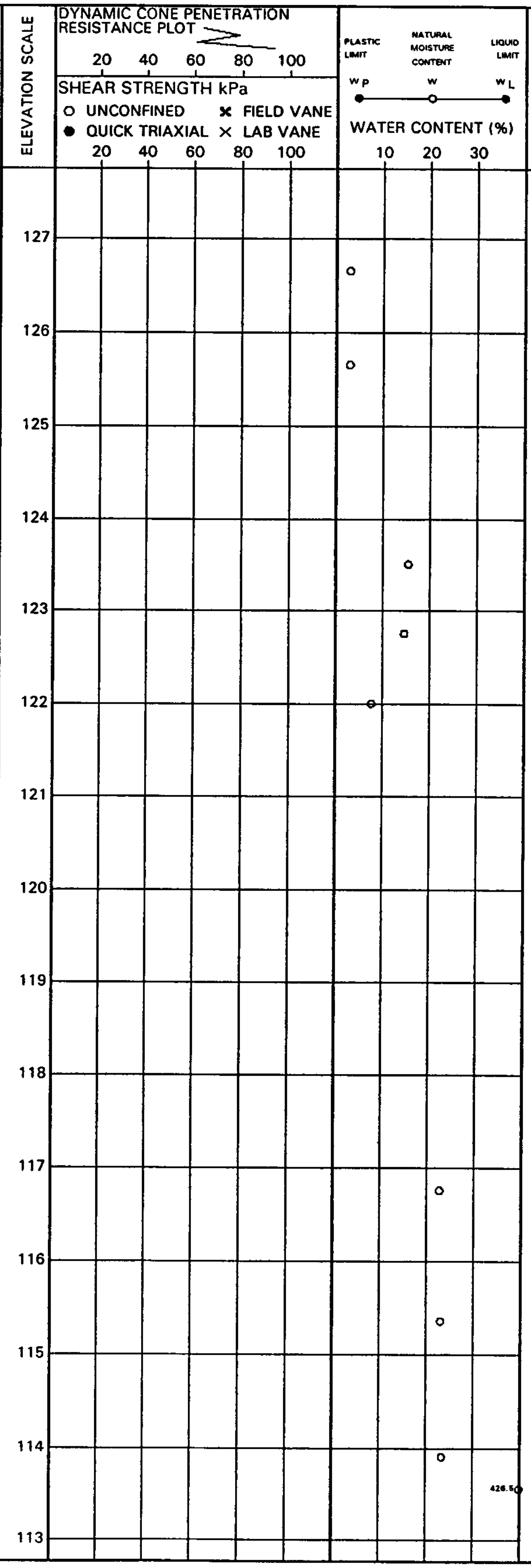
COMPILED BY J.L.L.

DATUM Assumed

DATE 99.02.24 & 99.03.05

CHECKED BY F.J.G.

SOIL PROFILE		SAMPLES						
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
127.8	Ground Surface							
0.0	1015 mm Asphalt							
126.8 1.0	Sand with gravel, trace silt, presence of piece of asphalt (Fill Material) Very dense to compact, brown	1	SS	100	ref			
		2	SS	16				
125.4 2.4	Sand, some gravel, some silt to fine to coarse sand with gravel, trace silt (Fill Material) Very dense to compact, brown to brownish grey	3	SS	4				
		4	SS	10	∇			
		5	SS	61				
		6	SS	18				
122.5 5.3	Gravel, some sand, trace silt, presence of fractured pieces of cobbles and boulders (Fill Material) Compact to very dense, brownish grey to greyish brown	7	SS	15				
		8	SS	46				
		9	SS	100	ref			
113.8 14.0	Organic, fine fibrous PEAT Dark brown	10	SS	25				



Continued Next Page

×³, ×³: Numbers refer to Sensitivity

$15 \overset{20}{\underset{10}{\oplus}} 5$ (%) STRAIN AT FAILURE

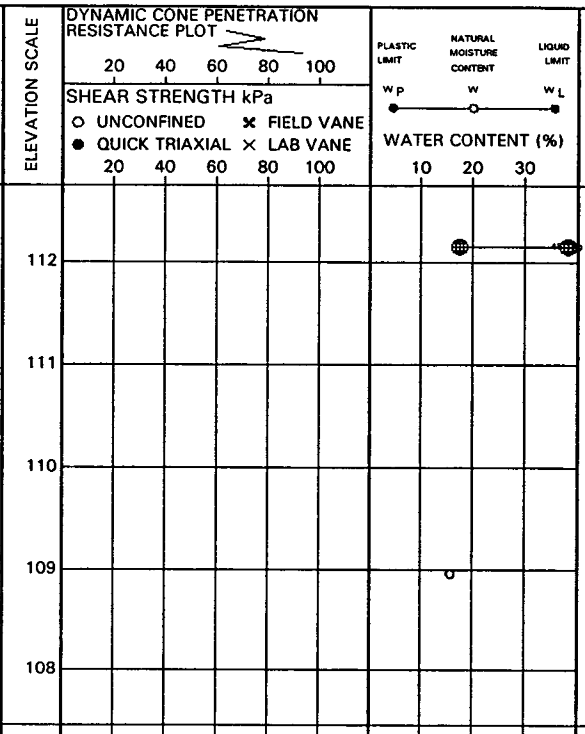
RECORD OF BOREHOLE No 99-2

2 OF 2

METRIC

W.P. 48-83-01
LOCATION Highway 15, South Elmsley Township, Station 10+250 1.5 LT C/L
ORIGINATED BY D.F.
DIST 41 HWY 15
BOREHOLE TYPE HS augers, split spoons
COMPILED BY J.L.L.
DATUM Assumed
DATE 99.02.24 & 99.03.05
CHECKED BY F.J.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			
112.5	PEAT							
15.3	SILTY CLAY Firm, grey		11	SS	3			
109.2 18.6	Heterogeneous mixture of sand with silt and clay, some gravel (Glacial Till)		12	SS	1			18 35 24 23
107.5 20.3	End of Borehole Auger Refusal on Inferred Bedrock (Estimated water level @ 3.2 m 99-02-24)							



×³, ×³: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

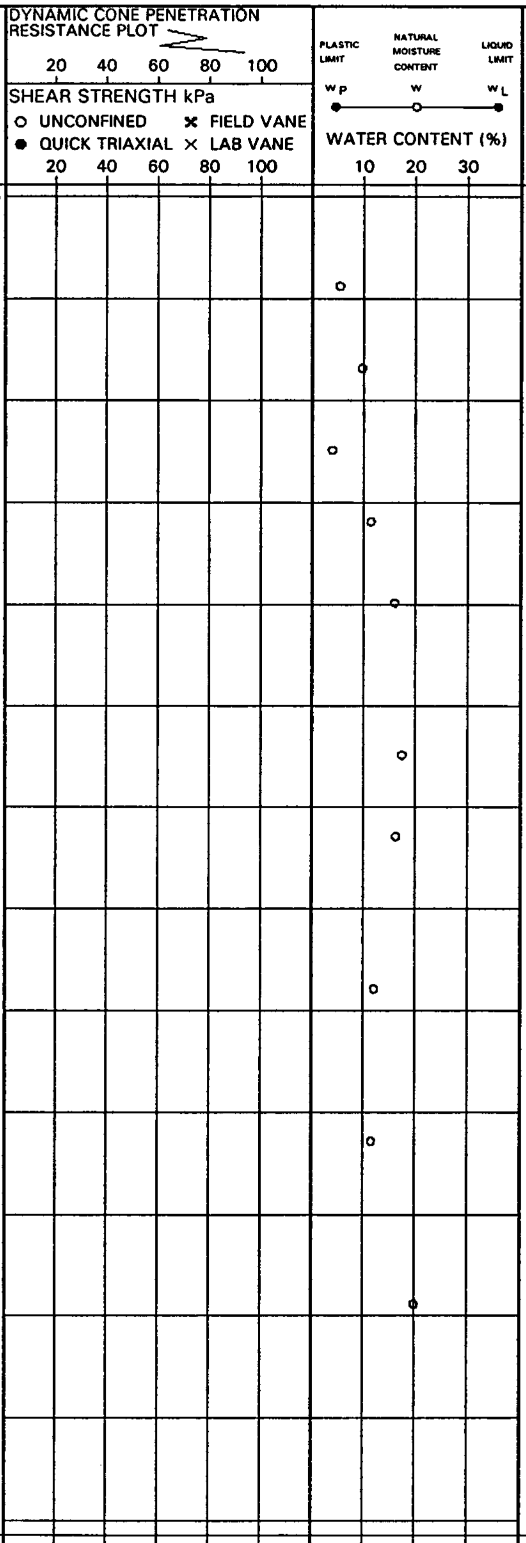
RECORD OF BOREHOLE No 99-3

1 OF 1

METRIC

W.P. 48-83-01
LOCATION Highway 15, South Elmsley Township, Station 10+275 1.5 RT C/L
ORIGINATED BY D.F.
DIST 41 HWY 15
BOREHOLE TYPE HS augers, split spoons
COMPILED BY J.L.L.
DATUM Assumed
DATE 99.02.23 & 99.03.05
CHECKED BY F.J.G.

SOIL PROFILE		SAMPLES							REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR SA SI CL
128.1	Ground Surface								
0.0	610 mm Asphalt						128		
127.5 0.6	Sand with gravel, trace silt (Fill Material)		1	SS	34		127		
~~127.1~~ 1.0	Sand with gravel, trace to some silt, presence of pieces of asphalt @ 1.0 m (Fill Material) Dense, brown		2	SS	38		126		
			3	SS	48				
125.1 3.0	Sand and gravel, some silt, presence of marl (Fill Material) Compact, brown and white		4	SS	19		125		34 53 13 0
124.3 3.8	Sandy gravel, trace silt to sand with gravel (Fill Material) Loose to compact, brownish grey to grey		5	SS	5	▽	124		
			6	SS	22		123		
			7	SS	100	ref			
			8	SS	36		122		41 51 8 0
			9	SS	24		121		
			10	SS	16		120		
			11	SS	22		119		
							118		
			12	SS	11		117		
							116		
114.9							115		
13.3	End of Borehole Auger Refusal on Inferred Boulders (Estimated water level @ 3.8 m 99-02-23)								



×³, ×³: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 99-4

1 OF 1

METRIC

W.P. 48-83-01
LOCATION Highway 15, South Elmsley Township, Station 10+325 1.5 LT C/L
ORIGINATED BY D.F.
DIST 41 HWY 15
BOREHOLE TYPE HS augers, split spoons, casing, coring
COMPILED BY J.L.L.
DATUM Assumed
DATE 99.02.24 &
CHECKED BY F.J.G.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED ✕ FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L
WATER CONTENT (%): 10 20 30
UNIT WEIGHT γ kN/m^3
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS
128.8	Ground Surface						
128.6 0.0	200 mm Asphalt						
0.2	Sand with gravel, trace silt (Fill Material)	1	SS	100	ref	128	
127.8 1.1	Sand, some gravel, trace silt, presence of pieces of asphalt @ 1.0 m to Sand with gravel, some silt (Fill Material) Very dense, brown	2	SS	100	ref	127	
		3	SS	100	ref	126	
		4	SS	100	ref		
125.3 3.5	Cobbles and boulders and/or rockfill (Fill Material)					125	
						124	
		5	SS	9		123	
		6	SS	11			
	- Auger Refusal on Inferred Boulders	7	SS	100	ref	122	
121.2		8	RC				Rec = 60%
7.6	End of Borehole (Estimated water level @ 2.0 m 99-02-24)						

$\times^3$, $\times^3$: Numbers refer to Sensitivity

15 ⊕ 5, 20, 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 99-5

1 OF 1 **METRIC**

W.P. 48-83-01
LOCATION Highway 15, South Elmsley Township, Station 10+375 1.5 RT C/L
ORIGINATED BY D.F.
DIST 41 HWY 15
BOREHOLE TYPE HS augers, split spoons
COMPILED BY J.L.L.
DATUM Assumed
DATE 99.02.24 &
CHECKED BY F.J.G.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
129.9	Ground Surface						
0.0 129.6	355 mm Asphalt	■					
0.4 128.9	Sand with gravel, trace silt (Fill Material) Compact, brown	▨	1	SS	100	ref	129
1.0	Sand, some gravel, trace silt, presence of cobbles and boulders throughout (Fill Material) Compact to very dense, brown	▨	2	SS	25		128
			3	SS	100	ref	
126.4			4	SS	100	ref	127
3.5	Sand, some gravel, trace silt, presence of cobbles and boulders throughout (Fill Material) Compact to very dense, brown	▨	5	SS	15		126
	- auger broken during drilling		6	SS	18	∇	125
124.3			7	SS	100	ref	
5.6	End of Borehole Auger Refusal on Inferred Bedrock (Estimated water level @ 5.2 m 99-02-24)						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ✖ FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$\times^3, \times^3$: Numbers refer to Sensitivity

$15\overset{20}{\underset{10}{\oplus}}5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 99-6

1 OF 1

METRIC

W.P. 48-83-01
LOCATION Highway 15, South Elmsley Township, Station 10+250 18.0 RT C/L
ORIGINATED BY D.F.
DIST 41 HWY 15
BOREHOLE TYPE HS augers, split spoons
COMPILED BY J.L.L.
DATUM Assumed
DATE 99.02.26 &
CHECKED BY F.J.G.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED ✖ FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%): 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)
124.8 0.0	Ground Surface						
124.7 0.1	ROOTMAT						
	Organic amorphous PEAT (some fine fibres and shells) Brown and dark brown				∇	124	
						123	
						122	
						121	
						120	
						119	
		1	SS	2			338.2 ○
						118	
117.0 7.8	Organic SILT, trace clay, frequent shells with presence of dark brown peat) Soft, beige	2	SS	2		117	193.1 ○
						116	
115.7 9.1	CLAYEY SILT to SILTY CLAY Soft, grey	3	SS	1			
						115	
		4	SS	1		114	40.7 ○
						113	
112.6 12.2	Heterogeneous mixture of sandy silt, trace gravel (Glacial Till) Loose, grey	5	SS	5			○
112.0 12.8	End of Borehole (Estimated water level @ 1.0 m 99-02-26)					112	

$\times^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⌖ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 99-7

1 OF 1

METRIC

W.P. 48-83-01
LOCATION Highway 15, South Elmsley Township, Station 10+275 18.5 RT C/L
ORIGINATED BY D.F.
DIST 41 HWY 15
BOREHOLE TYPE HS augers, split spoons
COMPILED BY J.L.L.
DATUM Assumed
DATE 99.02.25 &
CHECKED BY F.J.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED ✖ FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
124.8	Ground Surface										
124.7 0.0	ROOTMAT										
0.1	Organic, fine fibrous PEAT Dark brown						124				
			1	SS	1						
			2	SS	1		123		560 ○		
122.6 2.3	Organic, fine fibrous to amorphous PEAT Dark brown		3	SS	1	▽	122		655 ○		
			4	SS	1				565 ○		
	- presence of friable shells within		5	SS	1		121		540 ○		
			6	SS	1		120		577 ○		
			7	SS	1		119		507 ○		
							118				
	- inferred organic SILT layer						117				
							116				
115.1 9.8	Cone Penetration Probing Inferred soft to firm CLAYEY SILT and/or SILTY CLAY						115				
							114				
							113				
111.7	- end of cone penetration probing						112				
13.1	End of Borehole (Estimated water level @ 2.4 m 99-02-25)										

$\times^3, \times^3$: Numbers refer to Sensitivity

$15 \overset{20}{\underset{10}{\oplus}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 99-8

1 OF 1

METRIC

W.P. 48-83-01
LOCATION Highway 15, South Elmsley Township, Station 10+350 25.0 RT C/L
ORIGINATED BY D.F.
DIST 41 HWY 15
BOREHOLE TYPE HS augers, split spoons
COMPILED BY J.L.L.
DATUM Assumed
DATE 99.02.26 &
CHECKED BY F.J.G.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED ✖ FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES		
124.0	Ground Surface					
0.0	ROOTMAT					124
123.9 0.1	Organic, fine fibrous PEAT Dark brown				▽	123
121.9 2.1	Heterogeneous mixture of sandy silt, trace gravel, trace clay (Glacial Till) Loose, grey	1	SS	8		122
		2	SS	8		121
120.4 3.7	End of Borehole (Estimated water level @ 1.2 m 99-02-26)					

×³, ×³: Numbers refer to Sensitivity

$15\overset{20}{\underset{10}{\oplus}}5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 99-9 1 OF 1 METRIC

W.P. 48-83-01	LOCATION Highway 15, South Elmsley Township, Station 10+225 12.5 LT C/L		ORIGINATED BY D.F.
DIST 41	HWY 15	BOREHOLE TYPE HS augers, split spoons	COMPILED BY J.L.L.
DATUM Assumed	DATE 99.02.26 &		CHECKED BY F.J.G.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED ✖ FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
124.9	Ground Surface								
124.8 0.0	ROOTMAT								
0.1	Organic, fine fibrous to amorphous PEAT Dark brown				∇	124 123			
122.6 2.3	Organic SILT, some clay, trace sand with numerous friable shells Soft, beige	1	BS		-		420.8 ○		
		2	SS	2		122	161.6 ○		
		3	SS	1		121 120	148.6 139. ⊕		0 8 72 20
118.9 ~~6.0~~	CLAYEY SILT Soft, grey	4	SS	100	ref	119	○		
118.8 6.2	Gravel, trace sand (possible fractured pieces of bedrock)								
118.7 6.3	End of Borehole Auger Refusal on Inferred Bedrock (Estimated water level @ 1.0 m 99-02-26)								

$✖^3$, $\times^3$: Numbers refer to Sensitivity

$15 \overset{20}{\underset{10}{\oplus}} 5$ (%) STRAIN AT FAILURE

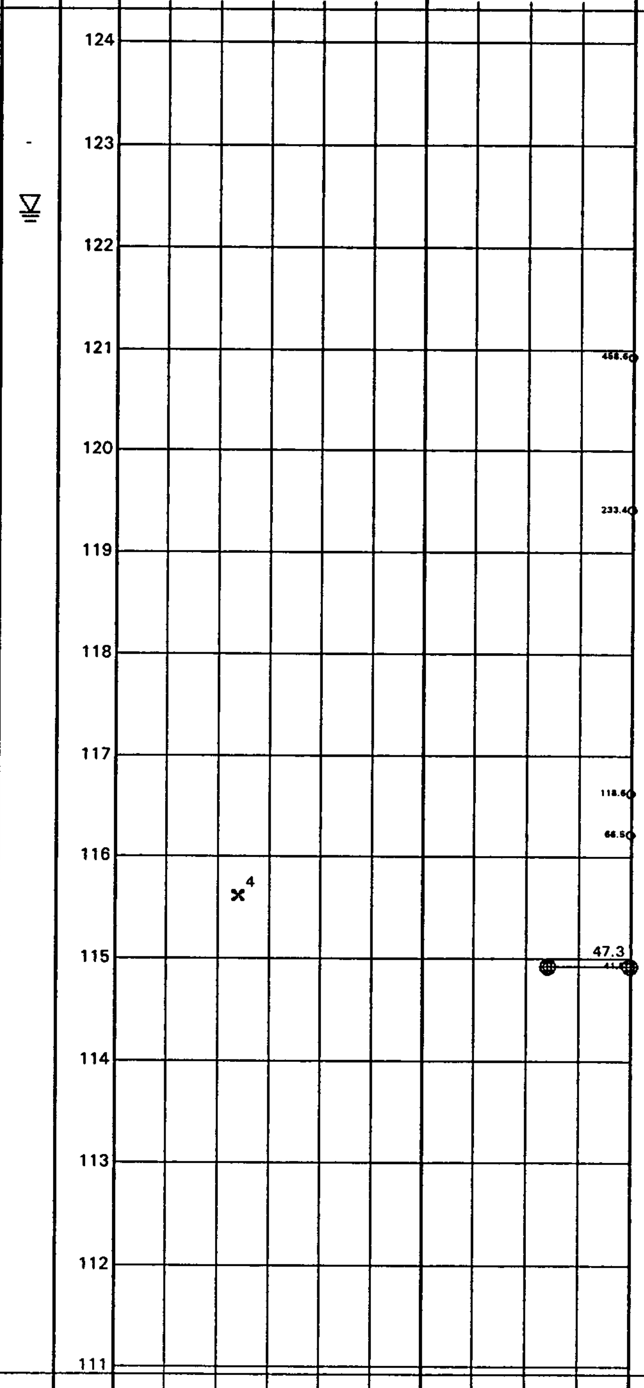
RECORD OF BOREHOLE No 99-10

1 OF 1 **METRIC**

W.P. 48-83-01
LOCATION Highway 15, South Elmsley Township, Station 10+300 12.5 LT C/L
ORIGINATED BY D.F.
DIST 41 HWY 15
BOREHOLE TYPE HS augers, split spoons
COMPILED BY J.L.L.
DATUM Assumed
DATE 99.02.26 &
CHECKED BY F.J.G.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES
124.3	Ground Surface			
124.2 0.0	ROOTMAT			
0.1	Organic, amorphous PEAT Dark brown	1	BS	
		2	SS	2
120.2 4.2	Organic SILT, trace clay, numerous friable shells Soft, light brown and beige	3	SS	1
		4	SS	1
		5	SS	1
116.4 7.9	CLAYEY SILT to SILTY CLAY Soft, grey	6	SS	1
		7	SS	1
		8	SS	1
		9	SS	1
111.5 12.8	Heterogeneous mixture of silt, some sand, some clay, trace gravel (Glacial Till) Compact, grey	10	SS	14
110.9 13.4	End of Borehole (Estimated water level @ 2.0 m 99-02-26)			

STRAT PLOT | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH kPa ○ UNCONFINED ✖ FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL



×³, ×³: Numbers refer to Sensitivity

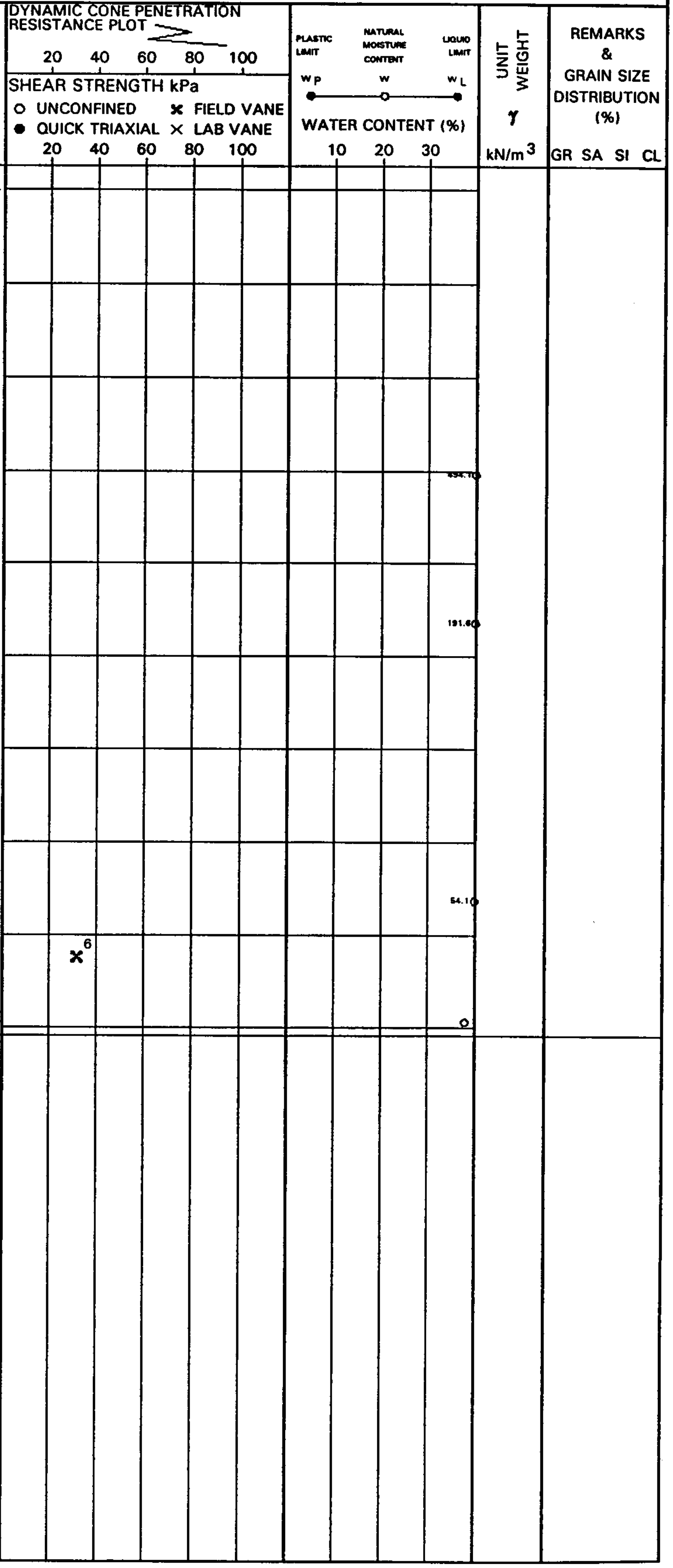
15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 99-11

1 OF 1 **METRIC**

W.P. 48-83-01
LOCATION Highway 15, South Elmsley Township, Station 10+325 12.5 LT C/L
ORIGINATED BY D.F.
DIST 41 HWY 15
BOREHOLE TYPE HS augers, split spoons
COMPILED BY J.L.L.
DATUM Assumed
DATE 99.03.01 &
CHECKED BY F.J.G.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
124.3	Ground Surface					
~~0.0~~ ~~124.2~~ 0.1	ROOTMAT Organic, amorphous to fine fibrous PEAT Dark brown					124 123
		1	SS	2	▽	122
		2	SS	3		121 120
119.5 4.7	Organic SILT, trace clay, numerous friable shells Soft, beige	3	SS	1		119 118 117
116.7 7.6	SILTY CLAY Firm, grey	4	SS	2		116
115.1 ~~9.2~~	~~Heterogeneous mixture of silty~~ sand, some gravel (Glacial Till) Compact, grey	5	SS	100	ref	115
114.9 9.4	End of Borehole Split Spoon Sampler Refusal on Inferred Bedrock (Estimated water level @ 2.0 m 99-03-01)					



✖^{3}, ×^{3}: Numbers refer to Sensitivity

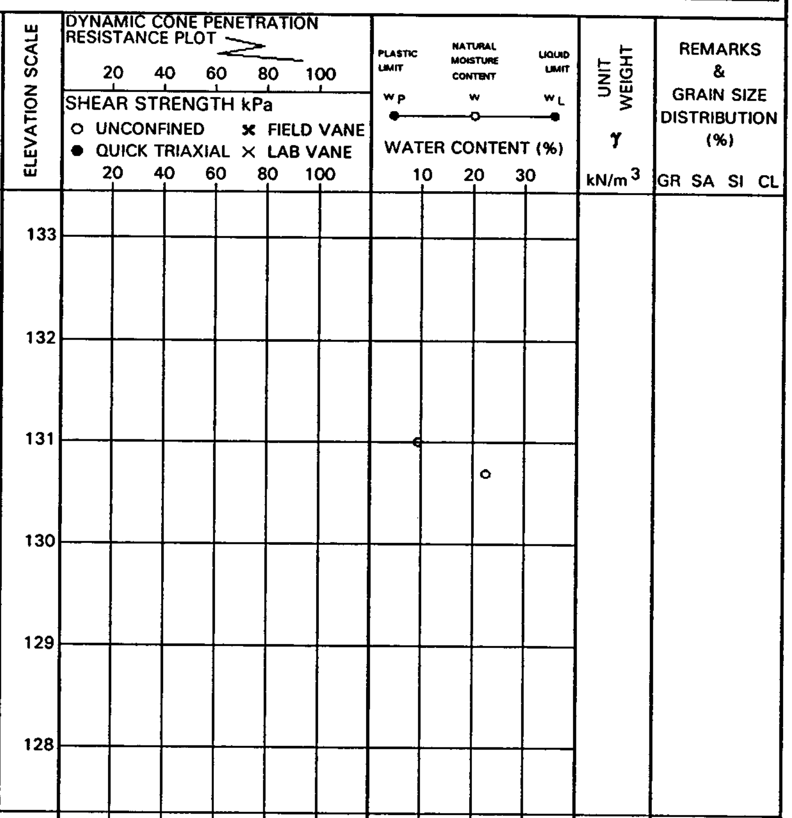
$15\overset{20}{\underset{10}{\oplus}}5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 99-12

1 OF 1 **METRIC**

W.P. 48-83-01
LOCATION Highway 15, Bastard Township, Station 22+600 1.6 RT C/L
ORIGINATED BY D.F.
DIST 41 HWY 15
BOREHOLE TYPE HS augers, split spoons
COMPILED BY J.L.L.
DATUM Assumed
DATE 99.02.23 &
CHECKED BY F.J.G.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
133.4	Ground Surface				
0.0 0.2	165 mm ASPHALT				
133.0 0.4	Brown, sand, with gravel, trace silt (frozen Fill Material)				
132.0 1.4	Sandy gravel, trace silt (Fill Material) Compact, brown	1	SS	100	ref
	Sandy gravel, trace to some silt, trace organics (Fill Material) Compact, brown	2	SS	18	▽
130.8 2.6		3	SS	11	
130.2 3.2	Woody organic PEAT				
	SILT to SILTY CLAY, trace gravel, trace brown organics Compact, grey and light brownish grey	4	SS	15	
		5	SS	20	
128.5 4.9		6	SS	26	
	Heterogeneous mixture of silt, some clay, trace gravel (Glacial Till) Compact, light brownish grey	7	SS	17	
127.3 6.1	End of Borehole				



$\times^3, \times^3$: Numbers refer to Sensitivity

$15\overset{20}{\underset{10}{\oplus}}5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 99-13

1 OF 1 **METRIC**

W.P. 48-83-01
LOCATION Highway 15, Bastard Township, Station 22+925 1.6 RT C/L
ORIGINATED BY D.F.
DIST 41 HWY 15
BOREHOLE TYPE HS augers, split spoons
COMPILED BY J.L.L.
DATUM Assumed
DATE 99.02.23 &
CHECKED BY F.J.G.

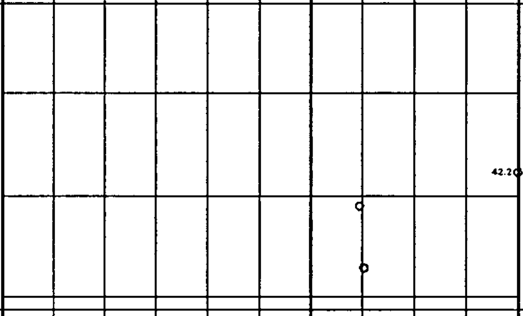
ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
132.9	Ground Surface					
~~132.7~~ 0.0 0.2	140 mm ASPHALT					
132.5 0.4	Sand with gravel, trace silt (frozen Fill Material) Brown	1	SS	100	∇ ~~ref~~	132
131.5 1.4	Sandy gravel, trace silt (Fill Material) Compact, brown, saturated	2	SS	21		131
~~131.1~~ 1.8	**Woody organic PEAT**					
129.9 3.0	Heterogeneous mixture of sandy silt, trace to some gravel (Glacial Till) Dense, light brown (presence of organics)	3	SS	36		130
	End of Borehole Auger Refusal on Inferred Bedrock					

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED × FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

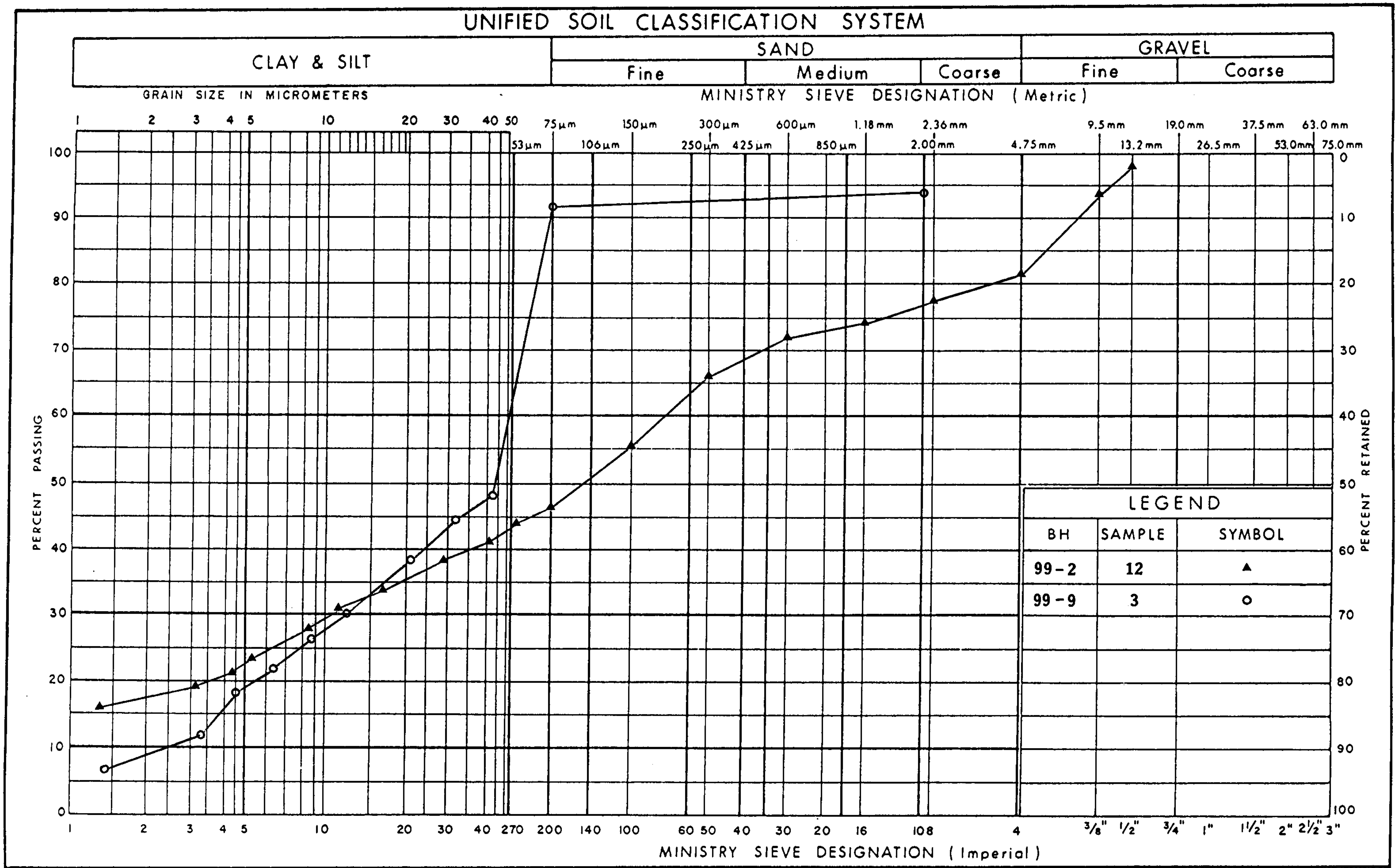
REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL



×³, ×³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

78 12 M



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

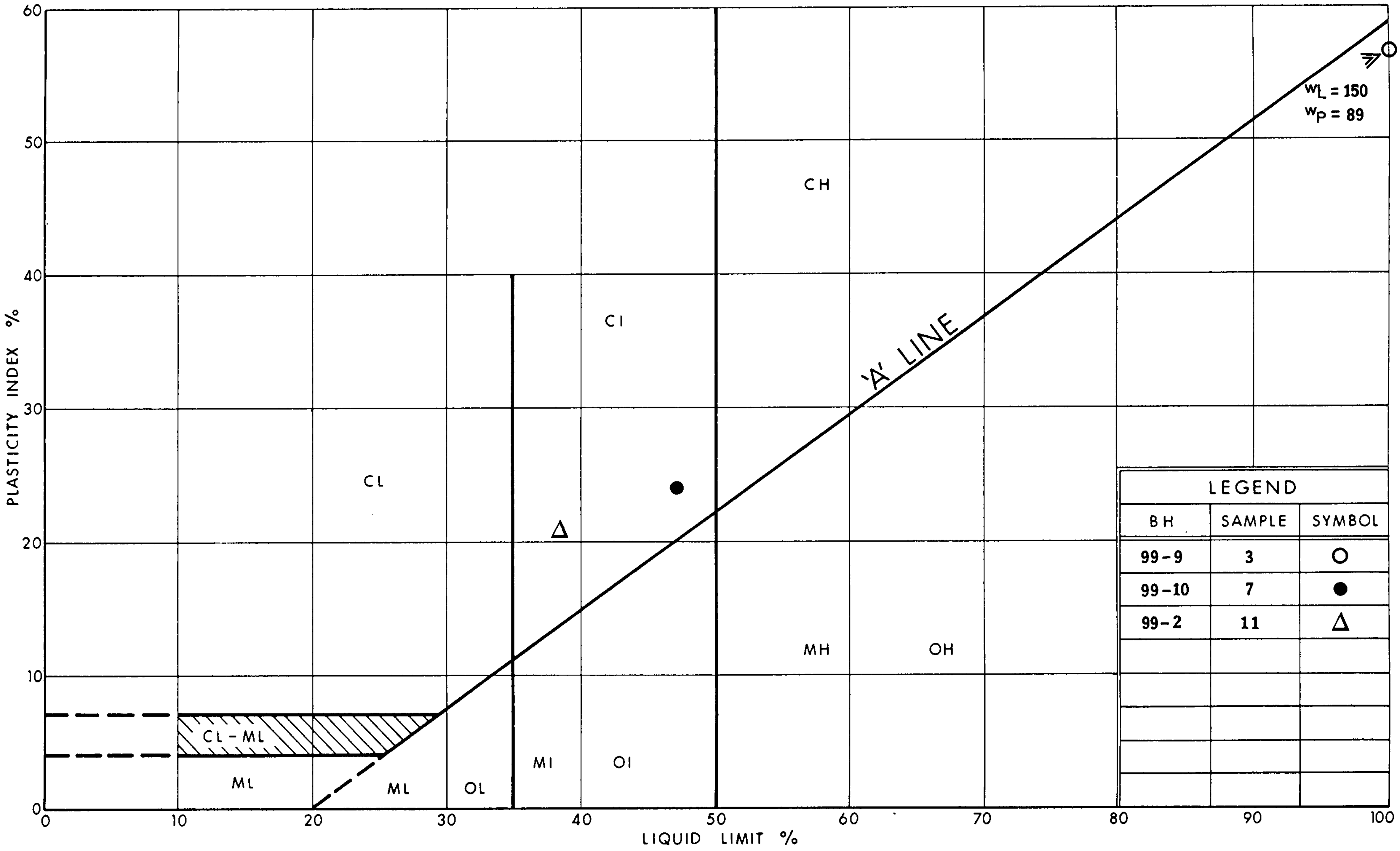
HETEROGENEOUS MIXTURE OF SAND, SILT, CLAY, GRAVEL (TILL)

& ORGANIC SILT, SOME CLAY, TRACE SAND

FIG No 1

W P 48-83-01

Oct 75, FF-S-21



Ministry of Transportation
Ontario

PLASTICITY CHART

CLAY OF INTERMEDIATE PLASTICITY (SILTY CLAY) & ORGANIC SILT OF EXTREMELY HIGH PLASTICITY

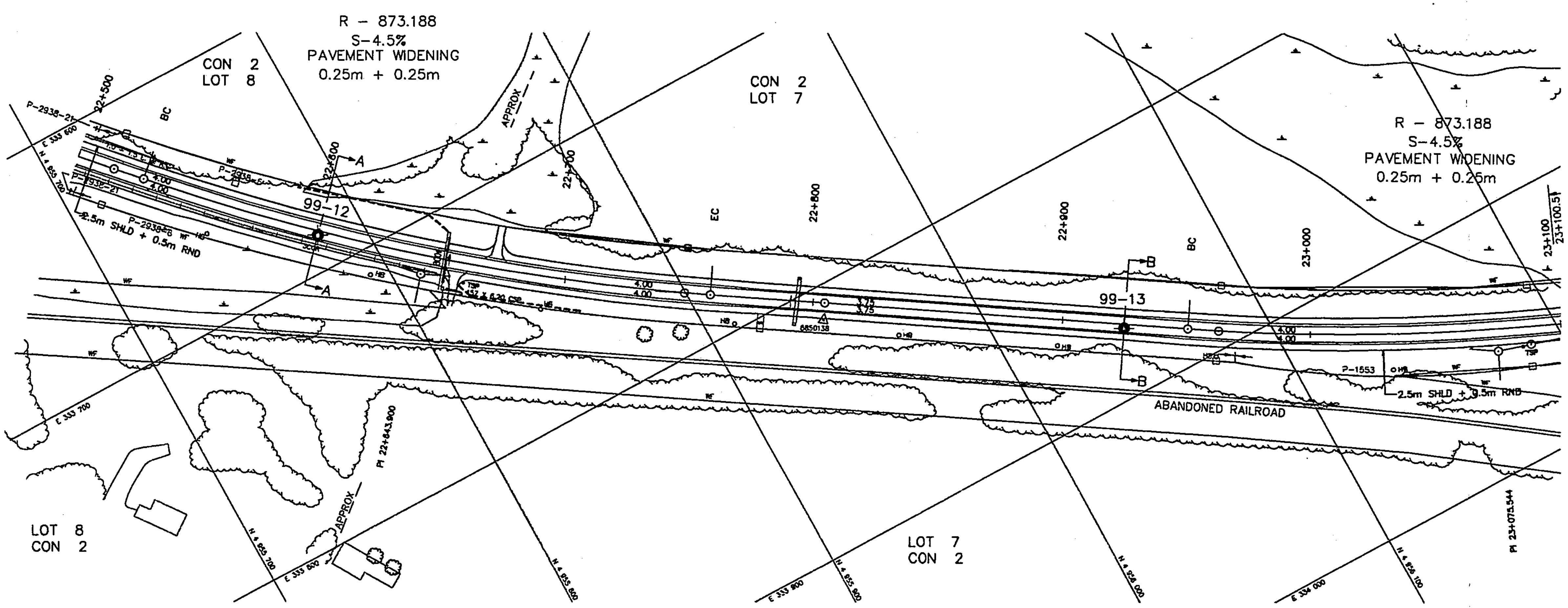
FIG No 2

W P 48 - 83 - 01

APPENDIX 2

- Key Plan & Borehole Location Plan Drawings (11108-FE1 and 11108-FE2)

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



PLAN

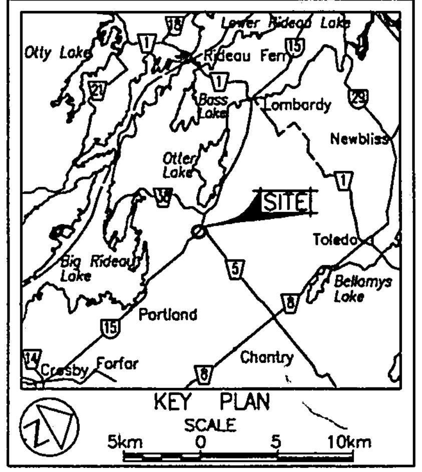
SCALE
20m 10 0 20m

CONT No
WP No 48–83–01

HIGHWAY 15
TOWNSHIP OF BASTARD
STA 22+500 TO STA 23+100
BORE HOLE LOCATIONS & SOIL STRATA

SHEET
1

JACQUES, WHITFORD LIMITED

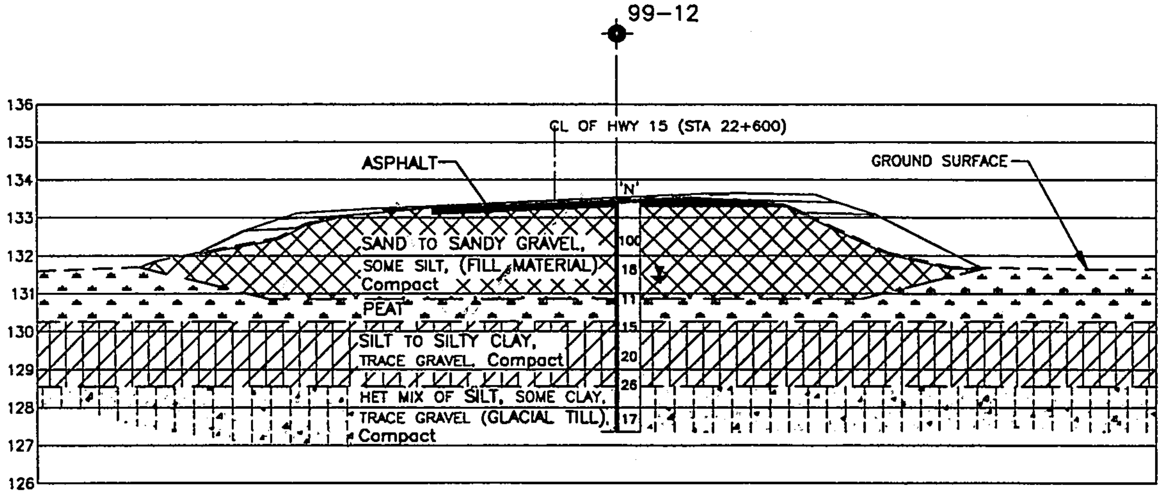


KEY PLAN
SCALE
5km 0 5 10km

LEGEND

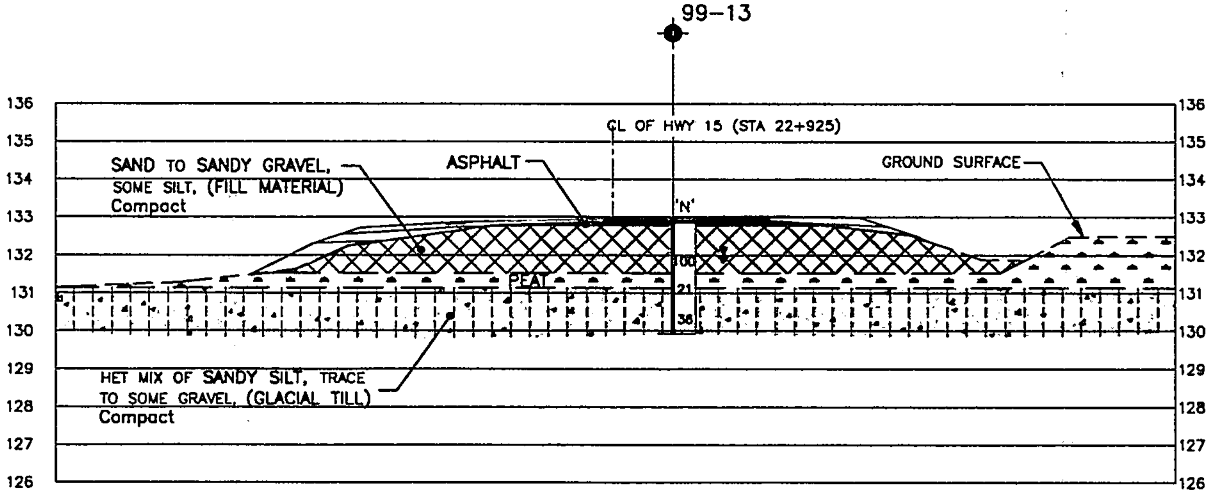
●	Bore Hole
☒	Pavement Hole
⊕	Dynamic Cone Penetration Test (Cone)
⊕	Bore Hole & Cone
N	Blows/0.3m (Std Pen Test, 475 J/blow)
CONE	Blows/0.3m (60° Cone, 475 J/blow)
↓	WL at time of investigation 99 03
↓	WL in Piezometer
▮	Piezometer

No	ELEVATION	COORDINATES NORTH	COORDINATES EAST
99–12	133.4	4 955 782.5	333 686.0
99–13	132.9	4 956 047.2	333 873.5



SECTION A–A

SCALE
2m 1 0 2m



SECTION B–B

SCALE
2m 1m 0 2m

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102–2 of Form 100.

Rev.	DATE	BY	DESCRIPTION
	–		–

GEOCRES No

HWY No 15			DIST –––
SUBM'D JLL	CHECKED	DATE APR 5, 1999	SITE
DRAWN GBB	CHECKED	APPROVED	DWG 11108–FE1

11108–FE1

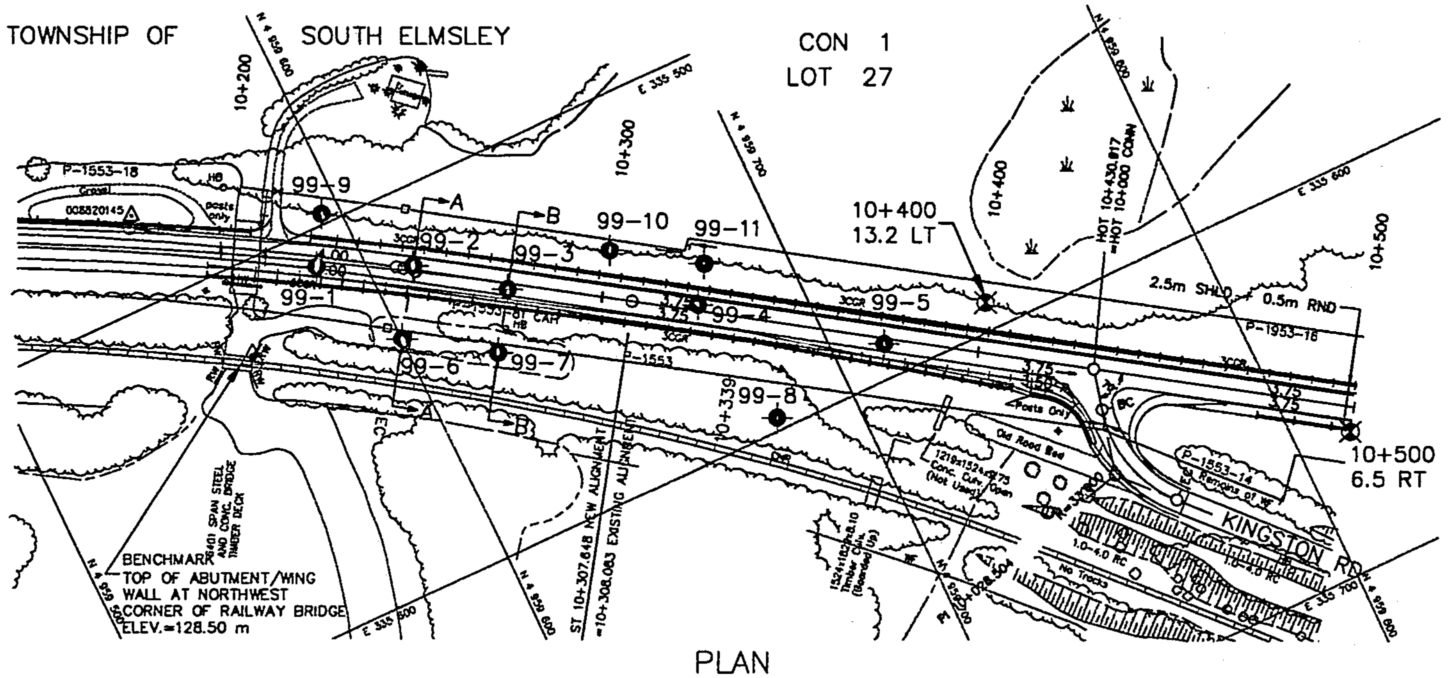
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 48-83-01

HIGHWAY 15
TOWNSHIP OF SOUTH ELMSLEY
STA 10+150 TO STA 10+450
BORE HOLE LOCATIONS & SOIL STRATA

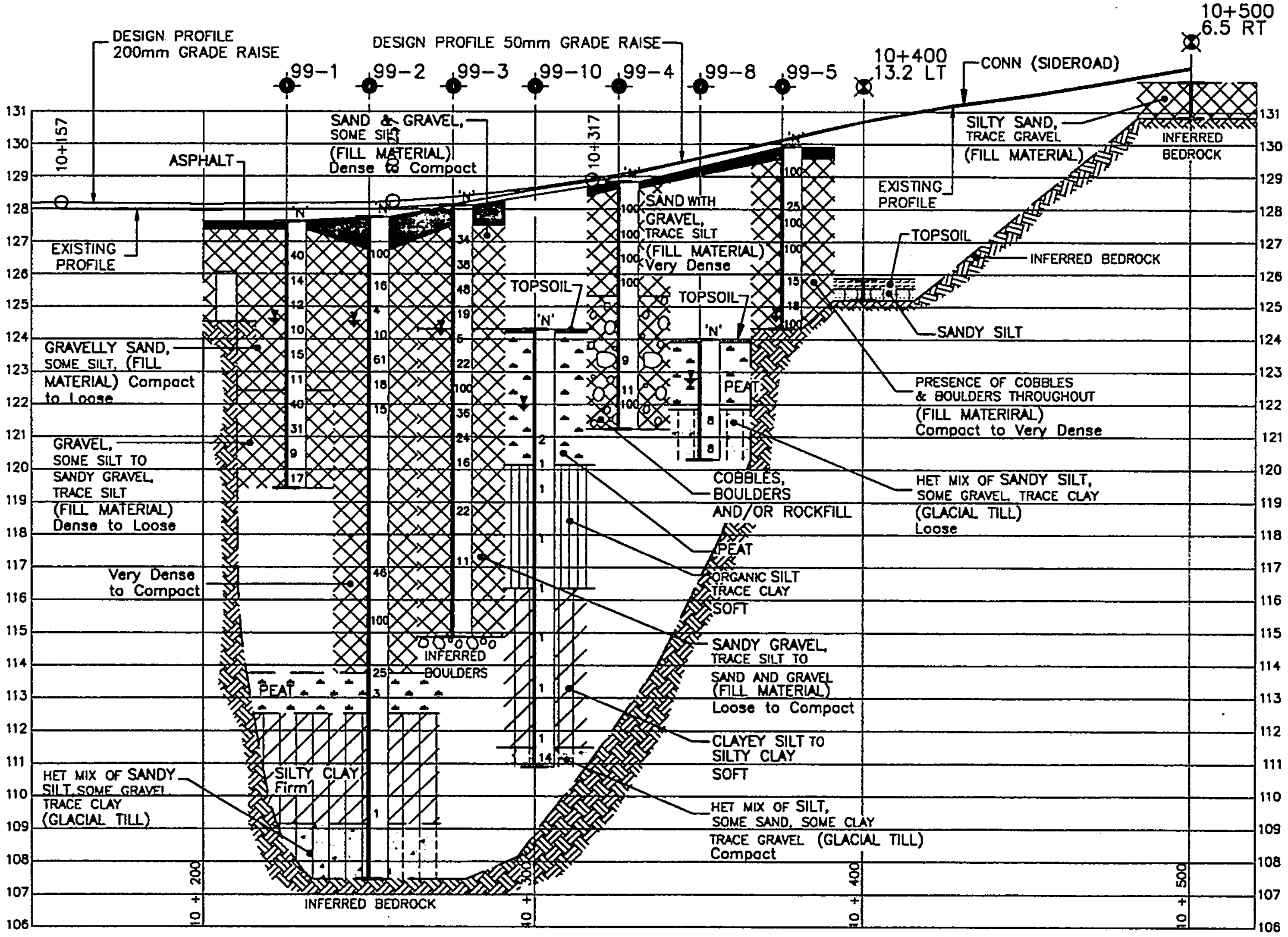
SHEET
2

JACQUES, WHITFORD LIMITED



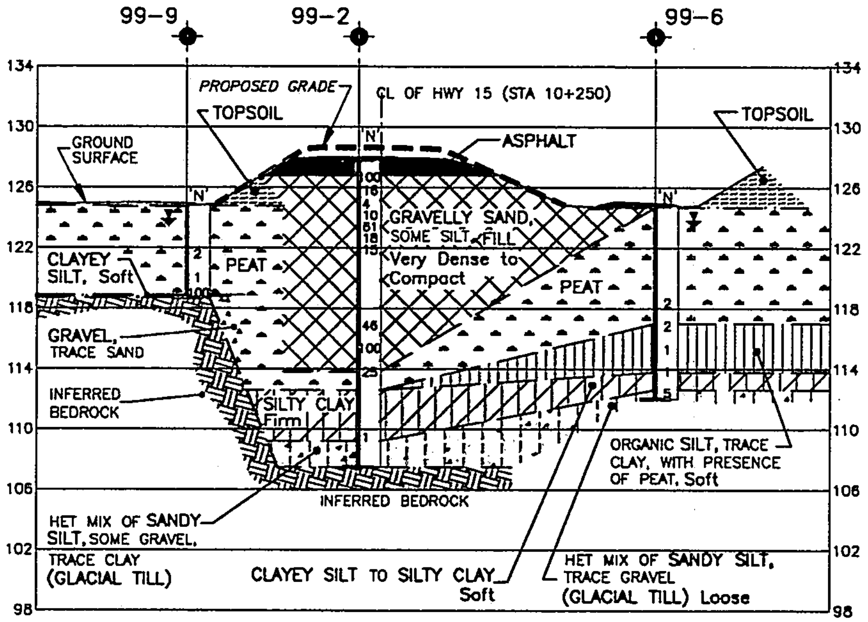
PLAN

SCALE
20m 10 0 20m



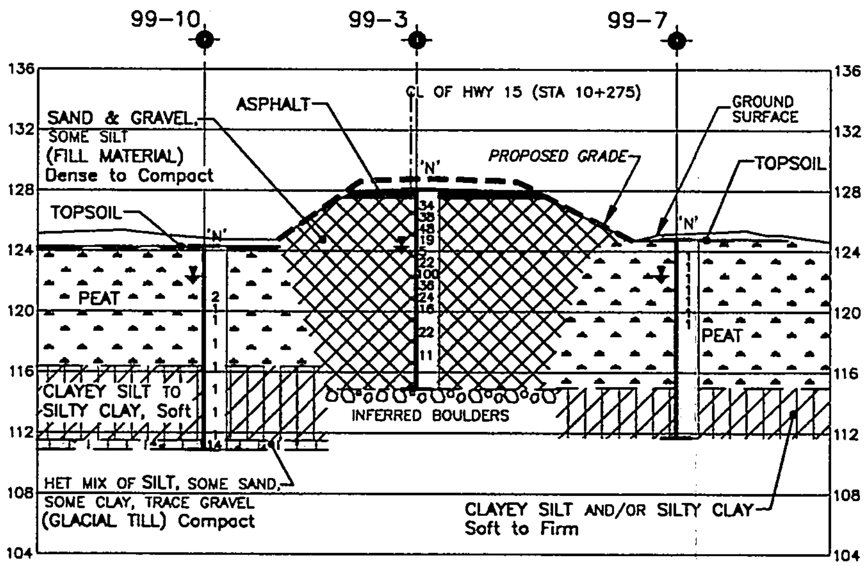
PROFILE ALONG ℄

SCALE
20m 10 0 20m Horizontal
2m 1 0 2m Vertical



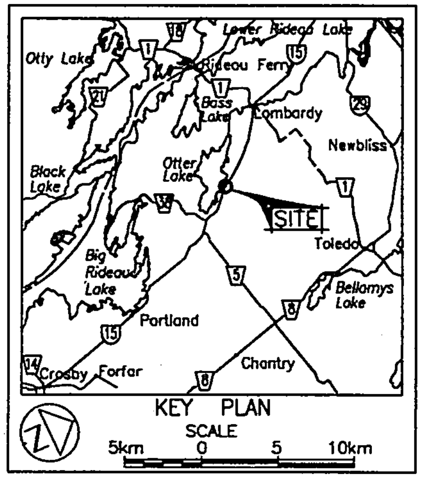
SECTION A-A

SCALE
5m 0 5m



SECTION B-B

SCALE
5m 0 5m



KEY PLAN

SCALE
5km 0 5 10km

LEGEND

⊕	Bore Hole
☒	Pavement Hole
⊕	Dynamic Cone Penetration Test (Cone)
⊕	Bore Hole & Cone
N	Blows/0.3m (Std Pen Test, 475 J/blow)
CONE	Blows/0.3m (60° Cone, 475 J/blow)
▼	WL at time of investigation 99 03
▼	WL in Piezometer
▮	Piezometer

No	ELEVATION	COORDINATES	
		NORTH	EAST
99-1	127.6	4 959 588.2	335 509.4
99-2	127.8	4 959 611.1	335 519.9
99-3	128.1	4 959 630.3	335 536.1
99-4	128.8	4 959 673.4	335 560.9
99-5	129.9	4 959 713.3	335 591.1
99-6	124.8	4 959 600.2	335 536.1
99-7	124.8	4 959 620.9	335 550.2
99-8	124.0	4 959 679.4	335 596.8
99-9	124.9	4 959 595.3	335 497.3
99-10	124.3	4 959 659.0	335 538.1
99-11	124.3	4 959 679.5	335 551.7
10+400	125.9	4 959 742.2	335 592.8
10+500	131.9	4 959 814.5	335 664.7

NOTE

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

Rev.	DATE	BY	DESCRIPTION
	-		-

GEOCRES No

HWY No 15			DIST ---
SUBM'D JLL	CHECKED	DATE APR 6, 1999	SITE
DRAWN GBB	CHECKED	APPROVED	DWG 11108-FE2

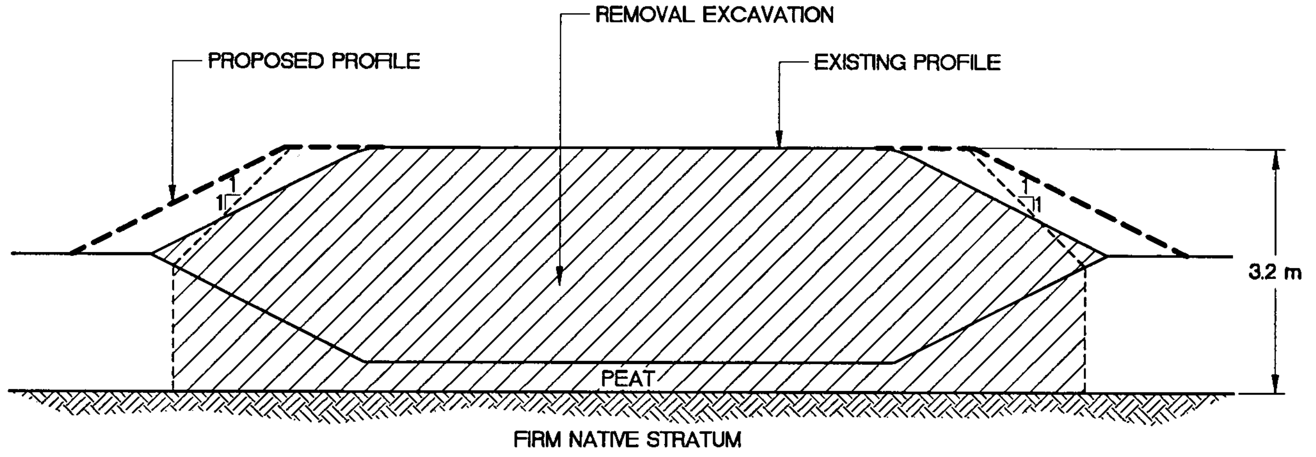
APPENDIX 3

- Detail Sketches of Viable Treatment Options
- Cost Estimates for Viable Treatment Options

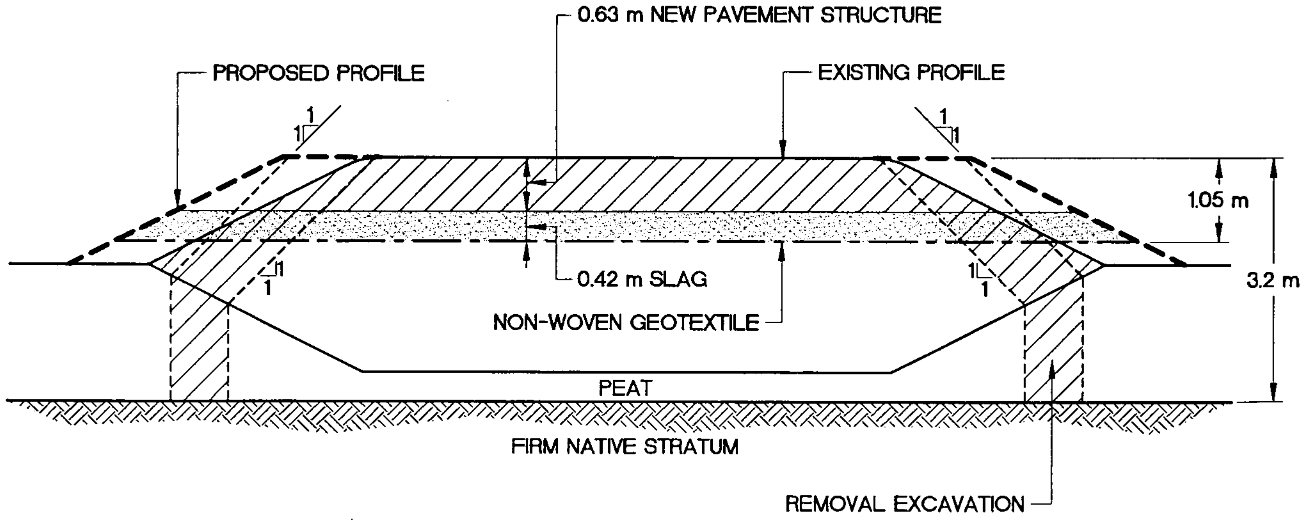
STATION 22+590 TO STATION 22+630

TOWNSHIP OF BASTARD

OPTION #2: **EXCAVATE TO 3.2 m AND REPLACE.**



OPTION #3: **OPSD 203.02 FOR WIDENING, EXCAVATION TO 1.05 m AND BACKFILL WITH 0.42 m SLAG AND 0.63 PAVEMENT STRUCTURE.**



MINISTRY OF TRANSPORTATION OF ONTARIO

HIGHWAY 15 - W.P. 48-83-01

DETAIL SKETCHES OF VIABLE TREATMENT OPTIONS

PORTLAND, ONTARIO

Scale: N.T.S.		**Dwg. No.:** 11108-FE3
Date: 99/04/07	**Dwn. by:** GBB	**Appd.:**

Jacques Whitford

COST ESTIMATES

Station 22+590 to Station 22+630, Township of Bastard

OPTION #2 Excavate to 3.2 m and replace

Excavation width = 17.5 m
Excavation volume = 2240 m^3
Excavation cost = \$10/m^3
Estimated Excavation Cost: \$22,400
Granular width = 17.5 m
Granular thickness = 3.07 m
Granular volume = 2149 m^3
Granular cost = \$10/m^3
Estimated Granular Cost: \$21,490
Geotextile (non-woven) area = 700 m^2
Geotextile cost = \$2/m^2
Estimated Geotextile Cost: \$ 1,400
OPTION #2 Total Cost: \$45,290

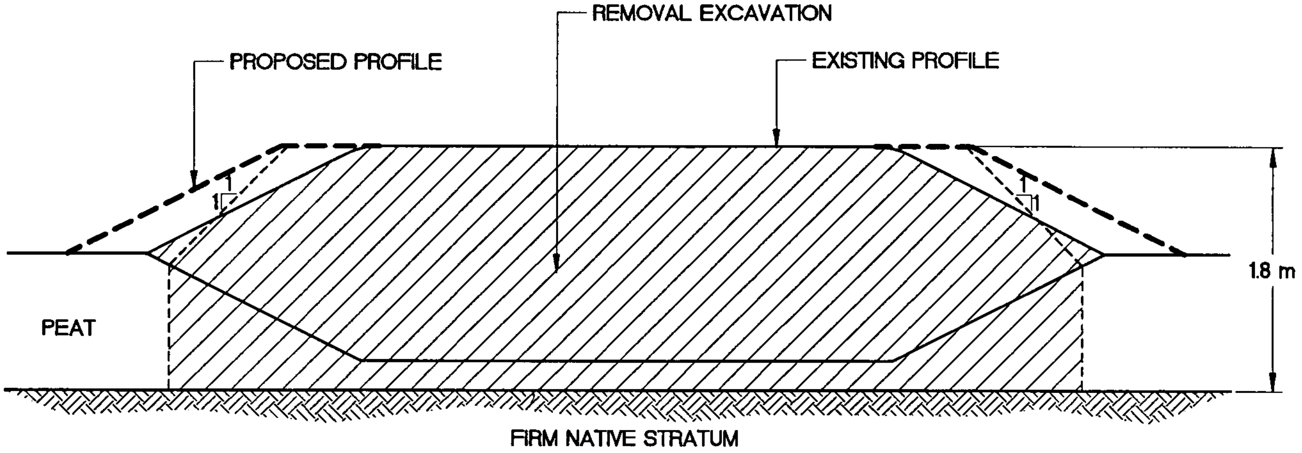
OPTION #3 OPSD 203.04 and Excavate to 1.05 m and backfill with 0.42 m slag and 0.63 m granular/asphalt pavement structure

Main Excavation width = 13 m
Main Excavation volume = 546 m^3
Main Excavation cost = \$10/m^3
Estimated Main Excavation Cost: \$ 5,460
OPSD 203.02 Excavation width (1.0m + 1.2m) = 2.2 m
OPSD 203.02 Excavation depth = 2.15 m
OPSD 203.02 Excavation volume = 189 m^3
OPSD 203.02 Excavation cost = \$10/m^3
Estimated OPSD 203.02 Excavation Cost: \$ 1,890
OPSD 203.02 granular backfill volume = 189 m^3
OPSD 203.02 granular backfill cost = \$10/m^3
Estimated OPSD 203.02 Granular Backfill Cost: \$ 1,892
Slag width = 18 m
Slag volume = 302.4 m^3
Slag cost = \$57/m^3
Estimated Slag Cost: \$17,237
Granular width = 16.5 m
Granular thickness = 0.5 m
Granular volume = 330 m^3
Granular cost = \$10/m^3
Estimated Granular Cost: \$ 3,300
Geotextile (non-woven) area = 720 m^2
Geotextile cost = \$2/m^2
Estimated Geotextile Cost: \$ 1,440
OPTION #3 Total Cost: \$31,219

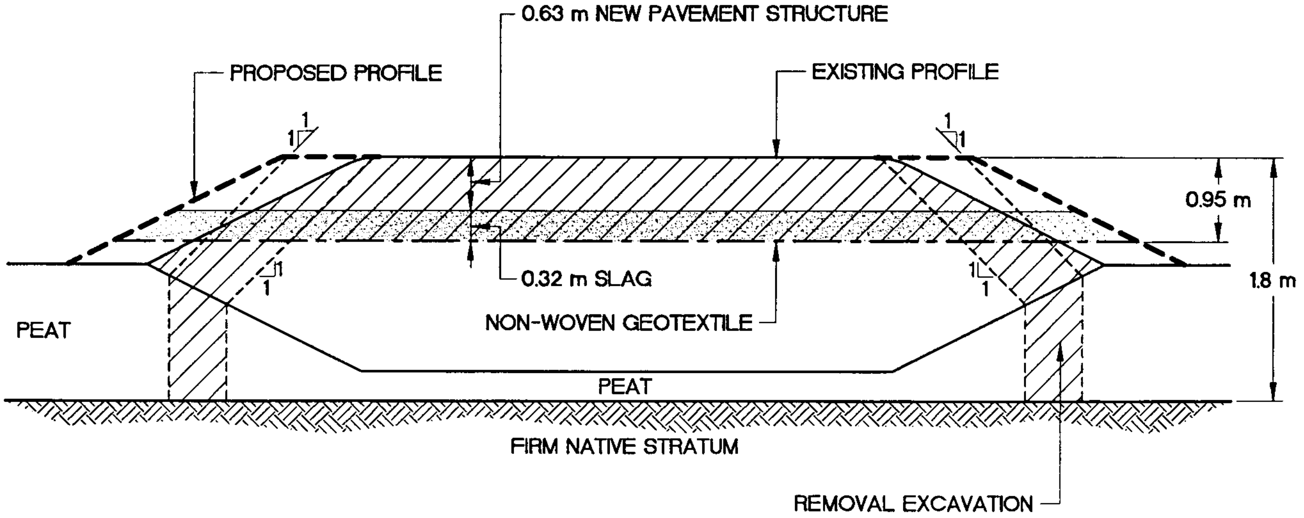
STATION 22+800 TO STATION 22+950

TOWNSHIP OF BASTARD

OPTION #2: **EXCAVATE TO 1.8 m AND REPLACE.**



OPTION #3: **OPSD 203.02 FOR WIDENING, EXCAVATION TO 0.95 m AND BACKFILL WITH 0.32 m SLAG AND 0.63 PAVEMENT STRUCTURE.**



MINISTRY OF TRANSPORTATION OF ONTARIO
HIGHWAY 15 - W.P. 48-83-01
DETAIL SKETCHES OF VIABLE TREATMENT OPTIONS
PORTLAND, ONTARIO

Scale:	Dwg. No.:	
N.T.S.	11108-FE4	

Date:	Dwn. by:	Appd.:
99/04/07	GBB	

Jacques Whitford

Station 22+800 to Station 22+950, Township of Bastard

OPTION #2 Excavate to 1.8 m and replace

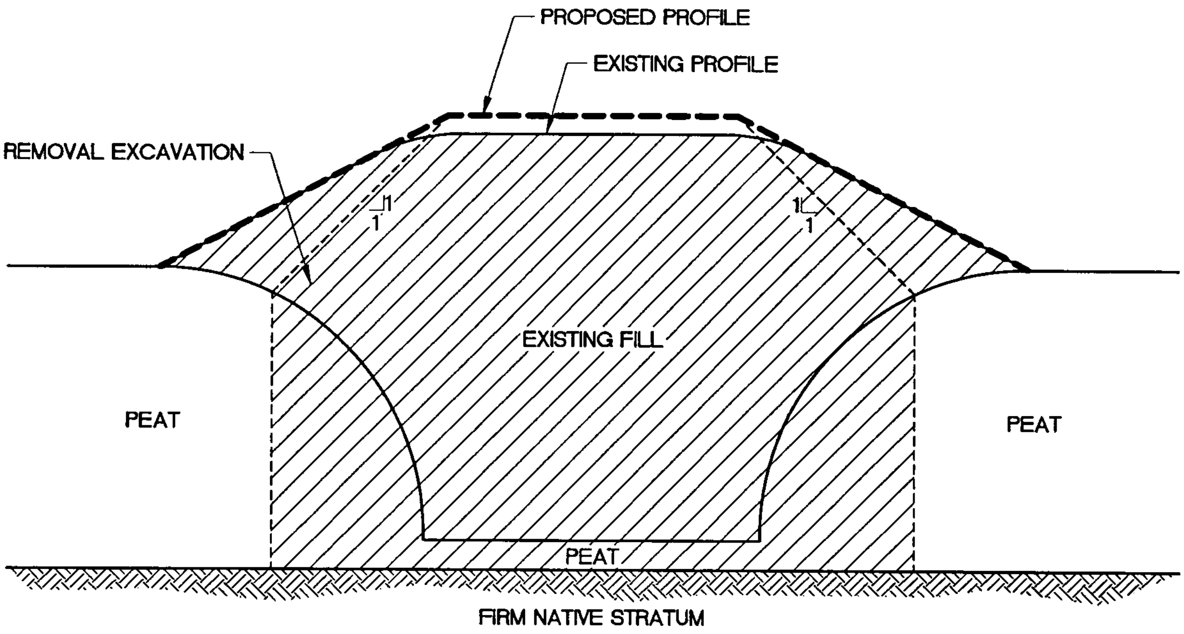
Excavation width = 16 m	
Excavation volume = 4320 m^3	
Excavation cost = $10/$m^3$	
Estimated Excavation Cost:	$43,200
Granular width = 18 m	
Granular thickness = 1.67 m	
Granular volume = 4509 m^3	
Granular cost = $10/$m^3$	
Estimated Granular Cost:	$45,090
Geotextile (non-woven) area = 2700 m^2	
Geotextile cost = $2/$m^2$	
Estimated Geotextile Cost:	$ 5,400
OPTION #2 Total Cost:	$99,090

OPTION #3 OPSD 203.04 and Excavate to 0.95 m and backfill with 0.32 m slag and 0.63 m granular/asphalt pavement structure

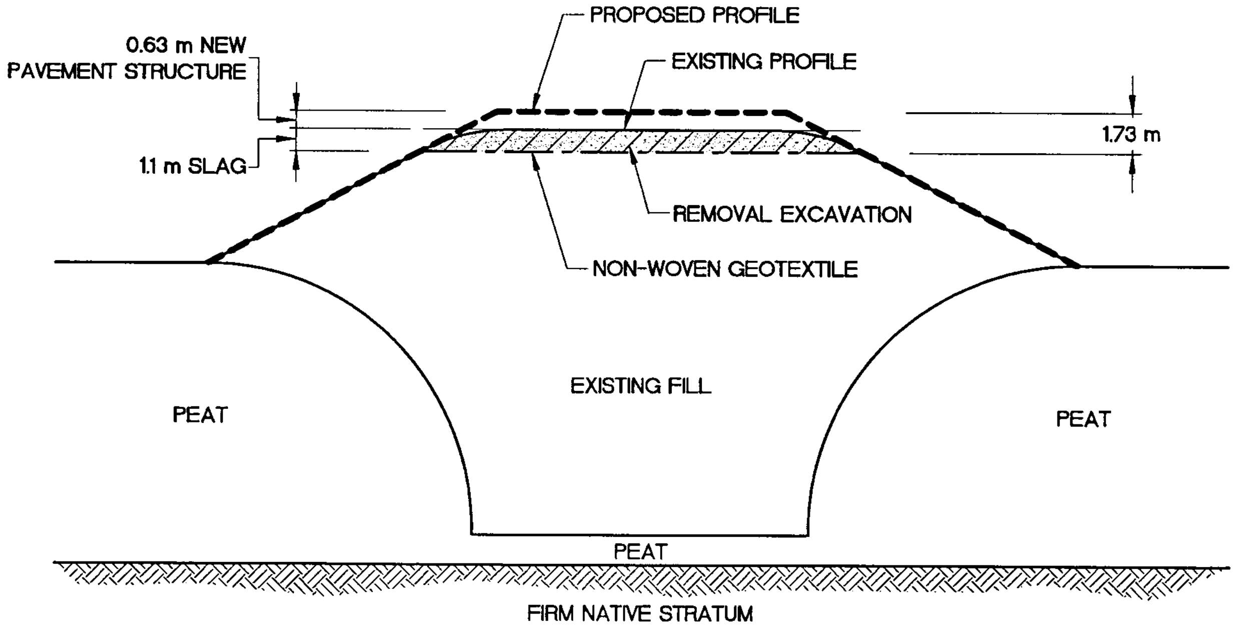
Main Excavation width = 14.5 m	
Main Excavation volume = 2066 m^3	
Main Excavation cost = $10/$m^3$	
Estimated Main Excavation Cost:	$20,660
OPSD 203.02 Excavation width (0.3m + 0.4m) = 0.7 m	
OPSD 203.02 Excavation depth = 0.85 m	
OPSD 203.02 Excavation volume = 90 m^3	
OPSD 203.02 Excavation cost = $10/$m^3$	
Estimated OPSD 203.02 Excavation Cost:	$ 900
OPSD 203.02 granular backfill volume = 90 m^3	
OPSD 203.02 granular backfill cost = $10/$m^3$	
Estimated OPSD 203.02 Granular Backfill Cost:	$ 900
Slag width = 15.5 m	
Slag volume = 840 m^3	
Slag cost = $57/$m^3$	
Estimated Slag Cost:	$47,880
Granular width = 15.5 m	
Granular thickness = 0.5 m	
Granular volume = 1162 m^3	
Granular cost = $10/$m^3$	
Estimated Granular Cost:	$11,620
Geotextile (non-woven) area = 2625 m^2	
Geotextile cost = $2/$m^2$	
Estimated Geotextile Cost:	$ 5,250
OPTION #3 Total Cost:	$87,210

STATION 10+200 TO STATION 10+400
TOWNSHIP OF SOUTH ELMSLEY

OPTION #1: FULL DEPTH ORGANIC/MUSKEG REMOVAL



OPTION #4: PARTIAL EMBANKMENT REMOVAL TO 1.73 m AND BACKFILL WITH 1.1 m SLAG AND 0.63 m PAVEMENT STRUCTURE.



MINISTRY OF TRANSPORTATION OF ONTARIO
HIGHWAY 15 - W.P. 48-83-01
DETAIL SKETCHES OF VIABLE TREATMENT OPTIONS
PORTLAND, ONTARIO

Scale: N.T.S.		**Dwg. No.:** 11108-FE5
Date: 99/04/07	**Dwn. by:** GBB	**Appd.:**

Jacques Whitford

Station 10+200 to Station 10+400, Township of South Elmsley

OPTION #1 Full Depth Organic/Muskeg Removal Over Entire Roadway Width

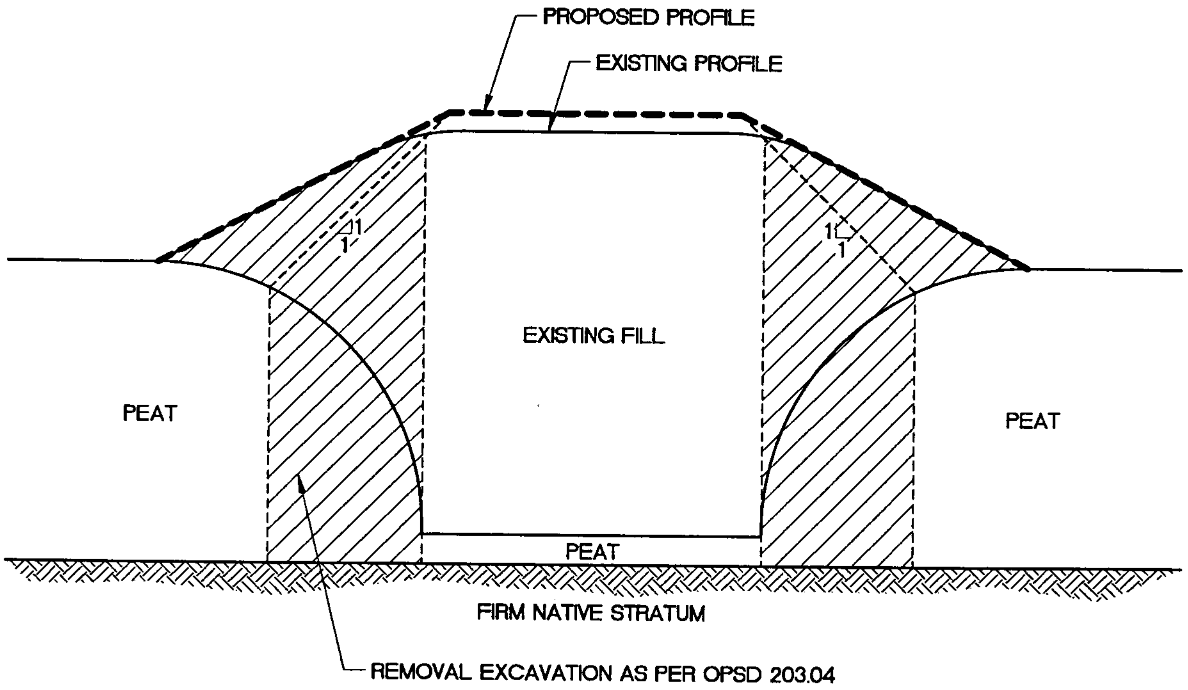
Excavation width = 18 m	
Excavation volume = 53855 m^3	
Excavation cost = \$20/m^3	
Estimated Excavation Cost:	$1,077,100
Granular backfill volume = 52838 m^3	
Granular backfill cost = \$10/m^3	
Estimated Backfill Cost:	$ 69,335
Pavement granular width = 14.5 m	
Pavement granular thickness = 0.5 m	
Pavement granular volume = 1450 m^3	
Pavement granular cost = \$10/m^3	
Estimated Pavement Granular Cost	$ 14,500
Shoring - Sheet Pile height = 14 m	
Shoring cost = $3500/m	
Estimated Shoring Cost:	$ 700,000
OPTION #1 Total Cost:	$2,319,980

OPTION #4 Partial Embankment Removal to 1.73 m and Backfill with 1.1 m slag and 0.63 m granular/asphalt pavement structure

Total Excavation width = 18 m	
Excavation volume = 4931 m^3	
Excavation cost = \$10/m^3	
Estimated Total Excavation Cost:	$ 49,310
Total slag width = 18.3 m	
Slag volume = 3597 m^3	
Slag cost = \$57/m^3	
Estimated Slag Cost:	$205,029
Total granular width = 14.4 m	
Granular thickness = 0.5 m	
Granular volume = 1440 m^3	
Granular cost = \$10/m^3	
Estimated Granular Cost:	$ 14,400
Geotextile (non-woven) area = 3600 m^2	
Geotextile cost = \$2/m^2	
Estimated Geotextile Cost:	$ 7,200
OPTION #4 Total Cost:	$275,939

STATION 10+200 TO STATION 10+400
TOWNSHIP OF SOUTH ELMSLEY

OPTION #5: **FULL DEPTH ORGANIC REMOVAL BEYOND EXISTING EDGE OF SHOULDER**



MINISTRY OF TRANSPORTATION OF ONTARIO HIGHWAY 15 - W.P. 48-83-01 DETAIL SKETCHES OF VIABLE TREATMENT OPTIONS PORTLAND, ONTARIO	**Scale:** N.T.S.	**Dwg. No.:** 11108-FE6	
	Date: 99/04/07	**Dwn. by:** GBB	**Appd.:**

Jacques Whitford

Station 10+200 to Station 10+400, Township of South Elmsley

OPTION #5 Full Depth Organic/Muskeg Removal Beyond Existing Edge of Shoulders

Peat excavation width (3m + 4.5m) = 7.5 m	
Peat excavation volume = 18000 m^3	
Embankment excavation width (7.3m + 5.2m) = 12.5 m	
Embankment excavation volume = 3750 m^3	
Excavation cost = $\$20/m^3$	
Estimated Excavation Cost:	\$ 435,000
Granular backfill volume = 18000 m^3	
Granular backfill cost = $\$10/m^3$	
Estimated Backfill Cost:	\$ 180,000
Embankment backfill volume = 4008 m^3	
Embankment backfill cost = $\$10/m^3$	
Embankment Backfill Cost:	\$ 40,080
Affected pavement granular width = 4.2 m	
Affected pavement granular thickness = 0.5 m	
Affected pavement granular volume = 420 m^3	
Affected pavement granular cost = $\$10/m^3$	
Estimated Affected Pavement Granular Cost	\$ 4,200
Shoring - Sheet Pile height = 14 m	
Shoring cost = \$3500/m	
Estimated Shoring Cost:	\$ 700,000
OPTION #5 Total Cost:	\$1,359,280

22+880 3.4 Rt C/L

0	-	120	Asph
120	-	360	Br Sa with Gr Tr Si (DF-104)
360	-	670	CTB (DF-105)
670	-	1.5	Dk Br Cl Si Tr Sa Tr Gr (DF-106)

22+880 4.1 Rt C/L

0	-	340	Br Sa with Gr Tr Si
340	-	670	CTB
670	-	1.5	Dk Br Cl Si Tr Sa Tr Gr

22+880 7.6 Rt C/L (D-0.7)

0	-	1.2	Dk Br-Blk Wdy Org Peat
1.2	-	1.5	Grey Br-Sa Si Tr Gr Tr Cl

22+880 9.5 Rt C/L (D-1.4)

0	-	960	Dk Br-Blk Wdy Org Peat
960	-	1.5	Br Sa Si Tr Gr Tr Cl

22+890 3.3 Rt C/L PA

0	-	180	Asph
180	-	550	Br Cr Gr
550	-	750	Asph
750	-	1.0	Br Si Sa Stny
1.0	-	1.2	Gry Cl Sa Tr Org
1.2	-	1.5	Blk Org Tr Wood
1.5	-		Br Si Sa (wet)

22+910 3.3 Lt C/L PA

0	-	260	Asph
260	-	600	Br Cr Gr
600	-	1.2	Br Si Sa Grly
1.2	-	NFP	RF

22+910 3.3 Rt C/L PA

0	-	180	Asph
180	-	550	Br Cr Gr
550	-	750	Asph
750	-	1.0	Br Si Sa Stny
1.0	-	1.5	Gry Cl Sa Tr Org

22+920 9.6 Lt C/L (D-1.3)

0	-	120	Dk Br Sa Si Tps
120	-	1.5	Lt Grey-Br Si Cl some Sa Tr Gr

22+920 7.4 Lt C/L (D-0.6)

0	-	160	Dk Br Si Sa Tps
160	-	1.1	Dk Br Si Cl Tr Gr
1.1	-	1.5	Lt Grey-Br Si Cl some Sa Tr Gr

22+920 7.6 Rt C/L (D-0.6)

0	-	170	Dk Br Si Sa Tps
170	-	1.0	Dk Br Si Cl Tr Gr (DF-107)
1.0	-	1.5	Lt Grey-Br Si Cl some Sa Tr Gr (DF-108)

22+920 9.6 Rt C/L (D-1.5)

60	-	0	**Water**
0	-	1.5	**Lt Grey-Br Si Cl some Sa Tr Gr**

22+930 3.3 Lt C/L PA

0	-	260	Asph
260	-	550	Br Cr Gr
550	-	1.3	Br Si Sa Grly
1.3	-	NFP	RF

23+100 3.3 Lt C/L PA

0	-	270	Asph
270	-	800	Gry Cr Gr (94-LV-118) % Ret. 4.75 mm = 60.7 % Passing 75 µm = 3.8 Accep Granular "A"
800	-	1.2	Br Si Sa
1.2	-	1.5	Grey Si Cl with Org (M&F)

23+100 3.4 Rt C/L PA

0	-	240	Asph
240	-	1.0	Gry Cr Gr
1.0	-	1.5	Br Si Sa (Dense)

23+150 10 Lt C/L (1.3) HA

0	-	200	Blk Org
200	-	1.2	Br Si Cl Tr Org

23+150 5 Lt C/L PA

0	-	300	Br Cr Gr
300	-	1.4	Br Si Sa wet @ 1.0m (94-LV-117) % Ret. 4.75 mm = 6.2 % Passing 75 µm = 17.4 Not Accep Gran "B" Type I Accep SSM
1.4	-	1.5	Blk Org

23+150 5 Rt C/L PA

0	-	150	Br Cr Gr
150	-	350	Br Si Sa
350	-	700	Gry Cr Gr
700	-	800	Asph
800	-	1.0	Gry Cr Gr
1.0	-	1.3	Br Si Sa
1.3	-		Gry Sa Cl Tr Org

23+150 -17 Rt C/L (-0.8) HA

0	-	300	Br Sa Tps
300	-	1.2	Br Sa Cl (M&F)

23+200 12 Lt C/L (-1.5) HA

0	-	400	Blk Org
400	-	1.2	Br SA Cl (moist& firm)

23+200 16 Rt C/L (-1.2) HA

0	-	250	Br Sa Tps
250	-	1.2	Br Sa Cl (M&F)