Foundation Investigation and Design Report

Highway 11 – 2+1 Roadway Model Project: ***Site SW2***

Assignment No. 5021-E-0038
GWP 5151-21-00
Geocres No. 31L12-004
(Latitude: 46.575311; Longitude: -79.629389)

Type of Document:
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A	May 3, 2024	pdf	E. Lu T. Lardner S. Micic	T.C. Kim	S. Gonsalves	Draft Report for Review by AECOM
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C	April 6, 2026	pdf	E. Lu T. Lardner S. Micic	T.C. Kim	S. Gonsalves	Final Report

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Appendices

PART I – FOUNDATION INVESTIGATION REPORT

1 FACTUAL INFORMATION

1.1 Introduction

This report presents the results of the geotechnical investigation completed by EXP Services Inc. (EXP) for the proposed widening of Highway 11 and the corresponding embankment/roadway construction at the site SW2. The site is located approximately 32 km north of the intersection of McKeown Avenue and Highway 11 from approximately Station 15+960 to 16+060 in the Township of Notman in the District of Nipissing, Ontario (Latitude: 46.575311; Longitude: -79.629389). The work was undertaken under Agreement No. 5021-E-0038, and the terms of reference (TOR) provided by AECOM. The AutoCAD drawings for Highway 11 at the site were also provided by AECOM.

The purpose of the investigation was to assess the subsurface conditions along the proposed Highway 11 widening and, using this information, develop a borehole location plan, subsurface cross-section profiles, borehole records, laboratory test results, and a detailed description of soil and groundwater conditions. These results support the detailed design and construction recommendations for the new embankment and roadway associated with the highway widening. Preliminary observations on the existing embankment drainage conditions have also been included. The site-specific geotechnical investigation consisted of field activities such as visual inspections, drilling, soil sampling, and laboratory testing.

This foundation investigation report has been prepared specifically and solely for the project described herein. It contains the factual results of the investigation and the laboratory testing completed for this project.

1.2 Site Description and Geological Setting

1.2.1 Site Description

The site is located approximately 32 km north of the intersection of McKeown Avenue and Highway 11 from approximately Station 15+960 to 16+060 in the Township of Notman in the District of Nipissing, Ontario. Within the project limits, Highway 11 runs predominantly in a north–south orientation with a posted speed limit of 90 km/h. The existing roadway platform varies from approximately 9.8 m to 10.7 m in width, with a 2.5 m paved shoulder on the east (northbound) side and a 1.3 m to 1.8 m paved shoulder on the west (southbound) side, resulting in a total roadway width of up to 15 m.

The highway profile is sloped, with the pavement centerline elevation ranging from approximately Elev. 298.4 m to Elev. 303.7 m, based on AECOM's AutoCAD drawings. Based on the existing surrounding ground level measured in off-road boreholes and drawings from AECOM, the height of embankment ranges from 9 m to 10 m on the west side and 7.5 m to 13.5 m on east side. The slope of the existing embankment is estimated to range from 1.5H:1V to 1.25H:1V based on EXP survey and field observations.

Select photographs of the site are presented in Appendix A. The site plan and cross-section profiles along the existing highway alignment are shown on the drawings attached in Appendix B.

The general site conditions were assessed during a site visit September 13, 2023 as well as during the field investigation works between November 8, 2023, and April 4, 2024 for boreholes BH2-2 to BH2-7. Probeholes (PH2-1 to PH2-8), which replaced BH2-1, were subsequently advanced on July 31, 2025.

Both sides of the embankment were observed to be mostly comprised of rockfill. Marshland was observed on both sides of the embankment with vegetation consisting primarily of large conifers and wild bushes. In general, the highway is founded on top of a built-up embankment while the natural terrain in the surrounding area slopes down towards the north. The water accumulation of an existing creek was observed on the east side of the embankment where the water level was measured to be at about Elev. 288.9 m. No signs of sinkholes/instabilities were observed on the SW2 section of highway.

Photographs 1 to 6 in Appendix A shows the site and activities during drilling photographed between November 2023 and April 2024 by EXP. Photograph 1 shows the surrounding area of the east side of the highway embankment, including the existing rockfill and vegetation. Photograph 2 shows the field investigation being carried out on the south bound lane at borehole BH2-5. Photograph 3 shows the field investigation being carried out at borehole BH2-6 in a swamp location using a tripod setup. Photograph 4 shows a surface spoon during sampling and highlights the condition of the swamped area at borehole BH2-7. Photograph 5 shows the accumulated water on the east side of the embankment. Photograph 6 shows the hand-held Honda GX35 Portable Soil Sampler used for advancing probeholes on the east side of the embankment.

1.2.2 Geological Setting

According to the Ministry of Northern Development and Mines, Map 2555 (Quaternary Geology of Ontario, East-Central Sheet, 1991) the surface conditions in the vicinity of the project area are expected to consist of Precambrian bedrock: undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift. According to Map 2543 (Bedrock Geology of Ontario, East-Central Sheet, 1991), the bedrock geology of the site is of migmatic rocks and gneisses of undetermined protolith: commonly layered biotite gneisses and migmatites; locally includes quartz of feldspathic gneisses, orthogneisses, paragneisses.

1.3 Previous Investigations

There are no available previous geotechnical reports at the location of the site in the MTO GEOCRES library; the nearest available reports on Highway 11 are approximately 11.4 km southeast and 9.3 km northwest, respectively, from the site:

- *Geocres No. 31L-209: "Foundation Investigation and Design Report, Temporary Protection System for Culvert STA 11+622, Highway 11, Blythe Township, North Bay, Ontario, GWP 5186-14-00", Prepared by Golder Associates Ltd., dated February 26, 2018.*
- *Geocres No. 31L-080: "Final Report on Detailed Foundation Investigation and Design, Tomiko River Bridge, Highway 11, North Bay, GWP 711-92-00 (WP 344-00-01), Site Number 43-10", Prepared by Golder Associates Ltd., dated December, 2001.*

1.4 Investigation Procedures

1.4.1 Site Investigation and Field Testing

A site reconnaissance was conducted by an EXP representative on September 13, 2023 to evaluate the general site conditions for the proposed borehole locations. Initially, the proposed field program consisted of drilling seven (7) sampled boreholes; three (3) boreholes on the road (BH2-2, BH2-3and BH2-5), one (1) borehole on the east side of the embankment (BH2-1) and three (3) boreholes on the west side of the embankment (BH2-4, BH2-6 and BH2-7).

The boreholes were strategically located along the highway and slightly beyond the footprint of the proposed expansion to provide subsurface information for the widening of the highway.

The site investigation for the three (3) roadway borehole (BH2-2, BH2-3and BH2-5) was carried out between November 8, 2023 and November 20, 2023. The investigation of the three (3) off-road boreholes at the west side (BH2-4, BH2-6 and BH2-7) was completed between March 25, 2024 and April 8, 2024, while the investigation at the east side was conducted on July 31,2025.

Roadway boreholes BH2-3 and BH2-5 were advanced on the west side (southbound lane) of the highway, while BH2-2 was advanced on the east side (northbound lane). Off-road boreholes BH2-4, BH2-6, and BH2-7 were drilled beyond the toe of the existing embankment on the west side of the highway. Due to access constraints, including a high, steep embankment and soft ground conditions, boreholes BH2-4 and BH2-6 were positioned slightly north of the SW2 north boundary. These boreholes were advanced either using a standard track-mounted drill rig or a mobile tripod system.

Access for a standard track-mounted drill rig or mobile tripod system was not feasible on the east side of the embankment because of its steep elevation and the presence of dense, mature trees and an open water body at its base. As a result, a hand-held Honda GX35 portable soil sampler was used to determine the depth to refusal and to collect samples from the loose to soft overburden soils. Probeholes (PH2-1 to PH2-8), replacing the originally planned BH2-1, were advanced at eight (8) locations along the east embankment toe. These probeholes were situated at the bottom of the steep embankment and extended northward from an area of accumulated water toward the SW2 north boundary.

The locations of all boreholes/probeholes advanced during this investigation are shown on Drawing 1 in Appendix B. Roadway boreholes BH2-2, BH2-3 and BH2-5 were advanced to depths of between 18.1 m and 22.9 m below ground surface. Off-road boreholes BH2-4, BH2-6 and BH2-7 were advanced to depths between 6.5 m to 10.1 m below ground surface. Probeholes on the east side were advanced to depths of 0.15 m to 0.60 m before refusal was encountered using the hand-held soil sampler.

Roadway boreholes drilled during this fieldwork was advanced using a truck mounted CME 75 drill rig, operated by a specialist drilling contractor, Marathon Drilling Ltd, while the off-road boreholes drilled during the site investigation were advanced using a Hilti DD250 alongside a mobile tripod setup, also operated by specialist drilling contractor, Marathon Drilling Ltd. All drill rigs were equipped with hollow stem augers, NW casing/NQ coring or HW casing/HQ coring, and standard soil sampling equipment. The hand-held Honda GX35 portable soil sampler was operated by EXP personnel. Traffic control was provided by Demora Construction Services Inc.

The borehole locations (referenced to the MTM NAD83 Zone 10) and their ground surface elevations were surveyed by EXP personnel using a Trimble DA2 GNSS receiver with Trimble Catalyst GNSS positioning, having an accuracy of ±0.1 m in the horizontal and vertical directions. Elevations for each borehole were referenced from the benchmark “HCP 150”, which was a stake located on the northbound lane shoulder at Elev. 300.568 m by the surveyor. Ground surface elevations of the boreholes are summarized in Table 1.1.

During the drilling of the boreholes, a combination of Standard Penetration Tests (SPT) and rock coring was attempted to obtain soil and rock samples. Soil samples were obtained using a 51 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586) at intervals ranging

from 0.75 m to 1.5 m in depth, as shown on the attached borehole logs (Appendix C). The original field (uncorrected) SPT "N" values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual (CFEM, pg. 103) and used to provide an assessment of the in-situ compactness of cohesionless soils or consistency of cohesive soils. The SPT "N" values taken within the particles larger than diameter of split spoon sampler may not be reliable and collected samples are possibly not representative of the layer. When a hard stratum was reached (refusal of split spoon), sampling of hard material was performed by diamond core drilling using a 1.5 m long NQ double tube wireline core barrel.

Where possible, groundwater level measurements were carried out in the boreholes before coring and at the completion of the boreholes, in accordance with MTO guidelines. However, all boreholes at this site were advanced using diamond casing/coring procedures. Water was used during advancement from ground surface; therefore groundwater could not measured in open boreholes during drilling. A standpipe piezometer was installed in BH2-6 to permit monitoring of the groundwater level on the west side of Highway 11. The recorded groundwater levels are presented in the borehole log sheets in Appendix C. All other drilled boreholes were decommissioned by bentonite/cement mixtures in accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the Ontario Water Resources Act) upon completion of drilling.

The fieldwork was supervised by an EXP geotechnical representative who directed the drilling and sampling operations, logged borehole data in accordance with MTO and/or ASTM Standards for Soils Classification and retrieved soil samples for subsequent laboratory testing and identification.

All recovered soil samples were placed in labelled moisture-proof bags and returned to EXP's laboratory for additional visual, textual, and olfactory examination, and selective testing. The rock cores were placed in wooden core boxes and photographed as shown in Appendix E.

Table 1.1. Summary of boreholes completed

Borehole No.	Location	Location (MTM NAD 83 Zone 10)		Latitude	Longitude	Ground Surface Elevation[1] (m)	Borehole Depth[2] (m)
		Northing	Easting				
Probeholes PH2-1 to PH2-8 replacing BH2-1	Off-road beyond toe of existing slope: East side of highway	Reference Drawing 1				289.5 to 290.8	0.15 to 0.60
BH2-2	East side (northbound lane) of highway	5159526.4	294876.6	46.575298	-79.629466	301.0	20.4
BH2-3	East side (northbound lane) of highway	5159568.7	294842.7	46.575677	-79.629909	298.4	18.1
BH2-4	Off-road beyond toe of existing slope: West side of highway	5159555.4	294812.4	46.575558	-79.630304	289.0	8.7
BH2-5	West side (southbound lane) of highway	5159515.0	294885.1	46.575195	-79.629354	301.7	19.8

Borehole No.	Location	Location (MTM NAD 83 Zone 10)		Latitude	Longitude	Ground Surface Elevation[1] (m)	Borehole Depth[2] (m)
		Northing	Easting				
BH2-6	Off-road beyond toe of existing slope: West side of highway	5159572.5	294795.8	46.575711	-79.630521	288.9	10.1
BH2-7	Off-road beyond toe of existing slope: West side of highway	5159538.8	294822.8	46.575409	-79.630168	289.2	6.5

Notes:

1. *The ground surface elevations are referenced from HCP 150.*
2. *Depths are relative to ground surface.*

1.4.2 Laboratory Testing

All samples returned to the laboratory were visually examined and classified. The laboratory testing program included natural moisture content determination on all samples and particle size distribution testing on approximately 25% of the recovered soils, where feasible. Due to the presence of rockfill, cobbles, and boulders, sample recovery was limited in several boreholes, which in turn restricted the extent of particle size distribution testing. All laboratory testing was performed in accordance with applicable MTO and ASTM standards.

1.5 Subsurface Conditions

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the borehole log sheets in Appendix C. The “Explanation of Terms Used in Report” preceding the borehole logs in Appendix C forms an integral part of and should be read in conjunction with this report.

A borehole location plan and cross section subsurface profiles are provided in Appendix B. It should be noted that the stratigraphic boundaries indicated on the borehole log and cross section stratigraphic profiles are inferred from semi-continuous sampling, observations of drilling progress and results of Standard Penetration Tests (SPT). These boundaries typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Furthermore, subsurface conditions may vary between and beyond the borehole locations.

Below the roadway, the subsurface conditions encountered within the investigated depths of the geotechnical investigation (BH2-2, BH2-3, BH2-5) indicates the general subsurface sequence: sand and gravel/gravelly sand fill underlain by rockfill underlain by a mixture of native cohesionless soils consisting of gravelly sand/sand and gravel/silty sand with cobbles and boulders. Bedrock was encountered in boreholes BH2-3 and BH2-5.

On the west side of the embankment, subsurface conditions encountered in the off-road boreholes (BH2-4, BH2-6, and BH2-7) indicate a general stratigraphic sequence consisting of topsoil or peat (organic materials) underlain by cohesionless soils, including silt, sand, and sand-and-gravel deposits containing cobbles and boulders. On the east side of the embankment, the probeholes encountered topsoil or peat overlying native silt and sand, with refusal reached at shallow depths ranging from 0.15 m to 0.60 m using the hand-held sampler. No bedrock was encountered in any of the boreholes advanced during this investigation.

A detailed description of the subsurface conditions encountered is discussed further in subsequent sections.

1.5.1 Subsoils

1.5.1.1 Asphalt Treatment

Asphalt treatment was encountered at the ground surface in boreholes BH2-2, BH2-3 and BH2-5. The thickness of the layer ranged from approximately 100 mm to 200 mm. Asphalt thicknesses may further vary beyond the borehole location.

1.5.1.2 Topsoil/Peat (Organics)

Topsoil/peat (organics) was encountered at the ground surface in boreholes BH2-4, BH2-6 and BH2-7 as well probeholes PH2-1 to PH2-8. The depths and elevations of this layer encountered are listed in Table 1.2. All probeholes were terminated upon reaching these depths due to refusal encountered at those locations. Some sand was also observed in these probeholes within this depth range.

Table 1.2. Summary of topsoil/peat (organics)

Probehole/Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
PH2-1	289.5	289.1	0.0	0.4[3]
PH2-2	289.5	288.9	0.0	0.6[3]
PH2-3	289.5	289.3	0.0	0.2[3]
PH2-4	290.4	289.9	0.0	0.5[3]
PH2-5	290.8	290.3	0.0	0.5[3]
PH2-6	290.4	290.0	0.0	0.4[3]
PH2-7	290.2	290.0	0.0	0.2[3]
PH2-8	290.6	290.2	0.0	0.4[3]
BH2-4	289.0	287.8	0.0	1.2
BH2-6	288.9	288.1	0.0	0.8
BH2-7	289.2	288.4	0.0	0.8

Notes:

1. *The elevations are referenced from HCP 150.*
2. *Depths are relative to ground surface.*
3. *Refusal encountered.*

The topsoil/peat consisted of silt and clay with grass and rootlets. The fill was generally brown to black in colour and moist to saturated. The SPT "N" values obtained within this material ranged from WH (weight of hammer) to 3 blows per 0.3 m penetration, suggesting that this layer was very loose in compactness or very soft to soft in consistency.

Laboratory testing performed on selected samples consisted of five (5) moisture content tests. The test results are as follows:

Moisture Content:

- 94% to 308%

The results of the moisture content tests are provided on the record of borehole sheets in Appendix C.

1.5.1.3 Cohesionless Fill: Sand and Gravel/Gravelly Sand

Cohesionless fill material consisting of predominantly sand and gravel was encountered below the asphalt treatment in boreholes BH2-2, BH2-3 and BH2-5. The depths and elevations of this layer encountered are listed in Table 1.3.

Table 1.3. Summary of cohesionless fill: sand and gravel/gravelly sand

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH2-2	300.9	299.5	0.2	1.4
BH2-3	298.2	296.3	0.2	1.9
BH2-5	301.6	298.1	0.1	3.6

Notes:
1. *The elevations are referenced from HCP 150.*
2. *Depths are relative to ground surface.*

The composition of this fill material generally consisted of sand and gravel. The fill was generally brown to grey in colour and moist to wet. It should be noted that increased moisture content in fill soils is likely affected by water that was introduced for casing/coring procedures during drilling. The SPT "N" values obtained within this material ranged from 17 to 138 blows per 0.3 m penetration, suggesting that this layer was compact to very dense in compactness condition.

Laboratory testing performed on selected samples consisted of eight (8) moisture content tests, and three (3) grain size distribution tests. The test results are as follows:

Moisture Content:

- 3% to 22%

Grain Size Distribution:

- 34% to 44% gravel
- 47% to 58% sand
- 8% to 9% silt and clay

The results of the moisture content, and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution test are also provided on Figure 1 in Appendix D.

1.5.1.4 Rockfill

Rockfill consisting of various sized fragments of rock in a soil matrix (gravel, sand and silt sized particles) was encountered in boreholes BH2-2, BH2-3 and BH2-5 below the sand and gravel/gravelly sand fill layer. The depths and elevations of this layer encountered are listed in Table 1.4.

Table 1.4. Summary of rockfill

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH2-2	299.5	290.3	1.5	9.2
BH2-3	296.3	289.3	2.1	7.0
BH2-5	298.1	290.3	3.6	7.8

Notes:
1. *The elevations are referenced from HCP 150.*
2. *Depths are relative to ground surface.*

The composition of this rockfill layer generally consisted of cobbles and boulders with silt, sand and gravel sized particles within the in-fill soil matrix. The particle size within the rockfill varies from silt to boulder size.

A combination of SPT and coring was carried out during the exploration of this layer. Where possible, split spoon sampling was attempted to obtain samples from this layer. However, it should be noted that in most cases, obtained samples from this layer were either not adequate or did not accurately represent the particle size distribution of this material as particles larger than 35 mm (inside diameter of SPT sampler) could not be obtained.

The silt/sand/gravel observed within the rockfill layer was generally brown and moist to wet (due to casing/coring procedures). The SPT “N” values obtained within the layers of silt/sand/gravel ranged from 18 to 100 blows per 0.3 penetration, suggesting that these soils were compact to very dense in compactness. However, refusal was generally encountered due to a cobble or boulder when the split spoon could not penetrate 0.3 m.

Laboratory testing performed on selected samples consisted of three (3) moisture content tests. The test results are as follows:

Moisture Content:

- 21% to 25%

The results of the moisture content tests are provided on the record of borehole sheets in Appendix C.

1.5.1.5 Glacial Till: Cobbles and Boulders

Glacial till comprised of cobbles and boulders in a silt, sand, and gravel soil matrix was encountered in below the rockfill layer in boreholes BH2-2 and BH2-3, below a native sand/silt layer in boreholes BH2-4 and BH2-6 and below a native sand and gravel layer in BH2-7. The depths and elevations of this layer encountered are listed in Table 1.5.

As noted in Section 1.5.1.2, all probeholes advanced on the east side of the embankment were terminated at shallow depths (0.2 m to 0.6 m) due to refusal encountered at those locations. It is suspected that the refusal was caused by a layer of boulders and cobbles at these depths; however, coring was not performed because only hand-operated equipment could be used, and therefore the presence of boulders and cobbles could not be confirmed.

Table 1.5. Summary of glacial till: cobbles and boulders

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH2-2	290.3	284.2	10.7	6.1
BH2-3	289.3	283.9	9.1	5.4
BH2-4	283.4	280.9	5.6	2.5
BH2-6	287.8	285.9	1.1	1.9
BH2-7	284.6	282.7	4.6	1.9

Notes:
1. *The elevations are referenced from HCP 150.*
2. *Depths are relative to ground surface.*

The composition of this layer generally consisted of cobbles and boulders with silt, sand and gravel sized particles within the soil matrix. The particle size varies from silt to boulder size.

A combination of SPT and coring was carried out during the exploration of this layer. Where possible, split spoon sampling was attempted to obtain samples from this layer. However, it should be noted that in most cases, obtained samples from this layer were either not adequate or did not accurately represent the particle size distribution of this material as particles larger than 35 mm (inside diameter of SPT sampler) could not be obtained.

The SPT “N” values obtained within the cobbles and boulders ranged from 14 to 100 blows per 0.3 penetration, suggesting that these soils were compact in compactness. In general, refusal was generally encountered due to a cobble or boulder when the split spoon could not penetrate 0.3 m.

Laboratory testing performed on selected samples consisted of one (1) moisture content test. The test result is as follows:

Moisture Content:

- 25%

The results of the moisture content test is provided on the record of borehole sheets in Appendix C.

1.5.1.6 Sand/Silty Sand/Silt

Native sand/silty sand/silt layers were encountered in boreholes BH2-2, BH2-4, BH2-6. The depths and elevations of this layer encountered are listed in Table 1.6.

Table 1.6. Summary of sand/silty sand/silt

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH2-2	284.2	281.2	16.8	3.0
BH2-4	287.8	283.4	1.2	4.4
	280.9	280.3	8.1	0.6
BH2-6	288.1	287.8	0.8	0.3
BH2-6	285.9	278.8	3.0	7.1

Notes:
1. *The elevations are referenced from HCP 150.*
2. *Depths are relative to ground surface.*

The composition of this layer predominately consisted of sand and silt with trace to some gravel and trace to some clay. Cobbles and boulders were also encountered within this layer. This layer was generally brown to grey in colour and moist to saturated. The SPT "N" values obtained within this material ranged from 3 to 30 blows per 0.3 m penetration, suggesting that this layer was loose to very dense, but generally loose to compact in compactness. Refusal blow counts were also encountered due to cobbles and boulders. Coring was carried out during the exploration of this layer when cobbles/boulders were encountered.

Laboratory testing performed on selected samples consisted of thirteen (13) moisture content tests and two (2) grain size distribution tests. The test results are as follows:

Moisture Content:

- 10% to 24%

Grain Size Distribution:

- 0% gravel
- 5% to 6% sand

- 83% to 90% silt
- 5% to 11% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests are also provided on Figure 2 in Appendix D.

1.5.1.7 Sand and Gravel to Gravelly Sand

Native sand and gravel to gravelly sand layers were encountered in boreholes BH2-2 (below the silty sand layer), BH2-3 (below the glacial till layer), BH2-5 (below rockfill) and BH2-7 (below the organic silty/clay layer). The depths and elevations of this layer encountered are listed in Table 1.7.

Table 1.7. Summary of sand and gravel to gravelly sand

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)	Layer Thickness (m)
	Top	Bottom		
BH2-2	281.2	280.6	19.8	0.6
BH2-3	283.9	283.2	14.5	0.7
BH2-5	290.3	281.9	11.4	8.4
BH2-7	288.4	284.6	0.8	3.8

Notes:
1. *The elevations are referenced from HCP 150.*
2. *Depths are relative to ground surface.*

The composition of this layer predominately consisted of sand and gravel with trace to some silt. Cobbles and boulders were also encountered within this layer. This layer was generally grey to brown in colour and moist to wet. The SPT "N" values obtained within this material ranged from 6 to 127 blows per 0.3 m penetration, suggesting that this layer was loose to very dense, but generally compact to dense in compactness.

Laboratory testing performed on selected samples consisted of eight (8) moisture content tests and four (4) grain size distribution tests. The test results are as follows:

Moisture Content:

- 3% to 18%

Grain Size Distribution:

- 21% to 28% gravel
- 59% to 72% sand
- 7% to 13% silt and clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution tests are also provided on Figure 3 in Appendix D.

1.5.2 Bedrock

Bedrock was only encountered beneath sand and gravel and gravelly sand layers in on-road boreholes BH2-3 and BH2-5 respectively. The elevations at the top of bedrock ranged between 281.9 m to 283.2 m. The presence of bedrock at these locations was confirmed by coring approximately 3.0 m into the stratum. The depths and elevations of the bedrock surface at these borehole locations are provided in Table 1.8, and photographs of recovered rock cores are included in Appendix E.

Table 1.8. Summary of bedrock

Borehole No.	Elevation[1] (m)		Layer Surface Depth[2] (m)
	Top	Bottom	
BH2-3	283.2	280.3	15.2
BH2-5	281.9	278.8	19.8

Notes:
1. *The elevations are referenced from HCP 150.*
2. *Depths are relative to ground surface.*

Based on the bedrock NQ cores (~ core diameter 47 mm) recovered, the bedrock at the site consisted of quartzofeldspathic gneiss. In general, the rock samples are described as grey with pink embedment in colour. The Rock Quality Designation (RQD) measured on the core samples typically ranged from approximately 60% to 94%, indicating a rock mass of fair to excellent quality. The total core recovery (TCR) of bedrock cores ranged from 93% to 100%.

1.6 Groundwater and Surface Water Conditions

All boreholes at this site were advanced using casing/coring procedures where water was used during advancement from ground surface, therefore groundwater was not measured in boreholes due to the drilling method.

Groundwater levels would be expected to reflect levels in the adjacent open water and to fluctuate seasonally. Seasonal variations in the water table should be expected, with higher levels occurring during wetter periods of the year and lower levels during drier periods. The water accumulation of an existing creek was observed on the east side of the embankment where the water level was measured to be at about Elev. 288.9 m.

The groundwater level measured in the piezometer installed in borehole BH2-6 is shown in Table 1.9 and on the record of borehole sheet in Appendix C. The groundwater was not measured in the open holes since water was used for drilling.

Table 1.9. Summary of observed groundwater levels

Borehole	Ground Surface Elevation[1] (m)	Water level Depth[2]/ Elevation[1] (m)	Date
BH2-6	288.9	0.1/288.8	In piezometer (Apr 24, 2024)
		0.0/288.9	In piezometer (May 15, 2024)
		0.4/288.5	In piezometer (May 28, 2024)
		0.7/288.2	In piezometer (Jun 18, 2024)
		0.5/288.4	In piezometer (Jul 31, 2024)

Notes:

1. *The elevations are referenced from HCP 150.*
2. *Depths are relative to ground surface.*

1.7 Chemical Analyses

One (1) soil sample was selected for chemical analyses during field investigation. The soil sample collected by EXP was tested at Bureau Veritas, a CALA-certified and accredited laboratory in Mississauga, Ontario.

The sample SS1B from borehole BH2-6 was subjected to corrosivity chemical analyses. The analytical results are summarized in Table 1.10 below and are presented in Appendix D.

Table 1.10. Summary of chemical analysis results

Sample Identification	pH (unitless)	Soluble Chloride (ppm)	Soluble Sulphate (ppm)	Resistivity (ohm-cm)	Conductivity (mS/cm)	Redox Potential (mV)
BH2-6, SS1B	5.35	400	48	1400	709	260

2 CLOSURE

A subsurface investigation is a limited sampling of a site; the subsurface conditions have been established only at the test hole locations. Should conditions at the site be encountered which differ from those reported at the test locations, we require that we be notified immediately in order to assess this additional information and our recommendations, as appropriate. It may then be necessary to perform additional investigations and analyses.

Contractors bidding on or undertaking any proposed work at this site should, relative to the subsurface conditions, decide on their own investigations, if deemed necessary, as well as their own interpretations of the factual results provided herein, so they may draw their own conclusions as to how the subsurface conditions may affect them.

This Foundation Investigation Report has been prepared by Elvis Lu, M.Eng., P.Eng., and Thomas Lardner, Ph.D., P.Eng. It was reviewed by TaeChul Kim, M.E.Sc., P.Eng. and by Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact. The field investigation was supervised by Daniel Mroz, M.E.Sc., P.Eng., Stephen Fredericks, M.Eng, P.Eng. and Bijaya Bhujel.

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PART II – FOUNDATION DESIGN REPORT

3 ENGINEERING DISCUSSION & RECOMMENDATIONS

3.1 General

This section of the report provides geotechnical design recommendations for the design and construction of the proposed widening of Highway 11 at site SW2. Site SW2 is located approximately 32 km north of the intersection of McKeown Avenue and Highway 11 from approximately Station 15+560 to 16+060 in the Township of Notman in the District of Nipissing, Ontario (Latitude: 46.575311; Longitude: -79.629389) in the Ministry of Transportation (MTO) Northeastern Region. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the conducted investigation at the site performed by EXP between November 8, 2023, and July 31, 2025. The compiled factual data is presented in **Part I-Foundation Investigation Report** of this report. The interpretation and recommendations provided are intended solely for the design of the proposed embankment widening. Preliminary commentary regarding the existing drainage conditions through the embankment has also been included. Comments on construction are only provided to highlight issues that could affect the design. Contractors bidding on the works should make their own assessments of the factual data and how it might affect construction means and methods, scheduling and the like.

Based on the AutoCAD information supplied by AECOM, the Highway 11 profile at SW2 is sloped, with centerline elevations ranging from approximately Elev. 298.4 m to Elev. 303.7 m. Ground surface elevations obtained from off-road boreholes and AECOM's drawings indicate that the existing embankment height varies from approximately 9 m to 10 m on the west side and from 7.5 m to 13.5 m on the east side. Preliminary design drawings for the proposed embankment widening show that the existing highway grade will remain unchanged relative to the original ground surface, and the roadway will be widened by approximately 7 m, about 2.5 m to the east and 4.5 m to the west.

Access for drilling on the west side of the embankment was feasible, and the boreholes on that side were advanced using standard soil-sampling equipment. However, due to the steep terrain and restricted equipment access on the east side, standard drilling methods could not be used. Consequently, probeholes replacing the originally planned BH2-1 were advanced using a hand-held Honda GX35 portable soil sampler.

At the time of preparing this report, detailed design solutions for the drainage issue on the east side of the embankment, specifically the accumulation of water associated with the existing creek, were not yet available. As such, drainage considerations have been addressed only at a preliminary level in this report. A final drainage solution will be developed in consultation with the design team and MTO.

This part of the report addresses the geotechnical design of the foundation for the proposed embankment widening by providing geotechnical design parameters in accordance with the *Canadian Highway Bridge Design Code (CHBDC) (CAN/CSA-S6-19)*, the *Canadian Foundation Engineering Manual (CFEM) (2023), Guideline for MTO Foundation Engineering Services Version 03 (April 2022),* and generally accepted good practice. Pertinent construction issues from a geotechnical standpoint were examined in general accordance with the Terms of Reference. This section provides discussion and recommendations for the widening of the Highway 11 side as well as a brief discussion and recommendations for drainage of the existing creek on the east side. Geotechnical and construction considerations such as an assessment of slope stability and settlement of the widened embankment, site preparation, excavation, and frost depth are presented.

A "typical consequence level" is considered appropriate for embankment widening at this site, as outline in Section 6.5 of the CHBDC (CAN/CSA-S6-19) and a MTO memorandum from Materials Engineering Research Office (MERO) #2020-01 dated March 23, 2020, respectively. Further, given the scope of work of the foundation field investigation and laboratory testing program a "typical degree of site and prediction model understanding" has been utilized.

3.2 Expected Ground Conditions

The following ground conditions along the proposed highway widening are evident from the current investigation:

a) Highway 11 at SW2 is a three-lane road (~9.8 m to 10.7 m wide) with paved shoulders (~3.8 m to 4.3 m wide). In total, the existing roadway with both shoulders included is about 14.1 m. Highway 11 is generally oriented in the north-south direction. The elevation of the centreline of the roadway is about Elev. 298.4 m and 303.7 m along SW2. Boulder-sized rockfill/riprap was observed on both sides of the embankment. Based on EXP's survey and field observations, the roadway embankment at SW2 could be up to 13.5 m above the existing ground with slope inclinations of about 1.5H:1V to 1.25H:1V. Marshland was observed on both sides of the embankment with vegetation consisting primarily of conifers, wild bushes, and various other species of vegetative cover.

b) Below the pavement structure (boreholes BH2-2, BH2-3, BH2-5), the highway embankment consisted of sand and gravel/gravelly sand fill (~1.4 to 3.6 m thick), followed by rockfill (~7.0 to 9.2 m thick), followed by a mixture of native cohesionless soils consisting of gravelly sand/sand and gravel/silty sand with cobbles and boulders (~6.1 to 9.7 m thick) underlain by bedrock encountered between Elev. 281.9 m to 283.2 m.

c) Along the west side of the highway beyond the toe of the existing embankment slope (boreholes BH2-4, BH2-6 and BH2-7) the general subsurface conditions encountered consisted of topsoil/peat (~0.8 to 1.2 m thick), followed by native silt/sand/sand and gravel with cobbles and boulders (~ 5.7 to 9.3 m thick). No bedrock was encountered within the investigated depths of these boreholes on the west side of the highway.

d) Probeholes PH2-1 to PH2-8, advanced at eight locations along the east side of the embankment, encountered topsoil or peat underlain by native silt and sand. Refusal was reached at shallow depths ranging from 0.15 m to 0.60 m below ground surface, where the presence of a cobble and boulder rich layer was suspected.

e) The groundwater level observed in the piezometer installed in borehole BH2-6 ranged from ground surface to approximately 0.7 m below ground surface (~Elev. 288.2 m to 288.9 m). The surface water level on the east side of the embankment was measured to be at about Elev. 288.9 m.

3.3 Site Considerations

3.3.1 Frost Depth

The frost depth in the area is estimated to be approximately 2.0 m in accordance with OPSD 3090.100.

3.3.2 Seismic Hazard Site Classification and Values

Seismic characterization of the site must comply with the CHBDC (CAN/CSA-S6-19). The potential for seismic loading should be considered in the design according to Section 4.4 of the CHBDC (CAN/CSA-S6-19), considering the soil conditions encountered at the site. Table 4.1 in the CHBDC (CAN/CSA-S6-19) (see Clause 4.4.3.2) provides site classifications for seismic site response based on the average properties of the top 30 m of soil.

At this site, the subsoil conditions below the roadway generally consist of sand and gravel/gravelly sand fill, followed by rockfill, followed by a mixture of native cohesionless soils consisting of sand/gravelly sand/sand and gravel/silty sand with cobbles and boulders underlain by bedrock encountered between Elev. 281.9 m to 283.2 m. The subsoil conditions at the bottom of the embankment generally consist of topsoil/peat (organics), followed by native silt/sand/sand and gravel with cobbles and boulders. During the fieldwork, the groundwater level was measured at about Elev. 288.8 m in the piezometer (BH2-6). Based on the soil characteristics, the site class for this site is estimated to be Class "C" according to Table 4.1 of the CHBDC.

From the Natural Resources Canada website, 2020 NBC seismic hazard values are obtained using the site location coordinates and the site-adjusted damped reference spectral accelerations for the project site are shown in Table 3.1 below:

Table 3.1 Seismic design values

Probability of Exceedance in 50 Years (Return Period)	Sa(0.2) (g)[1]	Sa(0.5) (g)	Sa(1.0) (g)	Sa(2.0) (g)	PGA (g)
Latitude: 46.575311; Longitude: -79.629389					
2% (1 in 2475-year)	0.418	0.256	0.136	0.062	0.223

Note:

1. *g = acceleration due to gravity (9.81 m/s^2)*

These values are associated with an earthquake having a 2% probability of exceedance in a 50-year period (1 in 2475-year) for Site Class C and is also shown on the seismic hazard calculation data sheet for this site attached in Appendix H.

The site coefficients used to determine the design spectral acceleration and displacement values are a function of the Site Class and the reference peak ground acceleration (PGA_{ref}). Since Sa(0.2)/PGA is less than 2.0 at this site, PGA_{ref} is equal to 0.8*PGA=0.223 g, as per Section 4.4.3.3. of the CHBDC (CAN/CSA-S6-19). The site coefficient F(PGA), for this site (Seismic Site Class C and PGA_{ref} = 0.223 g) is 1.0.

3.3.3 Liquefaction Potential

Liquefaction of cohesionless soils below the groundwater table, including the sand/gravelly sand/sand and gravel/silty sand with cobbles and boulders layers, at the project site was evaluated through the SPT-based liquefaction triggering procedures described in Boulanger and Idriss (2014) using the site's PGA = 0.223g (1 in 2475-year event).

SPT 'N' values were measured to be between 24 to 127 blows per 0.3 m penetration within the native gravelly sand/sand and gravel/silty sand with cobbles and boulders layers below the roadway boreholes (BH2-2, BH2-3 and BH2-5). For the off-road boreholes on the west side of the highway (BH2-4, BH2-6, BH2-7), SPT 'N' values were measured to be between 6 to 25 blows per 0.3 m penetration from within the native silt/ sand/ sand and gravel with cobbles and boulders layers, at depths ranging about 0.8 m to 8.7 m below ground.

Susceptibility to seismically induced liquefaction is not expected to significantly impact the overall project design due to the presence of coarser material (cobbles, boulders and gravel) within the cohesionless soils layer. All other SPT 'N' values of cohesionless soils below the groundwater table were above 25 blows per 0.3 m which suggesting that the soils at those depths are not expected to be susceptible to seismically induced liquefaction (as per CHBDC 6.14.8.1.2 for sands and non-plastic silts).

3.4 Embankment

3.4.1 General

The following sections present the findings of embankment stability and settlement analyses and include comments for stable embankment geometry, embankment fill and comments on mitigation requirements, if any, needed to improve stability and/or reduce post construction settlements. General requirements for subgrade preparation and embankment construction are also presented.

The geometry analyzed in this report is defined based on EXP's geotechnical investigation, observations at the site and the preliminary design cross sections provided by AECOM. The height of the embankment ranges from 9 m to 10 m on the west side and 7.5 m to 13.5 m on east side. The existing highway grade will remain unchanged relative to the original ground level, and the roadway will be widened by a total of approximately 7 m, consisting of about 2.5 m on the east side and 4.5 m on the west side. In general, it is proposed that the slope will be about 1.25H:1V on the east side and 2H:1V on the west side. Where the rockfill embankment height exceeds 10 m on the east side, a bench shall be implemented as per OPSD 202.010.

Design analyses and recommendations for the embankment widening were carried out using rock fill, in accordance with OPSD 203.020 and OPSD 203.030, as the existing embankment materials consist primarily of rock fill. The design of embankment widening through the swampy area should allow for sub-excavation of organic soils. Based on the results of the investigation, the maximum thickness of soft organic soils at SW2 was 1.5 m and 0.6 m on the west and east sides, respectively.

Preliminary cross sections were provided by AECOM for Sta. 16+000 and Sta. 16+030 illustrating both the east and west slopes of the existing and proposed embankment. The existing and proposed geometry of the embankment at Sta. 16+060 location was interpreted based on adjacent cross-sections and on measurements obtained during the geotechnical investigation. The geometry of the proposed embankment and the surrounding terrain (including the bottom-of-slope conditions) should be confirmed once the design cross-sections for the highway embankment at SW2 become available.

Three (3) critical cross-sections were identified and evaluated:

1. **Sta. 16+000 – East Side** – Where the embankment rises approximately 13.5 m above existing ground and is designed with 1.25H:1V side slopes, a 4 m-wide crest bench, and an additional 2 m-wide intermediate bench to satisfy the OPSD 202.010 requirement for benches on rockfill embankments exceeding 10 m in height
2. **Sta. 16+030 – East Side** – Where the embankment is about 10 m above the existing ground on the east side with slopes of 1.25:1V with a 4 m wide bench
3. **Sta. 16+060 – West Side** – Where the embankment is about 9.5 m above the existing ground on the west side with slopes of 2H:1V (assumed).

3.4.2 Stability Considerations

Slope stability analyses were performed to assess the global stability of the new embankment to check if a minimum Factor of Safety (FOS) of 1.5 for static and 1.1 for seismic conditions is achieved as per MTO criteria for typical degree of understanding. Static and seismic slope stability analyses were performed using the Morgenstern-Price method developed based on limit equilibrium. The SLOPE/W computer program developed by GeoSlope International was employed for computation.

The stratigraphy and groundwater conditions at the site were developed based on the results of the geotechnical investigation presented in Part I – Foundation Investigation Report. The seismic properties given in Appendix G (Section 3.3.2) were obtained from the Natural Resources Canada website, 2020 NBC, using the site location coordinates. Tabulated below in Table 3.2 are the soil parameters used for the slope stability analyses.

Table 3.2 Soil properties used in slope stability analyses

Material Type	Effective Stress Parameters		
	ϕ (degrees)	c (kPa)	γ (Kn/m3)
New Rockfill	42	0	18
Existing Rockfill	40	0	18
Peat	23	0	14
Cohesionless Fill: Sand and Gravel to Gravelly Sand (Compact to Very Dense)	34	0	20
Sand (Compact)	32	0	22
Sand and Gravel to Gravelly Sand (Compact to Very Dense)	34	0	20
Silty Sand (Dense)	31	0	20
Glacial Till: Cobbles and Boulders	36	0	18
Bedrock	(Impenetrable)		

Based on the borehole information, the subsoils encountered at the work area consist of cohesionless fill and native cohesionless soils above the bedrock. Therefore, only effective stress (drained conditions) analyses of the slopes for a long-term assessment were performed considering the subsoil conditions encountered at the site. The analysis assumes that all organic material will be removed prior to construction. In addition, a traffic surcharge pressure of 16 kPa was adopted in the slope stability assessments. Table 3.3 summarizes the results of performed slope stability analyses. The SLOPE/W graphical printouts for the analyses are included in Appendix F (Figures F1 – F6). The effective stress parameters were estimated from empirical correlations using field data informed by experience/ engineering judgment.

Table 3.3 Summary of results of embankment slope stability analyses

Embankment Material	Location	Max Height (m)	Conditions	Min FOS
Rockfill	Sta. 16+000 East Side (1.25H:1V)	13.5 m	Drained long-term conditions, static condition	1.5 (Figure F1)
			Drained long-term conditions, seismic condition	1.2 (Figure F2)
	Sta. 16+030 East Side (1.25H:1V)	10 m	Drained long-term conditions, static condition	1.6 (Figure F3)
			Drained long-term conditions, seismic condition	1.3 (Figure F4)
	Sta. 16+060 West Side (2H:1V)	~9.5 m	Drained long-term con, static condition	1.8 (Figure F5)
			Drained long-term conditions, seismic condition	1.3 (Figure F6)

As seen in Table 3.3, stability analyses with the slope of 1.25H:1V on the east side and 2H:1V on the west side using rockfill for the new widened embankment can be considered stable for static and seismic conditions (i.e., calculated FOS > 1.5 for static and FOS > 1.1 for seismic with k_h = 0.5*F(PGA)*PGA=0.112 g), assuming that all loose soils and any organic material are excavated and replaced with properly compacted rockfill.

Based on this assessment, no additional stability enhancement is indicated for the envisaged approach to embankment construction. Additional slope stability analyses and design commentary may be required for the embankment once the final design cross-sections at SW2 are available, should they materially differ from those analyzed.

3.4.3 Settlement Considerations

3.4.3.1 General

Based on the post-construction settlement criteria for embankment widening stipulated in MTO's "Embankment Settlement Criteria for Design", the maximum settlement limits during the pavement design life of the widened embankment are 75 mm for the total settlement and 100:1 for the differential settlement rate for non-freeways (i.e., including this segment of Highway 11). The differential settlement rate is applicable to both the new widened embankment and the differential settlement rate between the existing and the new embankment. The settlement across the widened embankment shall transition uniformly from the widening point (existing highway embankment rounding) to the new embankment rounding such that surface drainage is not impeded.

Potential sources of settlement include: 1) immediate settlement of native granular soil, 2) time-dependent: (a) primary and (b) secondary (creep) consolidation of any cohesive deposits, and 3) settlement of the embankment fills. A computer program, Settle 3D Version 2 (Rocscience Inc.) was employed for settlement calculation.

To estimate the expected settlements for comparison with required criteria, critical sections of the embankment (greatest height and /or maximum thickness of compressible soil) were selected for analyses. This approach permits

assessment of the need for any mitigation over the section being considered. The assessment assumes that prior to new construction, all peat, topsoil and related near surface deleterious material is removed and replaced in accordance with OPSD 203.010.

The following sections present the methods and results of the settlement analyses, along with a discussion of the total predicted settlement in relation to the MTO criteria.

3.4.3.2 Settlement of Foundation Soils

Fill to be placed on native soils for new embankment widening will induce some settlement of the existing native soils. Analyses were completed to estimate the magnitude of settlement associated with the proposed rockfill embankment at two critical cross sections: Sta. 16+000 on the east side, where the embankment rises approximately 13.5 m above existing ground with 1.25H:1V side slopes, and Sta. 16+060 on the west side, where the embankment height is about 9.5 m with 2H:1V slopes.

A computer program, Settle 3D Version 2 (Rocscience Inc.) was employed for settlement calculation. of foundation soils due to construction of new embankment/widening at the site. Settle3D is a 3-dimensional program for the analysis of immediate and consolidation settlement (if any) under foundations, embankments and surface loads. The program combines the simplicity of one-dimensional analysis with the power and visualization capabilities of more sophisticated three-dimensional programs.

A representative site stratigraphy was developed based on the Record of Borehole logs with material properties based on the results of in-situ field testing and laboratory testing. The magnitudes of total (immediate) settlement for the widened embankment have been assessed based on Standard Penetration Test (SPT) and engineering judgement. The parameters used in the settlement analyses are summarized in Table 3.4. These parameters were estimated using empirical relationships with measures soil properties at the site and available data in EXP and MTO libraries obtained in the area.

Table 3.4. Soil strength parameters used in settlement analyses

Soil Layers	**Bulk Unit Weight, γ (kN/m^3)**	**E (MPa)**
Sta. 16+000 East Side		
Sand and Gravel to Gravelly Sand (Compact to Very Dense)	20	50
Sta. 16+060 West Side		
Sand (Compact)	22	35
Glacial Till: Cobbles and Boulders	18	50

At Sta. 16+000 on the east side, where the thin organic layer will be excavated, the settlement analysis was completed based on the full proposed 13.5 m-high embankment at that location. At Sta. 16+060, approximately

1.5 m of excavation is anticipated to remove the existing organic material for the proposed widened embankment, which will then be replaced with rockfill. Accordingly, the settlement analysis was conducted using an 11 m thick rockfill section, comprising the 9.5 m high embankment and the additional 1.5 m of rockfill placed beneath the widened embankment

The summary of results of settlement analyses is given in Table 3.5. The Settle 3D results can be seen in Figures G1 and G2 in Appendix G.

Table 3.5. Results of settlement analyses

Location	Rockfill Thickness (m)	Calculated Settlement of Foundation Soils at Widened Portion (mm)[1]		
		At Edge of Existing Embankment	At Edge of Widened Embankment	Maximum Value Within Widening
Sta. 16+000 East Side	13.5	2	5	12
Sta. 16+060 West Side	11	3	8	11

Note:

1. *Immediate settlement only*

All settlement of the native granular materials is expected to occur during and immediately following construction of the embankment widening. This ground settlement will be accompanied by settlement of the embankment itself. The estimated magnitude of that settlement is presented in the following section.

3.4.3.3 Settlement of Embankment Fill

The embankment fill is estimated to compress by approximately 0.5 to 1 percent of its height under its self-weight, assuming placement in accordance with MTO practices. More granular fills would experience smaller settlements. At this site rockfill is proposed.

Settlement in rockfill embankments is primarily associated with crushing at points of contact and rearrangement of rock fragments under load, as well as potential changes in moisture content. If groundwater levels rise, poorly compacted or unsaturated rockfill may be particularly susceptible to settlement. The magnitude of this settlement depends on factors such as rockfill type, thickness, gradation, construction method, and underlying subgrade conditions. For rockfill embankments constructed on non-compressible soils, the MTO Guideline Rock Fill Settlement and Rock Fill Quantity Estimates (September 14, 2010) provides recommended short-term and long-term settlement values, summarized in Table 3.6 for compacted and dumped rockfills.

Table 3.6. Short- and long-term rockfill settlement

Height of Rockfill, H (m)	Compacted Rockfill		Dumped Rockfill	
	Short-term Settlement[1] (m)	Long-term Settlement (m)	Short-term Settlement[1] (m)	Long-term Settlement (m)
Up to 5	0.5% H	0.1% H	1.0%·H	0.2% H
>5 to 10	0.75% H		1.5%·H	
>10 to 15	1.0% H		2.0%·H	

Note:

1. *Approximately 90% of the short-term settlement may be expected to be complete within 6 months following construction to full height.*

For rockfill embankments placed on compressible subgrade soils, settlement estimates must include both rockfill compression (short- and long-term) and settlement of the underlying foundation soils, as outlined in Section 3.4.3.2. Table 3.7 presents the corresponding settlement estimates for the site.

At Sta. 16+000, the embankment height on the east side is approximately 13.5 m. Considering the geometry of the proposed widened embankment, which incorporates a 1.25H:1V slope with benches, together with the existing embankment profile, the maximum thickness of new rockfill required on the east side is estimated to be about 5 m. On the west side at Sta. 16+060, the maximum thickness of new rockfill is estimated at roughly 4 m for the 9.5 m high embankment with the proposed 2H:1V slope.

Table 3.7. Estimated short- and long-term settlement of rock fill.

Location	Max Rockfill Thickness (m)	Short-term Settlement of Rock Fill (mm)	Long-term Settlement of Rock Fill (mm)	Total (mm)
Sta. 16+000 East Side	5	25	5	30
Sta. 16+060 West Side	4	20	4	24

Note:

1. *Assumes base/subbase granular material below pavement will settle at approximately the same rate as rockfill*

On the east side of Sta. 16+000, the estimated settlement of the rockfill itself (both short- and long-term) is approximately 30 mm, whereas on the west side of Sta. 16+060, the settlement is estimated to be about 24 mm.

The surcharge load from the weight of the new fill is a maximum of 100 kN/m^2. The ultimate bearing capacity of the sand layer (i.e., assuming organics will be completely excavated) is higher than the estimated surcharge load, and no failure against bearing capacity is anticipated because of embankment widening.

3.4.3.4 Discussion of Settlement Results

The maximum value within widening corresponds to the largest magnitude of settlement within the widened portion cross-section. Assuming settlement at edge of existing travelled lane due to placement of rockfill is negligible, the settlement magnitude at edge of new embankment can also be considered the differential settlement between the existing and new edge of embankment.

Table 3.8. Settlement results for foundation soils and rock fill

Location[3]	Total Foundation Settlement (mm)	Total Rockfill Settlement (mm)	Total Post-Construction Settlement (mm)	Remaining Settlement after 6 months (mm)
Sta. 16+000 East Side				
At Edge of Widened Embankment	5	30	35	**8**
Maximum Value Within Widening	12	30	42	**8**
Sta. 16+060 West Side				
At Edge of Widened Embankment	8	24	32	**6**
Maximum Value Within Widening	11	24	35	**6**

Considering that the foundation soil settlement is expected to occur during and immediately following construction of the embankment widening, and that the rockfill settlement will be relatively uniform, the estimated post-construction settlement and differential settlement between the edge of existing and widened embankment, including settlement of the rockfill itself, meets the MTO Embankment Settlement Criteria for Design maximum limit of 75 mm for the pavement and a differential settlement rate of 100:1. Any differential movements should be able to be accommodated during the paving process.

3.5 Construction Considerations

3.5.1 Excavation

All excavations must be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety (OHSA) and good construction practice.

The existing fill and native soil are considered Type 3 soils above the groundwater table and Type 4 soils below the groundwater table. Temporary excavations (i.e., those that are open only for a short period) above the groundwater table may be made with side slopes not steeper than about 1H:1V, while the temporary slopes below the groundwater table have to be formed at 3H:1V unless a suitable dewatering system is installed to lower the water level below the base of the excavation.

Temporary excavation side slopes through organic soil shall be in accordance with the OHSA, OPSD 203.020 (Embankments Over Swamp; Existing Slopes Excavated) and/or OPSD 203.030 (Embankments Over Swamp; Existing Slope Maintained). The organic soil encountered in the lower area can be classified as Type 4 soil using OHSA classification, as it is usually deposited below the groundwater table. Type 4 soils must be sloped 3H:1V or flatter. The existing fill and native soils are considered as Type 3 soils above the groundwater table and Type 4 soils below the groundwater table. Temporary excavations in those soils (i.e., those that are open only for a short period) above the groundwater table may be made with side slopes not steeper than about 1H:1V, while the temporary slopes below the groundwater table have to be formed at 3H:1V.

Excavation of the soils at the project site may be carried out using conventional excavation equipment. During excavation, no excavated material should be piled close to the top of excavated slope. All excavated surfaces should be kept free from frost. In addition, runoff and surface flow shall be directed away from open excavations.

It is recommended that a NSSP be included in the Contract Documents to warn the Contractor of the presence of organic deposits along the lower area as well as about its excavation and backfilling with new fill. The NSSP is attached in Appendix J to 'red flag' this issue.

3.5.2 Subgrade Preparation

Prior to the placement of new fill for the embankment widening, the site will need to be cleared and grubbed of the existing trees and bushes. All surficial topsoil, organic (i.e., peat), loose, soft and/or deleterious materials should be subexcavated from below the proposed widening footprint. Considering the findings at the site, the anticipated subexcavation depths/elevations at the borehole locations are as follows:

Table 3.9 Anticipated subexcavation depths/elevations at borehole locations

Location	Borehole No.	Existing Ground Elevation at Borehole Location (m)	Recommended Subexcavation Depth/Elevation (m)
West Side	BH2-4	289.0	1.5/287.5
	BH2-6	288.9	1.1/287.8
	BH2-7	289.2	0.8/288.4
East Side	PH2-1 to PH2-8	289.5 to 290.8	0.15 to 0.60/288.9 to 290.3

After subexcavation, the exposed subgrade should be inspected and approved. The subgrade soils are susceptible to disturbance from construction traffic, precipitation, etc. Excavation to the anticipated founding levels for the embankment fill placement is expected to extend through organic soil and silt. The stabilized groundwater is expected to be near the ground surface based on the reading in the piezometer and the observed surface water.

Minimum subexcavation levels have been suggested in Table 3.9 but should be confirmed during construction. Subexcavated soft spots should be replaced with compacted granular material (i.e., Granular B Type II) or rockfill.

The peat/organics shall be excavated along the whole footprint of the existing embankment and new embankment widening in accordance with OPSD 203.020 (i.e. existing slope excavated) and OPSD 203.030 (i.e., existing slope maintained), which are attached in Appendix I.

3.5.3 Embankment Construction

The removal of peat/organic deposits within the proposed footprint shall follow the recommendations in Section 3.5.1. Backfilling of the excavation shall be carried out simultaneously in accordance with OPSS.PROV 209. Rockfill can be used as a backfill given that the rock particles are limited to 0.5 m in size (NSSP should be included in the Contract Document; an example is provided in Appendix J).

Grading and embankment construction should be conducted in accordance with OPSS.PROV 206 and OPSS.PROV 501. Except for the top 1.0 m, where a pavement structure should be placed, the embankment fills should consist of an approved rockfill. Rock embankments shall be constructed by placing embankment materials full width in successive uniform layers. As per OPSS.PROV 206, layers of rock embankment should not exceed 1.5 m thickness prior to compaction. The surface of the existing rockfill side slopes to be widened should be scratched to remove any soil/vegetation to provide a good bond between the existing rockfill and the rockfill placed for widening. Material in each layer should be fully compacted prior to the succeeding layer is placed. Each rock fill layer should be compacted with a tractor bulldozer with a minimum number of complete passes of 6 and the maximum passes of 8. A complete pass should be defined as 100% coverage of layer surface. Quality assurance should be provided as per MTO standard 501.08 (OPSS.PROV 501). Inspection and field density should be carried out by qualified personnel during placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

Adequate chinking at the top of the rockfill should be provided before the placement of Granular B Type II for the pavement. The objective of chinking of rockfill exposed to the subgrade level is to form a dense, compact mass which reduces the potential migration of surrounding soils into the existing rockfill which could cause future settlement/soil movements/sinkholes. Alternatively, a suitably robust geotextile can be placed for separation purposes. Transitions between earth fill and rockfill or granular fill, if any, should be constructed in accordance with OPSD 205.040.

For the embankment side slopes, adequate erosion protection against surface water runoff should be provided. The exposed slope surface should be covered with straw or plastic sheets as soon as the slope face is exposed. In general, to reduce surface erosion on the embankment side slopes, prompt seed and cover (OPSS.PROV 804) or sodding (OPSS.PROV 803) should be carried out as soon as possible after construction of the embankment.

As per OPSS.PROV 209, compaction of the rockfill is not a requirement until at least 600 mm above water level. Thus, water entering the sub-excavation is not anticipated to be a major concern.

3.5.4 Site Dewatering

Since excavation of organics within the footprint will be executed in sections parallel to the existing highway approximately 3 m to 5 m wide sections and then immediately backfilled with rockfill (see attached NSSP – Excavation of Organics in Appendix J). Placement of rockfill should be extend to about 0.6 m above the water level and compacted. Therefore, it is anticipated that dewatering will not be required.

3.6 Obstructions During Construction

Cobbles and boulders were encountered during the site investigation. Therefore, care must be taken since the presence of these obstructions may affect the excavation. It is recommended that an NSSP be included in the Contract Documents to warn the Contractor of the presence of cobbles and boulders within the embankment. An example of an NSSP for obstructions is provided in Appendix J.

3.7 Discussion on Drainage Issues

3.7.1 Current Conditions

An accumulation of water was observed on the east side of the highway. It is understood that a creek flowing from the east to the west existed at that site before the construction of Highway 11. Based on the information provided, no culvert was installed in the embankment during its construction to convey the creek below the highway. Instead, it was allowed that the water flows freely through the rockfill embankment toward the west toe of the embankment. Since there are no signs of sink holes on SW2 section of highway, it can be assumed that there has not been significant instability issues due to the water conveying freely through the embankment. However, for the new widening of Highway 11 the drainage issue at the site must be addressed and some potential solutions are discussed below.

3.7.2 Potential Solutions

The drainage issue pertaining to the accumulated water is a multi-disciplinary exercise that involves input from hydrology, drainage, environmental as well as the geotechnical perspectives. The final solution will be provided after discussion with MTO and the design team.

Below are two possible solutions for the drainage of the surface water from the east to the west:

1. Installation of a culvert by trenchless methods – Considering available trenchless methods to install the culvert through rockfill tunneling through the existing rockfill embankment with 1) grouting and forepoling and 2) Horizontal Down the Hole (DTH) drilling are the only technically practical tunneling options, since the nature of the embankment material (i.e., rockfill) may create significant obstructions during tunneling. Additionally, controlling the water (i.e., accumulated water on the east side) could be difficult during construction. Therefore, this solution would be very expensive to undertake.
2. Widening of highway using rockfill with geotextile – In this option a zone at the toe of the embankment should consist of material minimum cobble sized particles (>150 mm diameter) wrapped with geotextile. The geotextile will be a separator and filter, since sands and fines content within this zone needs to be minimized as free flowing water could transport sands/fines and cause instability. The design of this rockfill/geotextile zone requires additional seepage analyses for the embankment and accumulated water on the east side. For more details see a preliminary sketch of this proposed solution attached in Appendix J.

4 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project and are provided solely for the team responsible for the design of the works described herein.

We recommend that we be retained to review our recommendations as the design nears completion to ensure that the final design is in agreement with the assumptions on which our recommendations are based and that our recommendations have been interpreted as intended. If not accorded this review, EXP will assume no responsibility for the interpretation and use of the recommendations in this report.

A subsurface investigation is a limited sampling of a site; the subsurface conditions have been established only at the test hole locations. Should conditions at the site be encountered which differ from those reported at the test locations, we require that we be notified immediately in order to assess this additional information and our recommendations, as appropriate. It may then be necessary to perform additional investigations and analyses.

Contractors bidding on or undertaking any proposed work at this site should, relative to the subsurface conditions, decide on their own investigations, if deemed necessary, as well as their own interpretations of the factual results provided herein, so they may draw their own conclusions as to how the subsurface conditions may affect them.

This Foundation Investigation and Design Report has been prepared by Elvis Lu, M.Eng., P.Eng., Silvana Micic, Ph.D., P.Eng and Thomas Lardner, Ph.D., P.Eng. It was reviewed by TaeChul Kim, M.E.Sc., P.Eng. and by Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact.

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Ministry of Transportation, March 23, 2020. Material Engineering Research Office (MERO) #2020-01, Highway Standards Branch

Ministry of Transportation, April 2022. Guideline for MTO Foundation Engineering Services, Version 03

ASTM International:

ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

Ontario Provincial Standard Specifications (OPSS):

OPSS.PROV 206 Construction Specification for Grading

OPSS.PROV 209 Construction Specification for Embankments Over Swamps and Compressible Soils

OPSS.PROV 501 Construction Specification for Compacting

OPSS.PROV 803 Construction Specification for Vegetative Cover

OPSS.PROV 804 Construction Specification for Temporary Erosion Control

OPSS.PROV 905 Construction Specification for Steel Reinforcement for Concrete

OPSS.PROV 1350 Material Specification for Concrete – Materials and Production

Ontario Provincial Standard Drawings (OPSD):

OPSD 202.010 Slope Flattening Using Excess Material on Earth or Rock Embankment

OPSD 203.020 Embankments Over Swamp; Existing Slope Excavated

OPSD 203.030 Embankments Over Swamp; Existing Slope Maintained

OPSD 205.040 Transition Treatment, Earth Fill to Rock Fill, and Earth Fill to Granular Fill

OPSD 3090.100 Foundation Frost Penetration Depths for Northern Ontario

Ontario Water Resources Act:

R.R.O 1990, Regulation 903 Wells, under Ontario Water Resources Act, R.S.O. 1990, c. O.40

Ontario Occupational Health and Safety Act (OHSA):

Ontario Regulation 213/91 Construction Projects

LIMITATIONS AND USE OF REPORT

BASIS OF REPORT

This report ("Report") is based on site conditions known or inferred by the geotechnical investigation undertaken as of the date of the Report. Should changes occur which potentially impact the geotechnical condition of the site, or if construction is implemented more than one year following the date of the Report, the recommendations of EXP may require re-evaluation.

The Report is provided solely for the guidance of design engineers and on the assumption that the design will be in accordance with applicable codes and standards. Any changes in the design features which potentially impact the geotechnical analyses or issues concerning the geotechnical aspects of applicable codes and standards will necessitate a review of the design by EXP. Additional field work and reporting may also be required.

Where applicable, recommended field services are the minimum necessary to ascertain that construction is being carried out in general conformity with building code guidelines, generally accepted practices and EXP's recommendations. Any reduction in the level of services recommended will result in EXP providing qualified opinions regarding the adequacy of the work. EXP can assist design professionals or contractors retained by the Client to review applicable plans, drawings, and specifications as they relate to the Report or to conduct field reviews during construction.

Contractors contemplating work on the site are responsible for conducting an independent investigation and interpretation of the borehole results contained in the Report. The number of boreholes necessary to determine the localized underground conditions as they impact construction costs, techniques, sequencing, equipment and scheduling may be greater than those carried out for the purpose of the Report.

Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates are based on investigations performed in accordance with the standard of care set out below and require the exercise of judgment. As a result, even comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations or building envelope descriptions involve an inherent risk that some conditions will not be detected. All documents or records summarizing investigations are based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated. Some conditions are subject to change over time. The Report presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, these should be disclosed to EXP to allow for additional or special investigations to be undertaken not otherwise within the scope of investigation conducted for the purpose of the Report.

RELIANCE ON INFORMATION PROVIDED

The evaluation and conclusions contained in the Report are based on conditions in evidence at the time of site inspections and information provided to EXP by the Client and others. The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose as communicated by the Client. EXP has relied in good faith upon such representations, information and instructions and accepts no responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of any misstatements, omissions,

misrepresentation or fraudulent acts of persons providing information. Unless specifically stated otherwise, the applicability and reliability of the findings, recommendations, suggestions or opinions expressed in the Report are only valid to the extent that there has been no material alteration to or variation from any of the information provided to EXP.

STANDARD OF CARE

The Report has been prepared in a manner consistent with the degree of care and skill exercised by engineering consultants currently practicing under similar circumstances and locale. No other warranty, expressed or implied, is made. Unless specifically stated otherwise, the Report does not contain environmental consulting advice.

COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment form part of the Report. This material includes, but is not limited to, the terms of reference given to EXP by its client ("Client"), communications between EXP and the Client, other reports, proposals or documents prepared by EXP for the Client in connection with the site described in the Report. In order to properly understand the suggestions, recommendations and opinions expressed in the Report, reference must be made to the Report in its entirety. EXP is not responsible for use by any party of portions of the Report.

USE OF REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. No other party may use or rely upon the Report in whole or in part without the written consent of EXP. Any use of the Report, or any portion of the Report, by a third party are the sole responsibility of such third party. EXP is not responsible for damages suffered by any third party resulting from unauthorised use of the Report.

REPORT FORMAT

Where EXP has submitted both electronic file and a hard copy of the Report, or any document forming part of the Report, only the signed and sealed hard copy shall be the original documents for record and working purposes. In the event of a dispute or discrepancy, the hard copy shall govern. Electronic files transmitted by EXP have utilize specific software and hardware systems. EXP makes no representation about the compatibility of these files with the Client's current or future software and hardware systems. Regardless of format, the documents described herein are EXP's instruments of professional service and shall not be altered without the written consent of EXP.

Appendix A –
Site Photographs

Photograph 1. Embankment slope facing southeast (April 08, 2024)

Photograph 2. SPT sampling in the southbound lane (November 20, 2023)

Photograph 3. SPT sampling at SW2 at borehole BH2-6 using tripod setup in swamp (April 09, 2024)

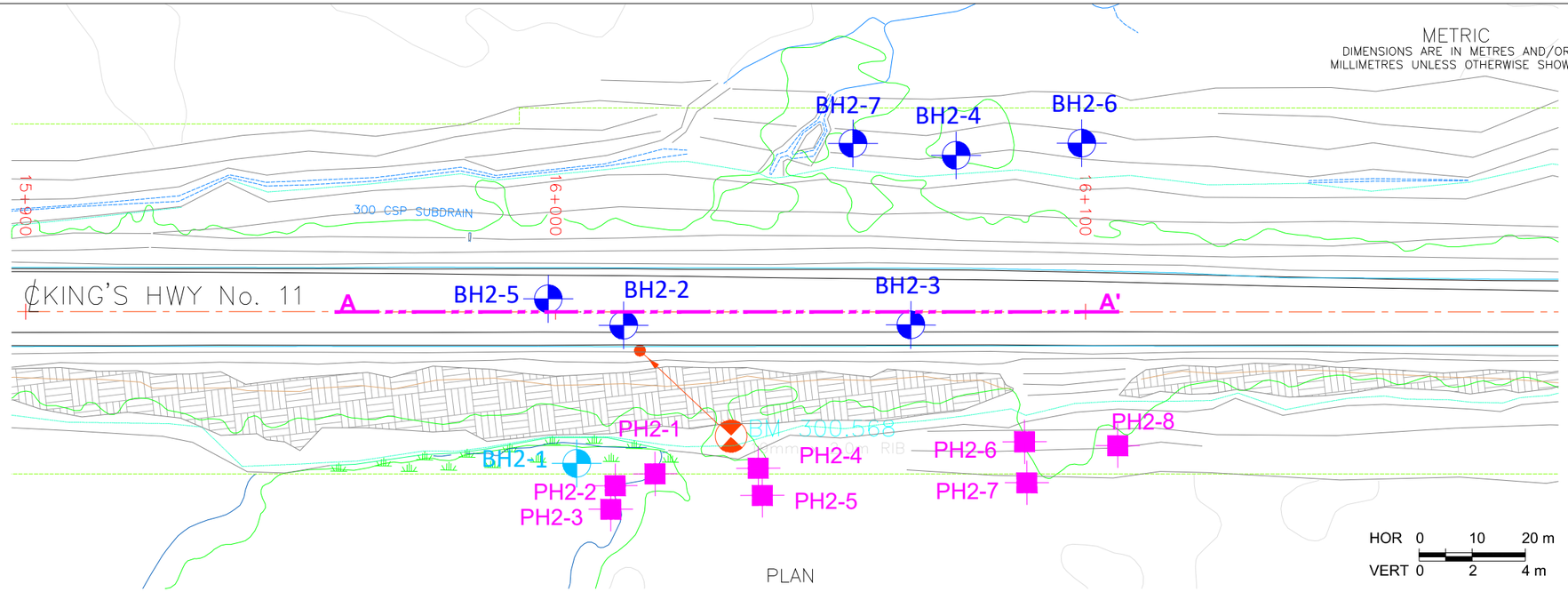
Photograph 4. Surface spoon in swamp at SW2 at borehole BH2-7 (March 25, 2024)

Photograph 5. East side of embankment near proposed location of BH2-1 (April 8, 2024)

Photograph 6. Honda GX35 Portable Soil Sampler used for the probeholes on the east side of the embankment

Appendix B – Drawings

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



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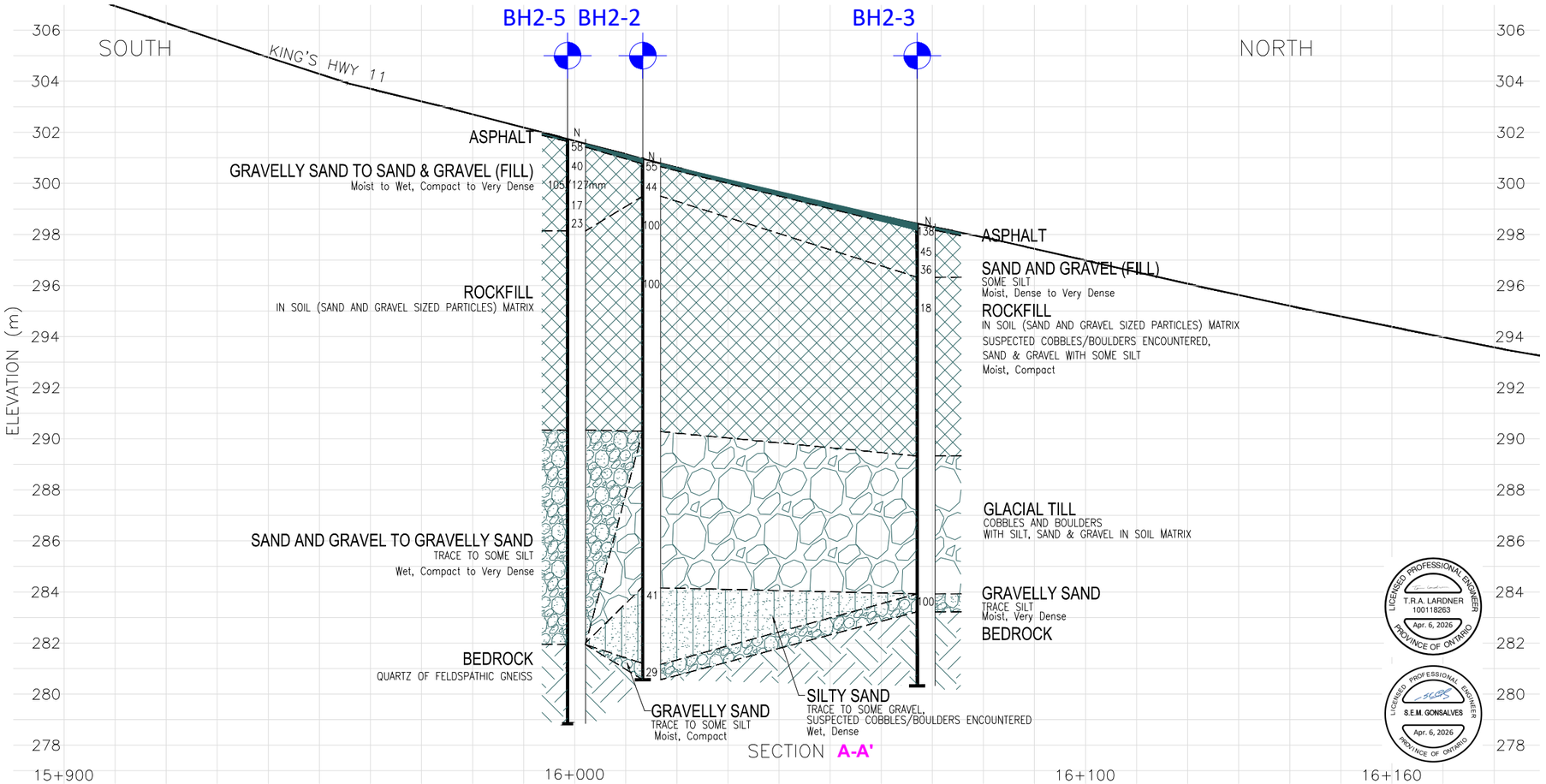

SECTION A-A'

CONT No. 5021-E-0038
ASSIG No.
GWP No. 5151-21-00

Highway 11 from Sand Dam Road Northerly 13.8 Km to Ellesmere Road (SW2)
Latitude: 46.575311°; Longitude: -79.629389°

BOREHOLE LOCATION PLAN & SOIL STRATA

SHEET 1

exp. **EXP SERVICES INC.**

KEY PLAN
N.T.S.

LEGEND

- Borehole Location (Drilled)
- Probehole Location
- Borehole Location (Replaced by Probeholes)
- N — Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level in Piezometer (most recent) (W. L. STABILIZED)
- Piezometer

SOIL STRATA SYMBOLS

TOPSOIL, ASPHALT, FILL, SILTY SAND, PEAT/ ORGANIC SILT, SAND, SAND & GRAVEL TO GRAVELLY SAND, COBBLES & BOULDERS, BEDROCK

BOREHOLE COORDINATES/ NAD 83/ MTM ON-10

BH No.	ELEV.	NORTHING	EASTING
BH2-2	301.0	5159526.4	294876.6
BH2-3	298.4	5159568.7	294842.7
BH2-4	289.0	5159555.4	294812.4
BH2-5	301.7	5159515.0	294885.1
BH2-6	288.9	5159572.5	294795.8
BH2-7	289.2	5159538.8	294822.8

NOTES

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LICENSED PROFESSIONAL ENGINEER — T.R.A. LARDNER — 100118263 — Apr. 6, 2026 — PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER — S.E.M. GONSALVES — Apr. 6, 2026 — PROVINCE OF ONTARIO

REVISIONS	NO	DATE	BY	DESCRIPTION
				SUBMISSION FOR MTO REVIEW

PROJECT No.	ADM-23010055-A0		GEOCRES No.	31L12-004	
SUBM'D SH	CHKD. TL		DATE Jan 12, 2026	SITE SW2	
DRAWN SH	CHKD. TL		APPRD SG	DWG 01	

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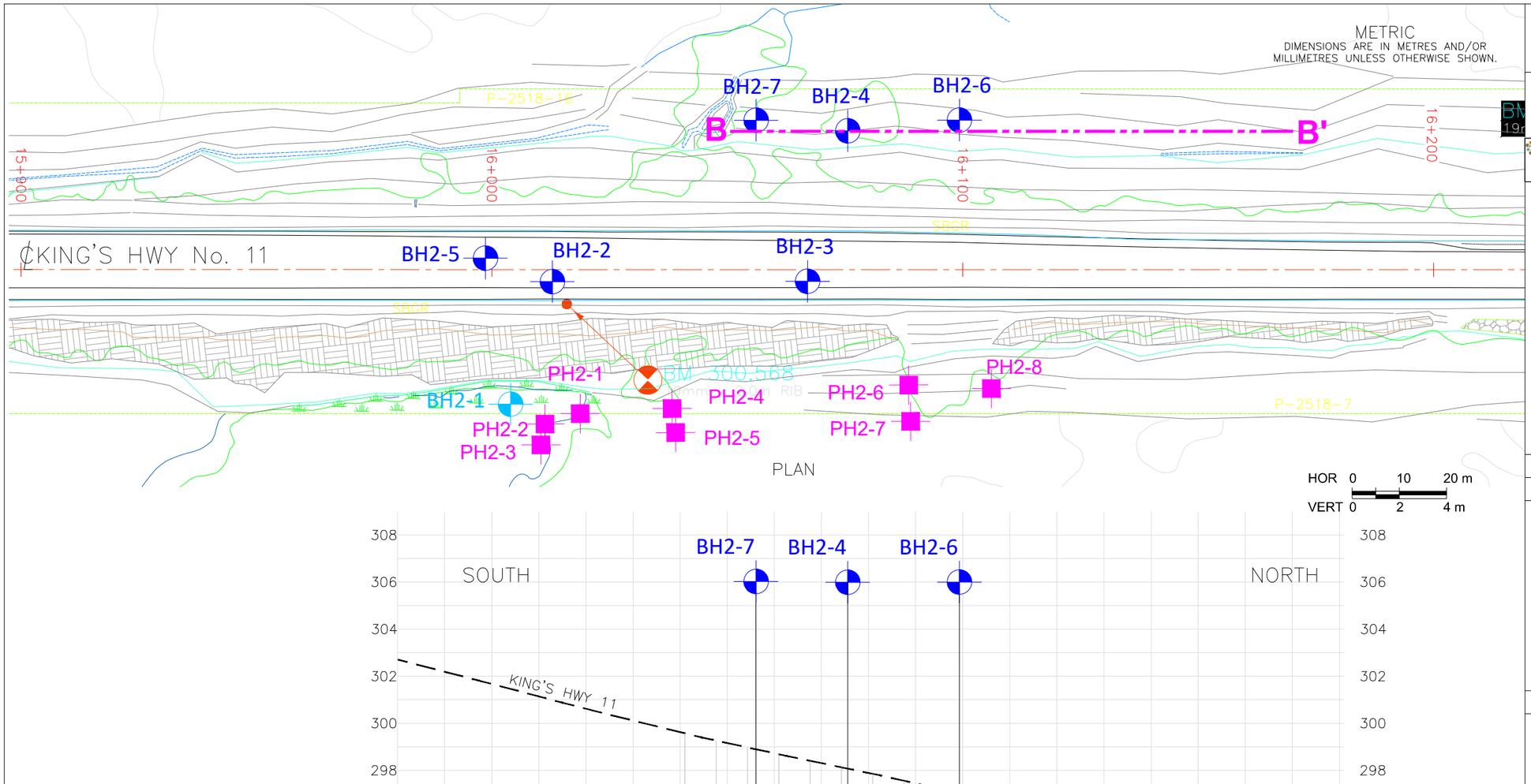

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CONT No. 5021-E-0038
ASSIG No.
GWP No. 5151-21-00

Highway 11 from Sand Dam Road Northerly 13.8 Km to Ellesmere Road (SW2)
Latitude: 46.575311°; Longitude: -79.629389°
BOREHOLE LOCATION PLAN & SOIL STRATA

SHEET 2

EXP SERVICES INC.

KEY PLAN
N.T.S.

LEGEND

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- Probehole Location
- Borehole Location (Replaced by Probeholes)
- N — Blows/0.3m (Std. Pen. Test, 475 J/blow)
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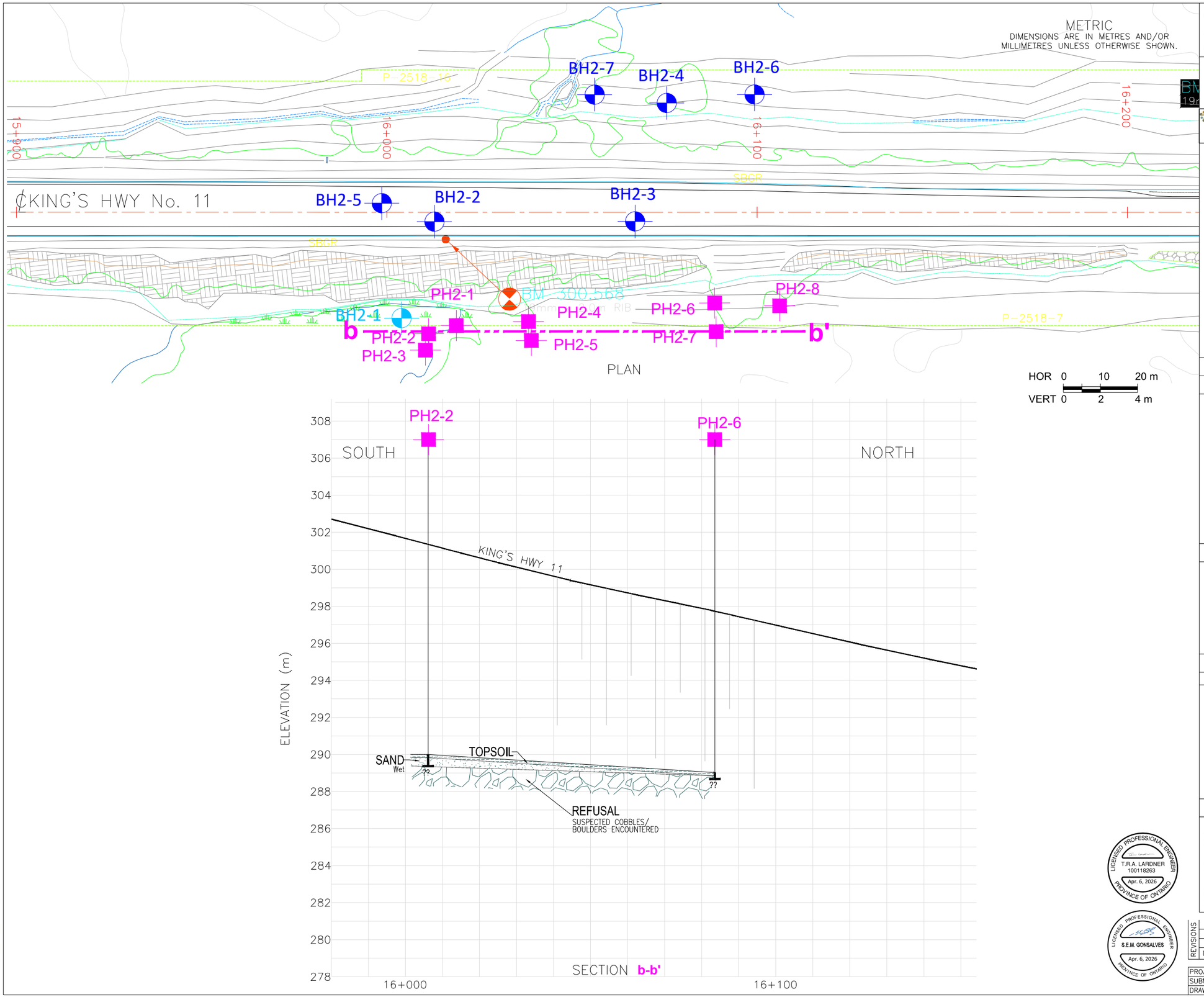
DRAWN	SH	CHKD.	TL	APPRD SG	DWG 02



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CONT No. 5021-E-0038
ASSIG No.
GWP No. 5151-21-00

SHEET 3

Highway 11 from Sand Dam Road Northerly 13.8 Km to Ellesmere Road (SW2)
Latitude: 46.575311°; Longitude: -79.629389°

BOREHOLE LOCATION PLAN & SOIL STRATA

EXP SERVICES INC.

KEY PLAN
N.T.S.

LEGEND

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- Probehole Location
- Borehole Location (Replaced by Probeholes)
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Apr. 6, 2026
PROVINCE OF ONTARIO

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S.E.M. GONSALVES
Apr. 6, 2026
PROVINCE OF ONTARIO

REVISIONS	NO	DATE	BY	DESCRIPTION
				SUBMISSION FOR MTO REVIEW

PROJECT No.	ADM-23010055-A0		GEOCRES No.	31L12-004	
SUBM'D	SH	CHKD.	TL	DATE Jan 12, 2026	SITE SW2
DRAWN	SH	CHKD.	TL	APPRD SG	DWG 03

CONT No. 5021-E-0038
ASSIG No.
GWP No. 5151-21-00

SHEET 4

Highway 11 from Sand Dam Road Northerly 13.8 Km to Ellesmere Road (SW2)
Latitude: 46.575311°; Longitude: -79.629389°

BOREHOLE LOCATION PLAN & SOIL STRATA

EXP SERVICES INC.

METRIC
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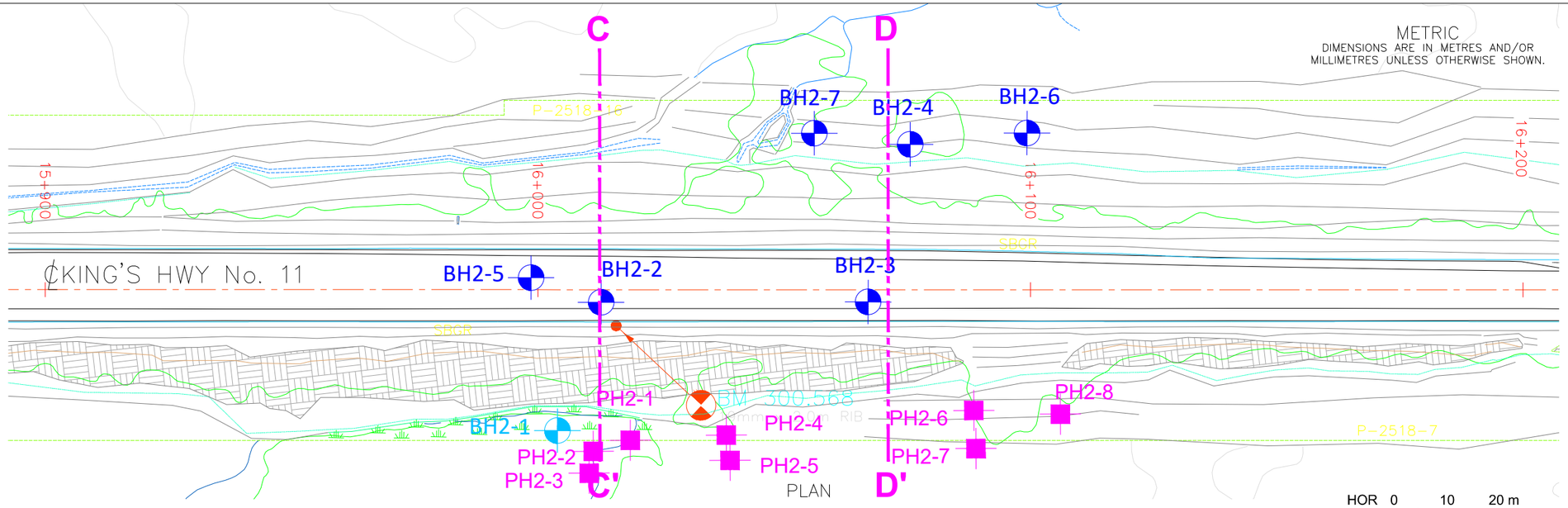
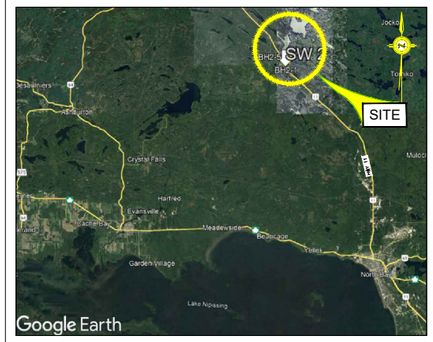




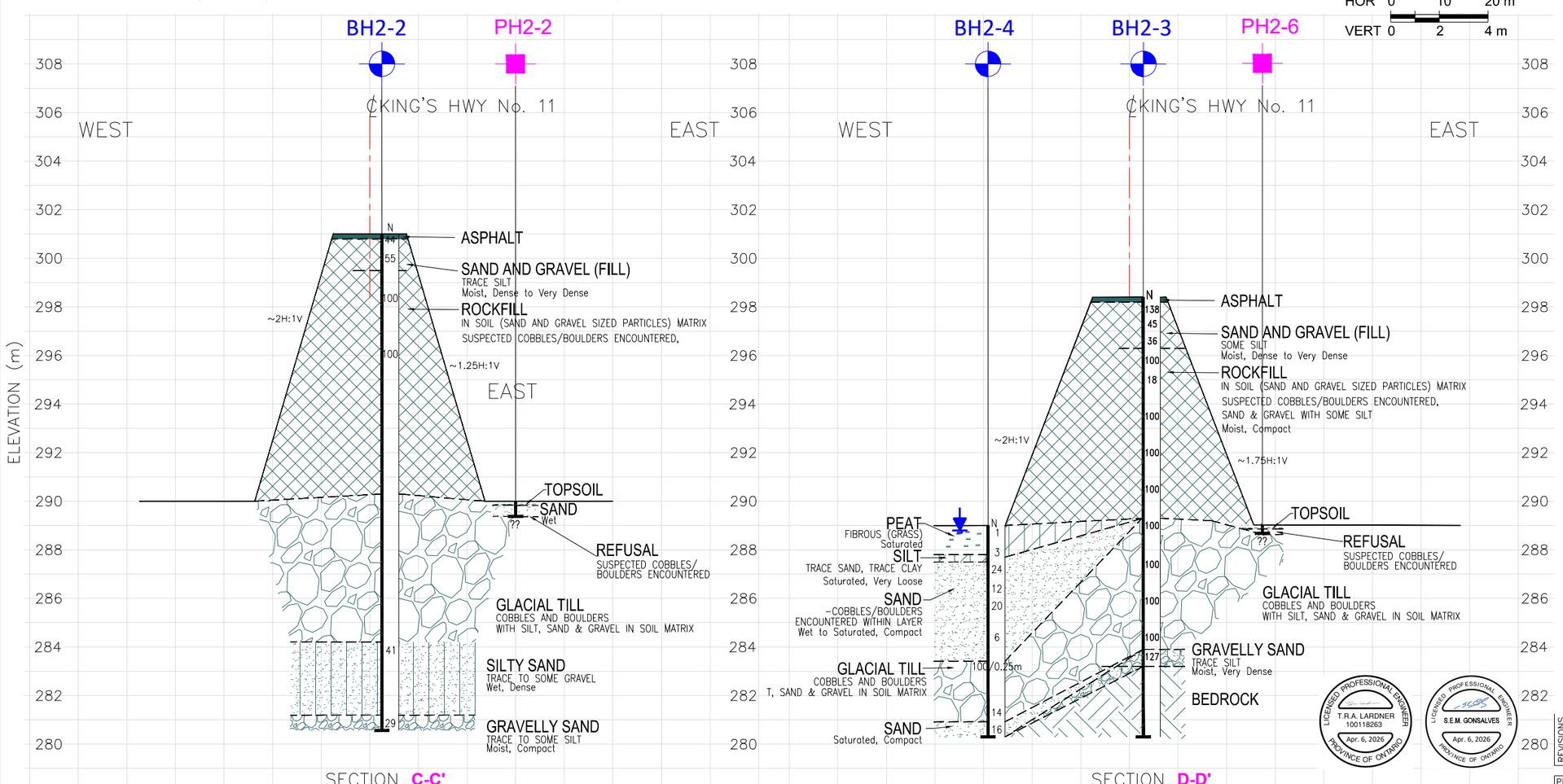
KEY PLAN
N.T.S.

LEGEND

- Borehole Location (Drilled)
- Probehole Location
- Borehole Location (Replaced by Probeholes)
- N — Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level in Piezometer (most recent) (W. L. STABILIZED)
- Piezometer

SOIL STRATA SYMBOLS

- TOPSOIL
- ASPHALT
- FILL
- SILTY SAND
- PEAT/ ORGANIC SILT
- SAND
- SAND & GRAVEL TO GRAVELLY SAND
- COBBLES & BOULDERS
- BEDROCK



BOREHOLE COORDINATES/ NAD 83/ MTM ON-10

BH No.	ELEV.	NORTHING	EASTING
BH2-2	301.0	5159526.4	294876.6
BH2-3	298.4	5159568.7	294842.7
BH2-4	289.0	5159555.4	294812.4
BH2-5	301.7	5159515.0	294885.1
BH2-6	288.9	5159572.5	294795.8
BH2-7	289.2	5159538.8	294822.8

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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

LICENSED PROFESSIONAL ENGINEER T.R.A. LARDNER 100118263 Apr. 6, 2026 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S.E.M. GONSALVES Apr. 6, 2026 PROVINCE OF ONTARIO

REVISIONS	NO	DATE	BY	DESCRIPTION
				SUBMISSION FOR MTO REVIEW

PROJECT No.	ADM-23010055-A0		GEOCRES No.	31L12-004	
SUBM'D SH	CHKD. TL		DATE Jan 12, 2026	SITE SW2	
DRAWN SH	CHKD. TL		APPRD SG	DWG 04	

FILE NAME: \\pbrmfsg001\data_zes\2003-Brampton\Proposals\Projects\International\MTO Projects\MTO 5021-E-0038 - Hwy 11 with AECOM\60 Execution\64 CAD\Working drawings\SW1 & SW2\CAD-b0533001100182_SW2_PLAN & PROFILE EL.dwg
MODIFIED: 2026-01-09 13:41

Appendix C –
Borehole Logs

Explanation of Terms Used on Borehole Records

SOIL DESCRIPTION

Terminology describing common soil genesis:

Topsoil: mixture of soil and humus capable of supporting good vegetative growth.

Peat: fibrous fragments of visible and invisible decayed organic matter.

Fill: where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

Till: the term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Terminology describing soil structure:

Desiccated: having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.

Stratified: alternating layers of varying material or color with the layers greater than 6 mm thick.

Laminated: alternating layers of varying material or color with the layers less than 6 mm thick.

Fissured: material breaks along plane of fracture.

Varved: composed of regular alternating layers of silt and clay.

Slickensided: fracture planes appear polished or glossy, sometimes striated.

Blocky: cohesive soil that can be broken down into small angular lumps which resist further breakdown.

Lensed: inclusion of small pockets of different soil, such as small lenses of sand scattered through a mass of clay; not thickness.

Seam: a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

Homogeneous: same color and appearance throughout.

Well Graded: having wide range in grain sized and substantial amounts of all predominantly on grain size.

Uniformly Graded: predominantly on grain size.

All soil sample descriptions included in this report follow generally the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) with some modification to reflect current MTO practices. The system divides soils into three major categories: (1) coarse grained, (2) fine-grained, and (3) highly organic. The soil is then subdivided based on either gradation or plasticity characteristics. The system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification. The classification excludes particles larger than 76 mm. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually in accordance with ASTM D2488-09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems. Others may use different classification systems; one such system is the ISSMFE Soil Classification.

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		

0.002	0.006	0.02	0.06	0.2	0.6	2.0	6.0	20	60	200

EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

UNIFIED SOIL CLASSIFICATION

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present and as described below in accordance with Canadian Foundation Engineering Manual (CFEM):

Table a: Percent or Proportion of Soil

Term	Description	Criteria
“trace”	trace gravel, trace sand, etc.	1% - 10%
“some”	some gravel, some sand, etc.	10% - 20%
Adjective	gravelly, sandy, silty and clayey	20% - 35%
“and”	and gravel, and sand, etc.	>35%
Noun	gravel, sand, silt, clay	>35% and main fraction

The
standard terminology to describe cohesionless soils includes the compactness as determined by the Standard Penetration Test ‘N’ value:

Table b: Apparent Density of Cohesionless Soil

	‘N’ Value (blows/0.3 m)
Very Loose	N<5
Loose	5≤N<10
Compact	10≤N<30
Dense	30≤N<50
Very Dense	50≤N

The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests or similar field and laboratory analysis, Standard Penetration Test 'N' values can also be used to provide an approximate indication of the consistency and shear strength of fine grained, cohesive soils:

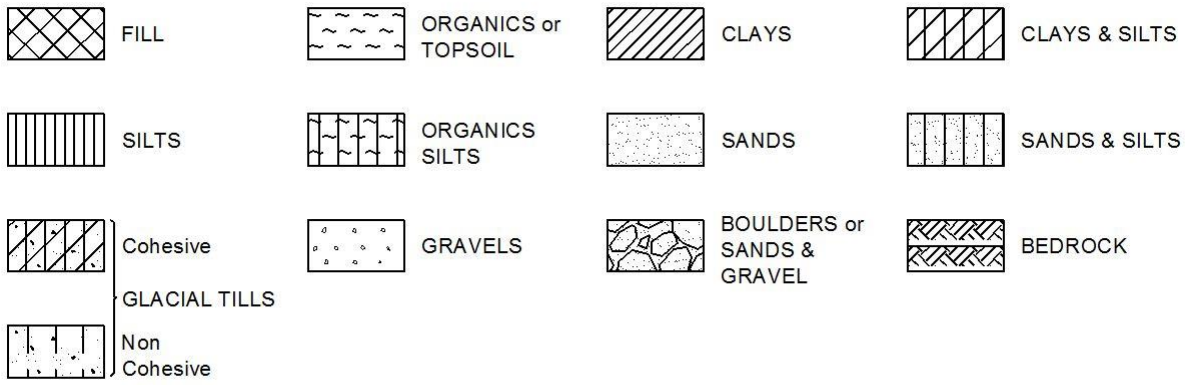
Table c: Consistency of Cohesive Soil

Consistency	Vane Shear Measurement (kPa)	'N' Value
Very Soft	<12.5	<2
Soft	12.5-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

Note: 'N' Value - The Standard Penetration Test records the number of blows of a 140 pound (64kg) hammer falling 30 inches (760mm), required to drive a 2 inch (50.8mm) O.D. split spoon sampler 1 foot (305mm). For split spoon samples where full penetration is not achieved, the number of blows is reported over the sampler penetration in meters (e.g. 50/0.15).

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



WATER LEVEL MEASUREMENT

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	Split spoon sample (obtained from the Standard Penetration Test)
WS	Wash sample
BS	Bulk sample
TW	Thin wall sample or Shelby tube
PS	Piston sample
AS	Auger sample
VT	Vane test
GS	Grab sample
HQ, NQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits

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
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal strains
E	kPa	Modulus of linear deformation
G	kPa	Modulus of shear deformation
μ	1	Coefficient of friction

MECHANICALL PROPERIES OF SOIL

m_v	kPa^{-1}	Coefficient of volume change
c_c	1	Compression index
c_s	1	Swelling index
c_r	1	Recompression index
c_v	m^2/s	Coefficient of consolidation
H	m	Drainage path
T_V	1	Time factor
U	%	Degree of consolidation
σ'_{v0}	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 = c_u/τ_r

PHYSICAL PROPERTIES OF SOIL

P_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	%	Liquidity index = $(W - W_P)/I_P$
I_C	%	Consistency index = $(W_L - W)/I_P$
e_{max}	1, %	Void ratio in loosest state
e_{min}	1, %	Void ratio in densest state
I_D	1	Density index = $(e_{max} - e)/(e_{max} - e_{min})$
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

RECORD OF BOREHOLE No BH2-2

1 OF 3 **METRIC**

W.P. GWP 5151-21-00 LOCATION 5159526.4N, 294876.6E, NAD83 MTM Zone 10 ORIGINATED BY ST

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY EL

DATUM Geodetic DATE 2023.11.15 - 2023.11.16 LATITUDE 46.575298 LONGITUDE -79.629466 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
301.0	GROUND SURFACE										
0.0 / 300.9	**ASPHALT** ~150 mm thick										
0.2	**SAND AND GRAVEL (FILL),** trace silt, brown, moist, dense to very dense		SS1	SS	55				○		
			SS2	SS	44		300		○		38 53 (9)
299.5											
1.5	**ROCKFILL,** in soil (sand and gravel sized particles) matrix - spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		299				
	- sand with some gravel, brown, wet, very dense		SS3	SS	100				○		
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		298				
	- sand with some gravel, brown, wet, very dense		SS4	SS	100		297		○		
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		296				
							295				
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		294				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-2

2 OF 3 **METRIC**

W.P. GWP 5151-21-00 LOCATION 5159526.4N, 294876.6E, NAD83 MTM Zone 10 ORIGINATED BY ST

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY EL

DATUM Geodetic DATE 2023.11.15 - 2023.11.16 LATITUDE 46.575298 LONGITUDE -79.629466 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	ROCKFILL, in soil (sand and gravel sized particles) matrix *(continued)*						292			
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		291			
290.3										
10.7	**COBBLES AND BOULDERS,** in soil (sand and gravel sized particles) matrix - spoon refusal; suspected boulders/rock fragments encountered			NR	100		290			
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		289			
							288			
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		287			
							286			

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-2

3 OF 3 **METRIC**

W.P. GWP 5151-21-00 LOCATION 5159526.4N, 294876.6E, NAD83 MTM Zone 10 ORIGINATED BY ST

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY EL

DATUM Geodetic DATE 2023.11.15 - 2023.11.16 LATITUDE 46.575298 LONGITUDE -79.629466 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
284.2	**COBBLES AND BOULDERS,** in soil (sand and gravel sized particles) matrix *(continued)* - spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100						
16.8	**SILTY SAND,** trace to some gravel, brown, wet, dense		SS5	SS	41		284		○		
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		283				
281.2							282				
19.8	**GRAVELLY SAND,** trace to some silt, grey, moist, compact		SS6	SS	29		281		○		28 62 (10)
280.6											
20.4	BOREHOLE TERMINATED AT ~ 20.4 m DEPTH Notes: 1. Groundwater level not measured due to water used for coring. 2. Borehole backfilled upon completion.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-3

1 OF 3 **METRIC**

W.P. GWP 5151-21-00 LOCATION 5159568.7N, 294842.7E, NAD83 MTM Zone 10 ORIGINATED BY ST

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY EL

DATUM Geodetic DATE 2023.11.08 - 2023.11.10 LATITUDE 46.575677 LONGITUDE -79.629909 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
298.4	GROUND SURFACE										
0.0 / 298.2	**ASPHALT** ~200 mm thickness										
0.2	**SAND AND GRAVEL (FILL),** some silt, brown, moist, dense to very dense		SS1	SS	138		298		○		
			SS2	SS	45		297		○		
296.3			SS3	SS	36				○		
2.1	**ROCKFILL,** in soil (sand and gravel sized particles) matrix						296				
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100						
	-sand and gravel with some silt, brown moist, compact		SS4	SS	18		295		○		
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		294				
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		293				
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		292				
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		291				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-3

2 OF 3 **METRIC**

W.P. GWP 5151-21-00 LOCATION 5159568.7N, 294842.7E, NAD83 MTM Zone 10 ORIGINATED BY ST

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY EL

DATUM Geodetic DATE 2023.11.08 - 2023.11.10 LATITUDE 46.575677 LONGITUDE -79.629909 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	ROCKFILL, in soil (sand and gravel sized particles) matrix *(continued)*						290			
289.3										
9.1	**COBBLES AND BOULDERS,** in soil (sand and gravel sized particles) matrix - spoon refusal; suspected boulders/rock fragments encountered			NR	100		289			
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		288			
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		287			
	- spoon refusal; suspected cobbles/boulders encountered, no recovery			NR	100		286			
283.9							285			
14.5	**GRAVELLY SAND,** trace silt, brown, moist, very dense		SS5	SS	127		284	o		21 72 (7)
283.2										
15.2	**BEDROCK,** grey with pink embedments, quartzofeldspathic gneiss		RUN 1	NQ			283			

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-3 3 OF 3 METRIC

W.P. GWP 5151-21-00 LOCATION 5159568.7N, 294842.7E, NAD83 MTM Zone 10 ORIGINATED BY ST

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY EL

DATUM Geodetic DATE 2023.11.08 - 2023.11.10 LATITUDE 46.575677 LONGITUDE -79.629909 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	BEDROCK, grey with pink embedments, quartzofeldspathic gneiss *(continued)* Run 1: Start/End: 15.2 to 16.6 m Recovery: 100% RQD: 60% Run 2: Start/End: 16.6 to 18.1 m Recovery: 100% RQD: 94%		RUN 2	NQ			282 281				
280.3 18.1	BOREHOLE TERMINATED AT ~ 18.1 m DEPTH Notes: 1. Groundwater level not measured due to water used for coring. 2. Borehole backfilled upon completion.										

$+^{3}$, $\times^{3}$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-4

1 OF 2 **METRIC**

W.P. GWP 5151-21-00 LOCATION 5159555.4N, 294812.4E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE Hilti DD250 COMPILED BY EL

DATUM Geodetic DATE 2024.03.28 - 2024.04.02 LATITUDE 46.575558 LONGITUDE -79.630304 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.0	GROUND SURFACE										
0.0	**PEAT,** fibrous (grass), black, saturated		SS1	SS	1				182		
287.8			SS2	SS	3		288				
1.2	**SILT,** trace sand, trace clay, brown, saturated, very loose										0 5 90 5
287.5											
1.5	**SAND,** brown to grey, wet to saturated, compact -cobbles/boulders encountered within layer		SS3	SS	24		287				
			SS4	SS	12						
			SS5	SS	20		286				
	-NQ Coring procedures commenced			NQ							
				NQ			285				
			SS6	SS	6						
283.4							284				
5.6	**COBBLES AND BOULDERS,** in soil (sand and gravel sized particles) matrix - spoon refusal; suspected boulders/rock fragments encountered		SS7	SS	100/ 0.25m		283				
	- pushed a rock, no recovery			NR	14		282				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-4 2 OF 2 METRIC

W.P. GWP 5151-21-00 LOCATION 5159555.4N, 294812.4E, NAD83 MTM Zone 10 ORIGINATED BY AM

DIST NER HWY 11 BOREHOLE TYPE Hilti DD250 COMPILED BY EL

DATUM Geodetic DATE 2024.03.28 - 2024.04.02 LATITUDE 46.575558 LONGITUDE -79.630304 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
280.9											
8.1	**SAND,** grey, saturated, compact		SS8	SS	16				○		
280.3											
8.7	BOREHOLE TERMINATED AT ~ 8.7 m DEPTH Notes: 1. Groundwater level not measured due to water used for coring. 2. Borehole backfilled upon completion.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-5

1 OF 3

METRIC

W.P. GWP 5151-21-00 LOCATION 5159515.0N, 294885.1E, NAD83 MTM Zone 10 ORIGINATED BY SF

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY EL

DATUM Geodetic DATE 2023.11.20 - 2023.11.20 LATITUDE 46.575195 LONGITUDE -79.629354 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
301.7	GROUND SURFACE										
300.6 1.0	**ASPHALT** ~100 mm thick										
0.1	**GRAVELLY SAND TO SAND AND GRAVEL (FILL),** brown to grey, moist to wet, compact to very dense		SS1	SS	58		301		○		
			SS2	SS	40				○		34 58 (8)
			SS3	SS	105/ 127mm		300		○		44 47 (9)
			SS4	SS	17		299				
			SS5	SS	23						
298.1											
3.6	**ROCKFILL,** in soil (sand and gravel sized particles) matrix -NQ Coring procedures commenced			NQ			298				
				NQ			297				
				NQ			296				
							295				
							294				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-5

2 OF 3 **METRIC**

W.P. GWP 5151-21-00 LOCATION 5159515.0N, 294885.1E, NAD83 MTM Zone 10 ORIGINATED BY SF

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY EL

DATUM Geodetic DATE 2023.11.20 - 2023.11.20 LATITUDE 46.575195 LONGITUDE -79.629354 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	ROCKFILL, in soil (sand and gravel sized particles) matrix *(continued)*			NQ			293			
				NQ			292			
							291			
290.3										
11.4	**SAND AND GRAVEL TO GRAVELLY SAND,** trace to some silt, brown to grey, wet, compact to very dense		SS6	SS	28		290			
							289			
			SS7	SS	34		288			
							287			
							286			

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-5

3 OF 3 **METRIC**

W.P. GWP 5151-21-00 LOCATION 5159515.0N, 294885.1E, NAD83 MTM Zone 10 ORIGINATED BY SF

DIST NER HWY 11 BOREHOLE TYPE Truck Mounted CME 75 COMPILED BY EL

DATUM Geodetic DATE 2023.11.20 - 2023.11.20 LATITUDE 46.575195 LONGITUDE -79.629354 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND AND GRAVEL TO GRAVELLY SAND, trace to some silt, brown to grey, wet, compact to very dense *(continued)*		SS8	SS	41						
							285				
			SS9	SS	102				○		28 59 (13)
			SS10	SS	24		284		○		
							283				
			SS11	SS	57						
281.9							282				
19.8	**BEDROCK,** grey with pink embedments, quartz of feldspathic gneiss Run 1: Start/End: 19.8 to 21.3 m Recovery: 93% RQD: 93%		Run 1	NQ							
							281				
	Run 2: Start/End: 21.3 to 22.9 m Recovery: 100% RQD: 79%		Run 2	NQ			280				
278.8							279				
22.9	BOREHOLE TERMINATED AT ~ 22.9 m DEPTH Notes: 1. Groundwater level not measured due to water used for coring. 2. Borehole backfilled upon completion.										

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-6

1 OF 2

METRIC

W.P. GWP 5151-21-00 LOCATION 5159572.5N, 294795.8E, NAD83 MTM Zone 10 ORIGINATED BY DM

DIST NER HWY 11 BOREHOLE TYPE Hilti DD250 COMPILED BY EL

DATUM Geodetic DATE 2024.04.08 - 2024.04.08 LATITUDE 46.575711 LONGITUDE -79.630521 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
288.9	GROUND SURFACE										
0.0 / 288.7	**TOPSOIL,** ~150 mm thick, black, moist										
0.2	- grass and rootlets observed		SS1	SS	WH						
	ORGANIC SILT, amorphous, brown, moist, very loose, - rootlets observed										
288.1											
0.8 / 287.8	**SILT,** some clay, trace sand, brown, moist, loose		SS2	SS	7		288				0 6 83 11
1.1	**COBBLES AND BOULDERS,** in soil (sand and gravel sized particles) matrix			NQ			287				
	-NQ Coring procedures commenced										
285.9							286				
3.0	**SAND,** trace to some gravel, trace silt, brownish grey to grey, wet to saturated, loose to dense		SS3	SS	25/ 0.1 m						
	-cobbles/boulders encountered within layer			NQ			285				
			SS4	SS	8						0 91 (9)
							284				
							283				
			SS5	SS	6						
							282				
			SS6	SS	6		281				

308
149

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-6 2 OF 2 METRIC

W.P. GWP 5151-21-00 LOCATION 5159572.5N, 294795.8E, NAD83 MTM Zone 10 ORIGINATED BY DM

DIST NER HWY 11 BOREHOLE TYPE Hilti DD250 COMPILED BY EL

DATUM Geodetic DATE 2024.04.08 - 2024.04.08 LATITUDE 46.575711 LONGITUDE -79.630521 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND, trace to some gravel, trace silt, brownish grey to grey, wet to saturated, loose to dense -cobbles/boulders encountered within layer *(continued)*						280				
				NQ							
278.8			SS7	SS	30		279		○		
10.1	BOREHOLE TERMINATED AT ~ 10.1 m DEPTH Notes: 1. Groundwater level not measured due to water used for coring. 2. 40 mm inside diameter piezometer installed upon completion screened from approximately 3.1 m to 6.1 m below ground surface 3. Water level measured in piezometer below ground surface: Date / Depth(m) / Elev. (m) 4/24/24 — 0.1 — 288.8 5/15/24 — 0.0 — 288.9 5/28/24 — 0.4 — 288.5										

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2-7

1 OF 1 **METRIC**

W.P. GWP 5151-21-00 LOCATION 5159538.8N, 294822.8E, NAD83 MTM Zone 10 ORIGINATED BY BK

DIST NER HWY 11 BOREHOLE TYPE Hilti DD250 COMPILED BY EL

DATUM Geodetic DATE 2024.03.25 - 2024.03.27 LATITUDE 46.575409 LONGITUDE -79.630168 CHECKED BY TL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × P. PENETROMETER 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.2	GROUND SURFACE									
0.0	**ORGANIC SILT/CLAY,** amorphous with trace of vegetation and rootletss, dark brown to black, wet, soft		SS1	SS	2		289			
288.4										
0.8	**SAND AND GRAVEL TO GRAVELLY SAND,** grey, moist to wet, loose to compact		SS2	SS	7		288			
			SS3	SS	16		287			
			SS4	SS	22		286			25 66 (9)
			SS5	SS	9		285			
284.6										
4.6	**COBBLES AND BOULDERS,** in soil (sand and gravel sized particles) matrix			NQ			284			
282.7							283			
6.5	BOREHOLE TERMINATED AT ~ 6.5 m DEPTH Notes: 1. Groundwater level not measured due to water used for coring. 2. Borehole backfilled upon completion.									

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Highway 11 – 2+1 Roadway Model Project: Site SW2
Probeholes
Drilling Date: July 31, 2025

PH2-1 Latitude: 46.575496, Longitude: -79.629231

0 – 125 mm	Topsoil, dark brown, wet
125 – 375 mm	Sand, trace gravel, grey, wet
	Refusal at 375 mm

PH2-2 Latitude: 46.575457, Longitude: -79.629145

0 – 125 mm	Topsoil, dark brown, wet
125 – 600 mm	Sand, trace gravel, grey, wet
	Refusal at 600 mm

PH2-3 Latitude: 46.575476, Longitude: -79.629093

0 – 175 mm	Topsoil, dark brown, wet
	Refusal at 175 mm

PH2-4 Latitude: 46.575628, Longitude: -79.629399

0 – 100 mm	Topsoil, dark brown, wet
100 – 475 mm	Silt, some sand, trace gravel, brown, moist
	Refusal at 475 mm

PH2-5 Latitude: 46.575662, Longitude: -79.629353

0 – 150 mm	Topsoil, dark brown, wet
150 – 475 mm	Silt, some sand, trace gravel, brown, moist
	Refusal at 475 mm

PH2-6 Latitude: 46.575952, Longitude: -79.629857

0 – 125 mm	Topsoil, dark brown, wet
125 – 375 mm	Silty sand, trace gravel, brown, moist
	Refusal at 375 mm

PH2-7 Latitude: 46.575999, Longitude: -79.629785

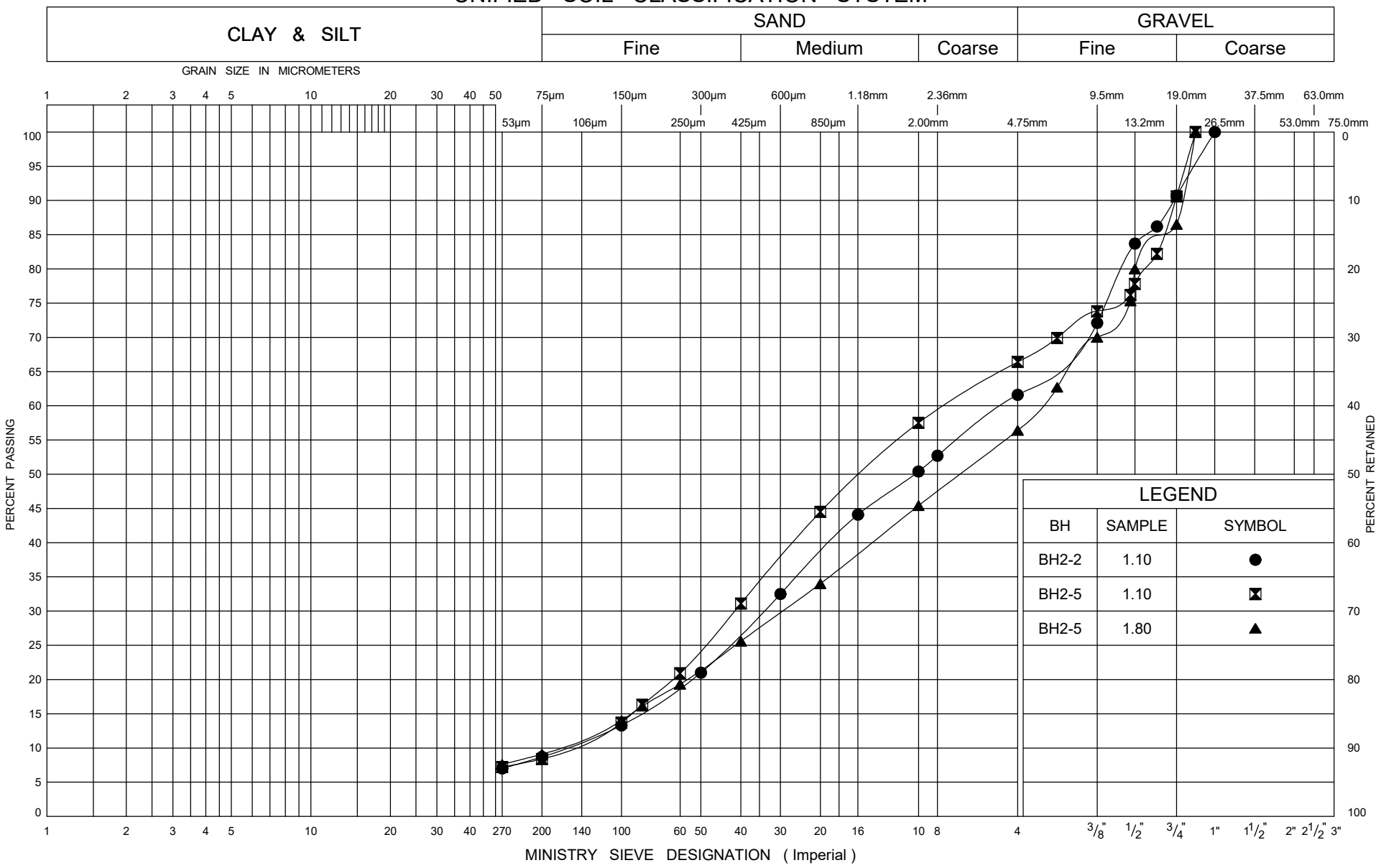
0 – 150 mm	Topsoil, dark brown, wet
	Refusal at 150 mm

PH2-8 Latitude: 46.576080, Longitude: -79.629996

0 – 125 mm	Topsoil, dark brown, wet
125 – 375 mm	Silty sand, trace gravel, brown, moist
	Refusal at 375 mm

Appendix D –
Laboratory Data

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Cohesionless Fill: Sand and Gravel/Gravelly Sand

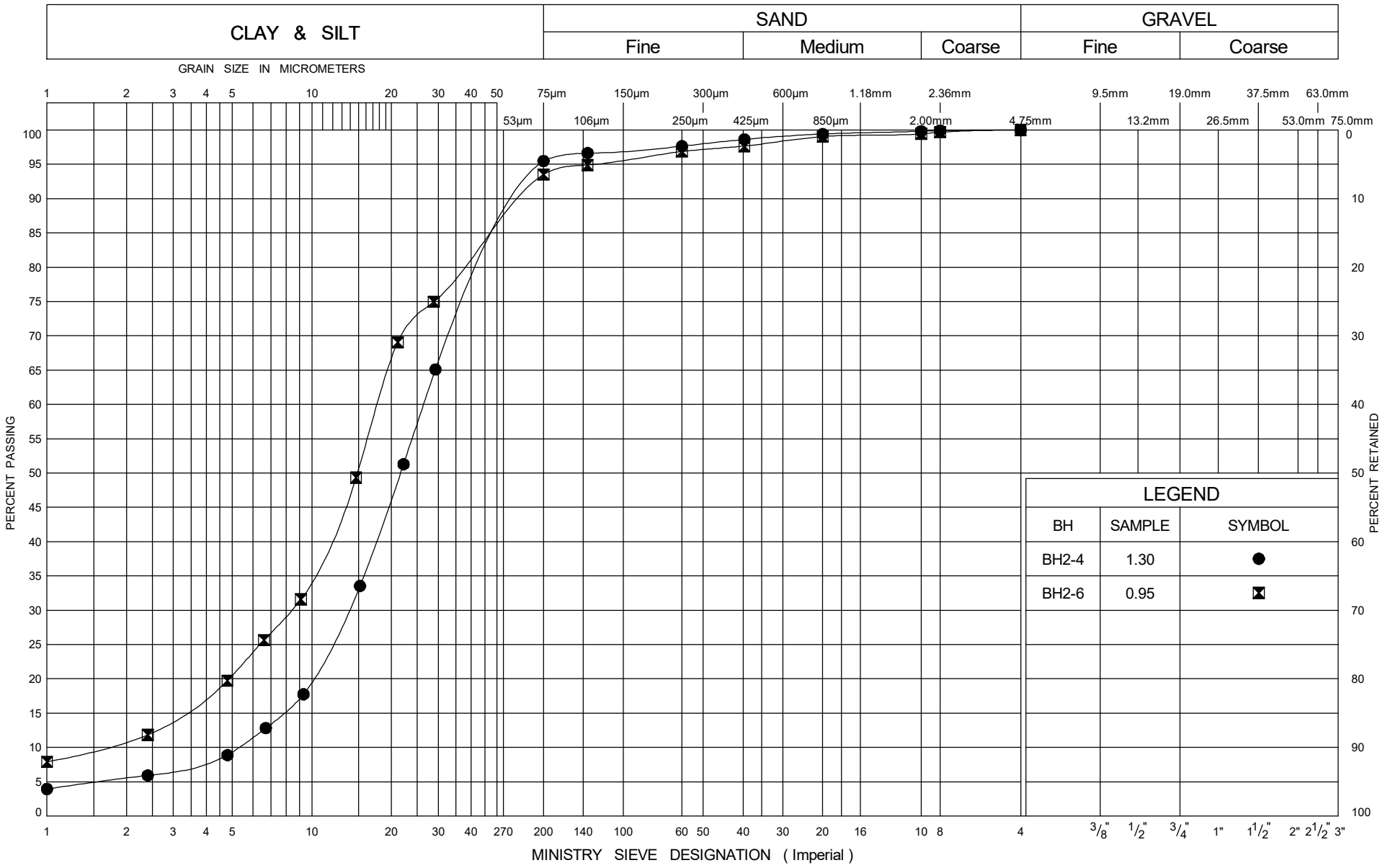
FIG No 1

W P GWP 5151-21-00

Highway 11 2+1 - SW2

ONTARIO MOT GRAIN SIZE HWY 11-2+1-SW2-V2.GPJ ONTARIO MOT.GDT 4/29/24

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silt

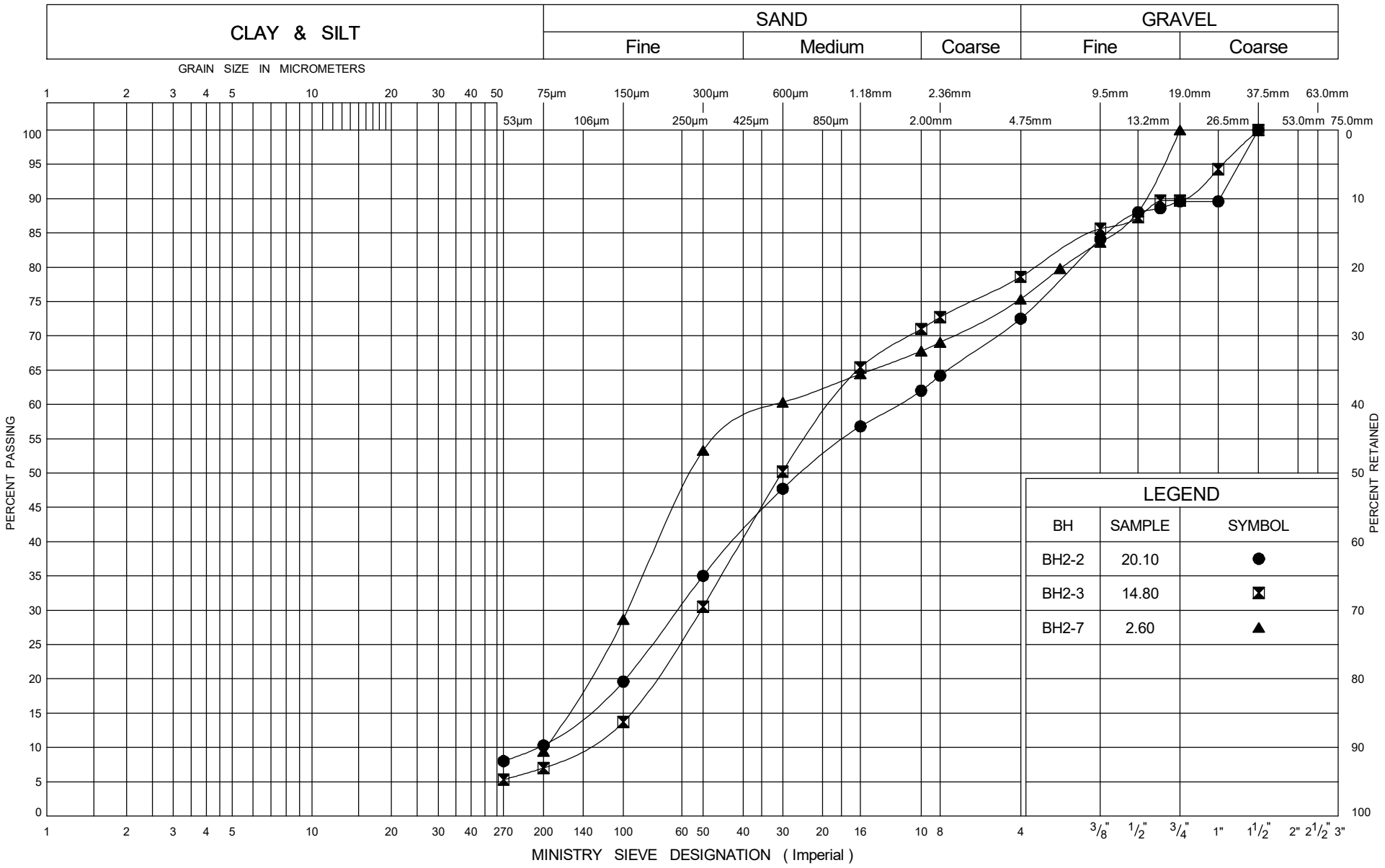
FIG No 2

W P GWP 5151-21-00

Highway 11 2+1 - SW2

ONTARIO MOT GRAIN SIZE HWY 11-2+1-SW2-V2.GPJ ONTARIO MOT.GDT 5/29/24

UNIFIED SOIL CLASSIFICATION SYSTEM



ONTARIO MOT GRAIN SIZE HWY 11-2+1-SW2-V2.GPJ ONTARIO MOT.GDT 5/28/24

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Sand and Gravel to Gravelly Sand

FIG No 3

W P GWP 5151-21-00

Highway 11 2+1 - SW2

Your Project #: ADM-23010055-A0
Site Location: SW2, HWY 11 2+1
Your C.O.C. #: 139121

Attention: Thomas Lardner

exp Services Inc
Brampton Branch
1595 Clark Blvd
Brampton, ON
CANADA L6T 4V1

Report Date: 2024/04/24
Report #: R8120667
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C4B2854
Received: 2024/04/16, 16:27

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (20:1 extract)	1	2024/04/19	2024/04/19	CAM SOP-00463	MOE E3013 m
Conductivity	1	2024/04/19	2024/04/19	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	1	N/A	2024/04/20	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	1	N/A	2024/04/21	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	1	2024/04/18	2024/04/18	CAM SOP-00413	EPA 9045 D m
Redox Potential (3)	1	2024/04/19	2024/04/19	CAM SOP-00421	SM 24 2580 B
Resistivity of Soil	1	2024/04/16	2024/04/19	CAM SOP-00414	SM 24 2510 m
Sulphate (20:1 Extract)	1	2024/04/19	2024/04/19	CAM SOP-00464	MOE E3013 m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, EPA, APHA or the Quebec Ministry of Environment.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by Bureau Veritas Calgary (19th), 4000 19th Street NE , Calgary, AB, T2E 6P8
(2) Offsite analysis requires that subcontracted moisture be reported.

Your Project #: ADM-23010055-A0
Site Location: SW2, HWY 11 2+1
Your C.O.C. #: 139121

Attention: Thomas Lardner

exp Services Inc
Brampton Branch
1595 Clark Blvd
Brampton, ON
CANADA L6T 4V1

Report Date: 2024/04/24
Report #: R8120667
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C4B2854

Received: 2024/04/16, 16:27

(3) Oxidation-Reduction Potential (ORP) values are determined using a Ag/AgCl reference electrode. The test is therefore, not SCC accredited for this matrix.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to:
Patricia Legette, Project Manager
Email: Patricia.Legette@bureauveritas.com
Phone# (905)817-5799

==========

This report has been generated and distributed using a secure automated process.
Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

Bureau Veritas Job #: C4B2854
Report Date: 2024/04/24

exp Services Inc
Client Project #: ADM-23010055-A0
Site Location: SW2, HWY 11 2+1
Sampler Initials: DM

SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		YXK801		
Sampling Date		2024/04/10 16:00		
COC Number		139121		
	UNITS	**BH2-6, SS1B (2-3')**	**RDL**	**QC Batch**
Calculated Parameters				
Resistivity	ohm-cm	1400		9336736
CONVENTIONALS				
Redox Potential	mV	260	N/A	9343452
Inorganics				
Soluble (20:1) Chloride (Cl-)	ug/g	400	20	9343427
Conductivity	umho/cm	709	2	9344150
Available (CaCl2) pH	pH	5.35		9341419
Soluble (20:1) Sulphate (SO4)	ug/g	48	20	9343428
Sulphide	mg/kg	<1.3 (1)	1.3	9349164

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable
(1) Detection limits raised due to high moisture content, samples contain => 50% moisture.
Sample contained greater than 10% headspace at time of extraction.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Bureau Veritas Job #: C4B2854
Report Date: 2024/04/24

exp Services Inc
Client Project #: ADM-23010055-A0
Site Location: SW2, HWY 11 2+1
Sampler Initials: DM

RESULTS OF ANALYSES OF SOIL

Bureau Veritas ID		YXK801		
Sampling Date		2024/04/10 16:00		
COC Number		139121		
	UNITS	**BH2-6, SS1B (2-3')**	**RDL**	**QC Batch**
Physical Testing				
Moisture-Subcontracted	%	61	0.30	9349163

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Bureau Veritas Job #: C4B2854
Report Date: 2024/04/24

exp Services Inc
Client Project #: ADM-23010055-A0
Site Location: SW2, HWY 11 2+1
Sampler Initials: DM

TEST SUMMARY

Bureau Veritas ID: YXK801
Sample ID: BH2-6, SS1B (2-3')
Matrix: Soil

Collected: 2024/04/10
Shipped:
Received: 2024/04/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	SKAL/EC	9343427	2024/04/19	2024/04/19	Alina Dobreanu
Conductivity	AT	9344150	2024/04/19	2024/04/19	Gurparteek KAUR
Moisture (Subcontracted)	BAL	9349163	N/A	2024/04/20	Ashley Henderson
Sulphide in Soil	SPEC	9349164	N/A	2024/04/21	Irene Donita Villanueva
pH CaCl2 EXTRACT	AT	9341419	2024/04/18	2024/04/18	Kien Tran
Redox Potential	COND	9343452	2024/04/19	2024/04/19	Gurparteek KAUR
Resistivity of Soil		9336736	2024/04/19	2024/04/19	Automated Statchk
Sulphate (20:1 Extract)	SKAL/EC	9343428	2024/04/19	2024/04/19	Alina Dobreanu

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	4.0°C

Results relate only to the items tested.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Bureau Veritas Job #: C4B2854
Report Date: 2024/04/24

QUALITY ASSURANCE REPORT

exp Services Inc
Client Project #: ADM-23010055-A0
Site Location: SW2, HWY 11 2+1
Sampler Initials: DM

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9341419	Available (CaCl2) pH	2024/04/18			100	97 - 103			1.1	N/A
9343427	Soluble (20:1) Chloride (Cl-)	2024/04/19	95	70 - 130	96	70 - 130	<20	ug/g	NC	35
9343428	Soluble (20:1) Sulphate (SO4)	2024/04/19	NC	70 - 130	96	70 - 130	<20	ug/g	6.4	35
9343452	Redox Potential	2024/04/19			102	95 - 105			0.75	35
9344150	Conductivity	2024/04/19			104	90 - 110	<2	umho/cm	0.24	10
9349163	Moisture-Subcontracted	2024/04/20					<0.30	%		
9349164	Sulphide	2024/04/21	80	75 - 125	103	75 - 125	<0.5	mg/kg		

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Bureau Veritas Job #: C4B2854
Report Date: 2024/04/24

exp Services Inc
Client Project #: ADM-23010055-A0
Site Location: SW2, HWY 11 2+1
Sampler Initials: DM

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Cristina Carriere, Senior Scientific Specialist

Veronica Falk, B.Sc., P.Chem., QP, Scientific Specialist, Organics

Suwan (Sze Yeung) Fock, B.Sc., Scientific Specialist

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

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CAM FCD-01191/5

REC'D IN LONDON

CHAIN OF CUSTODY RECORD 139121 Page ____ of ____

Invoice Information	Report Information (if differs from invoice)	Project Information (where applicable)	Turnaround Time (TAT) Required
Company Name: #17488 exp Services Inc.	Company Name: exp Services inc	Quotation #:	☐ Regular TAT (5-7 days) Most analyses
Contact Name: Accounts Payable	Contact Name: Daniel Mroz	P.O. #/ AFE#:	PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS
Address: 1595 Clark Blvd. Brampton, ON L6T 4V1	Address: Also email: thomas.lardner@exp.com	Project #: ADM-23010055-A0	Rush TAT (Surcharges will be applied) ☐ 1 Day ☐ 2 Days ☐ 3-4 Days
Phone: 905-793-9800 Fax:	Phone: 519-317-6526 Fax:	Site Location: SWQ, Hwy 11 Z+1	
Email: AP@exp.com	Email: daniel.mroz@exp.com	Site #:	Date Required:
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BUREAU VERITAS LABORATORIES' DRINKING WATER CHAIN OF CUSTODY		Site Location Province:	Rush Confirmation #:
		Sampled By:	

Regulation 153
☐ Table 1 ☐ Res/Park ☐ Med/ Fine
☐ Table 2 ☐ Ind/Comm ☐ Coarse
☐ Table 3 ☐ Agri/ Other
☐ Table ____
FOR RSC (PLEASE CIRCLE) Y / N

Other Regulations
☐ CCME ☐ Sanitary Sewer Bylaw
☐ MISA ☐ Storm Sewer Bylaw
☐ PWQO Region ____
☐ Other (Specify) ____
☐ REG 558 (MIN. 3 DAY TAT REQUIRED)

Include Criteria on Certificate of Analysis: Y / N

SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS

LABORATORY USE ONLY
CUSTODY SEAL: Present (Y) / Intact (N)
COOLER TEMPERATURES: 4 | 4 | 4.
6 | 9 | 9
COOLING MEDIA PRESENT: (Y) / N

COMMENTS

NONT-2024-04-1497

	SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHCs F2 - F4	VOCs	REG 153 METALS & INORGANICS	REG 153 ICPMS METALS	REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B)	Corrosivity Suite	HOLD- DO NOT ANALYZE
1	BH2-6, SS1B (2-3')	2024/04/10	16:00	Soil									X	
2														
3														
4														
5														
6														
7														
8														
9														
10														

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	BV JOB #
Daniel Mroz	2024/04/16	10:30	Soumya Ragavan	2024/04/16	10:27	
			Adam	2024/04/16	17 55	

Unless otherwise agreed to in writing, work submitted on this Chain of Custody is subject to Bureau Veritas Laboratories' standard Terms and Conditions. Signing of this Chain of Custody document is acknowledgment and acceptance of our terms available at http://www.bvlabs.com/terms-and-conditions

COC-1004 (06/19)

752406

White: Maxxam ~ Yellow: Client

Appendix E –
Bedrock Core Photograph

Photograph E1. Rock cores from BH2-5. Top: Run 1, Middle: Run 2, Bottom: Run 2 continued.

Appendix F –
Slope Stability Analyses

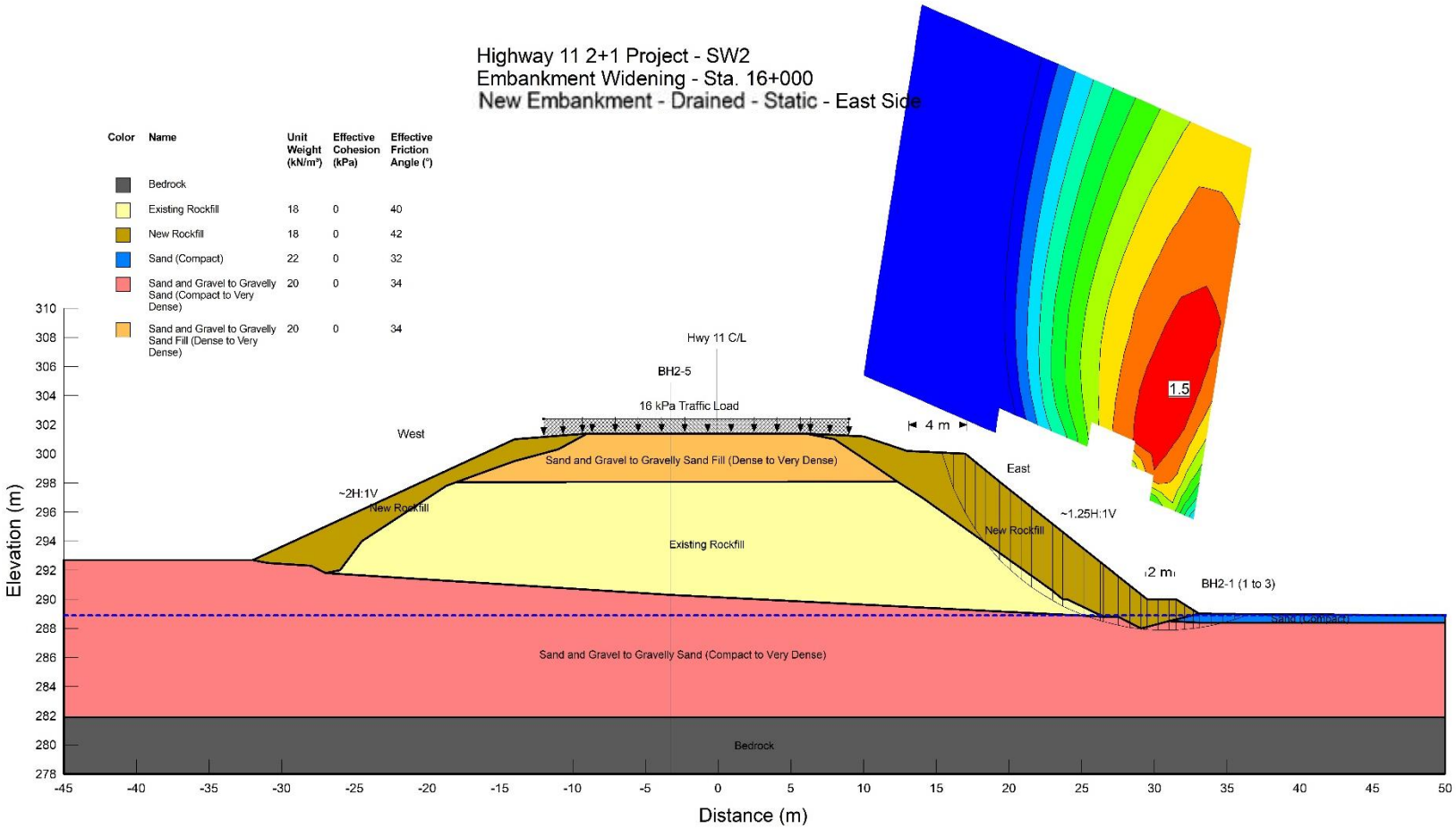


Figure F1: Slope stability analysis for Sta. 16+000 east side of embankment (1.25H:1V) – drained, static condition

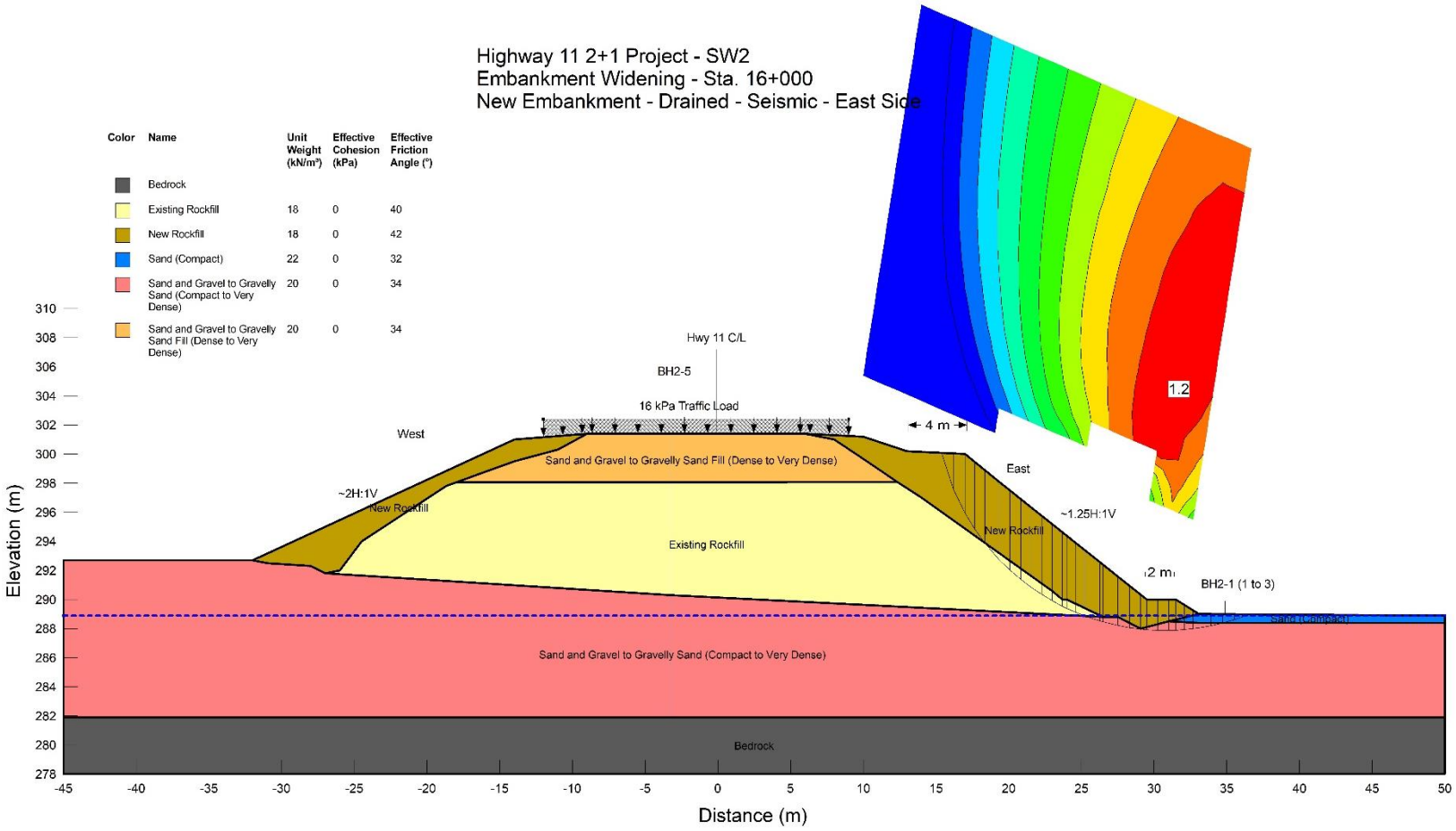


Figure F2: Slope stability analysis for Sta. 16+000 east side of embankment (1.25H:1V) – drained, seismic condition

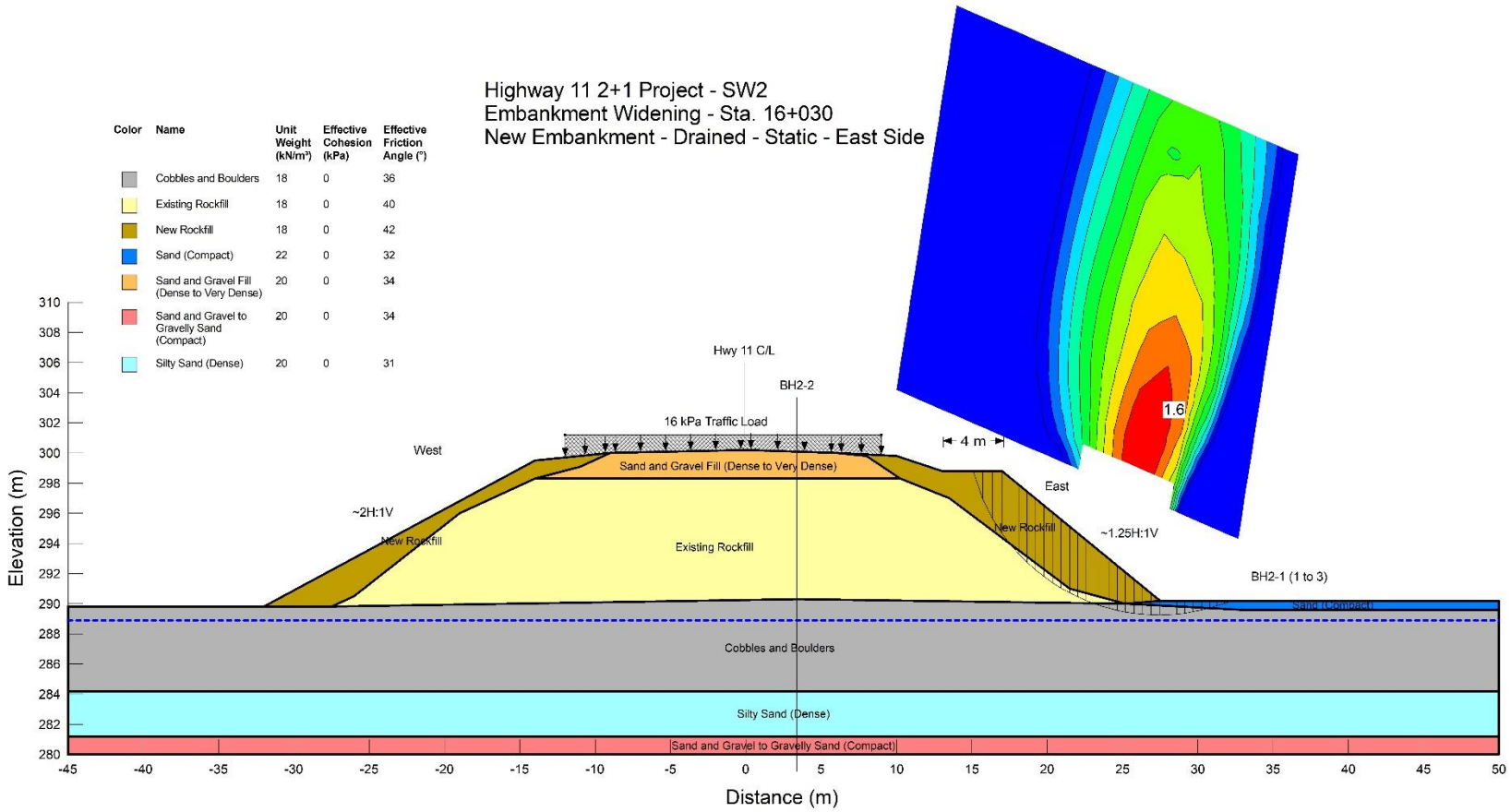


Figure F3: Slope stability analysis for Sta. 16+030 east side of embankment (1.25H:1V) – drained, static condition

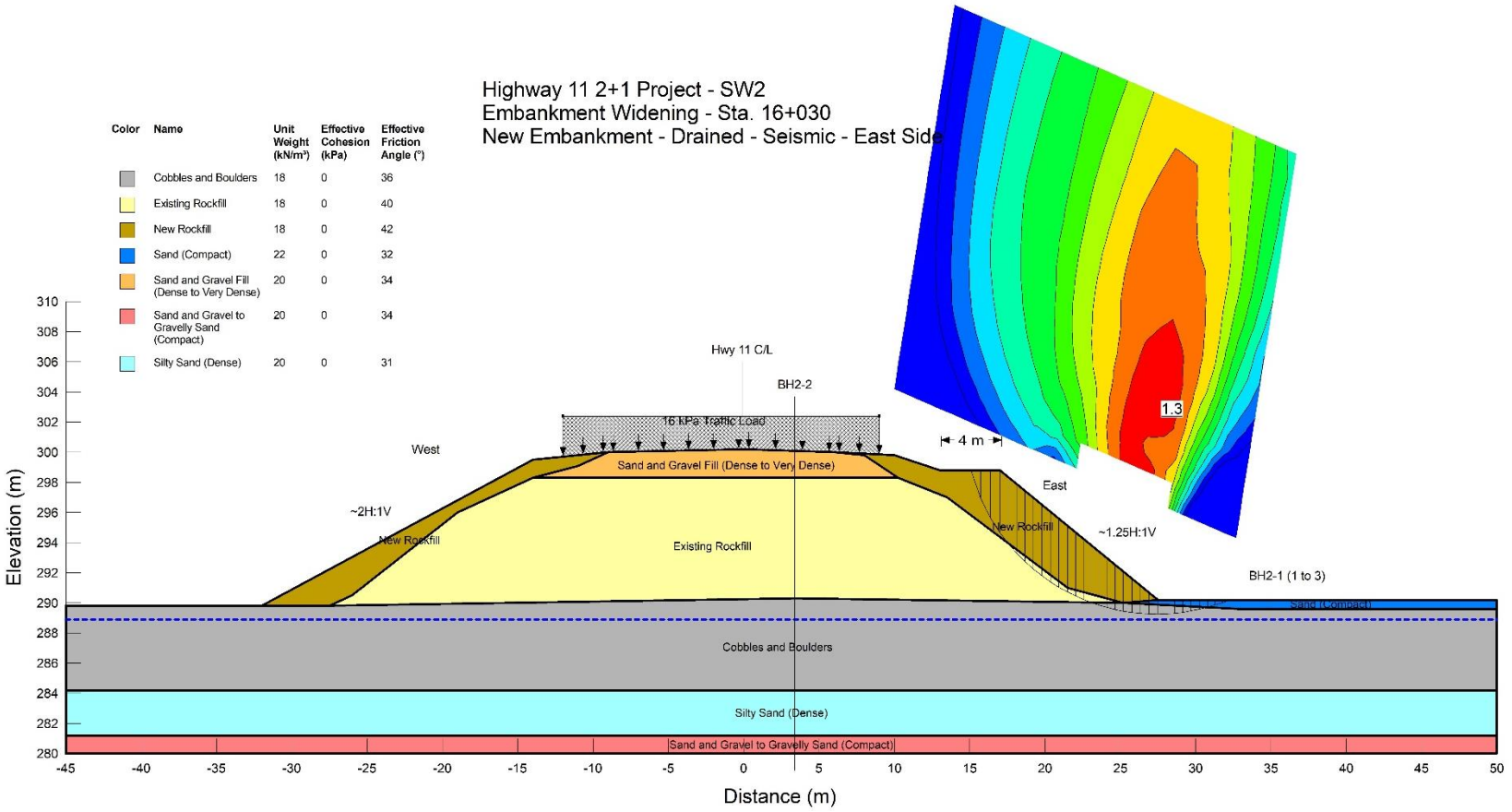


Figure F4: Slope stability analysis for Sta. 16+030 east side of embankment (1.25H:1V) – drained, seismic condition

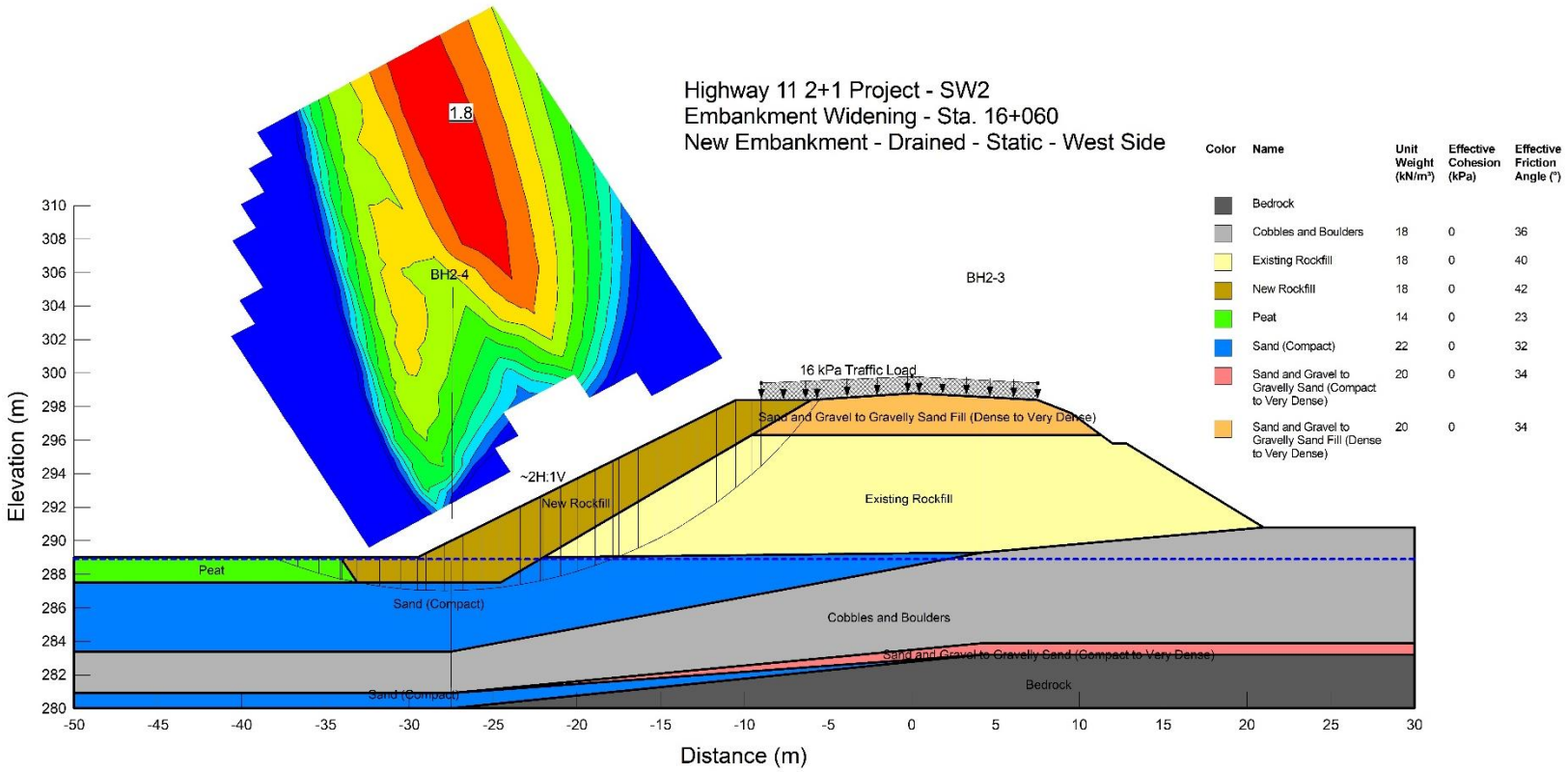


Figure F5: Slope stability analysis for Sta. 16+060 west side of embankment (2H:1V) – drained, static condition

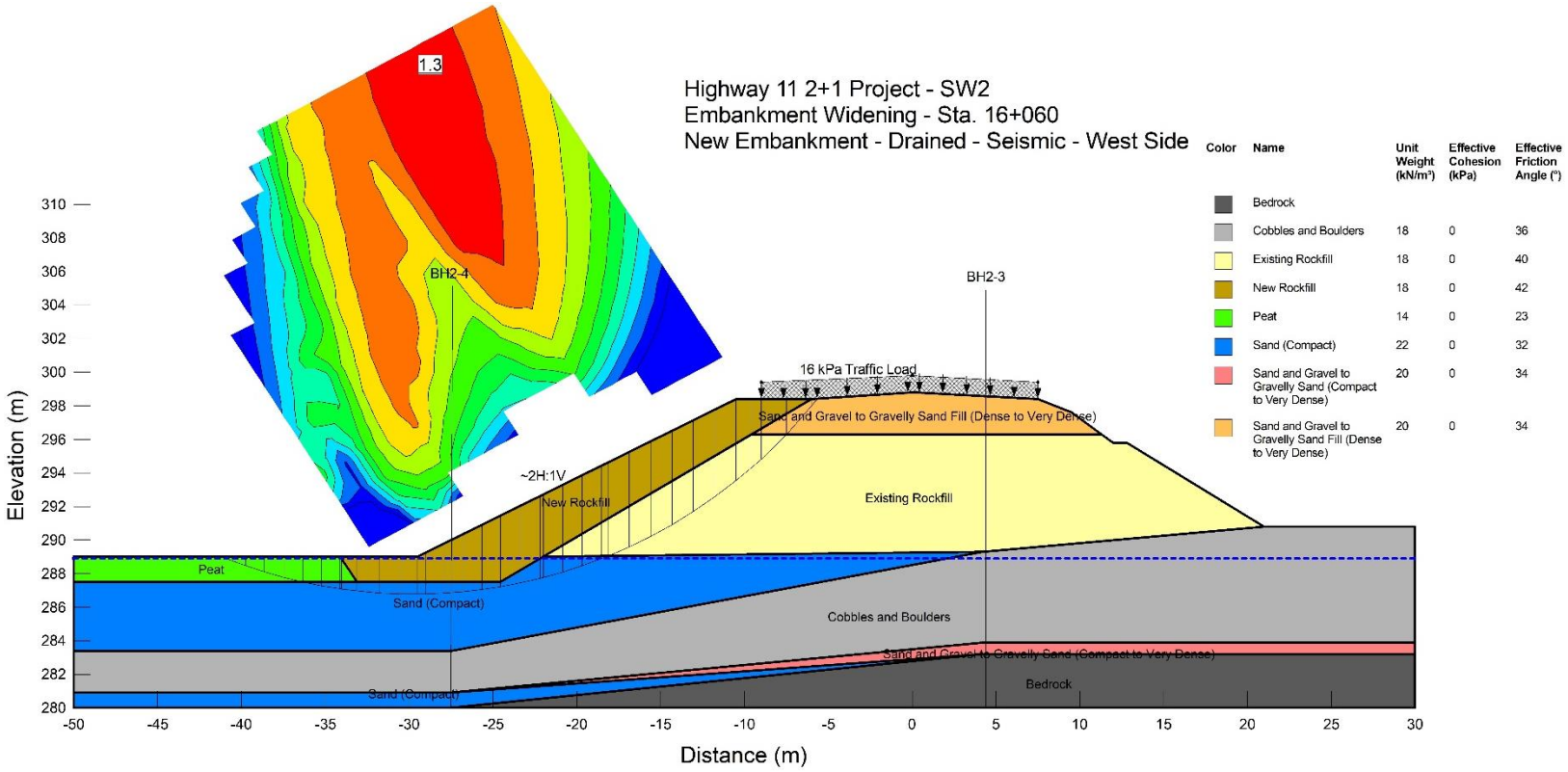
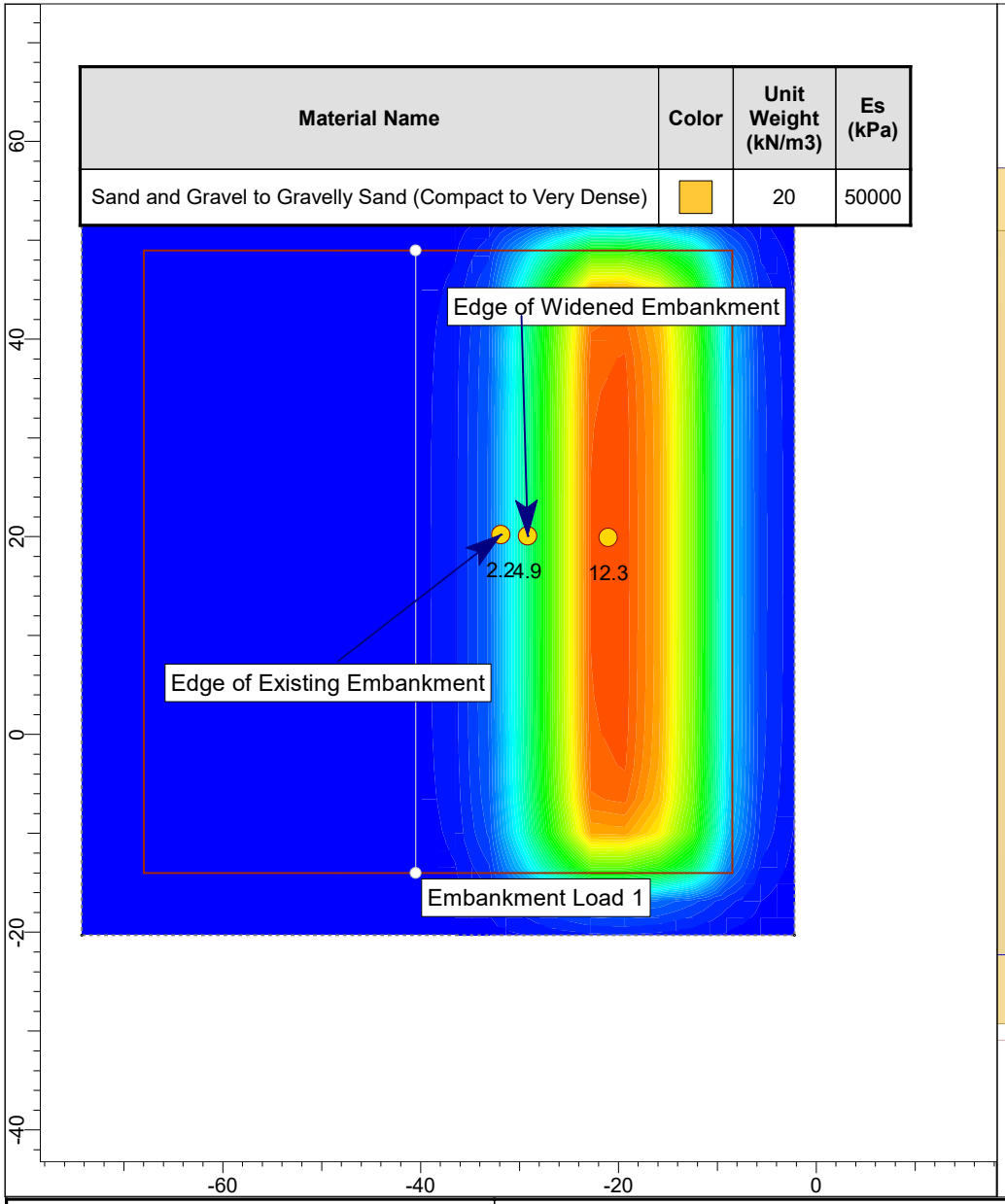
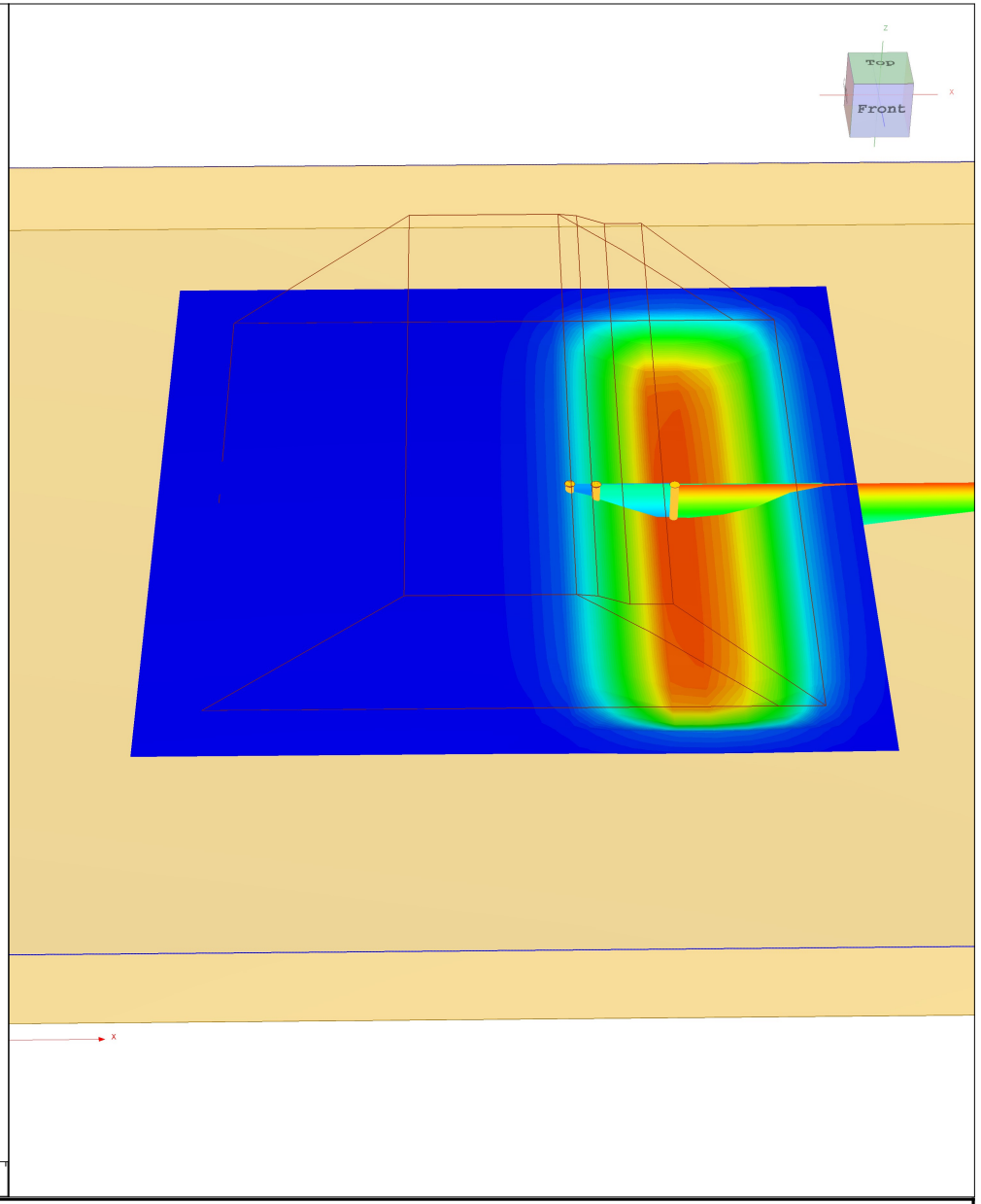


Figure F6: Slope stability analysis for Sta. 16+060 west side of embankment (2H:1V) – drained, seismic condition

Appendix G –
Settlement Analyses

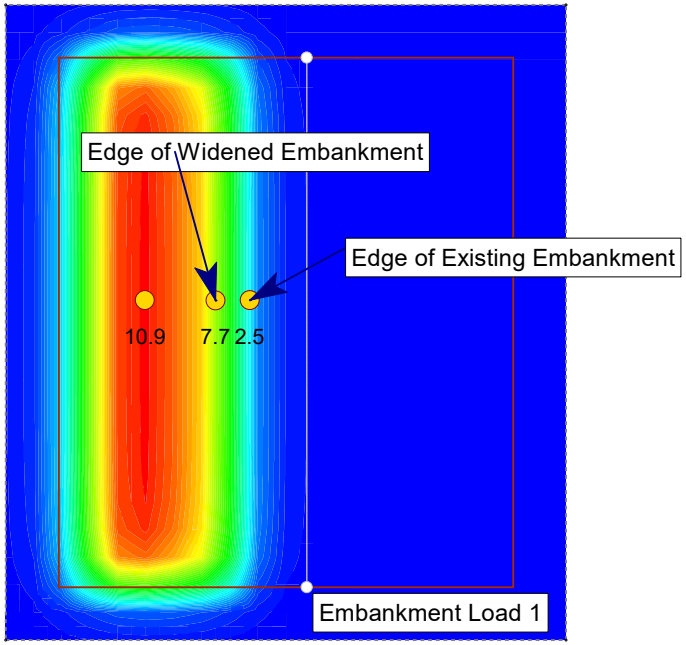
Material Name	Color	Unit Weight (kN/m3)	Es (kPa)
Sand and Gravel to Gravelly Sand (Compact to Very Dense)		20	50000

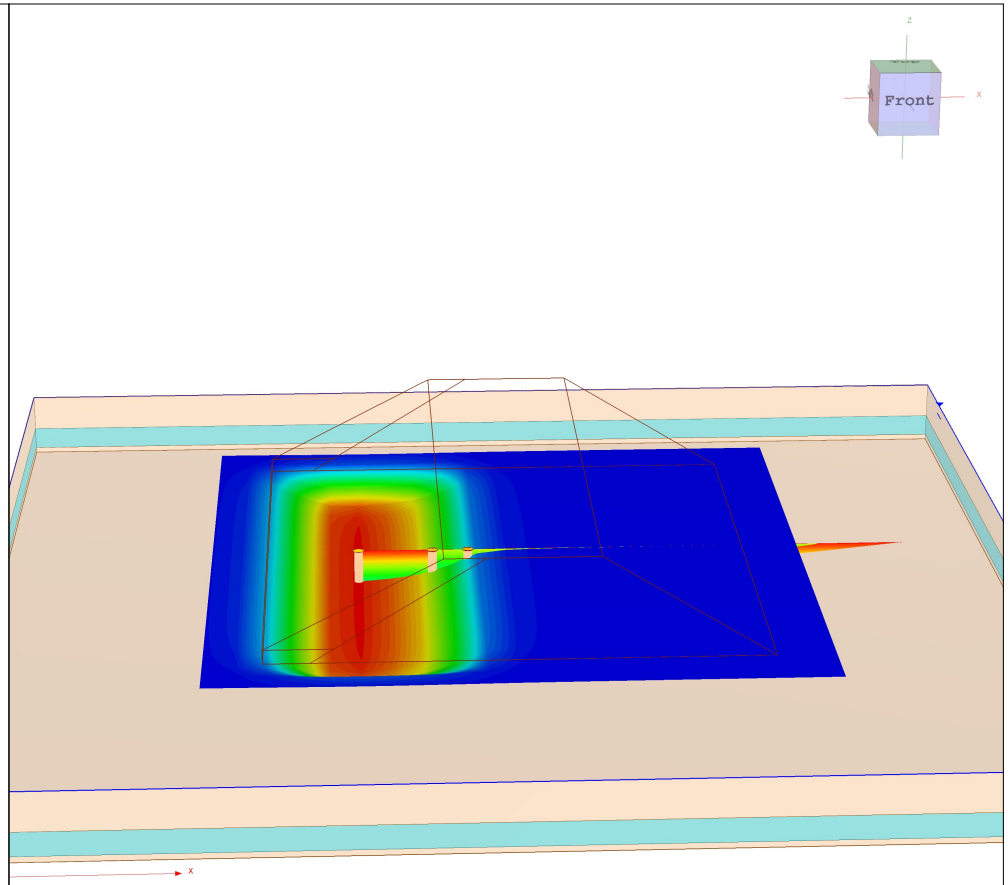




rocscience	*Project*	Hwy 11: 2+1 - SW2	
	Analysis Description	Sta. 16+000 - East Side	
	Figure No. G1	*Company*	EXP Services Inc.
SETTLE3 5.024		*File Name*	

Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Es (kPa)	Eur (kPa)
Compact Sand		22	22	35000	35000
Cobbles and Boulders		18	18	50000	50000





rocscience

SETTLE3 5.024

Project	Hwy 11: 2+1 - SW2
Analysis Description	Sta. 16+060 - West Side
Figure No. G2	*Company* EXP Services Inc.
	File Name

Appendix H –
Seismic Hazard Calculation

Government of Canada / Gouvernement du Canada

2020 National Building Code of Canada Seismic Hazard Tool

This application provides seismic values for the design of buildings in Canada under Part 4 of the National Building Code of Canada (NBC) 2020 as prescribed in Article 1.1.3.1. of Division B of the NBC 2020.

Seismic Hazard Values

User requested values

Code edition	NBC 2020
Site designation X_S	X_C
Latitude (°)	46.575
Longitude (°)	-79.629

Please select one of the tabs below.

NBC 2020 | Additional Values | Plots | API | Background Information

The 5%-damped spectral acceleration ($S_a(T,X)$, where T is the period, in s, and X is the site designation) and peak ground acceleration (PGA(X)) values are given in units of acceleration due to gravity (g, 9.81 m/s^2). Peak

ground velocity (PGV(X)) values are given in m/s. Probability is expressed in terms of percent exceedance in 50 years. Further information on the calculation of seismic hazard is provided under the *Background Information* tab.

The 2%-in-50-year seismic hazard values are provided in accordance with Article 4.1.8.4. of the NBC 2020. The 5%- and 10%-in-50-year values are provided for additional performance checks in accordance with Article 4.1.8.23. of the NBC 2020.

See the *Additional Values* tab for additional seismic hazard values, including values for other site designations, periods, and probabilities not defined in the NBC 2020.

NBC 2020 - 2%/50 years (0.000404 per annum) probability

$S_a(0.2, X_C)$	$S_a(0.5, X_C)$	$S_a(1.0, X_C)$	$S_a(2.0, X_C)$	$S_a(5.0, X_C)$	$S_a(10.0, X_C)$	$PGA(X_C)$	$PGV(X_C)$
0.418	0.256	0.136	0.0621	0.0161	0.00533	0.223	0.17

The log-log interpolated 2%/50 year $S_a(4.0, X_C)$ value is : **0.0224**

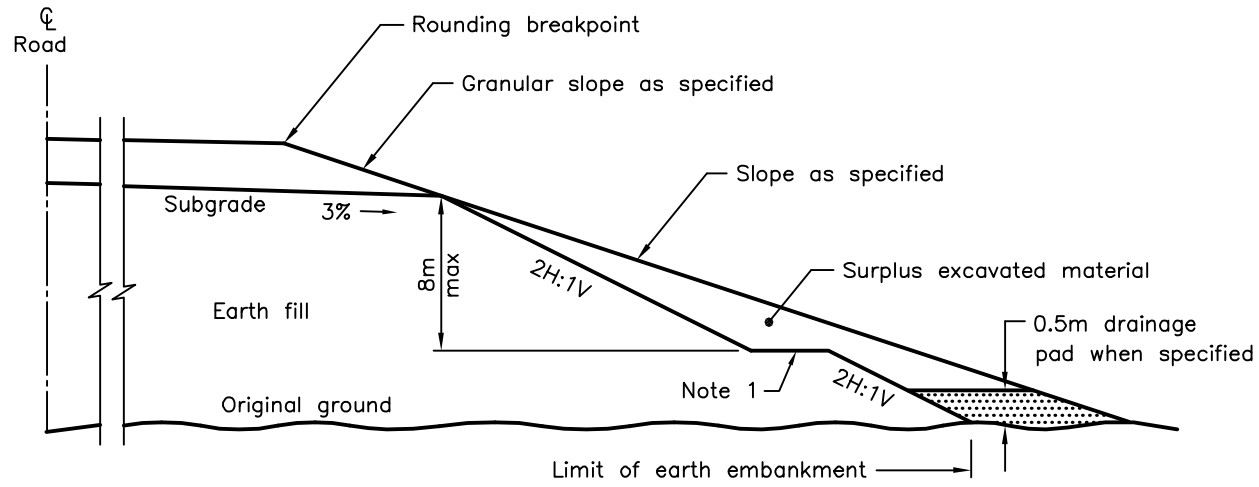
▶ Tables for 5% and 10% in 50 year values

Download CSV

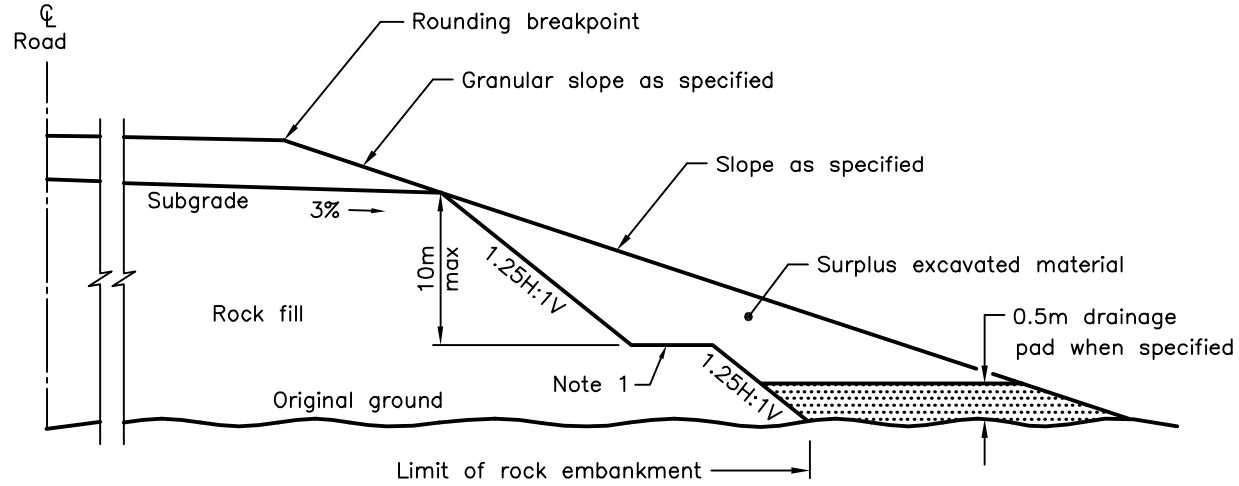
← Go back to the seismic hazard calculator form

Date modified: 2021-04-06

Appendix I – OPSDs



EARTH EMBANKMENT



ROCK EMBANKMENT

NOTES:

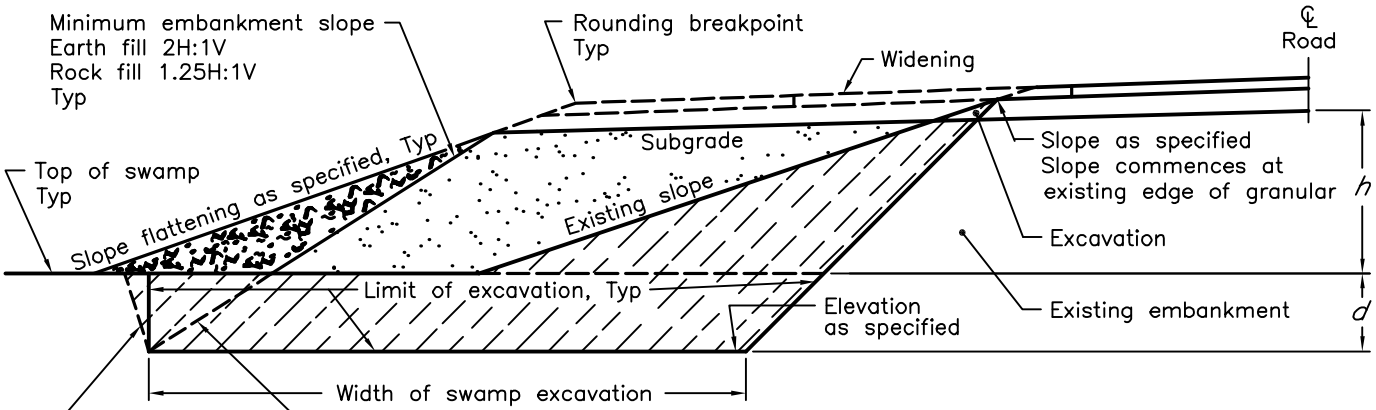
1 Benches 2m minimum in width are required along slopes at maximum vertical intervals as shown.

A Height of fill is the vertical difference between top of subgrade and top of original ground measured at new road centreline.

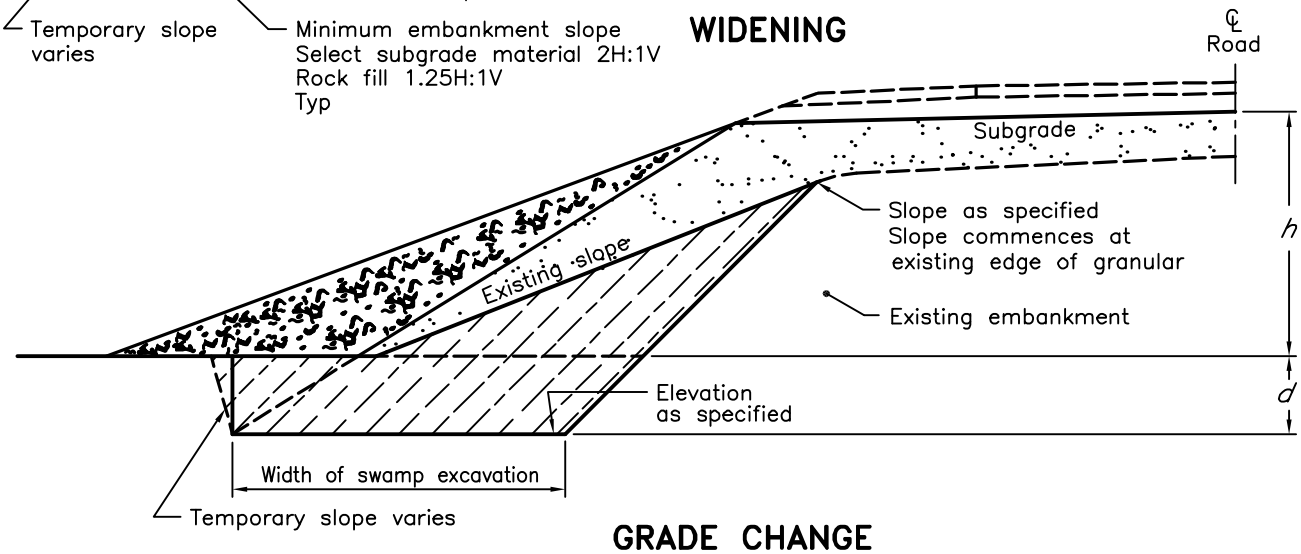
B Surplus excavated material placed shall not extend beyond the right–of–way.

C All dimensions are in metres unless otherwise shown.

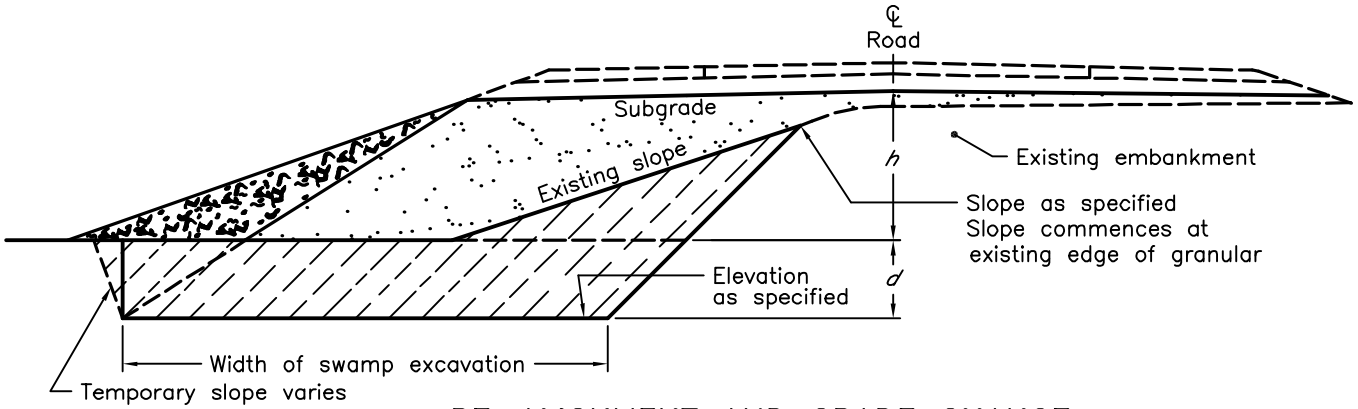
ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2016	Rev	3
SLOPE FLATTENING USING SURPLUS EXCAVATED MATERIAL ON EARTH OR ROCK EMBANKMENT			
	OPSD 202.010		



WIDENING



GRADE CHANGE



RE–ALIGNMENT AND GRADE CHANGE

LEGEND:

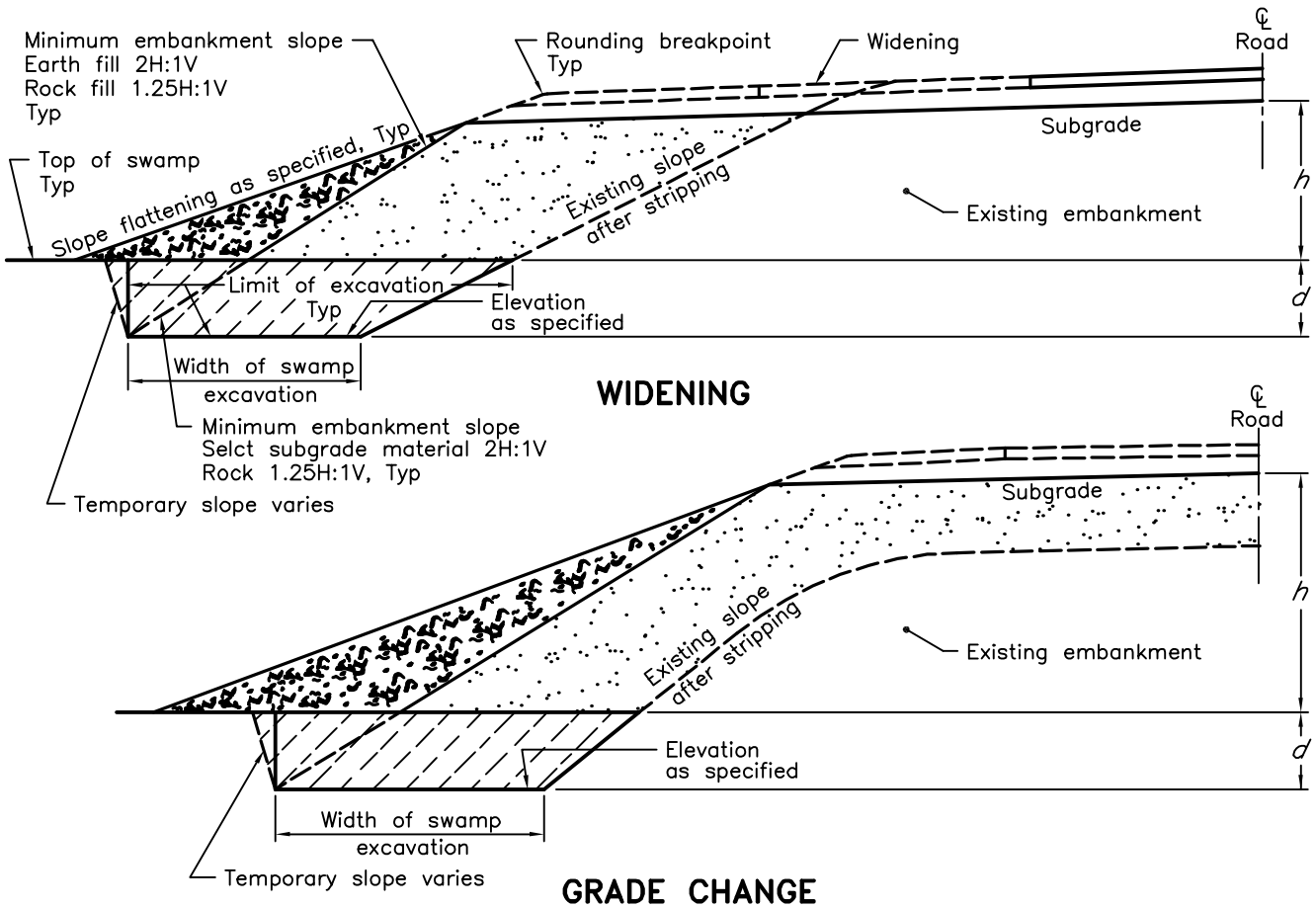
- *h* – Height of fill
- *d* – Depth of sub–excavation
- Embankment materials as specified
- Excavated swamp material
- Excavate and backfill as specified

NOTES:

A Height of fill is the vertical difference between subgrade and top of swamp measured at new road centreline.

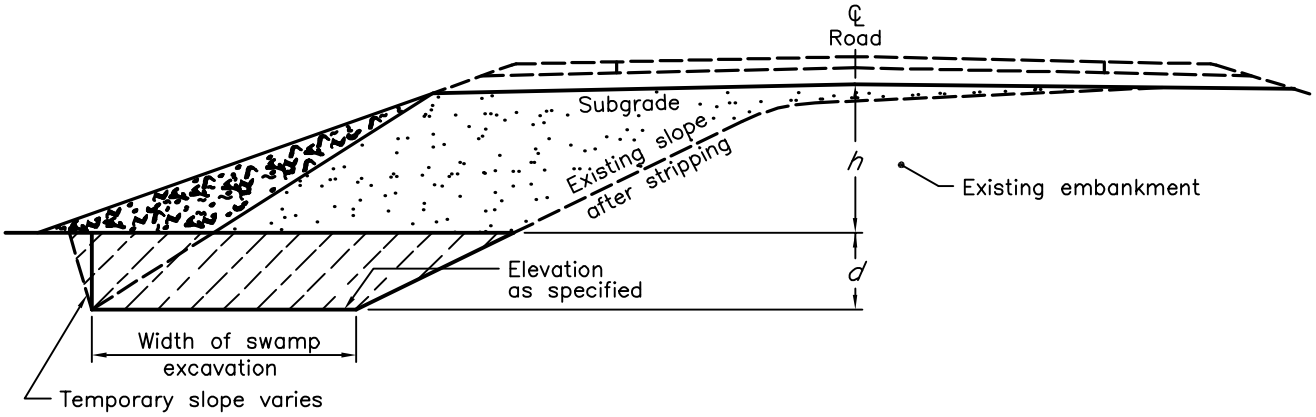
B Widening of existing earth embankments shall be benched according to OPSD 208.010.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2017	Rev	4
EMBANKMENTS OVER SWAMP EXISTING SLOPE EXCAVATED			
			OPSD 203.020



WIDENING

GRADE CHANGE



RE–ALIGNMENT AND GRADE CHANGE

NOTES:

A Topsoil shall be stripped from existing slopes.

B Height of fill is the vertical difference between subgrade and top of swamp measured at new road centreline.

C Widening of existing earth embankments shall be benched according to OPSD 208.010.

LEGEND:

h – Height of fill

d – Depth of sub–excavation

Embankment materials as specified

Excavated swamp material

Excavate and backfill as specified

ONTARIO PROVINCIAL STANDARD DRAWING

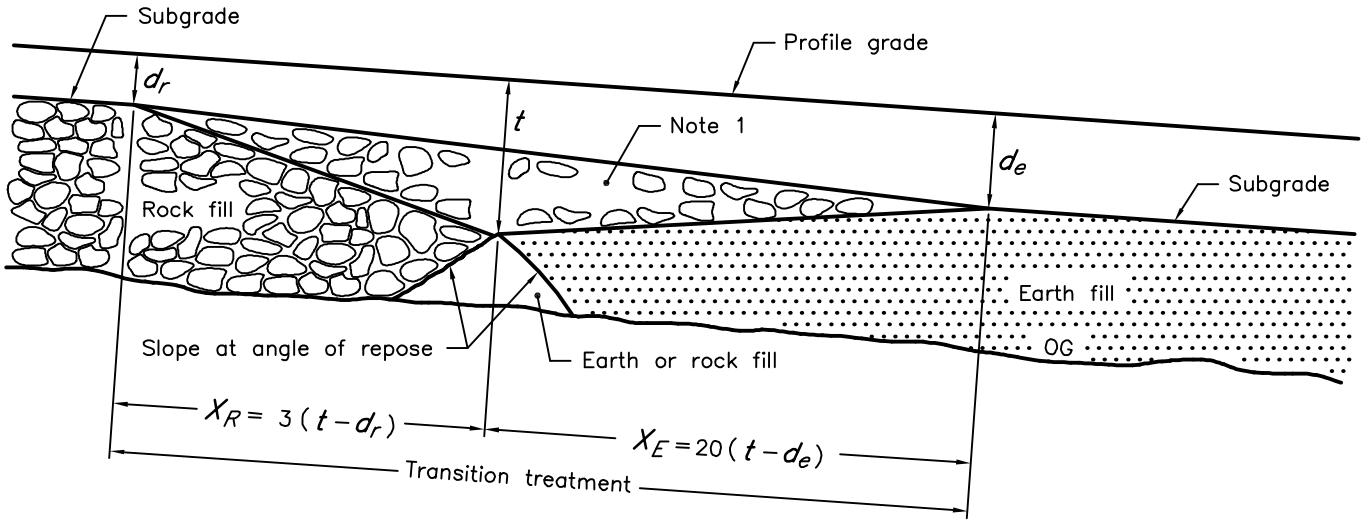
Nov 2017 | Rev 4

EMBANKMENTS OVER SWAMP

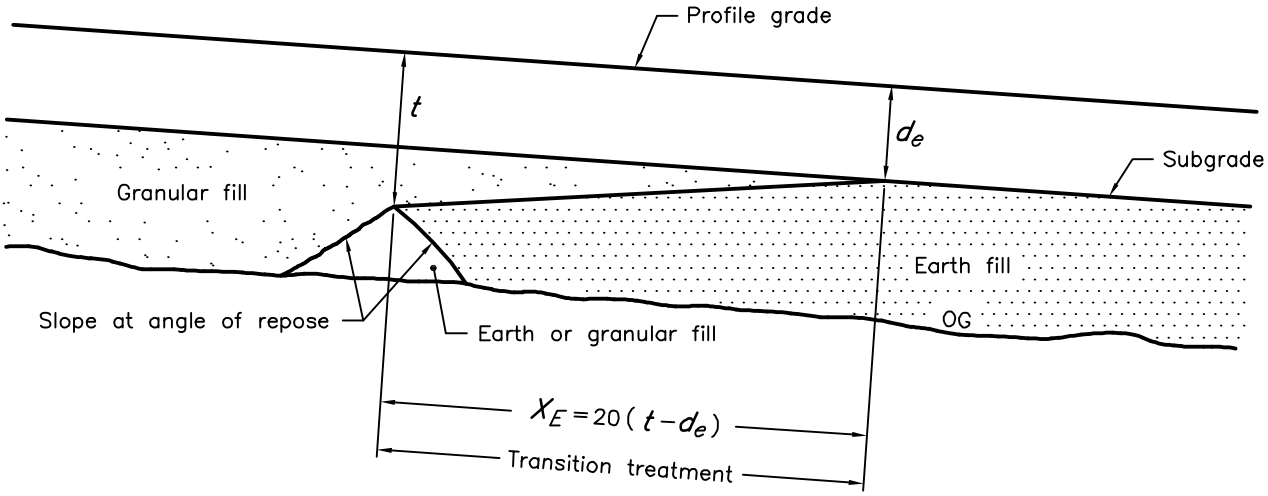
EXISTING SLOPES MAINTAINED

ONTARIO STANDARDS · MUNICIPAL – PROVINCIAL · OPSS

OPSD 203.030



EARTH FILL TO ROCK FILL



EARTH FILL TO GRANULAR FILL

NOTES:

1 Rock or granular fill.

A Embankment slopes to transition uniformly over distance X_R and X_E.

B Profile grade and subgrade lines apply across the transverse section.

LEGEND:

d_e – Depth of granular base and subbase over earth

d_r – Depth of granular base and subbase over rock fill

t – Transition treatment depth, as specified

X_E – Length of transition for earth fill, 15m maximum

X_R – Length of transition in rock fill

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2016	Rev 3
TRANSITION TREATMENT EARTH FILL TO ROCK FILL AND EARTH FILL TO GRANULAR FILL		OPSD 205.040

Appendix J –
NSSPs

EXCAVATION OF PEAT/ORGANIC DEPOSITS AT THE TOE OF HWY 11 EMBANKMENT AND BACKFILLING WITH ROCKFILL

Non-Standard Special Provision (NSSP)

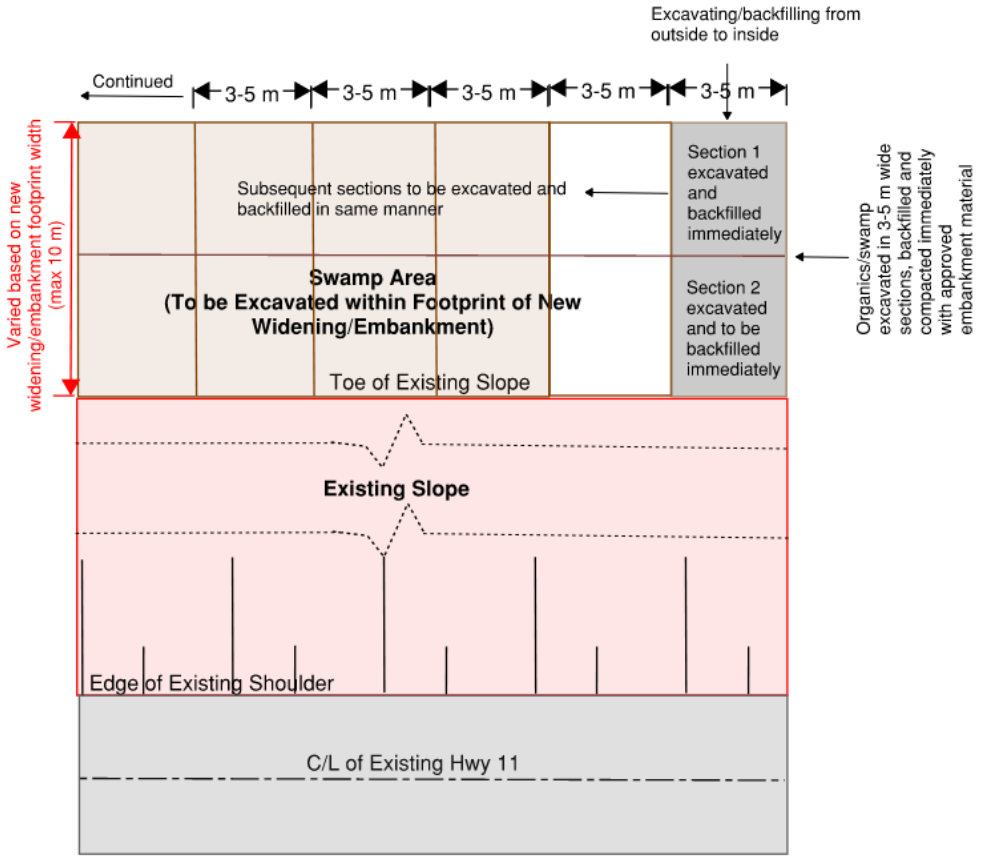
Scope of Work

Excavation of top layers of peat/organic material within the footprint of new embankment fill for widening of Highway 11, and backfill of excavation with rockfill.

Construction

The top peat/organic material shall be excavated along the whole footprint of the new embankment fill for widening. The excavation shall be in accordance with OPSD 203.020 and OPSD 203.030 following the slope of the existing rock fill embankment, and then, backfilled with rock fill immediately after excavation. Do not keep the excavation open under any circumstances.

These simultaneous excavation and backfilling operations shall be done from outside to inside in sections parallel to the existing highway as shown below. The sections shall be approximately 3 m to 5 m wide.



Obstructions

Non-Standard Special Provision (NSSP)

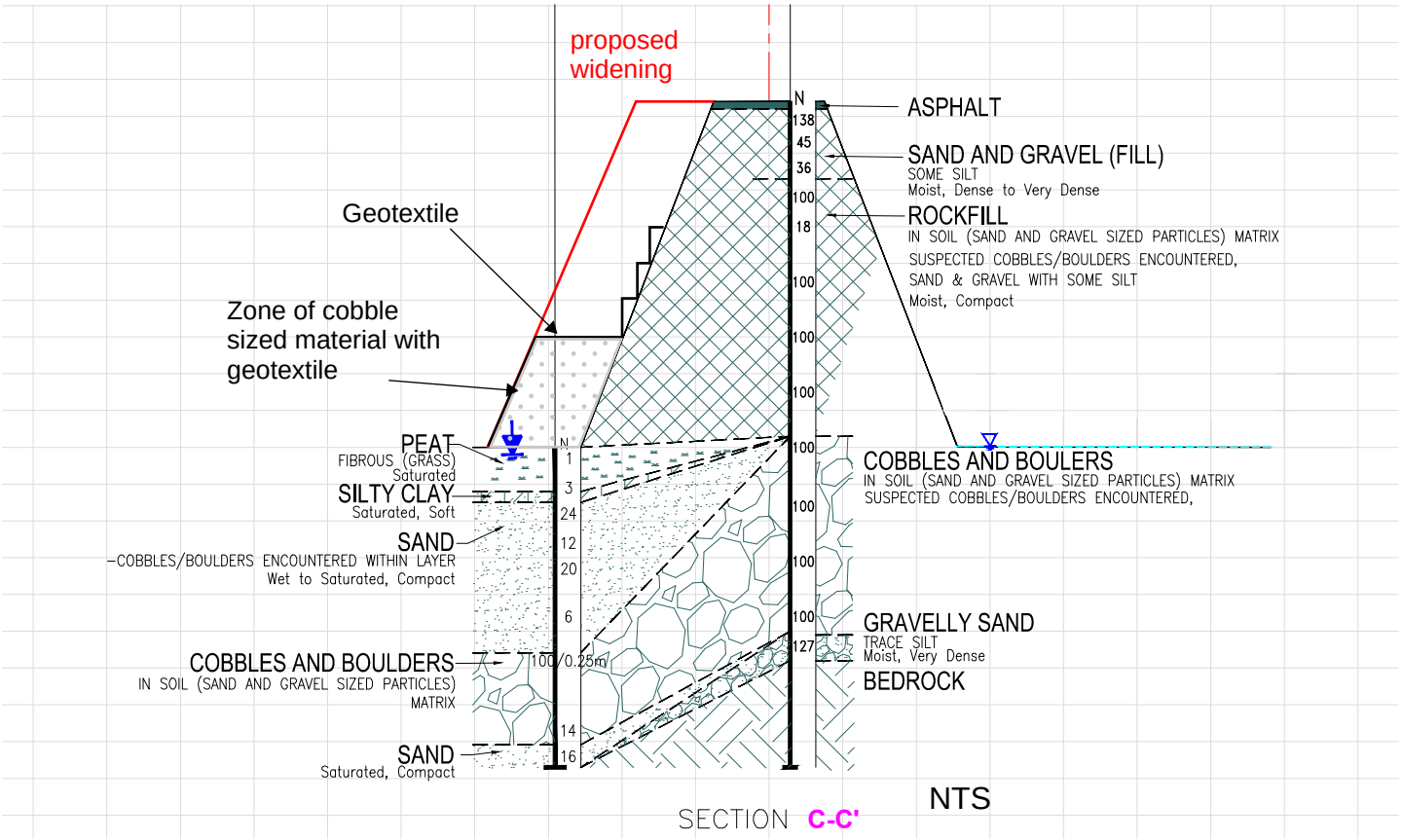
Scope of Work

The Contractor shall be alerted to the potential presence of cobbles and boulders in the fill and native till encountered in few boreholes advanced at the site. Therefore, appropriate equipment and procedures will be required for open cut excavation.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

Appendix K –
Schematic Sketches


proposed
widening
Geotextile
Zone of cobble
sized material with
geotextile
N
138
45
36
100
18
100
100
100
100
100
100
100
100
ASPHALT
SAND AND GRAVEL (FILL)
SOME SILT
Moist, Dense to Very Dense
ROCKFILL
IN SOIL (SAND AND GRAVEL SIZED PARTICLES) MATRIX
SUSPECTED COBBLES/BOULDERS ENCOUNTERED,
SAND & GRAVEL WITH SOME SILT
Moist, Compact
PEAT
FIBROUS (GRASS)
Saturated
SILTY CLAY
Saturated, Soft
SAND
-COBBLES/BOULDERS ENCOUNTERED WITHIN LAYER
Wet to Saturated, Compact
COBBLES AND BOULDERS
IN SOIL (SAND AND GRAVEL SIZED PARTICLES)
MATRIX
SAND
Saturated, Compact
N
1
3
24
12
20
6
100/0.25m
14
16
COBBLES AND BOULERS
IN SOIL (SAND AND GRAVEL SIZED PARTICLES) MATRIX
SUSPECTED COBBLES/BOULDERS ENCOUNTERED,
GRAVELLY SAND
TRACE SILT
Moist, Very Dense
127
BEDROCK
NTS
SECTION C-C'