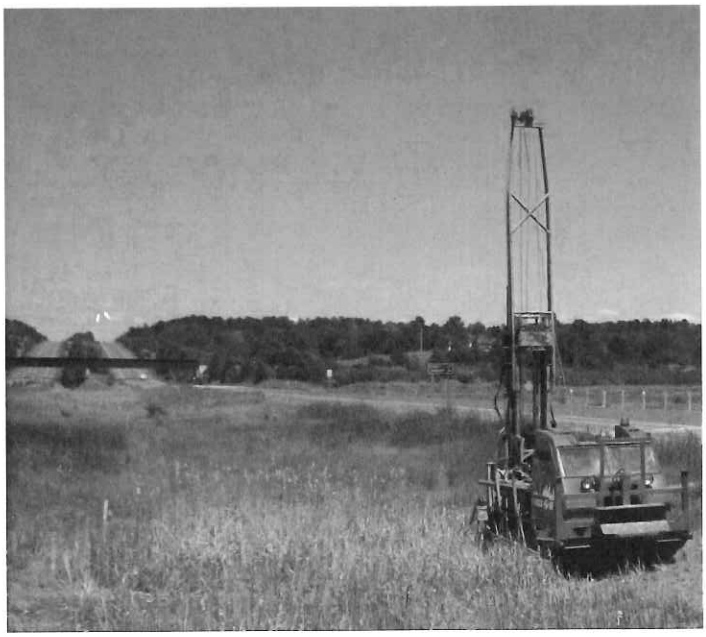
REPORT

June 6, 2015

FOUNDATION INVESTIGATION AND DESIGN REPORT

HIGH FILL EMBANKMENTS OVER SWAMPS
HIGHWAY 17 FOUR-LANING EXTENSION FROM 20.5 KM WEST OF HIGHWAY 144, EASTERLY FOR 6.5 KM
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 156-98-00

Submitted to:
D.M. Wills Associates Ltd.
150 Jameson Drive
Peterborough, Ontario
K9J 0B9



GEOCRES NO.: 41I-323

Report Number: 11-1191-0007-01

Distribution:

5 Copies - Ministry of Transportation, Ontario, North Bay, ON (Northeastern Region)
1 Copy - Ministry of Transportation, Ontario, Downsview, ON (Foundations Section)
2 Copies - D. M. Wills Associates Ltd., Peterborough, ON
1 Copy - Golder Associates Ltd., Sudbury, ON

Golder Associates

Table of Contents

PART A

FOUNDATION INVESTIGATION REPORT

HIGH FILL EMBANKMENTS OVER SWAMPS

HIGHWAY 17 FOUR-LANING EXTENSION FROM 20.5 KM WEST OF HIGHWAY 144, EASTERLY FOR 6.5 KM

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 156-98-00

June 6, 2015
Report No. 11-1191-0007-01

Golder Associates

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by D.M. Wills Associates Ltd. (DMW) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for high fill embankments crossing over swamp areas located within the limits of the new Highway 17 four-laning alignment. The proposed high fill embankments outlined in the project limits are part of the new Highway 17 interchange and extension of the existing four-laning at the West Junction of Sudbury Municipal Road 55, from 20.5 km west of Highway 144, easterly for 6.5 km. The general location of the Highway 17 four-laning extension is shown on the Site Location Plan on Drawing 1.

The Terms of Reference and the Scope of Work for the foundation investigation are outlined in MTO's Request for Proposal, dated March 2011. Golder's proposal for foundation engineering services associated is contained in Section 6.8 of DMW's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated November 11, 2011. The base plan showing the proposed horizontal alignment and a drawing showing the proposed vertical alignment for the Highway 17 four-laning extension was provided to Golder by DMW in January 2012.

This report addresses the investigation carried out for the high fill embankments over swamps only. A detailed list of the locations of the high fill embankments is presented in Table 1. Separate reports detail the results of the foundation investigations for the culverts and bridge structures for this project.

Preliminary subsurface information for this project is available and was supplied by MTO, in the reports and subsequent appendices titled below:

- *Planning, Preliminary Design, and Environmental Assessment Report, Highway 17, Town of Walden,* GWP 156-98-00, dated August 2008 by Stantec Consulting Limited
    - Appendix N: Alternate Route Geotechnical Assessment Report, Highway 17, Town of Walden, GWP 156-98-00, Index No: 080FGR, PML Ref: 05TF059G dated July 29, 2008 by Peto MacCallum Ltd.
    - Appendix O: Alternate Route Foundation Assessment Report, Highway 17, Town of Walden, GWP 156-98-00, Index No: 072FFR, PML Ref: 05TF059F, dated May 20, 2008 by Peto MacCallum Ltd.
- *Planning, Preliminary Design, and Environmental Supplementary Report, Highway 17, Town of Walden,* GWP 156-98-00, dated March 2009 by Stantec Consulting Limited
    - Preliminary Geotechnical Investigation Report, Highway 17, Town of Walden, GWP 156-98-00, Index No: 102FGIR, PML Ref: 05TF059G1 dated March 3, 2009 by Peto MacCallum Ltd.

2.0 SITE DESCRIPTION

The overall project consists of the detail design for the four-laning of Highway 17 from the end of the existing four lanes at the west junction of Sudbury Municipal Road 55, from approximately 20.5 km west of Highway 144 easterly for 6.5 km, including a new interchange. The proposed highway alignment approximately follows the existing alignment of Highway 17 generally oriented in an east to west direction and south of the existing highway within the project limits.

In general, the topography of this area consists of rolling terrain, including sparsely populated treed areas and numerous bedrock outcrops separated by low-lying swamps containing areas of standing water and various vegetation types and organic soils. The land use in the general area includes residential and scattered rural farm use. The ground surface within the limits of the study area varies between about Elevation 248 m and Elevation 239 m. A detailed description of each investigated area of high fill embankment over a swamp is presented in Section 4.0.

3.0 INVESTIGATION PROCEDURES

The investigation for the Highway 17 high fill embankments crossing over swamp areas was carried out between March 7 and July 12, 2012, between August 27 and October 1, 2012, October 23 and 24, 2012, and January 8 and 9, 2014, during which time a total of one hundred and nineteen (119) boreholes and fifty-three (53) Dynamic Cone Penetration Tests (DCPTs) were advanced. The locations of the boreholes and DCPTs are summarized in Table 1 and are shown on Drawings A1 to C1 in Appendices A to C. In general, boreholes and DCPTs were advanced along the centreline and the toes of the proposed embankment alignment.

The field investigation was carried out using a variety of drilling equipment due to the varying nature of the terrain within the project limits. The details of the drilling equipment and supplier are listed below. Hand excavation methods were used as appropriate depending on the terrain.

Drilling Equipment	Supplied and Operated By
Track Mounted CME-55 Track Mounted CME-850 Portable Tripod Equipment	Landcore Drilling Inc. of Chelmsford, Ontario

The boreholes were advanced through the overburden using 108 mm inner diameter hollow-stem augers and/or NW casing with wash boring techniques and NQ size core barrel for bedrock coring, where applicable, to advance through obstructions. In general, soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler (operated by automatic hammers on the drill rigs), in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586, Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils). Boreholes advanced by portable equipment generally employed full weight hammers lifted manually and dropped from the SPT height; however, a limited number of boreholes employed half-weight hammers lifted manually to the SPT height and the 'N'-values were corrected for the lower energy drive. Samples of the cohesive soils were obtained using 76 mm O.D. thin-walled 'Shelby' tubes (ASTM D1587, Standard Practice for Thin-Walled Tube Sampling) for relatively undisturbed samples. Field vane shear tests were conducted in cohesive soils for assessment of undrained shear strengths (ASTM D2573, Standard Test Method for Field Vane Strength Shear Test) using MTO Standard 'N' size vanes. All boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The boreholes were advanced to depths up to about 31 m below existing ground surface, generally penetrating 3 m into competent material, which is defined as material that will provide resistance to settlement or instability of the embankments, or to refusal. Some boreholes and DCPTs were terminated on refusal to further dynamic cone penetration, auger, casing and/or split-spoon advancement. These depths to refusal do not confirm bedrock surface elevations, but may be inferred to indicate the potential proximity to the bedrock surface. At

various locations where refusal was encountered at shallow depth, the bedrock was exposed by hand shovel excavation to confirm the refusal condition.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets provided in Appendices A to C. Groundwater elevations as encountered in the boreholes may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized upon completion of drilling. Furthermore, groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability.

The field work was observed by members of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury Geotechnical Laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected representative samples. In addition, one-dimensional consolidation (oedometer) tests were carried out on selected samples of the cohesive deposits and the results of the consolidation test results are presented in Table 2. The results of the laboratory testing for each of the high fill embankments are included in the associated appendices.

The proposed centreline of the new Highway 17 alignment was staked in the field by exp. prior to drilling. The as-drilled borehole locations, in stations and offsets, were measured in reference to the centreline alignment and were subsequently converted into coordinates in AutoCAD. Borehole elevations were surveyed by members of our technical staff in reference to the ground surface elevations at temporary benchmarks installed by exp. prior to the commencement of fieldwork. The borehole locations given in the Record of Borehole sheets and shown on the Drawings are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in the NOEGTS[1] Mapping, the subsoils in this section of Highway 17 are comprised of undulating to rolling glaciolacustrine plain, alluvial plain and organic terrain deposits interspersed with numerous bedrock knobs, outcrops and ridges. In the lower-lying glaciolacustrine plain and alluvial plain areas the primary material consists of wet silts, sands and clays, while the organic terrain deposit the primary material consists of peat. The surface water drainage in the area varies from moderate to poor, corresponding to areas of moderate to low relief.

Based on geological mapping by the Ministry of Natural Resources (Map 2542)[2], the site is underlain by rocks of the Paleoproterozoic Era belonging to the Huronian Supergroup and Elliot Lake Group consisting of conglomerate, wacke, arkose, quartz arenite, argillite, limestone and dolostone. Areas of mafic and related intrusive rocks comprised of diabase sills, dykes and related granophyre are also present in the vicinity of the

[1]Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Digital Map Reference Number 41ISW.

[2] Ministry of Natural Resources. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey - Map 2542

site. Based on geological mapping by the Ontario Department of Mines (Map 2170) [3] this area is characterized by extensive faults from distinct time periods. The Murray Fault has been identified to run parallel to the approximate proposed alignment of Highway 17.

4.2 General Overview of Local Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the borings advanced during this investigation together with the results of the laboratory tests carried out on selected soil samples for the respective high fill areas are presented on the Record of Borehole sheets and the laboratory test figures provided in Appendices A to C. The results of the in situ field tests (i.e., SPT 'N'-values and undrained shear strengths from the field vanes) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs and in situ testing. 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. The thickness of the overburden in the investigated areas as inferred from resistance to DCPT results are shown on the Record of Penetration Test sheets in Appendices A to C, as applicable.

The locations of the boreholes and DCPTs advanced in the Highway 17 high fill embankment areas are shown in plan on Drawings A1 to C1, while the inferred soil stratigraphy as encountered shown in profile are shown on Drawings A2 to A4, B2 to B5 and C2 to C4 in Appendices A to C. It should be noted that the orientation (i.e., north, south, east, west) stated in the text of the report is typically referenced to project north and therefore may differ from the Magnetic North shown on the drawings.

In general, the stratigraphy encountered at the various areas investigated is similar. However the overburden (soil materials) thickness is variable, ranging from no cover (bedrock outcrops exposed at the ground surface) to about 31 m. The generalized stratigraphy can be described as follows:

- embankment fill where the existing and proposed alignments overlap;
- surficial layers of topsoil or fibrous peat outside the existing highway;
- cohesionless deposits of sand to sandy silt underlying the organics/fill deposits in some areas;
- cohesive deposits of clayey silt to clay, varved in some areas; and
- cohesionless deposits of silt to sand and gravel below the cohesive deposits to the inferred bedrock surface.

Detailed descriptions of the subsurface conditions encountered at each investigated high fill embankment are provided in the following sections of this report. Where relatively significant thicknesses of overburden were encountered, the various soil types are described in detail for each main deposit or stratum.

[3] Ontario Department of Mines (1969), Sudbury Mining Area, Sudbury District, Map 2170.

4.3 Highway 17 WBL – STA 12+220 to 12+570 (High Fill H1)

The plan and profiles along the centreline and toes of the proposed embankment of the new Highway 17 West Bound Lane (WBL) alignment showing the borehole locations and interpreted stratigraphy between STA 12+220 to STA 12+570 in the Township of Louise are shown in Drawings A1 to A3 in Appendix A. The southerly portion of the alignment extends across a low-lying swampy area with the proposed embankment up to 5.7 m high above the existing ground surface. The northerly portion of the alignment overlaps with the existing Highway 17 embankment. A total of seventeen (17) boreholes (Boreholes H1-1 to H1-9, H1-11 to H1-15, C1-1 to C1-3) and six (6) DCPTs (H1-DC1 to H1-DC6) were completed to investigate the subsurface conditions within this portion of High Fill Area H1.

The subsurface soils along the WBL alignment in High Fill Area H1 consist of embankment fill or a peat/topsoil deposit underlain by a sand and silt deposit and a cohesive deposit of varved, silty clay to clay transitioning into clayey silt, which in turn is underlain by deposits of silt, sand and silt to sand and sand and gravel to gravelly sand.

4.3.1 Asphalt

A 130 mm thick layer of asphalt was encountered at ground surface in Boreholes H1-1 and H1-3.

4.3.2 Fill

Underlying the asphalt in Boreholes H1-1 and H1-3, and from ground surface in Boreholes H1-2, H1-4, H1-5, H1-7, H1-8, H1-9 and H1-12, a stratum of sand to sand and gravel mixed with blast rock fill was encountered. In Borehole H1-8 the sand and gravel transitioned into sandy silt at 2.2 m depth. The surface of the fill stratum was encountered between Elevation 246.5 m and 241.6 m, and the thickness ranges between 0.2 m and 6.1 m. Boreholes H1-1, H1-2 and H1-4 were terminated within this stratum and were located in close proximity to an exposed bedrock cut.

The SPT 'N'-values measured within the sand, sand and gravel and sandy silt fill stratum range from 19 blows to 79 blows per 0.3 m of penetration, indicating a compact to very dense relative density. In Borehole H1-9 a 'N'-value of 113 blows per 0.3 m of penetration was encountered, however it was likely indicative of the frozen nature of the fill at the time of the field investigation. Some instances within the sand and gravel to gravelly sand portions of the fill deposit the split-spoon sampler did not penetrate the full sample depth due to inferred blast rock fill fragments within the fill and rock coring techniques were required to advance the borehole through these zones.

The grain size distributions of two samples of the fill deposit are shown on Figure A1 in Appendix A.

The natural water content measured on a sample of the sand and gravel fill is about 3 per cent. The natural measured water content for a sample of the sandy silt fill is about 13 per cent.

4.3.3 Peat/Topsoil

In Boreholes H1-6, H1-11, H1-13, H1-14, C1-1 and C1-3, a deposit of black fibrous peat was encountered from ground surface. In Boreholes H1-15 and C1-2 a surficial layer of topsoil was encountered at ground surface.

The top of the peat/topsoil layer varies in elevation from 244.6 m to 241.3 m, and the thickness ranges from about to 0.1 m to 0.9 m.

The SPT 'N'-values measured within the peat/topsoil deposit range from 0 blows (weight of hammer) to 11 blows per 0.3 m of penetration, indicating a very soft to stiff consistency, however, the higher 'N'-values are attributed to frost.

The natural water content measured on two samples of the peat are about 48 per cent and 157 per cent.

4.3.4 Sand and Silt

A deposit of sand and silt was encountered underlying the fill in Boreholes H1-3, H1-5 and H1-7 and underlying the peat deposit in Borehole H1-6. The top of the sand and silt deposit was encountered between Elevation 242.1 m and 240.2 m, and the thickness ranges between 1.1 m and 2.3 m. Borehole H1-3 terminated within this deposit.

The SPT 'N'-values measured within the sand and silt layer range from 5 blows to 14 blows per 0.3 m of penetration indicating a loose to compact relative density.

The grain size distributions of two samples of the sand and silt deposit are shown on Figure A2 in Appendix A.

The natural water content measured on two samples of the sand and silt deposit is about 21 per cent and 23 per cent.

4.3.5 Cohesive Deposit

In Boreholes H1-5 to H1-9, H1-11 to H1-15 and C1-1 to C1-3, a cohesive deposit was encountered beneath the peat/topsoil or fill or sand and silt deposits. In general the cohesive deposit consisted of an upper varved silty clay to clay zone transitioning into a lower clayey silt zone. The top of the cohesive deposit was encountered between Elevation 244.2 m and 238.8 m and the overall deposit ranged between 1.8 m and 7.9 m in thickness.

Silty Clay to Clay

Underlying the peat/topsoil in Boreholes H1-11, H1-13, H1-14, H1-15 and C1-1 to C1-3 and underlying the fill and or sand and silt deposits in Boreholes H1-5 to H1-9 and H1-12, a deposit of brown to grey silty clay to clay was encountered. In the majority of the boreholes, the silty clay to clay was observed to be varved, consisting of irregular layers of clayey silt/silty clay and silty clay/clay. The top of the silty clay to clay deposit ranges from Elevation 244.2 m to 238.8 m and the thickness ranges from 1.8 m to 7.9 m.

The SPT 'N'-values measured within this deposit range between 0 blows (weight of hammer) and 17 blows per 0.3 m of penetration, suggesting a very soft to very stiff consistency. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 16 kPa to 61 kPa, and the sensitivity is calculated to range from about 2 to 25, typically less than 9. The field vane tests results indicate that the silty clay to clay has a soft to stiff consistency.

The grain size distributions of three samples of the silty clay to clay are shown on Figure A3 in Appendix A.

Atterberg limits tests were carried out on sixteen samples of the silty clay to clay portion of the deposit and indicated liquid limits ranging from about 35 per cent to 61 per cent, plastic limits ranging from about 20 per cent to 26 per cent and plasticity indices ranging from about 13 per cent to 37 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure A4 in Appendix A and indicate that the material is classified as silty clay of intermediate plasticity to clay of high plasticity.

The natural water content measured on twenty-two samples of the silty clay to clay ranges from about 23 per cent to 65 per cent.

Clayey Silt

Underlying the silty clay to clay portion of the deposit in Boreholes H1-6 and H1-15, the silty clay to clay transitioned into grey clayey silt. The top of the clayey silt portion of the deposit ranges from Elevation 241.2 m to 234.1 m and the thickness ranges from 0.9 m to 1.6 m.

The SPT 'N'-values measured within this deposit range between 1 blow and 12 blows per 0.3 m of penetration, suggesting a very soft to stiff consistency. One in situ field vane test carried out within this deposit measured an undrained shear strength of about 44 kPa, and the sensitivity is calculated to be about 9. The field vane test result indicates that the clayey silt has a firm consistency.

An Atterberg limits test was carried out on one sample of the clayey silt portion of the deposit and indicated a liquid limit of about 35 per cent, plastic limit of about 20 per cent and a plasticity index of about 15 per cent. The results of the Atterberg limits test are shown on the plasticity chart on Figure A5 in Appendix A and indicate that the material is classified as clayey silt of low plasticity.

The natural water content measured on one sample of the clayey silt is about 42 per cent.

4.3.6 Silt

Underlying the cohesive deposit in Boreholes H1-5 to H1-9, H1-11, H1-12, H1-14 and C1-1 to C1-3, a deposit of grey silt was encountered. The top of this deposit ranges from about Elevation 241.0 m to 232.4 m, and ranges from 1.3 m to 4.4 m in thickness. A DCPT was advanced below the borehole termination depth in Borehole C1-1.

The SPT 'N'-values measured within the silt to sandy silt portion of the deposit range between 1 blow and 15 blows per 0.3 m of penetration, indicating a very loose to compact relative density. One SPT 'N'-value was measured to be 75 blows per 0.08 m of penetration, likely indicative of the close proximity of the bedrock surface.

The grain size distributions of eight samples of the silt are shown on Figure A6 in Appendix A.

An Atterberg limits test was carried out on one sample of the silt and indicated a liquid limit of about 28 per cent, a plastic limit of about 24 per cent and a plasticity index of just below 4 per cent. The results of the Atterberg limit test are shown on the plasticity chart on Figure A7 in Appendix A and indicate that the material is classified as silt of slight plasticity. The results of four additional Atterberg limits tests indicate that the material is non-plastic.

The natural water content measured on ten samples of the silt deposit ranges between about 23 per cent and 32 per cent.

4.3.7 Sand and Silt to Sand

Underlying the silt in Boreholes H1-4 to H1-9, H1-11 and H1-14 and underlying the cohesive deposit in Boreholes H1-13 and H1-15, a stratum of grey, sand and silt to sand was encountered. The surface of the stratum was encountered between Elevation 240.3 m and 228.5 m. Boreholes H1-5 to H1-9, H1-13 were terminated within this stratum.

The SPT 'N'-values measured within the sand and silt to sand portion of the deposit range between 0 blows (weight of hammer) and 49 blows per 0.3 m of penetration indicating a very loose to dense relative density. One SPT 'N'-value was measured to be 10 blows per 0.1 m of penetration likely indicative of the close proximity of the bedrock surface.

The grain size distributions of six samples of the sand and silt to sand are shown on Figure A8 in Appendix A.

The results of Atterberg limits testing on one sample indicated that the material is classified as non-plastic.

The natural water content measured on six samples of this deposit ranges between about 19 per cent and 24 per cent.

4.3.8 Sand and Gravel

In Boreholes H1-11, H1-13 and H1-15, a deposit of grey sand and gravel was encountered underlying the silty sand deposit. The top of the sand and gravel deposit was encountered between Elevation 239.0 m and 237.6 m and ranged from 1.7 m to 5.4 m in thickness.

The SPT 'N'-values measured within this portion of the deposit range between 3 blows and 24 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The grain size distributions of three samples of the sand and gravel are shown on Figure A9 in Appendix A.

The natural water content measured on three samples of this portion of the deposit ranges between about 8 per cent and 12 per cent.

4.3.9 Refusal

Refusal to split-spoon and dynamic cone penetration, indicating proximity to the inferred bedrock surface was encountered in Boreholes H1-1 to H1-6, H1-11 to H1-15, C1-1 and DCPTs H1-DC1, H1-DC5 and H1-DC6 at depths ranging from 0.2 m and 19.4 m below the ground surface or between Elevation 245.2 m and 223.8 m. In Boreholes C1-2 and DCPTs H1-DC2 to H1-DC4, the DCPT terminated upon recording greater than 100 blows per 0.3 m of penetration, indicative of proximity to the inferred bedrock surface, at depths up to about 17 m below the existing ground surface.

In Borehole H1-12, split-spoon refusal was encountered at 6.6 m depth (Elevation 239.7 m) within the silt stratum. In this instance, refusal is likely indicative of the presence of an obstruction.

4.3.10 Groundwater Conditions

In general, the soil samples taken in the boreholes were moist to wet. Boreholes H1-1 to H1-4 were dry upon completion of drilling. Groundwater levels observed upon completion of drilling in the remaining boreholes range from Elevation 242.7 m to 239.8 m, measured between ground surface and 6.2 m below ground surface. Borehole H1-6 measured a groundwater level of 0.3 m above ground surface (Elevation 241.6 m) upon completion of drilling. It should be noted that the groundwater levels in the area fluctuate seasonally as well as during precipitation events and snowmelt.

4.4 Highway 17 EBL – STA 12+220 to 12+570 (High Fill H1)

The plan and profiles along the centreline and toes of the proposed embankment of the new Highway 17 East Bound Lane (EBL) alignment showing the borehole locations and interpreted stratigraphy between about STA 12+220 to STA 12+570 in the Township of Louise are shown in Drawings A1 to A4 in Appendix A. The EBL extends across a low-lying swampy area with the proposed embankment up to 5.7 m high above the existing ground. A total of seventeen (17) boreholes (Boreholes H1-16 to H1-30, C1-3 and C1-4) and six (6) DCPTs (H1-DC7 to H1-DC12) were completed to investigate the subsurface conditions within this portion of High Fill Area H1.

The subsurface soils along the EBL alignment in High Fill Area H1 consist of a surficial layer of peat/topsoil underlain by a sandy silt deposit and a cohesive deposit of clayey silt to silt transitioning into varved, silty clay to clay transitioning back into clayey silt, which in turn is underlain by deposits of silt to sandy silt, sand and silt to sand and gravelly sand.

4.4.1 Peat/Topsoil

In all boreholes except H1-29 a deposit of black fibrous peat was encountered from ground surface. In Borehole H1-29 a surficial layer of topsoil was encountered at ground surface. The top of the peat/topsoil layer varies in elevation from 241.6 m to 241.0 m and the thickness ranges from 0.2 m to 1.4 m. In Borehole H1-23, a layer of brown to black organic clay was encountered below the peat at 0.3 m depth and was 1.0 m in thickness.

The SPT 'N'-values measured within the peat/topsoil deposit range from 0 blows (weight of hammer) to 7 blows per 0.3 m of penetration, indicating a very soft to firm consistency, however, the higher 'N'-values are typically attributed to frozen ground conditions.

The natural water content measured on seven samples of the peat ranges from about 39 per cent to 420 per cent.

4.4.2 Sandy Silt

A layer of sandy silt was encountered underneath the peat/organics layer in Boreholes H1-16 to H1-19, and H1-22. The top of the deposit was encountered between Elevation 241.0 m and 239.8 m and ranged from 0.2 m to 0.8 m in thickness.

The SPT 'N'-values measured within the sandy silt layer range from 4 blows to 14 blows per 0.3 m of penetration indicating a loose to compact relative density.

The grain size distribution of one sample of the sandy silt is shown on Figure A10 in Appendix A.

The natural water content measured on two samples of the sandy silt deposit are about 23 per cent and 33 per cent.

4.4.3 Cohesive Deposit

In all boreholes, a cohesive deposit was encountered beneath the peat/organics deposit or beneath the sandy silt deposit. In general the cohesive deposit consisted of an upper clayey silt to silt zone transitioning into varved silty clay to clay, further transitioning back to a lower clayey silt to silt zone. The top of the cohesive deposit was encountered between Elevation 241.2 m and 239.0 m and the overall deposit ranged between 2.0 m and 9.4 m in thickness.

Clayey Silt to Silt

Underlying the sandy silt deposit in Borehole H1-17 and underlying the peat/organic clay deposit in Boreholes H1-23 and H1-25, a clayey silt to silt deposit was encountered. The top of the clayey silt to silt portion of the deposit was encountered between Elevation 240.6 m and 240.0 m and ranged from 0.9 m to 2.4 m in thickness.

The SPT 'N'-values measured within this portion of the deposit range between 1 blow and 7 blows per 0.3 m of penetration, indicating a very soft to firm consistency.

The grain size distribution of one sample of the clayey silt to silt portion of the deposit is shown on Figure A11 in Appendix A.

Atterberg limits tests were carried out on three samples of the clayey silt to silt portion of the deposit and test results indicate liquid limits ranging from about 24 per cent to 32 per cent, plastic limits ranging from about 17 per cent to 21 per cent and plasticity indices ranging from about 7 per cent to 12 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure A12 in Appendix A and indicate that the material is classified as clayey silt to silt of low plasticity.

The natural water content measured on three samples of this portion of the deposit ranges between about 26 per cent and 30 per cent.

Silty Clay to Clay

In all boreholes a deposit of grey, silty clay to clay was encountered underlying the peat and/or silt to sandy silt and/or the clayey silt deposit. In the majority of the boreholes, the silty clay to clay portion of the deposit was observed to be varved, consisting of irregular layers of clayey silt/silty clay and silty clay/clay. The top of the silty clay to clay portion of the deposit was encountered between Elevation 241.2 m and 238.2 m and ranged from 2.0 m to 8.2 m in thickness.

The SPT 'N'-values measured within this portion of the deposit range between 0 blows (weight of hammer) and 15 blows per 0.3 m of penetration, suggesting a very soft to stiff consistency. In situ field vane tests carried out within this portion of the deposit measured undrained shear strengths ranging from about 13 kPa to 82 kPa and

the sensitivity is calculated to range from about 2 to 18, typically less than 12. One in situ field vane in Borehole H1-21 was measured to be greater than 100 kPa. The field vane tests results indicate that the silty clay to clay has a soft to stiff consistency.

The grain size distributions of four samples of the silty clay to clay portion of the deposit are shown on Figure A3 in Appendix A.

Atterberg limits tests were carried out on twenty-four samples of the silty clay to clay portion of the deposit. The test results indicate liquid limits ranging from about 36 per cent to 76 per cent, plastic limits ranging from about 18 per cent to 30 per cent and plasticity indices ranging from about 17 per cent to 50 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure A14 in Appendix A and indicate that the material is classified as silty clay of intermediate plasticity to clay of high plasticity.

The natural water content measured on thirty samples of this portion of the deposit ranges between about 21 per cent and 79 per cent.

Laboratory consolidation (oedometer) tests were carried out on two samples of the silty clay to clay, obtained from Shelby tube samples in Boreholes H1-19 and H1-25. The preconsolidation stress was estimated from the void ratio versus logarithmic pressure plot and from the total work versus pressure plot. A bulk unit weight of 16.3 kN/m^3 and 16.9 kN/m^3 and a specific gravity of 2.77 and 2.78 were measured on the consolidation test samples. The detailed results of the oedometer tests are shown on Figures A15 and A16 in Appendix A, and the test results are summarized below, and in Table 2.

Borehole/ Sample No.	Sample Depth / Elevation	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	e_o	C_c	C_r	c_v^* (cm^2/s)
H1-19/Sample 6	4.6 m/ 236.4 m	31	256	225	8.3	1.86	1.04	0.02	2.1×10^{-3}
H1-25/Sample 8	6.6 m/ 234.6 m	56	135	79	2.4	1.52	0.66	0.02	3.8×10^{-3}

*For the normally consolidated stress range

where: σ_{vo}' is the effective overburden stress in kPa
σ_p' is the preconsolidation stress in kPa
OCR is the overconsolidation ratio
e_o is the initial void ratio
C_c is the compression index
C_r is the recompression index
c_v is the coefficient of consolidation in cm^2/s

Clayey Silt

Underlying the silty clay to clay in Boreholes H1-19 to H1-21, H1-23, H1-27 and C1-4, a deposit of grey clayey silt was encountered between Elevation 238.0 m and 231.9 m and ranged from 1.0 m to 2.4 m in thickness.

The SPT 'N'-values measured within the clayey silt deposit range between 0 blows (weight of hammer) and 5 blows per 0.3 m of penetration, suggesting a very soft to firm consistency. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 23 kPa to 61 kPa and the sensitivity is calculated to range from about 2 to 11, typically less than 4. The field vane test results indicate that the clayey silt has a soft to stiff consistency.

Atterberg limits tests were carried out on three samples of the clayey silt and indicate liquid limits ranging from about 29 per cent to 33 per cent, plastic limits ranging from about 20 per cent to 21 per cent and plasticity indices ranging from about 9 per cent to 13 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure A17 in Appendix A and indicate that the material is classified as clayey silt of low plasticity.

The natural water content measured on three samples of the deposit ranges between about 33 per cent and 42 per cent.

4.4.4 Silt to Sandy Silt

Underlying the cohesive deposit is a deposit of grey, wet, silt to sandy silt which was encountered in all boreholes except H1-27. The top of the silt to sandy silt deposit was encountered between Elevation 239.0 m and 230.9 m and ranged from 0.8 m to 7.6 m in thickness, where the deposit was fully penetrated. Borehole H1-24 was terminated within this deposit.

The SPT 'N'-values measured within this portion of the deposit range between 0 blows (weight of hammer) to 26 blows per 0.3 m of penetration, indicating a very loose to compact relative density. Two SPT 'N'-values did not penetrate the full sample depth and were measured to be 22 blows per 0.15 m of penetration and 2 blows per 0.1 m of penetration, likely indicative of the close proximity of the bedrock surface.

The grain size distributions of twelve samples of the silt to sandy silt are shown on Figure A18 in Appendix A.

The results of Atterberg limits testing on five samples indicated that the material is classified as non-plastic.

The natural water content measured on fifteen samples of this deposit ranges between about 22 per cent and 42 per cent.

4.4.5 Sand and Silt to Sand

Underlying the silt to sandy silt deposit in Boreholes H1-17 to H1-23, H1-25, H1-26, H1-29, H1-30, C1-3 and C1-4, a deposit of grey sand and silt to sand was encountered between Elevation 237.5 m and 227.7 m and ranged from 0.4 m to 8.8 m in thickness where the deposit was fully penetrated. DCPTs were advanced below the borehole termination depth in Boreholes H1-26, H1-30, C1-3 and C1-4. Boreholes H1-17, H1-21 to H1-23, H1-26, H1-29, H1-30, C1-3 and C1-4 were terminated within this deposit.

The SPT 'N'-values measured within this portion of the deposit range between 0 blows (weight of hammer) and 60 blows per 0.3 m of penetration, indicating a very loose to very dense relative density.

The grain size distributions of eight samples of the sand and silt to sand are shown on Figure A19 in Appendix A.

The natural water content measured on nine samples of this portion of the deposit ranges between about 17 per cent and 28 per cent.

4.4.6 Gravelly Sand

In Boreholes H1-19, H1-25 and H1-27, a deposit of gravelly sand was encountered underlying the sand and silt to sand and/or the cohesive deposit. The top of the gravelly sand deposit was encountered between Elevation 235.6 m and 225.6 m and ranged from 2.8 m to 3.4 m in thickness where the deposit was fully penetrated. A DCPT was advanced below the borehole termination depth in Borehole H1-25. Boreholes H1-19 and H1-25 were terminated within this deposit.

The SPT 'N'-values measured within this portion of the deposit range between 13 blows and 28 blows per 0.3 m of penetration, indicating a compact relative density.

The grain size distributions of two samples of the gravelly sand are shown on Figure A20 in Appendix A.

The natural water content measured on two samples of this portion of the deposit are about 11 per cent and 19 per cent.

4.4.7 Refusal

Refusal to split-spoon and dynamic cone penetration, indicating proximity to the inferred bedrock surface was encountered in Boreholes H1-16, H1-18, H1-20, H1-25 to H1-30, C1-3 and C1-4 and DCPTs H1-DC7 and H1-DC10 to H1-DC-12 at depths ranging from about 4.0 m and 20.7 m below the ground surface or between Elevation 237.3 m and 220.5 m. In DCPTs H1-DC8 and H1-DC9, the DCPT terminated due to recording greater than 100 blows per 0.3 m of penetration, indicative of proximity to the inferred bedrock surface, at depths up to about 21 m below the existing ground surface.

4.4.8 Groundwater Conditions

In general, the soil samples taken in the boreholes were moist to wet. Water levels observed upon completion of drilling ranged from Elevation 241.3 m to 238.3 m, corresponding to depths between ground surface and 3.0 m below ground surface. In Boreholes H1-21 and H1-22, 0.2 m of ponded water was encountered at the ground surface. It should be noted that the groundwater levels in the area fluctuate seasonally as well as during precipitation events and snowmelt.

4.5 Highway 17 WBL – STA 13+140 to 13+390 (High Fill H2)

The plan and profiles along the centreline and toes of the proposed embankment of the new Highway 17 WBL alignment showing the borehole locations and interpreted stratigraphy between STA 13+140 and STA 13+390 in the Township of Louise are shown on Drawings B1 to B6 in Appendix B. The alignment extends across a low-lying swampy area with the proposed embankment up to 5.0 m high above the existing ground. A total of twenty-one (21) boreholes (Boreholes H2-1 to H2-21) and ten (10) DCPTs (DCPTs H2-DC1 to H2-DC10) were completed to investigate the subsurface conditions within this portion of High Fill Area H2.

The subsurface soils along the WBL alignment in High Fill Area H2 consist of a surficial layer of peat/organics, underlain by a cohesive deposit of clayey silt transitioning into varved, silty clay to clay transitioning to clayey silt to silt, which in turn is underlain by deposits of silt to sand to gravelly sand.

4.5.1 Peat/Organics

An approximate 0.1 m to 4.0 m thick deposit of black, fibrous to amorphous peat was encountered at the ground surface in Boreholes H2-2 to H2-20. In Borehole H2-1, a layer of organics was encountered at the ground surface. The surface of the peat/organic deposit varies between Elevation 240.7 m and 239.7 m.

The SPT 'N'-values measured within the peat/organic deposit are typically 0 blows (weight of hammer) to 1 blow per 0.3 m of penetration, suggesting a very soft consistency, however 'N'-values up to 31 blows per 0.3 m of penetration were noted through frozen peat/organic materials.

The natural water content measured on seventeen samples of the peat ranges from about 82 per cent to 670 per cent.

4.5.2 Cohesive Deposit

In all boreholes, a cohesive deposit was encountered beneath the peat/organics deposit or from ground surface in Borehole H2-21. In general, the cohesive deposit consisted of an upper clayey silt to silt zone transitioning into varved silty clay to clay, further transitioning to a lower clayey silt to silt zone. The top of the cohesive deposit was encountered between Elevation 240.6 m and 235.8 m and the overall deposit ranged between 1.7 m and 6.9 m in thickness.

Clayey Silt

In Boreholes H2-1, H2-2 and H2-21 a deposit of grey clayey silt, trace sand, trace organics was encountered underlying the peat/organics deposit. The surface of this portion of the deposit was encountered between Elevation 240.6 m and 238.9 m and ranged from 0.8 m to 4.3 m in thickness.

The SPT 'N'-values measured within this portion of the deposit range between 0 blows (weight of hammer) and 15 blows per 0.3 m of penetration, suggesting a very soft to very stiff consistency. Two in situ field vane tests carried out within this portion of the deposit measured undrained shear strengths of about 43 kPa and 57 kPa and the sensitivity is calculated to be about 5 and 6. The field test results indicate that this portion of the deposit has a firm to stiff consistency.

Atterberg limits tests were carried out on three samples of the clayey silt and indicate liquid limits ranging from about 31 per cent to 34 per cent, plastic limits ranging from about 19 per cent to 22 per cent and plasticity indices ranging from about 9 per cent to 14 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B1 in Appendix B and indicate that the material is classified as clayey silt of low plasticity.

The natural water content measured on five samples of this portion of the deposit ranges between about 20 per cent and 35 per cent.

Silty Clay to Clay

Underlying the peat/organic deposit in Boreholes H2-3 to H2-20 and underlying the clayey silt layer in H2-21, a deposit of grey to brown, silty clay to clay was encountered. In the majority of the boreholes, the silty clay to clay portion of the deposit was observed to be varved, consisting of irregular layers of clayey silt/silty clay and silty

clay/clay. The surface of this portion of the deposit was encountered between Elevation 240.1 m and 235.8 m and ranged from 1.7 m to 6.8 m in thickness.

The SPT 'N'-values measured within this portion of the deposit range between 0 blows (weight of hammer) and 12 blows per 0.3 m of penetration, suggesting a very soft to stiff consistency. In situ field vane test carried out within this deposit measured undrained shear strengths ranging from about 14 kPa to 79 kPa and the sensitivity is calculated to be between about 2 and 16. The field test results indicate that the deposit has a soft to stiff consistency.

The grain size distributions of four samples of this portion of the deposit are presented on Figure B2 in Appendix B.

Atterberg limits tests were carried out on twenty-two samples of the silty clay to clay and indicate liquid limits ranging from about 38 per cent to 80 per cent, plastic limits ranging from about 21 per cent to 25 per cent and plasticity indices ranging from about 17 per cent to 54 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B3 in Appendix B and indicate that the material is classified as silty clay of intermediate plasticity to clay of high plasticity.

The natural water content measured on thirty samples of this portion of the deposit ranges between about 30 per cent and 73 per cent.

Clayey Silt to Silt

In Boreholes H2-7, H2-8, H2-11, H2-18, H2-19 and H2-20, the silty clay to clay transitioned into a grey, clayey silt. The surface of this portion of the deposit was encountered between Elevation 237.0 m and 231.0 m and ranged from 1.3 m to 3.8 m in thickness.

The SPT 'N'-values measured within this portion of the deposit range between 0 blows (weight of hammer) and 3 blows per 0.3 m of penetration, suggesting a very soft to soft consistency. In situ field vane test carried out within this portion of the deposit measured undrained shear strengths ranging from about 24 kPa to 53 kPa and the sensitivity is calculated to be between about 3 and 13. The field test results indicate that this portion of the deposit has a soft to stiff consistency.

A grain size distribution for one sample of this portion of the deposit is presented on Figure B4 in Appendix B.

Atterberg limits tests were carried out on four samples of the lower clayey silt to silt. The test results indicate liquid limits ranging from about 27 per cent to 29 per cent, plastic limits ranging from about 20 per cent to 23 per cent and plasticity indices ranging from about 6 per cent to 9 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B5 in Appendix B and indicate that the material is classified as clayey silt of low plasticity to silt of slight plasticity.

The natural water content measured on six samples of this portion of the deposit ranges between about 33 per cent and 44 per cent.

4.5.3 Silt to Sandy Silt

A deposit of grey silt to sandy silt, trace to some clay, trace to some sand was encountered beneath the cohesive deposit in all of the boreholes within this section of the project.

The surface of this deposit ranges from Elevation 238.5 m to 229.6 m and its thickness ranges from 0.5 m to 10.0 m where the deposit was fully penetrated. Boreholes H2-2 to H2-4, H2-9 to H2-11 and H2-13 were terminated within this deposit.

The SPT 'N'-values measured within this deposit range between 0 blows (weight of hammer) and 29 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The grain size distributions of nineteen samples of this deposit are presented on Figure B6 in Appendix B. The results of Atterberg limits testing on seven samples of the silt deposit indicated that the material is classified as non-plastic.

The natural water content measured on twenty-six samples of this deposit ranges between about 18 per cent and 37 per cent.

4.5.4 Sand and Silt to Sand

A deposit of grey sand and silt to sand, trace clay was encountered underlying the silt deposit in Boreholes H2-5, H2-6, H2-8, H2-14 to H2-18, H2-20 and H2-21. The surface of this deposit ranges from Elevation 233.3 m to 226.6 m. DCPTs were advanced below the borehole termination depth in Boreholes H2-5, to H2-7, H2-14 to H2-18 and H2-21. Borehole H2-8 was terminated within this deposit.

The SPT 'N'-values measured within this deposit range between 0 blows (weight of hammer) and 18 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The grain size distributions of six samples of this deposit are presented on Figure B7 in Appendix B.

The natural water content measured on six samples of this deposit ranges between about 10 per cent and 25 per cent.

4.5.5 Gravelly Sand

A 0.1 m to 2.5 m thick deposit of gravelly sand was encountered in Boreholes H2-1 and H2-19 underlying the silt to sandy silt deposit at Elevation 238.0 m and 226.9 m, respectively. Borehole H2-19 was terminated in this deposit.

The SPT 'N'-values measured within this portion of the deposit range between 6 blows and 17 blows per 0.3 m of penetration, indicating a loose to compact relative density.

A grain size distribution for one sample of the gravelly sand is presented on Figure B8 in Appendix B.

The natural water content measured on one sample of this portion of the deposit is about 10 per cent.

4.5.6 Refusal

Refusal to split-spoon, auger or casing advancement or dynamic cone penetration, indicating proximity to the inferred bedrock surface was encountered in Boreholes H2-1 to H2-6, H2-17, H2-18 and H2-20 and in DCPTs H2-DC1 to H2-DC3, H2-DC7 and H2-DC8 at depths ranging from 2.8 m to 20.3 m below the ground surface or between Elevation 237.9 m and 220.2 m. In Boreholes H2-7, H2-12, H2-14 and H2-21 and DCPTs H2-DC4 to

H2-DC6, H2-DC9 and H2-DC10, the DCPTs terminated upon recording greater than 100 blows per 0.3 m of penetration, indicative of proximity to the inferred bedrock surface, at depths up to about 23 m below the existing ground surface.

4.5.7 Groundwater Conditions

In general, the samples taken in the boreholes were wet. Artesian groundwater levels were measured in Borehole H2-6 and H2-8 with the groundwater level upon completion of drilling measured at 0.5 m and 0.8 m above ground surface, respectively, corresponding to Elevation 240.3 m and 239.9 m. In the remaining boreholes, the groundwater levels observed upon completion of drilling range from about Elevation 235.2 m to 239.9 m, typically measured at the ground surface up to 4.7 m below ground surface, except in Borehole H2-1, which was observed to be dry upon completion of drilling. It should also be noted that the groundwater levels in the area fluctuate seasonally, as well as during precipitation events and snowmelt.

4.6 Highway 17 EBL – STA 13+140 to 13+390 (High Fill H2)

The plan and profiles along the centreline and toes of the proposed embankment of the new Highway 17 EBL alignment showing the borehole locations and interpreted stratigraphy between about STA 13+140 to STA 13+390 in the Township of Louise are shown on Drawings B1 to B6 in Appendix B. The alignment extends across a low-lying swampy area with the proposed embankment up to 5.0 m high above the existing ground. A total of twenty-two (22) boreholes (Boreholes H2-22 to H2-43) and eleven (11) DCPTs (DCPTs H2-DC11 to H2-DC21) were completed to investigate the subsurface conditions within this portion of High Fill Area H2.

The subsurface soils along the EBL alignment in High Fill Area H2 consist of a surficial deposit of peat/organics underlain by a cohesive deposit of clayey silt transitioning into varved, silty clay to clay transitioning to clayey silt, which in turn is underlain by deposits of silt to sand to sand and gravel.

4.6.1 Peat/Organics

An approximately 0.1 m to 3.7 m thick layer of black, fibrous to amorphous peat was encountered at the ground surface in Boreholes H2-23 to H2-41. In Borehole H2-22, H2-42 and H2-43, a layer of organics was encountered at the ground surface. The top of the peat/organic deposit varies between Elevation 242.1 m and 239.6 m.

The SPT 'N'-values measured within the peat/organic deposit range from 0 blows (weight of hammer) to 2 blows per 0.3 m of penetration, suggesting a very soft consistency, however 'N'-values up to 14 blows per 0.3 m of penetration were noted through frozen peat.

The natural water content measured on eighteen samples of this portion of the deposit ranges from about 297 per cent to 774 per cent.

4.6.2 Cohesive Deposit

In all boreholes, a cohesive deposit was encountered beneath the peat/organics deposit. In general, the cohesive deposit consisted of an upper clayey silt to silt zone transitioning into varved silty clay to clay, further

transitioning back to a lower clayey silt to silt zone. The top of the cohesive deposit was encountered between Elevation 242.0 m and 236.0 m and overall deposit ranged between 0.5 m and 9.7 m in thickness.

Clayey Silt

In Boreholes H2-23, H2-30 to H2-35, H2-37, H2-39 and H2-43, a deposit of grey clayey silt trace sand, trace organics was encountered underlying the peat/organics deposit. The surface of this portion of the deposit was encountered between Elevation 242.0 m and 236.0 m and ranged from 0.5 m to 2.1 m in thickness.

The SPT 'N'-values measured within the clayey silt deposit range from 0 blows (weight of hammer) to 14 blows per 0.3 m of penetration, suggesting a very soft to stiff consistency. One in situ field vane test carried out within this portion of the deposit measured an undrained shear strength of about 24 kPa and the sensitivity is calculated to be about 2. The field test results indicate that this portion of the deposit has a soft consistency.

Atterberg limits tests were carried out on four samples of the clayey silt. The test results indicate liquid limits ranging from about 28 per cent to 34 per cent, plastic limits ranging from about 18 per cent to 22 per cent and plasticity indices ranging from about 9 per cent to 13 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B9 in Appendix B and indicate that the material is classified as a clayey silt of low plasticity.

The grain size distribution of one sample of the clayey silt portion of the deposit is shown on Figure B10 in Appendix B.

The natural water content measured on six samples of this portion of the deposit ranges from about 22 per cent to 36 per cent.

Silty Clay to Clay

A deposit of silty clay to clay was encountered underlying the peat/organic deposit or the clayey silt deposit in Boreholes H2-25 to H2-42. In the majority of the boreholes, the silty clay to clay portion of the deposit was observed to be varved, consisting of irregular layers of clayey silt/silty clay and silty clay/clay. The surface of the silty clay to clay was encountered between Elevation 241.7 m to 234.1 m, and ranged in thickness between 2.1 m and 8.5 m.

The SPT 'N'-values measured within the silty clay to clay deposit range between 0 blows (weight of hammer) and 12 blows per 0.3 m of penetration, suggesting a very soft to stiff consistency. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 12 kPa to 91 kPa and the sensitivity is calculated to be between about 2 and 35 (typically less than 16). The field test results indicate that the deposit has a soft to stiff consistency.

The grain size distributions of four samples of the silty clay to clay portion of the deposit are shown on Figure B11 in Appendix B.

Atterberg limits tests were carried out on twenty-four samples of the silty clay to clay. The test results indicate liquid limits ranging from about 36 per cent to 80 per cent, plastic limits ranging from about 19 per cent to 27 per cent and plasticity indices ranging from about 14 per cent to 55 per cent. The results of the Atterberg