



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 9 EMBANKMENT WIDENING FROM MILD MAY EAST LIMITS TO
CLIFFORD WEST LIMITS
MUNICIPALITY OF SOUTH BRUCE, ONTARIO
AGREEMENT NO. 3020-E-0004, WORK ITEM NO. 23
GWP 3076-14-00**

GEOCRES NO. 41A03-004

Location: Lat: 44.019170°, Long: -81.076287°

Client Name: R.V. Anderson Associates Limited

Date: March 25, 2024

File: 34935



TABLE OF CONTENTS

PART A. FACTUAL INFORMATION

1.	INTRODUCTION.....	1
2.	PROJECT AND SITE DESCRIPTION	1
3.	SITE INVESTIGATION AND FIELD TESTING	2
4.	LABORATORY TESTING.....	5
5.	DESCRIPTION OF SUBSURFACE CONDITIONS.....	5
5.1	Site Geology	5
5.2	Widening Areas 1 (STA 19+136 to 19+213) and 2 (STA 19+140 to 19+235)	6
5.2.1	Asphalt	6
5.2.2	Topsoil	6
5.2.3	Embankment Fill.....	6
5.2.4	Organic Silt.....	7
5.2.5	Clayey Silt-Silt to Silty Clay	8
5.2.6	Silty Sand Interlayer	9
5.3	Widening Areas 3 (STA 19+635 to 19+825) and 4 (STA 19+630 to 19+765)	9
5.3.1	Topsoil	9
5.3.2	Embankment Fill.....	10
5.3.3	Clayey Silt to Silt of slight plasticity.....	11
5.3.4	Sand and Gravel to Silty Sand to Sandy Silt to Gravelly Clayey Sand-Silty Sand (Till).....	12
5.3.5	Dynamic Cone Penetration Tests	13
5.4	Widening Area 5 (STA 22+568 to 22+595).....	13
5.4.1	Asphalt	13
5.4.2	Topsoil / Organics	13
5.4.3	Embankment Fill.....	14
5.4.4	Sandy Silt	14
5.4.5	Silty Sand	15
5.4.6	Silty Sand (Till)	15
5.5	Widening Areas 6 (STA 23+370 to 23+503) and 7 (STA 23+363 to 23+530)	16
5.5.1	Embankment Fill.....	17
5.5.2	Topsoil / Organics	17
5.5.3	Clayey Silt to Silty Clay.....	17
5.5.4	Silt and Sand to Silty Sand	18
5.5.5	Sand.....	19
5.5.6	Gravel to Sandy Gravel to Sandy Silty Gravel	19



5.5.7	Dynamic Cone Penetration Tests	20
5.6	Widening Area 8 (STA 23+890 to 23+937).....	20
5.6.1	Embankment Fill.....	20
5.6.2	Topsoil / Organics	21
5.6.3	Silty Sand and Gravel to Gravelly Sand.....	21
5.6.4	Silty Sand	22
5.7	Widening Area 9 (STA 24+130 to 24+205).....	22
5.7.1	Embankment Fill.....	23
5.7.2	Silt to Clayey Silt Fill (containing organics)	23
5.7.3	Silty Clay	24
5.7.4	Silty Sand to Sandy Silt to Silt	25
5.7.5	Dynamic Cone Penetration Tests	26
5.8	Groundwater Level.....	26
6.	MISCELLANEOUS	27
PART B. ENGINEERING DISCUSSION AND RECOMMENDATIONS		
7.	GENERAL	30
7.1	Background Information	30
7.2	Applicable Codes and Design Considerations.....	31
7.3	Widened Embankment Stability Requirements	31
7.4	Settlement Performance Requirements	32
8.	FILL EMBANKMENT PLATFORM WIDENING AREAS	32
8.1	Local and Imported Granular Borrow for Embankment Widening.....	33
8.2	Rock Fill for Embankment Widening	34
8.3	Methods for Embankment Design	34
8.3.1	Global Stability	35
8.3.2	Embankment Settlement	36
9.	RESULTS AND FOUNDATION DESIGN RECOMMENDATIONS.....	39
9.1	Widening Areas 1 (STA 19+136 to 19+213) and 2 (STA 19+140 to 19+235)	39
9.1.1	Subexcavation Requirements.....	41
9.2	Widening Areas 3 (STA 19+635 to 19+825) and 4 (STA 19+630 to 19+765)	41
9.3	Widening Area 5 (STA 22+568 to 22+595).....	43
9.4	Widening Areas 6 (STA 23+370 to 23+503) and 7 (STA 23+363 to 23+530)	44
9.5	Widening Area 8 (STA 23+890 to 23+937).....	45
9.5.1	Settlement of Rock Fill.....	47
9.6	Widening Area 9 (STA 24+130 to 24+205).....	47
9.6.1	Subexcavation Requirements.....	49
10.	SUBGRADE PREPARATION AND EMBANKMENT CONSTRUCTION	49



THURBER ENGINEERING LTD.

10.1	Temporary Excavations and Removal of Organic Soils.....	49
10.2	Control of Groundwater and Surface Water	50
10.3	Embankment Fill Placement	51
10.4	Erosion Protection.....	51
11.	CONSTRUCTION CONCERNS	52
12.	CLOSURE.....	53

REFERENCES

STATEMENT OF LIMITATIONS AND CONDITIONS

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

UNIFIED SOILS CLASSIFICATION

IN-TEXT TABLES

Table 2-1	Summary of Embankment Widening Locations	2
Table 3-1	Borehole Summary	3
Table 5-1	Groundwater Level Measurements	26
Table 7-1	Embankment Widening Locations	31
Table 8-1	Summary of Material Properties Used in Slope Stability Analyses	35
Table 8-2	Summary of Material Properties Used in Settlement Analyses	37

APPENDICES

APPENDIX A HIGHWAY 9 WIDENING

Drawing A1 Index Plan

APPENDIX B Highway 9 Widening Area No. 1 (EBL) – STA 19+136 to STA 19+213 Highway 9 Widening Area No. 2 (WBL) – STA 19+140 to STA 19+235

Drawing B1 Borehole Location Plan and Soil Stata

Photographs B1 to B2 Site Photographs

Borehole Records AR01-01, AR01-02, AR02-01, AR02-02

- Figure B1 Grain Size Distribution – Embankment Fill
- Figure B2 Plasticity Chart – Embankment Fill
- Figure B3 Grain Size Distribution – Silty Clay to Clayey Silt
- Figure B4 Plasticity Chart – Silty Clay to Clayey Silt
- Figure B5 Grain Size Distribution – Sand Interlayer



THURBER ENGINEERING LTD.

APPENDIX C Highway 9 Widening Area No. 3 (EBL) – STA 19+635 to STA 19+825
Highway 9 Widening Area No. 4 (WBL) – STA 19+630 to STA 19+765

Drawing C1 Borehole Location Plan and Soil Stata

Photographs C1 to C2 Site Photographs

Borehole Records AR03-01 to AR03-03
 AR04-01 to AR04-03

Figure C1 Grain Size Distribution – Embankment Fill

Figure C2 Grain Size Distribution – Clayey Silt-Silt to Silt of Slight Plasticity

Figure C3 Plasticity Chart – Clayey Silt-Silt to Silt of Slight Plasticity

Figure C4 Grain Size Distribution – Sand and Gravel to Silty Sand to Sandy Silt to
Gravelly Clayey Sand-Silty Sand (Till)

Figure C5 Plasticity Chart –Gravelly Clayey Sand (Till) (Fines Portion)

APPENDIX D Highway 9 Widening Area No. 5 (WBL) – STA 22+568 to STA 22+595

Drawing D1 Borehole Location Plan and Soil Stata

Photographs D1 to D2 Site Photographs

Borehole Records AR05-01, AR05-02

Figure D1 Grain Size Distribution – Sandy Organic Silt

Figure D2 Grain Size Distribution – Silty Sand

Figure D3 Grain Size Distribution – Silty Sand of slight plasticity

Figure D4 Plasticity Chart – Silty Sand of slight plasticity

APPENDIX E Highway 9 Widening Area No. 6 (EBL) – STA 23+370 to STA 23+503
Highway 9 Widening Area No. 7 (WBL) – STA 23+365 to STA 23+530

Drawing E1 Borehole Location Plan and Soil Stata

Photographs E1 to E2 Site Photographs

Borehole Records AR06-01, AR06-02
 AR07-01, AR07-02

Figure E1 Grain Size Distribution – Embankment Fill

Figure E2 Grain Size Distribution – Sandy Silt to Silt and Sand

Figure E3 Grain Size Distribution – Gravel and Sand to Sandy Gravel

APPENDIX F Highway 9 Widening Area No. 8 (WBL) – STA 23+890 to STA 23+937

Drawing F1 Borehole Location Plan and Soil Stata

Photographs F1 to F2 Site Photographs

Borehole Records AR08-01, AR08-02

Figure F1 Grain Size Distribution – Embankment Fill
 Figure F2 Grain Size Distribution – Gravelly Sand to Silty Sand and Gravel
 Figure F3 Grain Size Distribution – Silty Sand

APPENDIX G Highway 9 Widening Area No. 9 (EBL) – STA 24+130 to STA 24+205

Drawing G1 Borehole Location Plan and Soil Stata

Photographs G1 to G2 Site Photographs

Borehole Records AR09-01, AR09-02

Figure G1 Grain Size Distribution – Embankment Fill
 Figure G2 Grain Size Distribution – Silty Clay
 Figure G3 Plasticity Chart – Silty Clay
 Figure G4 Grain Size Distribution – Silty Sand to Sandy Silt to Silt of Slight Plasticity
 Figure G5 Plasticity Chart – Silt of Slight Plasticity

APPENDIX H Stability Figures

Figures H1 to H5 Highway 9 Widening Area No. 1 (EBL) – STA 19+136 to STA 19+213
 Figures H6 to H10 Highway 9 Widening Area No. 2 (WBL) – STA 19+140 to STA 19+235

Figures H11 to H15 Highway 9 Widening Area No. 3 (EBL) – STA 19+635 to STA 19+825
 Figures H16 to H19 Highway 9 Widening Area No. 4 (WBL) – STA 19+630 to STA 19+765

Figures H20 to H24 Highway 9 Widening Area No. 5 (WBL) – STA 22+568 to STA 22+595

Figures H25 to H28 Highway 9 Widening Area No. 6 (EBL) – STA 23+370 to STA 23+503
 Figures H29 to H33 Highway 9 Widening Area No. 7 (WBL) – STA 23+365 to STA 23+530

Figures H34 to H38 Highway 9 Widening Area No. 8 (WBL) – STA 23+890 to STA 23+937

Figures H39 to H41 Highway 9 Widening Area No. 9 (EBL) – STA 24+130 to STA 24+205

APPENDIX I Special Provisions



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 9 EMBANKMENT WIDENING FROM MILD MAY EAST LIMITS TO
CLIFFORD WEST LIMITS
MUNICIPALITY OF SOUTH BRUCE, ONTARIO
AGREEMENT NO.: 3020-E-0004, WORK ITEM NO.: 23
GWP 3076-14-00**

GEOCRETS NO.: 41A03-004

PART A. FACTUAL INFORMATION

1. INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the embankment widening at nine sites along Highway 9, from Mildmay east limits easterly to Clifford west limits in the Municipality of South Bruce, Ontario. Thurber Engineering Ltd. (Thurber) carried out the foundation investigation as a sub-consultant to R.V. Anderson Associates Limited (RVA) under Agreement No. 3020-E-0004, Work Item No. 23.

The purpose of the investigation was to explore the subsurface conditions at each of the embankment widening sites and, based on the data obtained, provide borehole location plans, record of boreholes, stratigraphic profiles, laboratory test results and a written description of the subsurface conditions. The stratigraphic profile of the subsurface conditions was developed during the current investigation.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. PROJECT AND SITE DESCRIPTION

The overall project involves the widening of Highway 9 from Mildmay east limits easterly to Clifford west limits. The project also includes the replacement of Culvert 02X-0466/C0 (STA 20+247) and rehabilitation of Culvert Site Nos. 02X-0467/C0 and 02X-0469/C0, located at STA 21+689 and STA 24+515, respectively. The Culvert Foundation Investigation and Design Reports are prepared by Thurber under separate covers.

The site is in a rural setting and the area adjacent to the roadway is primarily used for agriculture, with few residential homes located along Highway 9. The existing Highway 9



embankment side slopes are generally vegetated with grasses and small shrubs. Overhead utility lines were present along the north side of the roadway (i.e. along the WB lanes).

The existing roadway embankment side slopes at the site did not show any visible signs of global instability at the time of the investigation.

The approximate locations, length, and heights of the segments of embankment widening as part of this foundation investigation are summarized below and are based on AutoCAD drawings provided by RVA.

Table 2-1 Summary of Embankment Widening Locations

Embankment Area Widening Reference	Limits of Fill Area (Project Chainage)	Length of Segment (m)	Maximum Fill Height (m)	Width of Widening (m)
1	Highway 9 EBL STA 19+136 to 19+213	77	3.5 to 5 (W to E)	3.0
2	Highway 9 WBL STA 19+140 to 19+235	95	3.5 to 5 (W to E)	2.9
3	Highway 9 EBL STA 19+635 to 19+825	190	6 to 8 (W to E)	3.8
4	Highway 9 WBL STA 19+630 to 19+765	135	6 to 8 (W to E)	3.1
5	Highway 9 WBL STA 22+568 to 22+595	27	5	4.0
6	Highway 9 EBL STA 23+370 to 23+503	133	5 to 7 (W to E)	2.0
7	Highway 9 WBL STA 23+363 to 23+530	167	5 to 7 (W to E)	3.5
8	Highway 9 WBL STA 23+890 to 23+937	47	5	2.8
9	Highway 9 EBL STA 24+130 to 24+205	75	4.5 to 6 (W to E)	5.4

Photographs of each of the embankment widening areas are included in the corresponding appendices (Appendix B to Appendix G). These photographs show the existing site conditions at the time of the field investigation.

3. SITE INVESTIGATION AND FIELD TESTING

The foundation investigation and field-testing program was carried out between September 18 and November 2, 2023, and consisted of seven off-road boreholes advanced near the toes of



the existing highway embankment and fourteen highway grade boreholes. The off-road boreholes were advanced using a portable drilling set up utilized continuous sampling, tricone with casing, and wash boring techniques. The highway boreholes were advanced using a D50 track-mounted drill rig utilized hollow stem augers, Casing and Tricone mud rotary, and HQ coring equipment. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

A summary of the borehole coordinates, elevations, and termination depths is provided in the table below. The as-drilled borehole elevations were estimated by Thurber following completion of the field program. A Trimble GPS was used to collect the as-drilled borehole locations for most sites. Horizontal locations were also measured by Thurber relative to existing site features. The elevations and borehole coordinates were reviewed and referenced to the survey data provided by MTO. The borehole coordinates and elevations are shown on the Borehole Location and Soil Strata drawings and on the individual Record of Borehole Sheets included in Appendix B to Appendix G. The borehole coordinates are referenced to MTM Zone 11.

Table 3-1 Borehole Summary

Embankment Widening Area Reference	Borehole	Northing (m)	Easting (m)	Drilled Location	Ground Surface Elevation (m)	Termination Depth Below Ground Surface (m)
1	AR01-01	4,878,093.6	416,682.2	Embankment Toe	329.0	5.2
1	AR01-02	4,878,095.0	416,700.5	Through Embankment	333.9	15.8
2	AR02-01	4,878,104.1	416,726.4	Embankment Toe	329.2	5.2
2	AR02-02	4,878,081.7	416,732.3	Through Embankment	334.3	15.8
3	AR03-01	4,877,800.2	417,119.2	Through Embankment	326.9	15.8
3	AR03-02	4,877,738.4	417,207.3	Through Embankment	321.7	15.2
3	AR03-03	4,877,746.3	417,161.4	Embankment Toe	318.9	5.2
4	AR04-01	4,877,870.4	417,038.4	Through Embankment	330.7	18.9
4	AR04-02	4,877,778.0	417,167.6	Through Embankment	324.5	15.8
4	AR04-03	4,877,845.8	417,092.7	Embankment Toe	323.0	5.2
5	AR05-01	4,876,161.8	419,504.7	Embankment Toe	325.9	5.2
5	AR05-02	4,876,148.3	419,493.6	Through Embankment	331.0	13.1
6	AR06-01	4,875,698.2	420,130.5	Through Embankment	330.0	6.9



Embankment Widening Area Reference	Borehole	Northing (m)	Easting (m)	Drilled Location	Ground Surface Elevation (m)	Termination Depth Below Ground Surface (m)
6	AR06-02	4,875,627.5	420,232.7	Through Embankment	336.2	9.2
6	AR06-03	4,875,637.9	420,185.2	Embankment Toe	327.2	2.7
7	AR07-01	4,875,674.4	420,181.5	Through Embankment	332.8	9.0
7	AR07-02	4,875,626.6	420,251.0	Through Embankment	337.1	9.8
7	AR07-03	4,875,666.1	420,223.4	Embankment Toe	327.5	2.7
8	AR08-01	4,875,432.1	420,544.3	Embankment Toe	344.4	4.6
8	AR08-02	4,875,421.2	420,548.0	Through Embankment	347.1	9.8
9	AR09-01	4,875,249.7	420,777.2	Through Embankment	339.3	16.2
9	AR09-02	4,875,230.0	420,785.6	Embankment Toe	333.8	5.2

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in general accordance with ASTM D 1586. In addition, Dynamic Cone Penetration Testing (DCPT) was conducted in selected boreholes. A DCPT consists of advancing a 60-degree, 50 mm diameter inverted cone using a series of blows from the SPT hammer and recording the number of blows for each 0.3 m of advancement being recorded.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The drilling supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

In addition, a series of hand dug holes were carried out near the embankment toe at selected locations along the 9 embankment widening areas to determine topsoil / organics thickness.

19 mm diameter piezometers were installed in select boreholes to allow for measurements of the groundwater level after drilling, and are summarized in Section 5.8

Following completion of the field investigation, the boreholes were decommissioned in general accordance with O. Reg. 903, as amended.



4. LABORATORY TESTING

Laboratory testing was selected in general accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. Recovered soil samples were selected for grain size distribution testing in accordance with MTO and ASTM standards. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B.

All laboratory test results from the field investigation are provided, by widening area, in Appendix B to Appendix G.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered subsurface conditions at Widening Areas 1 to 9 are presented on the Record of Borehole sheets included in Appendix B to Appendix G. Borehole Location and Soil Strata Drawings are also included in Appendix B to Appendix G. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following sections. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions will vary between and beyond borehole locations.

5.1 Site Geology

Embankment widening areas 1 through 9 are within the Teeswater Drumlin Field physiographic region, as delineated in The Physiography of Southern Ontario (Chapman and Putnam, 1984).

The Teeswater Drumlin Field contains a variety of soil deposits that have developed over the deposited till, and include broad terraces of sand and gravel, filling low ground between drumlins. Locally, the Highway 9 embankment widening project alignment is generally along a spillway, between kame moraines and drumlinized till plains characteristic of the Teeswater Drumlin Field.

Based on geological mapping developed by the Ontario Geological Society, the underlying bedrock along the Highway 9 embankment widening limits generally consists of limestone and dolostone of the Bass Islands Formation, transitioning to the Salina Formation to the south (Ontario Geological Society, 2011).



5.2 Widening Areas 1 (STA 19+136 to 19+213) and 2 (STA 19+140 to 19+235)

The plan and profile along the highway centreline showing the borehole locations and interpreted stratigraphy between STA 19+136 and STA 19+235 are presented in Drawing B1. The proposed widened highway embankment within this section of the highway ranges between about 3.5 m and 5 m high relative to the existing ground surface.

A total of four boreholes (Boreholes AR01-01, AR01-02, AR02-01, and AR02-02) were advanced to investigate the subsurface conditions within the embankment widening areas 1 and 2.

In general, the encountered stratigraphy consists of embankment fill and surficial topsoil / organics overlying silty clay to clayey silt.

5.2.1 Asphalt

A 250 mm thick layer of asphalt was encountered at ground surface in Borehole AR02-02.

5.2.2 Topsoil

A 25 mm and 50 mm thick layer of topsoil was encountered at ground surface in boreholes AR01-01 and AR02-01, respectively.

A series of hand dug holes were carried out at Areas 1 and 2 in conjunction with the boreholes that were completed at the toe of the embankments to determine the topsoil/organic thicknesses. The topsoil / organic thicknesses near the toe of the highway embankment ranged from 300 to 610 mm.

Topsoil thickness may vary in other areas of the site and therefore, the thickness as encountered in the boreholes cannot be relied upon for the purpose of estimating quantities for stripping.

5.2.3 Embankment Fill

Embankment fill consisting of sand and gravel, some silt to silty sand with gravel to silt, trace sand, trace gravel, with a clayey silt interlayer, was encountered in both boreholes advanced through the highway embankment, AR01-02 and AR02-02. The fill layers were measured to extend to depths of 4.1 m below existing ground surface (Elev. 329.8 m and 330.2 m in boreholes AR01-02 and AR02-02, respectively). SPT N-values in the embankment fill generally ranged from 13 to 58 blows, indicating a compact to very dense relative density. SPT N-values of 102 and 100 for 0.25 m of penetration were also measured in this layer.

The measured moisture contents generally ranged from 2 per cent to 13 per cent.

The results of grain size analyses carried out on selected samples of the embankment fill are shown on the Record of Borehole sheets in Appendix B and presented in Figure B1 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	16 to 43
Sand	37 to 48
Silt	11 to 37
Clay	3 to 10

The results of the Atterberg Limits test carried out on the fines portion of a sample of the cohesive embankment fill materials is shown on the Record of Borehole logs in Appendix B and presented in Figure B2 of Appendix B. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	23
Plastic Limit	17
Plastic Index	6

The result of the Atterberg Limits testing indicates the fines portion of the material is a clayey silt-silt of low plasticity (CL-ML).

5.2.4 Organic Silt

A 1.7 m thick layer of organic silt, containing wood pieces, was encountered below the embankment fill in Borehole AR02-02 between depths 4.1 m and 5.8 m (Elev. 330.2 m to Elev. 328.5 m).

A SPT N-value of 10 blows per 0.3 m of penetration was measured in this layer, indicating a compact condition.

The measured moisture content on a sample from this layer was 55 per cent.



5.2.5 Clayey Silt-Silt to Silty Clay

A layer of clayey silt-silt to silty clay, trace to some sand, was encountered below the topsoil in Boreholes AR01-01 and AR02-01, below the embankment fill in Borehole AR01-02, and below the organic silt in Borehole AR02-02. The thickness of the silty clay ranged from at least 1.1 m to 11.7 m and the deposit extends to depths of at least 5.2 m to 15.8 m (Elev. 324.0 m to Elev. 318.1 m). Borehole AR01-01, AR01-02, AR02-01, and AR02-02 were terminated in this deposit.

SPT N-values measured in the clayey silt-silt to silty clay were 2 blows to 32 blows per 0.3 m of penetration, suggesting a soft to hard consistency. Shear vane testing was carried out in this deposit in Borehole AR01-02 and recorded an undrained shear strength of 32 kPa. The sensitivity of this test was measured to be 2.7. The measured moisture contents were 11 per cent to 56 per cent.

The results of grain size analyses carried out on selected samples of the clayey silt to silty clay are shown on the Record of Borehole sheets in Appendix B and presented in Figure B3 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	1 to 16
Silt	65 to 75
Clay	18 to 25

The results of the Atterberg Limits test carried out on samples of the clayey silt to silty clay layer are shown on the Record of Borehole logs in Appendix B and presented in Figure B4 of Appendix B. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	19 to 26
Plastic Limit	14 to 15
Plastic Index	5 to 11

The result of the Atterberg Limits testing indicates the material is a clayey silt-silt of low plasticity (CL-ML) to a clayey silt of low plasticity (CL).

5.2.6 Silty Sand Interlayer

A 2.9 m thick silty sand, trace gravel interlayer was encountered within the clayey silt deposit in Borehole AR01-01 between depths of 1.2 m and 4.1 m (Elev. 327.8 m to Elev. 324.9 m).

SPT 'N' values recorded in the silty sand interlayer ranged from 15 blows per 0.3 m of penetration to 25 blows per 0.3 m of penetration, indicating a compact condition.

The measured moisture contents were between 12 per cent and 17 per cent.

The result of grain size analysis carried out on a sample of this interlayer are shown on the Record of Borehole sheets in Appendix B and presented in Figure B5 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	1
Sand	54
Silt	42
Clay	3

5.3 Widening Areas 3 (STA 19+635 to 19+825) and 4 (STA 19+630 to 19+765)

The plan and profile along the highway centreline showing the borehole locations and interpreted stratigraphy between STA 19+630 and STA 19+825 are presented in Drawing C1. The proposed widened highway embankment within this section of the highway ranges between about 6 m and 8 m high relative to the existing ground surface.

A total of six boreholes (Boreholes AR03-01 to AR03-03 and AR04-01 to AR4-03) were advanced to investigate the subsurface conditions within the embankment widening areas.

In general, the encountered stratigraphy consists of embankment fill and surficial topsoil / organics underlain by layers and deposits of clayey silt-silt to silt of slight plasticity, gravelly silty sand to sandy silt, silt and sand to sand, and gravelly clayey sand-silty sand till. The thickness of the existing embankment generally increased to the south.

5.3.1 Topsoil

A 100 mm and 25 mm thick layer of topsoil was encountered at ground surface in boreholes AR03-03 and AR04-03, respectively.

A series of hand dug holes were carried out at Areas 3 and 4 in conjunction with the boreholes that were completed at the toe of the highway embankments to determine the topsoil/organic thicknesses. The topsoil / organic thicknesses near the embankment ranged from 100 to 250 mm.

Topsoil thickness may vary in other areas of the site and therefore, the thickness as encountered in the boreholes cannot be relied upon for the purpose of estimating quantities for stripping.

5.3.2 Embankment Fill

Granular embankment fill was encountered at ground surface in Boreholes AR03-01, AR03-02, AR04-01, and AR04-02 and below the topsoil in Boreholes AR03-03 and AR04-03. The embankment fill material is a non-homogenous mixture and is comprised of sandy gravel, some non-plastic fines to gravelly sand to silty sand, some gravel to gravelly, to sandy silt, trace to some gravel. The embankment fill extends to depths ranging from 1.4 m to 7.2 m (Elev. 327.7 m to Elev. 317.1 m) in Boreholes AR03-01 to AR03-03 and AR04-01 to AR04-03. The Highway 9 road surface and base of embankment fill generally decreased in elevation to the south.

The SPT 'N' values recorded in the embankment fill ranged from 6 blows per 0.3 m of penetration to 60 blows per 0.3 m of penetration, indicating a loose to very dense condition. Auger grinding was observed during borehole advancement in the embankment fill in Borehole AR03-02, indicating possible presence of obstructions such as cobbles, boulders or building debris. The measured moisture contents generally ranged from 4 per cent to 20 per cent.

The results of grain size analyses carried out on selected samples of the embankment fill are shown on the Record of Borehole sheets in Appendix C and presented in Figure C1 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	5 to 61
Sand	28 to 48
Silt	9 to 54
Clay	2 to 13
Silt and Clay	11



5.3.3 Clayey Silt to Silt of slight plasticity

A clayey silt to silt, some gravel, trace sand deposit 14.8 m thick and at least 3.8 m thick was encountered below the embankment fill Boreholes AR04-01 and AR04-03, respectively. A 1.5 m thick layer of this material was also encountered below the silty sand till layer in Borehole AR04-02, at a depth of 10.2 m (Elev. 314.3 m). The clayey silt to silt deposit extends to a depth of 17.8 m (Elev. 312.9 m) in Borehole AR04-01 and a depth of at least 5.2 m (Elev. 317.8 m) in Borehole AR04-03. Borehole AR04-03 was terminated in this deposit.

SPT 'N' values recorded in the clayey silt to silt of slight plasticity deposit ranged from 6 blows per 0.3 m of penetration to 29 blows per 0.3 m of penetration, suggesting a soft to very stiff consistency. Where encountered as an interlayer within the till in Borehole AR04-02, the SPT 'N' value recorded in silt of slight plasticity was 20 blows per 0.3 m of penetration, suggesting a very stiff consistency.

The measured moisture contents were between 15 per cent and 22 per cent.

The results of grain size analysis carried out on samples of the deposit and interlayer are shown on the Record of Borehole sheets in Appendix C and presented in Figure C2 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 11
Sand	2 to 14
Silt	72 to 81
Clay	9 to 18

The results of the Atterberg Limits test carried out on a sample of the clayey silt to silt deposit are shown on the Record of Borehole logs in Appendix C and presented in Figure C3 of Appendix C. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	19 to 24
Plastic Limit	15 to 17
Plastic Index	4 to 7



The result of the Atterberg Limits testing indicates the material is a clayey silt to silt of low plasticity (CL-ML) to a silt of low / slight plasticity (ML).

5.3.4 Sand and Gravel to Silty Sand to Sandy Silt to Gravelly Clayey Sand-Silty Sand (Till)

A non-homogenous till deposit at least 1.1 m to 10.2 m thick was encountered below the embankment fill in Boreholes AR03-01 to AR03-03 and AR04-02, and below the clayey silt-silt deposit in Borehole AR04-01. The till deposit generally consisted of a non-cohesive sand and gravel, trace non-plastic fines to silty sand, trace to some gravel to silt and sand, some gravel, to sandy silt. The deposit transitioned to a cohesive gravelly clayey sand-silty sand material in Borehole AR04-02. The till deposit extends to depths of at least 5.2 m (Elev. 313.7 m) to 15.8 m (Elev. 308.7 m). Boreholes AR03-01, AR03-02, AR03-03, AR04-01, and AR04-02 were terminated in this deposit.

SPT 'N' values recorded in the sand and gravel to silty sand to sand and sand till deposit ranged from 11 blows per 0.3 m of penetration to 61 blows per 0.3 m of penetration, indicating a generally compact to very dense condition. Where the till was cohesive, in Borehole AR04-02, the SPT 'N' values suggest a hard consistency.

The measured moisture contents were between 6 per cent and 28 per cent.

The result of grain size analysis carried out on samples of the till deposit are shown on the Record of Borehole sheets in Appendix C and presented in Figure C4 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	7 to 41
Sand	31 to 68
Silt	10 to 52
Clay	1 to 10
Silt and Clay	10

The result of the Atterberg Limits test carried out on a cohesive sample of the deposit recovered from Borehole AR04-02 is shown on the Record of Borehole logs in Appendix C and presented in Figure C5 of Appendix C. The result is summarized as follows:



Index Property	Percentage (%)
Liquid Limit	15
Plastic Limit	10
Plastic Index	5

The result of the Atterberg Limits testing indicates the material is a clayey silt-silt of low plasticity (CL-ML). Glacial till inherently contains cobbles and boulders.

5.3.5 Dynamic Cone Penetration Tests

Dynamic Cone Penetration Testing (DCPT) was carried out in Borehole AR03-02. The results of DCPT are summarized below:

Borehole	Starting and End Depth (m)	Starting and End Elevation (m)	Remark
AR09-01	9.1 / 15.2	312.6 / 306.5	Encountered 100 blows at a depth of 15.2 m below ground surface.

5.4 Widening Area 5 (STA 22+568 to 22+595)

The plan and embankment cross section showing the borehole locations and interpreted stratigraphy are presented in Drawing D1. The proposed widened highway embankment within this section of the highway is about 5 m high relative to the existing ground surface.

A total of two boreholes (Boreholes AR05-01 and AR05-02) were advanced to investigate the subsurface conditions within embankment widening Area 5.

In general, the encountered stratigraphy consists of embankment fill (generally non-cohesive) and surficial topsoil / organics underlain by a layer of sandy silt (containing rootlets), underlain by a silty sand deposit.

5.4.1 Asphalt

A 265 mm thick layer of asphalt was encountered at ground surface in Borehole AR05-02.

5.4.2 Topsoil / Organics

A series of hand dug holes were carried out at Area 5 in conjunction with the boreholes that were completed at the toe of the embankment to determine the topsoil/organic thicknesses. The topsoil / organic thicknesses ranged from 250 to 270 mm.

Topsoil / organics thickness may vary in other areas of the site and therefore, the thickness as encountered in the boreholes cannot be relied upon for the purpose of estimating quantities for stripping.

5.4.3 Embankment Fill

Embankment fill was encountered below the asphalt in Borehole AR05-02 and is comprised of gravel, trace silt to sand and gravel, trace fines, to clayey sand, some gravel. Concrete was encountered in the embankment fill at a depth of 1.5 m and was observed to be 200 mm thick. The embankment fill in Borehole AR05-02 extends to a depth of 4.1 m below ground surface (Elev. 326.9 m).

The SPT 'N' values recorded in the embankment fill generally ranged from 29 blows per 0.3 m of penetration to 64 blows per 0.3 m of penetration, indicating a generally compact to very dense condition. A SPT 'N' value of 100 for 0.05 m of penetration was measured at the depth at which concrete was observed in the fill, and a SPT 'N' value of 7 was measured in the lower part of the embankment fill (i.e. in the clayey sand, some gravel). The measured moisture contents generally ranged from 3 per cent to 22 per cent.

5.4.4 Sandy Silt

A 1.1 m thick layer of sandy silt, containing rootlets was encountered below the embankment fill in Borehole AR05-02 between depths of 4.1 m and 5.2 m (Elev. 326.9 m and Elev. 325.8 m).

The SPT 'N' value recorded in the sandy silt layer was 5 blows per 0.3 m of penetration, indicating a loose condition.

The measured moisture content was 84 per cent.

The result of grain size analysis carried out on a sample of the layer is shown on the Record of Borehole sheets in Appendix D and presented in Figure D1 of Appendix D. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	30
Silt	58
Clay	12

5.4.5 Silty Sand

A silty sand, trace gravel deposit at least 5.2 m and 6.5 m thick was encountered at surface in Borehole AR05-01 and below the sandy silt containing rootlets in Borehole AR05-02. The silty sand deposit extends to a depth of at least 5.2 m (Elev. 320.7 m) in Borehole AR05-01 and to a depth of 11.7 m (Elev. 319.3 m) in Borehole AR05-02. Borehole AR05-01 was terminated in this deposit.

SPT 'N' values recorded in the silty sand deposit ranged from 7 blows per 0.3 m of penetration to 22 blows per 0.3 m of penetration, indicating a loose to compact condition.

The measured moisture contents were between 12 per cent and 37 per cent.

The result of grain size analysis carried out on samples of the deposit are shown on the Record of Borehole sheets in Appendix D and presented in Figure D2 of Appendix D. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	1 to 6
Sand	80 to 86
Silt	12
Clay	1
Silt and Clay	13 to 14

5.4.6 Silty Sand (Till)

A silty sand of slight plasticity, some gravel till deposit at least 1.4 m thick was encountered below the silty sand deposit in Borehole AR05-02. The silty sand till deposit extends to a depth of 13.1 m (Elev. 317.9 m). Borehole AR05-02 was terminated in this deposit upon split spoon refusal.

The SPT 'N' values recorded in the silty sand till deposit were 6 blows per 0.3 m of penetration and 50 blows for 0 m of penetration (i.e. split spoon refusal), generally indicating a loose to very dense condition.

The measured moisture content was 11 per cent.

The result of grain size analysis carried out on a sample of the till deposit is shown on the Record of Borehole sheets in Appendix D and presented in Figure D3 of Appendix D. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	17
Sand	42
Silt	36
Clay	5

The result of the Atterberg Limits test carried out on the fines portion of a sample of the silty sand till deposit is shown on the Record of Borehole logs in Appendix D and presented in Figure D4 of Appendix D. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	15
Plastic Limit	12
Plastic Index	3

The result of the Atterberg Limits testing indicates the material is a silt of low / slight plasticity (ML). Glacial till inherently contains cobbles and boulders.

5.5 Widening Areas 6 (STA 23+370 to 23+503) and 7 (STA 23+363 to 23+530)

The plan and profile along the highway centreline showing the borehole locations and interpreted stratigraphy between STA 23+363 and STA 23+530 are presented in Drawing E1. The proposed widened highway embankment within this section of the highway ranges between about 5 m to 7 m high relative to the existing ground surface.

A total of six boreholes (Boreholes AR06-01 to AR06-03, AR07-01 to AR07-03) were advanced to investigate the subsurface conditions within embankment widening Areas 6 and 7.

In general, the encountered stratigraphy consists of embankment fill and surficial topsoil / organics underlain by clayey silt to silty clay downhill (i.e. to the north) and sand to silty sand to silt uphill (i.e. to the south), underlain by gravel to sandy gravel to sandy silty gravel.

5.5.1 Embankment Fill

Granular embankment fill was encountered at ground surface in Boreholes AR06-01, AR06-02, AR07-01, and AR07-02 and is generally comprised of gravel, trace silt, trace sand to silty gravel and sand to gravelly sand to gravelly silty sand. The embankment fill extends to depths ranging from 4.1 m to 7.2 m (Elev. 331.5 m to Elev. 325.6 m) in Boreholes AR06-01, AR06-02, AR07-01, and AR07-02.

The SPT 'N' values recorded in the embankment fill ranged from 9 blows per 0.3 m of penetration to 46 blows per 0.3 m of penetration, indicating a loose to dense condition. The measured moisture contents generally ranged from 5 per cent to 12 per cent.

The results of grain size analyses carried out on selected samples of the embankment fill are shown on the Record of Borehole sheets in Appendix E and presented in Figure E1 of Appendix E. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	28 to 49
Sand	36 to 48
Silt	12 to 22
Clay	1 to 3

5.5.2 Topsoil / Organics

A series of hand dug holes were carried out at Areas 6 and 7 in conjunction with the boreholes that were completed at the toe of the embankments to determine the topsoil/organic thicknesses. The topsoil / organic thicknesses ranged from 200 to 300 mm.

Topsoil / organics thickness may vary in other areas of the site and therefore, the thickness as encountered in the boreholes cannot be relied upon for the purpose of estimating quantities for stripping.

5.5.3 Clayey Silt to Silty Clay

A deposit of clayey silt to silty clay was encountered at ground surface in Boreholes AR06-03 and AR07-03 and is generally comprised of clayey silt to silty clay, trace gravel, trace sand. The clayey silt to silty clay extends depths of 1.1 m and 0.5 m (Elev. 326.1 m and Elev. 327.0 m) in Boreholes AR06-03 and AR07-03, respectively.

The SPT 'N' values recorded in this layer ranged from 5 blows per 0.3 m of penetration to 9 blows per 0.3 m of penetration, indicating a firm to stiff consistency. The measured moisture contents generally ranged from 18 per cent to 36 per cent.

5.5.4 Silt and Sand to Silty Sand

A silt and sand to sandy silt deposit was encountered below the embankment fill in Boreholes AR06-01, AR07-01, and below the clayey silt to silty clay in Boreholes AR06-03 and AR07-03.

Where encountered below the embankment fill in Boreholes AR06-01 and AR07-01, the deposit was 1.5 m and 1.3 m thick and extends to a depth of 5.6 m (Elev. 324.4 m) and 8.5 m (Elev. 324.3 m), respectively. Where encountered below the clayey silt to silty clay in Boreholes AR06-03 and AR07-03, the layer was encountered at a depth of 1.1 m and 0.9 m and extends to a depth of 1.8 m and 2.7 m (Elev. 325.4m and Elev. 324.8 m), respectively. Sampling in Borehole AR07-01 was terminated in this deposit upon auger and split spoon refusal, at a depth of 8.5 m (Elev. 324.3 m). Borehole AR07-03 was terminated in this deposit upon split spoon refusal, at a depth of 2.7 m (Elev. 324.8).

SPT 'N' values recorded in the silt and sand to silty sand deposit ranged from 7 blows per 0.3 m of penetration to 28 blows per 0.3 m of penetration, indicating a loose to compact condition.

The measured moisture contents were between 12 per cent and 19 per cent.

The result of grain size analysis carried out on samples of the deposit are shown on the Record of Borehole sheets in Appendix E and presented in Figure E2 of Appendix E. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 11
Sand	27 to 51
Silt	42 to 64
Clay	2 to 5

The result of the Atterberg Limits testing on a selected sample of this deposit indicates the material is non-plastic.

5.5.5 Sand

A 0.8 m thick layer of sand was encountered below the silt and sand deposit in Borehole AR06-01 and extends a depth of 6.4 m (Elev. 323.6 m).

The SPT 'N' value recorded in the sand layer was 71 blows for 0.13 m of penetration, indicating a very dense condition. The measured moisture content was 18 per cent.

5.5.6 Gravel to Sandy Gravel to Sandy Silty Gravel

A gravel to sandy gravel to sandy silty gravel deposit was encountered below the sand layer in Borehole AR06-01, below the silt and sand to sandy silt deposit in Borehole AR06-03, and below the embankment fill in Boreholes AR06-02 and AR07-02. This deposit was at least 0.5 m to 4.2 m thick and extends to depths of 2.7 m to 9.8 m (Elev. 328.0 m to Elev. 323.1 m). Boreholes AR06-01, AR06-03, and AR07-02 were terminated in this deposit and sampling was terminated in AR06-02 in this deposit. Auger grinding was observed in this deposit in Borehole AR07-02 at a depth of 9.1 m.

SPT 'N' values recorded in the gravel to sandy gravel to sandy silty gravel deposit ranged from 8 blows per 0.3 m of penetration to 21 blows per 0.3 m of penetration. SPT 'N' values of 50 blows for 0 m of penetration (i.e. split spoon refusal) and 100 blows for 0.10 m of penetration were also recorded in this deposit, indicating a loose to very dense condition.

The measured moisture contents were between 7 per cent and 22 per cent.

The result of grain size analysis carried out on samples of the deposit are shown on the Record of Borehole sheets in Appendix E and presented in Figure E3 of Appendix E. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	40 to 66
Sand	23 to 31
Silt	9 to 25
Clay	2 to 4
Silt and Clay	24



5.5.7 Dynamic Cone Penetration Tests

Dynamic Cone Penetration Testing (DCPT) was carried out in Boreholes AR06-02 and AR07-01. The results of DCPTs are summarized below:

Borehole	Starting and End Depth (m)	Starting and End Elevation (m)	Remark
AR06-02	8.2 / 9.2	328.0 / 327.0	Encountered 100 blows at a depth of 9.2 m below ground surface.
AR07-01	8.5 / 9.0	324.3 / 323.8	Encountered 80 blows at a depth of 9.0 m below ground surface.

5.6 Widening Area 8 (STA 23+890 to 23+937)

The plan and embankment cross section showing the borehole locations and interpreted stratigraphy are presented in Drawing F1. The proposed widened highway embankment within this section of the highway ranges between about 5 m high relative to the existing ground surface.

A total of two boreholes (Boreholes AR08-01 and AR08-02) were advanced to investigate the subsurface conditions within embankment widening Area 8.

In general, the encountered stratigraphy consists of embankment fill and surficial topsoil / organics underlain by silty sand and gravel to gravelly sand, underlain by silty sand.

5.6.1 Embankment Fill

Granular embankment fill was encountered at ground surface in Boreholes AR08-01 and AR08-02 and is generally comprised of sandy silty gravel to gravelly sand. The upper 0.6 m of embankment fill in Borehole AR08-01 was comprised of sandy silt, trace gravel, containing organics. The embankment fill extends to depths of 1.8 m (Elev. 342.6 m) and 4.1 m (Elev. 343.0 m) in Boreholes AR08-01 and AR08-02, respectively.

The SPT 'N' values recorded in the embankment fill ranged from 5 blows per 0.3 m of penetration to 22 blows per 0.30 m of penetration, indicating a loose to compact condition. The measured moisture contents generally ranged from 5 per cent to 32 per cent.

The results of grain size analyses carried out on a selected sample of the embankment fill are shown on the Record of Borehole sheets in Appendix F and presented in Figure F1 of Appendix F. The results are summarized as follows:



Soil Particle	Percentage (%)
Gravel	65
Sand	21
Silt and Clay	14

5.6.2 Topsoil / Organics

A series of hand dug holes were carried out at Area 8 in conjunction with the boreholes that were completed at the toe of the embankment to determine the topsoil/organic thicknesses. The topsoil / organic thicknesses ranged from 230 to 250 mm.

Topsoil / organics thickness may vary in other areas of the site and therefore, the thickness as encountered in the boreholes cannot be relied upon for the purpose of estimating quantities for stripping.

5.6.3 Silty Sand and Gravel to Gravelly Sand

A silty sand and gravel to gravelly sand, trace non-plastic fines deposit at least 2.8 m thick and 4.6 m thick was encountered below the embankment fill in Boreholes AR08-01 and AR08-02, respectively. The silty sand and gravel to gravelly sand deposit extends to a depth of at least 4.6 m (Elev. 339.8 m) and 8.7 m (Elev. 338.4 m) in Boreholes AR08-01 and AR08-02, respectively. Borehole AR08-01 was terminated in this deposit. A 100 mm cobble was recovered from this deposit in auger cuttings from a depth of approximately 1.8 m in Borehole AR08-01.

SPT 'N' values recorded in the silty sand and gravel to gravelly sand deposit ranged from 16 blows per 0.3 m of penetration to 28 blows per 0.3 m of penetration, indicating a compact condition.

The measured moisture contents were between 3 per cent and 7 per cent.

The result of grain size analysis carried out on samples of the deposit are shown on the Record of Borehole sheets in Appendix F and presented in Figure F2 of Appendix F. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	30 to 48
Sand	33 to 61
Silt	9 to 17
Clay	0 to 2
Silt and Clay	15

5.6.4 Silty Sand

A silty sand, trace gravel layer at least 1.1 m thick was encountered below the gravelly sand deposit in Borehole AR08-02. The silty sand layer extends to a depth of at least 9.8 m (Elev. 337.3 m) in Borehole AR08-02. Borehole AR08-02 was terminated in this deposit due to auger and split spoon refusal.

The SPT 'N' value recorded in the silty sand layer was 23 blows per 0.3 m of penetration, indicating a compact condition. A SPT 'N' value of 100 blows for 0.0 m of penetration was also recorded at the termination depth (Elev. 337.3 m) in Borehole AR08-02.

The measured moisture content was 16 per cent.

The result of grain size analysis carried out on a sample of the deposit are shown on the Record of Borehole sheets in Appendix F and presented in Figure F3 of Appendix F. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	2
Sand	50
Silt	45
Clay	3

5.7 Widening Area 9 (STA 24+130 to 24+205)

The plan and embankment cross section showing the borehole locations and interpreted stratigraphy are presented in Drawing G1. The proposed widened highway embankment within this section of the highway ranges between about 4.5 m and 6 m high relative to the existing ground surface.

A total of two boreholes (Boreholes AR09-01 and AR09-02) were advanced to investigate the subsurface conditions within embankment widening Area 9.

In general, the encountered stratigraphy consists of embankment fill (generally non-cohesive) and surficial topsoil / organics underlain by silt to clayey silt fill (containing organics), underlain by a silty sand to sandy silt to silt deposit.

5.7.1 Embankment Fill

Granular embankment fill was encountered at ground surface in Borehole AR09-01 and is comprised of sand and gravel to silty sand and gravel to silty sand, some gravel. The embankment fill in Borehole AR09-01 extends to a depth of 7.2 m below ground surface (Elev. 332.1 m). 50 mm of wood was recovered from this layer at a depth of 6.7 m. Wood pieces were observed in the recovered sample.

The SPT 'N' values recorded in the embankment fill ranged from 11 blows per 0.3 m of penetration to 20 blows per 0.30 m of penetration, indicating a compact condition. The measured moisture contents generally ranged from 5 per cent to 14 per cent. The fill at a depth of 6.7 m had a water content of 254 per cent, likely reflecting organics or wood pieces.

The results of grain size analyses carried out on a selected sample of the embankment fill are shown on the Record of Borehole sheets in Appendix G and presented in Figure G1 of Appendix G. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	37
Sand	42
Silt	17
Clay	4

5.7.2 Silt to Clayey Silt Fill (containing organics)

A layer of silt to clayey silt fill, trace gravel, trace sand, containing organics was encountered at ground surface in Borehole AR09-02. The silt to clayey silt layer was about 2.1 m thick in Borehole AR09-02 and extended to a depth of 2.1 m below ground surface (Elev. 331.7 m).

SPT N-values measured in the silt to clayey silt ranged between 1 blow and 3 blows per 0.3 m of penetration, suggesting a very loose to firm consistency. The measured moisture contents

generally ranged from 137 per cent to 254 per cent. The high water contents likely reflects organic content.

A series of hand dug holes were carried out at Area 9 in conjunction with the boreholes that were completed at the toe of the embankment to determine the topsoil/organic thicknesses. The topsoil / organic thicknesses ranged from 270 to greater than 760 mm.

Topsoil / organics thickness may vary in other areas of the site and therefore, the thickness as encountered in the boreholes cannot be relied upon for the purpose of estimating quantities for stripping. In addition, these materials were classified based on visual and textural evidence and therefore, cannot be relied upon for the reuse for landscaping purposes.

5.7.3 Silty Clay

A layer of silty clay, some sand, trace gravel was encountered below the organic clayey silt in Borehole AR09-02. The thickness of the silty clay was 0.9 m and extends to a depth of 3.0 m (Elev. 330.8 m).

SPT N-values measured in the silty clay were 2 blows and 3 blows per 0.3 m of penetration, suggesting a soft consistency. The measured moisture contents were 25 per cent to 39 per cent.

The results of grain size analyses carried out on a selected sample of the silty clay are shown on the Record of Borehole sheets in Appendix G and presented in Figure G2 of Appendix G. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	3
Sand	20
Silt	67
Clay	10

The results of the Atterberg Limits test carried out on a sample of the silty clay layer are shown on the Record of Borehole logs in Appendix G and presented in Figure G3 of Appendix G. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	38
Plastic Limit	21
Plastic Index	17

The result of the Atterberg Limits testing indicates the material is a silty clay of intermediate plasticity (CI).

5.7.4 Silty Sand to Sandy Silt to Silt

A silty sand, some gravel to sandy silt to silt deposit at least 7.1 m and 2.2 m thick was encountered below the organic fill in Borehole AR09-01 and below the silty clay in Borehole AR09-02. The silty sand to sandy silt to silt deposit extends to a depth of at least 14.3 m (Elev. 325.0 m) and 5.2 m (Elev. 328.6 m) in Boreholes AR09-01 and AR09-02, respectively. Boreholes AR09-01 and AR09-02 were terminated in this deposit.

SPT 'N' values recorded in the silty sand to sandy silt to silt deposit ranged from 10 blows per 0.3 m of penetration to 23 blows per 0.3 m of penetration, indicating a compact condition.

The measured moisture contents were between 14 per cent and 19 per cent.

The result of grain size analysis carried out on samples of the deposit are shown on the Record of Borehole sheets in Appendix G and presented in Figure G4 of Appendix G. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 17
Sand	5 to 64
Silt	17 to 86
Clay	2 to 9

The results of the Atterberg Limits test carried out on a sample of the silt deposit are shown on the Record of Borehole logs in Appendix G and presented in Figure G5 of Appendix G. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	18
Plastic Limit	16
Plastic Index	2

The result of the Atterberg Limits testing indicates the material is a silt of low / slight plasticity (ML).

5.7.5 Dynamic Cone Penetration Tests

Dynamic Cone Penetration Testing (DCPT) was carried out in Borehole AR09-01. The results of DCPTs are summarized below:

Borehole	Starting and End Depth (m)	Starting and End Elevation (m)	Remark
AR09-01	15.2 / 16.2	324.1 / 323.1	Encountered 100 blows at a depth of 16.2 m below ground surface.

5.8 Groundwater Level

The measured groundwater levels from the piezometers installed at the various widening areas and in open boreholes are summarized in the table below. Groundwater levels measured in open boreholes or within hollow stem augers may not be representative as the water level may not have been stabilized.

Table 5-1 Groundwater Level Measurements

Embankment Widening Area	Borehole	Groundwater Level		Date of Reading	Note
		Depth (m)	Elevation (m)		
1 and 2	AR01-01	0.7	328.3	December 1, 2023	In piezometer
	AR01-01	0.3	328.7	January 31, 2024	In piezometer
	AR01-02	7.1	326.8	October 19, 2023	In piezometer
	AR02-01	0.6	328.6	December 1, 2023	In piezometer
	AR02-01	0.4	328.8	January 31, 2024	In piezometer
	AR02-02	9.1	325.2	September 19, 2023	In hollow stem augers upon completion of drilling
3 and 4	AR03-01	10.7	316.2	September 21, 2023	Upon completion of drilling



Embankment Widening	Borehole	Groundwater Level		Date of Reading	Note
	AR03-03	1.3	317.6	December 1, 2023	In piezometer
	AR03-03	0.9	318.0	January 31, 2024	In piezometer
	AR04-01	10.1	320.6	October 19, 2023	Upon completion of drilling
	AR04-02	9.7	314.8	October 19, 2023	Upon completion of drilling
	AR04-03	5.2	317.8	September 22, 2023	In open borehole upon completion of drilling
5	AR05-01	1.1	324.8	December 1, 2023	In piezometer
	AR05-01	0.8	325.1	January 31, 2024	In piezometer
6 and 7	AR06-01	5.2	324.8	October 19, 2023	In hollow stem augers upon completion of drilling
	AR06-02	Dry	-	October 18, 2023	In hollow stem augers upon completion of drilling
	AR06-03	1.5	325.7	December 1, 2023	In piezometer
	AR06-03	1.1	326.1	January 31, 2024	In piezometer
	AR07-02	Dry	-	October 18, 2023	In hollow stem augers upon completion of drilling
	AR07-03	2.1	325.4	December 1, 2023	In piezometer
	AR07-03	1.5	326.0	January 31, 2024	In piezometer
8	AR08-01	3.7	340.7	December 1, 2023	In piezometer
	AR08-01	3.7	340.7	January 31, 2024	In piezometer
	AR08-02	Dry	-	October 17, 2023	In hollow stem augers upon completion of drilling
9	AR09-01	7.0	332.3	October 17, 2023	In hollow stem augers during drilling
	AR09-02	0.0	333.8	December 1, 2023	In piezometer
	AR09-02	0.0	333.8	January 31, 2024	In piezometer

The water levels in open boreholes upon completion of drilling may not be the stabilized water level. It should be noted that the above values are considered short-term readings and may not reflect the groundwater level at the time of construction. Seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

6. MISCELLANEOUS

The borehole locations reflect existing site features and access constraints. The as-drilled borehole locations and ground surface elevations were measured / surveyed by Thurber



THURBER ENGINEERING LTD.

following completion of the field program. Walker Drilling Ltd. of Utopia, Ontario, supplied and operated the drill rig used to drill, test, sample, and decommission boreholes drilled through the existing highway embankment. OGS Inc. of Almonte, Ontario and Limitless Drilling Inc. of Horton, Ontario, supplied and operated the portable drilling equipment used to drill, test, sample, and decommission boreholes near the toe of the highway embankment. Traffic control was performed in accordance with Ontario Book 7 and was provided by Geotech Support Services Inc. of Markham, Ontario. The field investigation was supervised on a full-time basis by Mr. L. Scalena, EIT and Mr. J. Flood. Overall supervision of the field investigation program was provided by Mr. R. de Castro, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's geotechnical laboratories.

Interpretation of the factual data and preparation of this report was completed by Ms. Alysha Kobylinski, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.



THURBER ENGINEERING LTD.

Thurber Engineering Ltd.
Report Prepared By:



Alysha Kobylinski, P.Eng.
Geotechnical Engineer



P.K. Chatterji, Ph.D., P.Eng.
Designated Principal Contact
Senior Geotechnical Engineer



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 9 EMBANKMENT WIDENING FROM MILD MAY EAST LIMITS TO
CLIFFORD WEST LIMITS
MUNICIPALITY OF SOUTH BRUCE, ONTARIO
AGREEMENT NO.: 3020-E-0004, WORK ITEM NO.: 23
GWP 3076-14-00**

GEOCRES NO.: 41A03-004

PART B. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This section of the report provides an interpretation of the factual data from Part 1 of this report and presents foundation design recommendations to assist the project team in the design of Highway 9 embankment widening at nine sites from Mildmay east limits easterly to Clifford west limits in the Municipality of South Bruce, Ontario. Thurber Engineering Ltd. (Thurber) carried out the foundation investigation as a sub-consultant to R.V. Anderson Associates Limited (RVA) under Agreement No. 3020-E-0004, Work Item No. 23. The discussion and recommendations presented in this report are based on information provided by RVA and the factual data obtained during the current field investigation.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ontario Ministry of Transportation (MTO) and their designer, RVA, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. Contractors must make their own interpretation based on the factual data in Part A of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, and scheduling and the like.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

7.1 Background Information

It is indicated in Appendix 2A: Work Item Quote Form that this assignment involves the embankment widening of Highway 9, a two lane, asphalt paved road with gravel shoulders, at the following nine locations:

Table 7-1 Embankment Widening Locations

Site No.	Limits of Fill Area (Project Chainage)	Fill Widening Side	Widening Width at Highway 9 Road Platform, m	Maximum Fill Height, m
		North (N) / South (S)		
1	Highway 9 EBL STA 19+136 to 19+213	S	3.0	3.5 to 5 (W to E)
2	Highway 9 WBL STA 19+140 to 19+235	N	2.9	3.5 to 5 (W to E)
3	Highway 9 EBL STA 19+635 to 19+825	S	3.8	6 to 8 (W to E)
4	Highway 9 WBL STA 19+630 to 19+765	N	3.1	6 to 8 (W to E)
5	Highway 9 WBL STA 22+568 to 22+595	N	4.0	5
6	Highway 9 EBL STA 23+370 to 23+503	S	2.0	5 to 7 (W to E)
7	Highway 9 WBL STA 23+363 to 23+530	N	3.5	5 to 7 (W to E)
8	Highway 9 WBL STA 23+890 to 23+937	N	2.8	5
9	Highway 9 EBL STA 24+130 to 24+205	S	5.4	4.5 to 6 (W to E)

Larger farm equipment uses the highway along this corridor. The main reasons for widening the existing through lanes to standard widths and widening the shoulders are to better accommodate horse and buggy traffic and farm equipment.

7.2 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available information provided by RVA, existing ground surface conditions and in accordance with the Canadian Highway Bridge Design Code (CHBDC) version CSA S6-19.

7.3 Widened Embankment Stability Requirements

For the purpose of the stability analysis and design, the target minimum Factor of Safety for design is equal to the inverse of the product of the consequence factor, Ψ , and the geotechnical resistance factor, ϕ_{gu} . (i.e., $Factor\ of\ Safety = 1/(\Psi \cdot \phi_{gu})$). The following minimum factors of safety have been used for the design of the embankment side slopes proposed, as per Table 6.2 of CHBDC, 2019:

- 1.5 for permanent conditions; and
- 1.3 for temporary conditions.

7.4 Settlement Performance Requirements

The settlement performance criterion of design for embankment widening is in accordance with Section 1.3 of MTO's July 2010 guideline titled, "*Embankment Settlement Criteria for Design.*" In general, embankment widenings not approaching a structural element are to be designed as follows:

- Total settlement and differential settlement rate are to be less than 75 mm and 100:1, respectively, over a 15-year period following construction of the pavement structure for a secondary highway.

Furthermore, the guideline indicates that 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.*"

These performance criteria form part of the overall design performance for each high fill platform widening area.

8. FILL EMBANKMENT PLATFORM WIDENING AREAS

Based on the section cuts of the widened Highway 9 alignment provided to Thurber by RVA, the embankment widening areas within the project limits are proposed to range from about 3.5 m to about 8.0 m in height.

Section 8.1 of this report address various borrow material types that can be considered for the platform widenings at the high fill areas. Sections 8.3.1 and 8.3.2 summarize the methods used to analyze the stability and settlement at critical sections of the high fill areas, respectively. The aforementioned sections also provide foundation engineering parameters used in the analyses. Section 9 provides a summary of stability and settlement analyses and recommendations regarding design and construction alternatives to mitigate stability issues and/or post-construction settlement, where applicable. General aspects of subgrade preparation and embankment construction are presented in Sections 10.1 and 10.3.

At all high fill areas, the analyses assume that any near surface organic soils, topsoil, and any softened/loose soils will be removed prior to placement of new embankment fill (as discussed in Section 10.1).

8.1 Local and Imported Granular Borrow for Embankment Widening

The following alternate borrow materials were considered for construction of the widened embankment:

- Imported Granular A or B Type I or II material
- Local Granular Borrow meeting Granular B Type I or Type II gradation requirements.

It is proposed to flatten a vertical curve from STA 23+610 to 23+830 with a minimum profile cut of 325 mm. Excavated shoulder granulars are also proposed as a source of borrow. These areas are expected to yield granular borrow materials with variable fines content. It is understood that these local borrows are preferred for construction of the widening.

For this project, it has been necessary to use the following minimum strength parameter for potential granular borrow material to achieve the required factor of safety of the widened fill:

Material	Unit Weight (kN/m³)	Effective Friction Angle (°)
Granular Borrow (from local cuts or imported Granular B Type I)	22	32

Any local granular borrow used to construct the fill widenings must meet Granular B Type I or II gradation as per OPSS PROV 1010 requirements and be free of organics, any deleterious material, building debris, unfrozen, with less than 10 per cent fines content, and a compactable moisture content of +/- 2 per cent of the optimum moisture content of the borrow. The borrow must also meet the strength requirement outlined above.

From the laboratory index test results presented in the report by Amec Foster Wheeler titled "Assignment #3 – Park B MTO West Region Retainer 3015-E-0022 GWP 3076-14-00 Hwy 9 Mildmay East Limit to Clifford West Limit", dated December 11, 2017, the local granular material excavated from flattening the vertical curve, may not meet the requirements of OPSS Granular B Type I or II due to the high fines content. The high fines content is likely to render the local granular borrow frost susceptible and may not meet the strength requirement. These locally available soils would need to be screened to remove the fines, which may not be feasible given the quantity of material required for embankment widening within the project limits.

Accordingly, it is recommended that imported Granular B Type I or Type II be used for widening of Fill Areas.



8.2 Rock Fill for Embankment Widening

In areas of limited right-of-way such as in Area 8, to achieve steeper side slopes (i.e. 1.5H:1V), rock fill may be considered for the embankment widening.

Embankment construction using rock fill should be carried out in accordance with OPSS.PROV 206. Rock particles should be no greater than 300 mm in maximum dimension, and otherwise be controlled in accordance with OPSS.PROV 206. The rock fill must be well graded with 0-5% passing 4.75 mm sieve size. The material must be 100% crushed and the rock fill must be angular and sourced from a quarry.

The rock fill particles must be hard and durable with a minimum unconfined compressive strength (UCS) of 100 MPa and meet the physical requirements of "Rock Protection" as provided in Table 7 of OPSS 1004 (November 2012). Soft rocks, such as shale and sandstone, are not permitted as rock fill. Limestone screenings or rounded cobbles and boulders are not permitted as rock fill. Rock fill should be placed in lifts not exceeding 600 mm in thickness and each lift compacted as per OPSS 206. Rock fill placed above the water table should be constructed in a controlled manner (not end dumped) including blading, dozing, compacting and chinking of the rock to minimize voids and bridging.

At the pavement subgrade level (i.e. where the granular fill (Granular B Type II) is to be placed over rock fill) the rock fill subgrade must be blinded with spall material and rock fill chinking shall be in accordance with OPSS.PROV 206. All granular fill (Granular B Type II) must be compacted as per OPSS.PROV 501.

It is recommended to use rock fill for the widening of Fill Area 8. To maintain adequate slope stability, slope inclination of the new rock fill embankment in this section should not be steeper than 1.5H:1V, and is discussed further in Section 9.5.

8.3 Methods for Embankment Design

The following sections outline the method used to evaluate embankment global stability and settlement at the Highway 9 platform widening areas and present the soil/fill engineering parameters used in the analyses for each critical section. The results of the stability analyses are presented in Section 9 where they are discussed together with the results of the settlement analyses and recommendations regarding possible design and construction alternatives to mitigate stability issues and/or post-construction settlement, where applicable



8.3.1 Global Stability

Stability analyses were carried out for the critical sections of each embankment widening area. Critical sections correspond to the greatest embankment height and/or maximum thickness of weak foundation deposits. A 17 kPa surcharge representing traffic loading was considered across the top of the embankment (i.e. the Highway 9 road surface). The stability of the proposed high fill sections were analyzed using limit equilibrium methods. The stability analyses assume that all topsoil, peat, and organic soils encountered at the ground surface within the footprint of the proposed high fill platform widening areas will be removed and replaced with compacted granular backfill prior to the placement of fill for the platform widening.

All limit equilibrium slope stability analyses were carried out using the commercially available program Slide2, developed by Rocscience Inc., employing the Morgenstern-Price method of analysis.

The material properties used in the stability analyses at each embankment widening area are summarized in the table below and were determined by in-situ testing and soil index correlations.

Table 8-1 Summary of Material Properties Used in Slope Stability Analyses

Location	Material	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
Areas 1 and 2	OPSS Granular B Type II or Granular A	22	0	35
	Local Granular Borrow (meeting the gradation of Granular B Type I) or Imported Granular B Type I	22	0	32
	Existing Embankment Fill	21	0	32
	Clayey Silt-Silt to Silty Clay	20.5	0	30
	Silty Sand Interlayer	21.5	0	31
Areas 3 and 4	OPSS Granular B Type II or Granular A	22	0	35
	Local Granular Borrow (meeting the gradation of Granular B Type I) or Imported Granular B Type I	22	0	32
	Existing Embankment Fill	21	0	32
	Clayey Silt to Silt	20	0	29
	Dense Gravelly Silty Sand to Sandy Silt Till	21.5	0	34
	Dense Silt and Sand to Gravelly Silty Sand Till	21.5	0	35
Area 5	OPSS Granular B Type II or Granular A	22	0	35



Location	Material	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Local Granular Borrow (meeting the gradation of Granular B Type I) or Imported Granular B Type I	22	0	32
	Existing Embankment Fill – Non-cohesive	22	0	32
	Existing Embankment Fill - Cohesive	20	0	28
	Sandy Silt	20	0	31
	Silty Sand	22	0	30
Areas 6 and 7	OPSS Granular B Type II or Granular A	22	0	35
	Local Granular Borrow (meeting the gradation of Granular B Type I) or Imported Granular B Type I	22	0	32
	Existing Embankment Fill	22	0	32
	Silt and Sand to Silty Sand	20	0	31
	Gravel to Sandy Gravel to Sandy Silty Gravel	20	0	30
Area 8	OPSS Granular B Type II or Granular A	22	0	35
	Rock Fill	19	0	42
	Existing Embankment Fill	22	0	32
	Silty Sand and Gravel to Gravelly Sand	22	0	32
	Silty Sand	22	0	30
Area 9	OPSS Granular B Type II or Granular A	22	0	35
	Local Granular Borrow (meeting the gradation of Granular B Type I) or Imported Granular B Type I	22	0	32
	Existing Embankment Fill	22	0	32
	Lower Existing Embankment Fill – containing organics	20	0	30
	Silty Clay	18	0	28
	Silty Sand to Sandy Silt to Silt	21.5	0	32

The groundwater table assumed in the stability analyses at each site was based on the groundwater level measured in the nearby monitoring wells.

8.3.2 Embankment Settlement

To estimate the magnitude of the expected settlements, analyses were carried out at critical sections of the proposed fill embankments using the commercially available program Settle3,



developed by Rocscience Inc. Critical sections correspond to the greatest embankment height and/or maximum thickness of compressible foundation soil deposits. The settlement analyses assume that all organic soils encountered at the ground surface within the footprint of the proposed high fill platform widening areas will be removed and replaced with compacted granular fill prior to the proposed platform widening. If organic soils are not fully excavated from within the footprint of the proposed highway platform widening areas, the proposed platform widenings will result in additional loading of the organic soils which will experience settlement under the new loading condition and may lead to poor long-term performance in the widened areas.

The thickness of the foundation soils and the height of the embankments vary along the proposed highway alignment within each of the widening areas along Highway 9, and as such the settlements along each alignment will vary.

The material properties for the simplified stratigraphy together with the selected deformation parameters used for native soil types at the critical sections are summarized below.

Table 8-2 Summary of Material Properties Used in Settlement Analyses

Location	Material	Unit Weight (kN/m ³)	Elastic Modulus (MPa)
Areas 1 and 2	Clayey Silt-Silt to Silty Clay	20.5	5
	Silty Sand Interlayer	21.5	15
Areas 3 and 4	Clayey Silt to Silt of Slight Plasticity	21	10
	Gravelly Silty Sand to Sandy Silt Till	21.5	20
	Silt and Sand to Gravelly Silty Sand Till	21.5	25
Area 5	Sandy Silt	15	4
	Silty Sand	22	5
Areas 6 and 7	Silt and Sand to Silty Sand	22.5	15
	Gravel to Sandy Gravel to Sandy Silty Gravel	20	5
Area 8	Silty Sand and Gravel to Gravelly Sand	22	5
	Silty Sand	22	5
Area 9	OPSS Granular B Type I	22	10
	Lower Existing Embankment Fill – containing organics	20	5
	Silty Clay	18	5
	Silty Sand to Sandy Silt to Silt	21.5	10

The immediate compression of the granular foundation deposits was modelled by estimating an elastic modulus of deformation (E') based on the results of in-situ SPT 'N'-values and using correlations proposed by Bowles (1984) and Kulhawy and Mayne (1990). These estimated values were compared with the typical range of expected values for similar soil types, as outlined in CHBDC (2019) and adjusted, as appropriate, using engineering judgment based on precedent experience in similar soil conditions.

8.3.2.1 Short Term Rock Fill Settlement

The magnitude of short-term post-construction settlement associated with compacted and end-dumped rock fill may be estimated in accordance with the MTO Guideline (September 2010).

Total Height of Rock Fill, H	Short-Term Rock Fill Settlements	
	Compacted Rock Fill	Dumped Rock Fill
Up to 5 m	$0.5\% \cdot H$	$1.0\% \cdot H$
> 5 m to 10 m	$0.75\% \cdot H$	$1.5\% \cdot H$

Approximately 90% of the short-term settlement may be expected to occur within the first six months following construction of the embankment to full height. The short-term settlement is expected to be fully completed within one year following the completion of embankment construction to full height.

8.3.2.2 Long Term Rock Fill Settlement

The magnitude of long-term post-construction settlement for compacted and end-dumped rock fill may be estimated in accordance with the MTO Guideline (September 2010), as follows:

Total Height of Rock Fill, H	Long-Term Rock Fill Settlements	
	Compacted Rock Fill	Dumped Rock Fill
Up to 15 m	$0.1\% \cdot H$	$0.2\% \cdot H$

The long-term rock fill settlement is expected to occur from one year following the completion of construction over the life of the embankment.



9. RESULTS AND FOUNDATION DESIGN RECOMMENDATIONS

The stability analysis plots for the conditions analyzed are presented in Appendix H. The results of the stability and settlement analyses are summarized in the table below and discussed further in the following sections.

Site No.	Limits of Fill Area (Project Chainage)	Fill Widening Side	Maximum Fill Height, m	Recommended Widening Material and Side Slope Inclination
		North (N) / South (S)		
1	Highway 9 EBL STA 19+136 to 19+213	S	3.5 to 5 (W to E)	Granular B Type I: 2.5H:1V Granular B Type II: 2.25H:1V Subexcavation depth of organics in Area 1: up to 610 mm
2	Highway 9 WBL STA 19+140 to 19+235	N	3.5 to 5 (W to E)	Granular B Type I: 2.5H:1V Granular B Type II: 2.25H:1V
3	Highway 9 EBL STA 19+635 to 19+825	S	6 to 8 (W to E)	Granular B Type I: 2.5H:1V Granular B Type II: 2.25H:1V
4	Highway 9 WBL STA 19+630 to 19+765	N	6 to 8 (W to E)	Granular B Type I: 2.25H:1V Granular B Type II: 2.25H:1V
5	Highway 9 WBL STA 22+568 to 22+595	N	5	Granular B Type I: 2.5H:1V Granular B Type II: 2.25H:1V
6	Highway 9 EBL STA 23+370 to 23+503	S	5 to 7 (W to E)	Granular B Type I: 2.25H:1V Granular B Type II: 2.25H:1V
7	Highway 9 WBL STA 23+363 to 23+530	N	5 to 7 (W to E)	Granular B Type I: 2.5H:1V Granular B Type II: 2.25H:1V
8	Highway 9 WBL STA 23+890 to 23+937	N	5	Rock Fill, Replace 2 m of existing embankment side slope with Rock Fill + 2 m of widening + Sub excavate to Elev. 342 m under widening and replacement with rockfill (1.5H:1V) Consider utilizing reinforced earth slope designed at 1.5H:1V
9	Highway 9 EBL STA 24+130 to 24+205	S	4.5 to 6 (W to E)	Granular B Type II, with subexcavation of organic soils, replaced with Granular B Type II. Excavations extend 1.5 m below existing ground surface at embankment toe and 5 m beyond the toe of the proposed embankment toe (2H:1V)

9.1 Widening Areas 1 (STA 19+136 to 19+213) and 2 (STA 19+140 to 19+235)

The results of stability and settlement analyses for the approximately 3.5 m to 5 m high widened Highway 9 embankment carried out of the critical section (STA 19+175) are presented in the tables below.



Location	Embank. Fill	Side	Slope Inclination	Long Term / Permanent Factor of Safety	Figure No.
STA 19+175 (Widening Area 1)	Granular Borrow (Gran. B Type I)	South	2H:1V	1.3	H1
			2.25H:1V	1.4	H2
			2.5H:1V	1.6	H3
	Gran. B Type II		2H:1V	1.4	H4
			2.25H:1V	1.5	H5
STA 19+175 (Widening Area 2)	Granular Borrow (Gran. B Type I)	North	2H:1V	1.3	H6
			2.25H:1V	1.4	H7
			2.5H:1V	1.6	H8
	Gran. B Type II		2H:1V	1.3	H9
			2.25H:1V	1.5	H10

Fill Type of Widening	Scenario	Unit Weight (kN/m ³)	Total Settlement of Foundation Soils
OPSS Granular B Type II	3 m widening with up to 2.25H:1V side slope to the north and south	22	Up to 50 mm
Granular Borrow (Gran. B Type I)	3 m widening with up to 2.5H:1V side slope to the north and south	22	Up to 50 mm

The stability analyses indicate the computed factors of safety meet the requirements of Table 6.2 of Section 6.9.1 of the CHBDC for the following conditions:

Location	Embankment Fill	Recommended Slope Inclination
STA 19+175 (Widening Area 1)	Granular Borrow (Gran. B Type I)	2.5H:1V
	Gran. B Type II	2.25H:1V
STA 19+175 (Widening Area 2)	Granular Borrow (Gran. B Type I)	2.5H:1V
	Gran. B Type II	2.25H:1V

It is estimated that most of the foundation settlement at Areas 1 and 2 will have occurred by construction completion. It is recommended road paving at Areas 1 and 2 after completion of all other sites (except Area 4). Considering that the estimated post-construction settlement for both



fill options is less than 75 mm over a 15-year design life, settlement mitigation measures are not required along this proposed embankment widening section.

The magnitude of the self-compression for the widened embankments constructed with Granular B Type I or II is in the order of 0.5% of the newly placed embankment height and is expected to predominantly occur during fill placement.

9.1.1 Subexcavation Requirements

Based on the subsurface information encountered in the boreholes advanced during the field investigation, soils containing organics were encountered at Area 1 and are summarized below.

Embankment Area Widening Reference	Limits of Fill Area (Project Chainage)	Evidence of Organics in Soils Encountered in AR-series boreholes	Subexcavation Requirements Under Widening Footprint/ Thickness of Organic Materials, m
1	19+136 to 19+213	Topsoil / organics encountered at hand-dug holes at toe of the embankment up to 610 mm	Up to 610 mm
2	19+140 to 19+235	-	-

Subexcavation of organics below the embankment widening footprint must be done in short, 5 m long sections and backfilled with granular promptly so as to not adversely impact the stability of the existing highway embankment. A Special Provision is included in Appendix I. Subexcavation and replacement of organic soils found must extend at least 610 mm below existing ground surface at embankment toe and 5 m beyond the toe of the proposed embankment toe.

9.2 Widening Areas 3 (STA 19+635 to 19+825) and 4 (STA 19+630 to 19+765)

The results of stability and settlement analyses for the approximately 6 m to 8 m high widened Highway 9 embankment carried out of the critical section (STA 19+700) are presented in the tables below.



Location	Embank. Fill	Side	Slope Inclination	Long Term / Permanent Factor of Safety	Figure No.
STA 19+700 (Widening Area 3)	Granular Borrow (Gran. B Type I)	South	2H:1V	1.3	H11
			2.25H:1V	1.4	H12
			2.5H:1V	1.6	H13
	Gran. B Type II		2H:1V	1.3	H14
			2.25H:1V	1.5	H15
STA 19+700 (Widening Area 4)	Granular Borrow (Gran. B Type I)	North	2H:1V	1.3	H16
			2.25H:1V	1.5	H17
	Gran. B Type II		2H:1V	1.4	H18
			2.25H:1V	1.5	H19

Fill Type of Widening	Scenario (Long-Term/Permanent)	Unit Weight (kN/m ³)	Settlement of Foundation Soils
OPSS Granular B Type II	4 m total widening with 2.25H:1V side slope to the south and 2.25H:1V side slope to the north	22	Up to 55 mm
Granular Borrow (Gran. B Type I)	4 m total widening with 2.5H:1V side slope to the south and 2.25H:1V side slope to the north	22	Up to 55 mm

The stability analyses indicate the computed factors of safety meet the requirements of Table 6.2 of Section 6.9.1 of the CHBDC for the following:

Location	Embankment Fill	Recommended Slope Inclination
STA 19+700 (Widening Area 3)	Granular Borrow (Gran. B Type I)	2.5H:1V
	Gran. B Type II	2.25H:1V
STA 19+700 (Widening Area 4)	Granular Borrow (Gran. B Type I)	2.25H:1V
	Gran. B Type II	2.25H:1V

It is estimated that most of the foundation settlement at Area 3 will have occurred by construction completion. It is recommended to pave Area 4 after completion of all other sites (except Areas 1 and 2). Considering that the estimated post-construction settlement for both fill

options is less than 75 mm over a 15-year design life, settlement mitigation measures are not required along this proposed embankment widening section.

The magnitude of the self-compression for the widened embankments constructed with Granular B Type I or II is in the order of 0.5% of the newly placed embankment height and is expected to predominantly occur during fill placement.

9.3 Widening Area 5 (STA 22+568 to 22+595)

The results of stability and settlement analyses for the approximately 5 m high widened Highway 9 embankment carried out of the critical section (STA 22+575) are presented in the tables below.

Location	Embank. Fill	Side	Slope Inclination	Long Term / Permanent Factor of Safety	Figure No.
STA 22+575 (Widening Area 5)	Granular Borrow (Gran. B Type I)	North	2H:1V	1.3	H20
			2.25H:1V	1.4	H21
			2.5H:1V	1.6	H22
	Gran. B Type II		2H:1V	1.4	H23
			2.25H:1V	1.5	H24

Fill Type of Widening	Scenario (Long-Term/Permanent)	Unit Weight (kN/m ³)	Settlement of Foundation Soils
OPSS Granular B Type II	4 m total widening with 2.5H:1V side slope to the north	22	Up to 35 mm
Granular Borrow (Gran. B Type I)	4 m total widening with 2.5H:1V side slope to the north	22	Up to 35 mm

The stability analyses indicate the computed factors of safety meet the requirements of Table 6.2 of Section 6.9.1 of the CHBDC for the following:

Location	Embankment Fill	Recommended Slope Inclination
STA 22+575 (Widening Area 5)	Granular Borrow (Gran. B Type I)	2.5H:1V
	Gran. B Type II	2.25H:1V

It is estimated that most of the foundation settlement at Area 5 will have occurred by



construction completion. Considering that the estimated post-construction settlement for both fill options is less than 75 mm over a 15-year design life, settlement mitigation measures are not required along this proposed embankment widening section.

The magnitude of the self-compression for the widened embankments constructed with Granular B Type I or II is in the order of 0.5% of the newly placed embankment height and is expected to predominantly occur during fill placement.

9.4 Widening Areas 6 (STA 23+370 to 23+503) and 7 (STA 23+363 to 23+530)

The results of stability and settlement analyses for the approximately 5 m to 7 m high widened Highway 9 embankment carried out of the critical section (STA 23+450) are presented in the tables below.

Location	Embank. Fill	Side	Slope Inclination	Long Term / Permanent Factor of Safety	Figure No.
STA 23+450 (Widening Area 6)	Granular Borrow (Gran. B Type I)	South	2H:1V	1.3	H25
			2.25H:1V	1.5	H26
	Gran. B Type II		2H:1V	1.4	H27
			2.25H:1V	1.5	H28
STA 23+450 (Widening Area 7)	Granular Borrow (Gran. B Type I)	North	2H:1V	1.3	H29
			2.25H:1V	1.4	H30
			2.5H:1V	1.6	H31
	Gran. B Type II		2H:1V	1.4	H32
			2.25H:1V	1.6	H33

Fill Type of Widening	Scenario (Long-Term/Permanent)	Unit Weight (kN/m ³)	Settlement of Foundation Soils
OPSS Granular B Type II	4 m total widening with 2.5H:1V side slope to the north	22	Up to 15 mm
Granular Borrow (Gran. B Type I)	4 m total widening with 2.5H:1V side slope to the north	22	Up to 15 mm

The stability analyses indicate the computed factors of safety meet the requirements of Table 6.2 of Section 6.9.1 of the CHBDC for the following:

Location	Embankment Fill	Recommended Slope Inclination
STA 23+450 (Widening Area 6)	Granular Borrow (Gran. B Type I)	2.25H:1V
	Gran. B Type II	2.25H:1V
STA 23+450 (Widening Area 7)	Granular Borrow (Gran. B Type I)	2.5H:1V
	Gran. B Type II	2.25H:1V

It is estimated that most of the foundation settlement at Areas 6 and 7 will have occurred by construction completion. Considering that the estimated post-construction settlement for both fill options is less than 75 mm over a 15-year design life, settlement mitigation measures are not required along this proposed embankment widening section.

The magnitude of the self-compression for the widened embankments constructed with Granular B Type I or II is in the order of 0.5% of the newly placed embankment height and is expected to predominantly occur during fill placement.

9.5 Widening Area 8 (STA 23+890 to 23+937)

The results of stability and settlement analyses for the approximately 5 m high widened Highway 9 embankment carried out of the critical section (STA 23+900) are presented in the tables below. Given the right of way / property constraints at this location, the shallowest slope inclination with the platform widening that can be accommodated within the right of way is 1.5H:1V. Accordingly, rock fill was considered as potential borrow for widening of the highway embankment in Area 8.



Location	Embank. Fill	Side	Slope Inclination	Long Term / Permanent Factor of Safety	Figure No.
STA 23+900 (Widening Area 8)	Gran. B Type II or Gran. A	North	1.5H:1V	1.1	H34
	Rock Fill (approx. 2 m widening)		1.5H:1V	1.2	H35
	Rock Fill, Replace 1 m of existing embankment side slope with Rock Fill + 2 m of widening		1.5H:1V	1.4	H36
	Rock Fill, Replace 2 m of existing embankment side slope with Rock Fill + 2 m of widening		1.5H:1V	1.4	H37
	Rock Fill, Replace 2 m of existing embankment side slope with Rock Fill + 2 m of widening + Sub excavate to Elev. 342 m under widening and replacement with rock fill		1.5H:1V	1.5	H38

Fill Type of Widening	Scenario (Long-Term/Permanent)	Unit Weight (kN/m ³)	Settlement of Foundation Soils
OPSS Granular B Type II	2.8 m total widening with up to 2H:1V side slope to the north	22	Up to 45 mm
Rock Fill	2.8 m total widening with up to 1.5H:1V side slope to the north	19	Up to 25 mm

The stability analyses indicate the computed factors of safety meet the requirements of Table 6.2 of Section 6.9.1 of the CHBDC for the following:

Location	Embankment Fill	Recommended Slope Inclination
STA 23+900 (Widening Area 8)	Rock Fill, Replace 2 m of existing embankment side slope with Rock Fill + 2 m of widening + Sub excavate to Elev. 342 m under widening and replacement with rock fill	1.5H:1V

The specification for rockfill borrow is provided in Section 8.2. Placement and compaction specification of rockfill is also presented in Section 8.2. It is estimated that most of the foundation soils settlement at Area 8 will have occurred by construction completion. Considering that the estimated post-construction settlement for the rock fill option is less than 75 mm over a 15-year design life, settlement mitigation measures are not required along this proposed embankment widening section.

An alternative to widening the embankment in Area 8 with rock fill, consideration may be given to widening the highway embankment using a reinforced earth slope inclined at 1.5H:1V. The

reinforced earth slopes are proprietary designs provided by a number of suppliers on MTO's DSM List such as Terrafix Geosynthetics Inc., Armtec Inc., or Layfield Canada Ltd. And others who are usually retained by the construction contractor. Once a proprietary design is available, the global stability of the slope design must be checked by Thurber.

9.5.1 Settlement of Rock Fill

If rock fill is used for the construction of the proposed widening at widening Area 8, there will be settlement due to compression of the rock fill itself under self-weight, in addition to the underlying foundations soils described. The magnitude of settlement of the rock fill depends on the type of rock / strength of rock particles, size and shape of rock particles, gradation of rock fill, total height or thickness of rock fill (i.e. stress level), and method of construction.

The settlement of rock fill occurs due to re-arrangement of rock particles under load and wetting and as a result of local crushing of the rock particles where in contact. The magnitude of short and long term post-construction settlement of the rock fill is a function of the height or thickness of the fill as well as the method in which the rock fill was placed (i.e. compacted vs dumped rock fill) as outlined in "MTO Guideline for Rockfill Settlement and Rock Fill Quantity Estimates," dated September 2010.

Rock Fill should be placed, where possible, in a controlled manner (i.e. not end dumped) in accordance with OPSS.PROV 206 (Grading). Blading, dozing, compacting, and 'chinking' the rock fill to form a dense, compact mass is required to minimize voids, bridging, and to reduce settlement. Post-construction settlements are greater where rock fill cannot be placed in a controlled manner (i.e. below the groundwater table).

Settlements of the rock fill (assuming up to 3.0 m of rock fill placed above existing embankment fill) are estimated to be 15 mm to 30 mm short term, depending on placement method, and up to 10 mm long term.

9.6 Widening Area 9 (STA 24+130 to 24+205)

The results of stability and settlement analyses for the approximately 4.5 m to 6 m high widened Highway 9 embankment carried out of the critical section (STA 24+150) are presented in the tables below.



Location	Embank. Fill	Side	Slope Inclination	Long Term / Permanent Factor of Safety	Figure No.
STA 24+150 (Widening Area 9)	Granular Borrow (Gran. B Type I) ¹	South	2H:1V	1.3	H39
			2.25H:1V	1.5	H40
	Gran. B Type II ¹		2H:1V	1.6	H41

Note:

1. Embankment fill widening includes subexcavation of organic soils, replaced with Granular B Type II. Excavations extend 1.5 m below existing ground surface at embankment toe and 5 m beyond the toe of the proposed embankment toe.

Fill Type of Widening	Scenario (Long-Term/Permanent)	Unit Weight (kN/m ³)	Settlement of Foundation Soils
OPSS Granular B Type II	5.4 m total widening with up to 1.5H:1V side slope to the north	22	Up to 40 mm
Granular Borrow (Gran. B Type I)	5.4 m total widening with up to 2.25H:1V side slope to the north	22	Up to 40 mm

The stability analyses indicate the computed factors of safety meet the requirements of Table 6.2 of Section 6.9.1 of the CHBDC for the following:

Location	Embankment Fill	Steepest Slope Inclination
STA 24+150 (Widening Area 9)	Granular Borrow (Gran. B Type I) (subexcavation of organic soils, replaced with Granular B Type II. Excavations extend 1.5 m below existing ground surface at embankment toe and 5 m beyond the toe of the proposed embankment toe)	2.25H:1V
	Gran. B Type II (subexcavation of organic soils, replaced with Granular B Type II. Excavations extend 1.5 m below existing ground surface at embankment toe and 5 m beyond the toe of the proposed embankment toe)	2H:1V

It is estimated that most of the foundation settlement at Area 9 will have occurred by construction completion. Considering that the estimated post-construction settlement for both fill options is less than 75 mm over a 15-year design life, settlement mitigation measures are not required along this proposed embankment widening section.

The magnitude of the self-compression for the widened embankments constructed with Granular B Type I or II is in the order of 0.5% of the newly placed embankment height and is expected to predominantly occur during fill placement.

9.6.1 Subexcavation Requirements

Based on the subsurface information encountered in the boreholes advanced during the field investigation, soils containing organics were encountered at Area 9 and are summarized below.

Embankment Area Widening Reference	Limits of Fill Area (Project Chainage)	Evidence of Organics in Soils Encountered in AR-series boreholes	Subexcavation Requirements Under Widening Footprint/ Thickness of Organic Materials, m
9	24+130 to 24+205	Silt to Clayey Silt Embankment Fill encountered in Boreholes AR09-01 and AR09-02. Wood pieces recovered in samples from this layer and high moisture contents measured.	1.5

Subexcavation of organics below the embankment widening footprint must be done in short, 5 m long sections and backfilled with Granular B Type II and compacted promptly so as to not adversely impact the stability of the existing highway embankment. A Special Provision is included in Appendix I. Subexcavation and replacement of organic soils found must extend at least 1.5 m below existing ground surface at embankment toe and 5 m beyond the toe of the proposed embankment toe.

10. SUBGRADE PREPARATION AND EMBANKMENT CONSTRUCTION

The following sections discuss general aspects of subgrade preparation and embankment construction for the Highway 9 platform widening areas, including: removal of surficial and near surface organic materials; groundwater control; and placement of new embankment fills.

10.1 Temporary Excavations and Removal of Organic Soils

Based on the subsurface information encountered in the boreholes advanced during the field investigation, soils containing organics were encountered at several widening areas and are summarized in the recommendations for the relevant Embankment widening areas, in Sections 9.

Subexcavation of organics must be done in short, 5 m long sections and backfilled with Granular B Type II and compacted promptly so as to not adversely impact the stability of the existing highway embankment. A Special Provision is included in Appendix I.

A low-lying area was observed to be present along the Fill Area No. 9 – that is, at the toe of the existing highway embankment. Low-lying/swampy environments are generally indicators of the presence of organic deposits (e.g., peat, loam, organic silts). Probeholes were advanced at the toe of existing highway embankment in the vicinity of the marsh at Fill Area No. 9 where approximately 0.8 m of fibrous/organic silt was encountered. Embankment fill widening at this location includes subexcavation up to 1.5 m of organic soils, replaced with Granular B Type II.

Consequently, all surficial and near surface topsoil and organic deposits up to 600 mm in thickness encountered during construction within the proposed high fill embankment platform widening Areas 1 to 8 should be fully sub-excavated from the plan limits of the proposed works and replaced with well compacted Granular B Type II fill.

All organic materials within the footprint of the widenings shall be removed using construction procedures in accordance with OPSS.PROV 209 (*Embankments Over Swamps and Compressible Soils*). Furthermore, all excavation operations carried out adjacent to the existing highway embankment should be carried out in accordance with OPSS.PROV 206 (*Grading*), and in particular, Clause 206.07.03.03 (*Excavation for Widening*). The clause stipulates that the excavation operation shall at no time be in advance of the backfilling operation by a distance greater than the limits as specified in the Contract Documents. A Non-Standard Special Provision (NSSP) has been prepared to address subexcavation and is provided in Appendix I. Furthermore, the clause stipulates that excavation shall be backfilled prior to closing down operations each day.

All excavations must be carried out in accordance with Ontario Regulation 213, *Ontario Occupational Health and Safety Act for Construction Projects* (as amended). If workers are required to enter temporary excavations, the organic deposits are classified as Type 4 soils, and any temporary excavations must be sloped at 3H:1V or flatter.

In addition, provisions for traffic control measures should be included in the Contract Documents to maintain the safe operation of Highway 9.

10.2 Control of Groundwater and Surface Water

Excavation within the plan limits of the proposed widening work will be required to sub-excavate surficial organics prior to embankment fill placement, which will likely extend below the groundwater level at the embankment widening areas. Groundwater flow / seepage into the



excavations will occur due to the presence of generally permeable deposits and relatively high groundwater levels observed at the fill areas. Dewatering may be required for the excavation and backfilling in the proposed embankment widening areas, as all fill material must be placed in the dry.. The Contractor is to design the dewatering for each site. Surface water should be directed away from the excavations at all times.

10.3 Embankment Fill Placement

Placement of granular fill (satisfying OPSS.PROV 1010 Granular 'A' or 'B' Type II requirements) above the water table for construction of the Highway 9 platform embankment widening areas should be carried out in accordance with the requirements as outlined in OPSS.PROV 206 (*Grading*).

Side slopes for granular fill and earth borrow fill embankments should be no steeper than the side slopes recommended for each widening area in Section 9. Mid-height berms comprising 2 m wide benches should be incorporated along the length of embankments with heights exceeding 8 m in earth fill and 10 m in rock fill. Where the embankment is constructed of earth fill, the bench should maintain a 2 per cent slope to shed surface run-off.

New granular fill or rock fill placed on the side slopes of the existing embankment shall be keyed into the existing embankment fill by benching in accordance with OPSD 208.010 (*Benching of Earth Slopes*). Considering the presence of cobbles encountered within the existing highway embankment fill, it is noted that it may be challenging to carry out the benching requirements, but the contractor must make all efforts to bench the slopes in accordance with OPSD 208.010. Further, any vegetation / organics and loose soils/fills present along the face of the existing embankment side slopes should be stripped and all attempts should be made to carry out the required benching. All granular fill material must be compacted to a minimum of 100% of Standard Maximum Dry Density as per OPSS.PROV 501.

10.4 Erosion Protection

If granular material is used along the Highway 9 platform embankment widening areas, the slopes should be vegetated as soon as practicable after construction to minimize the potential for erosion due to surface water run-off/ snow melt, either by placement of topsoil in accordance with OPSS.PROV 802 (*Topsoil*) and seeding in accordance with OPSS.PROV 804 (*Temporary Erosion Control*) or pegged sod in accordance with OPSS.PROV 803 (*Vegetative Cover*).

If vegetation protection is not in place before the winter season, an alternate protection, such as covering the slopes with granular sheeting or temporary erosion control blankets, is



recommended to reduce the potential for remedial works required on the side slopes in the spring season prior to topsoil and seeding.

11. CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- Consideration will have to be given to the proximity of nearby overhead utility lines and special attention will need to be accounted for during construction to avoid any damage to the utilities.
- The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing soils to support the proposed construction equipment and supplies.



THURBER ENGINEERING LTD.

12. CLOSURE

Engineering analyses were carried out by Ms. Alysha Kobylinski, P.Eng. and Mr. Keli Shi, P.Eng. Preparation of the foundation design report was carried out by Ms. Alysha Kobylinski, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.
Report Prepared By:



Alysha Kobylinski, P.Eng.
Geotechnical Engineer



P.K. Chatterji, Ph.D., P.Eng.
Designated Principal Contact
Senior Geotechnical Engineer

REFERENCES

- Amec Foster Wheeler. December 11, 2017. *Assignment #3 – Part B MTO West Region Retainer 3015-E-0022 GWP 3076-14-00 Hwy 9 Mildmay East Limit to Clifford West Limit*
- Canadian Geotechnical Society. 2006. *Canadian Foundation Engineering Manual* (CFEM), 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.
- Canadian Standard Association (CSA) Group. *Canadian Highway Bridge Design Code* (CHBDC (2019)) and *Commentary on CAN/CSA-S6-19*.
- Chapman, L.J. and Putnam, D.F. 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.
- Ministry of Transportation, Ontario. July 2, 2010. *Embankment Settlement Criteria for Design*.
- Ministry of Transportation, Ontario. September 14, 2010. *Rockfill Settlement and Rock Fill Quantity Estimates*
- Ontario Geological Survey 2011. 1:250 000 scale *Bedrock Geology of Ontario*; Ontario Geological Survey, Miscellaneous Release---Data 126-Revision 1.

Commercial Software:

Settle3 (Version 5.0) by Rocscience Inc.

Slide (Version 9.0) by Rocscience Inc.

Ontario Regulations:

- O. Reg. 213 Construction Projects (as amended)
- O. Reg. 903 Wells (as amended)

Ontario Provincial Standard Specifications (OPSS)

- OPSS.PROV 206 Construction Specification for Grading
- OPSS.PROV 209 Embankments over Swamps and Compressible Soils
- OPSS.PROV 501 Construction Specification for Compacting
- OPSS.PROV 802 Construction Specification for Topsoil



THURBER ENGINEERING LTD.

OPSS.PROV 803 Vegetative Cover

OPSS.PROV 804 Construction Specification for Temporary Erosion Control

OPSS.PROV 1010 Material Specification for Aggregates – Base, Subbase, Select Subgrade,
and Backfill Material

Special Provision 109F57 Amendment to OPSS.PROV 903

Ontario Provincial Standard Drawings (OPSD)

OPSD 208.010 Benching of Earth Slopes

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE 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 OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer


4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			



APPENDIX A

Highway 9 Widening

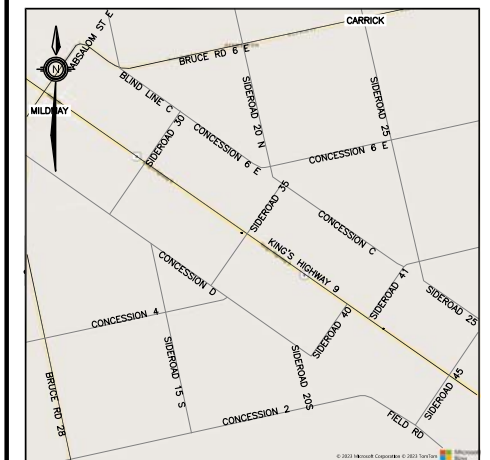
Drawing A1 Index Plan



CONT No	(
GWP No 3076-14-00	






HIGHWAY 9
MILDMAY EMBANKMENT
WIDENING
INDEX PLAN

SHEET



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 11.

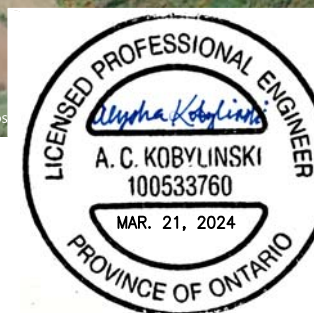
GEOCRES No. 41A03-004

REVISIONS									
	DATE	BY				DESCRIPTION			
DESIGN	AK		CHK	PKC			LOAD		DATE MAR 2024
DRAWN	AN		CHK	AK		CODE			
						SITE	STRUCT	DWG	A1

FILENAME: H:\Drafting\34000\34935\IED-34935-PLP.R.dwg
PLOTDATE: 3/20/2024 2:19 PM



© 2024 Micro



PLAN

400 0 400 800m

SCALE 1:20,000

APPENDIX B

Highway 9 Widening Area No. 1 (EBL) – STA 19+136 to STA 19+213

Highway 9 Widening Area No. 2 (WBL) – STA 19+140 to STA 19+235

Drawing B1 Borehole Location Plan and Soil Stata

Photographs B1 to B2 Site Photographs

Borehole Records AR01-01, AR01-02, AR02-01, AR02-02

Figure B1 Grain Size Distribution – Embankment Fill

Figure B2 Plasticity Chart – Embankment Fill

Figure B3 Grain Size Distribution – Silty Clay to Clayey Silt

Figure B4 Plasticity Chart – Silty Clay to Clayey Silt

Figure B5 Grain Size Distribution – Sand Interlayer

SHEET



LEGEND

[illegible]

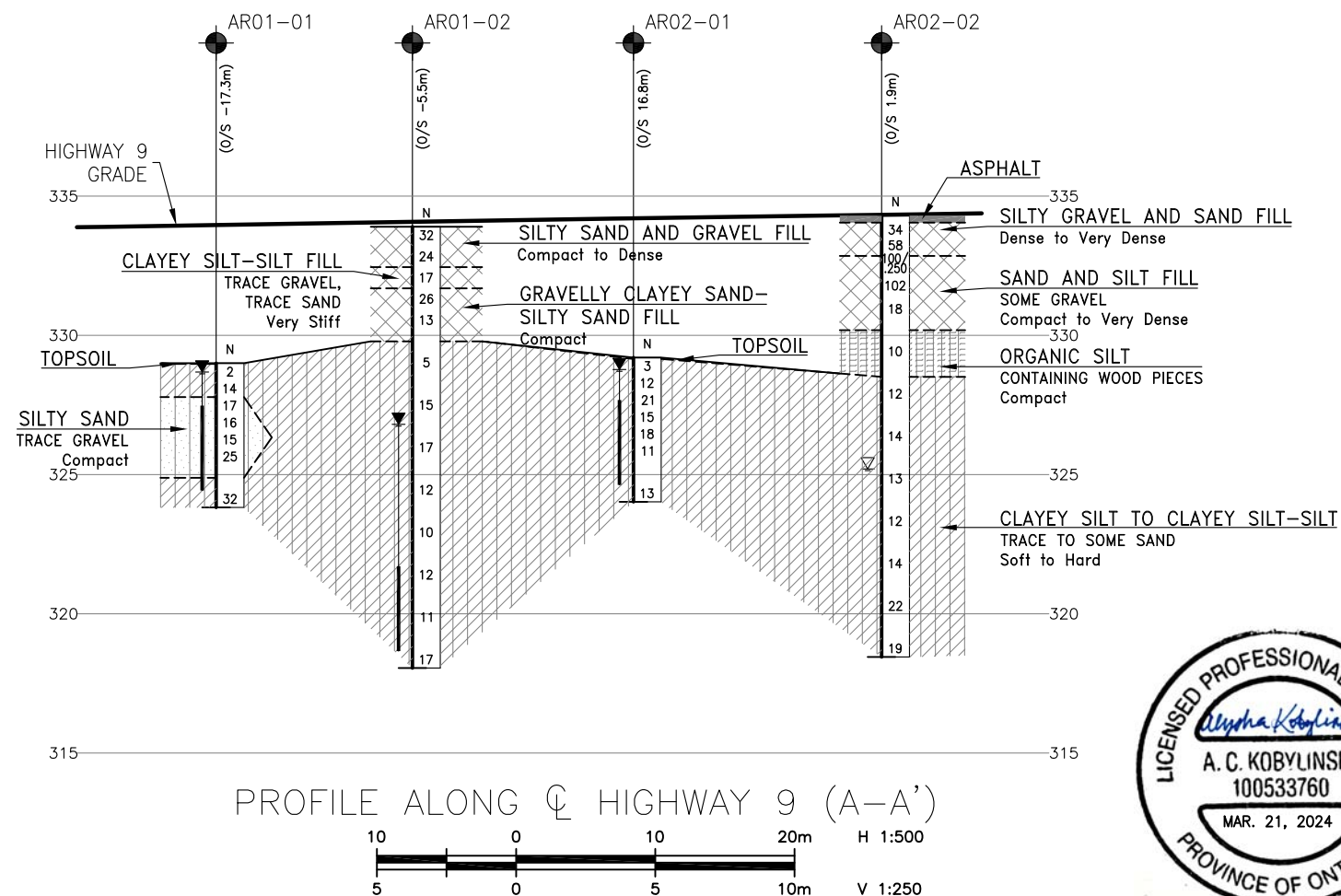
- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 11.

A circular professional seal for a Licensed Professional Engineer in the Province of Ontario. The outer ring contains the text "LICENSED PROFESSIONAL ENGINEER" at the top and "PROVINCE OF ONTARIO" at the bottom. Inside the ring, the name "A. C. Kobylinski" is written in a stylized script. Below the name, the license number "100533760" is printed. At the bottom of the seal, the expiration date "MAR. 21, 2024" is displayed.



REVISIONS									
	DATE	BY				DESCRIPTION			
DESIGN	AK		CHK	PKC			LOAD		DATE MAR 2024
DRAWN	AN		CHK	AK		CODE	STRUCT	DWG	B1

PLOTDATE: 3/20/2024 2:20 PM





THURBER ENGINEERING LTD.

PHOTOS



Photograph B1: Widening Area #1 looking west along south slope of Highway 9 embankment.





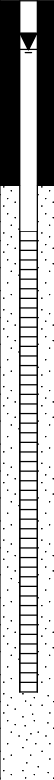



Photograph B2: Widening Area #2 looking east along north slope of Highway 9 embankment.

RECORD OF BOREHOLE No AR01-01

1 OF 1

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 878 093.6 E 416 682.2 ORIGINATED BY SG
DIST Bruce HWY 9 BOREHOLE TYPE Portable Drilling: Continuous Sampling; 75 mm diameter Tricone (N Casing) COMPILED BY AK
DATUM Geodetic DATE 2023.10.29 - 2023.10.29 LATITUDE 44.034304 LONGITUDE -81.104128 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)									
329.0	GROUND SURFACE							20	40	60	80	100		W _P	W	W _L	kN/m ³	GR	SA	SI	CL	
0.0	TOPSOIL: (25mm) Clayey SILT , some sand, containing organics Soft to Stiff Brown to Dark Brown Moist to Wet		1	SS	2										o				1	54	42	3
			2	SS	14										o							
327.8																						
1.2	Silty SAND , trace gravel Compact Brown Wet		3	SS	17										o							
			4	SS	16										o							
			5	SS	15										o							
			6	SS	25										o							
324.9																						
4.1	Clayey SILT , trace sand Hard Grey Wet		7	SS	32													0	7	75	18	
323.8																						
5.2	END OF BOREHOLE AT 5.2m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.12.01 0.7 328.3 2024.01.31 0.3 328.7																					

RECORD OF BOREHOLE No AR01-02

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 878 095.0 E 416 700.5 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers COMPILED BY AK
 DATUM Geodetic DATE 2023.09.18 - 2023.09.18 LATITUDE 44.034314 LONGITUDE -81.103900 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
333.9	GROUND SURFACE							20 40 60 80 100								
0.0	Silty SAND and GRAVEL , some silt, trace clay Compact to Dense Brown Moist (FILL)		1	SS	32											
			2	SS	24											
332.5																
1.4	Clayey SILT - SILT , trace gravel, trace sand Very Stiff Brown Moist (FILL)		3	SS	17											
331.7																
2.2	Gravelly Clayey SAND - Silty SAND Compact Brown Moist (FILL)		4	SS	26											
			5	SS	13											
329.8																
4.1	Clayey SILT , trace sand Firm to Very Stiff Brown Moist		6	SS	5											
					</											

Continued Next Page

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

RECORD OF BOREHOLE No AR01-02

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 878 095.0 E 416 700.5 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers COMPILED BY AK
 DATUM Geodetic DATE 2023.09.18 - 2023.09.18 LATITUDE 44.034314 LONGITUDE -81.103900 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page							20 40 60 80 100						
	Clayey SILT , trace sand Firm to Very Stiff Grey Wet		10	SS	10		323							
							322							
			11	SS	12		321							
							320							
			12	SS	11		319							
			13	SS	17									
318.1														
15.8	END OF BOREHOLE AT 15.8m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.10.19 7.1 326.8													

ONTMT452 2020LIBRARY(MTO) - COPY.GLB MTO-34935.GPJ 2/7/24

RECORD OF BOREHOLE No AR02-01

1 OF 1

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 878 104.1 E 416 726.4 ORIGINATED BY SG
DIST Bruce HWY 9 BOREHOLE TYPE Portable Drilling: Continuous Sampling; 75 mm diameter Tricone (N Casing) COMPILED BY AK
DATUM Geodetic DATE 2023.10.29 - 2023.10.30 LATITUDE 44.034392 LONGITUDE -81.103576 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							20	40	60	80	100						
							○ UNCONFINED	+	FIELD VANE								
							● QUICK TRIAXIAL	×	LAB VANE								
329.2	GROUND SURFACE																
0.0	TOPSOIL: (50mm)																
	Clayey SILT, trace to some sand Soft to Very Stiff Brown Wet		1	SS	3												
			2	SS	12											0 16 65 19	
			3	SS	21												
			4	SS	15											0 3 72 25	
			5	SS	18												
	Grey below a depth of 3.4m		6	SS	11												
			7	SS	13												
324.0																	
5.2	END OF BOREHOLE AT 5.2m. Piezometer installation consists of 19mm diameter piezometer with a 3.05m slotted screen.																
	WATER LEVEL READINGS																
	DATE DEPTH(m) ELEV.(m)																
	2023.12.01 0.6 328.6																
	2024.01.31 0.4 328.8																

RECORD OF BOREHOLE No AR02-02

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 878 081.7 E 416 732.3 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers COMPILED BY AK
 DATUM Geodetic DATE 2023.09.19 - 2023.09.19 LATITUDE 44.034189 LONGITUDE -81.103506 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W _P	W	W _L			WATER CONTENT (%)		
334.3	GROUND SURFACE						20	40	60	80	100					GR	SA	SI	CL
0.0 334.0	ASPHALT: (250mm)						20	40	60	80	100								
0.3	Silty GRAVEL and SAND Dense to Very Dense Brown Moist (FILL)		1	SS	34														
			2	SS	58														
332.9																			
1.4	SAND and SILT, some gravel Compact to Very Dense Brown Moist (FILL)		3	SS	100/ 0.250														
			4	SS	102														
			5	SS	18														
330.2																			
4.1	Organic SILT, containing wood pieces Compact Dark Brown Moist		6	SS	10														
328.5																			
5.8	Clayey SILT to Silty CLAY, trace sand Stiff to Very Stiff Brown Moist		7	SS	12														
			8	SS	14														
			9	SS	13														
	Grey and wet below a depth of 3.4m																		

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

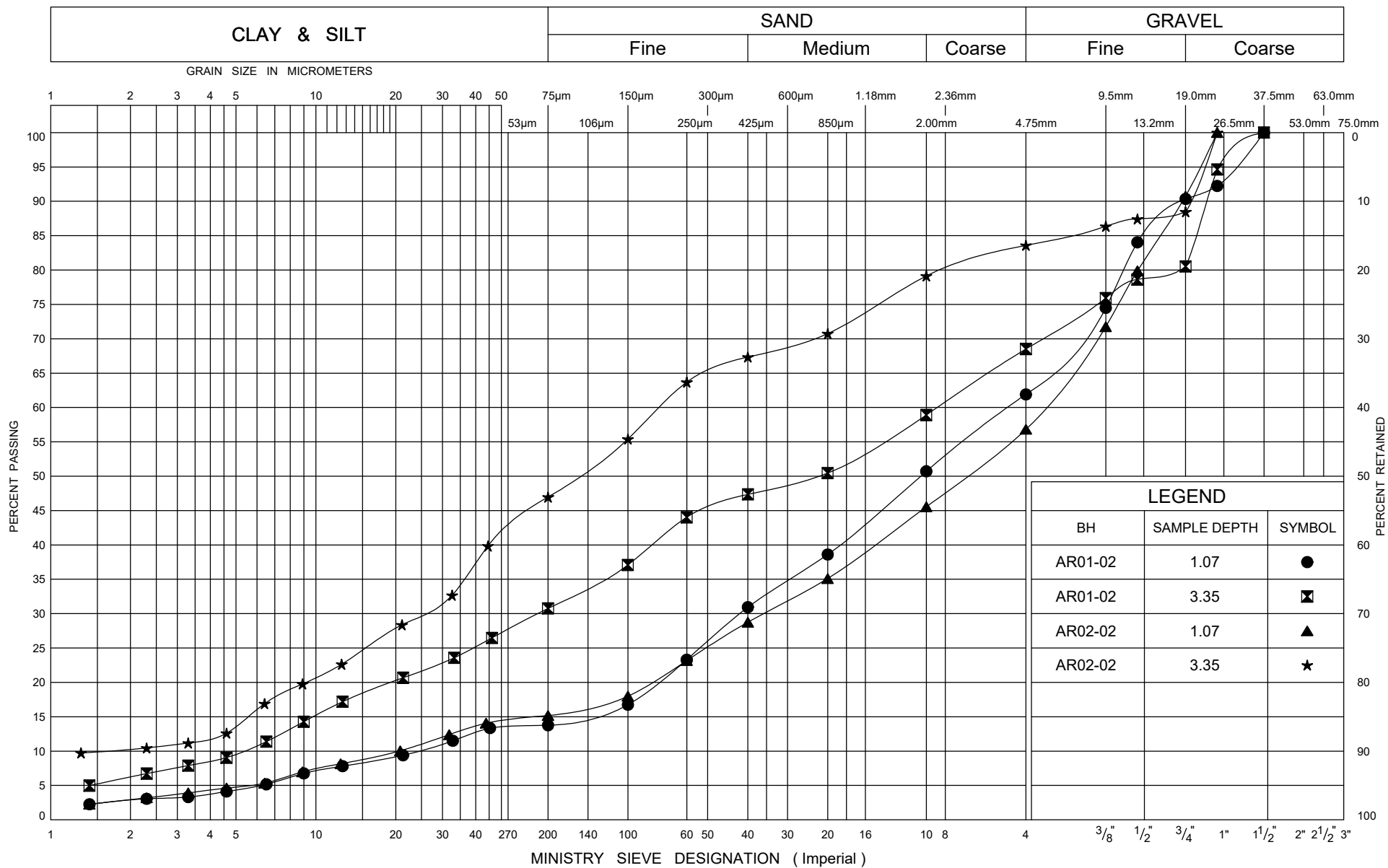
RECORD OF BOREHOLE No AR02-02

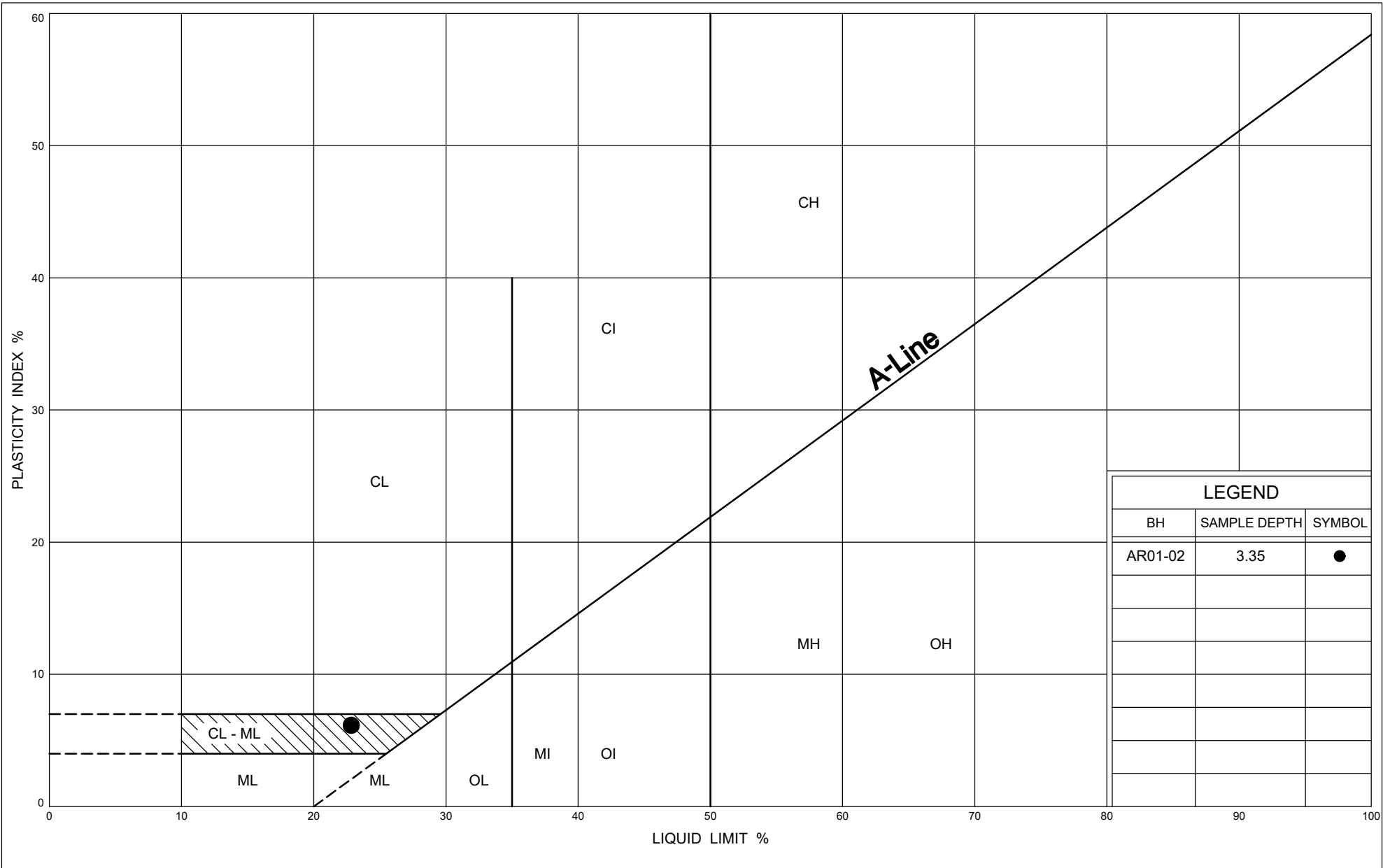
2 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 878 081.7 E 416 732.3 ORIGINATED BY SG
DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers COMPILED BY AK
DATUM Geodetic DATE 2023.09.19 - 2023.09.19 LATITUDE 44.034189 LONGITUDE -81.103506 CHECKED BY AK

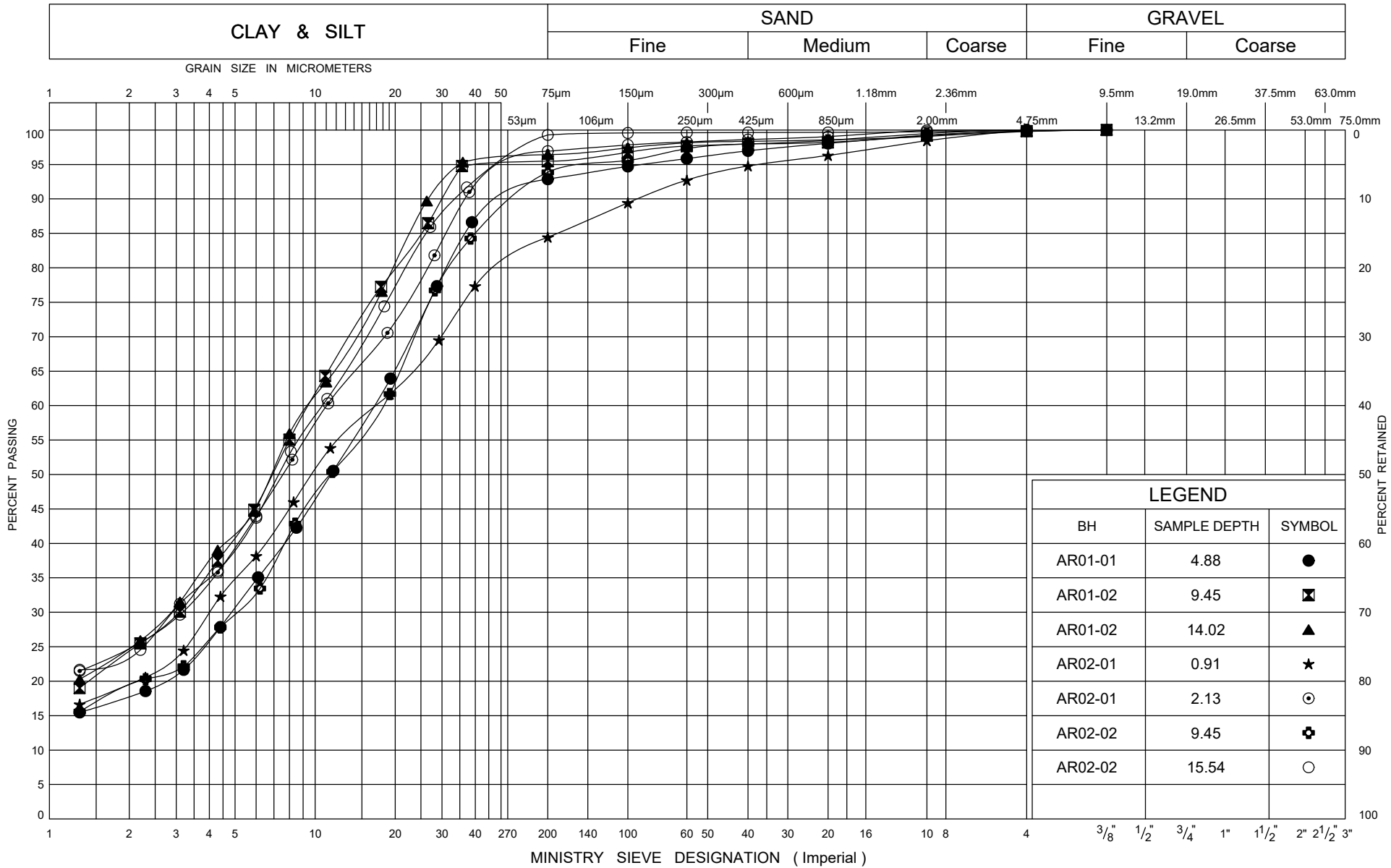
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				W _p	W	W _L		
	Continued From Previous Page															
	Clayey SILT to Silty CLAY , trace sand Stiff to Very Stiff Grey Wet		10	SS	12		324									
							323									
			11	SS	14		322									
							321									
			12	SS	22		320									
							319									
318.5			13	SS	19										0 1 75 24	
15.8	END OF BOREHOLE AT 15.8m. WATER LEVEL AT 9.1m UPON COMPLETION.															

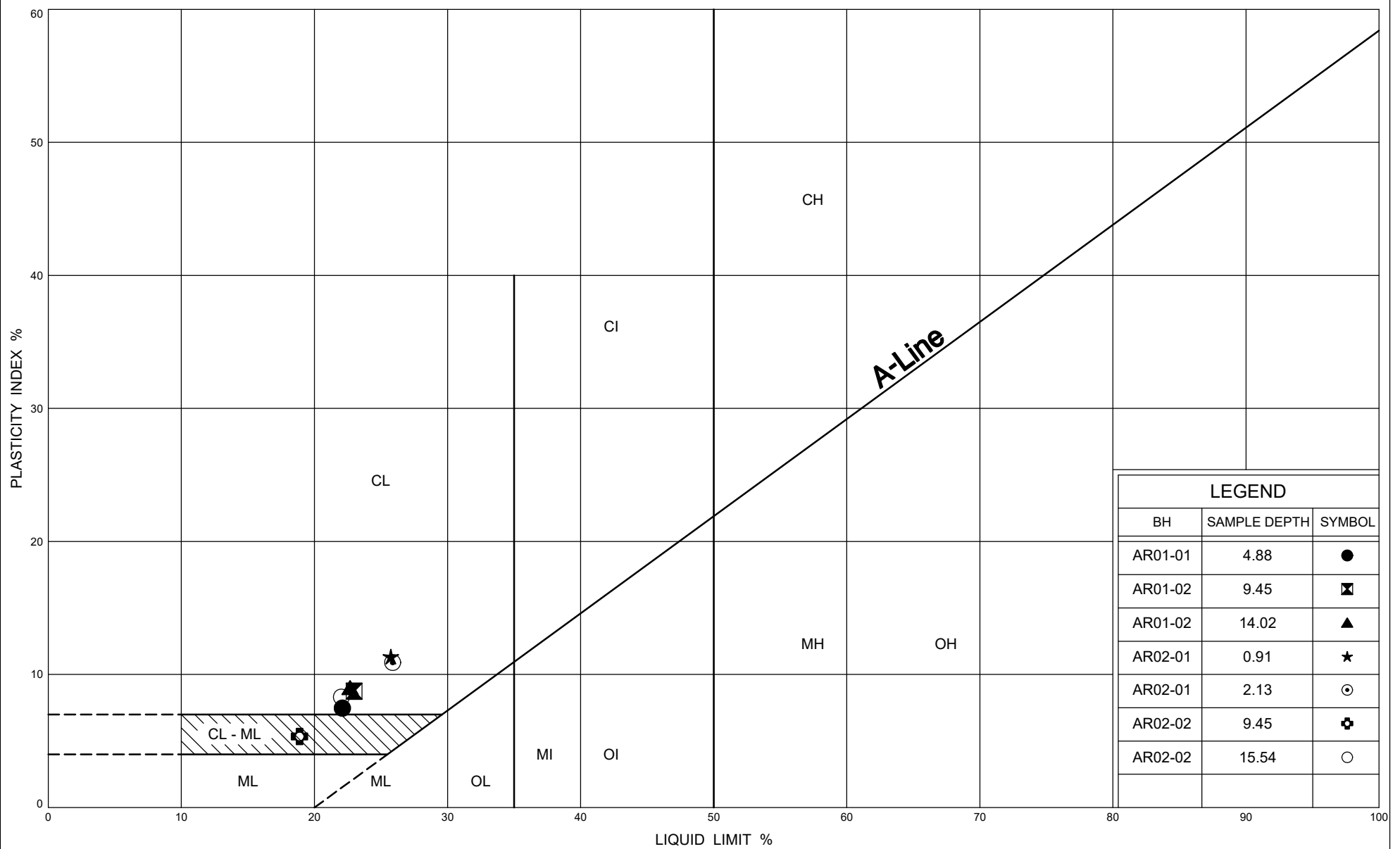




LEGEND		
BH	SAMPLE DEPTH	SYMBOL
AR01-02	3.35	●

ONTARIO MOT PLASTICITY CHART 2 MTO-34935.GPJ ONTARIO MOT.GDT 1/1/24





Ministry of
Transportation

PLASTICITY CHART

Silty CLAY to Clayey SILT

FIG No B4

GWP# 3076-14-00



FIG No B5

GWP# 3076-14-00

APPENDIX C

Highway 9 Widening Area No. 3 (EBL) – STA 19+635 to STA 19+825

Highway 9 Widening Area No. 4 (WBL) – STA 19+630 to STA 19+765

Drawing C1 Borehole Location Plan and Soil Stata

Photographs C1 to C2 Site Photographs

Borehole Records AR03-01 to AR03-03
AR04-01 to AR04-03

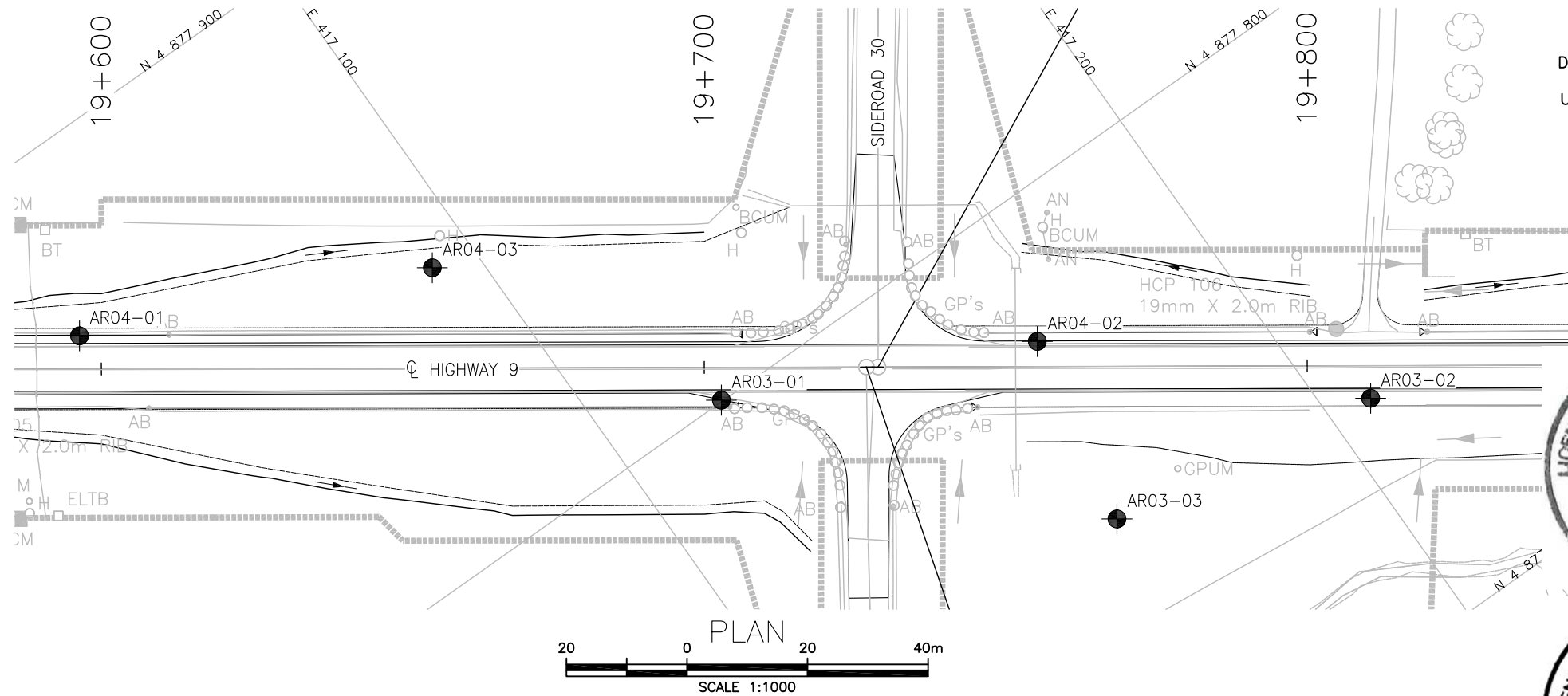
Figure C1 Grain Size Distribution – Embankment Fill

Figure C2 Grain Size Distribution – Clayey Silt-Silt to Silt of Slight Plasticity

Figure C3 Plasticity Chart – Clayey Silt-Silt to Silt of Slight Plasticity

Figure C4 Grain Size Distribution – Sand and Gravel to Silty Sand to Sandy Silt
to Gravelly Clayey Sand-Silty Sand (Till)

Figure C5 Plasticity Chart –Gravelly Clayey Sand (Till) (Fines Portion)



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

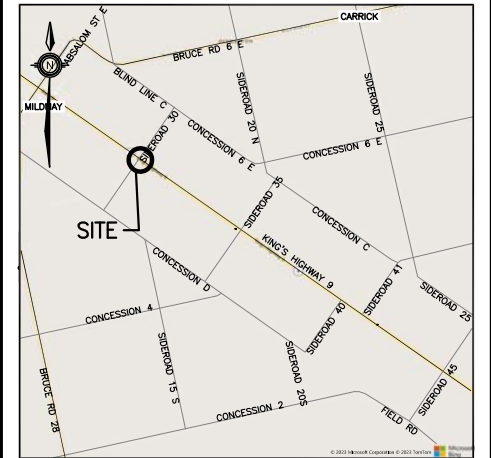


CONT No
GWP No 3076-14-00

HIGHWAY 9
WIDENING AREAS 3 AND 4
STA. 19+630 TO STA. 19+825
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

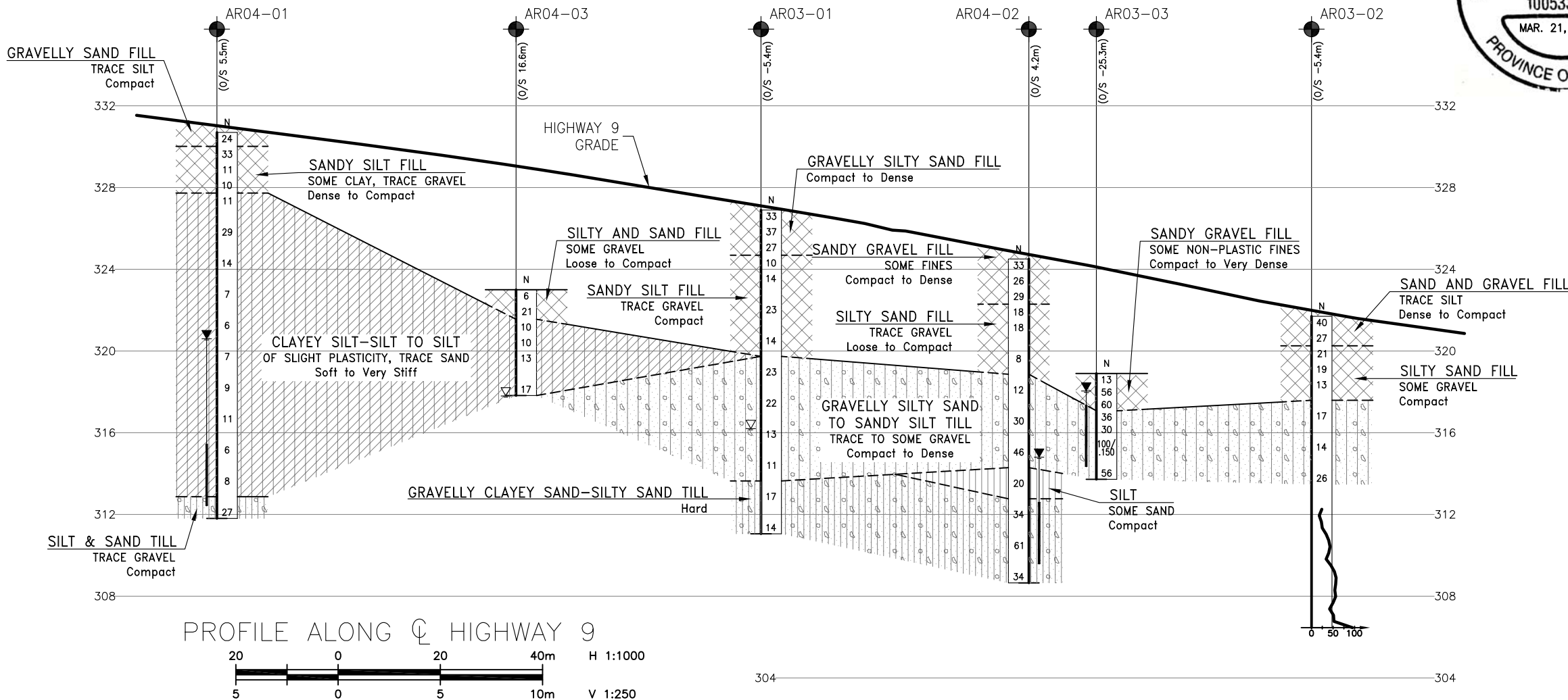
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
AR03-01	326.9	4 877 800.2	417 119.2
AR03-02	321.7	4 877 738.4	417 207.3
AR03-03	318.9	4 877 746.3	417 161.4
AR04-01	330.7	4 877 870.4	417 038.4
AR04-02	324.5	4 877 778.0	417 167.6
AR04-03	323.0	4 877 845.8	417 092.7

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 11.

GEOCRES No. 41A03-004



REVISIONS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
-----------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--



Photograph C1: Widening Area #3 looking east along south slope of Highway 9 embankment.



Photograph C2: Widening Area #4 looking west along north slope of Highway 9 embankment.

RECORD OF BOREHOLE No AR03-01

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 877 800.2 E 417 119.2 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers COMPILED BY AK
 DATUM Geodetic DATE 2023.09.20 - 2023.09.21 LATITUDE 44.031597 LONGITUDE -81.098740 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
								○ UNCONFINED		+ FIELD VANE			● QUICK TRIAXIAL					× LAB VANE
326.9	GROUND SURFACE					20	40	60	80	100	20	40	60	kN/m ³	GR	SA	SI	CL
0.0	Gravelly Silty SAND Compact to Dense Brown Moist (FILL)		1	SS	33													
				2	SS	37												
				3	SS	27												
324.7																		
2.2	Sandy SILT , some gravel Compact Brown Moist (FILL)		4	SS	10													
				5	SS	14												
			6	SS	23													
	Gravelly sand layer at a depth of 6.1m		7	SS	14													
319.7																		
7.2	Silty SAND , some gravel Compact Brown Moist (TILL)		8	SS	23													
			9	SS	22													

Continued Next Page

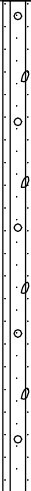



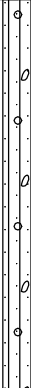


+³, ×³: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No AR03-01

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 877 800.2 E 417 119.2 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers COMPILED BY AK
 DATUM Geodetic DATE 2023.09.20 - 2023.09.21 LATITUDE 44.031597 LONGITUDE -81.098740 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL			
								20 40 60 80 100					W _P W W _L										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE															
Continued From Previous Page																							
313.6	Silty SAND , some gravel Compact Brown Moist (TILL)		10	SS	13		316												19	68	10	3	
							315																
			11	SS	11			314															
13.3	SILT and SAND , some gravel Compact Brown to Grey Wet (TILL)		12	SS	17		313																
							312																
311.1			13	SS	14																		
15.8	END OF BOREHOLE AT 15.8m. WATER LEVEL AT 10.7m UPON COMPLETION.																						



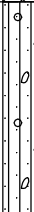

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No AR03-02

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 877 738.4 E 417 207.3 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers; Dynamic Cone Penetration Test (DCPT) COMPILED BY AK
 DATUM Geodetic DATE 2023.09.21 - 2023.09.21 LATITUDE 44.031027 LONGITUDE -81.097654 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _p w w _L					
321.7	GROUND SURFACE						20	40	60	80	100						
0.0	SAND and GRAVEL , trace silt Dense to Compact Brown Moist (FILL)		1	SS	40												
	Auger grinding from surface to a depth of 1.4m		2	SS	27												
320.3																	
1.4	Silty SAND , some gravel Compact Brown Moist (FILL)		3	SS	21												
	Auger grinding from a depth of 1.4m to 4.1m		4	SS	19												
			5	SS	13												
317.6																	
4.1	Sandy SILT , trace gravel Compact Brown Wet (TILL)		6	SS	17												
			7	SS	14												
314.5																	
7.2	Gravelly Silty SAND Compact Brown Wet (TILL)		8	SS	26												
313.5																	
8.2																	
312.6																	
9.1	End of sampling and start of Dynamic Cone Penetration Test (DCPT)																

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No AR03-02

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 877 738.4 E 417 207.3 ORIGINATED BY SG
DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers; Dynamic Cone Penetration Test (DCP) COMPILED BY AK
DATUM Geodetic DATE 2023.09.21 - 2023.09.21 LATITUDE 44.031027 LONGITUDE -81.097654 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)					
	Continued From Previous Page													
							311							
							310							
							309							
							308							
							307							
306.5														
15.2	END OF BOREHOLE AT 15.2m.													

RECORD OF BOREHOLE No AR03-03

1 OF 1

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 877 746.3 E 417 161.4 ORIGINATED BY JF
DIST Bruce HWY 9 BOREHOLE TYPE Portable Drilling; Continuous Sampling; Wash Boring (A Casing)** COMPILED BY AK
DATUM Geodetic DATE 2023.10.12 - 2023.10.12 LATITUDE 44.031105 LONGITUDE -81.098225 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
318.9	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL: (100mm)							20	40	60	80	100					
0.1	Sandy GRAVEL, some non-plastic fines Compact to Very Dense Brown to Grey Moist to Wet		1	SS	13												
			2	SS	56												
			3	SS	60												
317.1																	
1.8	SAND and GRAVEL, trace non-plastic fines Dense to very dense Brown Wet (TILL)		4	SS	36												
			5	SS	30												
			6	SS	100/ 0.150												
			7	SS	56												
313.7																	
5.2	END OF BOREHOLE AT 5.2m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.12.01 1.3 317.6 2024.01.31 0.9 318.0																

ONTMT452 2020LIBRARY(MTO) - COPY.GLB MTO-34935.GPJ 2/15/24

RECORD OF BOREHOLE No AR04-01

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 877 870.4 E 417 038.4 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers COMPILED BY AK
 DATUM Geodetic DATE 2023.09.19 - 2023.09.20 LATITUDE 44.032241 LONGITUDE -81.099733 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
330.7	GROUND SURFACE							20	40	60	80	100					
0.0	Gravelly SAND , trace silt Compact Brown Moist (FILL)		1	SS	24												
330.0																	
0.7	Sandy SILT , trace gravel Dense to Compact Brown Moist (FILL)		2	SS	33												
			3	SS	11												
			4	SS	10												
327.7																	
3.0	SILT , some gravel, trace sand Compact to Loose Brown Moist		5	SS	11												
			6	SS	29												
			7	SS	14												
			8	SS	7												
	Becoming Grey																
322.0																	
8.7	Clayey SILT - SILT , trace sand Firm to Stiff Grey Wet		9	SS	6												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No AR04-01

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 877 870.4 E 417 038.4 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers COMPILED BY AK
 DATUM Geodetic DATE 2023.09.19 - 2023.09.20 LATITUDE 44.032241 LONGITUDE -81.099733 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _P	W	W _L		
	Continued From Previous Page							20 40 60 80 100						
	Clayey SILT - SILT , trace sand Firm to Stiff Grey Wet							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
			10	SS	7		320							0 2 80 18
							319							
				11	SS	9		318						
								317						0 7 81 12
				12	SS	11		316						
								315						
				13	SS	6		314						
							313							
			14	SS	8		312							
312.9														
17.8	SILT and SAND , trace gravel Compact Grey Wet (TILL)													
			15	SS	27									9 37 48 6
311.8														
18.9	END OF BOREHOLE AT 18.9m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.10.19 10.1 320.6													

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No AR04-02 1 OF 2 METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 877 778.0 E 417 167.6 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers; 100 mm diameter Tricone Mud Rotary COMPILED BY AK
 DATUM Geodetic DATE 2023.09.28 - 2023.09.29 LATITUDE 44.031390 LONGITUDE -81.098141 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
324.5	GROUND SURFACE													
0.0	Sandy GRAVEL , some fines Compact to Dense Brown Moist (FILL)		1	SS	33									
			2	SS	26									
			3	SS	29									
322.3														
2.2	Silty SAND , trace gravel Loose to Compact Brown Moist (FILL)		4	SS	18									
			5	SS	18									
			6	SS	8									
318.9														
5.6	Silty SAND , trace gravel Compact to Dense Brown Moist (TILL)		7	SS	12									
			8	SS	30									
			9	SS	46									
	Wet below a depth of 9.1m													

Continued Next Page

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

RECORD OF BOREHOLE No AR04-02 2 OF 2 METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 877 778.0 E 417 167.6 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers; 100 mm diameter Tricone Mud Rotary COMPILED BY AK
 DATUM Geodetic DATE 2023.09.28 - 2023.09.29 LATITUDE 44.031390 LONGITUDE -81.098141 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
								WATER CONTENT (%)					
Continued From Previous Page													
314.3													
10.2	SILT of slight plasticity, some sand Compact Brown Wet		10	SS	20								0 14 77 9
312.8													
11.7	Gravelly ClayeySAND - Silty SAND Hard Brown Wet (TILL)		11	SS	34								
				12	SS	61							22 34 38 6

ONTMT452 2020LIBRARY(MTO) - COPY.GLB MTO-34935.GPJ 2/15/24

RECORD OF BOREHOLE No AR04-03

1 OF 1

METRIC

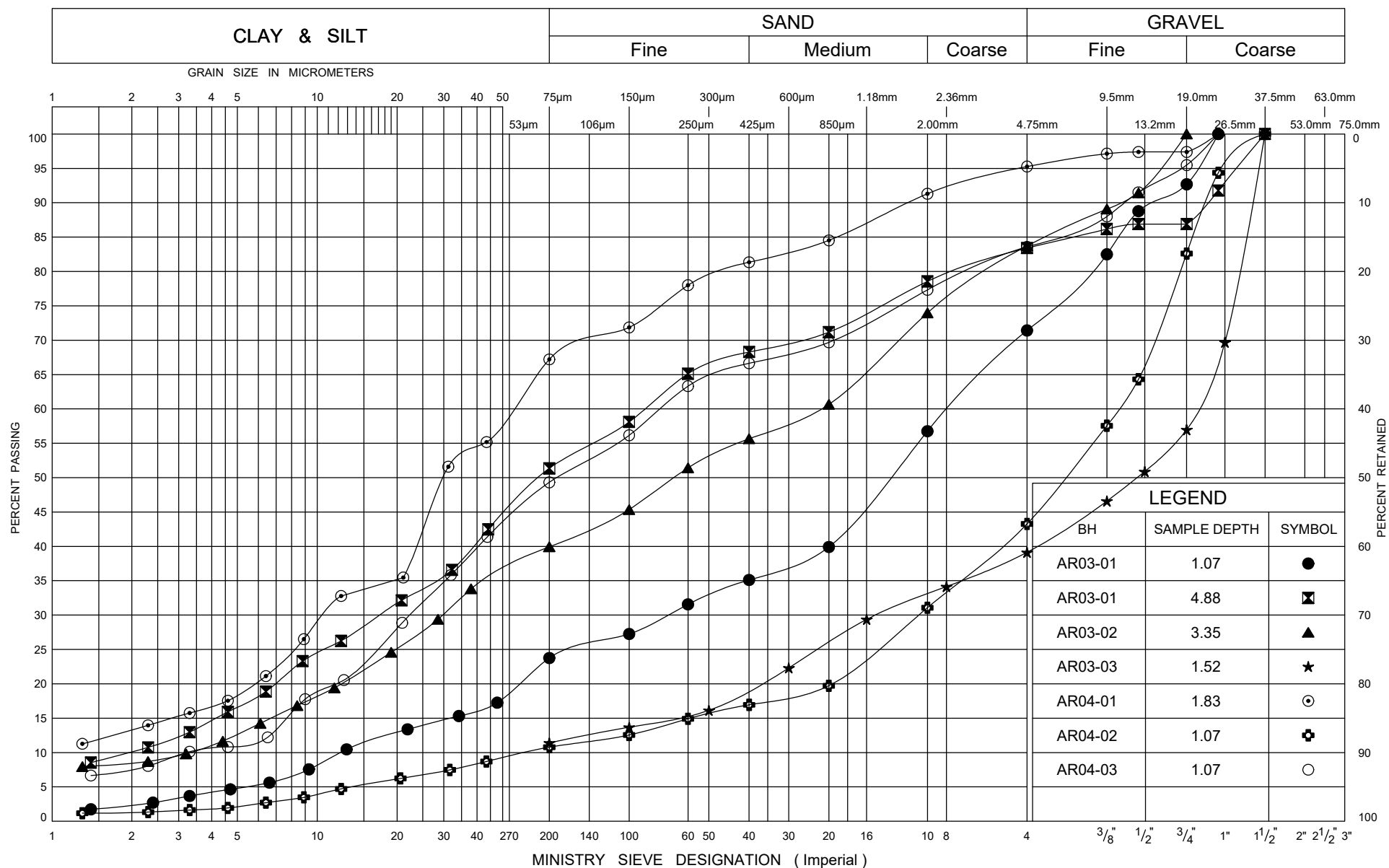
GWP# 3076-14-00 LOCATION MTM 83-11: N 4 877 845.8 E 417 092.7 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers COMPILED BY AK
 DATUM Geodetic DATE 2023.09.22 - 2023.09.22 LATITUDE 44.032012 LONGITUDE -81.099061 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
323.0	GROUND SURFACE							20	40	60	80	100						
0.8	TOPSOIL: (25mm) SILT and SAND, some gravel Loose to Compact Brown Moist (FILL)		1	SS	6													
321.6			2	SS	21		322											16 34 42 8
1.4	ClayeySILT - SILT, trace sand Stiff to Very Stiff Brown Moist		3	SS	10		321											
			4	SS	10		320											
			5	SS	13													0 4 79 17
			6	SS	17		319											
317.8							318											
5.2	END OF BOREHOLE AT 5.2m. NOTE: 1. Water level measured in open borehole at a depth of 5.2m upon completion of drilling.																	

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE



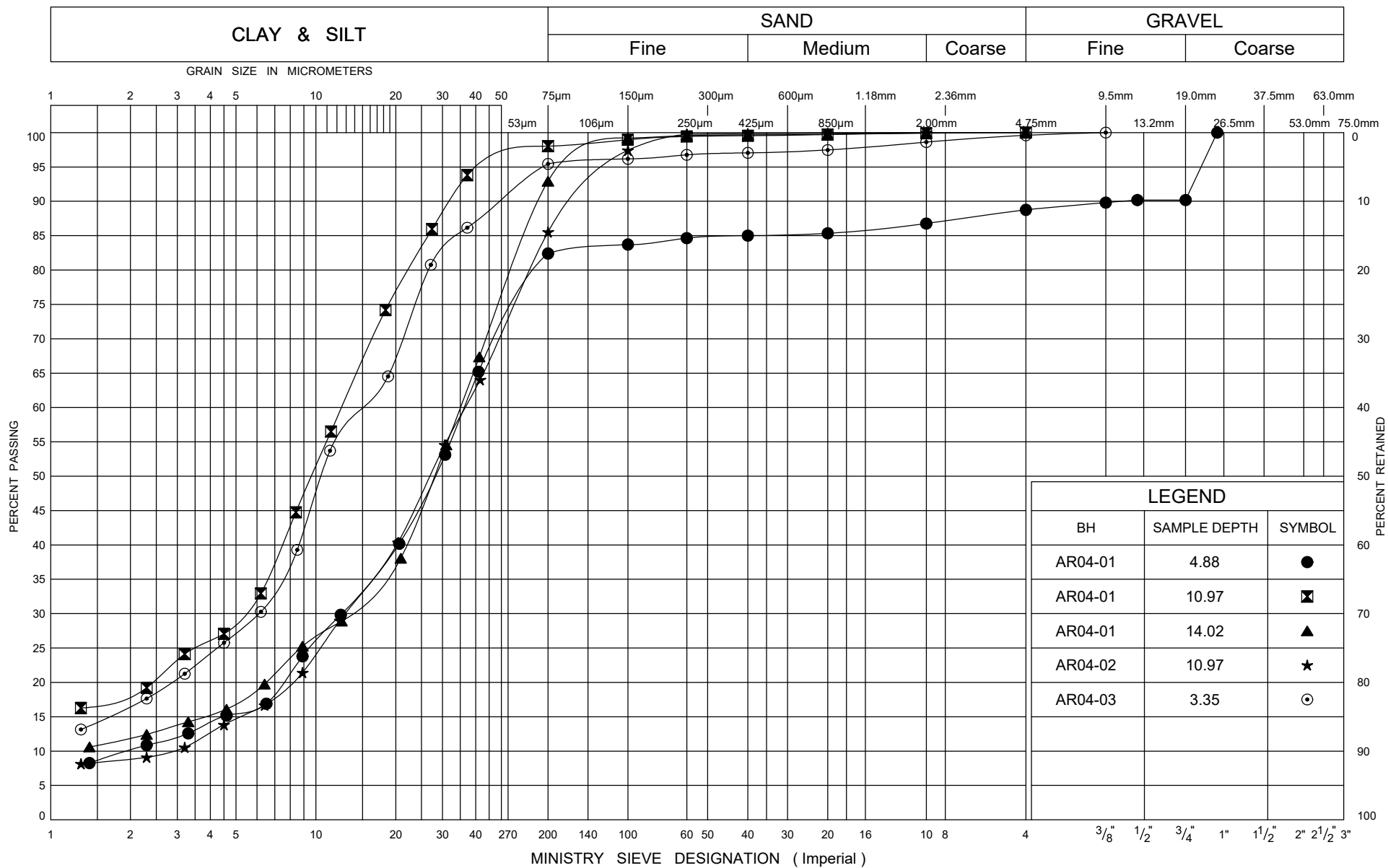
Ministry of
Transportation

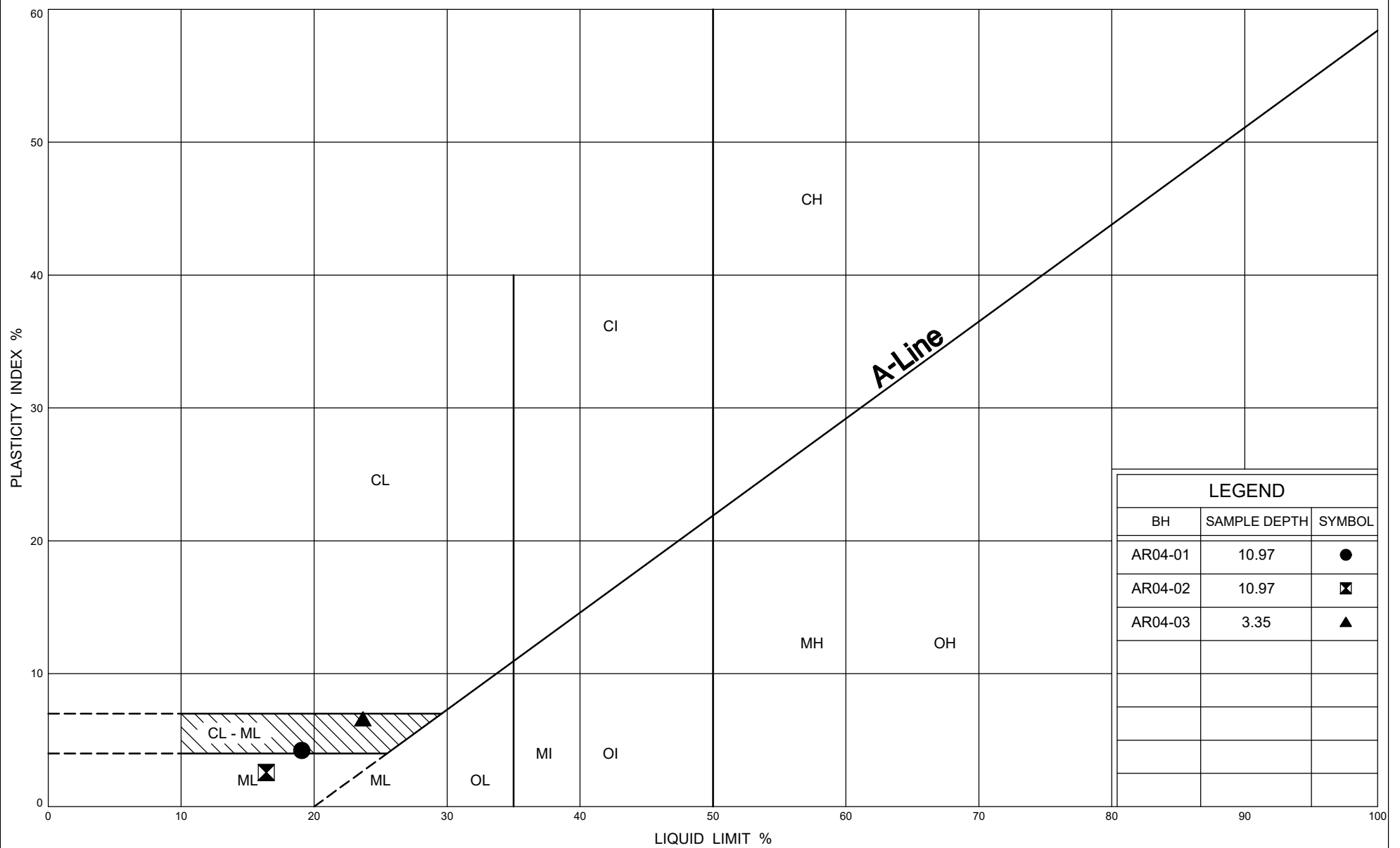
GRAIN SIZE DISTRIBUTION

Embankment FILL

FIG No C1

GWP# 3076-14-00





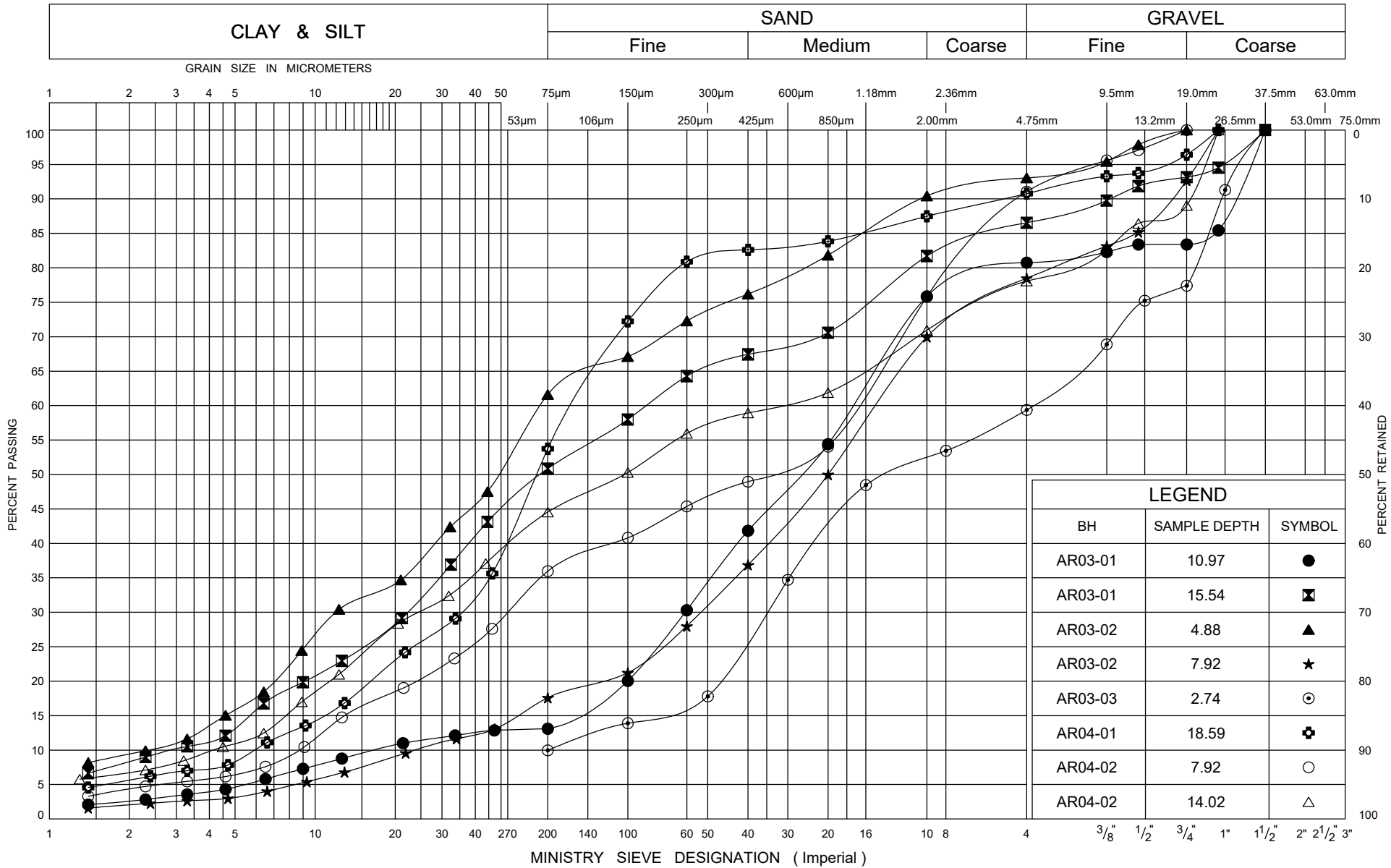
Ministry of
Transportation

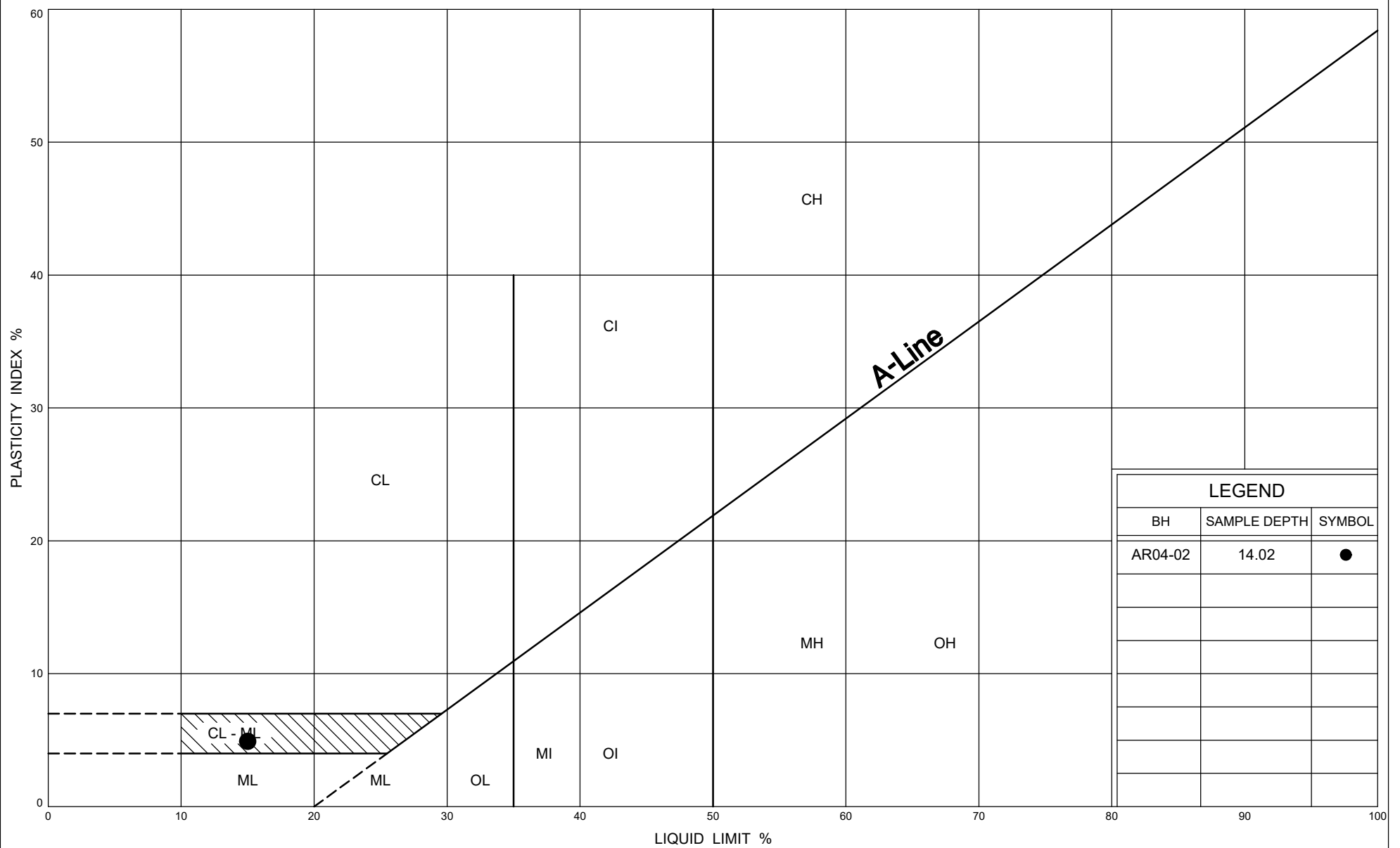
PLASTICITY CHART

Clayey SILT - SILT to SILT of Slight Plasticity

FIG No C3

GWP# 3076-14-00





Ministry of
Transportation

PLASTICITY CHART

Gravelly Clayey SAND (Fine Portion)

FIG No C5

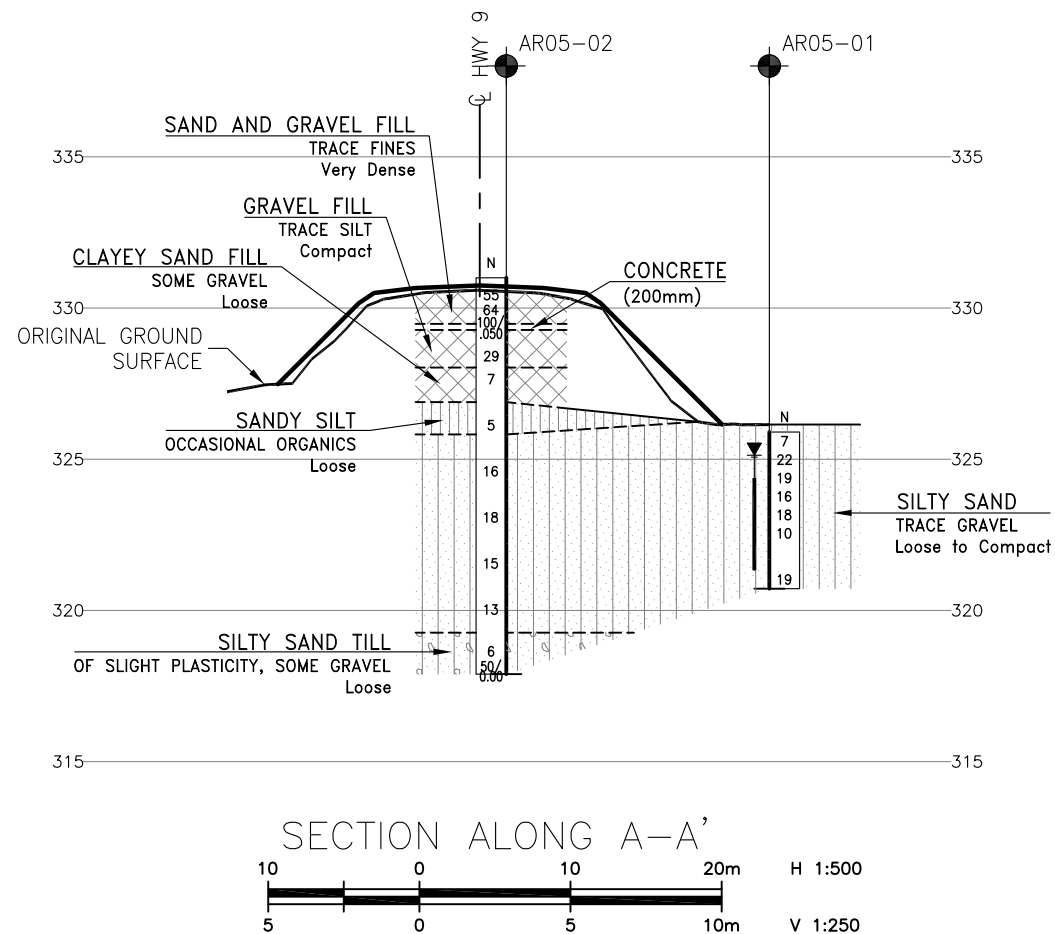
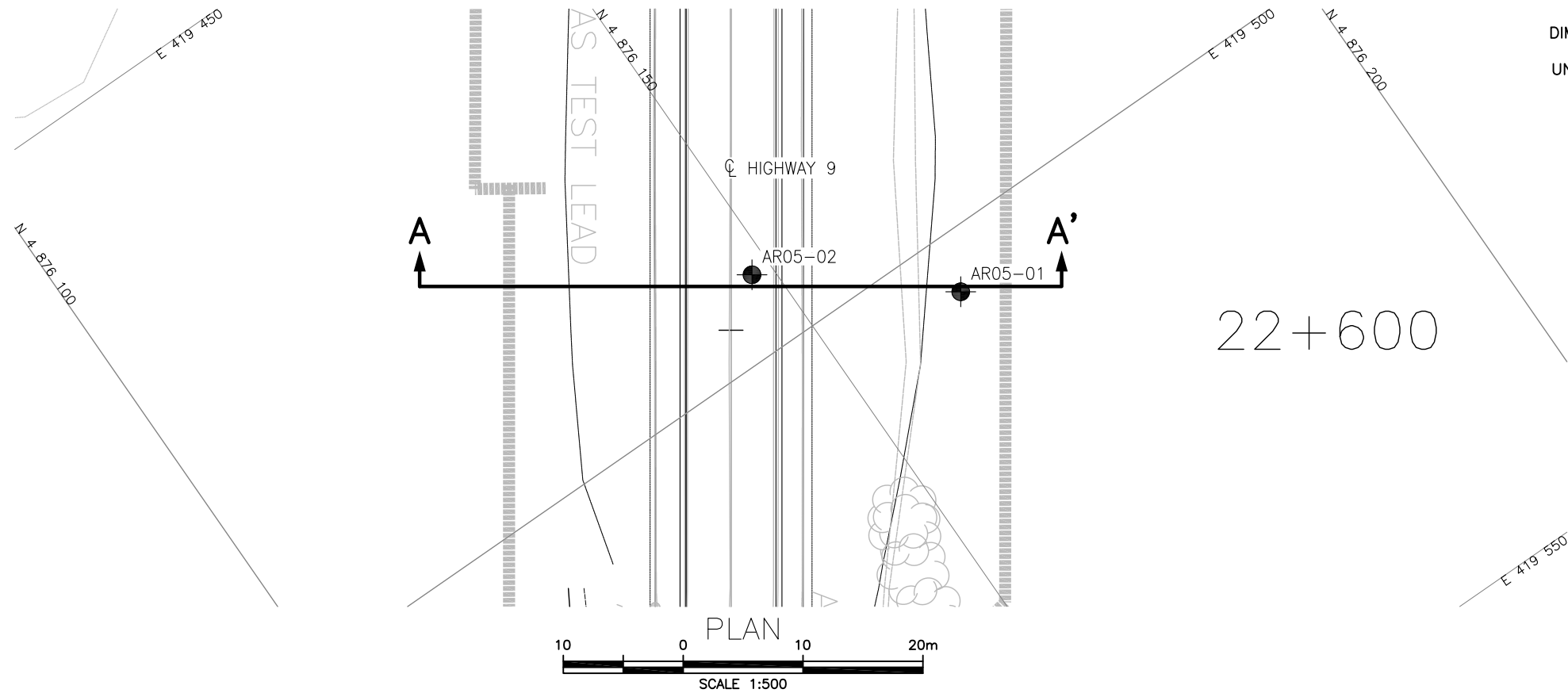
GWP# 3076-14-00



APPENDIX D

Highway 9 Widening Area No. 5 (WBL) – STA 22+568 to STA 22+595

Drawing D1	Borehole Location Plan and Soil Stata
Photographs D1 to D2	Site Photographs
Borehole Records	AR05-01, AR05-02
Figure D1	Grain Size Distribution – Sandy Organic Silt
Figure D2	Grain Size Distribution – Silty Sand
Figure D3	Grain Size Distribution – Silty Sand of slight plasticity
Figure D4	Plasticity Chart – Silty Sand of slight plasticity



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

CONT No	(
GWP No 3076-14-00	






<p> HIGHWAY 9 WIDENING AREA 5 STA. 22+658 TO STA. 22+595 BOREHOLE LOCATIONS AND SOIL STRATA </p>	
---	--

SHEET



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 11.

GEOCRES No. 41A03-004

[illegible]



Photograph D1: Widening Area #5 looking east along north slope of Highway 9 embankment.




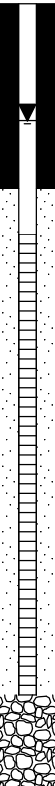
Photograph D2: Concrete pieces encountered at ~1.5 m depth at Borehole AR05-02

RECORD OF BOREHOLE No AR05-01

1 OF 1

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 876 161.8 E 419 504.7 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE Portable Drilling: Continuous Sampling; 75 mm diameter Tricone (N Casing) COMPILED BY AK
 DATUM Geodetic DATE 2023.10.28 - 2023.10.28 LATITUDE 44.016486 LONGITUDE -81.069343 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _p w w _L				GR	SA	SI	CL		
325.9	GROUND SURFACE							20	40	60	80	100									
0.0	Silty SAND , trace gravel Loose to Compact Brown Moist to Wet		1	SS	7																
			2	SS	22																
			3	SS	19																
			4	SS	16																
			5	SS	18																
			6	SS	10																
320.7	END OF BOREHOLE AT 5.2m. WATER LEVEL AT 2.4m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.																				
5.2	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.12.01 1.1 324.8 2024.01.31 0.8 325.1																				

ONTMT452 2020LIBRARY(MTO) - COPY.GLB MTO-34935.GPJ 2/7/24

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

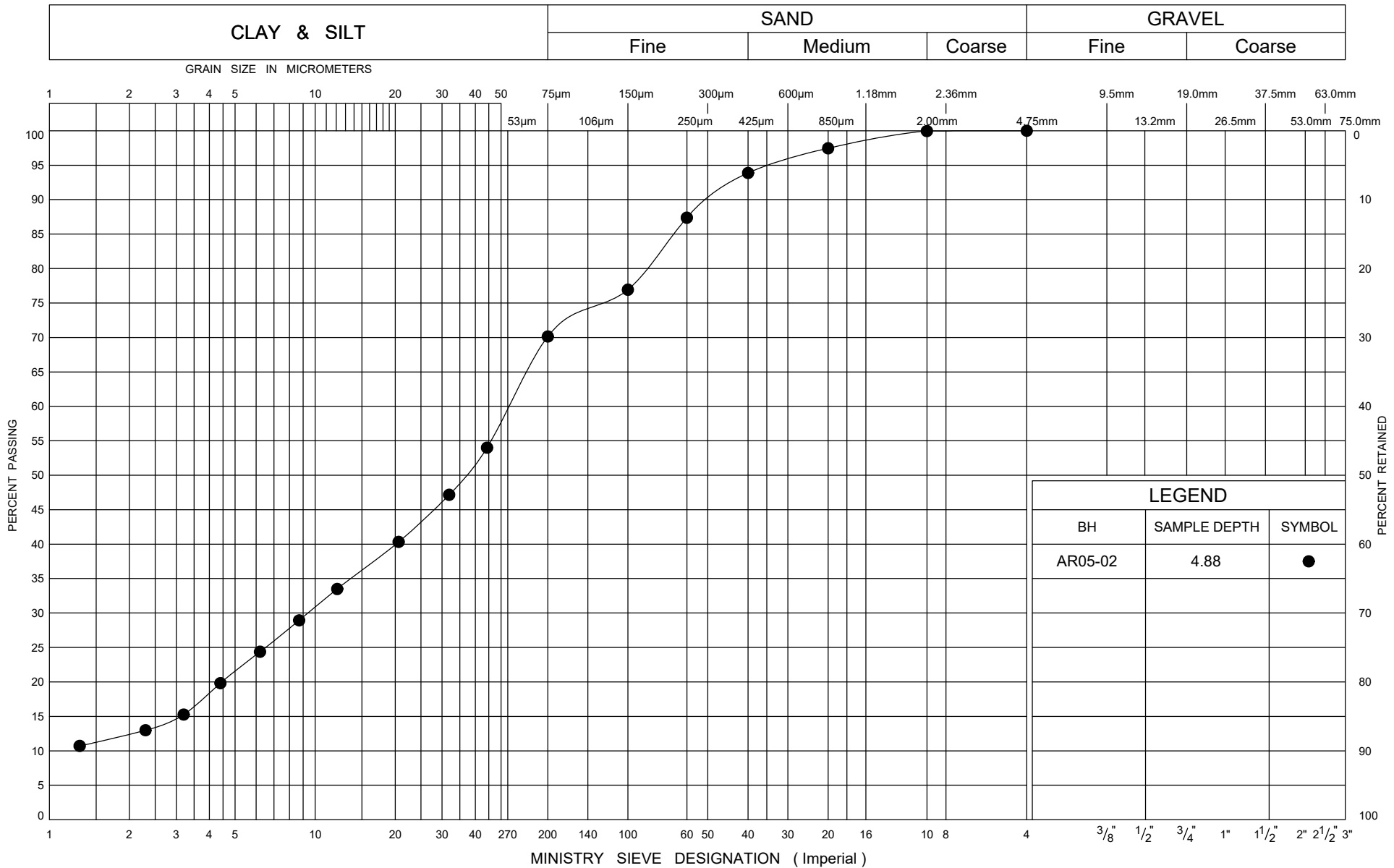
RECORD OF BOREHOLE No AR05-02

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 876 148.3 E 419 493.6 ORIGINATED BY SG
DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers and P Casing; Coring (H Casing); 100 mm Hole; 100 mm Rotary
DATUM Geodetic DATE 2023.10.05 - 2023.10.06 LATITUDE 44.016366 LONGITUDE -81.069484 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
Continued From Previous Page								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
							20	40	60	80	100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	
							20	40	60	80	100	W _P	W	W _L	
												WATER CONTENT (%)			
							20	40	60	80	100	20	40	60	



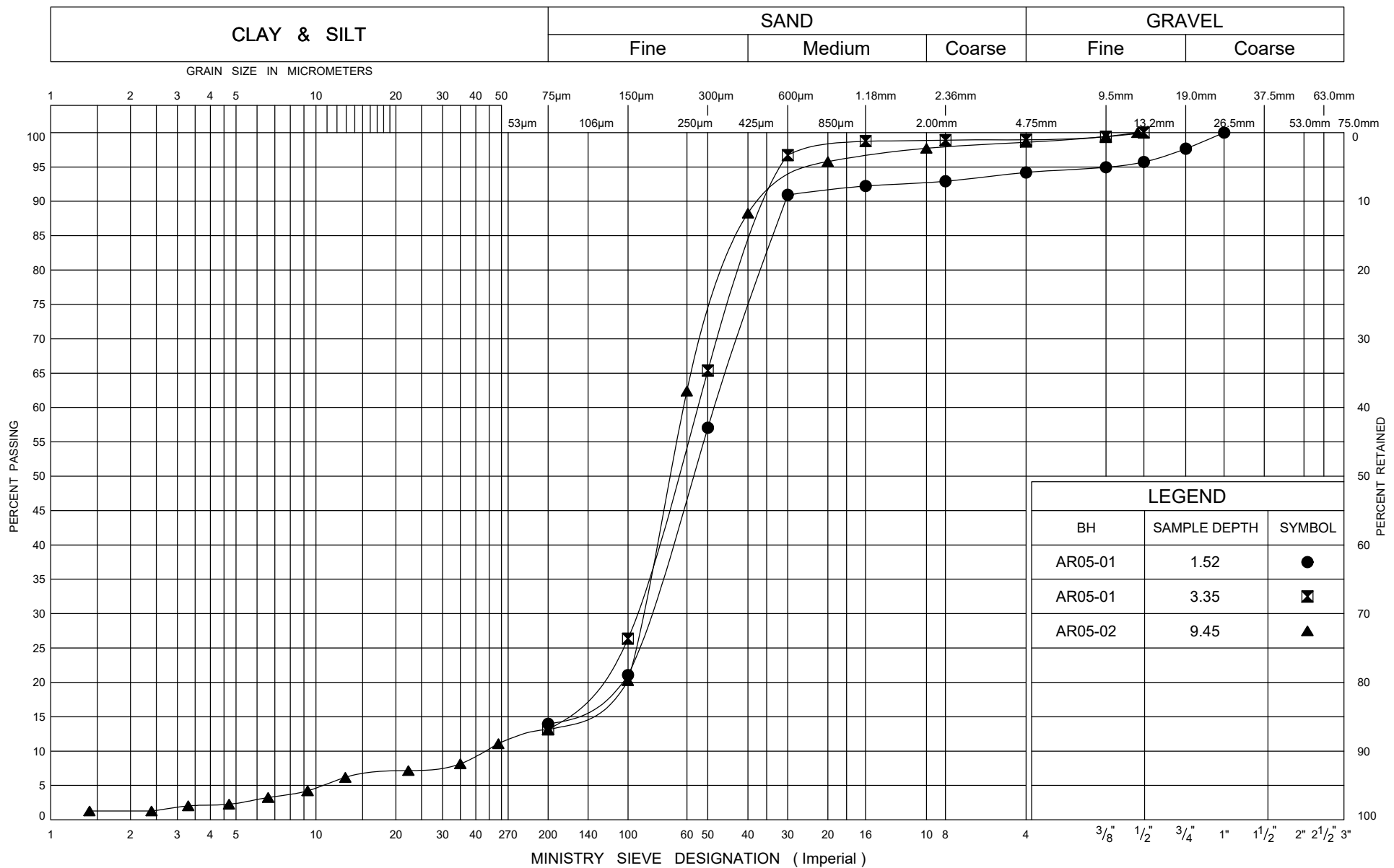
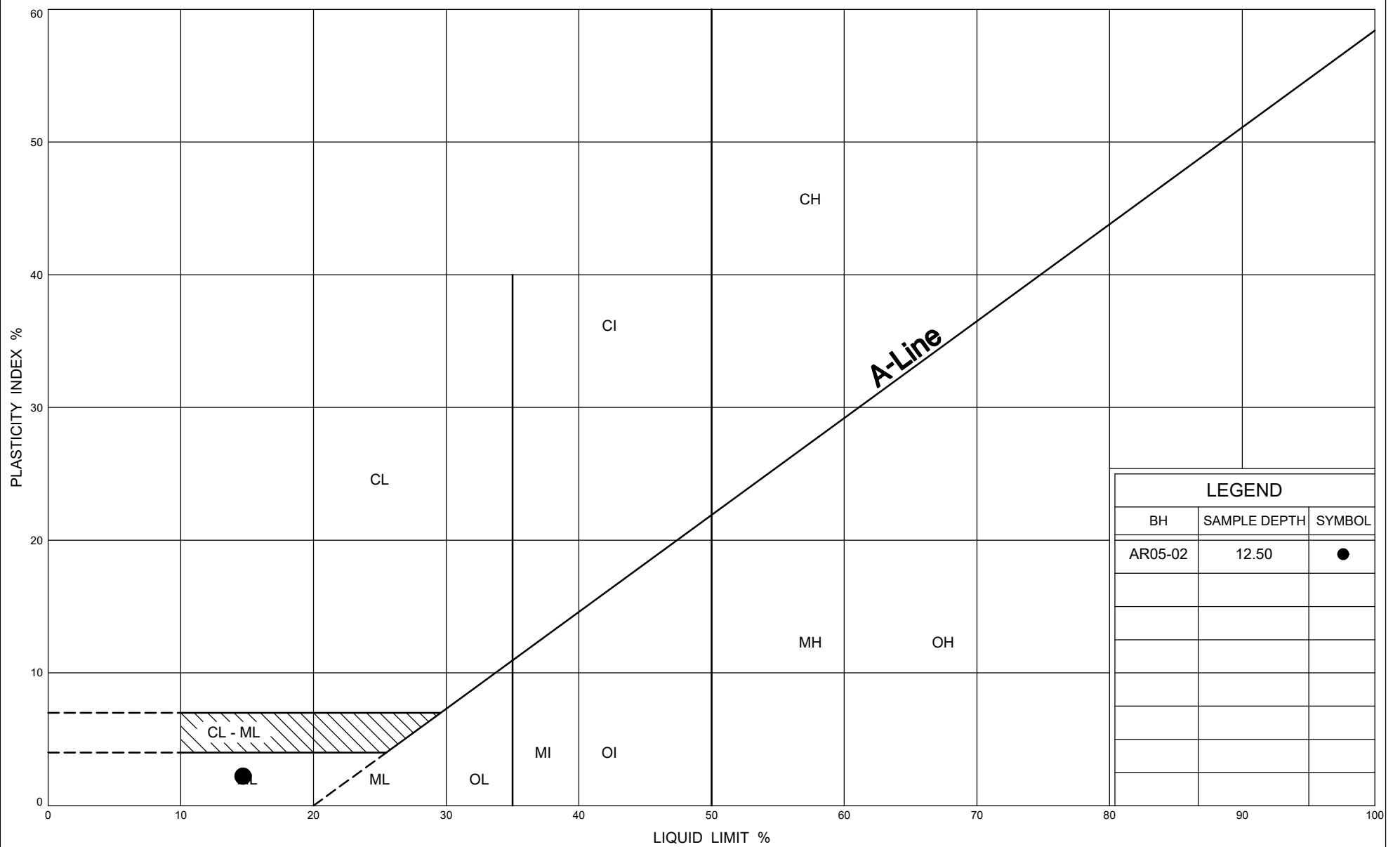




FIG No D3

GWP# 3076-14-00





APPENDIX E

Highway 9 Widening Area No. 6 (EBL) – STA 23+370 to STA 23+503

Highway 9 Widening Area No. 7 (WBL) – STA 23+365 to STA 23+530

Drawing E1 Borehole Location Plan and Soil Stata

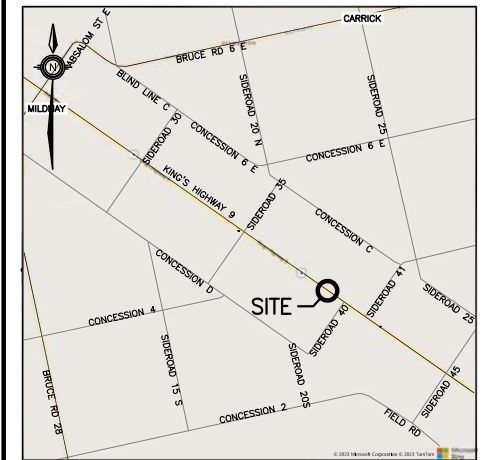
Photographs E1 to E2 Site Photographs

Borehole Records AR06-01, AR06-02
AR07-01, AR07-02

Figure E1 Grain Size Distribution – Embankment Fill

Figure E2 Grain Size Distribution – Sandy Silt to Silt and Sand

Figure E3 Grain Size Distribution – Gravel and Sand to Sandy Gravel



LEGEND

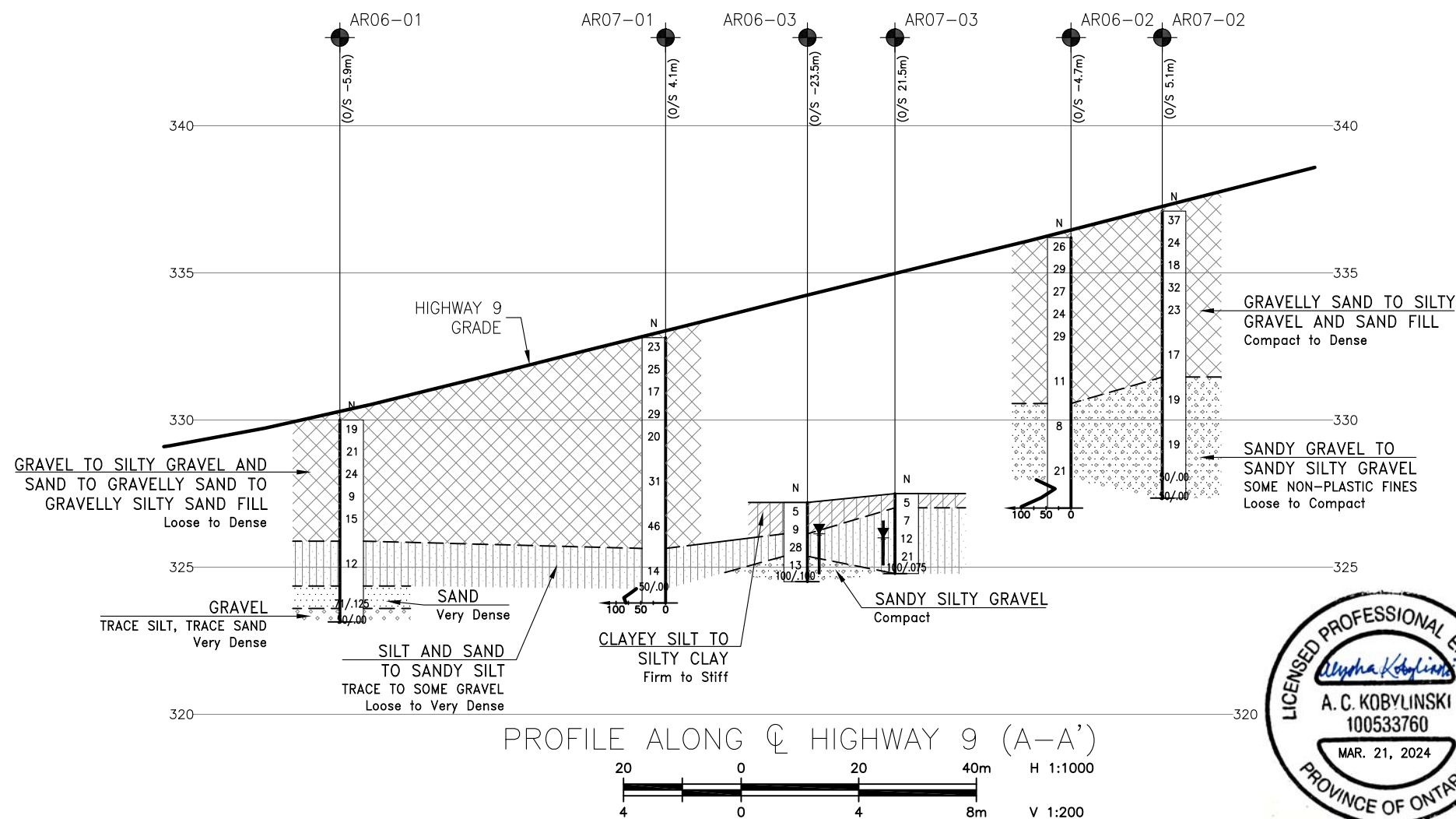
NO	ELEVATION	NORTHING	EASTING
AR06-01	330.0	4 875 698.2	420 130.5
AR06-02	336.2	4 875 627.5	420 232.7
AR06-03	327.2	4 875 637.9	420 185.2
AR07-01	332.8	4 875 674.4	420 181.5
AR07-02	337.1	4 875 626.6	420 251.0
AR07-03	327.5	4 875 666.1	420 223.4

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 11.

0



REVISIONS								
	DATE	BY	DESCRIPTION					
DESIGN	AK	CHK	PKC	CODE	LOAD	DATE	MAR 2024	
DRAWN	AN	CHK	AK	SITE	STRUCT	DWG	E1	





Photograph E1: Widening Area #6 looking west along south slope of Highway 9 embankment.



Photograph E2: Widening Area #7 looking east along north slope of Highway 9 embankment.

RECORD OF BOREHOLE No AR06-01

1 OF 1

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 875 698.2 E 420 130.5 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers; Dynamic Cone Penetration Test (DCPT) COMPILED BY AK
 DATUM Geodetic DATE 2023.10.18 - 2023.10.19 LATITUDE 44.012216 LONGITUDE -81.061642 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
330.0	GROUND SURFACE							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>						
0.0	Gravelly SAND to Gravelly Silty SAND Loose to Compact Brown Moist (FILL)		1	SS	19		329							
			2	SS	21									
			3	SS	24		328							
			4	SS	9									28 48 22 2
			5	SS	15		327							
325.9							326							
4.1	SILT and SAND , some gravel Compact Grey Moist		6	SS	12		325							11 36 50 3
324.4														
5.6	SAND Very Dense Grey Wet		7	SS	71/ 0.125		324							
323.6														
6.4	GRAVEL , trace silt, trace sand Very Dense													
323.1	Grey Wet		8	SS	50/ 0.0									
6.9	Auger, split-spoon and DCPT refusal END OF BOREHOLE AT 6.9m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE. NOTE: 1. Water level measured at a depth of 5.2m in hollow stem augers upon completion of drilling.													

ONTMT452 2020LIBRARY(MTO) - COPY, GLB MTO-34935.GPJ 2/7/24

RECORD OF BOREHOLE No AR06-02

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 875 627.5 E 420 232.7 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers; Dynamic Cone Penetration Test (DCP) COMPILED BY AK
 DATUM Geodetic DATE 2023.10.18 - 2023.10.18 LATITUDE 44.011564 LONGITUDE -81.060382 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE								
										20	40	60	80	100			20
336.2	GROUND SURFACE																
0.0	Silty GRAVEL and SAND to Gravelly SAND Compact Brown Moist (FILL)		1	SS	26			336									
			2	SS	29			335									
			3	SS	27			334								44 36 17 3	
			4	SS	24			333									
			5	SS	29			332									
			6	SS	11			331									
330.6																	
5.6	Sandy GRAVEL , some non-plastic fines Loose to Compact Brown Moist		7	SS	8			330								66 23 9 2	
								329									
			8	SS	21			328									
328.0																	
8.2	End of sampling and start of Dynamic Cone Penetration Test																
327.0																	
9.2	END OF BOREHOLE AT 15.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.2m, THEN ASPHALT COLD PATCH TO																

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

METRIC

[illegible]

RECORD OF BOREHOLE No AR06-03

1 OF 1

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 875 637.9 E 420 185.2 ORIGINATED BY JF
DIST Bruce HWY 9 BOREHOLE TYPE Portable Drilling: Continuous Sampling COMPILED BY AK
DATUM Geodetic DATE 2023.11.02 - 2023.11.02 LATITUDE 44.011666 LONGITUDE -81.060972 CHECKED BY AK



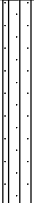
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) w _p w w _L				GR	SA	SI	CL	
327.2	GROUND SURFACE							20	40	60	80	100									
0.0	Clayey SILT Firm Dark Brown Moist		1	SS	5		327								○						
326.6																					
0.6	Silty CLAY , trace gravel, trace sand Stiff Grey Moist		2	SS	9										○						
326.1							326														
1.1																					
	Silty SAND , trace gravel Compact Brown Moist		3	SS	28										○			4	49	42	5
325.4																					
1.8	Sandy Silty GRAVEL Compact Brown Moist		4	SS	13		325								○			51	25	24	(SI+CL)
324.5	Auger and split-spoon refusal		5	SS	100/										○						
2.7	END OF BOREHOLE AT 2.7m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.12.01 1.5 325.7 2024.01.31 1.1 326.1				0.100																

RECORD OF BOREHOLE No AR07-01

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 875 674.4 E 420 181.5 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers; Dynamic Cone Penetration Test (DCPT) COMPILED BY AK
 DATUM Geodetic DATE 2023.10.19 - 2023.10.19 LATITUDE 44.011995 LONGITUDE -81.061011 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE												
332.8	GROUND SURFACE							20	40	60	80	100									
0.0	Silty GRAVEL and SAND to Gravelly SAND Compact to Dense Brown Moist to Wet (FILL)		1	SS	23																
			2	SS	25																
			3	SS	17																
			4	SS	29																
			5	SS	20																
			6	SS	31																
327.2																					
5.6	GRAVEL , trace sand, trace silt Dense Brown Moist (FILL)		7	SS	46																
325.6																					
7.2	Sandy SILT , trace gravel Compact Brown Wet		8	SS	14																
			9	SS	50/ 0.0																
324.3																					
8.5	Auger and split-spoon refusal No recovery in SS9																				
323.8	End of sampling and start of Dynamic Cone Penetration Test (DCPT)																				
9.0	DCPT refusal																				
	END OF BOREHOLE AT 9.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.2m, THEN																				

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC



SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100			W _P	W	W _L
		Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		WATER CONTENT (%)			γ				
		ASPHALT COLD PATCH TO SURFACE.							20	40	60	80	100	20	40	60	kN/m ³	GR SA SI CL

RECORD OF BOREHOLE No AR07-02

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 875 626.6 E 420 251.0 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers COMPILED BY AK
 DATUM Geodetic DATE 2023.10.17 - 2023.10.18 LATITUDE 44.011553 LONGITUDE -81.060154 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) w _p w w _L				GR	SA	SI	CL
337.1	GROUND SURFACE							20	40	60	80	100								
0.0	Silty GRAVEL and SAND to Gravelly SAND Compact to Dense Brown Moist (FILL)		1	SS	37		337							○						
				2	SS	24		336							○					
				3	SS	18		335							○					
				4	SS	32		334							○					45 41 12 2
				5	SS	23		333							○					
				6	SS	17		332							○					
331.5	Sandy Silty GRAVEL Compact Brown Moist		7	SS	19		331							○					40 31 25 4	
5.6				8	SS	19		330							○					
	Auger grinding at a depth of 9.1m No recovery in SS9			9	SS	50/ 0.00		329												
327.3	Auger and split spoon refusal			10	SS	50/ 0.00		328												
9.8	END OF BOREHOLE AT 9.8m																			

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No AR07-02

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 875 626.6 E 420 251.0 ORIGINATED BY SG
DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers COMPILED BY AK
DATUM Geodetic DATE 2023.10.17 - 2023.10.18 LATITUDE 44.011553 LONGITUDE -81.060154 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
	Continued From Previous Page																
	BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.																
	NOTE:																
	1. Borehole dry in hollow stem augers upon completion of drilling.																

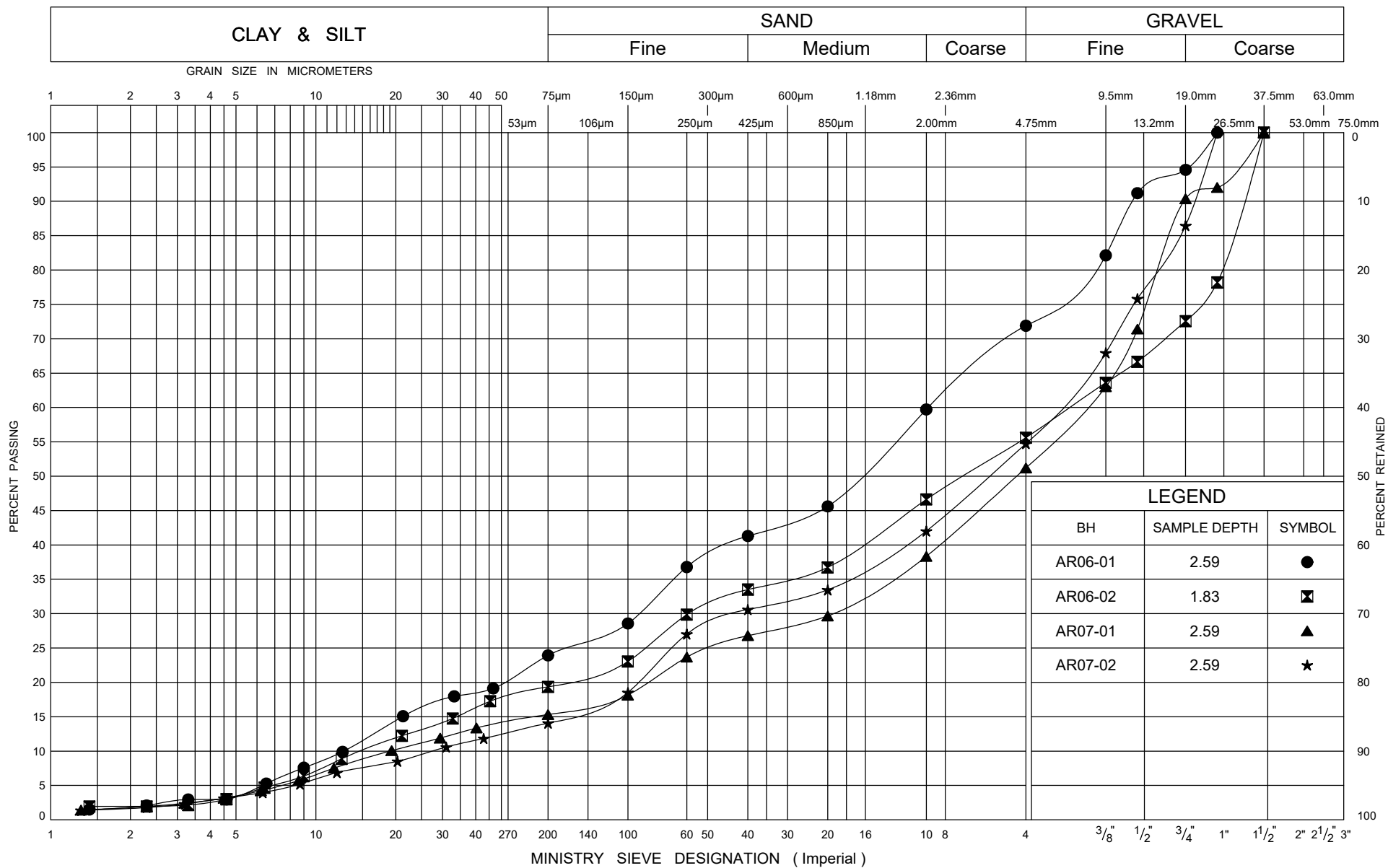
RECORD OF BOREHOLE No AR07-03

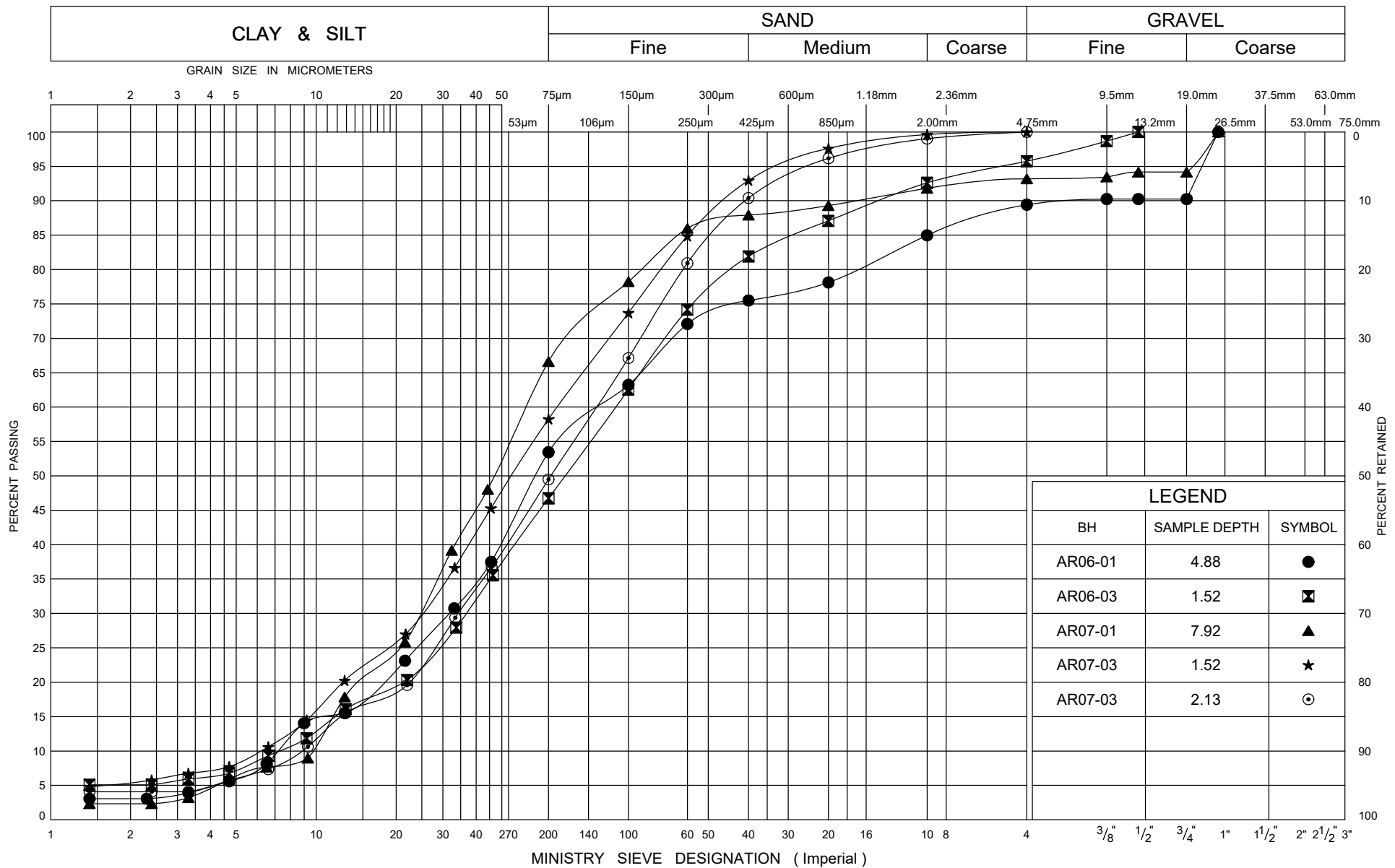
1 OF 1

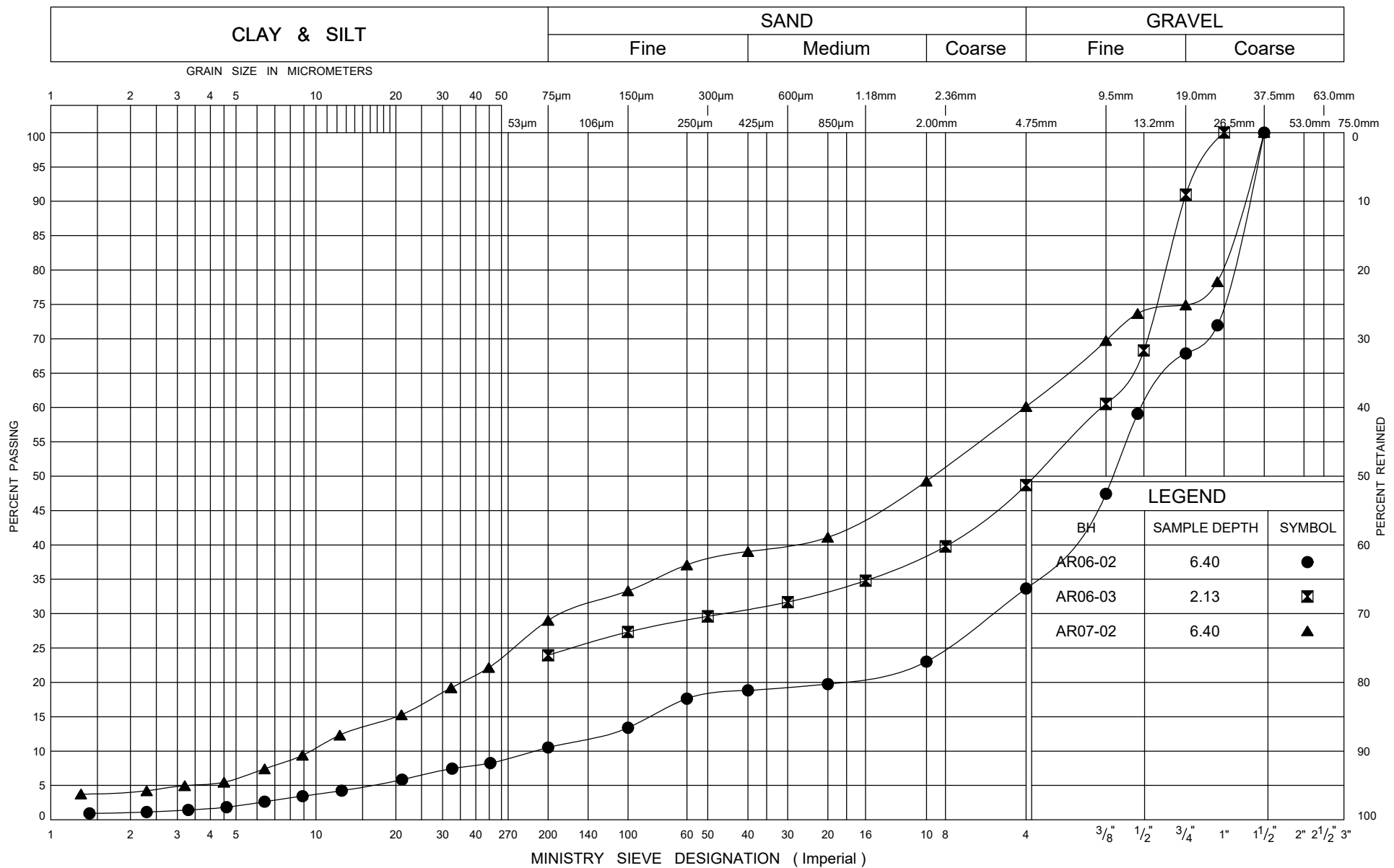
METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 875 666.1 E 420 223.4 ORIGINATED BY JF
DIST Bruce HWY 9 BOREHOLE TYPE Portable Drilling: Continuous Sampling COMPILED BY AK
DATUM Geodetic DATE 2023.11.02 - 2023.11.02 LATITUDE 44.011913 LONGITUDE -81.060490 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
327.5	GROUND SURFACE							20	40	60	80	100					
0.0	Clayey SILT Firm Dark Brown Moist		1	SS	5		327										
327.0																	
0.5	Silty SAND to SILT and SAND Loose to very dense Brown Moist		2	SS	7												
			3	SS	12		326										0 42 53 5
			4	SS	21												0 51 45 4
324.8	Split spoon refusal		5	SS	100/		325										
2.7	END OF BOREHOLE AT 2.7m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.12.01 2.1 325.4 2024.01.31 1.5 326.0				0.075												





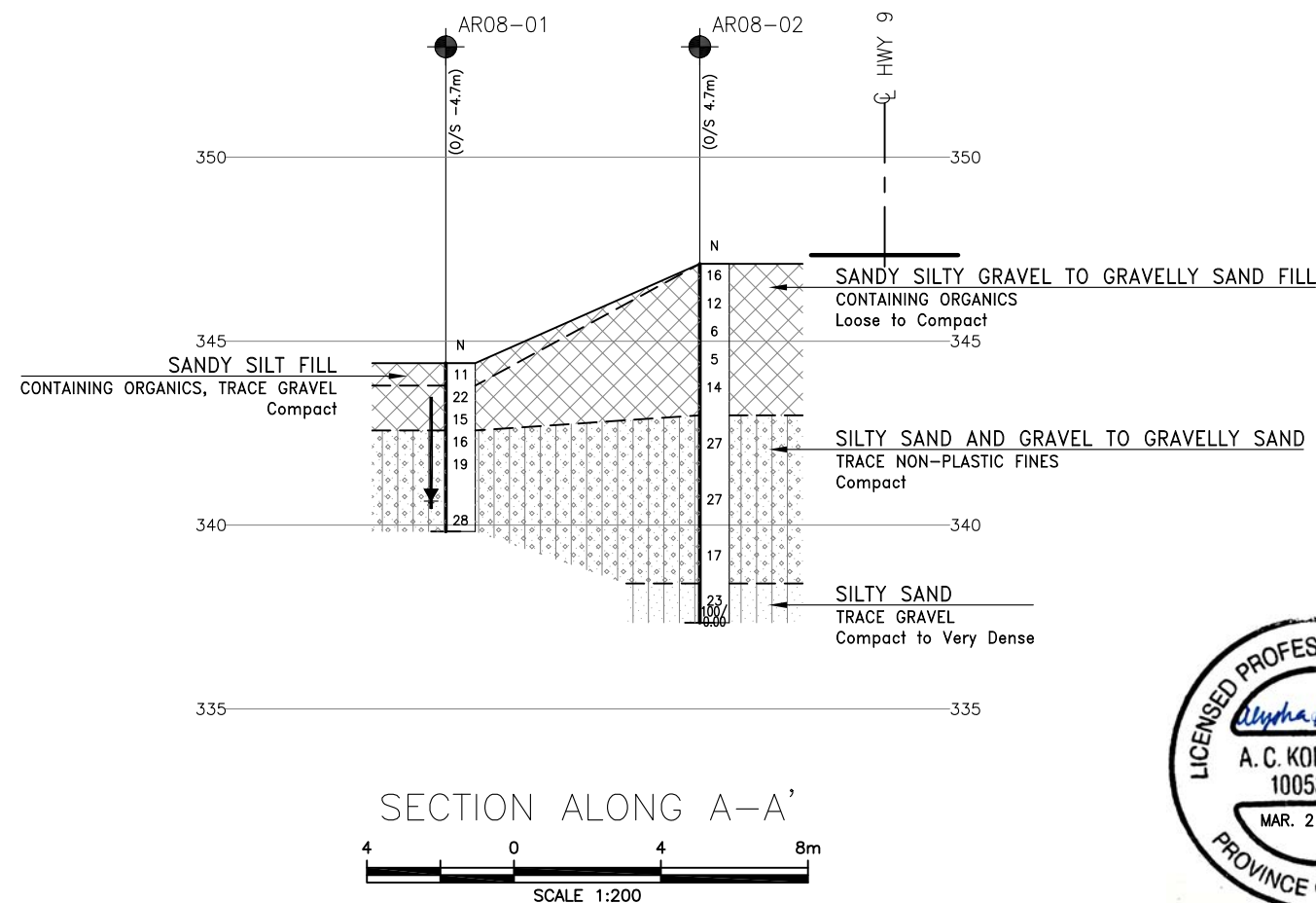
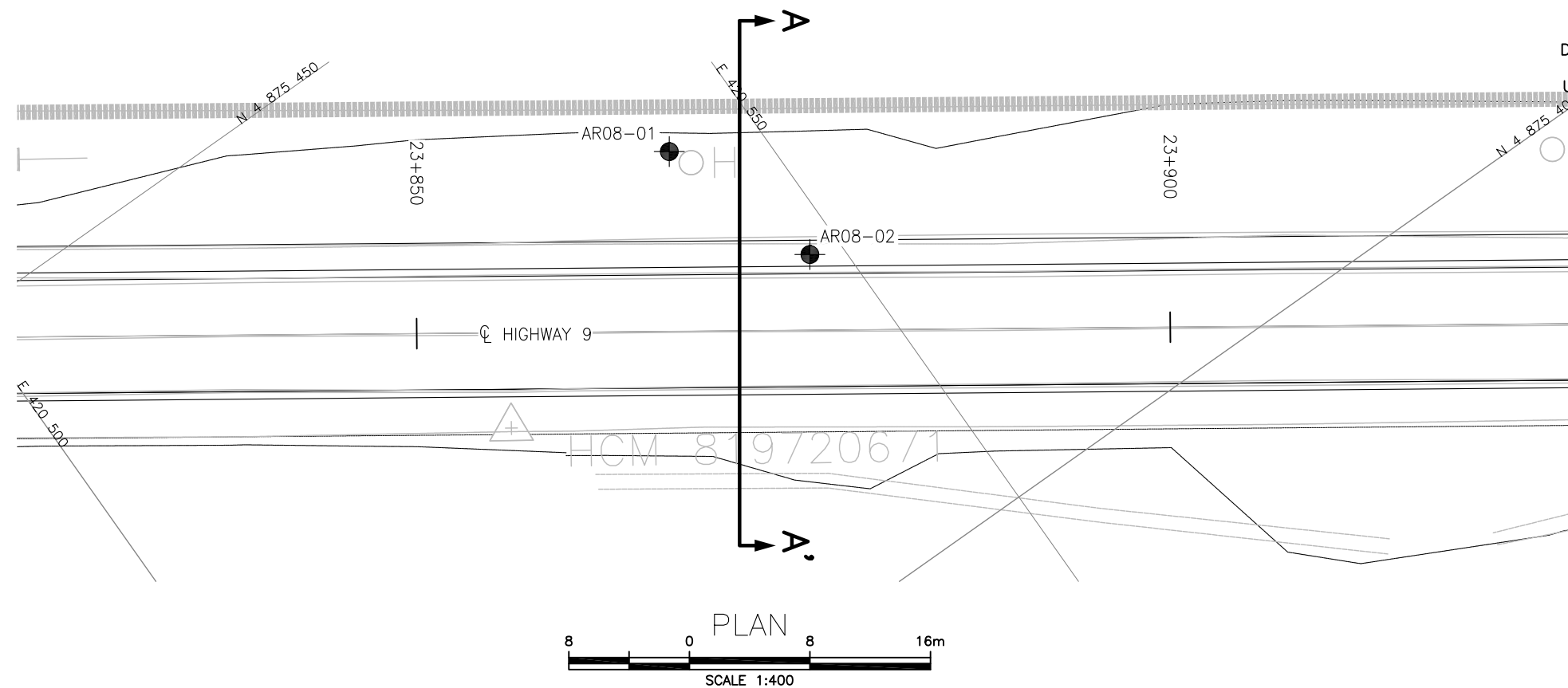




APPENDIX F

Highway 9 Widening Area No. 8 (WBL) – STA 23+890 to STA 23+937

Drawing F1	Borehole Location Plan and Soil Stata
Photographs F1 to F2	Site Photographs
Borehole Records	AR08-01, AR08-02
Figure F1	Grain Size Distribution – Embankment Fill
Figure F2	Grain Size Distribution – Gravelly Sand to Silty Sand and Gravel
Figure F3	Grain Size Distribution – Silty Sand



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

CONT No	(
GWP No 3076-14-00	






<p> HIGHWAY 9 WIDENING AREA 8 STA. 23+890 TO STA. 23+937 BOREHOLE LOCATIONS AND SOIL STRATA </p>	
---	--

SHEET



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 11.

GEOCRES No. 41A03-004

[illegible]



Photograph F1: Widening Area #8 looking west along north slope of Highway 9 embankment.




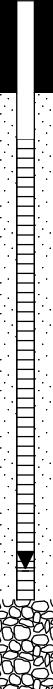
Photograph F2: ~100 mm Cobble piece encountered at ~1.8 m in Borehole AR08-01

RECORD OF BOREHOLE No AR08-01

1 OF 1

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 875 432.1 E 420 544.3 ORIGINATED BY SG
DIST Bruce HWY 9 BOREHOLE TYPE Portable Drilling; Continuous Sampling; Wash Boring (N Casing); 75 mm diameter COMPLIED BY AK
DATUM Geodetic DATE 2023.10.31 - 2023.11.01 LATITUDE 44.009757 LONGITUDE -81.056541 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
344.4	GROUND SURFACE							20	40	60	80	100						
0.0	Sandy SILT , trace gravel, containing organics Compact		1	SS	11		344										65 21 14 (SI+CL)	
343.8	Dark Brown Moist (FILL)		2	SS	22													
0.6	Sandy Silty GRAVEL Compact Brown Moist (FILL)		3	SS	15													
342.6							343											
1.8	Silty SAND and GRAVEL Compact Brown Moist		4	SS	16													
	100mm cobble recovered from a depth of 1.8m		5	SS	19													
							342											
							341											
	Wet below a depth of 4.0m		6	SS	28		340										39 46 15 (SI+CL)	
339.8																		
4.6	END OF BOREHOLE AT 4.6m Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.																	
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.12.01 3.7 340.7 2024.01.31 3.7 340.7																	

ONTMT452 2020LIBRARY(MTO) - COPY.GLB MTO-34935.GPJ 2/7/24

RECORD OF BOREHOLE No AR08-02

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 875 421.2 E 420 548.0 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers COMPILED BY AK
 DATUM Geodetic DATE 2023.10.17 - 2023.10.17 LATITUDE 44.009658 LONGITUDE -81.056497 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _p w w _L				
347.1	GROUND SURFACE							20	40	60	80	100				
0.0	Sandy Silty GRAVEL to Gravelly SAND Loose to Compact Brown Moist (FILL)		1	SS	16		347							○		
			2	SS	12		346							○		
			3	SS	6		345							○		
			4	SS	5		344							○		
			5	SS	14		343							○		
343.0							342							○		
4.1	Gravelly SAND , trace non-plastic fines Compact Brown Moist		6	SS	27		341							○		
			7	SS	27		340							○		
			8	SS	17		339							○		
338.4							338							○		
8.7	Silty SAND , trace gravel Compact Brown Wet		9	SS	23									○		
337.3	Auger and split-spoon refusal		10	SS	100/											
9.8	END OF BOREHOLE AT 9.8m.				0.00											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

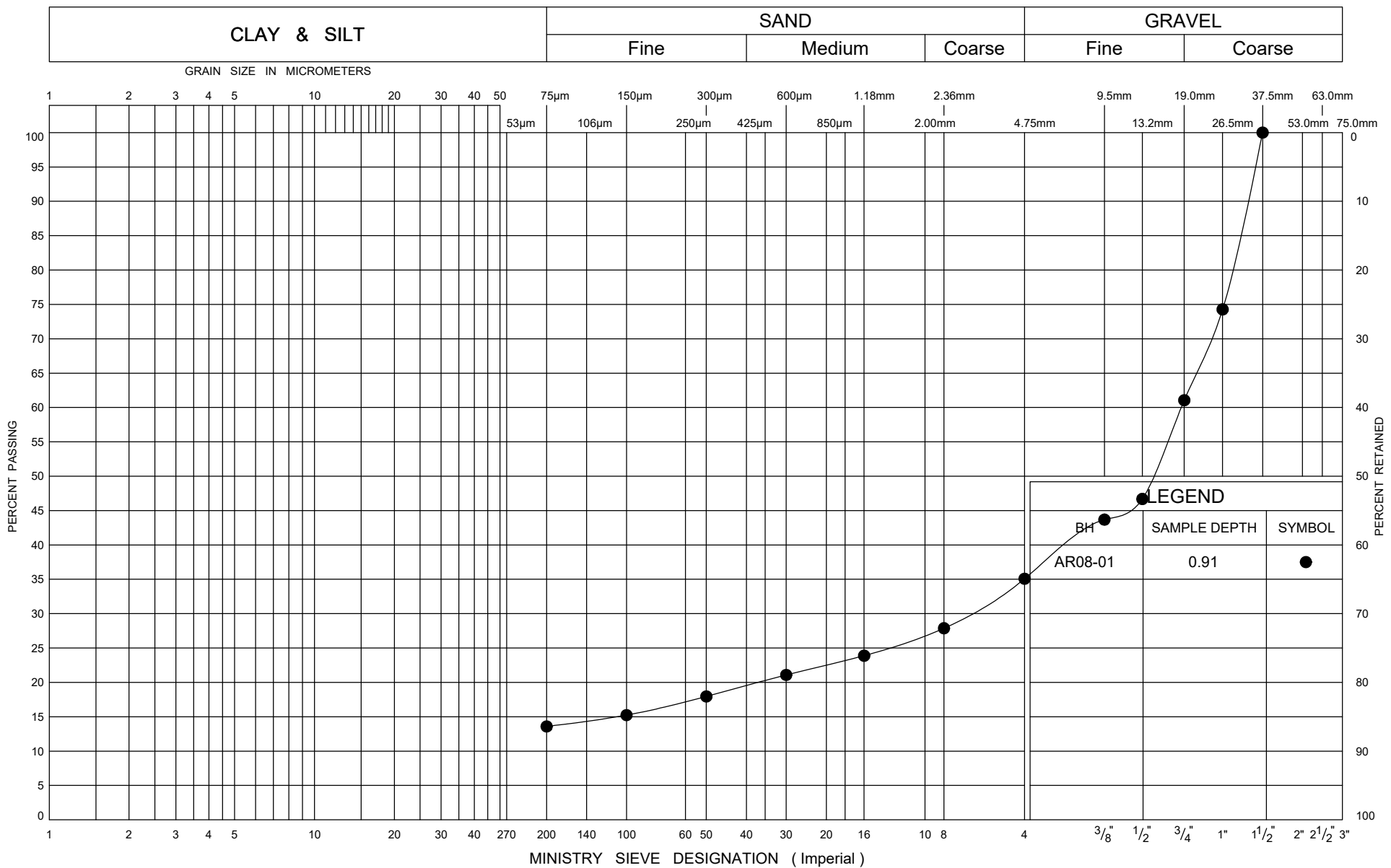
20
15
10
(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES			
	Continued From Previous Page						<div style="text-align: center;"> 20 40 60 80 100 </div> <div style="text-align: center;"> w_p ————— w ————— w_L 20 40 60 </div>	kN/m ³	GR SA SI CL	

[illegible]

+³, ×³: Numbers refer to Sensitivity



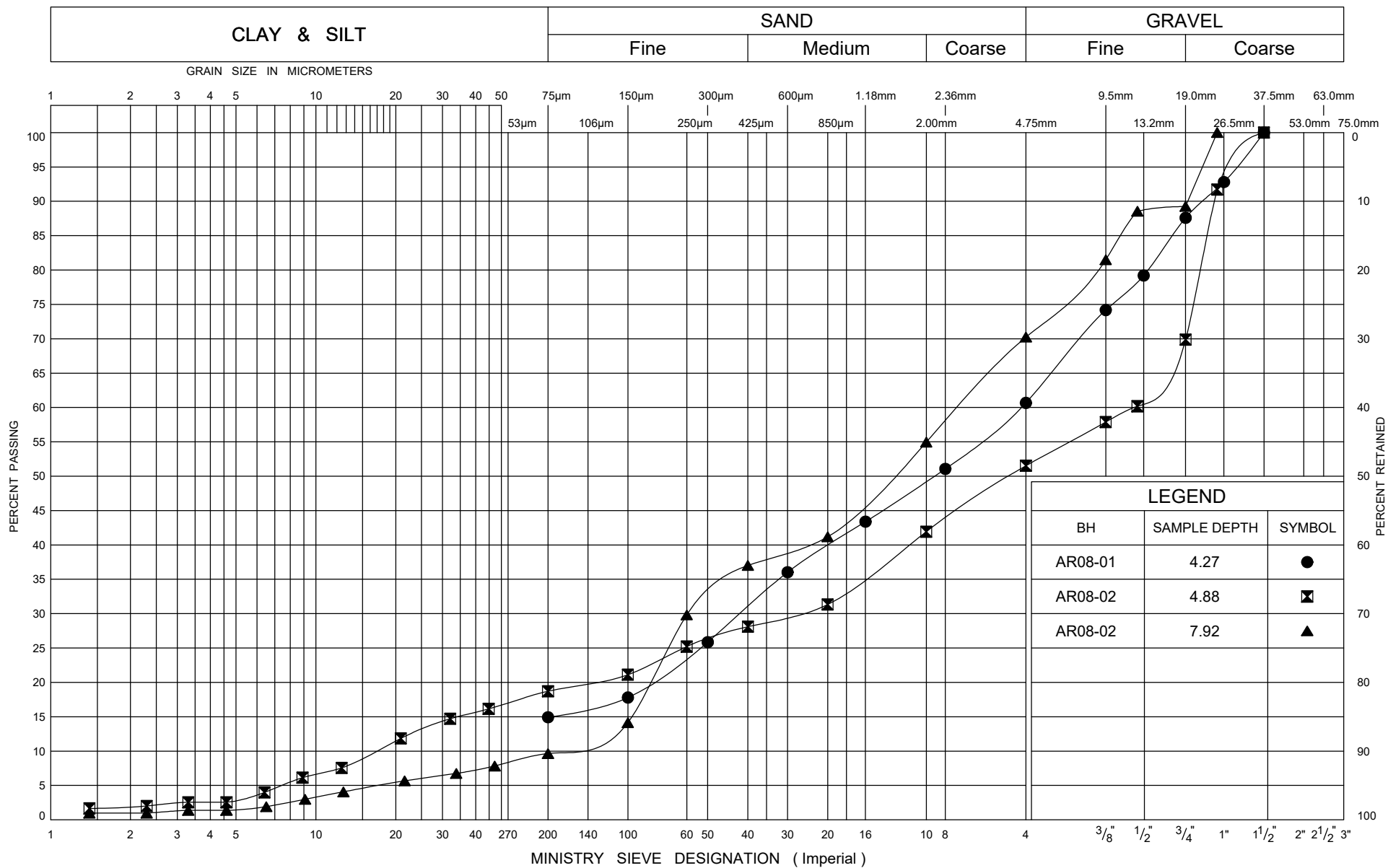


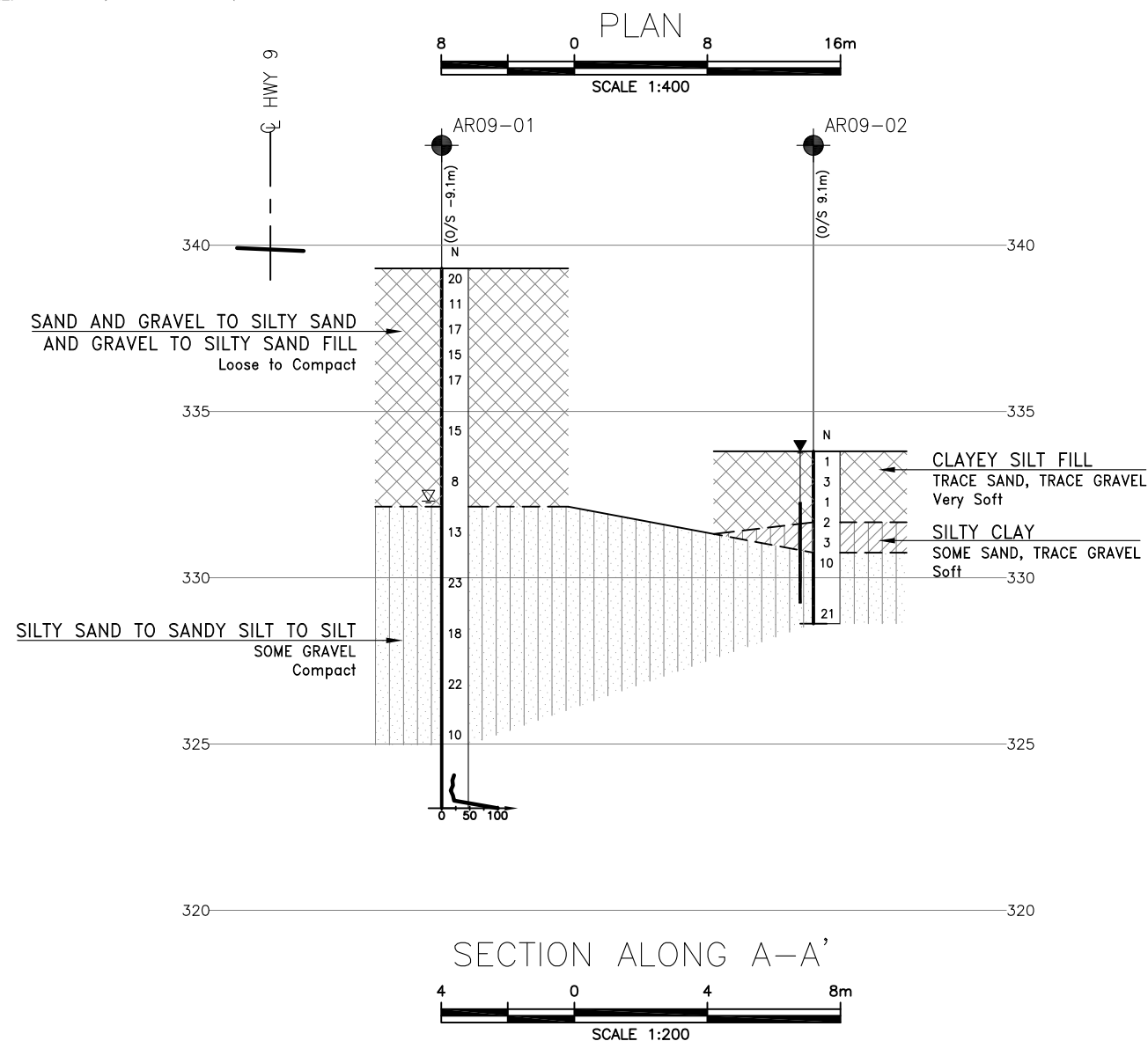
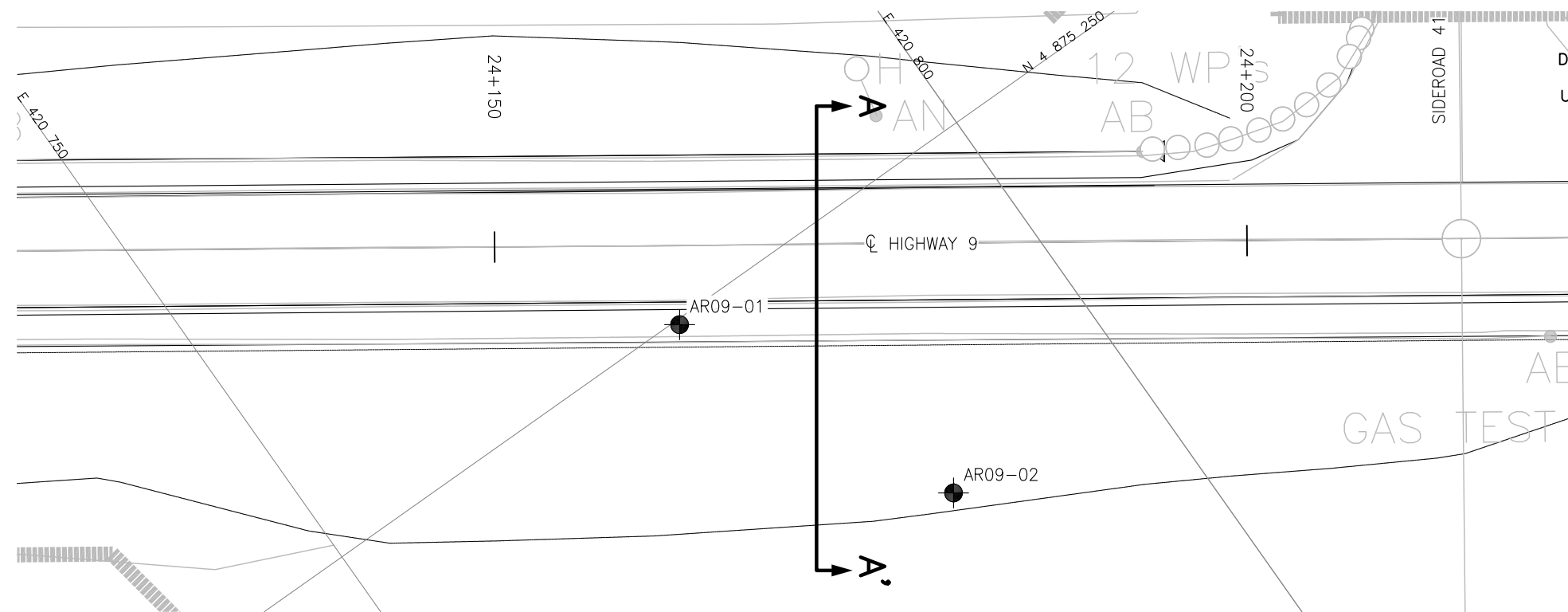



FIG No F3
GWP# 3076-14-00

APPENDIX G

Highway 9 Widening Area No. 9 (EBL) – STA 24+130 to STA 24+205

Drawing G1	Borehole Location Plan and Soil Stata
Photographs G1 to G2	Site Photographs
Borehole Records	AR09-01, AR09-02
Figure G1	Grain Size Distribution – Embankment Fill
Figure G2	Grain Size Distribution – Silty Clay
Figure G3	Plasticity Chart – Silty Clay
Figure G4	Grain Size Distribution – Silty Sand to Sandy Silt to Silt of Slight Plasticity
Figure G5	Plasticity Chart – Silt of Slight Plasticity



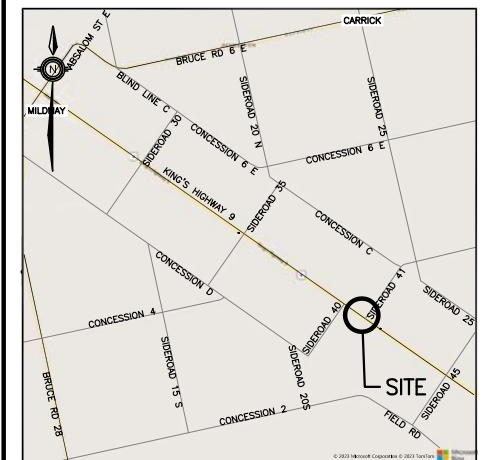
 METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No	(
GWP No 3076-14-00	






<p> HIGHWAY 9 WIDENING AREA 9 STA. 24+130 TO STA. 24+205 BOREHOLE LOCATIONS AND SOIL STRATA </p>	
---	--

SHEET



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 11.

GEOCRES No. 41A03-004



REVISIONS								
	DATE	BY	DESCRIPTION					
DESIGN	AK	CHK	PKC	CODE	LOAD	DATE	MAR 2024	
DRAWN	AN	CHK	AK	SITE	STRUCT	DWG	G1	



Photograph G1: Widening Area #9 looking east along south slope of Highway 9 embankment.



Photograph G2: Widening Area #9 looking east along south shoulder of Highway 9 embankment.

RECORD OF BOREHOLE No AR09-01

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 875 249.7 E 420 777.2 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers; Dynamic Cone Penetration Test (DCP) COMPILED BY AK
 DATUM Geodetic DATE 2023.10.16 - 2023.10.17 LATITUDE 44.008079 LONGITUDE -81.053676 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
339.3	GROUND SURFACE												
0.0	Silty SAND and GRAVEL Compact Brown Moist (FILL)		1	SS	20		339						
338.6													
0.7	Silty SAND , some gravel Compact Brown Wet (FILL)		2	SS	11		338						
337.9													
1.4	SAND and GRAVEL to Silty SAND and GRAVEL Loose to Compact Brown to Grey Moist (FILL)		3	SS	17		337						
			4	SS	15								37 42 17 4
			5	SS	17		336						
							335						
			6	SS	15		334						
	Grey and wet below a depth of 6.1m		7	SS	8		333					25	
	50mm of wood recovered at a depth of 6.7m												
332.1													
7.2	Sandy SILT of slight plasticity to SILT , trace sand Compact Grey Wet		8	SS	13		332						0 27 70 3
							331						
			9	SS	23		330						

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No AR09-01

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 875 249.7 E 420 777.2 ORIGINATED BY SG
 DIST Bruce HWY 9 BOREHOLE TYPE D50 Rig: 205 mm O.D. Hollow Stem Augers; Dynamic Cone Penetration Test (DCPT) COMPILED BY AK
 DATUM Geodetic DATE 2023.10.16 - 2023.10.17 LATITUDE 44.008079 LONGITUDE -81.053676 CHECKED BY AK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								20 40 60 80 100	○ UNCONFINED + FIELD VANE			w _P w w _L				
	Continued From Previous Page							20 40 60 80 100				20 40 60				
325.0	Sandy SILT of slight plasticity to SILT , trace sand Compact Grey Wet						329									
			10	SS	18											
			11	SS	22											
			12	SS	10		326									
325.0	14.3	End of sampling					325									
		Start of Dynamic Cone Penetration Test (DCPT)					324									
323.1		DCPT refusal														
16.2	END OF BOREHOLE AT 16.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE. NOTE: 1. Water level measured at a depth of 7.0m in hollow stem augers on October 17, 2023.															


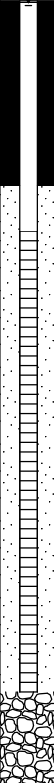


ONTMT452 2020LIBRARY(MTO) - COPY.GLB MTO-34935.GPJ 2/7/24

RECORD OF BOREHOLE No AR09-02

1 OF 1

METRIC

GWP# 3076-14-00 LOCATION MTM 83-11: N 4 875 230.0 E 420 785.6 ORIGINATED BY SG
DIST Bruce HWY 9 BOREHOLE TYPE Portable Drilling: Continuous Sampling; Wash Boring (N Casing): 75 mm diameter COMPILED BY AK
DATUM Geodetic DATE 2023.10.28 - 2023.10.28 LATITUDE 44.007900 LONGITUDE -81.053576 CHECKED BY AK

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			GR	SA	SI	CL	
333.8	GROUND SURFACE						20	40	60	80	100	20	40	60						
0.0	CLAYEY SILT , trace gravel, trace sand, containing organics Very Soft Grey Moist to wet (FILL)		1	SS	1															
			2	SS	3															
			3	SS	1															
331.7			4	SS	2															
2.1	Silty CLAY , some sand, trace gravel Soft Grey Wet		5	SS	3															
330.8			6	SS	10															
3.0	Silty SAND , some gravel Compact Grey Wet																			
			7	SS	21															
328.6																				
5.2	END OF BOREHOLE AT 4.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.12.01 0.0 333.8 2024.01.31 0.0 333.8																			

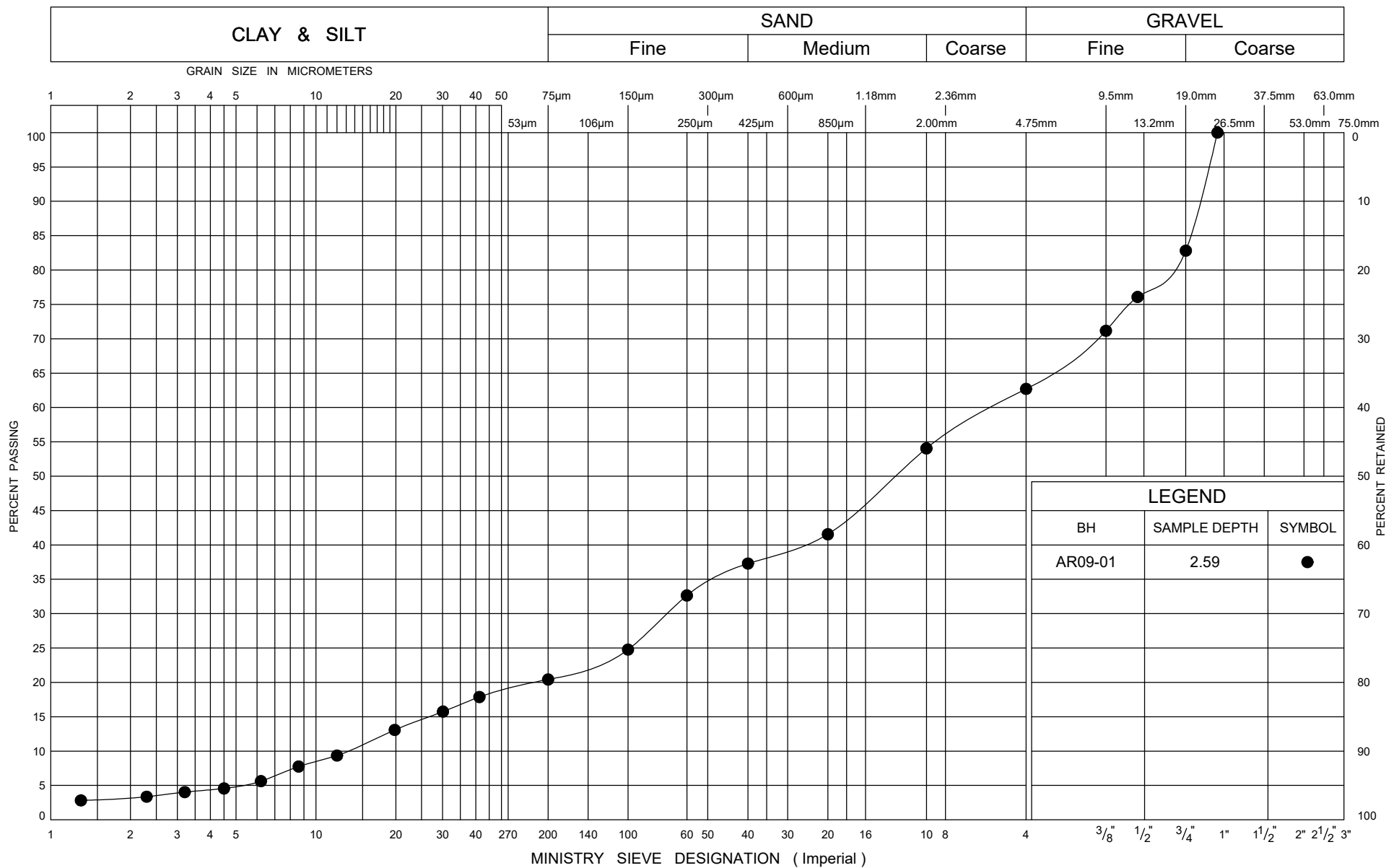
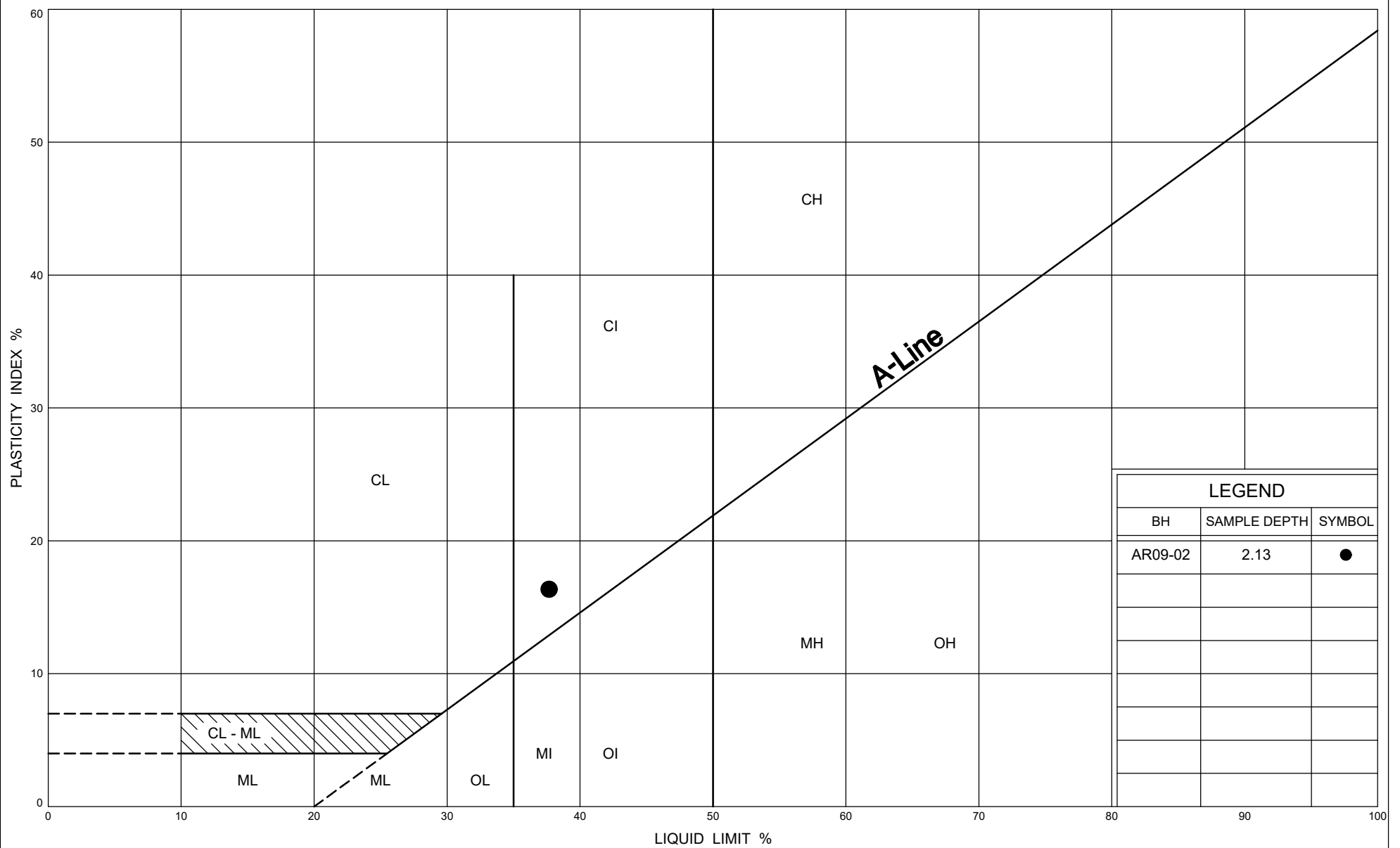




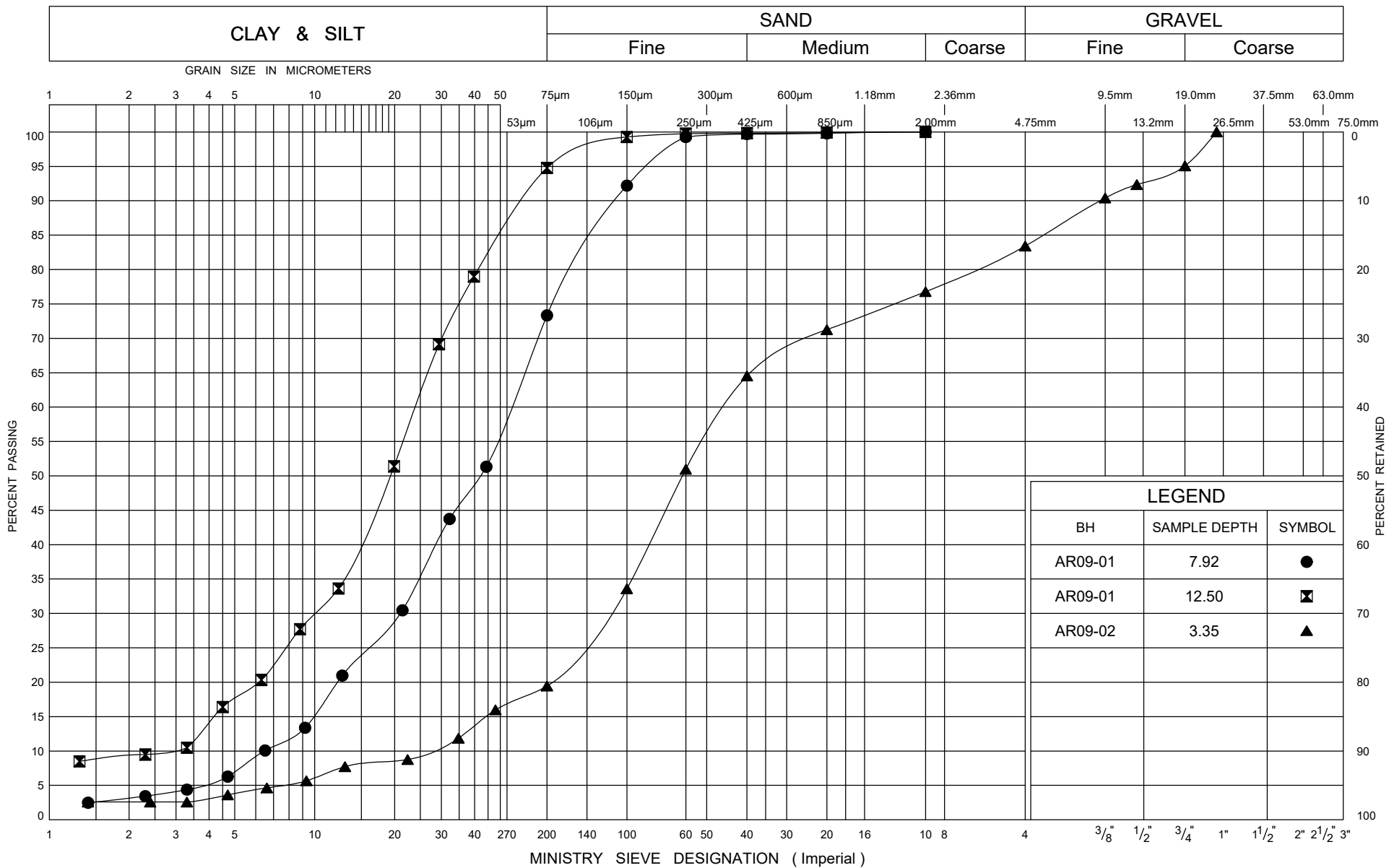
FIG No G2

GWP# 3076-14-00

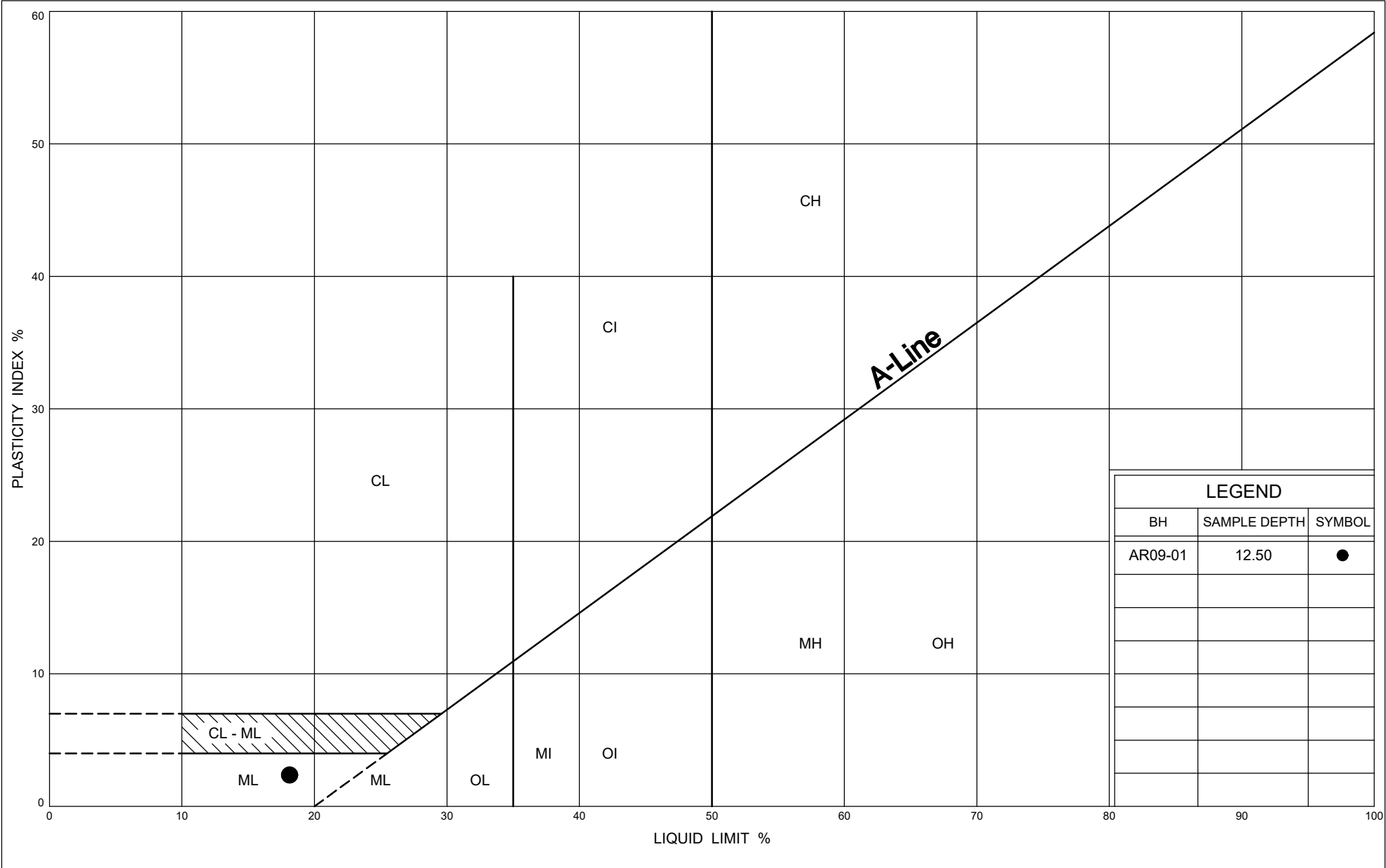


LEGEND		
BH	SAMPLE DEPTH	SYMBOL
AR09-02	2.13	●

ONTARIO MOT PLASTICITY CHART 2 MTO-34935.GPJ ONTARIO MOT.GDT 1/11/24



ONTARIO MOT PLASTICITY CHART 2 MTO-34935.GPJ ONTARIO MOT.GDT 1/11/24





APPENDIX H

Stability Figures

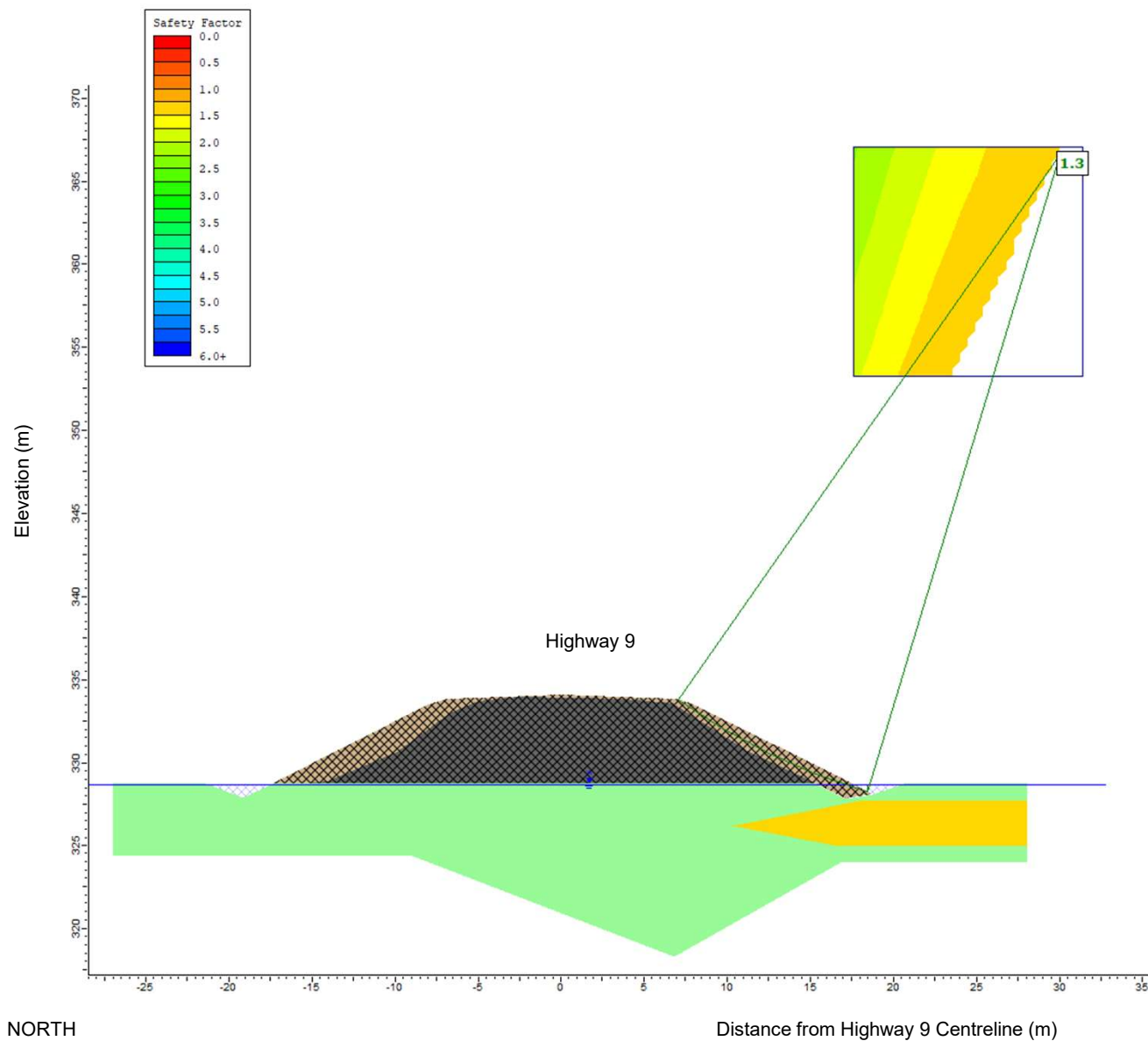
Figures H1 to H5	Highway 9 Widening Area No. 1 (EBL) – STA 19+136 to STA 19+213
Figures H6 to H10	Highway 9 Widening Area No. 2 (WBL) – STA 19+140 to STA 19+235
Figures H11 to H15	Highway 9 Widening Area No. 3 (EBL) – STA 19+635 to STA 19+825
Figures H16 to H19	Highway 9 Widening Area No. 4 (WBL) – STA 19+630 to STA 19+765
Figures H20 to H24	Highway 9 Widening Area No. 5 (WBL) – STA 22+568 to STA 22+595
Figures H25 to H28	Highway 9 Widening Area No. 6 (EBL) – STA 23+370 to STA 23+503
Figures H29 to H33	Highway 9 Widening Area No. 7 (WBL) – STA 23+365 to STA 23+530
Figures H34 to H38	Highway 9 Widening Area No. 8 (WBL) – STA 23+890 to STA 23+937
Figures H39 to H41	Highway 9 Widening Area No. 9 (EBL) – STA 24+130 to STA 24+205

Highway 9 Mildmay Embankment Widening - Area 1, EBL STA 19+175

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2H:1V Side Slope

Figure H1



Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (°)
Existing Embankment Fill		21	Mohr-Coulomb	0	32
Granular B Type I		22	Mohr-Coulomb	0	32
Clayey Silt-Silt to Silty Clay - Drained		20.5	Mohr-Coulomb	0	30
Silty Sand Interlayer		21.5	Mohr-Coulomb	0	31

Note:

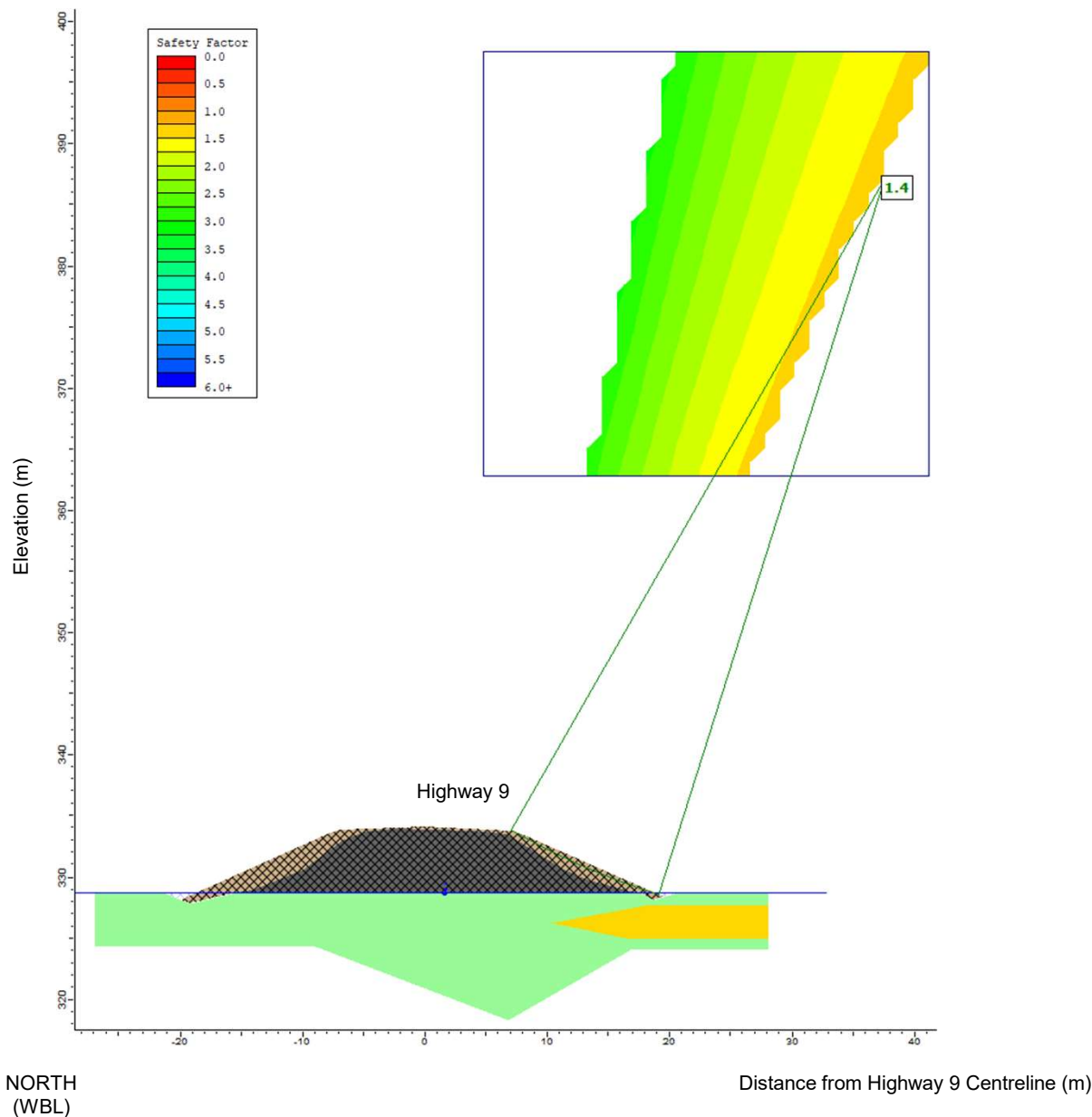
1. The placement of new granular fill should be carried out in accordance with OPSP 208.010 (Benching of Earth Slopes) to integrate the new granular fill into the existing embankment side slopes.

Highway 9 Mildmay Embankment Widening - Area 1, EBL STA 19+175

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2.25H:1V Side Slope

Figure H2



Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (°)
Existing Embankment Fill		21	Mohr-Coulomb	0	32
Granular B Type I		22	Mohr-Coulomb	0	32
Clayey Silt-Silt to Silty Clay - Drained		20.5	Mohr-Coulomb	0	30
Silty Sand Interlayer		21.5	Mohr-Coulomb	0	31

Note:

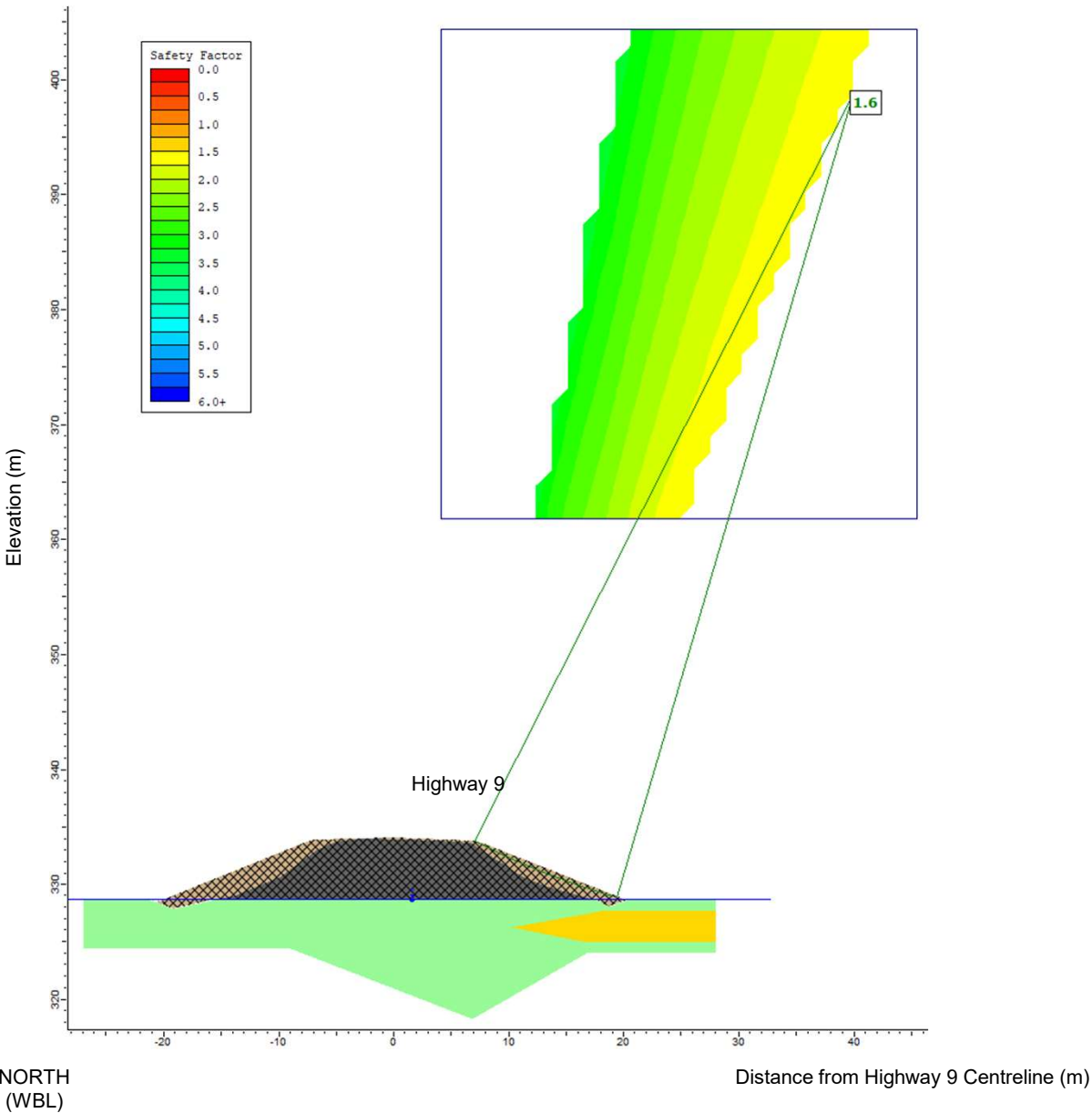
1. The placement of new granular fill should be carried out in accordance with OPSD 208.010 (Benching of Earth Slopes) to integrate the new granular fill into the existing embankment side slopes.

Highway 9 Mildmay Embankment Widening - Area 1, EBL STA 19+175

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2.5H:1V Side Slope

Figure H3



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)
Existing Embankment Fill		21	Mohr-Coulomb	0	32
Granular B Type I		22	Mohr-Coulomb	0	32
Clayey Silt-Silt to Silty Clay - Drained		20.5	Mohr-Coulomb	0	30
Silty Sand Interlayer		21.5	Mohr-Coulomb	0	31

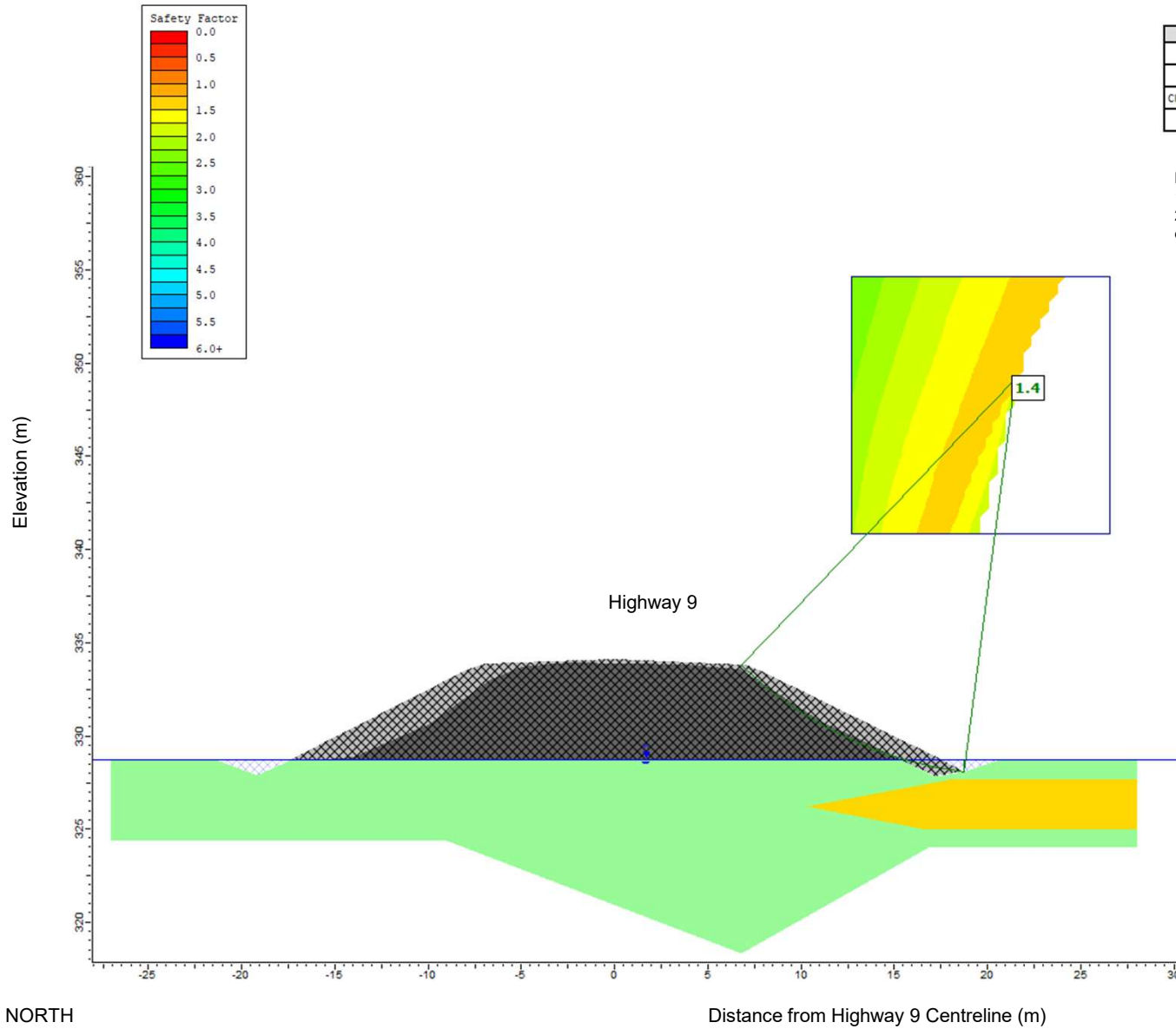
Note:
 1 . The placement of new granular fill should be carried out in accordance with OPSD 208.010 (Benching of Earth Slopes) to integrate the new granular fill into the existing embankment side slopes.

Highway 9 Mildmay Embankment Widening - Area 1, EBL STA 19+175

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II Fill Embankment Widening with 2H:1V Side Slope

Figure H4



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)
Existing Embankment Fill		21	Mohr-Coulomb	0	32
Granular B Type II		22	Mohr-Coulomb	0	35
Clayey Silt-Silt to Silty Clay - Drained		20.5	Mohr-Coulomb	0	30
Silty Sand Interlayer		21.5	Mohr-Coulomb	0	31

Note:

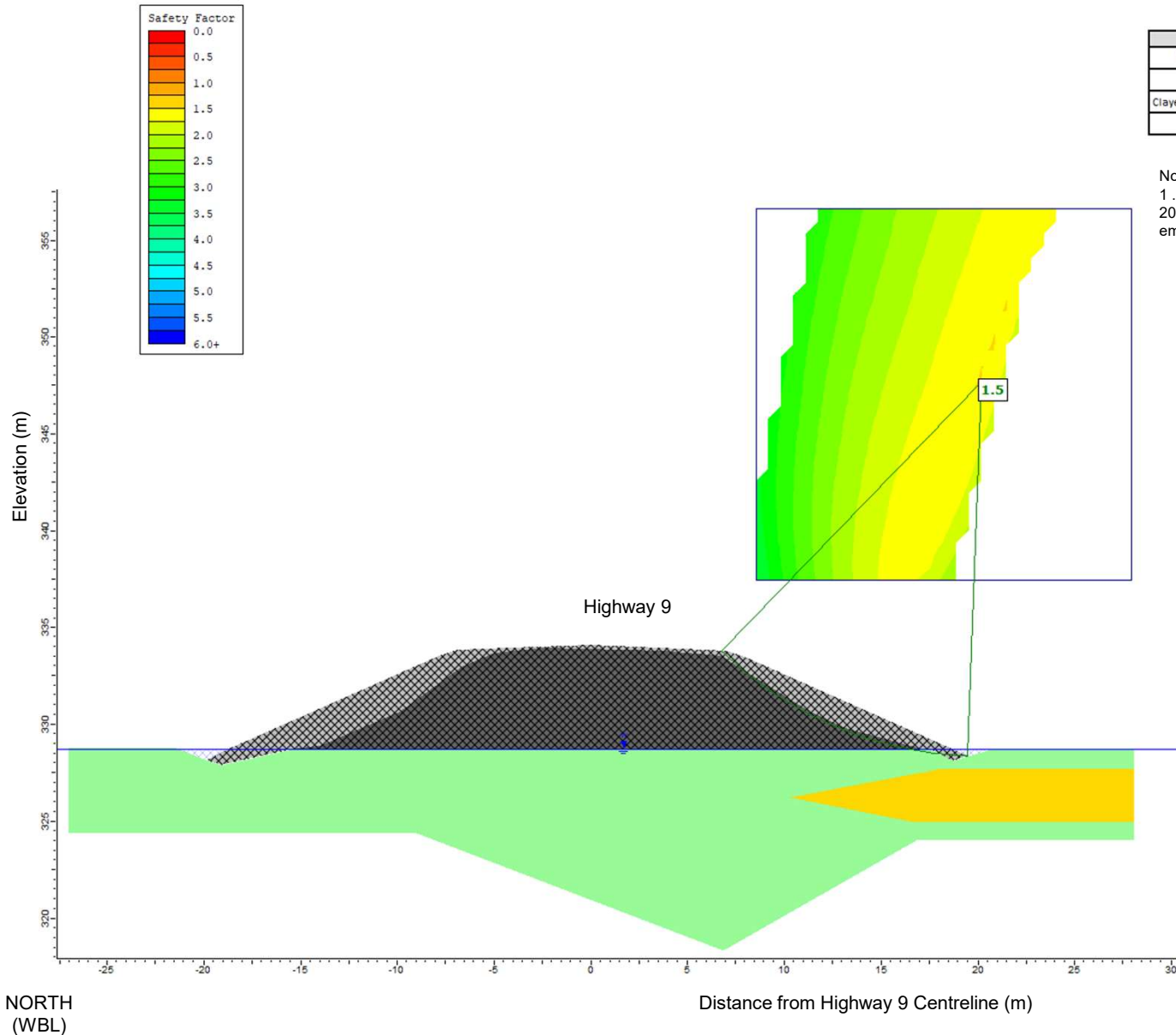
1. The placement of new granular fill should be carried out in accordance with OPSD 208.010 (Benching of Earth Slopes) to integrate the new granular fill into the existing embankment side slopes.

Highway 9 Mildmay Embankment Widening - Area 1, EBL STA 19+175

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II Fill Embankment Widening with 2.25H:1V Side Slope

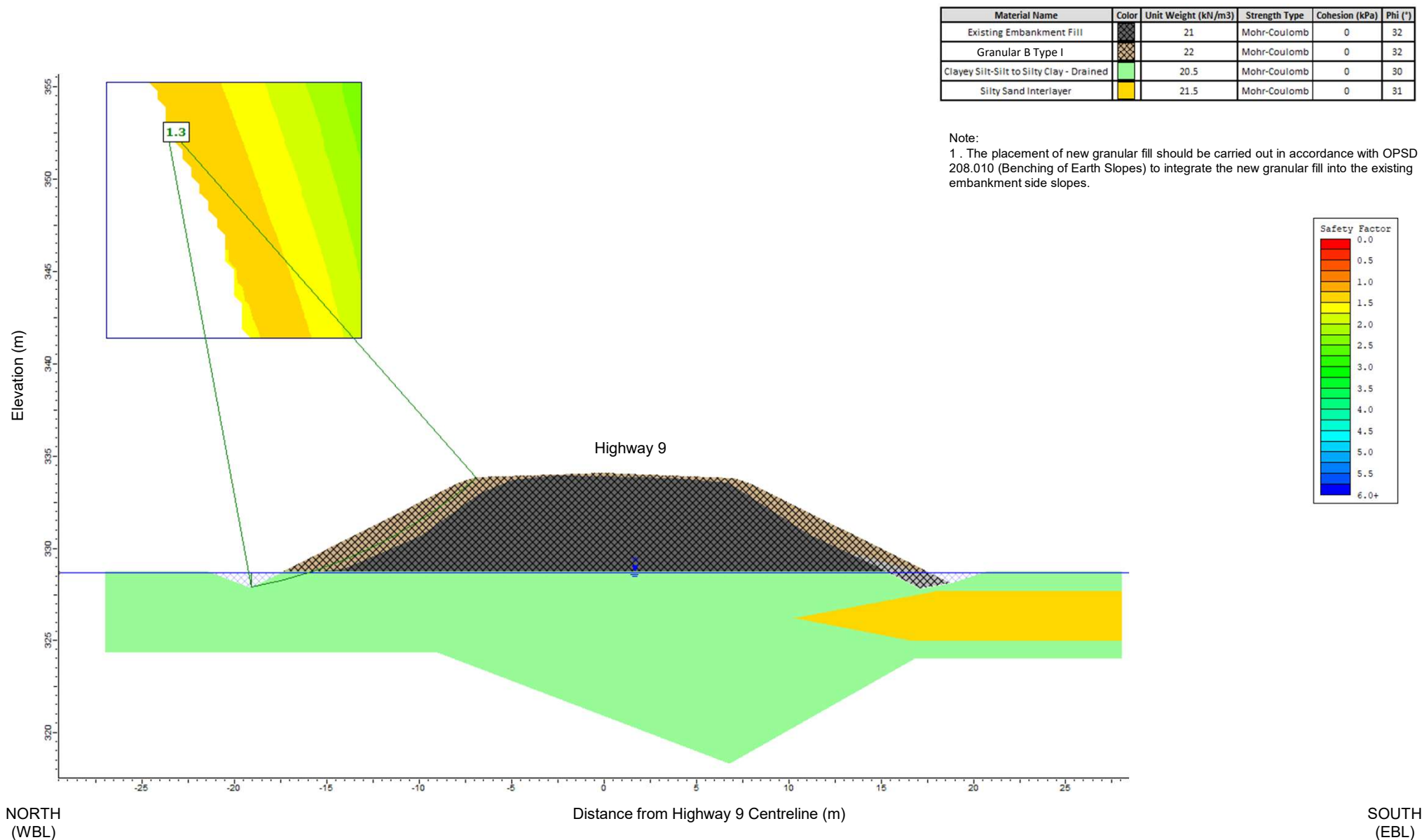
Figure H5



Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (°)
Existing Embankment Fill		21	Mohr-Coulomb	0	32
Granular B Type II		22	Mohr-Coulomb	0	35
Clayey Silt-Silt to Silty Clay - Drained		20.5	Mohr-Coulomb	0	30
Silty Sand Interlayer		21.5	Mohr-Coulomb	0	31

Note:

1. The placement of new granular fill should be carried out in accordance with OPSD 208.010 (Benching of Earth Slopes) to integrate the new granular fill into the existing embankment side slopes.

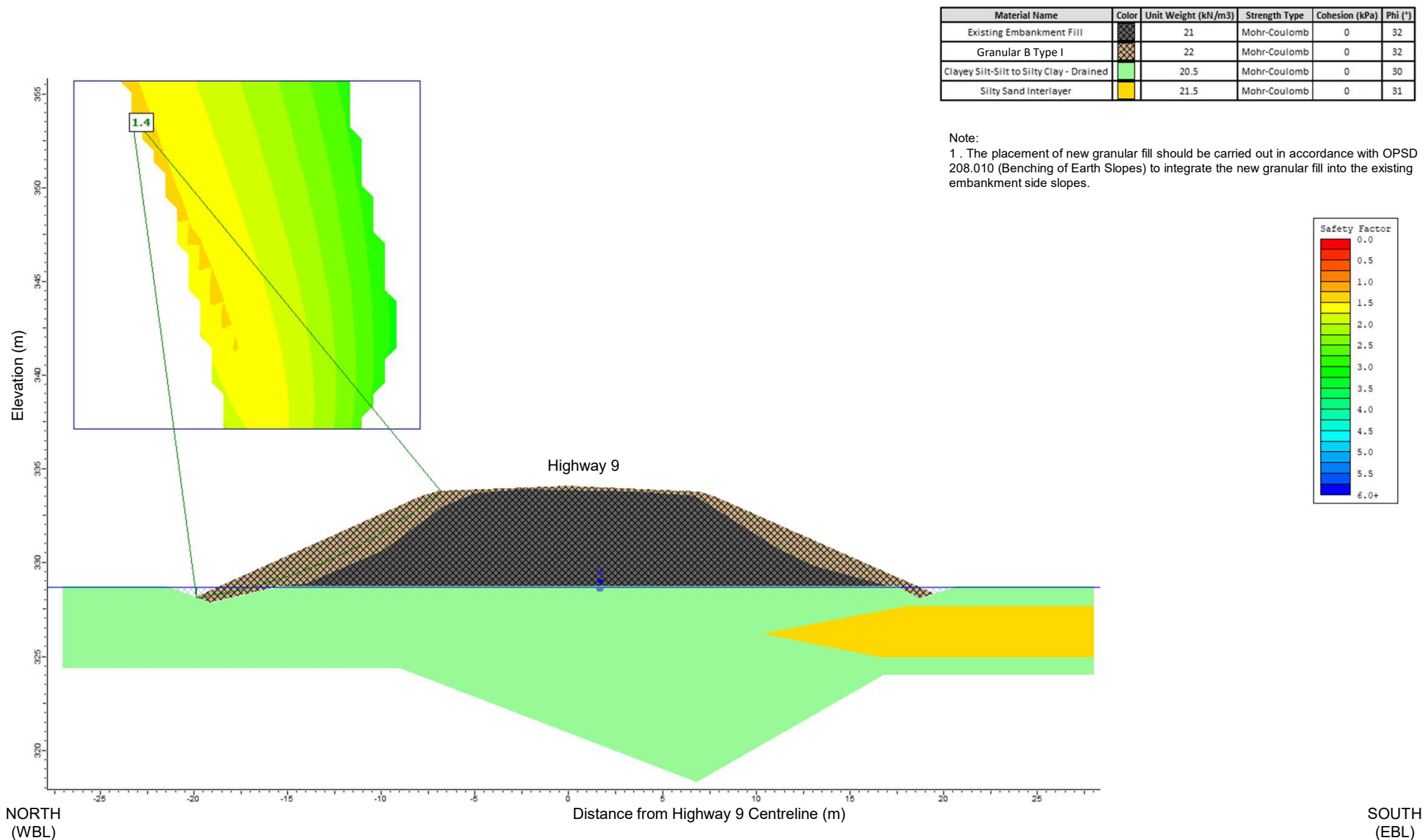


Highway 9 Mildmay Embankment Widening - Area 2, WBL STA 19+175

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2.25H:1V Side Slope

Figure H7

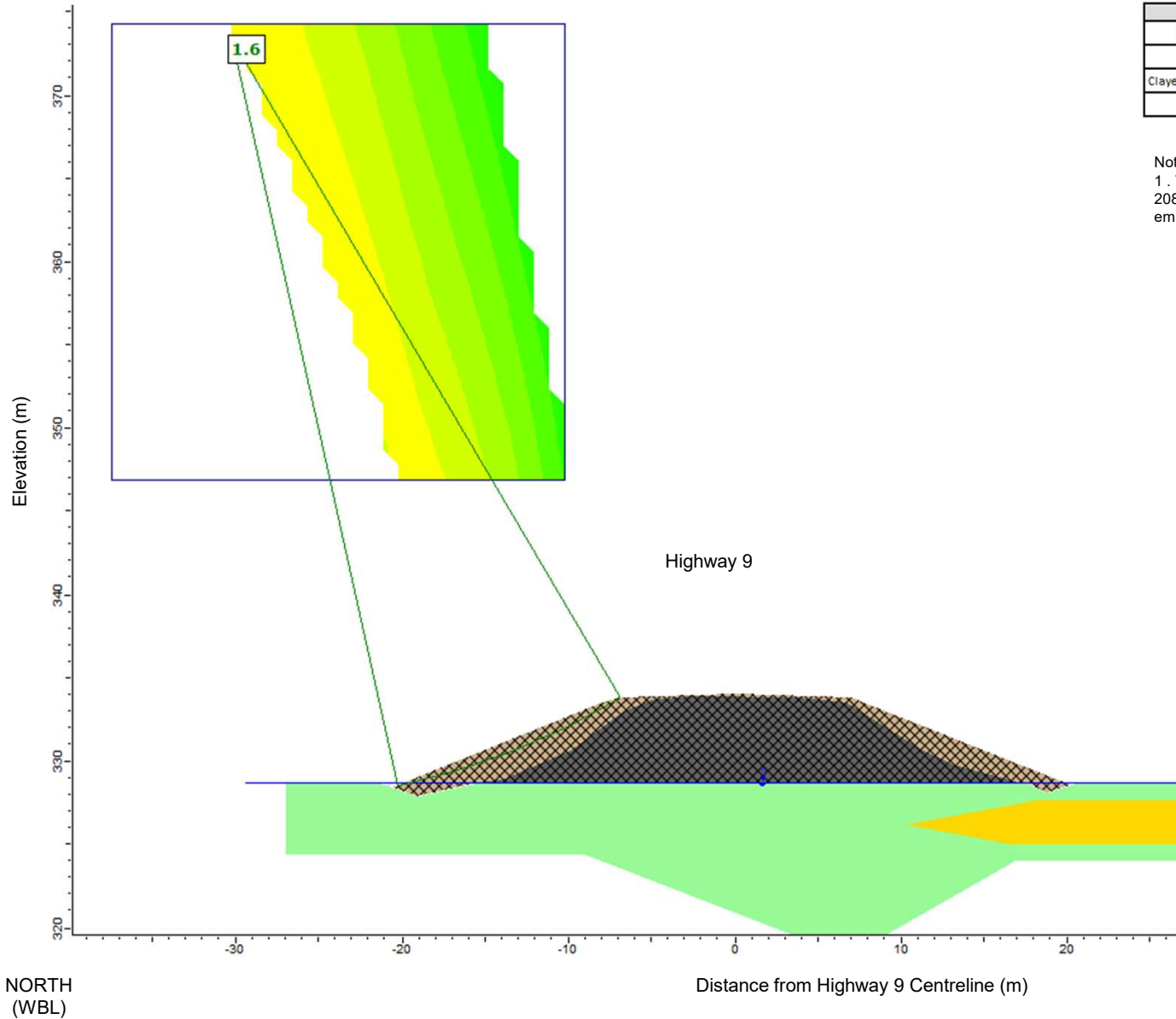


Highway 9 Mildmay Embankment Widening - Area 2, WBL STA 19+175

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2.5H:1V Side Slope

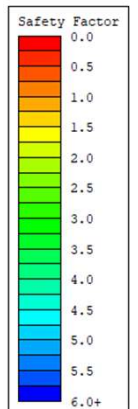
Figure H8



Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (°)
Existing Embankment Fill		21	Mohr-Coulomb	0	32
Granular B Type I		22	Mohr-Coulomb	0	32
Clayey Silt-Silt to Silty Clay - Drained		20.5	Mohr-Coulomb	0	30
Silty Sand Interlayer		21.5	Mohr-Coulomb	0	31

Note:

1. The placement of new granular fill should be carried out in accordance with OPSD 208.010 (Benching of Earth Slopes) to integrate the new granular fill into the existing embankment side slopes.

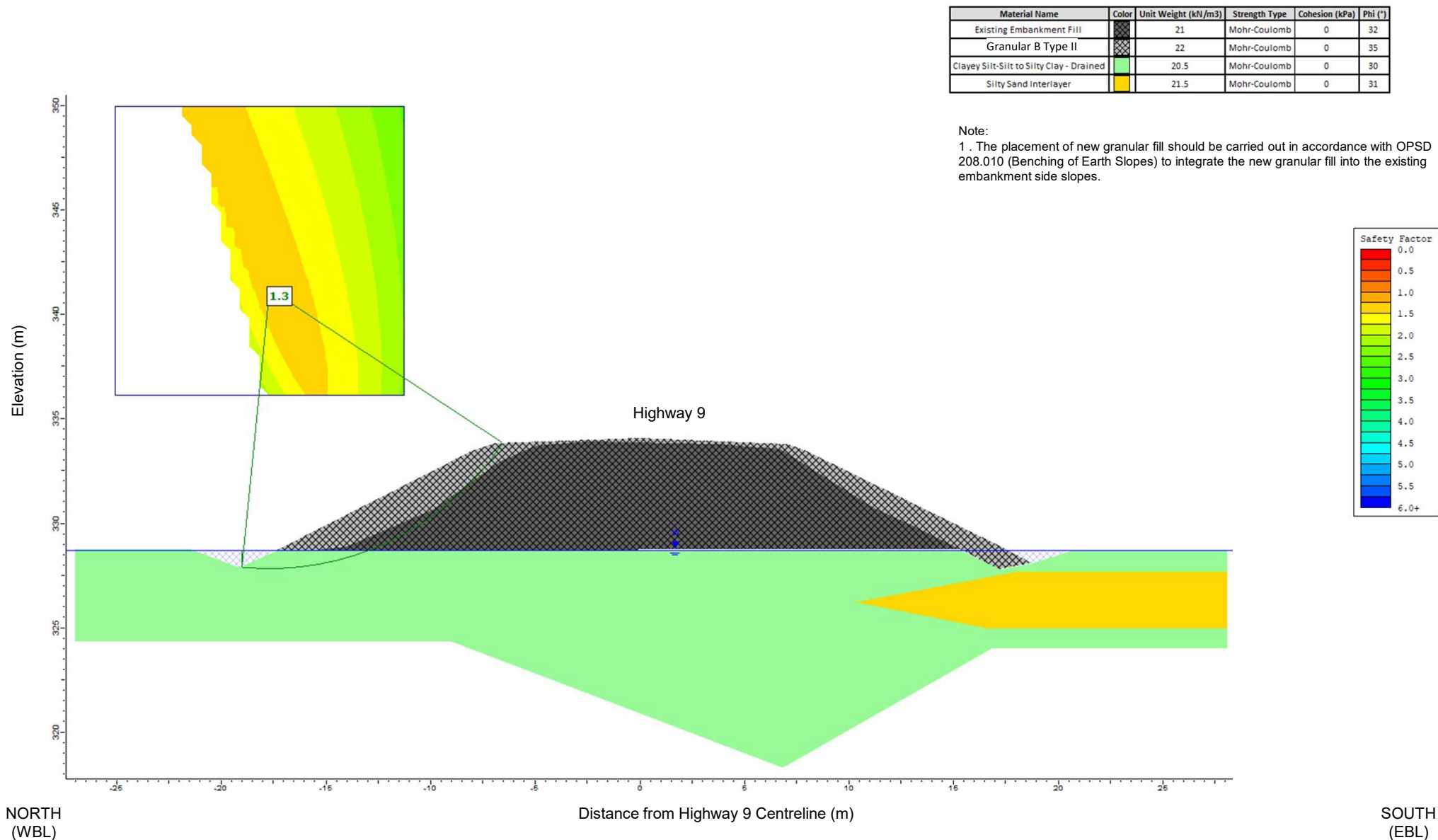


Highway 9 Mildmay Embankment Widening - Area 2, WBL STA 19+175

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II Fill Embankment Widening with 2H:1V Side Slope

Figure H9

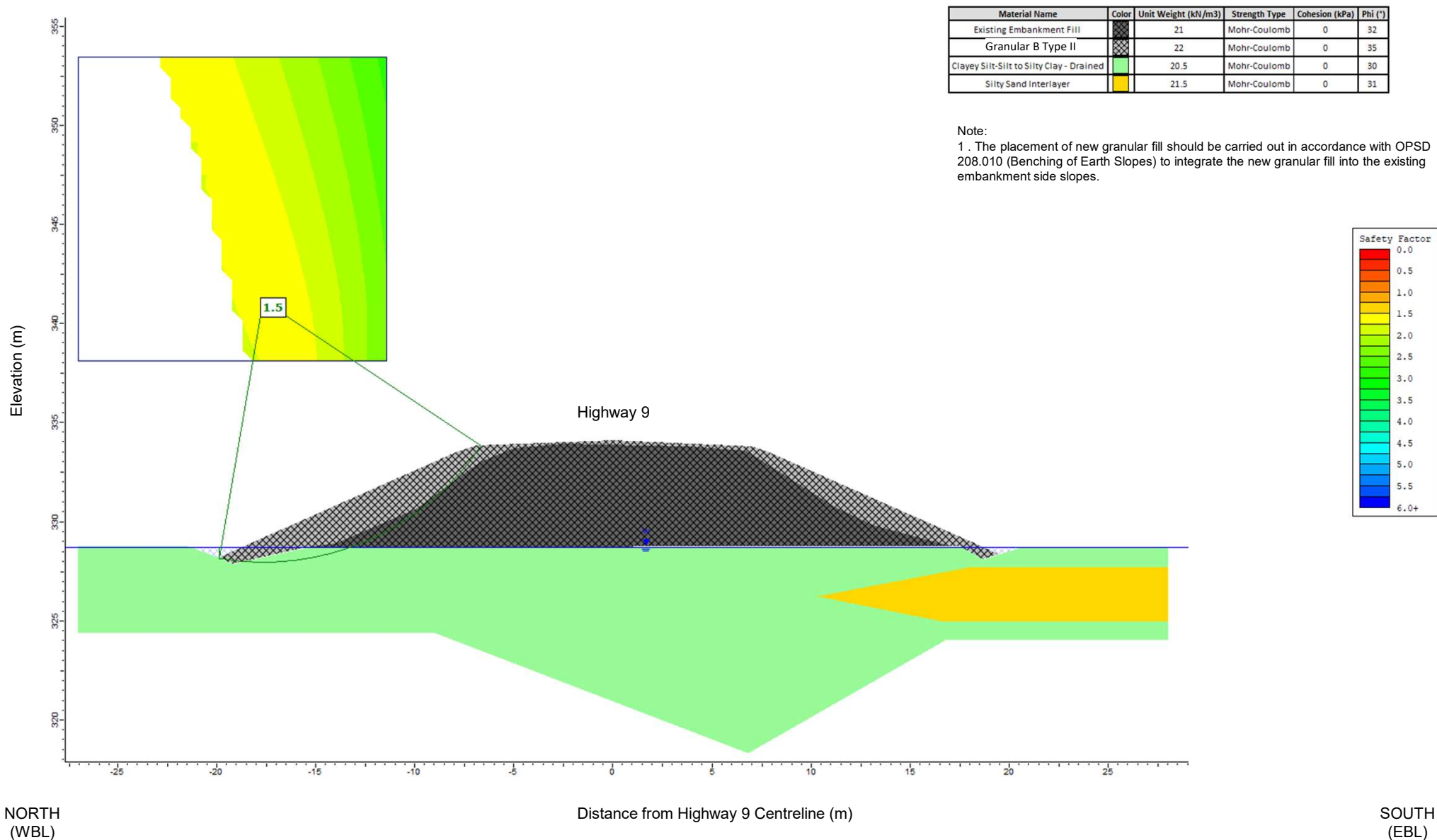


Highway 9 Mildmay Embankment Widening - Area 2, WBL STA 19+175

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II Fill Embankment Widening with 2.25H:1V Side Slope

Figure H10

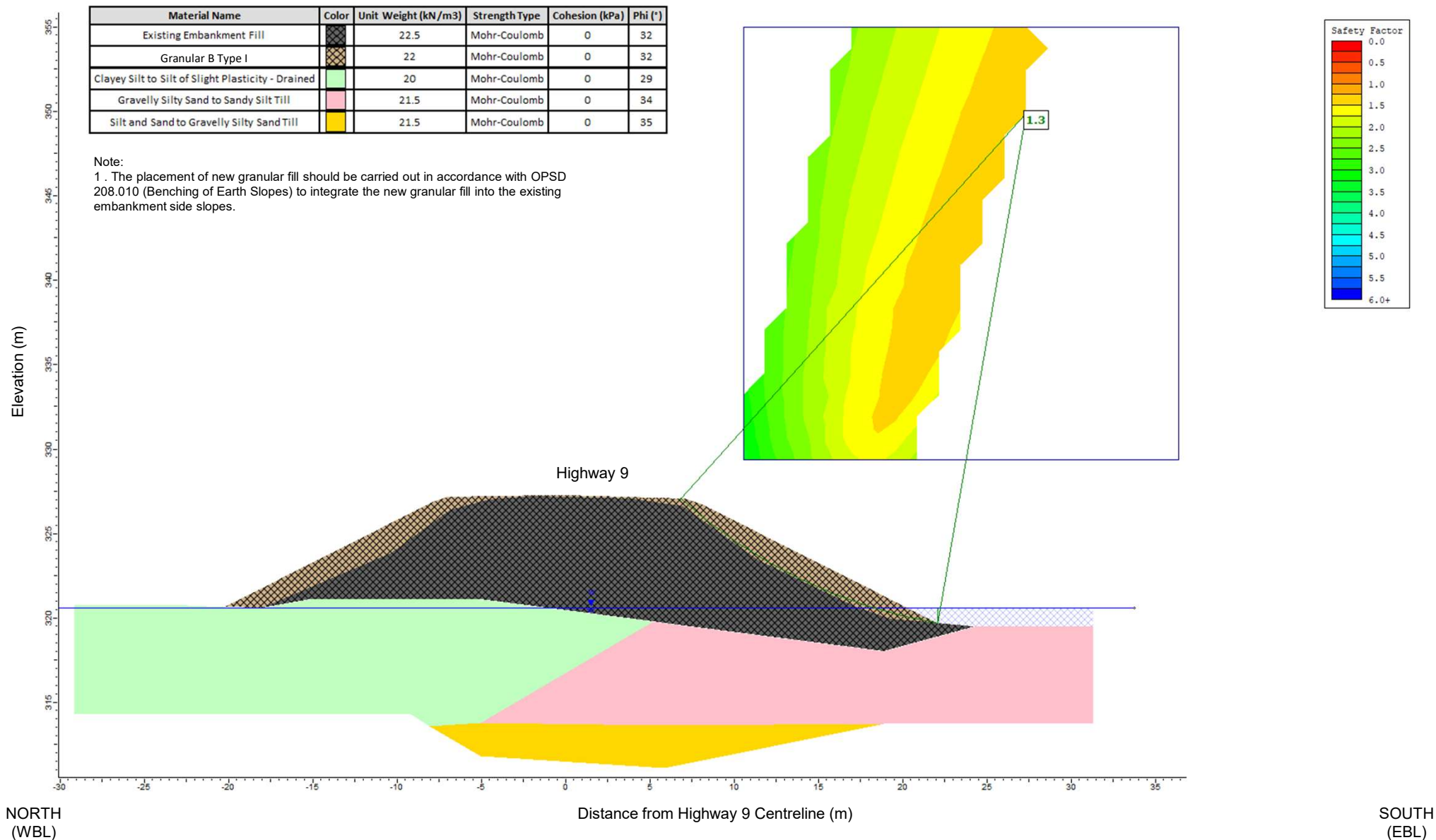


Highway 9 Mildmay Embankment Widening - Area 3, EBL STA 19+700

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2H:1V Side Slope

Figure H11

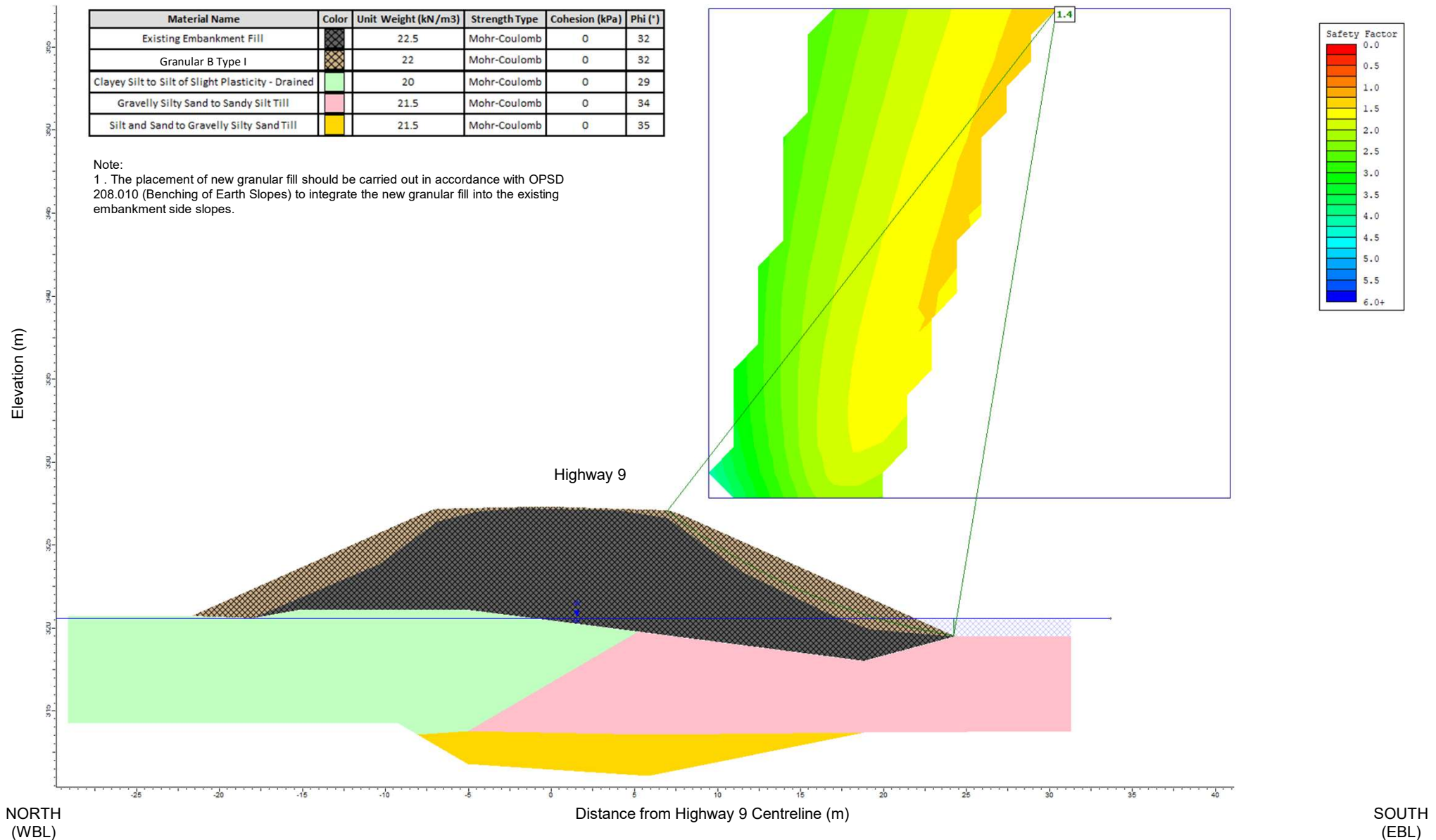


Highway 9 Mildmay Embankment Widening - Area 3, EBL STA 19+700

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2.25H:1V Side Slope

Figure H12

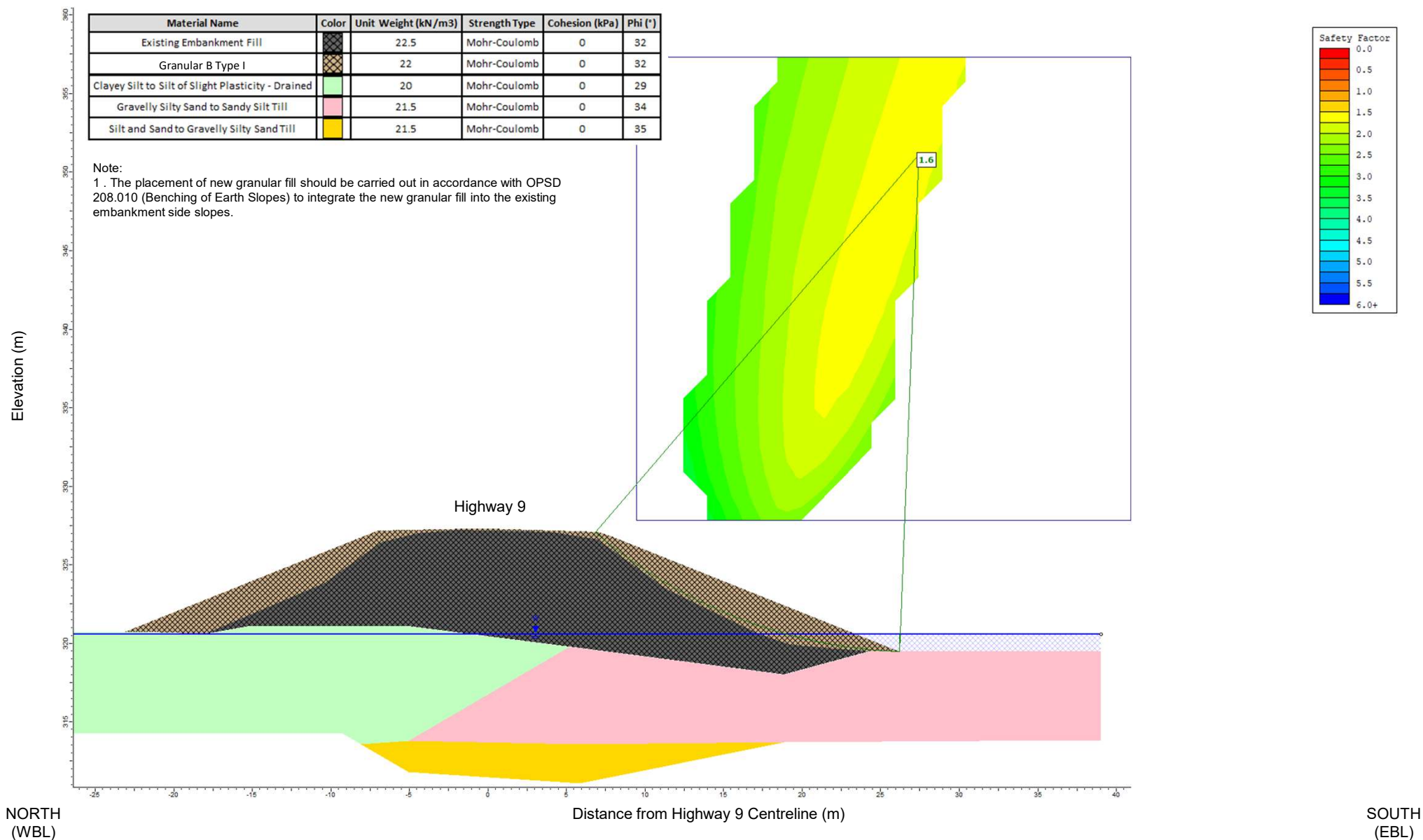


Highway 9 Mildmay Embankment Widening - Area 3, EBL STA 19+700

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2.5H:1V Side Slope

Figure H13

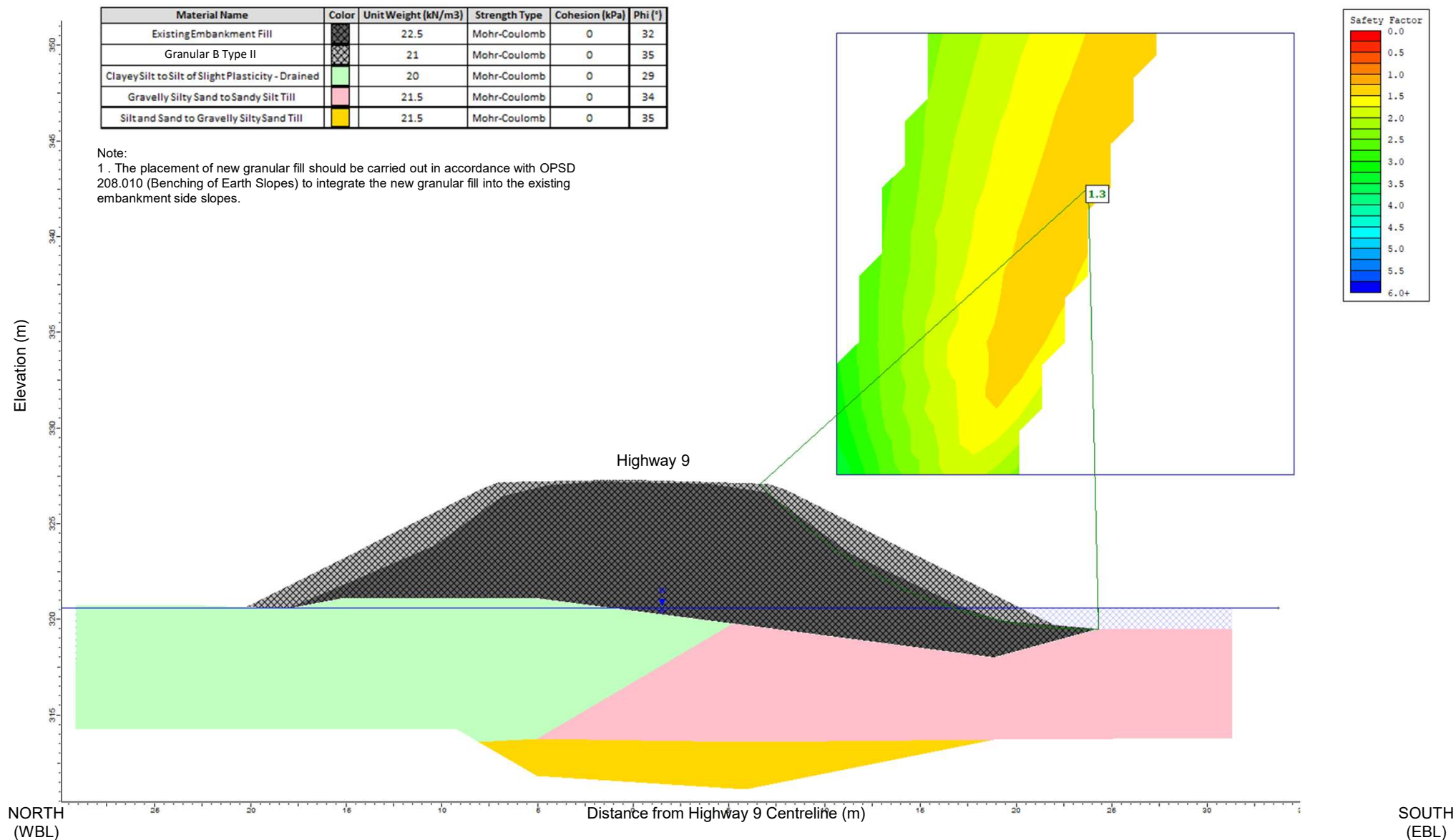


Highway 9 Mildmay Embankment Widening - Area 3, EBL STA 19+700

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II Fill Embankment Widening with 2H:1V Side Slope

Figure H14

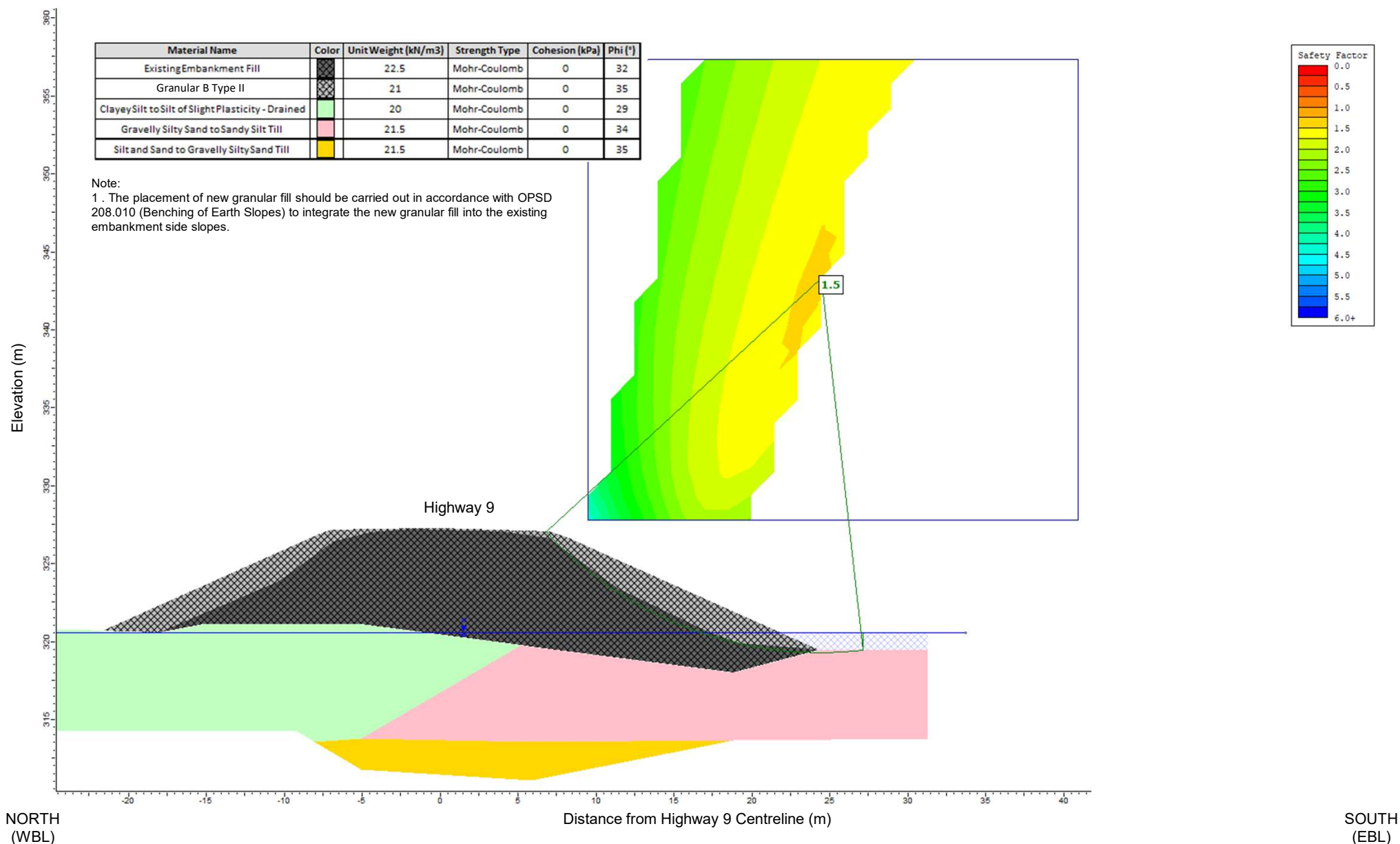


Highway 9 Mildmay Embankment Widening - Area 3, EBL STA 19+700

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II Fill Embankment Widening with 2.25H:1V Side Slope

Figure H15

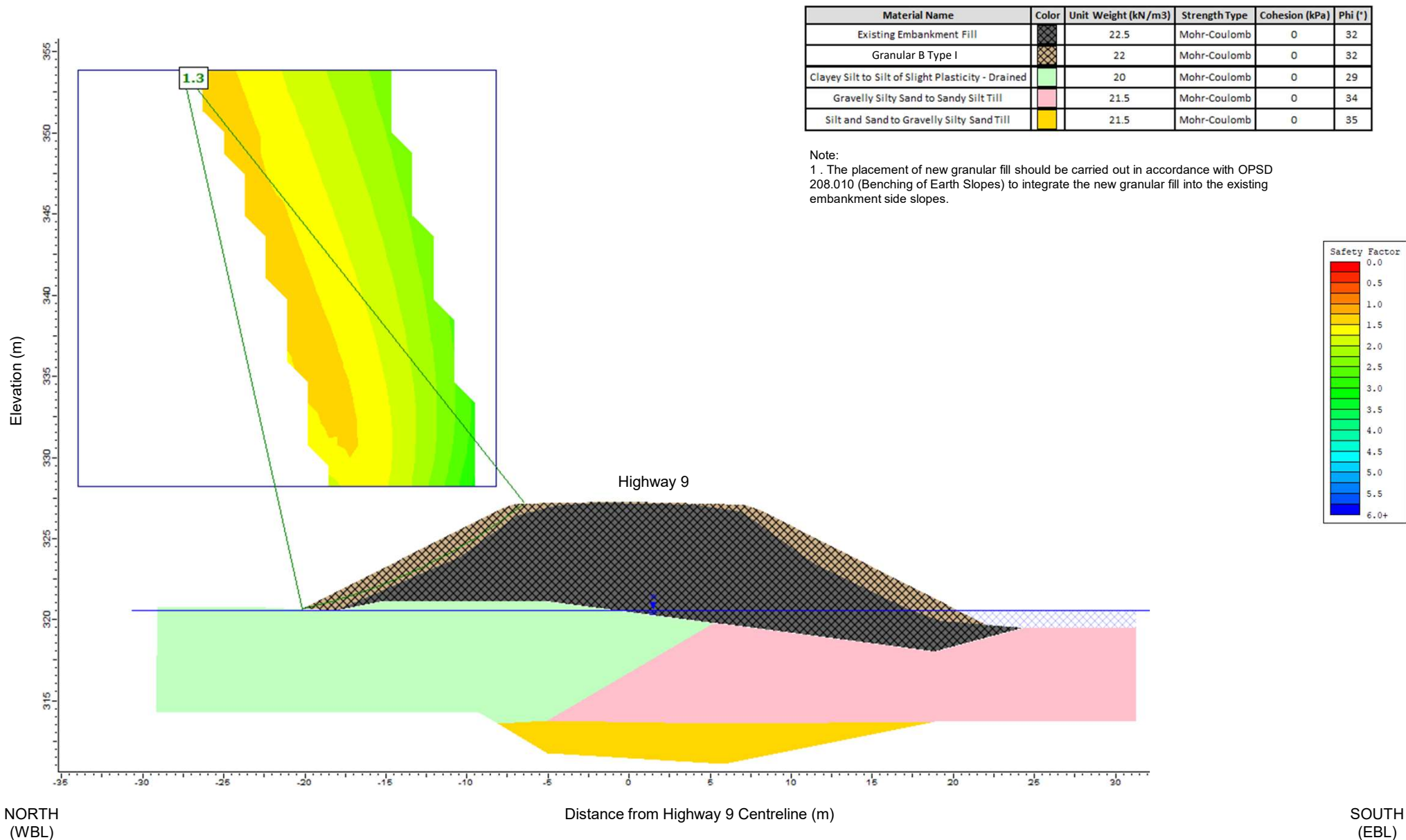


Highway 9 Mildmay Embankment Widening - Area 4, WBL STA 19+700

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2H:1V Side Slope

Figure H16

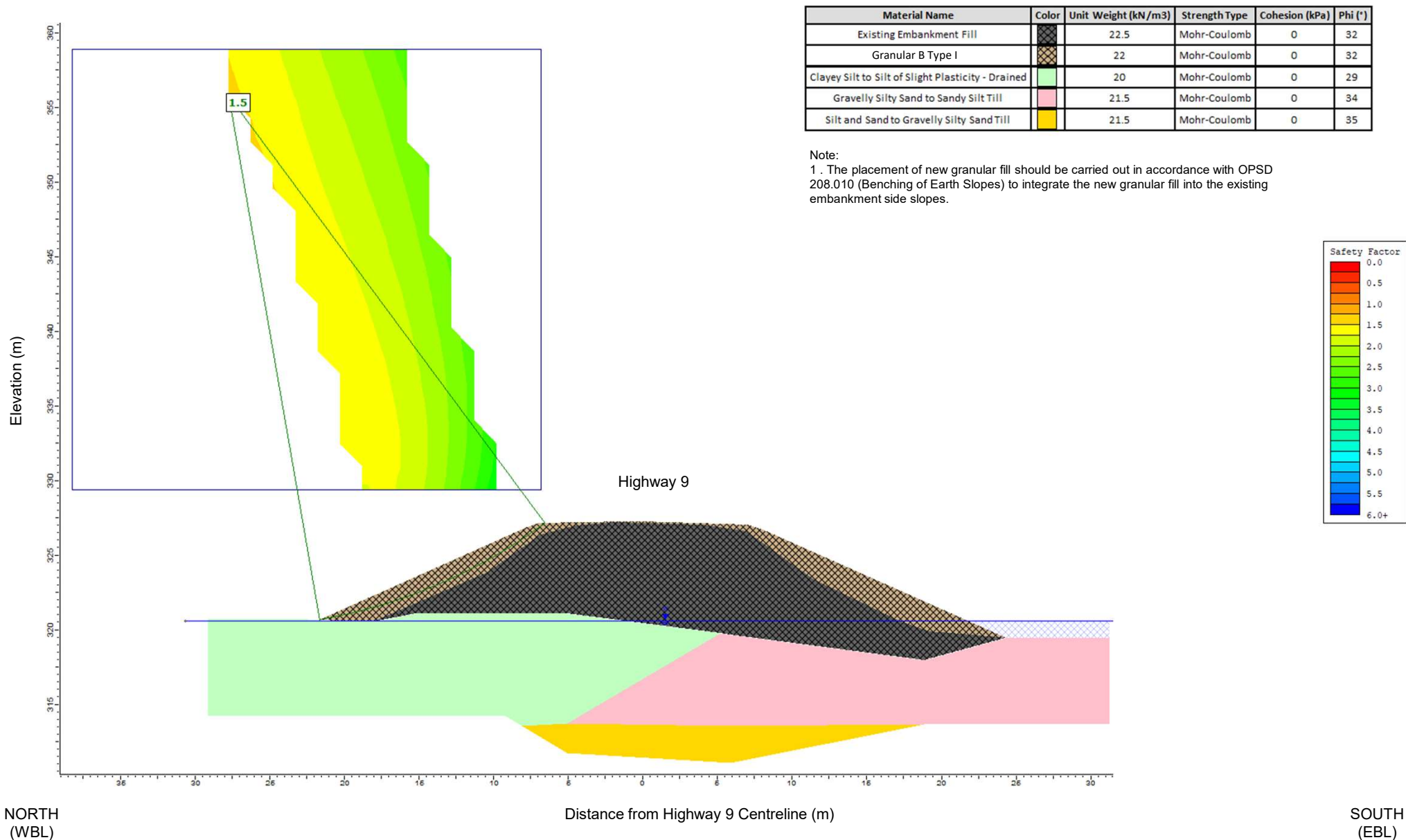


Highway 9 Mildmay Embankment Widening - Area 4, WBL STA 19+700

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2.25H:1V Side Slope

Figure H17

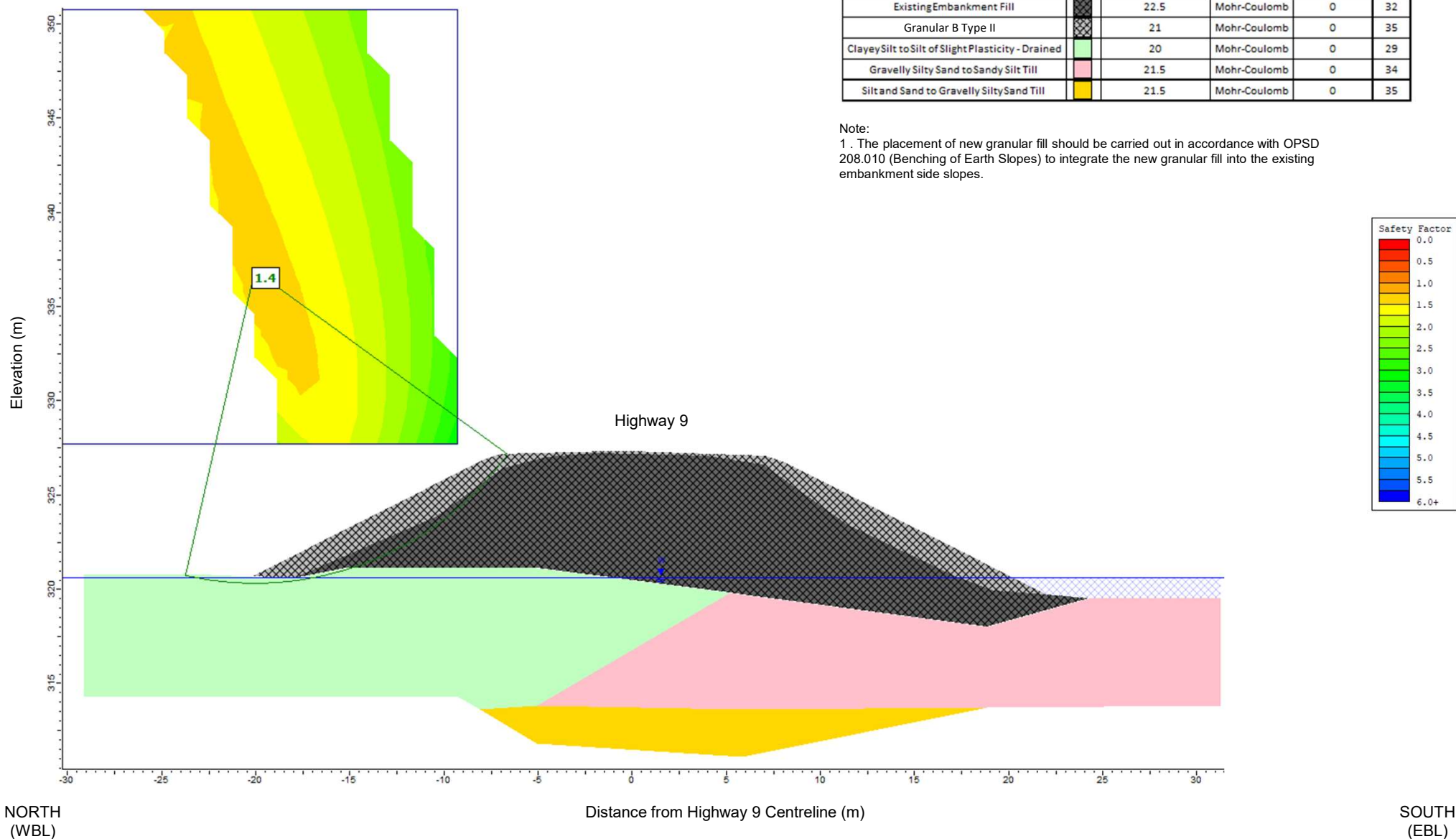


Highway 9 Mildmay Embankment Widening - Area 4, WBL STA 19+700

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II Fill Embankment Widening with 2H:1V Side Slope

Figure H18

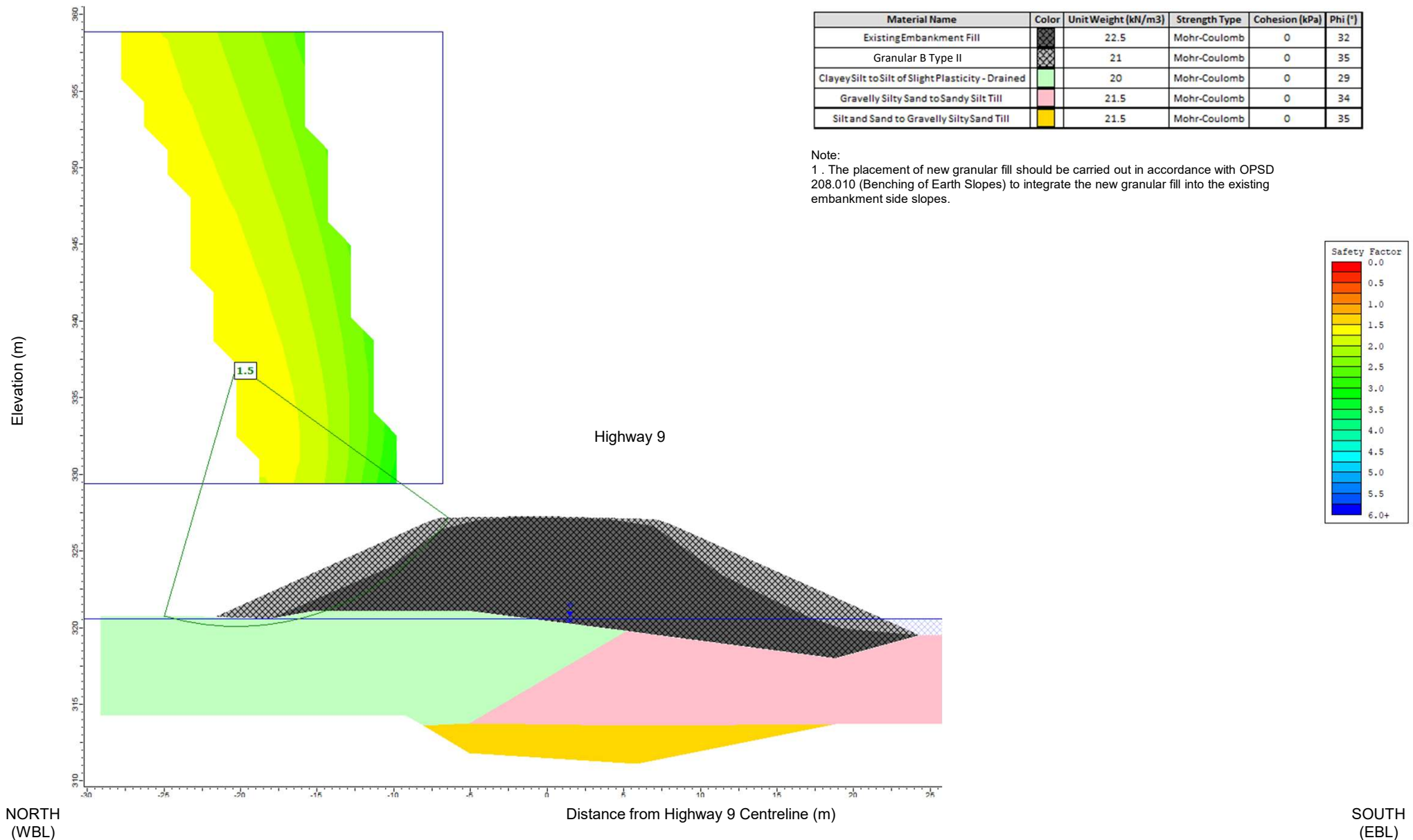


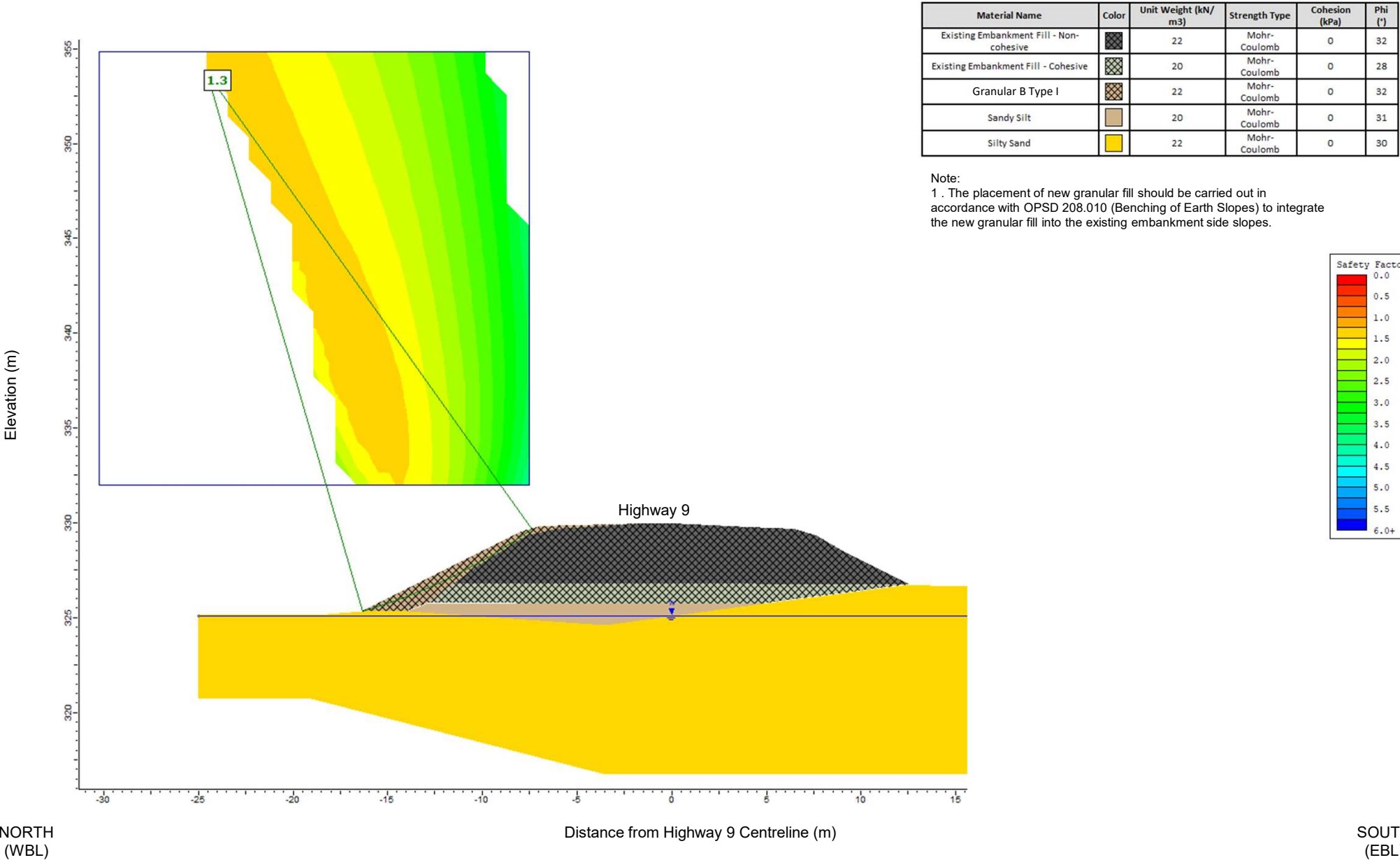
Highway 9 Mildmay Embankment Widening - Area 4, WBL STA 19+700

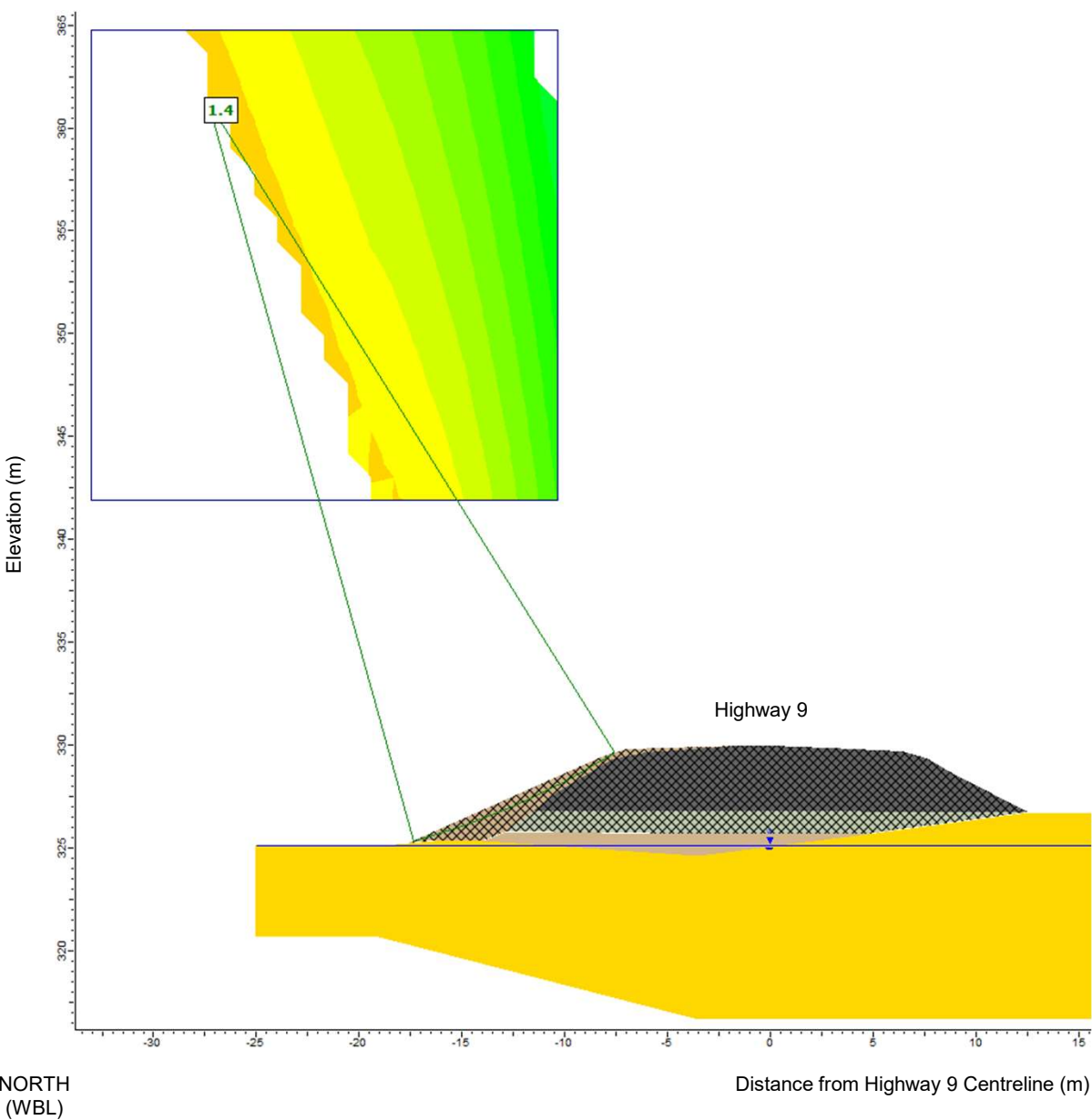
Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II Fill Embankment Widening with 2.25H:1V Side Slope

Figure H19

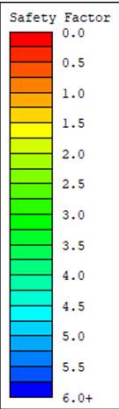






Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (°)
Existing Embankment Fill - Non-cohesive		22	Mohr-Coulomb	0	32
Existing Embankment Fill - Cohesive		20	Mohr-Coulomb	0	28
Granular B Type I		22	Mohr-Coulomb	0	32
Sandy Silt		20	Mohr-Coulomb	0	31
Silty Sand		22	Mohr-Coulomb	0	30

Note:
 1 . The placement of new granular fill should be carried out in accordance with OPSD 208.010 (Benching of Earth Slopes) to integrate the new granular fill into the existing embankment side slopes.

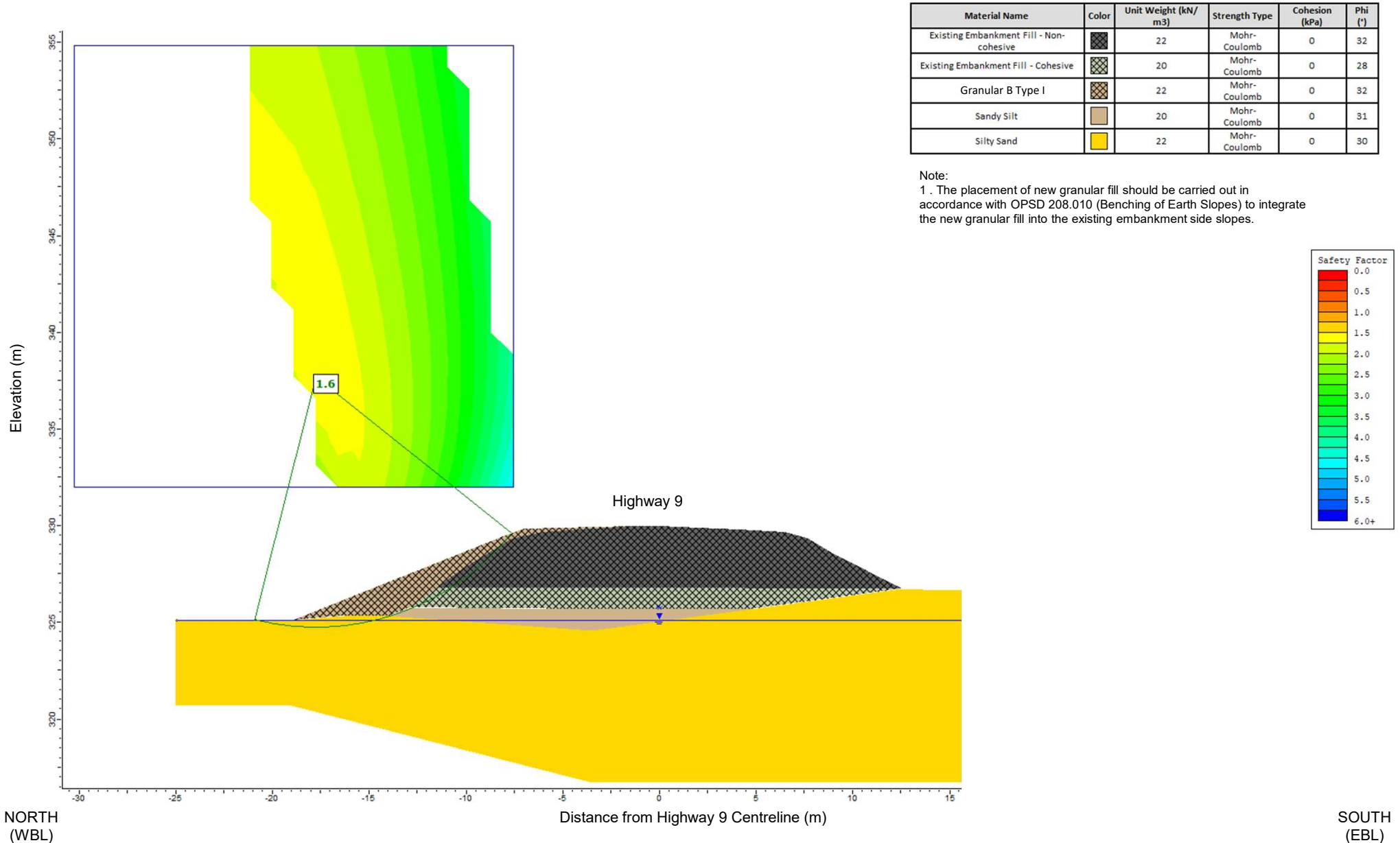


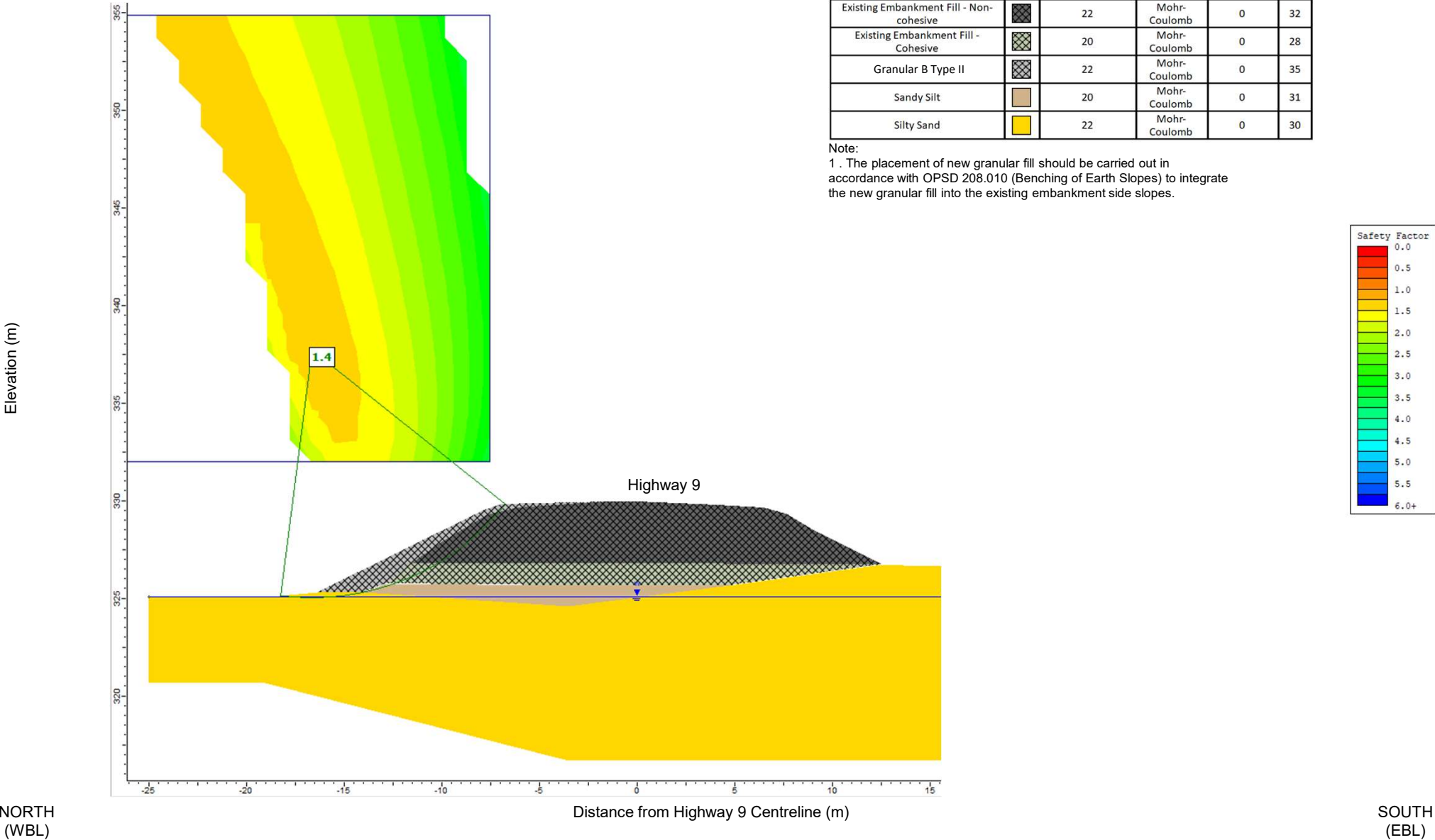
Highway 9 Mildmay Embankment Widening - Area 5, WBL STA 22+575

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2.5H:1V Side Slope

Figure H22



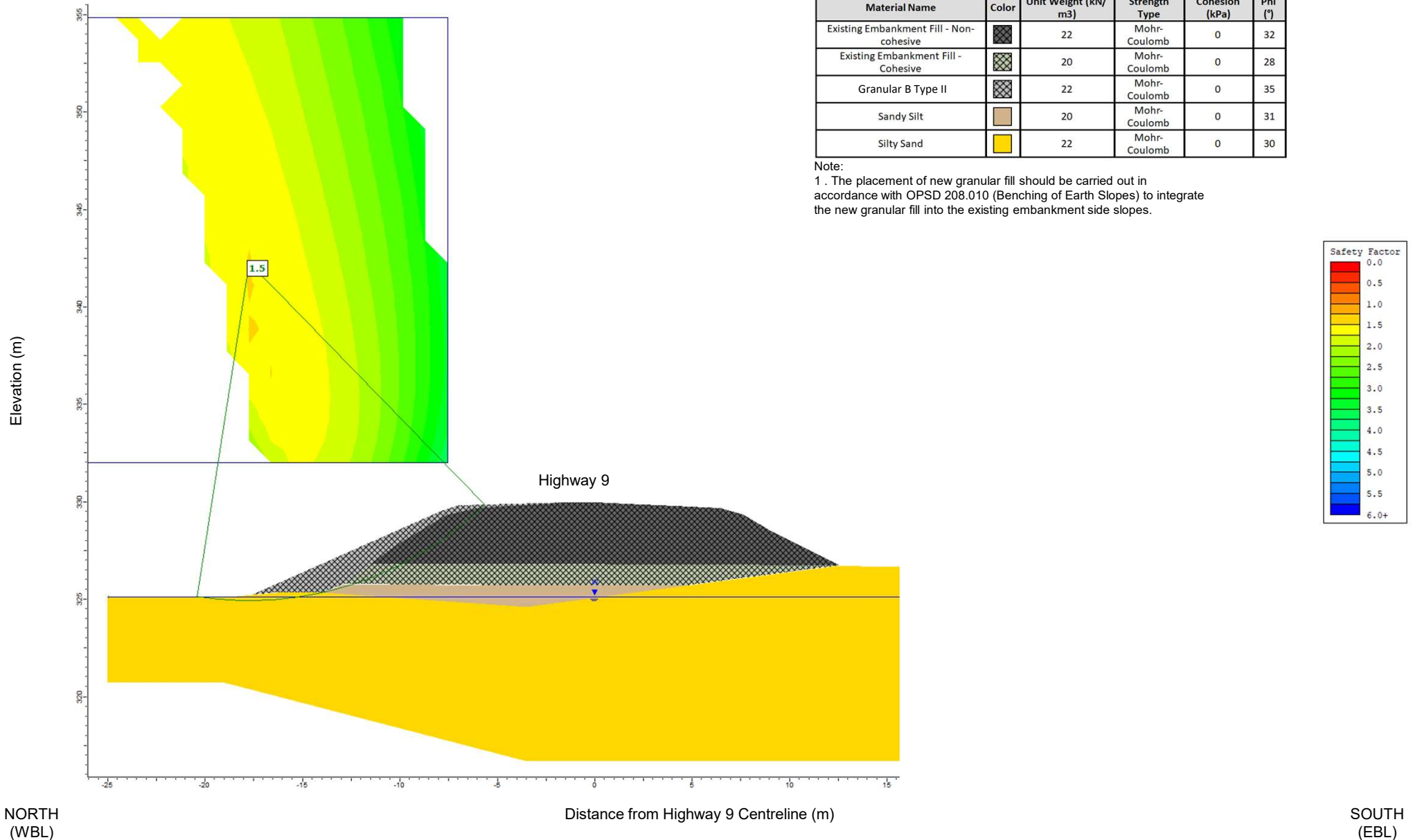


Highway 9 Mildmay Embankment Widening - Area 5, WBL STA 22+575

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II Fill Embankment Widening with 2.25H:1V Side Slope

Figure H24

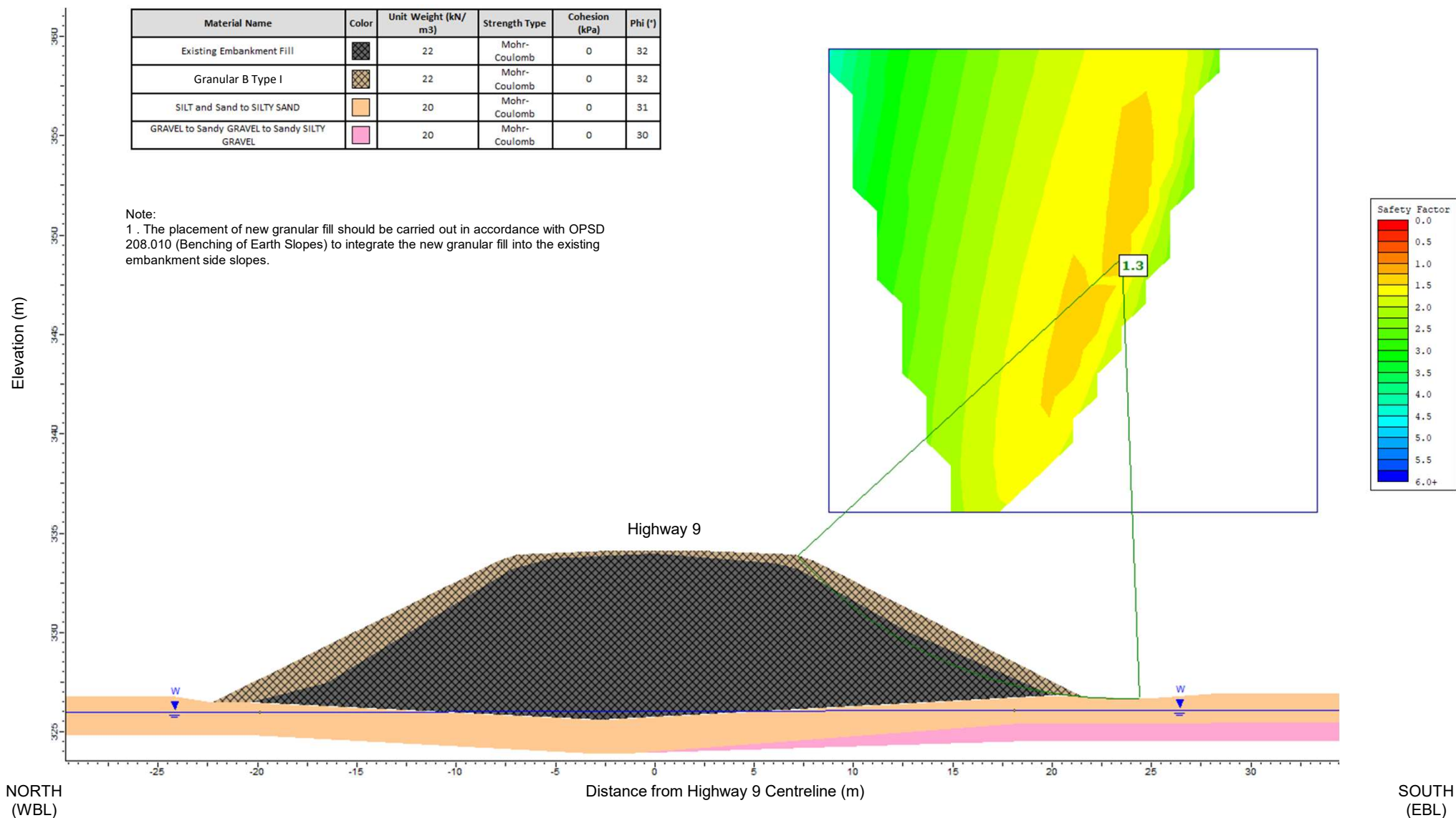


Highway 9 Mildmay Embankment Widening - Area 6, EBL STA 23+450

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2H:1V Side Slope

Figure H25

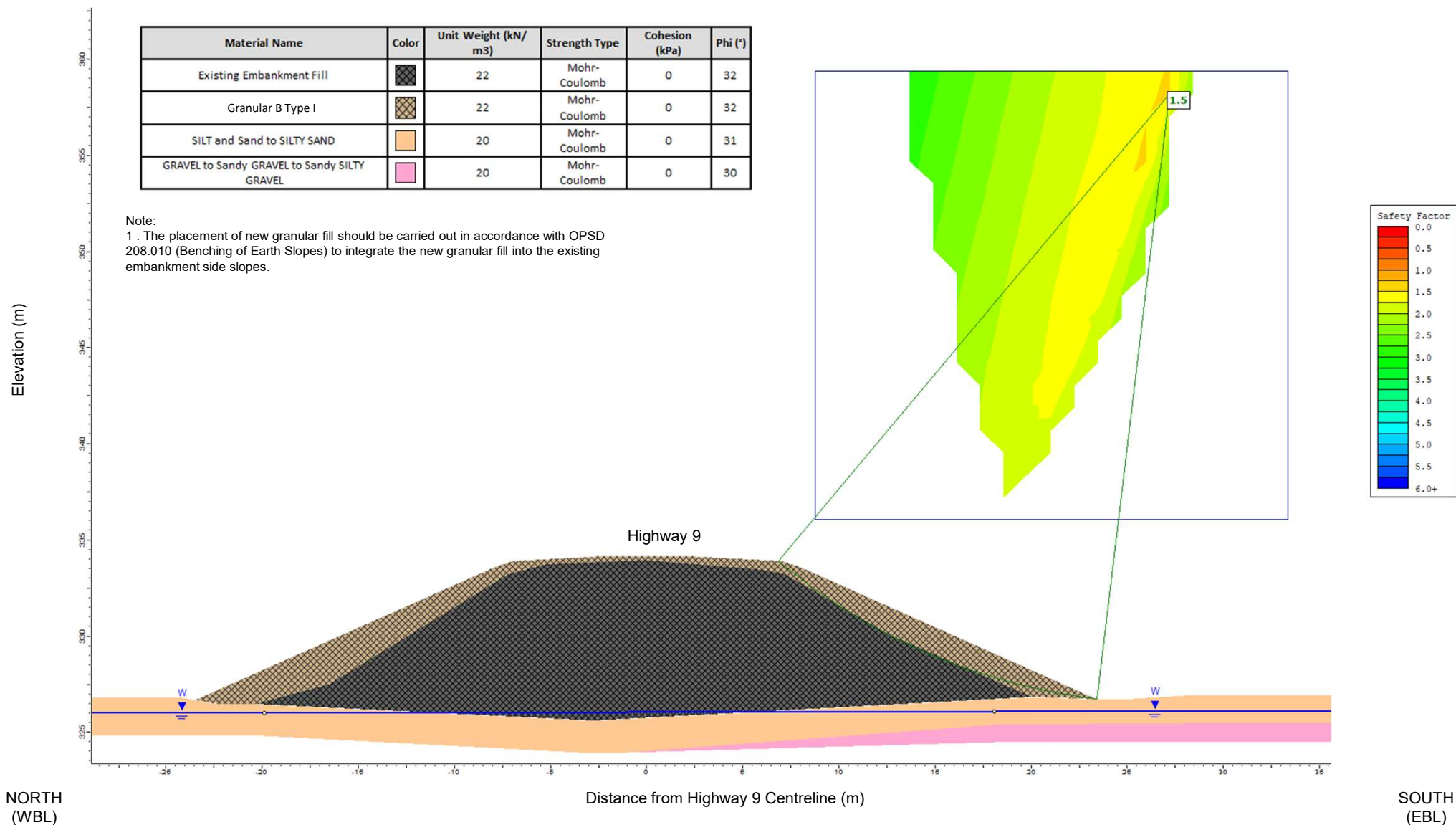


Highway 9 Mildmay Embankment Widening - Area 6, EBL STA 23+450

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2.25H:1V Side Slope

Figure H26

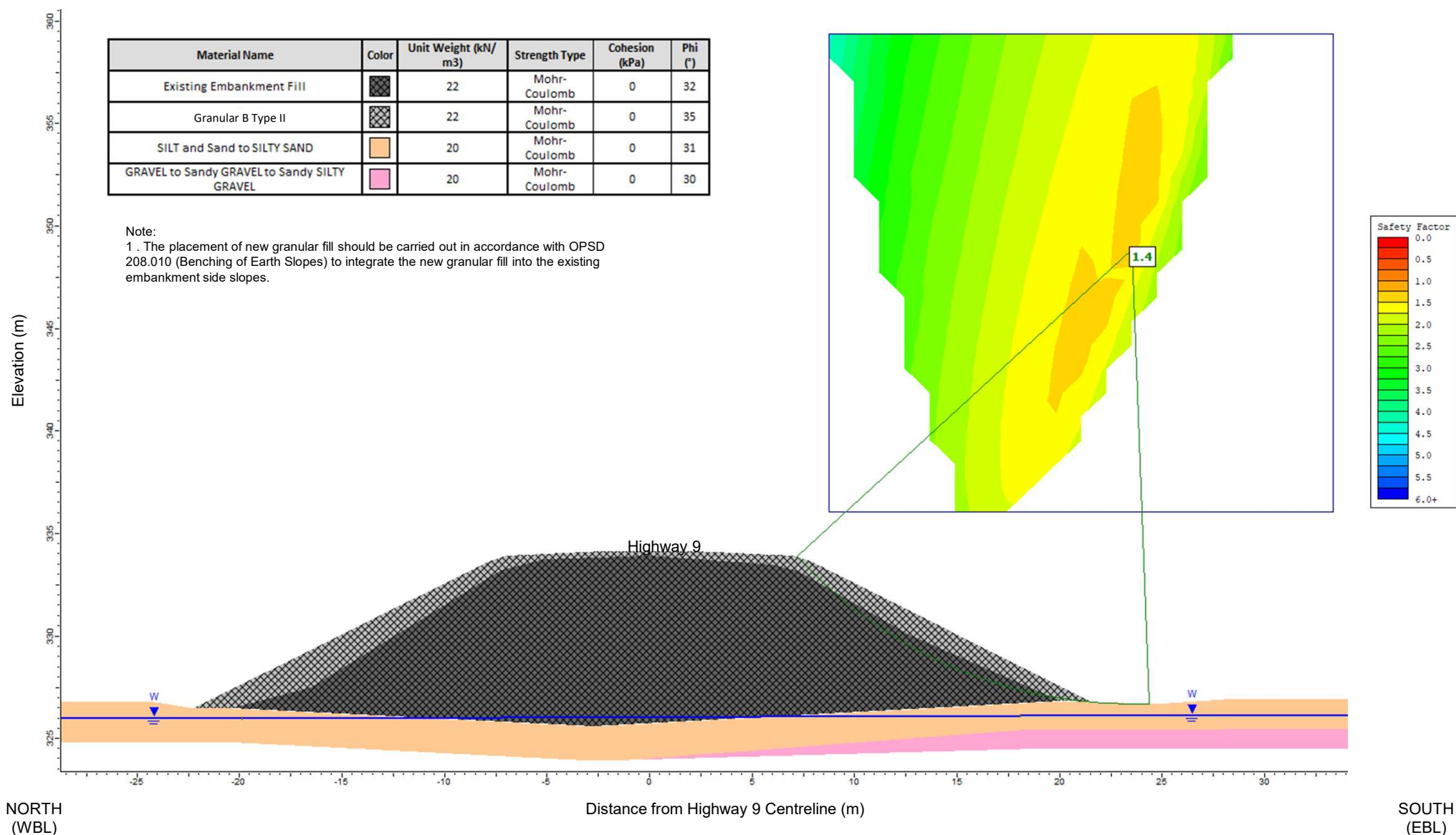


Highway 9 Mildmay Embankment Widening - Area 6, EBL STA 23+450

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II Fill Embankment Widening with 2H:1V Side Slope

Figure H27

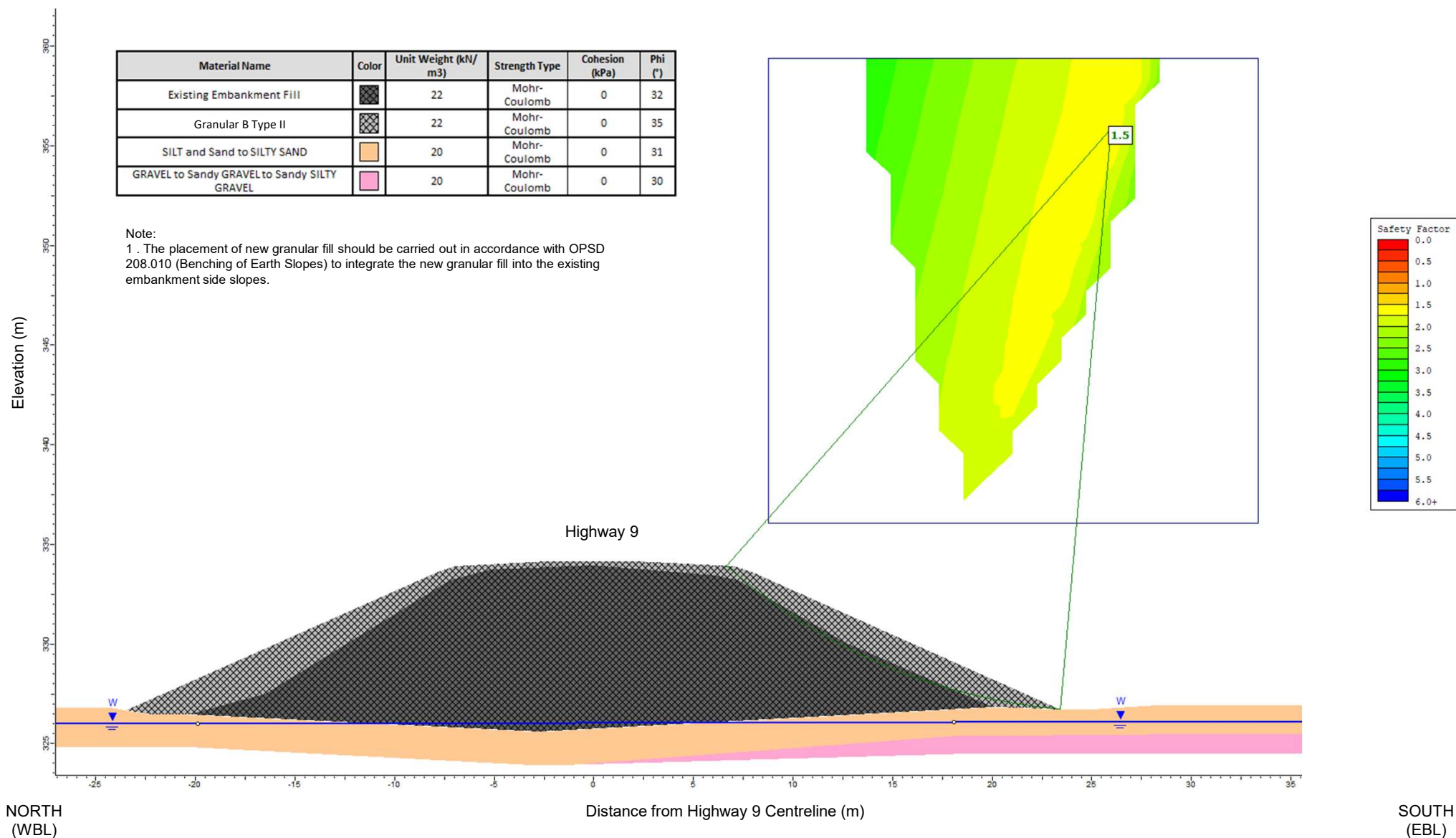


Highway 9 Mildmay Embankment Widening - Area 6, EBL STA 23+450

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II Fill Embankment Widening with 2.25H:1V Side Slope

Figure H28

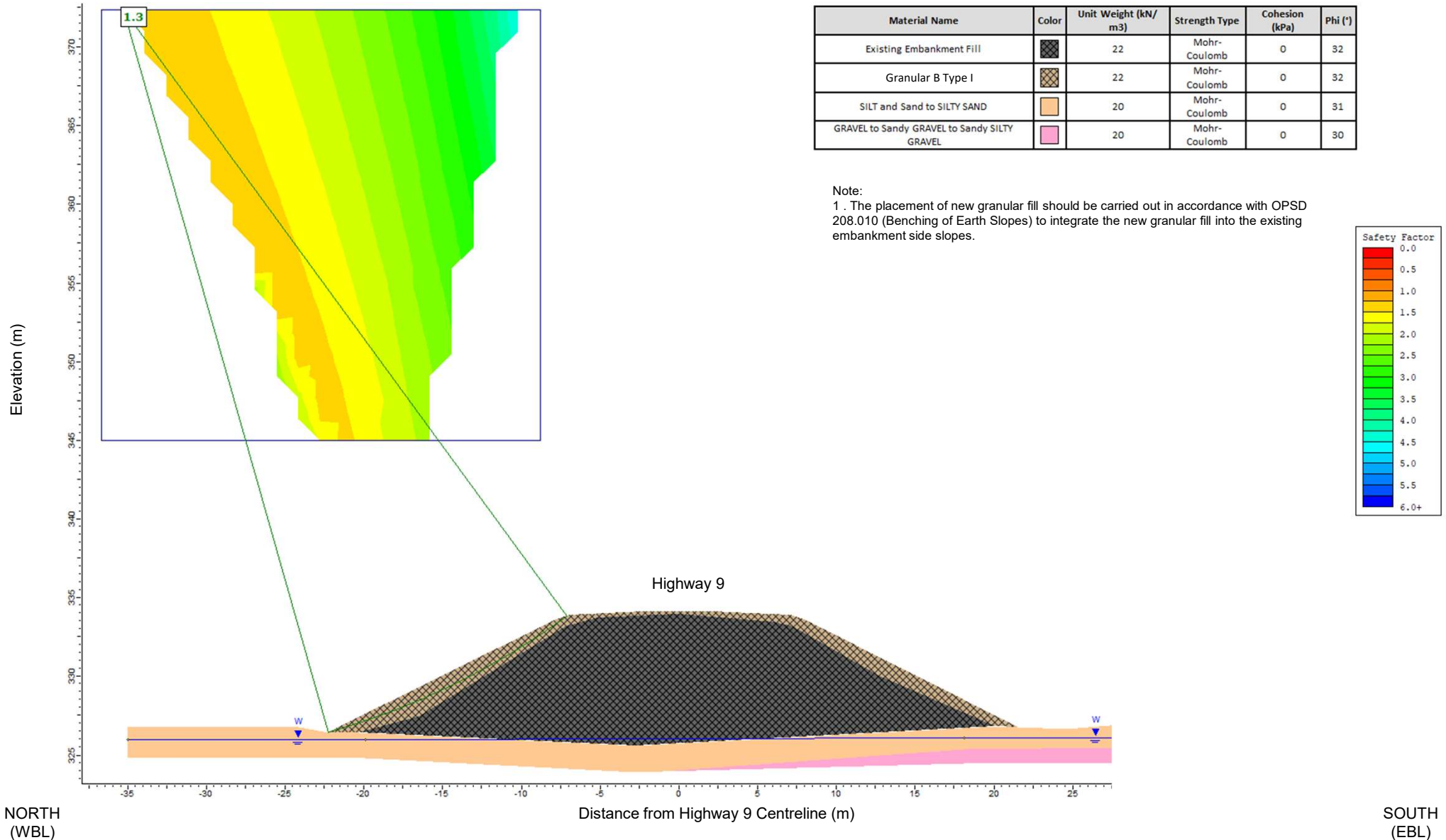


Highway 9 Mildmay Embankment Widening - Area 7, WBL STA 23+450

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2H:1V Side Slope

Figure H29

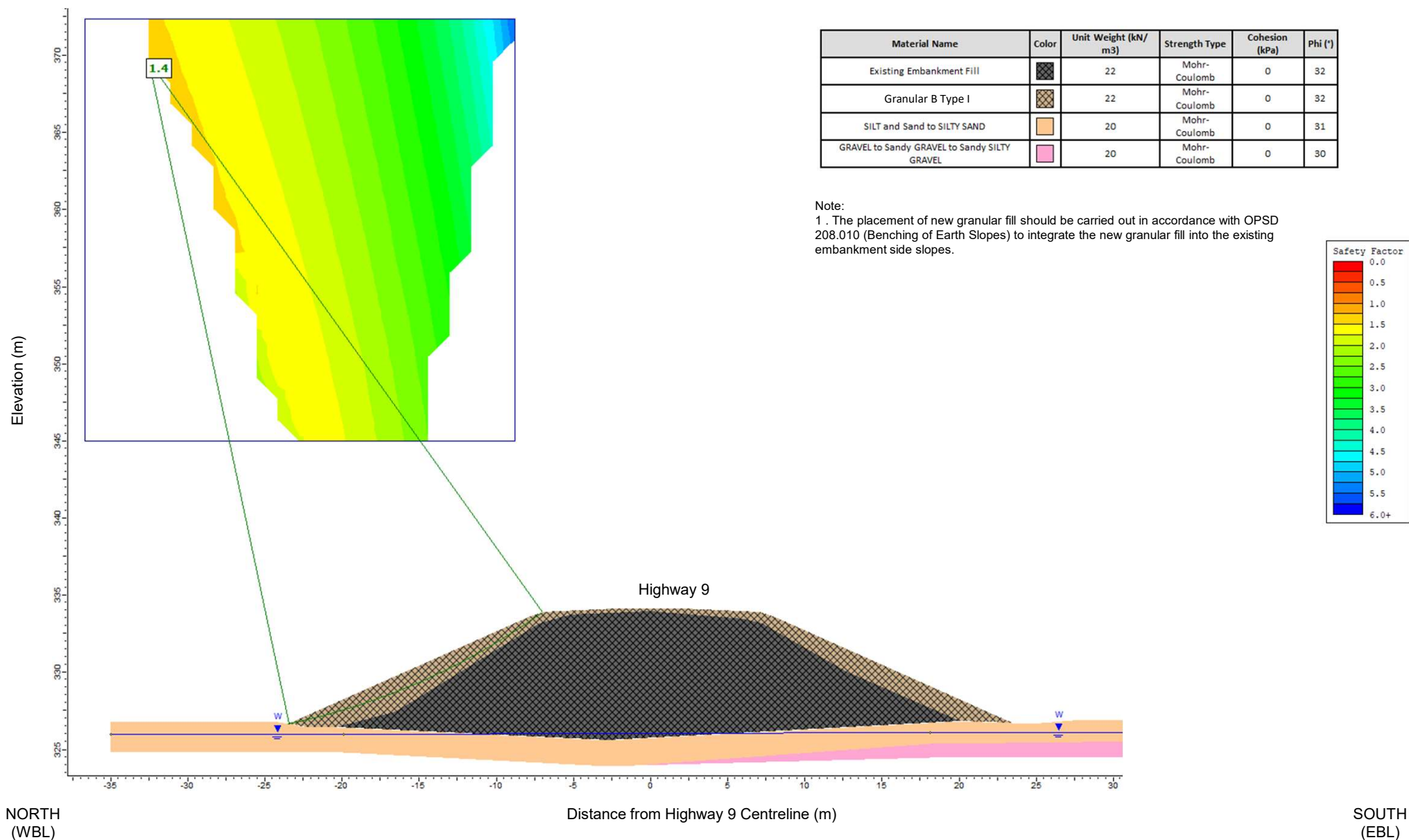


Highway 9 Mildmay Embankment Widening - Area 7, WBL STA 23+450

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2.25H:1V Side Slope

Figure H30

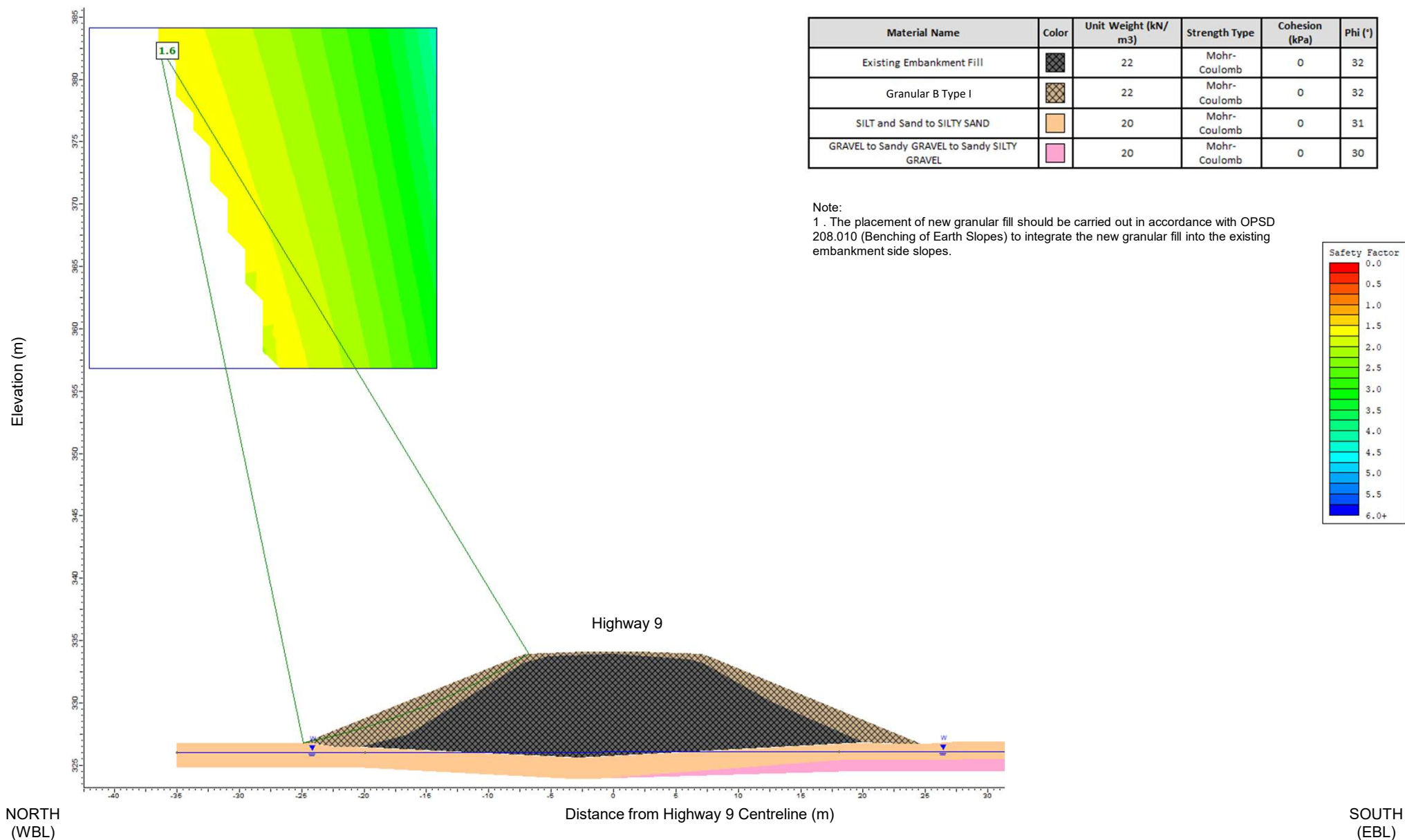


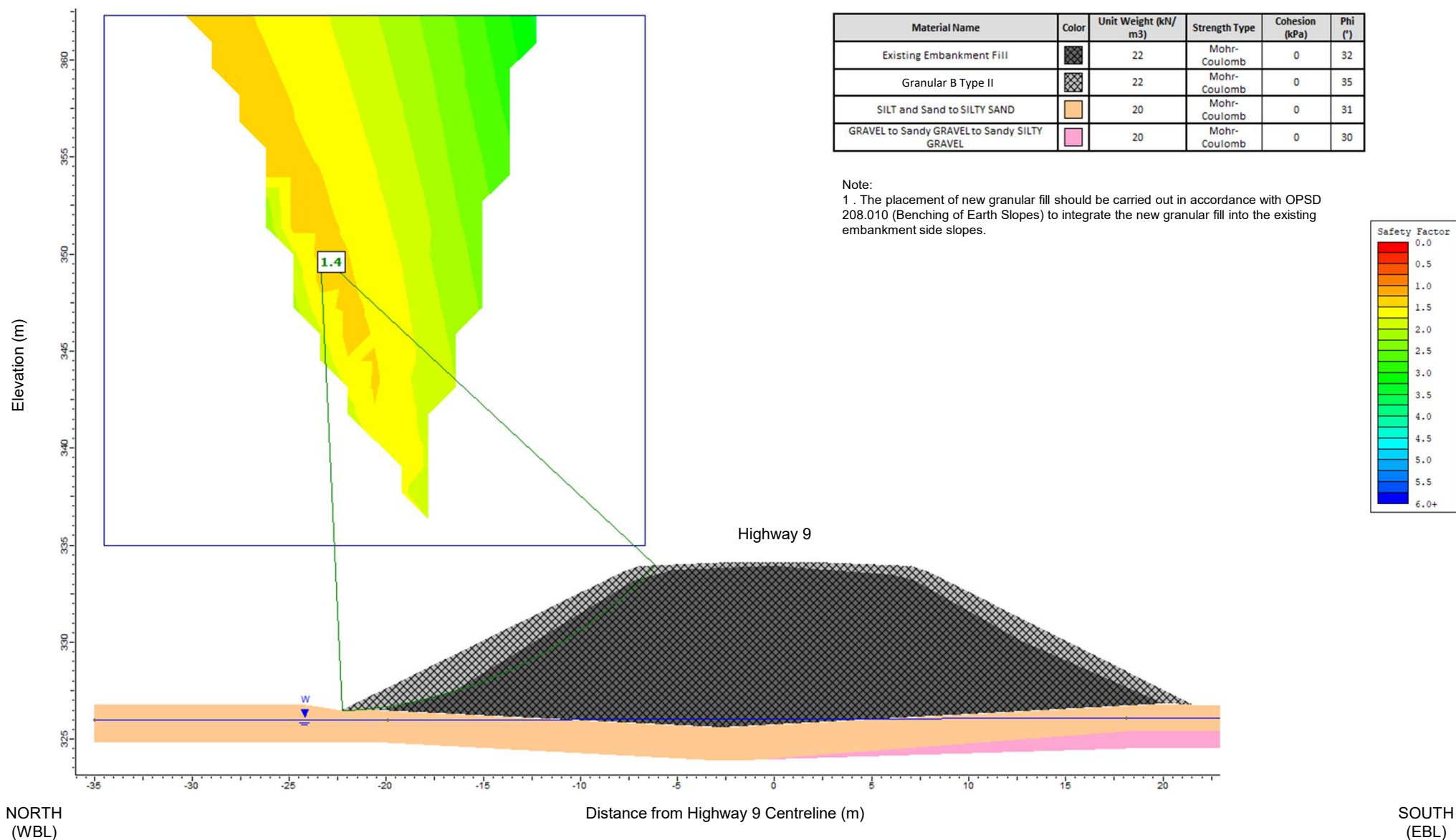
Highway 9 Mildmay Embankment Widening - Area 7, WBL STA 23+450

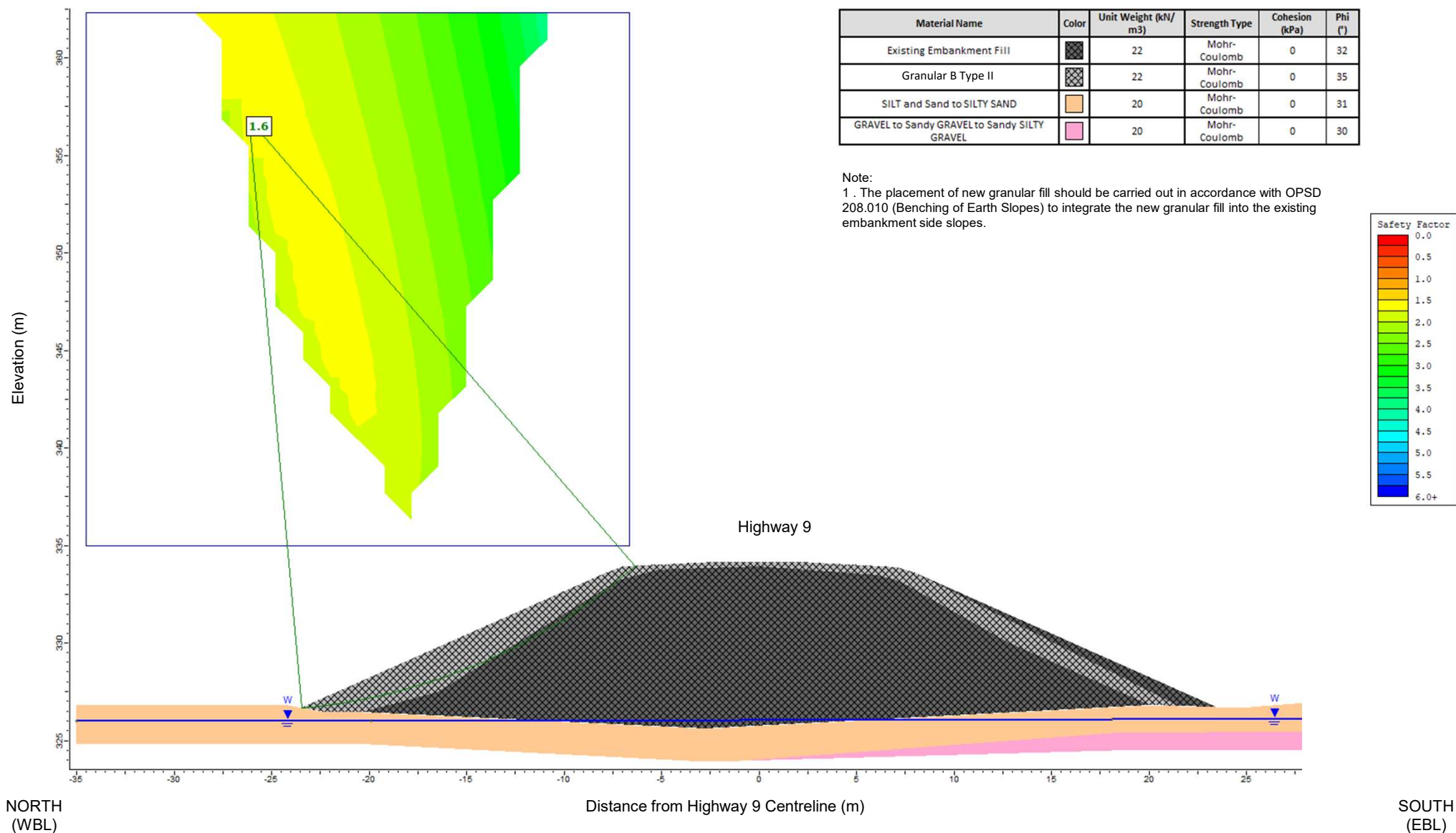
Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2.5H:1V Side Slope

Figure H31





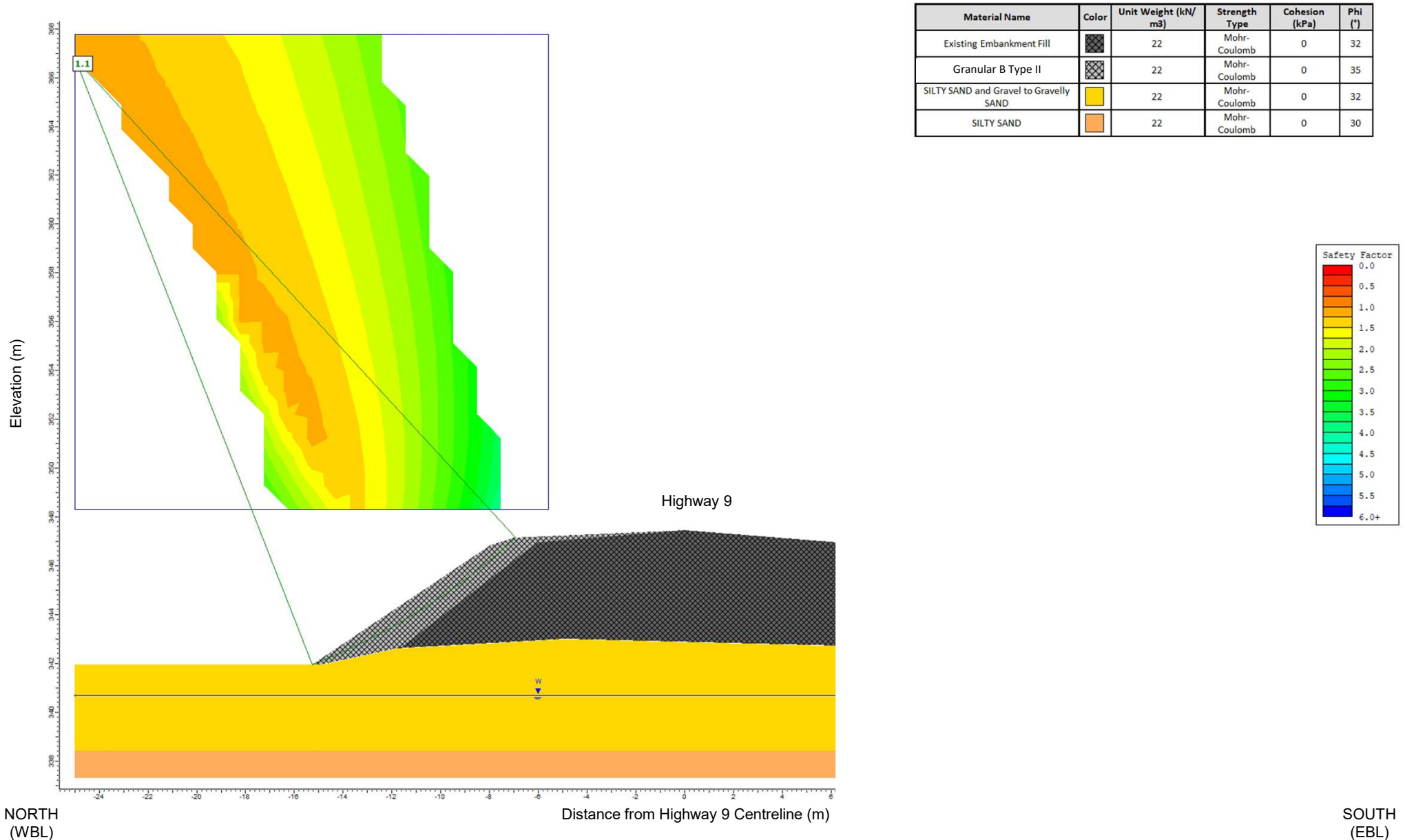


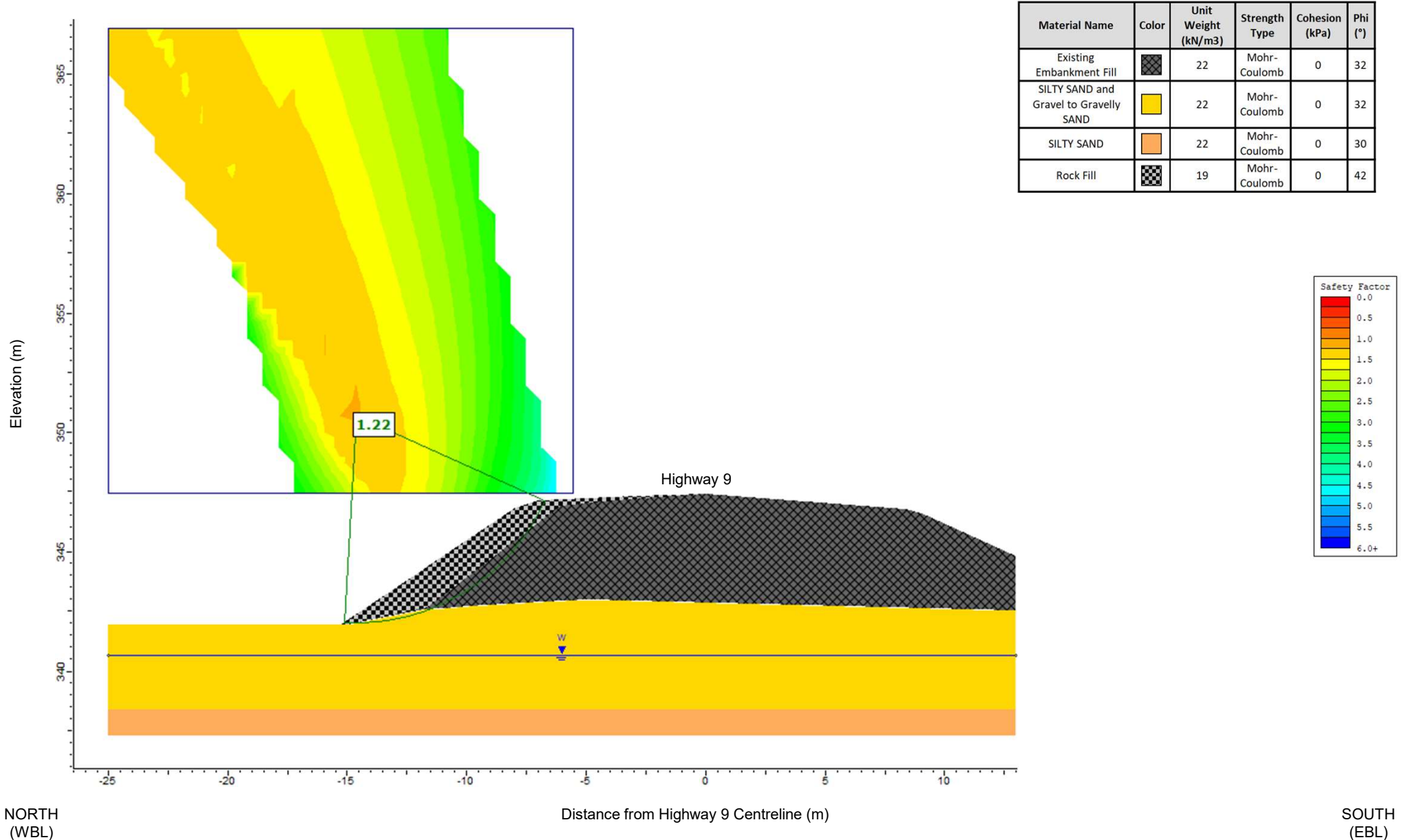
Highway 9 Mildmay Embankment Widening - Area 8, WBL STA 23+900

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II / Granular A Fill Embankment Widening (1.5H:1V Side Slope)

Figure H34



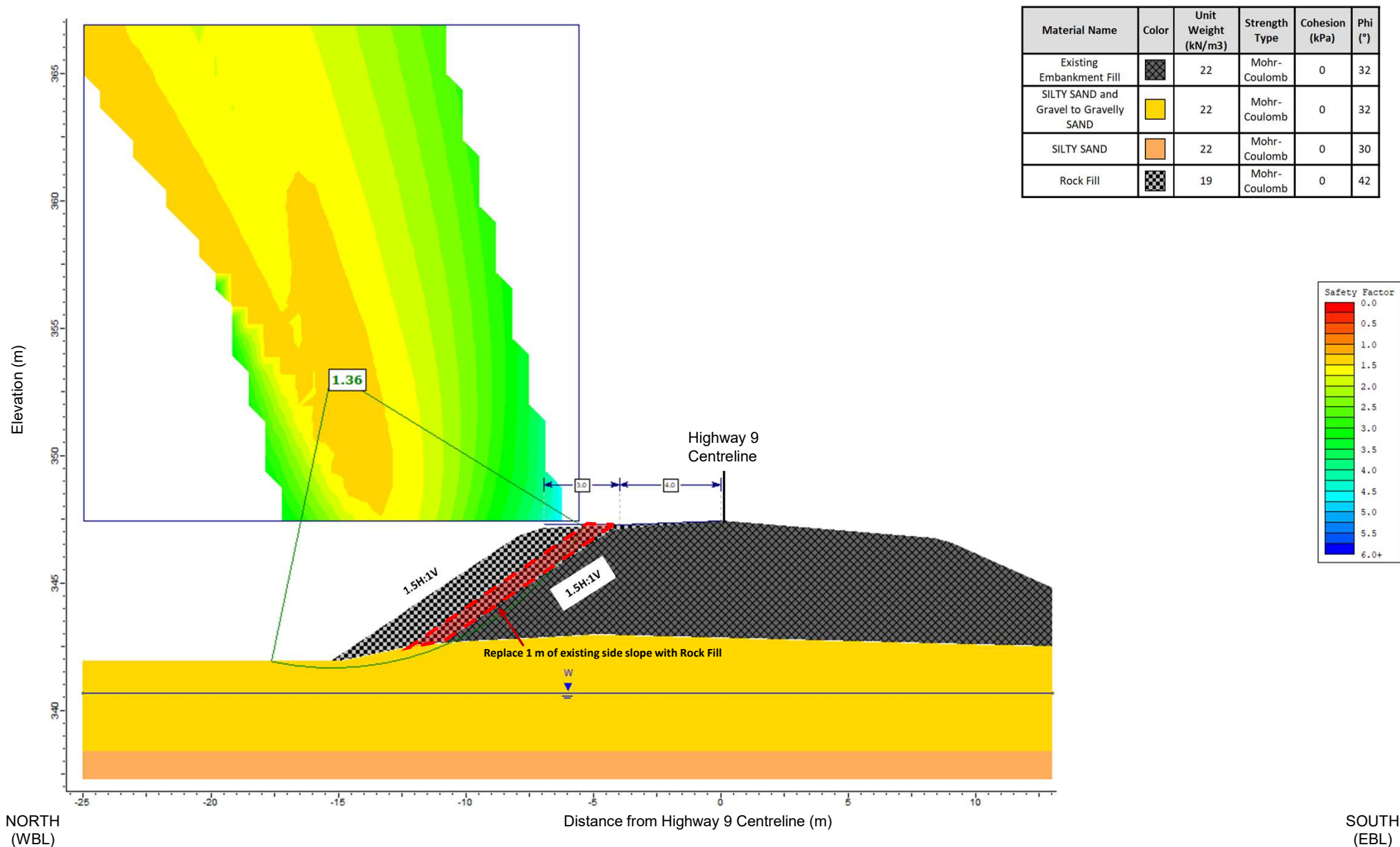


Highway 9 Mildmay Embankment Widening - Area 8, WBL STA 23+900

Global Slope Stability (Permanent, Long-Term Condition)

Rock Fill Embankment Widening with 1.5H:1V Side Slope, 4 m N of Centreline

Figure H36

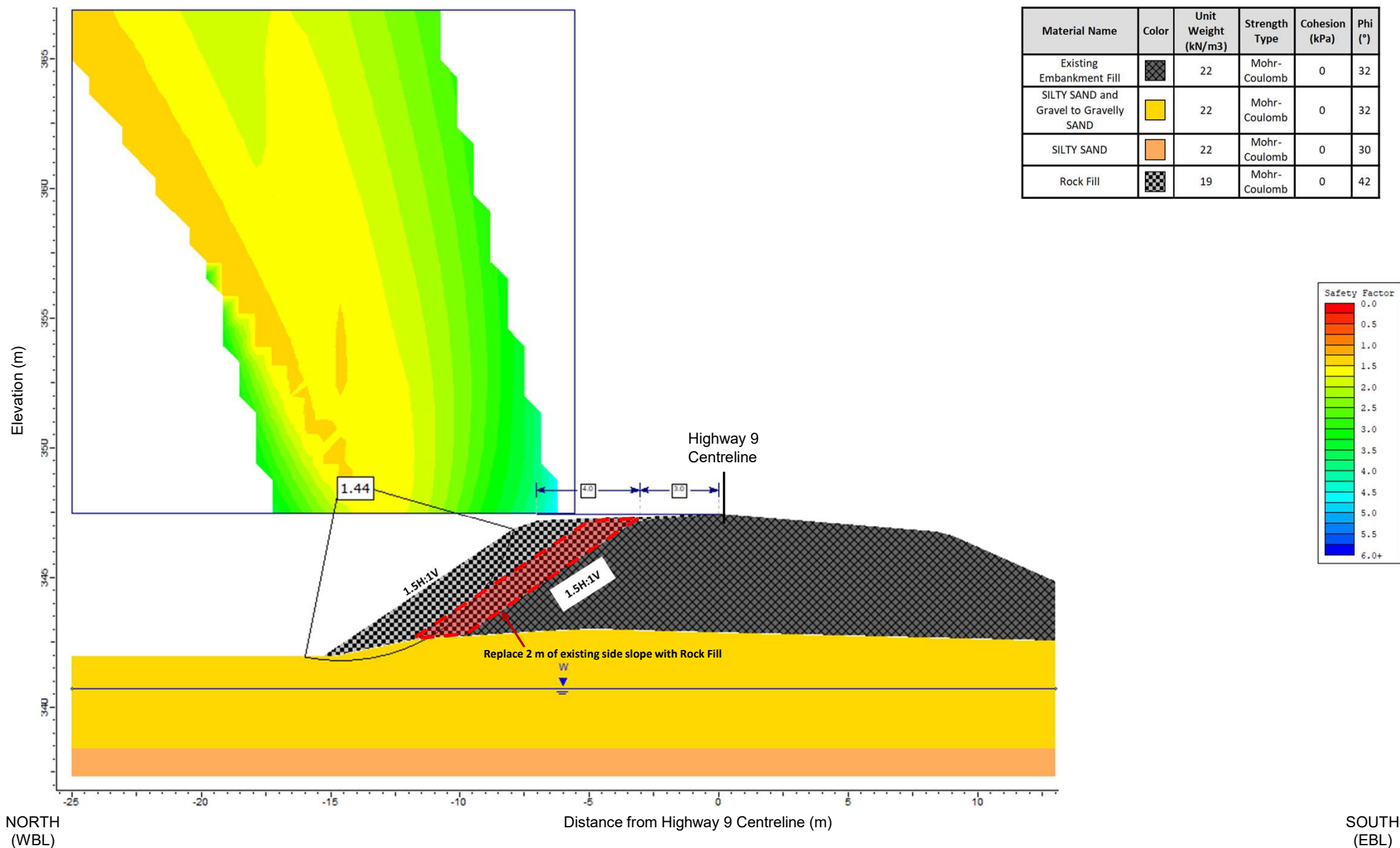


Highway 9 Mildmay Embankment Widening - Area 8, WBL STA 23+900

Global Slope Stability (Permanent, Long-Term Condition)

Rock Fill Embankment Widening with 1.5H:1V Side Slope, 3 m N of Centreline

Figure H37

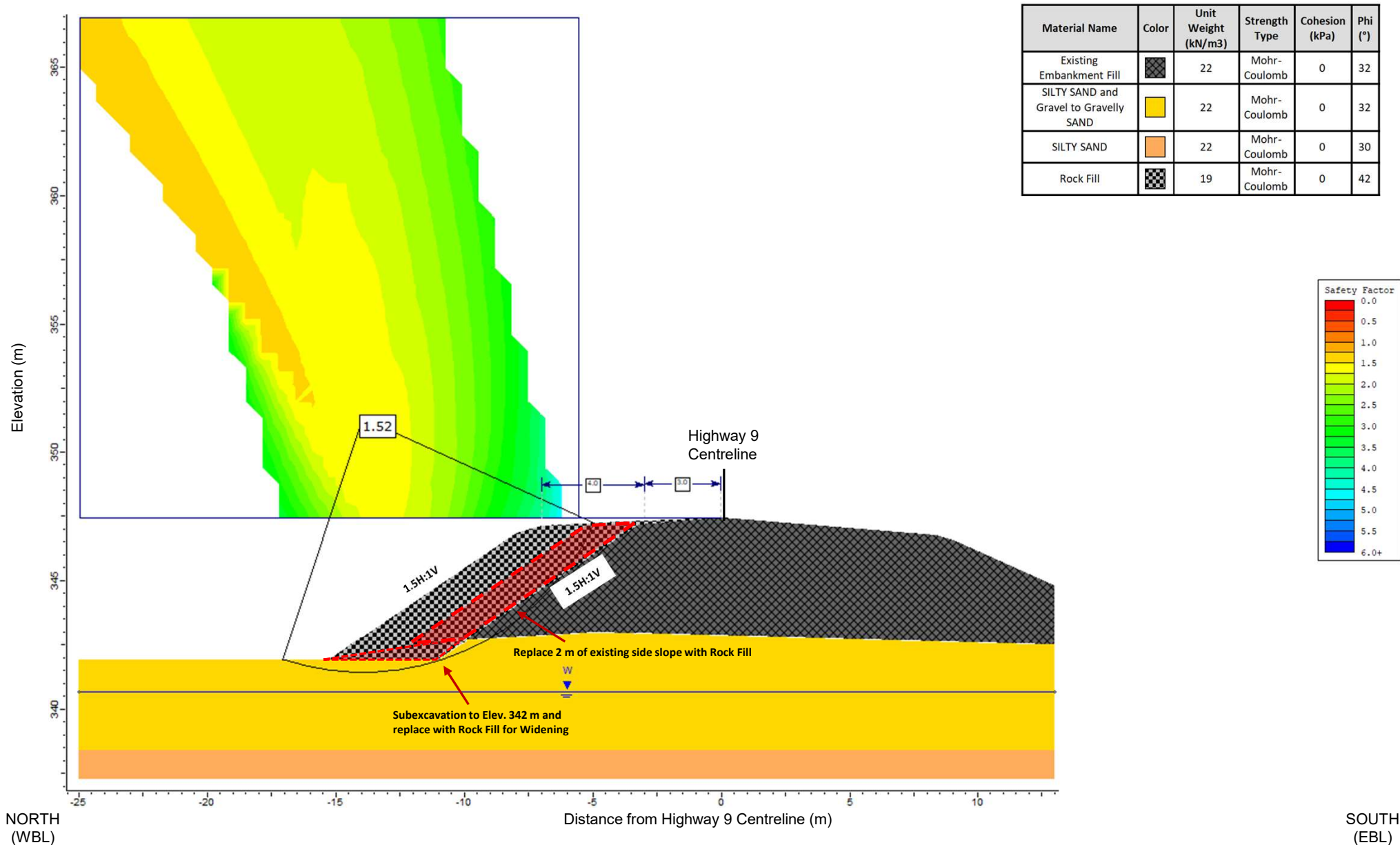


Highway 9 Mildmay Embankment Widening - Area 8, WBL STA 23+900

Global Slope Stability (Permanent, Long-Term Condition)

Rock Fill Embankment Widening with 1.5H:1V Side Slope, 3 m N of Centreline with subexcavation to Elev. 342 m

Figure H38

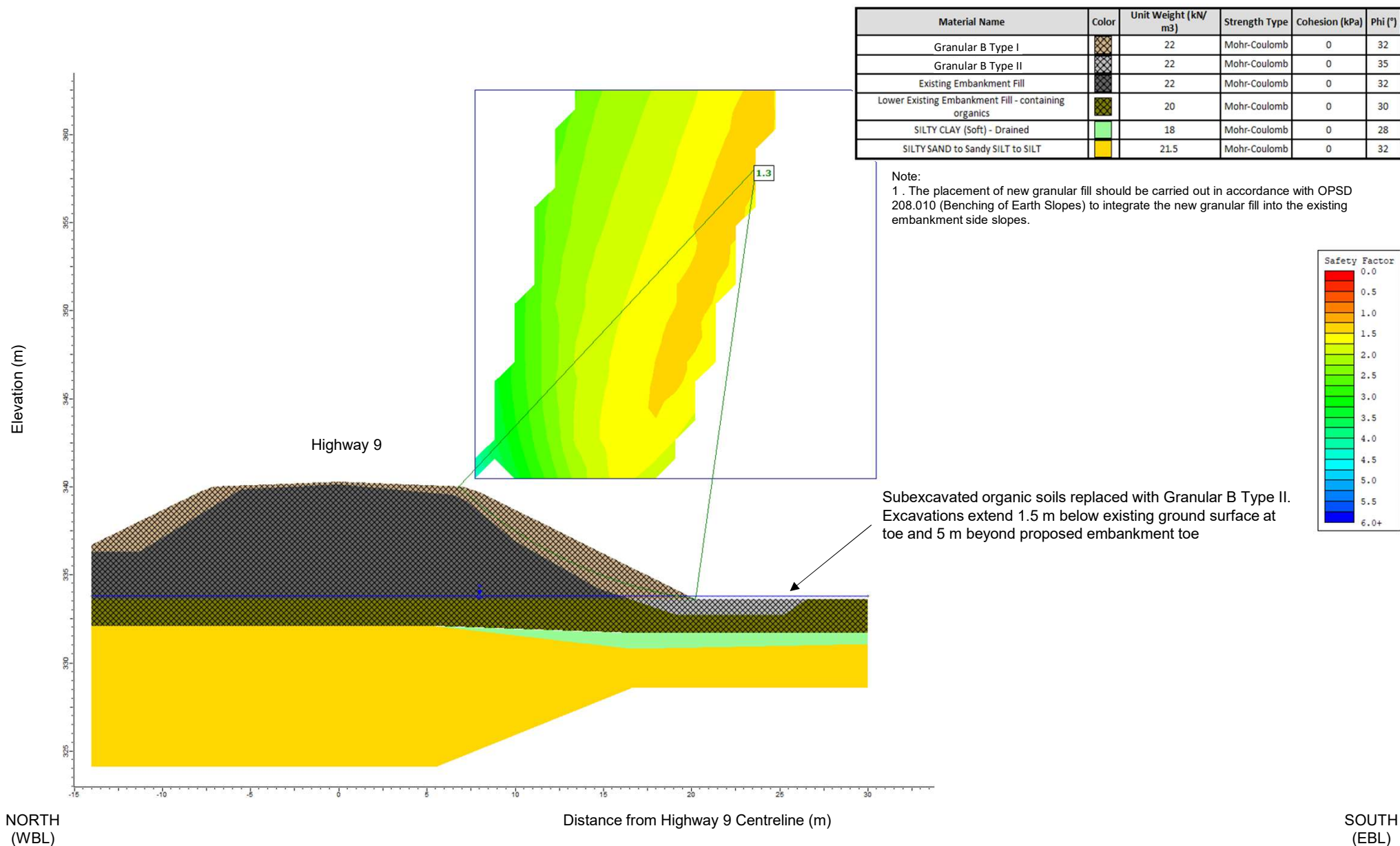


Highway 9 Mildmay Embankment Widening - Area 9, EBL STA 24+150

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2H:1V Side Slope and 1.5 m subexcavation

Figure H39

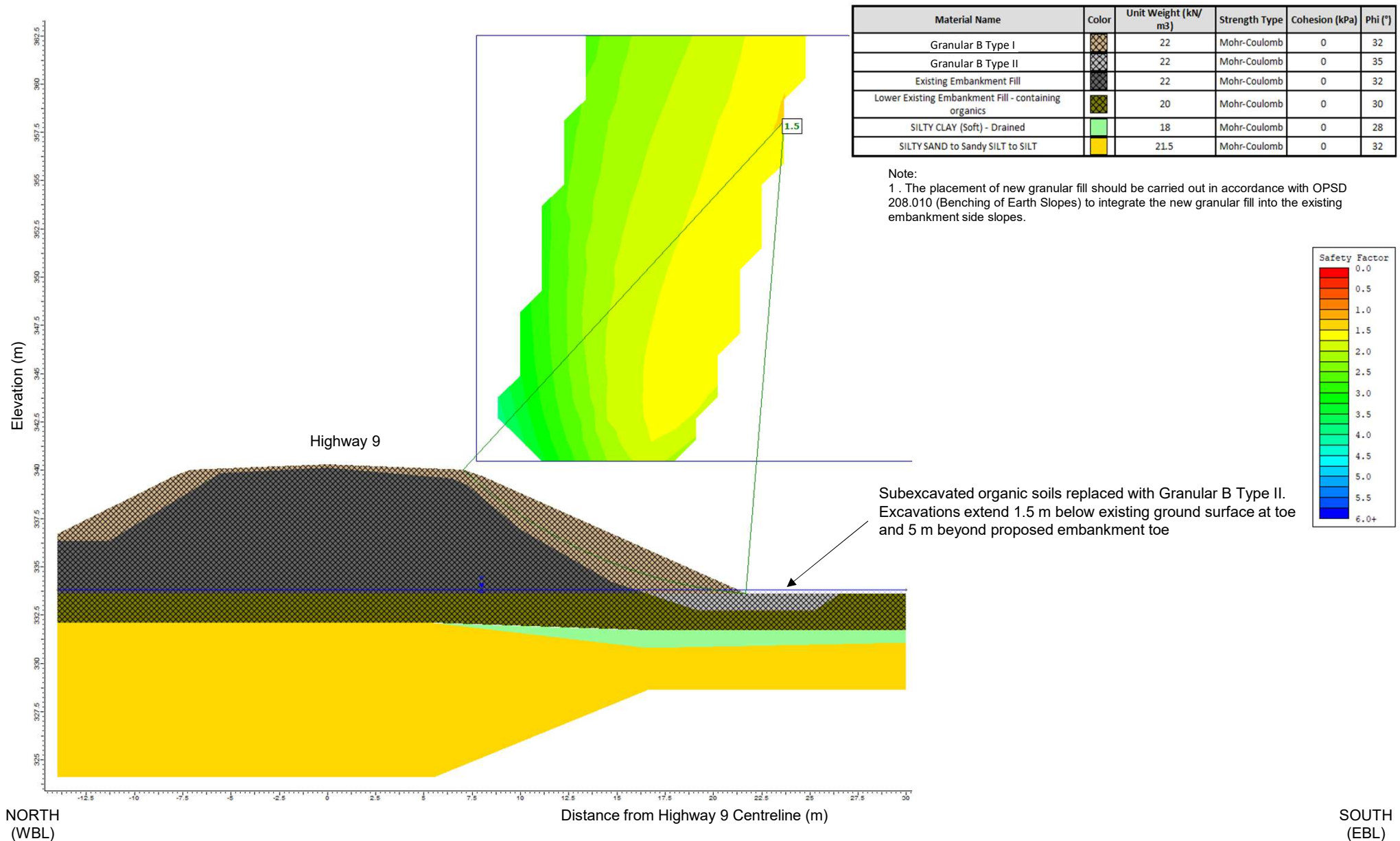


Highway 9 Mildmay Embankment Widening - Area 9, EBL STA 24+150

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type I Fill Embankment Widening with 2.25H:1V Side Slope and 1.5 m subexcavation

Figure H40

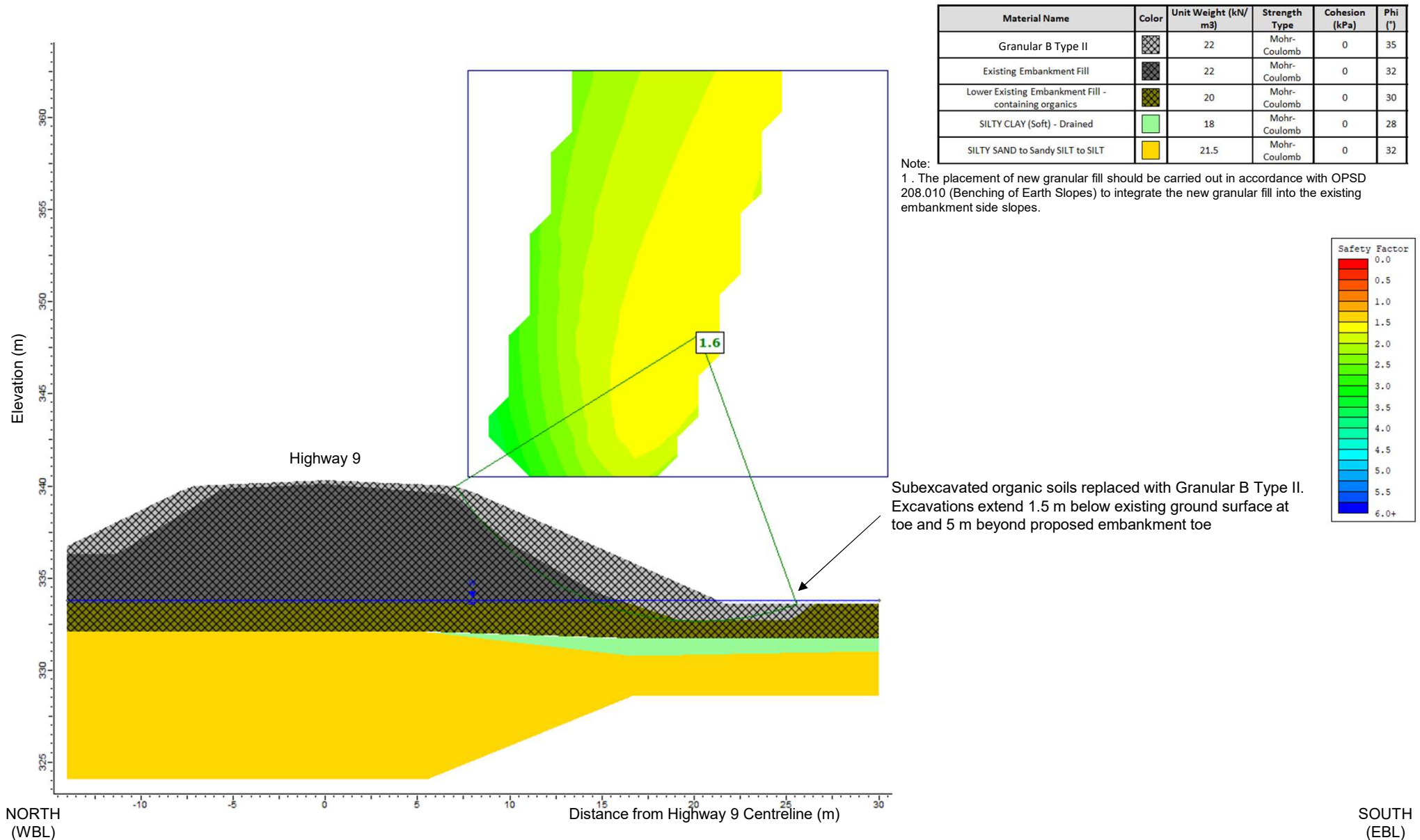


Highway 9 Mildmay Embankment Widening - Area 9, EBL STA 24+150

Global Slope Stability (Permanent, Long-Term Condition)

Granular B Type II Fill Embankment Widening with 2H:1V Side Slope and 1.5 m subexcavation

Figure H41





APPENDIX I

Special Provisions

SP Excavating for Widening

Special Provision

Subexcavation of all organic materials within the footprint of the embankment widenings shall be carried out at the following Areas (as indicated in the Contract Drawings).:

Embankment Area Widening Reference	Limits of Fill Area (Project Chainage)	Evidence of Organics in Soils Encountered in AR-series boreholes	Subexcavation Requirements Under Widening Footprint/ Thickness of Organic Materials, m
1	19+136 to 19+213	Topsoil / organics at the toe of the existing highway embankment	up to 610 mm
9	24+130 to 24+205	Silt to Clayey Silt Embankment Fill encountered in Boreholes AR09-01 and AR09-02. Wood pieces recovered in samples from this layer and high moisture contents measured.	1.5

Subexcavation of existing organic soils along the toe of Highway 9 embankment (as indicated in the Contract Drawings) shall be undertaken in such a way that the maximum length of open excavation in any area at a given time shall be 5 m. The Contractor shall backfill the sub-excavation with Granular B Type II fill material immediately behind the excavation operation such that the maximum 5 m open excavation length requirement is maintained. At the end of each day's work, the Contractor shall ensure all excavations are backfilled with granular fill. All granular fill must be placed in the dry.