

Final Foundation Investigation and Design Report (FIDR)

Highway 559 Earth Management Berm

Station 26+850 to 27+035, Township of Carling

LEA Consulting Ltd.

Ontario Ministry of Transportation (MTO)

GWP 5120-17-00

GEOCRES No. 41H-177

Assignment No.: 5019-E-0024

Latitude: 45.43392°; Longitude: -80.13953°

February 24, 2023

P-0023230



eNGLOBE

LEA Consulting Ltd.

GWP 5120-17-00

Prepared by:

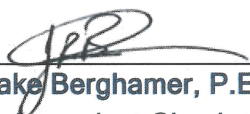


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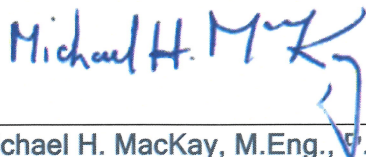
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2023-02-23

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0A	January 26, 2023	Draft FIDR issued for Client information only
1A	February 24, 2023	Final FIDR issued

Distribution

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1 Introduction

Englobe Corp. (Englobe) has been retained by LEA Consulting Ltd. (Client), on behalf of the Ministry of Transportation of Ontario (MTO, Owner), to carry out a foundation investigation for the proposed construction of an earth management berm between approximate Stations 26+850 to 27+035 on Highway No. 559 in the Township of Carling, Ontario (Site) shown on Drawing No. 1, Appendix A. This assignment was performed at the request of the Client as per the project Terms of Reference outlined in MTO Request for Quotation (RFQ) Version 3.2 under Assignment Number 5120-17-00 (GEOCRES No. 41H-177).

2

2 Project Background

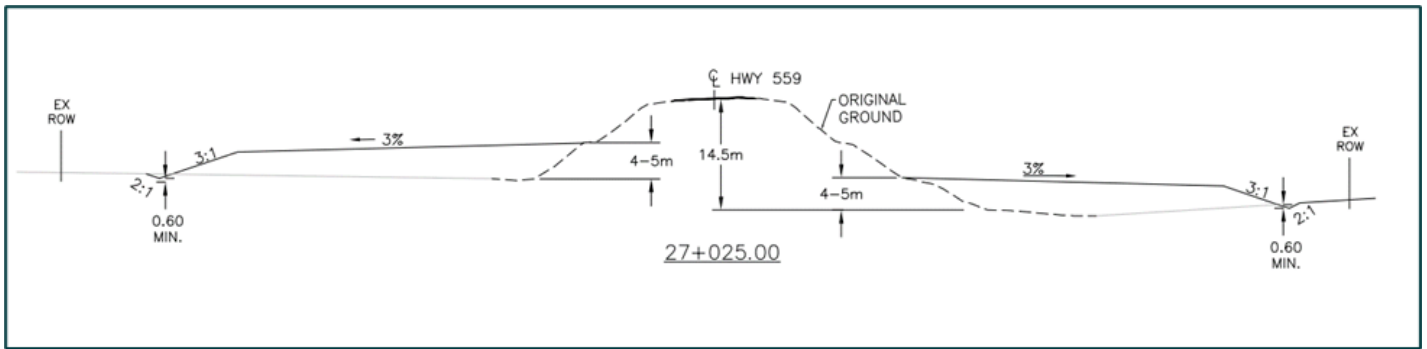
The section of Highway 559 proposed for rehabilitation is in the Township of Carling in the Parry Sound Area. The project limits are defined as from Highway 559 intersection at Nobel Road (Highway 7909) westerly to the end of Highway 559 for 17.4 km.

Englobe understands that the rehabilitation of Highway 559 will generate approximately 16,200 m³ of excavated earth fill material which will be re-used as earth management berm on this project within the Ministry's ROW adjacent to Highway 559 (Stations 26+850 to 27+035) as indicated in the following figures. The berm will be 4 to 5 m high and will be constructed on both sides of the highway.

Figure 2.1 – Potential Earth Berm locations adjacent to Highway 559 (Sta. 26+900 to 27+025)



Figure 2.2 – Cross section of the potential earth berms adjacent to Highway 559



At the proposed location of the berm, there is a pre-existing rock berm (particularly on the south side of the highway) that was placed previously forming a perimeter ring line within the ROW. It is assumed that the new fill will be placed on top of this pre-existing rock berm to form the new earth berm.

The purpose of the foundation investigation was to explore and record the subsurface conditions at the proposed earth berm location, and based on that, conduct a stability assessment of the proposed berm.

3

3 Investigation Procedures

3.1 Site Investigation

The fieldwork was carried out on November 24, 2022 and consisted of two boreholes at the toe of the pre-existing rock berm (as site access permitted) extending to a maximum depth of 4.9 m below existing ground surface (mbgs).

The fieldwork included locating the boreholes, clearing the borehole locations of underground services, in-situ sampling and testing operations, logging of the boreholes, labeling and preparation of samples for transportation to the Englobe North Bay laboratory, plus overall drill supervision.

Englobe's staff visited the site before the planned site investigation to mark out the proposed borehole locations. Utility clearance was obtained from Ontario-1-Call. Public utility authorities were informed, and all utility clearance documents were obtained before the commencement of drilling work. The drilling rigs used for drilling were owned and operated by Marathon Underground Constructors Corporation of Ottawa, Ontario. Boreholes were advanced using a CME 850 track mounted drilling rig.

The fieldwork for this investigation included two (2) sampled boreholes (BH). The boreholes were advanced at the toe of the existing earth berm. The locations of the boreholes are shown on Drawing No. 2 in Appendix A and are provided in the Table below.

Table 1 Borehole Locations

Borehole No.	Borehole Location (MTM Nad 83)		Borehole Location (Geographic)	
1	N 5032804.0	E 254858.8	Lat: 45.43339°	Long: - 80.13829°
2	N 5032800.3	E 254788.7	Lat: 45.38335°	Long: - 80.13918°

BH Nos. 1 and 2 were advanced using hollow stem auger by track-mounted CME 850 drilling rig equipped with wash boring equipment, N-size casing, rock coring equipment (NQ size core) and routine geotechnical sampling equipment.

Soil samples were obtained at regular intervals of depth at the borehole locations using a standard 51 mm split spoon sampler advanced in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). All soil samples taken during this investigation were stored in labeled airtight containers for transport to the Englobe North Bay laboratory for visual examination and select laboratory testing.

Groundwater conditions in the open boreholes were observed during the advancement of the individual boreholes. The boreholes were backfilled upon completion of drilling in accordance with requirements of Ontario Regulation 903.

The location of the individual boreholes was determined in the field using a handheld GPS device. The MTO coordinates, northing and easting, were then established for the boring locations using coordinates from MTM Zone 10, NAD 83 CSRS. The borehole elevations are inferred from Google Earth elevation data based on the borehole locations. The borehole locations were outside of the provided survey extents.

4

4 Laboratory Investigation

All soil and rock samples obtained during the investigation were transported to Englobe Laboratory in North Bay, Ontario. All retrieved samples were subjected to visual identification and tactile categorization to describe the soils. The laboratory tests to determine index properties were performed in accordance with the Ministry of Transportation Ontario (MTO) test procedures, which follow the American Society for Testing Materials (ASTM) test procedures. Laboratory testing included grain size distribution; sieve and hydrometer analysis according to ASTM D422 and LS-702, Atterberg's Limits ASTM D4318 and LS-703/704, water content ASTM D2216 and LS-701. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix B), with a summary of results presented on the laboratory sheets in Appendix C (Figures Nos. L-1 to L-3).

5

5 Subsurface Conditions

The subsurface conditions revealed by the investigation program are summarized in Table 2 below and on the stratigraphic profile presented on Drawing No. 2 (Appendix A) and on the detailed Records of Borehole Logs (Appendix B). It should be noted that the stratigraphic delineation presented on the borehole logs and soil strata plot is interpreted from the results of non-continuous sampling, response to drilling progress, recorded SPT 'N'-values, plus field observations. Typically, such boundaries represent transitions from one zone to another and are not an exact demarcation of specific geological units. Additional consideration should be given to the fact that subsurface conditions may vary markedly between adjacent boreholes and beyond any specific boring location and are shown on the drawings for illustration purposes only.

Table 2 Summary of Generalized Stratigraphy in Boreholes with Depth and Elevation (m)

Deposit/Layer Description	Depths/Elevations (m)	
	Borehole No. 1	Borehole No. 2
Soft to Stiff Sandy Clay	--	0.0 - 1.4 (El. 198.0 - 196.6)
Loose to Compact Silty Sand	0.0 - 0.7 (El. 200.0 - 199.3)	1.4 - 2.2 (El. 196.6 - 195.8)
Soft to Very Stiff Silty Clay	0.7 - 1.4 (El. 199.3 - 198.6)	2.2 - 3.0 (El. 195.8 - 195.0)
Compact to Very Dense Silty Sand	1.4 - 1.7 (El. 198.6 - 198.3)	3.0 - 4.9 (El. 195.0 - 193.1)
Auger Refusal- Inferred bedrock	1.7 (El. 198.3)	4.9 (El. 193.1)

5.1 Sandy Clay

At ground surface in BH No. 2, a 1.4 m thick native soft sandy clay layer (probable fill) was encountered between El.198.0 m and 196.6 m. This sandy clay layer was observed to be grey to brown and wet.

The results for grain size analyses and Atterberg limits (Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI)) of a representative soil sample of the sandy clay layer are summarized in Table 3 and presented on Figure No. L-1 in Appendix C.

Table 3 Particle Size Distribution and Atterberg Limit Results of the Sandy Clay

Sample Tested	Sample Depth / Elev. (m)	Grain Size Analysis (%)				Atterberg Limits (%)			Water Content (%)	Soil Classification
		Gravel	Sand	Silt	Clay	LL	PL	PI		
BH No. 2/SS-2	1.0 (197.0)	0	51	27	22	25	8	17	23	CL

The sandy clay layer was soft to stiff, based on recorded SPT 'N' values ranging from Weight of the Hammer (WH) to 9 blows/300 mm.

5.2 Upper Silty Sand

A silty sand deposit was encountered underlying the sandy clay in BH No. 2 and at surface in BH No. 1. The silty sand in BH No. 2 was encountered at approximate depth of 1.4 mbgs (El. 196.6 m) and it extended down to an approximate depth of 2.2 mbgs (El. 195.8 m). The native silty sand was encountered to a depth of 0.7 mbgs (El. 199.3 m) in BH No. 1

The layer was observed to be brown to grey in general and moist to wet. The upper silty sand deposit generally varied from loose to compact based on recorded SPT 'N' values ranging from 4 to 13 blows/300 mm.

The natural moisture contents measured on samples recovered from this deposit ranged from 25 to 28%.

5.3 Silty Clay

Underlying the native silty sand in BH No. 1 and 2, a deposit of silty clay was encountered.

The silty clay was encountered in BH No. 1 at an approximate depth of 0.7 mbgs (El. 199.3 m) and it extended down to a depth of 1.4 mbgs (El. 198.6 m). The native silty clay was encountered in BH No. 2 at an approximate depth of 2.2 mbgs (El. 195.8 m) and it extended down to 3.0 mbgs (El. 195.0 m). This deposit mainly consisted of silty clay with portions of sand. This deposit was observed to be brown to grey in general.

The natural moisture contents measured on samples recovered from the deposit ranged from 18 to 31%. Two (2) gradation analyses and two (2) Atterberg were carried out on samples from this deposit, and the results are summarized in Table 4 and provided in Figure Nos. L-2 and L-3, Appendix C.

Table 4 Particle Size Distribution and Atterberg Limits Results of the Native Silt

Sample Tested	Sample Depth / Elev. (m)	Grain Size Analysis (%)				Atterberg Limits (%)			Water Content (%)	Soil Classification
		Gravel	Sand	Silt	Clay	LL	PL	PI		
BH No. 1/SS-2	1.0 (199.0)	0	11	60	29	28	16	12	18	CL
BH No. 2/SS-4	2.6 (195.4)	0	23	60	17	25	17	8	31	CL

The consistency of this deposit generally varied from soft to hard based on recorded SPT 'N' values ranging from WH to 31 blows/300 mm penetration.

5.4 Lower Silty Sand

Below the silty clay in BH Nos. 1 and 2, a lower silty sand deposit was encountered. The lower silty sand in BH No. 1 was encountered at an approximate depth of 1.4 mbgs (El. 198.6) and extended beyond the maximum depth of drilling in BH No. 1 (i.e. 1.7 mbgs, El. 198.3 m). In BH No. 2, the lower silty sand was encountered at an approximate depth of 3.0 mbgs (El. 195.0m) and extended beyond the maximum depth of drilling in BH No. 2 (i.e. 4.9 mbgs, El. 193.1 m).

The layer consisted mainly of medium to fine sand and silt. The layer was observed to be brown in general and wet with measured natural moisture content ranging from 16 to 24%.

The lower silty sand deposit generally varied from compact to very dense based on recorded SPT 'N' values ranging from 10 to 87 blows/230 mm penetration.

5.5 Inferred Bedrock

Underlying the above-described lower silty sand at BH Nos. 1 and 2, bedrock was inferred by refusal to augers. The refusal was encountered at depths of 1.7 mbgs in BH No. 1 (El. 198.3 m) and 4.9 mbgs in BH No.2 (El. 193.1 m).

5.6 Groundwater Conditions

Groundwater and cave-in levels were measured in the open boreholes during the course of the fieldwork as summarized in Table 5. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix B).

Table 5 Groundwater Levels

BH No.	Drilling Date	Ground Surface Elev. (m)	Borehole Bottom		Monitoring Date	GW in BH	
			Depth (m)	Elev. (m)		Depth (m)	Elev. (m)
BH No. 1	Nov. 24, 2022	200.0	1.7	198.3	Nov. 24, 2022	Dry	--
BH No. 2	Nov. 24, 2022	198.0	4.9	193.1	Nov. 24, 2022	Dry	--

The groundwater and surface water levels should be expected to fluctuate seasonally/yearly.

6

6 General Comments

The field investigation was carried out using a track mounted CME 850 drilling rig and operated by Marathon Underground Constructors Corporation. Laboratory testing of select soil samples was undertaken at the Englobe Laboratory in North Bay. The fieldwork for this site investigation was under the full-time supervision of Englobe technical staff. The report was written by Mr. Ala Abu Obeid, M.Sc., P.Eng., PMP and peer reviewed by Jake Berghamer, P.Eng. The report was also reviewed and approved by Michael MacKay, M.Eng., P.Eng., MTO Designated Contact.

7

7 Slope Stability Evaluation

A two-dimensional (2-D) limit equilibrium stability analysis, using the GEO-SLOPE computer program, Slope/W (GeoStudio 2020, version 10.02, Geo-Slope International Ltd.), was carried out using the Morgenstern-Price method for two roadway cross sections provided for Station 26+850 and Station 27+035.

Models were constructed to represent both the existing side slopes and the anticipated berm dimensions. The stratigraphy and groundwater conditions adopted for modelling were based on the available geotechnical borehole logs (presented in Section 5 of this report). Suitable strength parameters for the modelled soil materials were identified based on Englobe's experience with similar materials. The design parameters used to model the slopes are summarized in Table 6 below.

Table 6 Recommended Soil Parameters for Slope Stability

Material	Unit Weight (kN/m ³)	Effective Angle of Friction (ϕ)	Effective Cohesion (kPa)
Embankment Fill	19.0	32	0
Sandy Clay / Silty Clay	18.0	24	2.5
Silty Sand	18.0	28	0
New Berm Fill	18.0	24	0
Bedrock	Impenetrable		

The analysis indicated that the factor of safety was estimated at 1.2 to 1.3 for the existing embankment slopes, see Figure Nos. S1 and S2 (Slope Stability for Existing Condition), Appendix D.

If the new berm is constructed adjacent to the embankment slopes with side slopes established at an angle of 3H:1V, a higher factor of safety is achieved (between 2.4 to 2.8) as the new berm will provide additional rotational resistance to the embankment slope, see Figure Nos. S3 and S4 (Slope Stability with Berm), Appendix D.

Temporary erosion control measures to protect disturbed earth surfaces during construction should be installed as per OPSS.PROV 804. The berm should be graded to shed surface water and final slopes should be topsoiled and vegetated as soon as possible after construction to reduce surface erosion. A minimum of 100 mm of approved topsoil (OPSS 802) should be placed free of weeds and other deleterious material.

If the berm final slopes are subject to inundation from water, then the slopes should be suitably protected with rip-rap as per OPSS.PROV 511.



8 Settlement of the Embankment Foundation

Considering the response of the existing highway embankment and given that the new berms will be constructed on both sides of the highway, settlement of the highway embankment will not be a concern.

A settlement analysis of the proposed berms based on the information provided was conducted by Englobe using a two-dimensional (2-D) finite element analysis program, Sigma/W (version 2020) from Geo-slope International Ltd.

The results of the settlement analysis are provided in Figure Nos. S5 and S6, Appendix D. As shown in Figure No. S6, the existing highway embankment will not be affected by the new berms and zero settlement is anticipated under the highway embankment centreline.

9

9 STATEMENT OF LIMITATIONS

The design recommendations given in this geotechnical report are applicable only to the project described in the text and only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known, in our analysis certain assumptions had to be made. The actual conditions, however, may vary from those assumed, in which case changes and modifications may be required to our geotechnical recommendations.

The comments in this report are intended solely for the guidance of the design engineer and address the geotechnical conditions only. The number of boreholes required to determine the localized conditions between boreholes directly affecting construction costs, equipment, scheduling, etc. would in fact be greater than what has been carried out for design purposes. Therefore, contractors bidding on this project or undertaking this work should make their own interpretations of the factual borehole results and carry out further work as they deem necessary to assess the scope of the project.

Foundation Design of this report is intended solely for the use of the client and the design team for the detail design of this specific project on behalf of the Ministry of Transportation and is not intended to be included in the tender documents; and shall not be used for any other purposes or by any other parties including the construction Contractor.

Appendix A

Drawings

Drawing No. 1 - Site Location Plan & Key Map
Drawing No. 2 - Borehole Location Plan

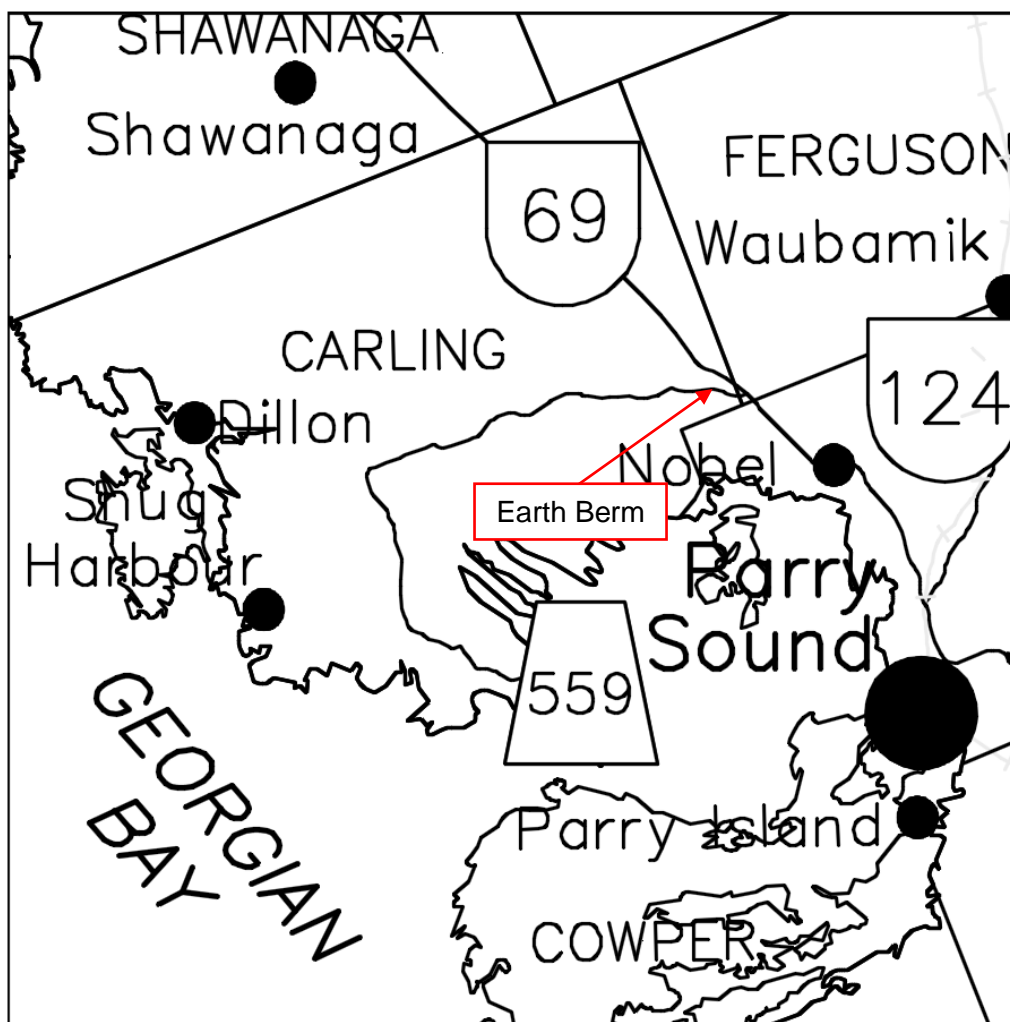


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KEY PLAN

Drawing No. 1

NOT TO SCALE



DRAFT FOUNDATION INVESTIGATION and DESIGN REPORT

Highway No. 559

Earth Berm between Stations $\pm 26+850$ to $\pm 27+035$

Twp. of Carling

Assignment Number 5019-E-0024

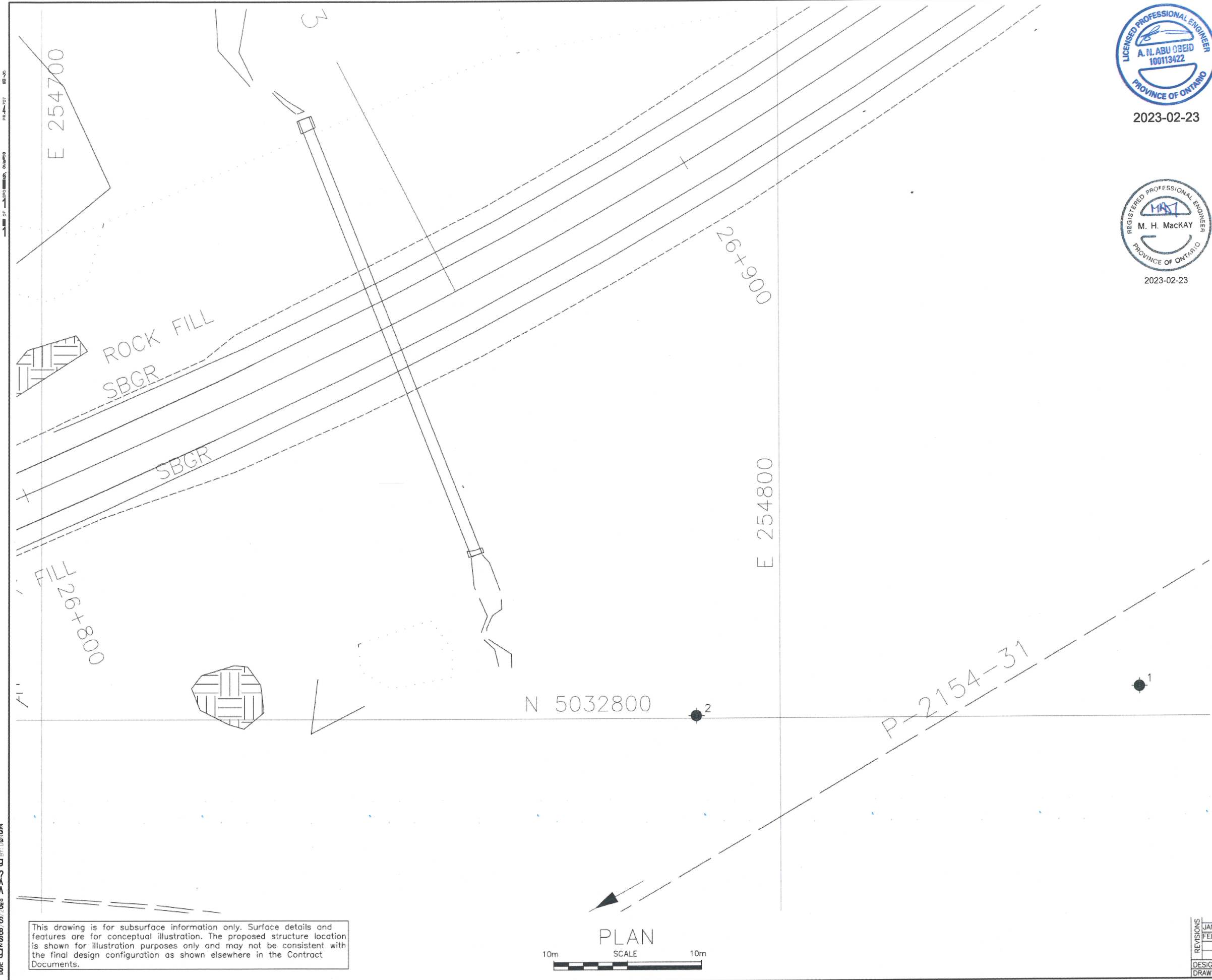
GWP 5120-17-00

Reference No: P0023230

January 2023



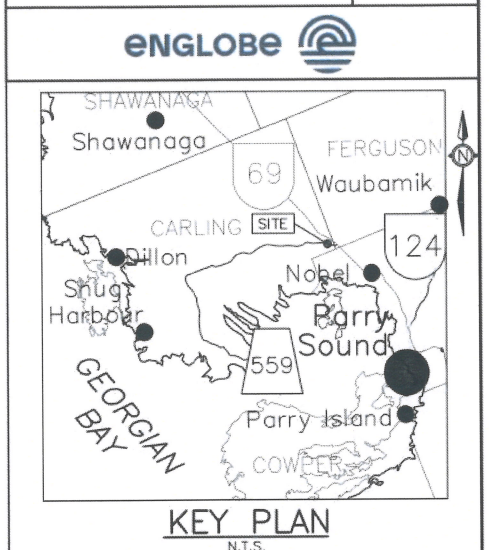
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DISTRICT
CONT. No.
GWP No. 5120-17-00
HWY 559 EARTH BERM
STA. 26+850 TO 27+035
ASSIGNMENT NO. 5019-E-0024
BOREHOLE LOCATIONS
SHEET
2



LEGEND				
	Borehole			
N	Blows/0.3 m (Std Pen Test, 475 J/blow)			
DCPT	Blows/0.3 m (60° Cone, 475 J/blow)			
	Water Level at Time of Investigation			
A/R	Auger Refusal at Elevation			
E/S	End of Sampling			
	Piezometer			

BOREHOLE No.	ELEVATION	O/S	NORTHING	EASTING
1	200.0	92.6 Rt	5032804.0	254848.8
2	198.0	65.9 Rt	5032800.3	254788.7

NOTES:
The boundaries between soil strata have been established at the borehole locations only. The boundaries illustrated and stratigraphy between boreholes on this drawing are assumed based on borehole data and may vary. They are intended for design only.
Base plan and alignment provided in digital format by LEA Consulting on January 17, 2023

GEOCRES No. 41H-177

REVISIONS		DATE		DESCRIPTION	
JAN/23	DM	DRAFT			
FEB/23	DM	FINAL			
DESIGN	CHK	CODE	LOAD	DATE	FEB/23
DRAWN	DM	CHK	SH	SITE	STRUCT
					SCHEME
					DWG
					2

Appendix B

Subsurface Data

Enclosure No. 1 List of Abbreviations and Symbols
Enclosure Nos. 2 to 3 Record of Borehole Sheets



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LIST OF SYMBOLS AND DEFINITIONS FOR GEOTECHNICAL SAMPLING AND COMMON LITHOLOGIES

The following is a reference sheet for commonly used symbols and definitions within this report and in any figures or appendices, including borehole logs and test results. Symbols and definitions conform to the standard proposed by the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) wherever possible. Discrepancies may exist when comparing to third-party results using the Unified Soil Classification System (USCS).

PART A – SOILS

Standard Penetration Test (SPT) 'N'

The number of blows required to drive a 50-mm (2 in) split barrel sampler 300 mm (12 in). The standard hammer has a mass of 63.5 kg (140 lbs) and is dropped vertically from a height of 760 mm (30 in). Additional information can be found in ASTM D1586-11 and in §4.5.2 of the CFEM 4th Ed.

For penetration less than 300 mm, 'N' is recorded with the penetration that was achieved.

Non-Cohesive Soils

The relative density of non-cohesive soils relates empirically to SPT 'N' as follows:

Relative Density	'N'
Very Loose	0 – 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	> 50

Cohesive Soils

The consistency and undrained shear strength of cohesive soils relates empirically to SPT 'N' as follows:

Consistency	Undrained Shear Strength (kPa)	'N'
Very Soft	< 12	0 – 2
Soft	12 – 25	2 – 4
Firm	25 – 50	4 – 8
Stiff	50 – 100	8 – 15
Very Stiff	100 – 200	15 – 30
Hard	> 200	> 30

PART B – ROCK

The following parameters are used to describe core recovery and to infer the quality of a rockmass.

Total Core Recovery, TCR (%)

The total length of solid drill core recovered, regardless of the quality or length of the pieces, taken as a percentage of the length of the core run.

Solid Core Recovery, SCR (%)

The total length of solid, full-diameter drill core recovered, taken as a percentage of the length of the core run.

Rock Quality Designation, RQD (%)

The sum of the lengths of solid drill core greater than 100 mm long, taken as a percentage of the length of the core run. RQD is commonly used to infer the quality of the rockmass, as follows:

Rockmass Quality	RQD (%)
Very Poor	< 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	> 90

Weathering

The terminology used to describe the degree of weathering for recovered rock core is defined as follows, as suggested by the *Geological Society of London*:

Completely weathered: All rock material is decomposed and/or disintegrated to soil. The original mass structure is largely intact.

Highly weathered: More than half the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a discontinuous framework or as core stone.

Moderately weathered: Less than half the rock material is decomposed and/or disintegrates to soil. Fresh or discolored rock is present either as a continuous framework or as core stone.

Slightly weathered: Discoloration indicates weathering of rock material and discontinuity of surfaces. All the rock material may be discolored by weathering and may be somewhat weaker than its fresh condition.

Fresh: No visible signs of weathering.

PART C – SAMPLING SYMBOLS

Symbol	Description
SS	Split spoon sample
TW	Thin-walled (Shelby Tube) sample
PH	Sampler advanced by hydraulic pressure
WH	Sampler advanced by static weight
SC	Soil core

PART D – IN-SITU AND LAB TESTING

SOIL NAMING CONVENTIONS

Particle sizes are described as follows:

Particle Size Descriptor	Size (mm)
Boulder	> 300
Cobble	75 – 300
Gravel	Coarse Fine
	19 – 75 4.75 – 19
	Coarse
	2.0 – 4.75
Sand	Medium
	0.425 – 2.0
	Fine
	0.075 – 0.425
Silt	0.002 – 0.075
Clay	< 0.002

The principle constituent of a soil is written in uppercase. The minor constituents of a soil are written according to the following convention:

Descriptive Term	Proportion of Soil (%)
Trace	1 – 10
Some	10 – 20
(ey) or (y)	20 – 35
And	35 – 50

Eg.: A soil comprising 65% Silt, 21% Sand and 14% Clay would be described as a: Sandy SILT, Some Clay

METRIC**RECORD OF BOREHOLE NO. 1**

REFERENCE P-0023230 DATUM TBM LOCATION N XXX E XXX - Twp. of Carling, Station XX+XXX ORIGINATED BY SG
 PROJECT Hwy 559 - Earth Berm Investigation BOREHOLE TYPE Track Mounted CME 850 - Hollow Stem Augers COMPILED BY DM
 CLIENT LEA Consulting DATE (Started) 2022 November 24 TIME
 DATE (Completed) 2022 November 24 (Completed) CHECKED BY AO

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 (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE			"N" VALUES	UNDRAINED SHEAR STRENGTH (Su, kPa)					
0.0	Ground Surface												
0.0	SILTY SAND - fine brown, moist (compact)		1	SS	13								
-0.7	SILTY CLAY - some fine sand brown, moist (very stiff)		2	SS	31								
-1.4	SAND & SILT - medium to fine brown, wet (very dense)		3	SS	87/230 mm								
-1.7	Auger Refusal - Bedrock End of Borehole												

WATER LEVEL RECORDS	
Date (dd/mm/yy)/Time	Water Depth (m) / Cave In (m)
1)	- / -
2)	- / -
3)	- / -

COMMENTS

+ 3, X³ : Numbers on right refer to Sensitivity
 Numbers on left refer to values greater than 100 kPa
 ○ 3% STRAIN AT FAILURE

The stratification lines represent approximate boundaries. The transition may be gradual.

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MEL-GEO P0023230 - BOREHOLE LOGS, EARTH BERM.GPJ MEL-GEO.GDT 23-2-24

METRIC

RECORD OF BOREHOLE NO. 2



REFERENCE P-0023230 DATUM TBM LOCATION N XXX E XXX - Twp. of Carling, Station XX+XXX ORIGINATED BY SG
 PROJECT Hwy 559 - Earth Berm Investigation BOREHOLE TYPE Track Mounted CME 850 - Hollow Stem Augers COMPILED BY DM
 CLIENT LEA Consulting DATE (Started) 2022 November 24 TIME
 DATE (Completed) 2022 November 24 (Completed) CHECKED BY AO

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 (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE			"N" VALUES	UNDRAINED SHEAR STRENGTH (S _u , kPa)					
0.0	Ground Surface												
0.0	SANDY CLAY - fine, with silt (possible fill) grey/brown, wet (soft)		1	SS	WH								
			2	SS	9								0 51 27 22
-1.4	SILTY SAND - fine grey, wet (loose)		3	SS	4								
-2.2	SILTY CLAY - with fine sand grey, wet (soft)		4	SS	WH								0 23 60 17
-3.0	SILTY SAND - some clay grey, wet (loose)		5	SS	10								
-3.7	SAND - fine to medium, some silt brown, wet (compact)		6	SS	11								
-4.9	Auger Refusal - Bedrock End of Borehole		7	SS	42/150 mm								
COMMENTS							+ 3, X 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 100 kPa ○ 3% STRAIN AT FAILURE						
							WATER LEVEL RECORDS Date (dd/mm/yy)/Time Water Depth (m) Cave In (m) 1) - ▽ - 2) - ▽ - 3) - ▽ -						

The stratification lines represent approximate boundaries. The transition may be gradual.

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Appendix C

Laboratory Data

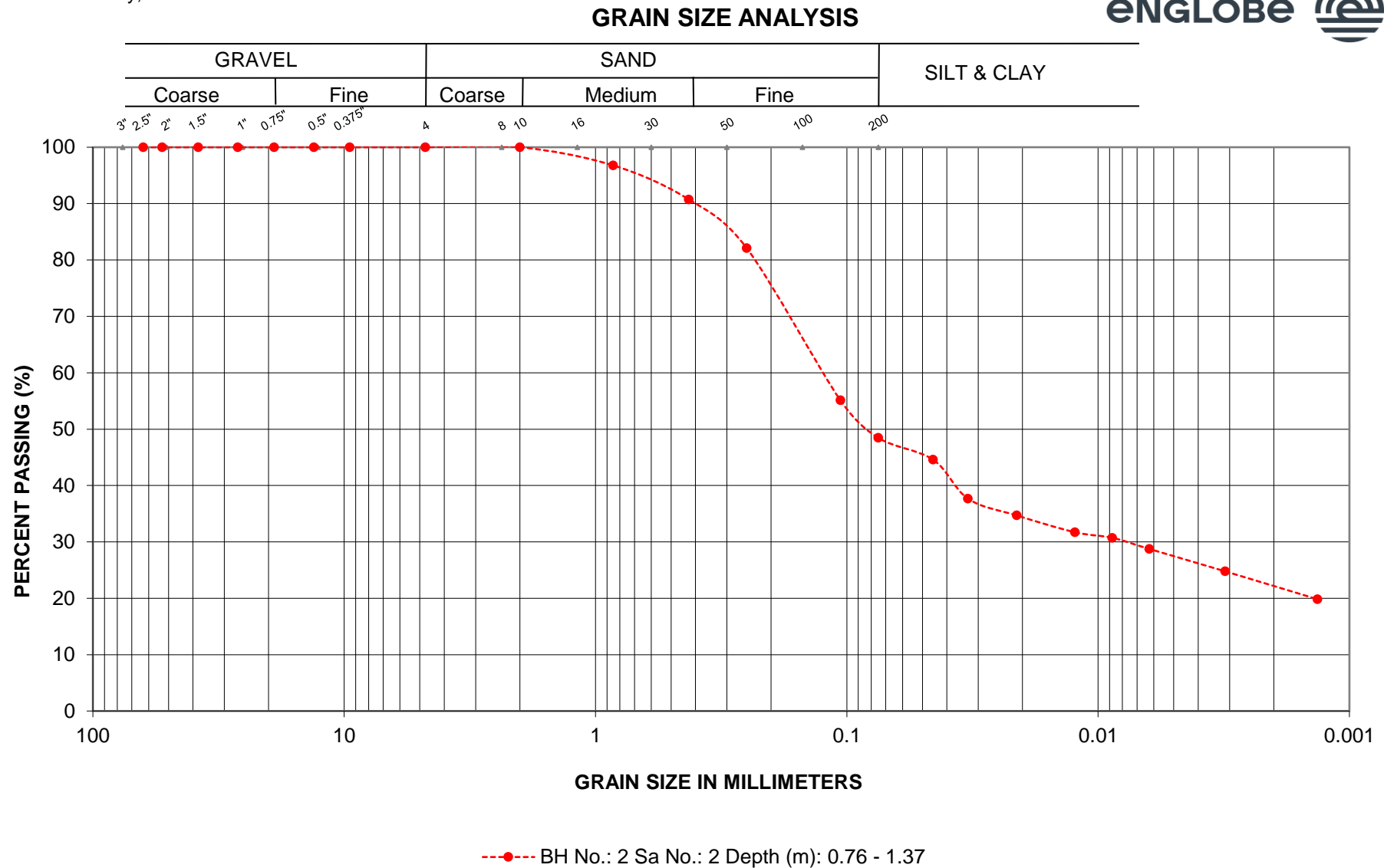
Figure No. L-1: Sandy Clay Grain Size Distribution Curve

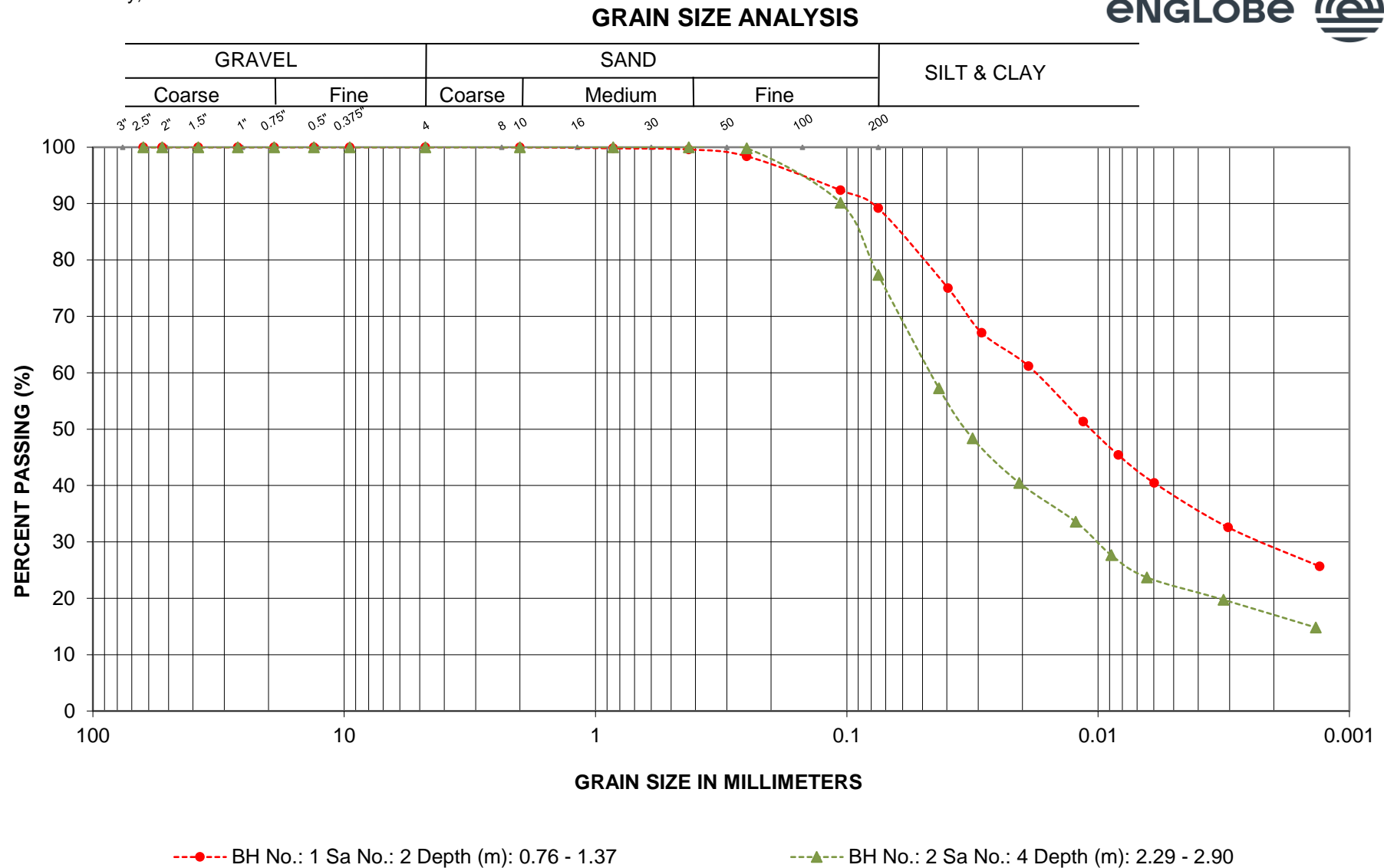
Figure No. L-2: Silty Clay Grain Size Distribution Curve

Figure No. L-3: Atterberg Limits



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SILTY CLAY

PROJECT: Earth Berm, Hwy 559

LOCATION: 26+850 to 27+035

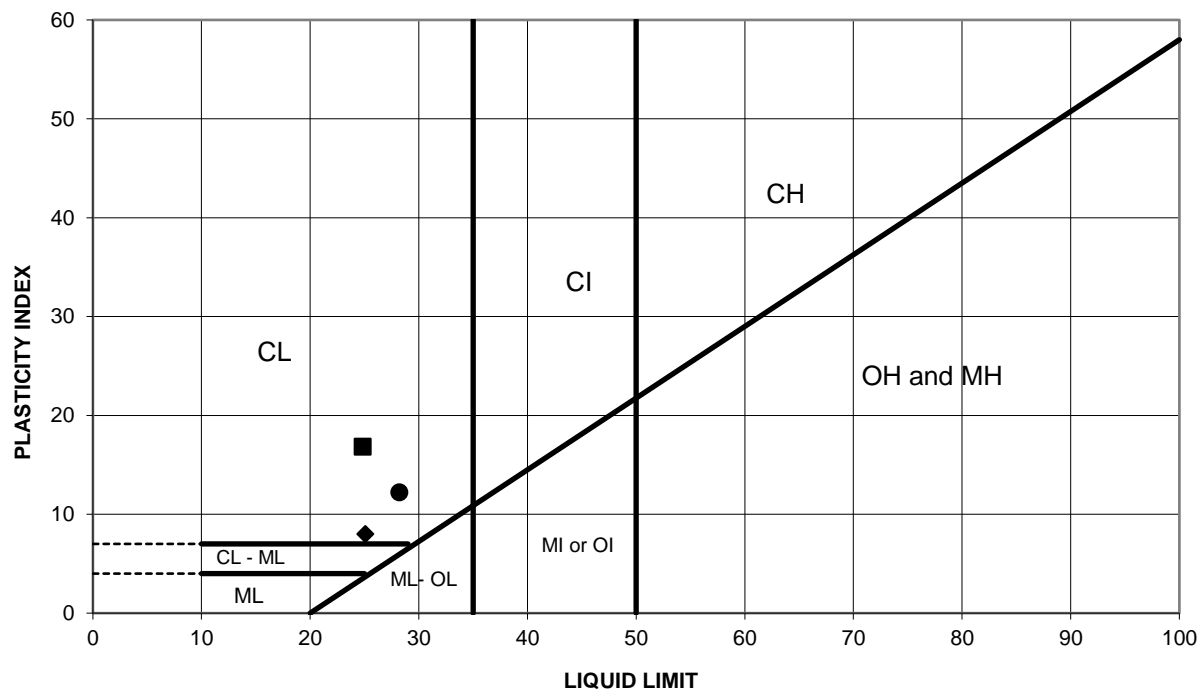
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FIGURE L-2

ATTERBERG LIMITS TEST RESULTS

FIGURE L-3

ATTERBERG INDICES



SYMBOL	BH No.	Sa No.	Depth (m)	Plasticity Index	Plastic Limit	Liquid Limit	NMC %
●	1	2	1.1	12.2	16.0	28.2	17.7
■	2	2	1.1	16.9	8.0	24.8	23.2
◆	2	4	2.6	8.0	17.1	25.1	31.1

Date: Jan-23
Project: Earth Berm, Hwy 559

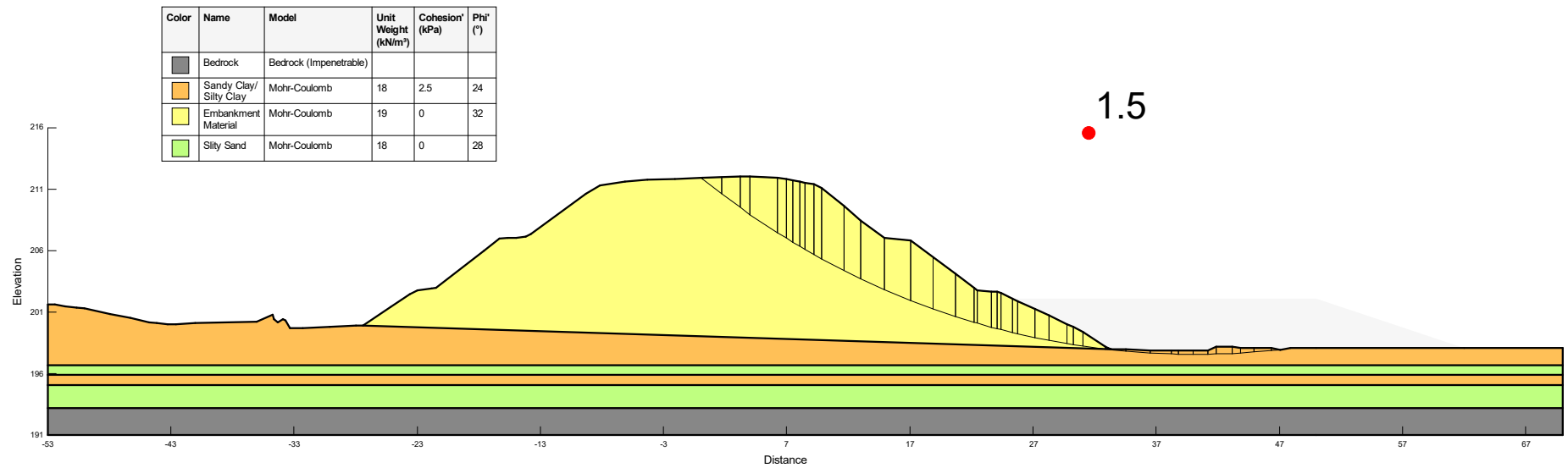
Prepared By: DM

ENGLOBE CORP.

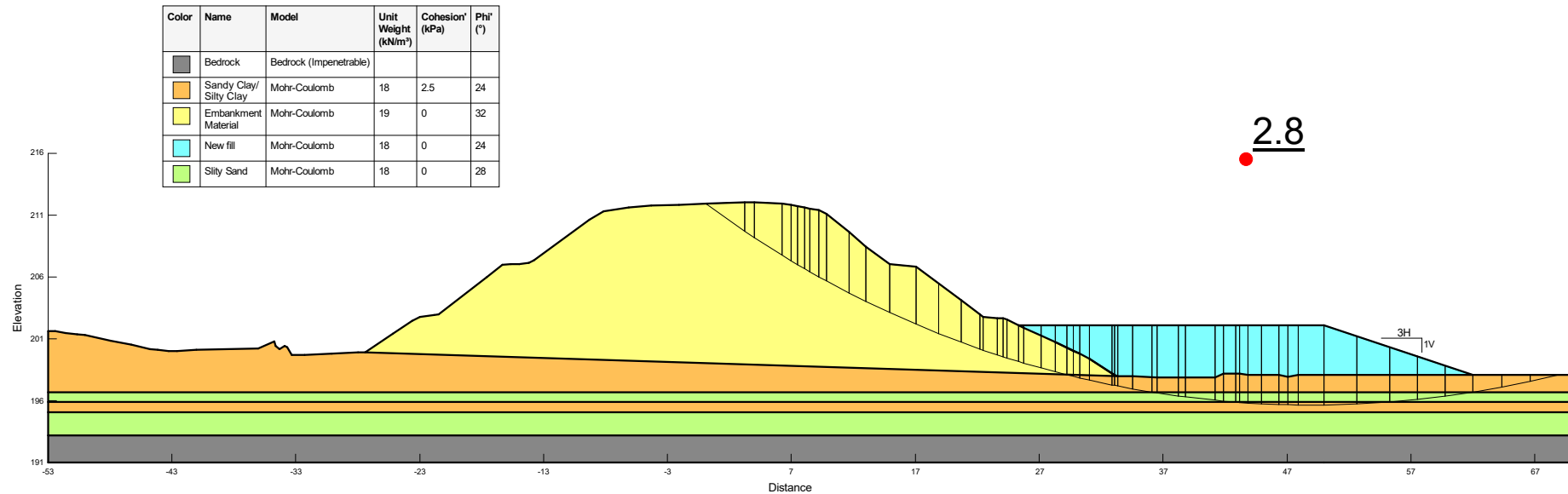
Appendix D Slope Stability Assessment



eNGLOBE

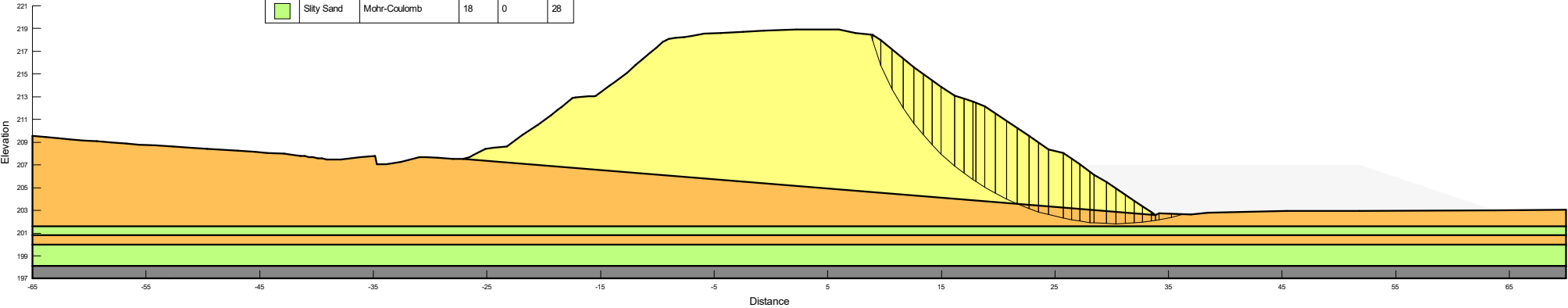


Slope Stability-Existing condition	S1
Highway 559 -Earth Berm Station 26+850.gsz	
2023-01-13	1:520



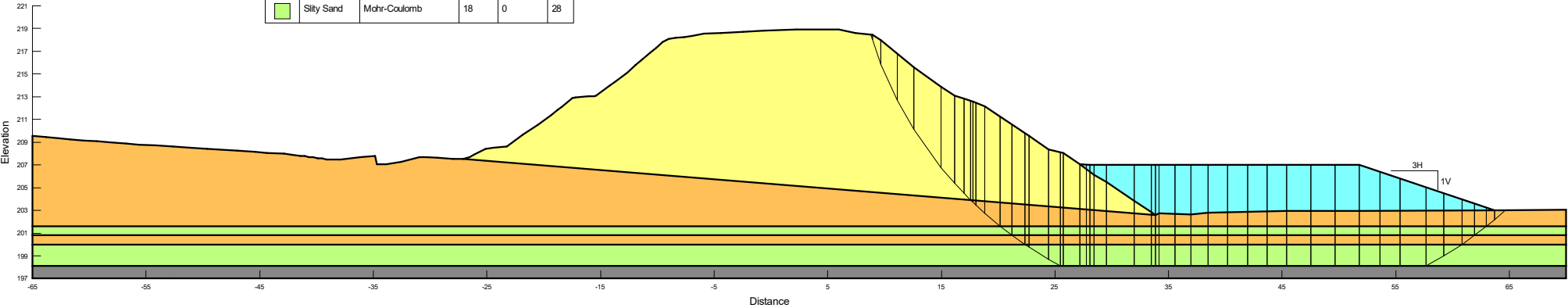
Slope Stability-With New Berm	S2
Highway 559 -Earth Berm Station 26+850.gsz	
2023-01-13	1:520

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Phi (°)
Bedrock	Bedrock	Bedrock (Impenetrable)			
Sandy Clay/ Silty Clay	Sandy Clay/ Silty Clay	Mohr-Coulomb	18	2.5	24
Embankment Material	Embankment Material	Mohr-Coulomb	19	0	32
Silty Sand	Silty Sand	Mohr-Coulomb	18	0	28



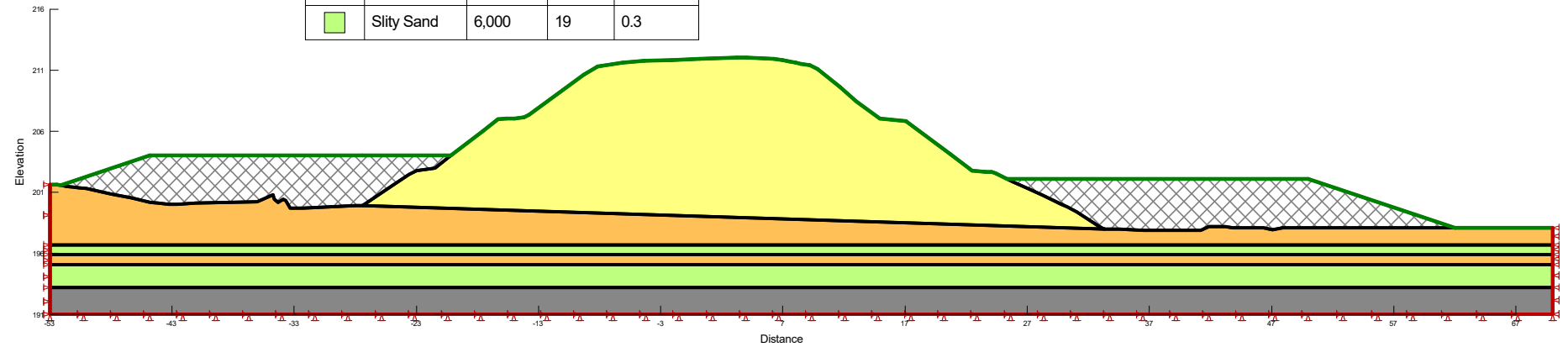
Slope Stability-Existing Condition	S3
Highway 559 -Earth Berm Station 27+035.gsz	
2023-01-13	1:520

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Phi (°)
Bedrock	Bedrock	Bedrock (Impenetrable)			
Sandy Clay/ Silty Clay	Sandy Clay/ Silty Clay	Mohr-Coulomb	18	2.5	24
Embankment Material	Embankment Material	Mohr-Coulomb	19	0	32
New Fill	New Fill	Mohr-Coulomb	18	0	24
Silty Sand	Silty Sand	Mohr-Coulomb	18	0	28








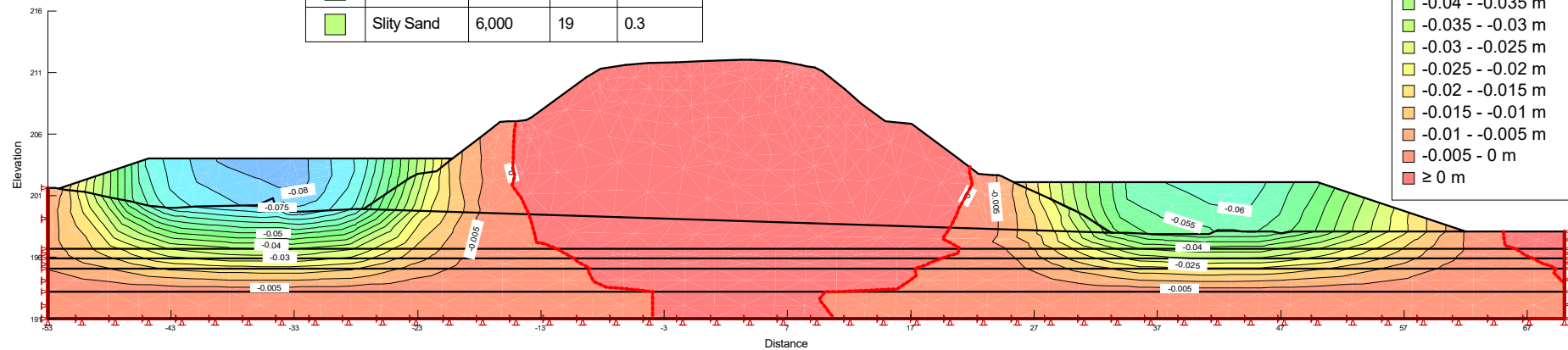
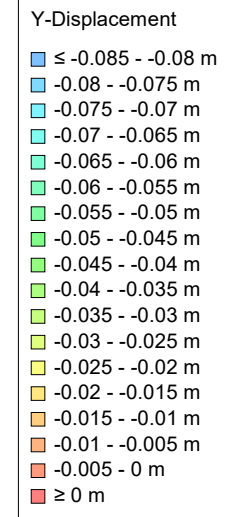
Slope Stability-with Berm	S4
Highway 559 -Earth Berm Station 27+035.gsz	
2023-01-13	1:520

Color	Name	Young's Modulus (E) (kPa)	Unit Weight (kN/m³)	Poisson's Ratio
Grey	Bedrock	75,000	19	0.15
Orange	Sandy Clay/ Silty Clay	4,000	18	0.35
Yellow	Embankment Material	8,000	19	0.3
Cyan	New fill	4,000	18	0.49
Light Green	Slity Sand	6,000	19	0.3



With side berms	S5
Highway 559 -Earth Berm Station 26+850 -settlement.gsz	
2023-01-25	1:520

Color	Name	Young's Modulus (E) (kPa)	Unit Weight (kN/m³)	Poisson's Ratio
	Bedrock	75,000	19	0.15
	Sandy Clay/Silty Clay	4,000	18	0.35
	Embankment Material	8,000	19	0.3
	New fill	4,000	18	0.49
	Slity Sand	6,000	19	0.3



With side berms	S6
Highway 559 -Earth Berm Station 26+850 -settlement.gsz	
2023-01-25	1:520