



THURBER ENGINEERING LTD.

Foundation Investigation and Design Report

Fort Severn MTO Bridge Replacement

Wapusk Road, District of Thunder Bay, Ontario

Agreement 6021-E-0007, Work Order 013

G.W.P. 6581-16-00, Site No. 41N-0243/B0

Latitude: 56.013437°, Longitude: -87.671875°

GEOCRES No. 44D04-001

Client Name: HATCH

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TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1.	INTRODUCTION.....	1
2.	SITE DESCRIPTION	1
3.	SITE INVESTIGATION AND FIELD TESTING	3
4.	LABORATORY TESTING.....	4
5.	DESCRIPTION OF SUBSURFACE CONDITIONS.....	4
5.1	Sand and Gravel to Sand.....	5
5.2	Sand and Silt	5
5.3	Silty Clay.....	6
5.4	Groundwater Conditions	9
6.	FORT SEVERN PIT SAMPLES.....	9
7.	CORROSIVITY AND SULPHATE TEST RESULTS	10
8.	MISCELLANEOUS.....	11

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

9.	GENERAL	12
10.	PROPOSED REPLACEMENT CULVERT	13
10.1	Summary of Subsurface Conditions	13
10.2	Culvert Replacement Alternatives	13
10.3	Culvert Construction	14
10.4	Structural Plate CSP Culvert.....	14
10.4.1	Subgrade Preparation	14
10.4.2	Frost Protection	14
10.4.3	Surface Water and Groundwater Control.....	14
10.4.4	Construction in Wet Conditions	15
10.4.5	Backfill and Lateral Earth Pressures.....	16
11.	SETTLEMENT UNDER NEW EMBANKMENT	17
12.	SLOPE STABILITY ASSESSMENT OF NEW AND TEMPORARY EMBANKMENTS ...	18
13.	EXCAVATION AND GROUNDWATER CONTROL	19
14.	SEISMIC CONSIDERATIONS.....	20
15.	SCOUR AND EROSION PROTECTION	21
16.	CORROSION AND SULPHATE ATTACK POTENTIAL.....	21



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17.	CONSTRUCTION CONCERNS	22
18.	CLOSURE.....	23

STATEMENT OF LIMITATIONS AND CONDITIONS

IN-TEXT TABLES

Table 3.1 Borehole Completion Details	4
Table 7.1 Analytical Test Results	10
Table 10.1 Lateral Earth Pressure Coefficients (K)	17
Table 12.1 Slope Stability Assessment Results.....	18
Table 14.1 Seismic Earth Pressure Parameters.....	21

IN-TEXT FIGURES

Figure 1 Vane Results vs Depth Plot.....	8
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APPENDICES

APPENDIX A

- Preliminary General Arrangement (GA) drawing
- Borehole Locations and Soil Strata Drawings

APPENDIX B

- Record of Borehole Sheets

APPENDIX C

- Laboratory Test Results

APPENDIX D

- Site Photographs

APPENDIX E

- List of OPSS and OPSD Documents and Suggested Wording for NSSPs

APPENDIX F

- Settlement Analysis Figures

APPENDIX G

- Slope Stability Analysis Figures



APPENDIX H

General Arrangement Drawing

**FOUNDATION INVESTIGATION AND DESIGN REPORT
FORT SEVERN MTO BRIDGE REPLACEMENT
WAPUSK ROAD, DISTRICT OF THUNDER BAY, ONTARIO
AGREEMENT 6021-E-0007, WORK ORDER 13
G.W.P. 6581-16-00, SITE NO. 41N-0243/B0
LATITUDE: 56.013437°, LONGITUDE: -87.671875°**

GEOCRES No. 44D04-001

PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for design of the proposed Fort Severn Culvert replacing the existing modular bridge. The Fort Severn Culvert is located on Wapusk Road, approximately 0.8 km southeast of the MTO's Fort Severn Airport, in the Unsurveyed Territory, District of Thunder Bay, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the proposed culvert location and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results and a written description of the subsurface conditions.

Thurber carried out the investigation as a sub-consultant to Hatch Corporation (Hatch), under the Ministry of Transportation Ontario (MTO) Retainer Agreement Number 6021-E-0007, Work Order 13.

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. SITE DESCRIPTION

The site is located on Wapusk Road, in the Unsurveyed Territory, District of Thunder Bay, Ontario. The existing modular bridge, spanning approximately 27 m in length, allows Severn River Tributary to flow in a general south to north direction under Wapusk Road. Wapusk Road generally runs in a northwest-southeast direction at the bridge site, connecting the Fort Severn

MTO Airport to Fort Severn. For the purposes of this report, Wapusk Road is described as running in a west-east direction.

Located in Fort Severn, Ontario, the community is positioned along the south coast of Hudson's Bay. As Ontario's most northern community, access is limited to fly-in only for most of the year to the local MTO Airport. In the winter, Road access from Manitoba is available for a limited time each year. Due to this, the investigation was limited to portable drilling equipment that could be flown into the site and had total weight limitations for take off from the gravel runway in Fort Severn.

In addition to the modular bridge, a local culvert and Road access has been constructed parallel to the existing Road alignment. The culvert was verified by Hatch on site to be a 2800 mm SPCSP with a span of 11.43 m. It is understood that the culvert and the access Road had been installed by the local community to permit the passage of wider equipment unable to pass over the modular bridge. The centreline to centerline distance between the two Roads is approximately 12 m over the River Tributary.

Photographs in Appendix D show the general nature of the site and the existing bridge.

The available design plan drawing provided by Hatch indicates that the existing structure consists of a temporary modular bridge with 9 bays, extending a total length of 27.4 m and a total width of 5.3 m. The bridge is gradually sloped, increasing in elevation from west to east with an underside elevation of the bridge of 12.7 m near the centreline of the Severn River Tributary. Wapusk Road is a gravel Road with an existing grade level of approximate Elevation 15 m west and east of the site, decreasing to 13 m at its lowest near the west abutment. The highway embankment is approximately 5 m high at both abutments.

The local River Tributary water level was reportedly measured at Elevation 9.29 m in September 2016 and measured by Thurber to be 10.3 m on July 18, 2024. The site is surrounded by shrubs and low trees, with marshy areas near the River Tributary banks.

Based on a 1991 Geocres report (Geocres No. 43M-1) for a new airport building in Fort Severn, the site is located within the Hudson Bay Lowlands and within the continuous permafrost zone, but near the southern limit boundary with the discontinuous permafrost zone. The report provides information on the encountered soils to be sand overlaying sand, sandy silt to silt material, before terminating in a silt some clay, clayey silt to silty clay deposit. The deepest borehole extended to a depth of 7.6 meters below ground surface (estimated elevation 8.6 m based on available survey data).

3. SITE INVESTIGATION AND FIELD TESTING

The site investigation and field-testing program for this project was carried out from July 14 to 18, 2024 with an additional 1-2 days of mobilization to and from the site. The field program consisted of drilling and sampling five (5) boreholes (24-01 to 24-05) to depths ranging from 8.0 to 10.4 m below the riverbed (Elevation 0.5 to -0.7 m).

All boreholes were advanced in the river using a raft and portable drilling equipment. Boreholes 24-01 and 24-03 were advanced on the east side of the proposed culvert, near the prepared location of the temporary diversion pipe. Boreholes 24-02, 24-04 and 24-05 were advanced along the centre and west of the proposed culvert alignment. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawings in Appendix A. The Record of Borehole sheets are included in Appendix B.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from field measurements and the topographic drawings provided to Thurber by Hatch. The coordinate system MTM NAD 83, Zone 14 was used for the boreholes.

All boreholes were advanced using a portable Hilti drill and tripod equipment using wash boring techniques. In all boreholes, soil samples were obtained at selected intervals with a 50 mm outside diameter split spoon sampler driven with a full weight hammer in conjunction with the Standard Penetration Test (SPT). MTO B Field Vane measurements were also taken at select depths in all boreholes for the Silty Clay material.

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

No monitoring wells were installed as part of this geotechnical program.

Details of the drilling program, including water and drilling depths and completion details are summarized in Table 3.1 below.

Table 3.1 Borehole Completion Details

Borehole Number	Water depth (m)	Borehole Depth Below Riverbed/ Base Elevation (m)	Completion Details
24-01	0.6	10.4 / -0.7	Bentonite holeplug to ground surface.
24-02	1.2	8.6 / 0.5	Bentonite holeplug to ground surface
24-03	1.8	8.3 / 0.2	Bentonite holeplug to ground surface
24-04	0.6	9.6 / 0.1	Bentonite holeplug to ground surface
24-05	1.8	8.0 / 0.5	Bentonite holeplug to ground surface

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification. Selected samples were subjected to natural moisture content determination, grain size distribution analyses (sieve and hydrometer), and Atterberg Limits, where appropriate. The results of this testing program are summarized on the Record of Borehole sheets in Appendix B and are shown on the figures included in Appendix C.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, two soil samples were collected during the investigation and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix B. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata drawings in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface stratigraphy below the river tributary bed consists of native very loose to loose sand and gravel to sand to sand and silt, with deposits of sand and silt. These cohesionless soils were underlain by very stiff to soft silty clay until the termination of each borehole. More detailed descriptions of the individual strata are presented below.

5.1 Sand and Gravel to Sand

Sand and gravel to sand was encountered at the riverbed in Boreholes 24-01, 24-02, 24-04 and 24-05. The surficial layer consisted of sand and gravel to sand, some gravel, trace silt with occasional wood fragments and pieces. Occasional silt to silty clay seams were also observed within the sand and gravel to sand layers in Boreholes 24-02 and 24-05 and noted on the Borehole Logs.

The sand and gravel to sand extended to depths ranging from 0.6 m to 3.9 m below the riverbed (Elevation 9.1 to 4.6 m).

SPT 'N' values in the sand and gravel to sand generally ranged from 1 to 21 blows per 0.3 m penetration, indicating a very loose to compact relative density, typically ranging from very loose to loose.

The measured moisture contents generally ranged from 7 to 30%. One sample (BH 24-02) measured a higher moisture content of 55%.

The results of a grain size analysis conducted on a selected sample of the sand and gravel to sand are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C1 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	92
Silt & Clay	8

5.2 Sand and Silt

A surficial layer of sand and silt and a deposit of sand and silt were encountered in Boreholes 24-03 and 24-04 respectively. The sand and silt contained trace clay, trace gravel with rootlets, wood fragments and organics throughout the material.

In Borehole 24-03, the sand and gravel layer extended to a depth of 1.4 m below the riverbed (Elevation 7.1 m). In Borehole 24-04, the sand and silt deposit was encountered from a depth ranging from 1.2 to 3.6 m (Elevation 7.1 to 6.1 m) below the riverbed.

SPT 'N' Values in the sand and silt ranged from weight of hammer to 8 blows per 0.3 m penetration, indicating a very loose to loose relative density.

Measured moisture contents ranged from 18 to 26% with higher moisture contents ranging from 33 to 74% where samples contained rootlets, wood fragments and organics.

The results of grain size analyses conducted on samples of the sand and silt deposit are provided on the Record of Borehole sheets in Appendix B, and plotted on Figure C2 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	44 to 98
Silt	49 to 51
Clay	2 to 5
Silt and Clay	2

5.3 Silty Clay

A silty clay deposit was encountered with trace sand below the sand and gravel layer in Boreholes 24-01, 24-02 and 24-05 and beneath the sand and silt layer/deposit in Boreholes 24-03 and 24-05.

The silty clay deposit was encountered in all boreholes until the termination depths ranging from 8.0 m to 10.4 m (Elevation 0.5 to -0.7 m) below the riverbed.

SPT 'N' Values in the silty clay deposit ranged from 9 blows per 0.3 m penetration to weight of hammer, indicating a stiff to very soft consistency.

MTO 'B' Field Vane measurements in the silty clay deposit ranged from 132 to 48 kPa undrained shear strength from elevation 6.8 to 5.0 m where measured, indicating the presence of a crust which is very stiff to firm in consistency. Below elevation 5.0 m, the undrained shear strength ranged from 60 to 24 kPa, indicating a stiff to firm consistency. Field vane results are plotted in Figure 1 below. Clay sensitivity appears to range from 7 to 20.

Recorded moisture contents in the silty clay ranged from 19 to 29%.

The results of grain size analyses conducted on samples of the silty clay deposit are provided on the Record of Borehole sheets in Appendix B and plotted in Figure C3 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	4 to 10
Silt	72 to 80
Clay	15 to 21

The results of Atterberg Limit tests conducted on samples of the silty clay deposit are provided on the Record of Borehole sheets in Appendix B and plotted in Figure C4 in Appendix C. The results are summarized as follows:

Limit	Percentage (%)
Liquid Limit	22 to 30
Plastic Limit	15 to 18
Plasticity Index	6 to 12

The silty clay is a low plastic silty clay (CL).

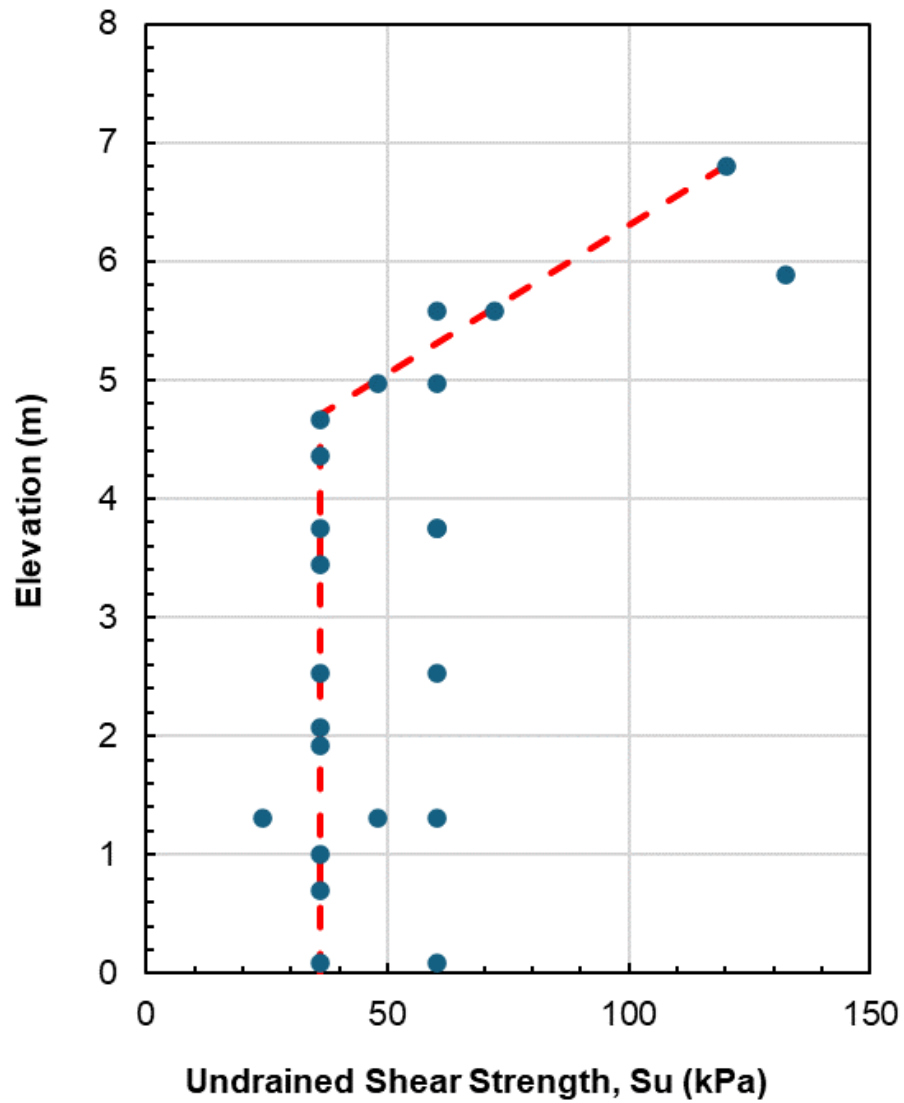


Figure 1: Vane Results vs Depth Plot

5.4 Groundwater Conditions

Groundwater conditions were unable to be observed following the completion of each borehole since boreholes were advanced within the Severn River Tributary and used boring techniques which introduced water into the borehole. The water depth at the borehole locations ranged from 0.6 to 1.8 m.

The groundwater level is likely to reflect the local Severn River Tributary water level. The local River Tributary water level was measured at Elevation 10.3 m on July 18, 2024.

It should also be noted that groundwater levels are short term observations and 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 and spring snow melts.

6. FORT SEVERN PIT SAMPLES

Due to the remoteness of the site and difficulties with importing granular materials meeting OPSS.PROV 1010 standards to the site, MTO requested Thurber and Hatch to visit any local pits where granular till may be available for the construction of the new embankment over the replacement culvert. Thurber and Hatch collected samples from the following three available pits within the community with approximate coordinates:

Sample Pit	Latitude/Longitude	MTM NAD 83, Zone 14	
		Northing	Easting
MTO Fort Severn Pit (Stockpile) for use at the airport	56.019294, -87.685848	6,212,097.68	261,068.15
Band Office Severn River Pit	56.004182, -87.610086	6,208,575.73	266,743.23
Band Office Forrest Pit	56.035331, -87.701629	6,210,302.43	262,034.02

Each pit was visited by Thurber and Hatch to collect a bulk sample for gradation testing. Lab testing completed on the samples are shown in on the figures C5 to C7 included in Appendix C. Although the samples collected from both the Band Office Pits (refereed to as Band Pit material herein) are close to an OPSS.PROV 1010 Granular A gradation, there is concern that the material may be non-uniform and may contain organic material as noted at the time of sampling the Pit location. The MTO Fort Severn Pit (referred to as MTO Pit material herein) is understood to be screened from locally available sources by MTO Personnel and is the preferred material for embankment construction at the replacement culvert site. For the purposes of this report the MTO Pit material may be considered similar to Granular A and the Band Pit material may be considered similar to Granular B Type I.

7. CORROSIVITY AND SULPHATE TEST RESULTS

Samples of the silty clay and sand and gravel from Boreholes 24-01 and 24-05 collected were submitted for analytical testing of corrosivity parameters and sulphate. The laboratory certificates of analysis are presented in Appendix C. The results of the analytical tests are summarized below in Table 7.1.

Table 7.1 Analytical Test Results

Parameter	Units (Soil)	Test Results	
		24-01 SS2 (4'-6') (1.2 – 1.8 m)	24-05 SS1&2 (6'-10') (1.8 – 3.1 m)
		(Silty Clay)	(Sand and Gravel)
Redox Potential	mV	343	332
Sulphide	%	<0.01	0.01
pH	-	8.32	8.63
Chloride	µg/g	660	15
Sulphate	µg/g	5.5	19
Conductivity	µS/cm	34	19
Resistivity*	ohm-cm	29400	52600

* Calculated based on conductivity result

8. MISCELLANEOUS

Thurber obtained utility clearances for the borehole locations prior to drilling. Borehole locations were selected and established in the field by Thurber Engineering Ltd and Hatch Ltd.

Limitless Drilling of Renfrew, Ontario supplied a portable Hilti drill with tripod and raft, to conduct the drilling, sampling and in-situ testing operations for the boreholes.

Geotechnical laboratory testing was carried out in Thurber's geotechnical laboratory. Analytical testing was carried out by SGS Canada Inc.

The field investigation was supervised on a full-time basis by Mr. Joshua Alexander, P. Eng. of Thurber. Overall supervision of the field program was provided by Mr. Joshua Alexander, P. Eng. and Mr. Mark Farrant, P. Eng. of Thurber.

Interpretation of the field data and preparation of this report was carried out by Mr. Joshua Alexander, P. Eng. and reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.



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**FOUNDATION INVESTIGATION AND DESIGN REPORT
FORT SEVERN MTO BRIDGE REPLACEMENT
WAPUSK ROAD, DISTRICT OF THUNDER BAY, ONTARIO
AGREEMENT 6021-E-0007, WORK ORDER 13
G.W.P. 6581-16-00, SITE NO. 41N-0243/B0
LATITUDE: 56.013437°, LONGITUDE: -87.671875°**

GEOGRES No. 44D04-001

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

9. GENERAL

This report provides an interpretation of the factual data from Part 1 of the report and presents foundation recommendations for the proposed replacement of the existing Fort Severn modular bridge with a culvert crossing located on Wapusk Road. The discussion and recommendations presented in this report are based on the information provided by Hatch and MTO and on the factual data obtained during the course of the investigation.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation and Hatch, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data in Part 1 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. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The site is located on Wapsuk Road, in the Unsurveyed Territory, District of Thunder Bay, Ontario. The site is in Fort Severn, Ontario, which is along the south coast of Hudson's Bay with limited transportation means to access the community. Aside from a winter ice Road, year-round transportation is limited to flying in or using cargo ships. The recommendations herein consider these access and construction limitations, considering that not all means and methods may not be practical to implement in the remote northern community.

The available base plan drawing provided by Hatch indicates that the existing modular bridge is proposed to be replaced with a structural plate corrugated steel pipe (SPCSP). The available design plan drawing provided by Hatch indicates that the existing structure consists of a

temporary modular bridge with 9 bays, extending a total length of 27.4 m and a total width of 5.3 m. The bridge is gradually sloped, increasing in elevation from west to east with an underside elevation of the bridge of 12.7 m at the centreline of the Severn River Tributary. Wapusk Road consists of a gravel Road with an existing grade level of approximate Elevation 15 m west and east of the site, decreasing to 12.3 m at its lowest near the west abutment. The highway embankment is approximately 5 m high at both abutments.

A local access Road with a 2800 mm SP00CSP had been constructed by the local community north of the existing bridge. We understand that this culvert is undersized, which causes flooding between the bridge and the access Road. Debris is also known by the community to build at the inlet, which worsens the flooding issue.

10. PROPOSED REPLACEMENT CULVERT

10.1 Summary of Subsurface Conditions

In general, the subsurface stratigraphy under the Severn River Tributary bed consists of native very loose to loose sand and gravel to sand to sand and silt, with deposits of sand and silt. The overburden soils were underlain by very stiff to soft silty clay until the termination of each borehole.

The local River Tributary water level was measured at Elevation 10.3 m on July 18, 2024.

10.2 Culvert Replacement Alternatives

Following removal of the existing bridge and unloading of the approach embankments, a Structural Plate Corrugated Steel Pipe (SPCSP) is considered the preferred replacement and practical option for this site due to its remoteness.

The preliminary draft General Arrangement (GA) drawing provided by Hatch is attached in Appendix A. The GA drawing indicates that the proposed replacement culvert is a 4.6 m diameter, 30.4 m long SPCSP. The proposed invert level of the culvert ranges from Elev. 7.80 m at the inlet to 7.65 m at the outlet. A small grade raise of approximately 150 mm is proposed over the new culvert. A temporary diversion pipe, approximately 2.8 m in diameter is proposed east of the replacement culvert to carry the river flow during construction of the replacement culvert.

Recommendations for the design and installation of the replacement culvert are presented below.

10.3 Culvert Construction

The main construction consideration at the site is whether the temporary excavation for construction of the replacement culvert can be fully dewatered to enable culvert construction in the dry. The stratigraphy drawing indicates that the proposed invert of the new culvert will be in the cohesionless sand and gravel and sand layer. Even with diversion of the river through a temporary diversion pipe, there is no guarantee that the temporary excavation for the new culvert can be fully dewatered. Considering the remoteness of the site and that no sheet piling equipment is available locally, dewatering with a full sheet pile enclosure of the temporary excavation for culvert installation by driving the sheet piles into the foundation clay is not practical. Accordingly, culvert construction will likely have to be constructed in the wet. The subsequent sections providing foundation recommendations for the culvert assume that the culvert will be constructed in the wet through a depth of standing water.

10.4 Structural Plate CSP Culvert

10.4.1 Subgrade Preparation

Preparation of the culvert subgrade in the wet will be difficult. The excavation to reach the subgrade will be done through sand and gravel and the underlying sands and silts below the riverbed. The GA drawing indicates a fair bit of excavation of the approach slopes on both sides of the culvert. Temporary slopes below the water level should be 3H:1V or flatter. These excavated soils should be wasted and not used as new embankment fill.

10.4.2 Frost Protection

The depth of frost penetration at this site is approximately 3.3 m based on OPSD 3090.100. The frost cover requirement does not apply to pipe culvert installations.

10.4.3 Surface Water and Groundwater Control

Diversion of the surface water flow through the temporary diversion pipe will be required. A combination of sandbag cofferdam enclosures and stream diversion along with pumping from properly filtered sumps within the sandbag enclosure will be required to lower the water level in the temporary excavation.

As indicated earlier, due to the remoteness of the site, sheet piling may be difficult to transport and install to achieve dewatering with a sheet pile enclosure. It is recommended that the contractor utilize sandbags/meter bags to prepare a cofferdam using sub excavated materials on

site to fill the bags. If these dewatering measures do not result in a dry excavation, backfilling in the wet conditions (below water level) may have to be considered (see Section 10.4.4).

The temporary diversion pipe should be placed on a minimum 300 mm thick layer of bedding material consisting of material from one of the local three pits identified in Section 6. The bedding material should be placed on the prepared subgrade as soon as practical, following its inspection and approval. The subgrade preparation should be carried out in the dry, if practical. The prepared subgrade should be protected from disturbance during construction.

10.4.4 Construction in Wet Conditions

Given that seepage of groundwater through the foundation sand and silt soil and of surface water penetrating through the sandbag cofferdam may be encountered, backfilling in the wet conditions (below the water level) may have to be considered. This approach will still require diversion of the stream flow and surface water so that the excavations can be done within a stagnant water pool. When backfilling is conducted in the wet, usual practice is to use clear stone below the water level until the fill placement daylights above water level.

However, clear stone is not locally available and as an alternative, consideration should be given to using the granular borrow from the MTO Pit fully wrapped in geotextile below the water table. It will not be possible to compact this fill placed in the water. Once this fill is above the water level, the remainder of the granular fill must be compacted in thin lifts as per OPSS 501. The geotextile should meet the specifications for the OPSS Class II (OPSS 1860) and have a fabric opening size (FOS) not greater than 212 μm .

It is recommended that the permanent embankment hosting the new culvert be constructed using the granular borrow from MTO's airport stockpile.

Considering the remoteness of the site, it may not be possible to monitor the compaction density of each lift of embankment fill. It is understood that a vibratory roller may be available at the airport site for compaction of fill. A minimum of 8 passes of the roller should be used to compact each 300 mm of lift placed above the water level. Special attention should be paid to adequately compact the edges of the fill. The degree of compactness of each lift shall be visually examined assisted by a probe rod pushed into the compacted fill at a number of locations all over each lifts. If the rod is meeting refusal within a couple of inches, the lift is well compacted. Suggested wording for an NSSP on monitoring of embankment fill compaction is included in Appendix E.

Since the lower part of the embankment fill may be placed in the wet without compaction, lateral support of the fill to the new culvert may not be as strong in comparison to the granular fill being

placed in the dry and compacted well. Accordingly, it is recommended that the culvert gauge be accordingly increased/thickened to enhance the structural capacity of the culvert.

10.4.5 Backfill and Lateral Earth Pressures

Backfill to the culvert should consist of free-draining, non-frost susceptible material from the MTO Airport Pit. Reference should be made to the backfill arrangements stipulated in OPSD 802.010. Backfilling for the culvert should be in accordance with OPSS.PROV 401. All fills should be placed in regular lifts and be compacted when above the water level in accordance with OPSS.PROV 501. The placement of the backfill must be done from the toe of the excavation slopes and proceed to the top. The backfill should be placed and compacted in simultaneous lifts on both sides of the culvert, and the top of backfill elevation should not differ more than 500 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the sides and top of the culvert. Compaction equipment to be used adjacent to the culvert should be restricted in accordance with OPSS.PROV 501.

Lateral earth pressures acting on the culvert walls may be assumed to be a triangular distribution. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2019, but are generally given by the expression:

$$p_h = K (\gamma h + q)$$

where	p_h	=	horizontal pressure on the wall at depth h (kPa)
	K	=	earth pressure coefficient (see table below)
	γ	=	bulk unit weight of retained soil (see table below)
	h	=	depth below top of fill where pressure is computed (m)
	q	=	value of any surcharge (kPa)

Earth pressure coefficients for backfill to the culvert walls are dependent on the material used as backfill. Recommended unfactored values are shown in Table 10.1 below.

Table 10.1 Lateral Earth Pressure Coefficients (K)

Loading Condition	MTO Pit Granular $\phi = 35^\circ$; $\gamma = 22.8 \text{ kN/m}^3$		River and Forrest Band Pit Granular $\phi = 32^\circ$; $\gamma = 19.0 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active, K_A (Unrestrained Wall)	0.27	0.40*	0.31	0.48*
At-rest, K_0 (Restrained Wall)	0.43	0.62	0.47	0.70
Passive, K_P	3.7	-	3.2	-

Note: Submerged unit weight should be used below the groundwater level/high River Tributary level.

The use of a material with a high friction angle and low active pressure coefficient (MTO Pit Granular) is required to support a 2H:1V embankment side slope as outlined in Section 12.

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added. The magnitude of the surcharge should be 12 kPa at the top of fill and decrease to 0 kPa at a depth of 1.7 m for material from the Band Pits, or at a depth of 2.0 m for MTO Pit Granular.

11. SETTLEMENT UNDER NEW EMBANKMENT

For the installation of a new embankment on Wapusk Road following installation of the culvert, in order to match the existing vertical Roadway profile will require a 5.6 m high embankment and generally maintaining the previous vertical elevations with a minor grade raise to the west of the site.

In order to assess the settlement of the foundation soil under the proposed embankment options, Thurber considered the new embankment fill to consist of locally available granular borrow material around the site as outlined in Section 6 of the of the FIR.

Thurber conducted settlement analyses at the new culvert with a new 5.6 m high embankment fill. The estimated total settlement due to the new embankment fill for both the permanent embankment and temporary diversion pipe embankment are shown on the settlement profile Figures F1 and F2 in Appendix F.

For the new 5.6 m high embankment fill, Figure F1 shows foundation settlement of approximately 120 mm under the highway centreline, and 45 mm at the ends of the culvert (approximately 15 m either side of the highway centreline).

An analysis was also conducted for the settlement of the temporary embankment over the diversion pipe. The temporary culvert proposed is approximately 15 m in length and has embankment fill height of approximately 3.3 m. Figure F2 shows foundation settlement of approximately 90 mm under the temporary Road centreline, and 83 mm at the ends of the culvert (approximately 7.5 m either side of the temporary Road centreline).

The new culvert must be designed to tolerate the estimated settlement induced by the placement of the embankment fill. As the highway embankment surface will experience settlement, the embankment should also be overbuilt to allow for settlement.

12. SLOPE STABILITY ASSESSMENT OF NEW AND TEMPORARY EMBANKMENTS

Slope stability analyses were conducted to assess the new Wapusk Road embankment side slopes to be constructed as part of the new culvert installation. The stability analyses were based on an approximately 5.6 m high embankment at the new culvert location. Due to the remoteness of the site, local granular material options were considered as the embankment fill material for the analyses. In consultation with Hatch and MTO, rock fill was not considered to be available at the site for embankments and therefore was not analyzed.

The slope stability analysis figures are included in Appendix G and the results are summarized in the table below. All stability assessments were carried out with an embankment slope of 2H:1V.

Table 12.1 Slope Stability Assessment Results

Figure	Fill Material	Horz Seismic Coef:	Excavation Cond.	Drained / Undrained	Geogrid Reinforcement	Safety Factor
G1, G2	River or Forrest Band Pit	0	Dry	Drained, Undrained	N/A	1.2
G3, G4	MTO Pit	0	Dry	Drained, Undrained	1 Layer of Geogrid, 0.5 m above water level	1.7
G5	MTO Pit	0.0336	Dry	Drained, Undrained	1 Layer of Geogrid, 0.5 m above water level	1.6
G6	MTO Pit	0	Dry	Drained	1 Layer of Geogrid, 0.5 m above base of excavation	1.3
G7	MTO Pit	0	Construction in the wet (WL Elev. 10.3 m)	Drained	None	1.2

Figure	Fill Material	Horz Seismic Coef:	Excavation Cond.	Drained / Undrained	Geogrid Reinforcement	Safety Factor
G8, G9	MTO Pit	0	Construction in the wet (WL Elev. 10.3 m)	Drained, Undrained	1 Layer of Geogrid, 0.5 m above water level	1.7
G10	MTO Pit	0.0336	Construction in the wet (WL Elev. 10.3 m)	Undrained	1 Layer of Geogrid, 0.5 m above water level	1.5
G11	MTO	0	Construction in the wet (WL Elev. 10.3 m)	Drained	1 Layer of Geogrid, 0.5 m above base of excavation	1.3
G12 (Temporary Embankment)	River or Forrest Band Pit	0	Dry	Drained	None	1.4

As outlined in the table above, an embankment slope of 2H:1V with material sourced from the MTO Pit would be required to maintain stable slopes for the permanent embankment in either dry or wet conditions. Additionally, a layer of geogrid is required to be placed 0.5 meters above the seasonally high-water level which was estimated at an elevation of 10.8 m. The geogrid should consist of a single layer of Miragrid 22XT or equivalent and be installed as per the manufacturer's instructions. Construction of the new embankment should be carried out in accordance with OPSS.PROV 206. The fill material should be well graded and must be placed in lifts in a controlled manner and proceed from the base of the embankment up to the top. The fill must not be placed by end-dumping and must be well compacted above the water level. Additionally, the embankment should be overbuilt for settlement, exceeding the design width.

In addition, Figure G12 shows the stability analysis for a 3.3 m high temporary embankment constructed of local material sourced from the local Band River or Forrest Pits at a 2H:1V slope. The Factor of Safety of 1.4 shown, indicates that short-term (drained) condition for this configuration is acceptable for the short-term period during construction.

13. EXCAVATION AND GROUNDWATER CONTROL

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the embankment fill and the native sand and silt mixed with organics at this site are classified as a Type 3 soil above the water table. Below the water table (i.e., if the groundwater flow is not controlled), these soils would be classified as Type 4 soils. Suggested wording for an NSSP on obstructions is included in Appendix E.

Selection of the method of excavation is the responsibility of the Contractor and should be based on the Contractor's experience, equipment, and interpretation of the site conditions.

It is anticipated that excavation for new culvert will be carried out below the River Tributary water level, and diversion of the River Tributary flow will be required. Furthermore, groundwater and surface runoff will tend to seep into and accumulate in the excavations. Due to the presence of the water-bearing cohesionless soil layers, full dewatering to the base of the temporary excavations may not be practical at this site. Furthermore, due to the invert elevation of the proposed culvert being above where silty clay was contacted, it is possible that sandbag cofferdam enclosures may not form an effective groundwater flow cut-off for dewatering purposes. Therefore, it may be necessary to construct the culvert in the wet, as described in Section 10.3.5. Please note that this option of constructing in the wet will still require some dewatering within the allowable pumping limits to lower the groundwater level as much as possible to facilitate culvert construction.

Dewatering if used must be carried out in accordance with OPSS.PROV 517 and SP517F01. Full dewatering to below the base of the culvert excavation may not be practical at this site and may require an EASR or PTTW, however additional site investigation and sampling would be required to determine this. The design of any dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility. A preconstruction survey is not required at this site. The dewatering design engineer and design-checking engineer must have a minimum of 5 years of experience in designing systems of a similar nature. Suggested wording for an NSSP on dewatering is included in Appendix E.

14. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy. Based on the presence of generally stiff to soft silty clay soils, the site is classified as Seismic Site Class E in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC, assuming a Shear Wave Average Velocity of 180 m/s. The peak ground acceleration, PGA, for a 2,475-year return period seismic event (2% probability of being exceeded in 50 years) at this site is 0.0671 g as per the National Building Code of Canada (NBCC 2020).

The coefficients of horizontal earth pressures for seismic loading on walls assuming a level backfill, a Site Class E, and a reference PGA of 0.0671 are presented in Table 14.1 below. The vertical acceleration coefficient k_v has been ignored ($k_v = 0$).

Table 14.1 Seismic Earth Pressure Parameters

Loading Condition	Horizontal Acceleration Coefficient, k_h	Seismic Earth Pressure Coefficients (K_{AE})	
		Granular Fill (Dry/Compact) $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	Granular Fill (Wet/Loose) $\phi = 30^\circ, \gamma = 19.0 \text{ kN/m}^3$
Active (Unrestrained Wall)	0.0336	0.30	0.36

In view of the low potential for seismic activity and the subsurface material in the area, liquefaction is not considered to be a concern at this site.

15. SCOUR AND EROSION PROTECTION

Erosion protection should be provided at the culvert inlet and outlet. The design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field in accordance with OPSP 810.010, OPSS.PROV 511 and OPSS.PROV 1004.

Typically, rock protection obtained locally should be provided over all surfaces with which River Tributary water is likely to be in contact. It is understood that rock protection may be difficult to source locally and every effort by the contractor should be made to keep the existing rocks and boulders on site. An erosion control cover such as Terrafix's Terrawebb may be used to protect against surficial erosion, of the embankment fill side slopes.

A clay seal (only at the inlet) should be used to minimize the potential for erosion or piping around the culvert. The clay seal should extend to approximately 0.3 m above the high-water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS.PROV 1205. A geosynthetic clay liner may be used in place of a compacted clay seal.

Selection of streambed material should be in accordance with OPSS.PROV 1005.

16. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate content analytical tests conducted on select soil samples indicate the following conditions at the locations tested:

- The potential for corrosion on metal culverts from the surrounding silty clay is considered corrosive due to the high concentrations of chloride in the samples tested at BH24-01.

- The potential for corrosion on metal culverts from the surrounding sand and gravel is considered not corrosive due to the low concentrations of chloride and sulphate in the samples tested at BH24-05.
- The potential for sulphate attack on concrete from the surrounding soil or surface water is considered to be negligible due to the low sulphate concentration in the samples tested.
- Appropriate protection measures are recommended for metal structural elements.

17. CONSTRUCTION CONCERNS

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

- Due to the remoteness of the site, importing materials are not practical. The use of sandbag cofferdams and locally available MTO Pit granular material will be required to construct the new culvert bedding and new embankment. Geogrid reinforcement is required to enhance stability of the new embankment.
- As existing sand and silt mixed with wood fragments and organics was encountered in the vicinity of the proposed culvert, care must be taken during culvert construction to inspect the subgrade soils where practical and sub-excavate and replace any organic material encountered within the culvert or foundation footprints prior to placing the culvert bedding. This may not be practical for construction in the wet.
- The water level in the River Tributary may fluctuate and be at a higher elevation at the time of construction than indicated in the report.
- Full dewatering to below the base of the culvert excavation may not be practical at this site and may require an EASR or PTTW, however additional site investigation and sampling would be required to determine this. Accordingly, appropriate methods for constructing in the wet have been suggested.

18. CLOSURE

Engineering analysis and preparation of the design report was carried out by Mr. Joshua Alexander, P.Eng and Dr Mohamed Hosney, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.



Joshua Alexander, P.Eng.

Geotechnical Engineer



Dr Mohamed Hosney, P.Eng.

Associate/ Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Principal, Designated MTO Contact



Date: September 27, 2024
File: 50440

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.

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- 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

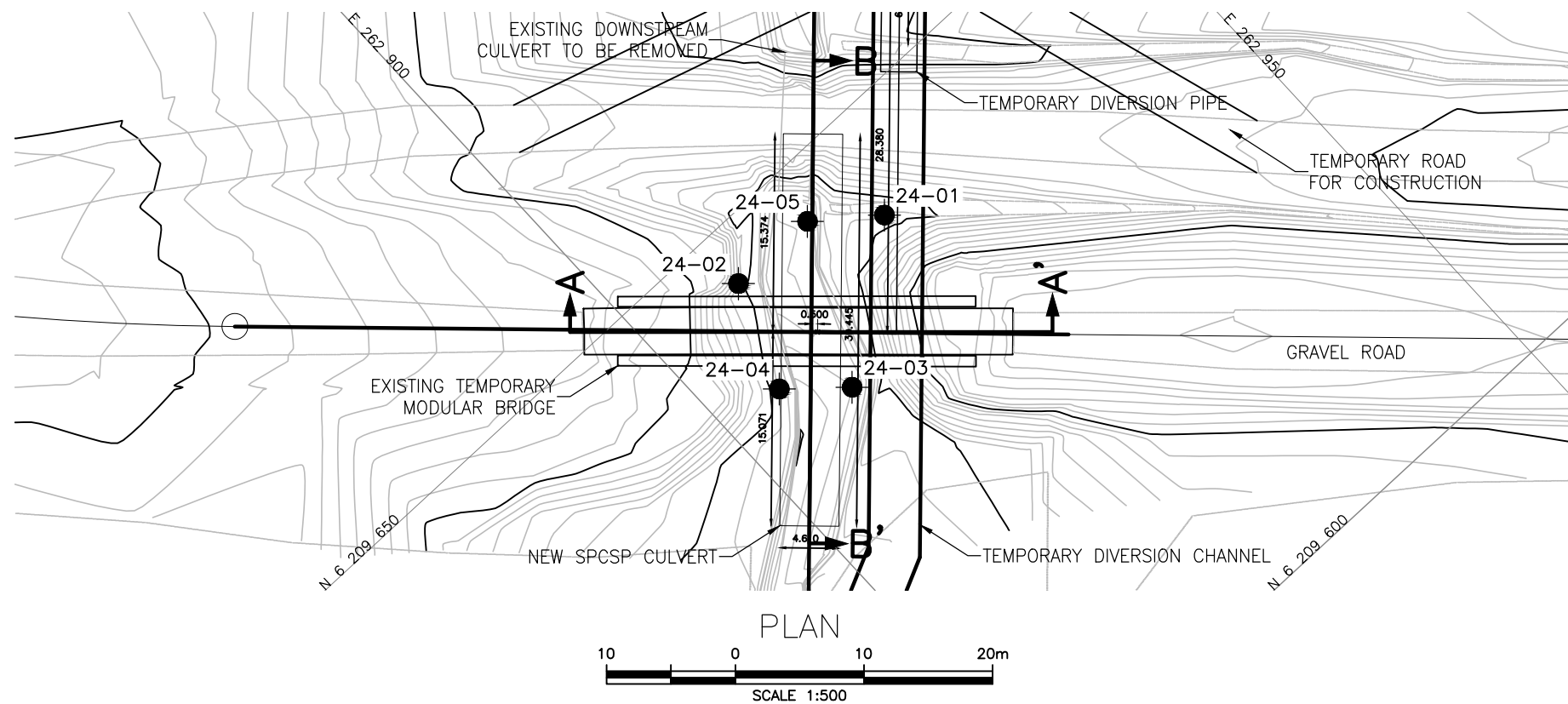
Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, 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.

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APPENDIX A

Borehole Locations and Soil Strata Drawings



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



CONT No	(
GWP No 6581-16-00	

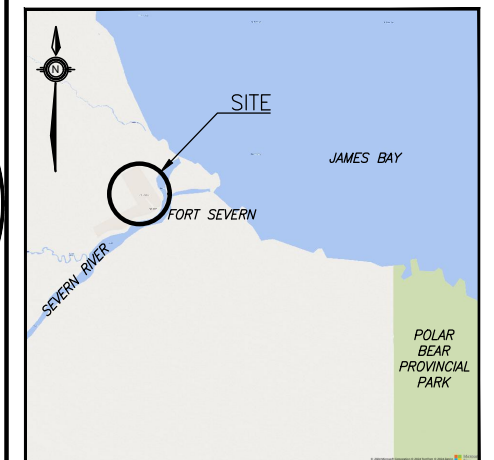
FORT SEVERN
BAILEY BRIDGE

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
9

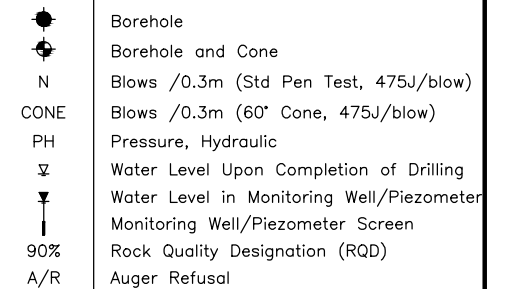


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KEYPLAN

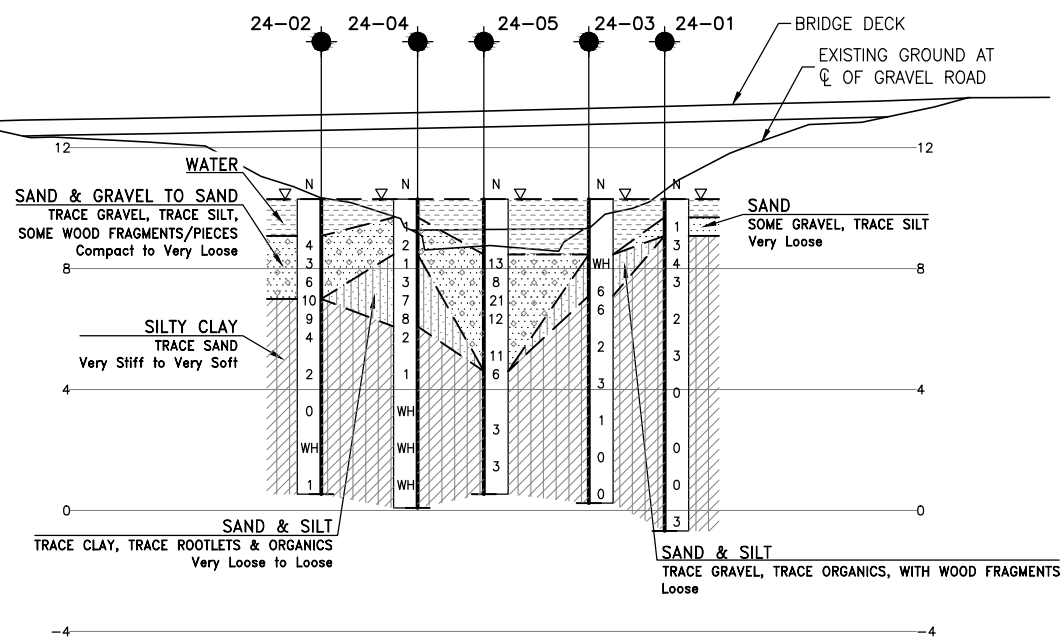
LEGEND

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-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 CSRS Zone 14.

GEOCRES No. 44D04-001

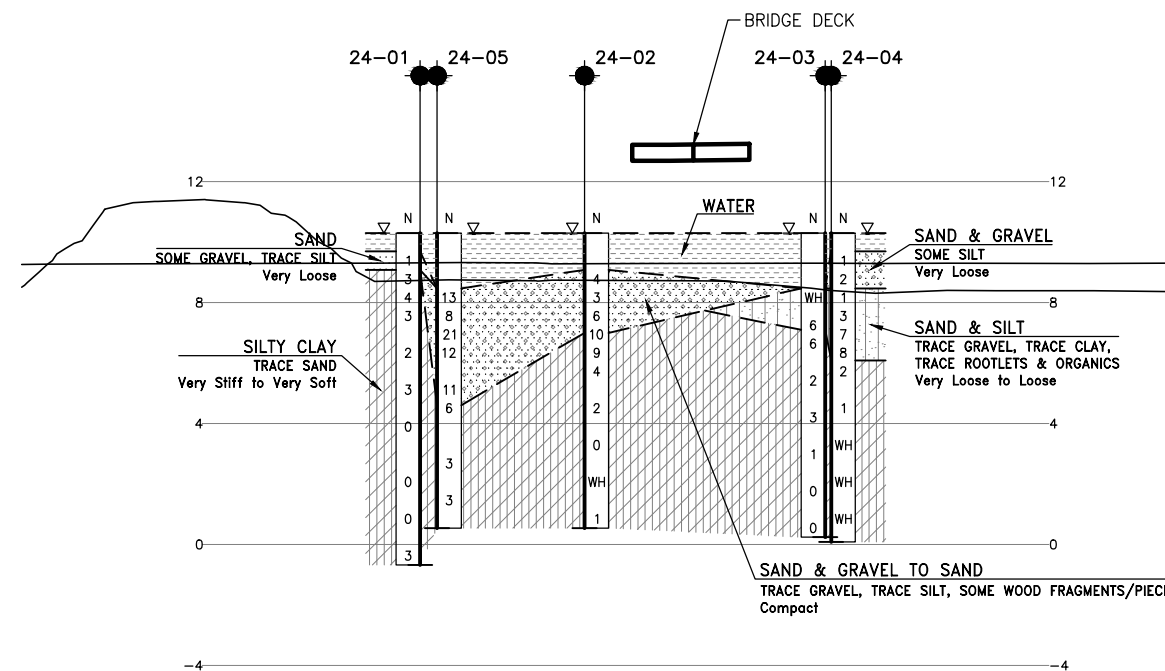


SECTION A-A'



H 1:250

V 1:250



SECTION B-B'



H 1:250

V 1:250

REVISIONS								
	DATE	BY			DESCRIPTION			
DESIGN	JA	CHK	PKC	CODE	LOAD	DATE	SEP 2024	
DRAWN	MA/MC	CHK	JA	SITE 41N-0243/B0	STRUCT	DWG	2	

APPENDIX B

Record of Borehole Sheets

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
 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			

RECORD OF BOREHOLE No 24-01

1 OF 2

METRIC

WP# 6581-16-00 LOCATION Fort SevernMTM NAD83 CSRS Zone 14 N 6 209 641.2 E 262 921.1 ORIGINATED BY JA
DIST Thunder Bay HWY Wapsuk Road BOREHOLE TYPE Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2024.07.14 - 2024.07.14 LATITUDE 56.013433 LONGITUDE -87.671520 CHECKED BY PKC

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	WATER CONTENT (%)					
10.3	GROUND SURFACE													
0.0	WATER													
9.7														
0.6	SAND, some gravel, trace silt Very Loose Grey Wet		1	SS	1									
9.1														
1.2	Silty CLAY, trace sand Very Stiff to Very Soft Grey Wet		2	SS	3									
			3	SS	4									0 5 74 21
			4	SS	3									0 8 77 15
			5	SS	2									
			6	SS	3									0 5 74 21
			7	SS	0									
			8	SS	0									
			9	SS	0									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 24-01

2 OF 2

METRIC

WP# 6581-16-00 LOCATION Fort SevernMTM NAD83 CSRS Zone 14 N 6 209 641.2 E 262 921.1 ORIGINATED BY JA
DIST Thunder Bay HWY Wapsuk Road BOREHOLE TYPE Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2024.07.14 - 2024.07.14 LATITUDE 56.013433 LONGITUDE -87.671520 CHECKED BY PKC

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 (%)				GR	SA	SI	CL
	Continued From Previous Page							20	40	60	80	100								
	Silty CLAY , trace sand Soft Grey Wet						0				20.0									
-0.7			10	SS	3									o						
11.0	END OF BOREHOLE AT 11.0m.																			

METRIC

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METRIC[illegible][illegible]

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+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 24-03

1 OF 2

METRIC

WP# 6581-16-00 LOCATION Fort SevernMTM NAD83 CSRS Zone 14 N 6 209 633.6 E 262 909.6 ORIGINATED BY JA
DIST Thunder Bay HWY Wapsuk Road BOREHOLE TYPE Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2024.07.16 - 2024.07.16 LATITUDE 56.013364 LONGITUDE -87.671703 CHECKED BY PKC

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			20	40	60					
10.3	GROUND SURFACE														
0.0	WATER														
8.5															
1.8	SAND and SILT, trace gravel, trace organics, with wood fragments, no recovery for SS1 Loose Grey Wet		1	SS	WH										
7.1			2	SS	6										0 49 49 2
3.2	Silty CLAY, some to trace sand Very Stiff to Firm Grey Wet		3	SS	6										0 10 72 18
			4	SS	2										
			5	SS	3										
			6	SS	1										
			7	SS	0										
			8	SS	0										

Continued Next Page

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

METRIC

[illegible]

RECORD OF BOREHOLE No 24-04

1 OF 2

METRIC

WP# 6581-16-00 LOCATION Fort Severn MTM NAD83 CSRS Zone 14 N 6 209 639.8 E 262 902.7 ORIGINATED BY JA
DIST Thunder Bay HWY Wapsuk Road BOREHOLE TYPE Mud Rotary COMPILED BY AN
DATUM Geodetic DATE 2024.07.17 - 2024.07.17 LATITUDE 56.013420 LONGITUDE -87.671815 CHECKED BY PKC

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						
10.3	GROUND SURFACE							○ UNCONFINED + FIELD VANE						
0.0	WATER							● QUICK TRIAXIAL × LAB VANE						
9.7														
0.6	SAND and GRAVEL, some silt Very Loose Wet No recovery		1	SS	1									
	No recovery		2	SS	2									
8.5														
1.8	SAND and SILT, trace clay, trace rootlets and organics Very Loose to Loose Black to Grey Wet		3	SS	1									
			4	SS	3									
	Sand deposit (400mm)		5	SS	7									
			6	SS	8									
6.1														
4.2	Silty CLAY, trace sand Firm Grey Wet		7	SS	2									
			8	SS	1									
			9	SS	WH									
	Stiff to Firm		10	SS	WH									
			11	SS	WH									

Continued Next Page

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

RECORD OF BOREHOLE No 24-04

2 OF 2

METRIC

WP# 6581-16-00 LOCATION Fort SevernMTM NAD83 CSRS Zone 14 N 6 209 639.8 E 262 902.7 ORIGINATED BY JA
DIST Thunder Bay HWY Wapsuk Road BOREHOLE TYPE Mud Rotary COMPILED BY AN
DATUM Geodetic DATE 2024.07.17 - 2024.07.17 LATITUDE 56.013420 LONGITUDE -87.671815 CHECKED BY PKC

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									
	Continued From Previous Page																
0.1																	
10.2	END OF BOREHOLE AT 10.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																

RECORD OF BOREHOLE No 24-05

1 OF 2

METRIC

WP# 6581-16-00 LOCATION Fort Severn MTM NAD83 CSRS Zone 14 N 6 209 644.2 E 262 917.2 ORIGINATED BY JA
DIST Thunder Bay HWY Wapsuk Road BOREHOLE TYPE Mud Rotary COMPILED BY AN
DATUM Geodetic DATE 2024.07.18 - 2024.07.18 LATITUDE 56.013460 LONGITUDE -87.671583 CHECKED BY PKC

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	WATER CONTENT (%)					
10.3	GROUND SURFACE							20 40 60 80 100						
0.0	WATER							20 40 60 80 100						
8.5														
1.8	SAND and GRAVEL to SAND, trace gravel Compact Brown Wet		1	SS	13									
			2	SS	8									
	Silty clay seam (150mm)		3	SS	21									
	Silty clay seam (300mm-600mm)		4	SS	12									
			5	SS	11									
4.6														
5.7	Silty CLAY, trace sand Stiff to Firm Grey Wet		6	SS	6									
			7	SS	3									
			8	SS	3									
0.5														
9.8	END OF BOREHOLE AT 9.8m.													

Continued Next Page

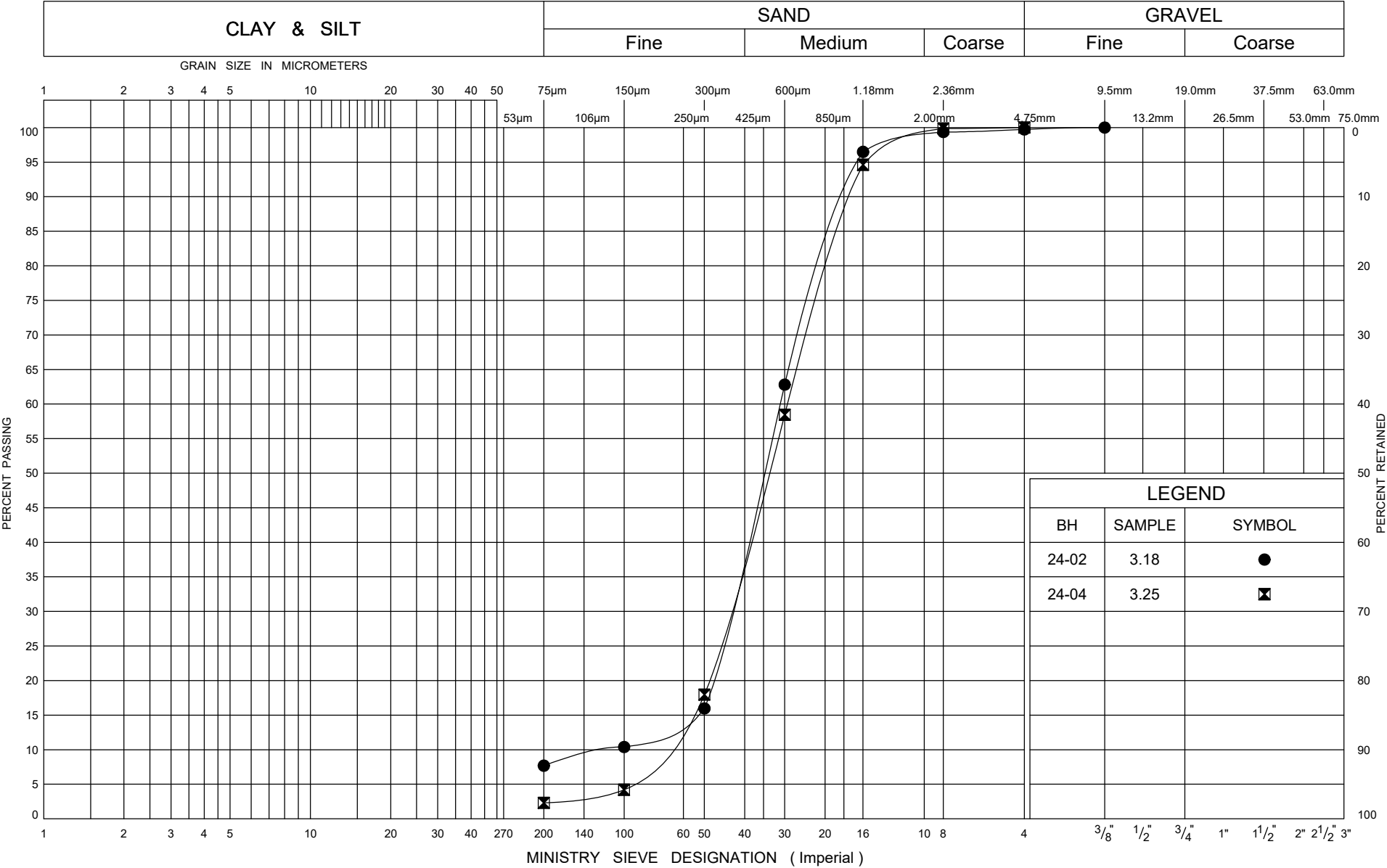
+³, ×³: Numbers refer to Sensitivity
20
15
10
(%) STRAIN AT FAILURE

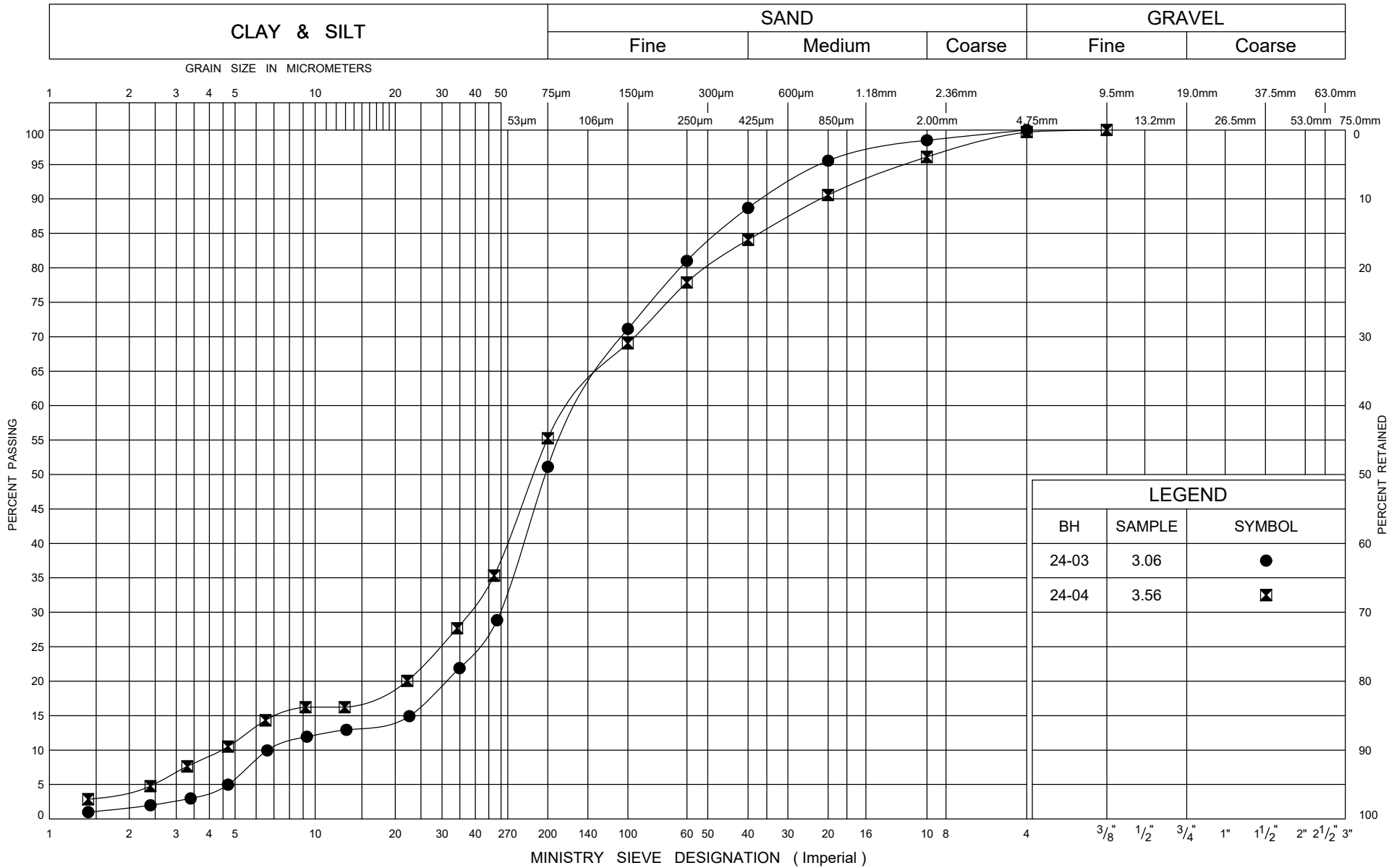
METRIC

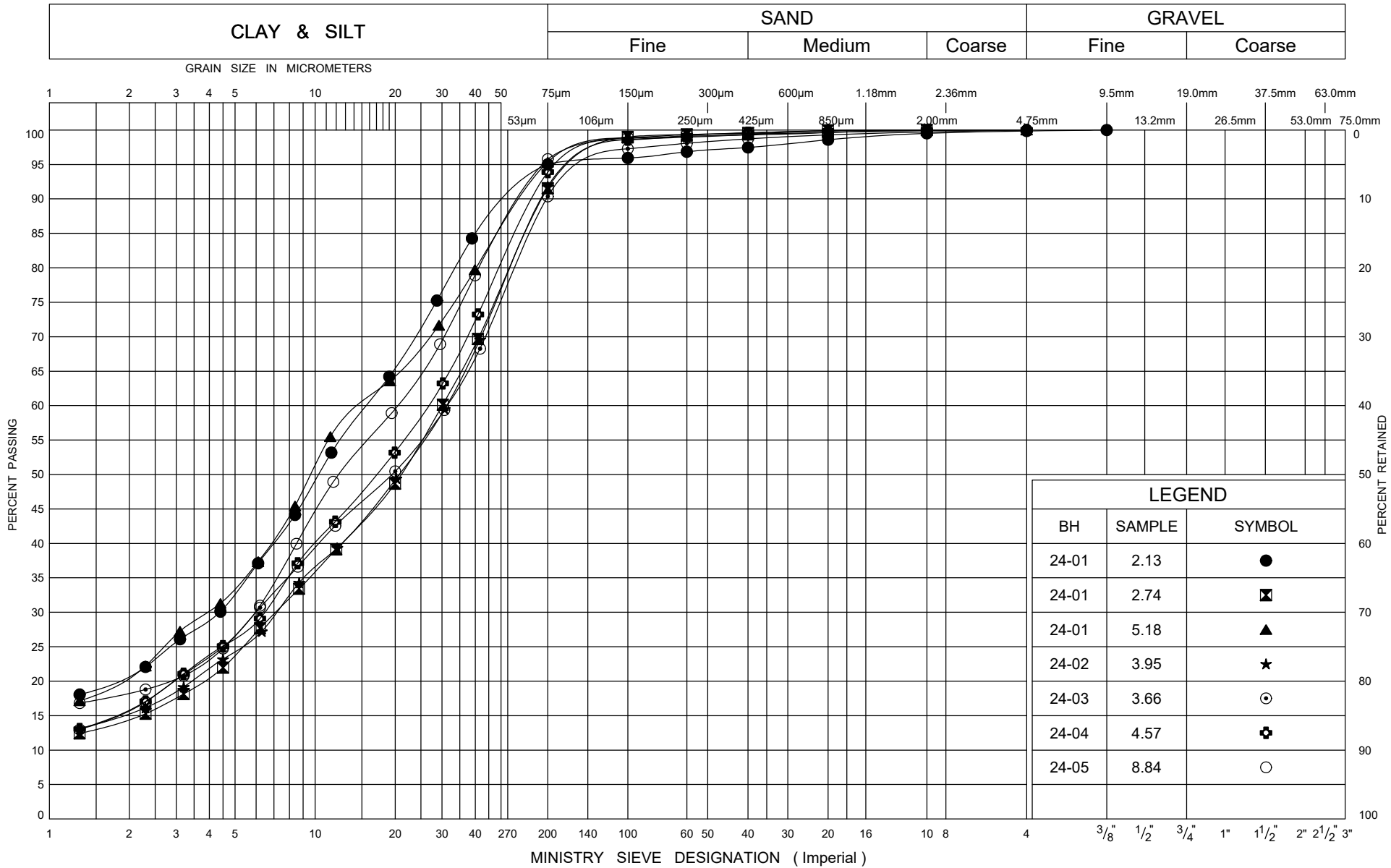
[illegible]

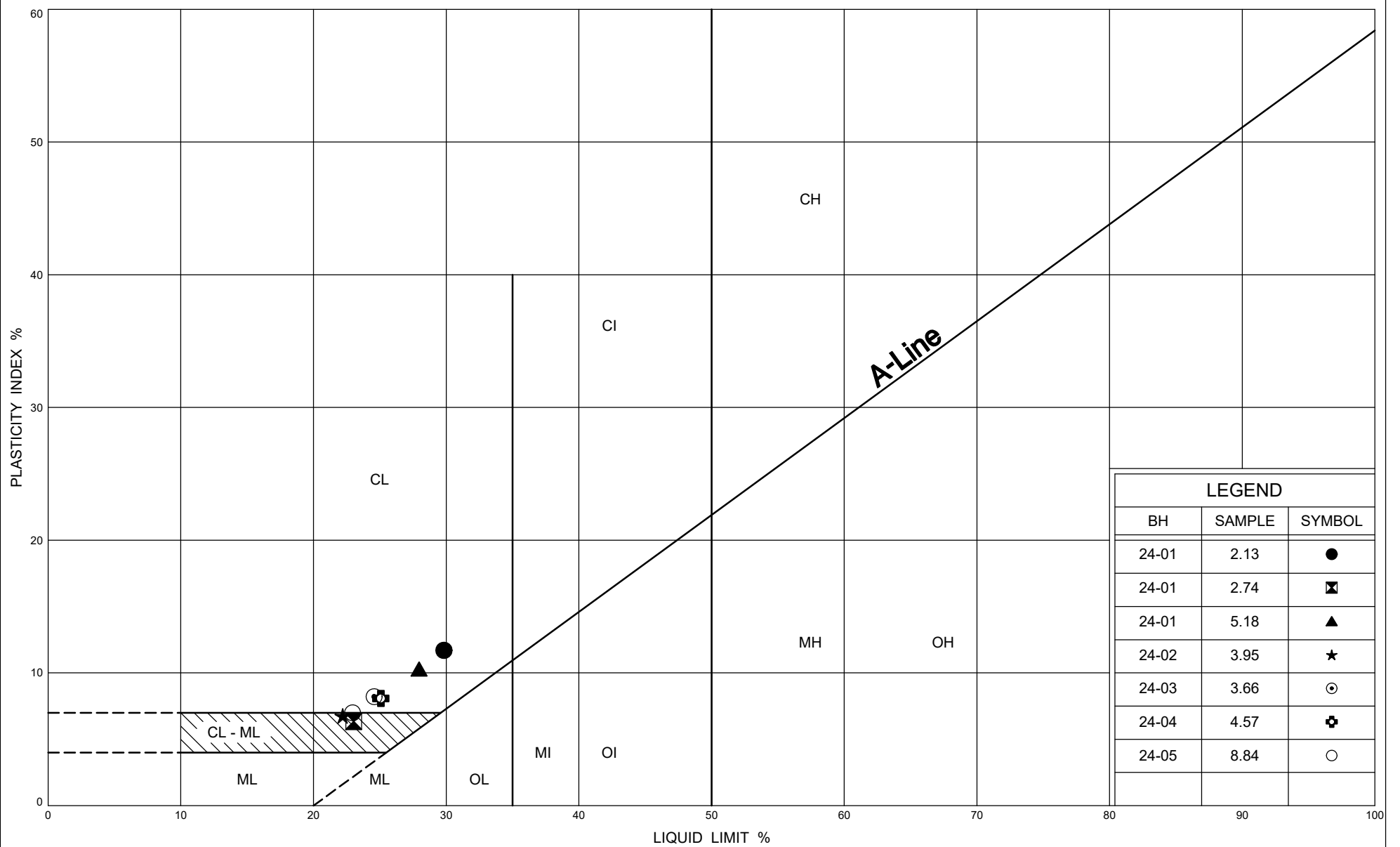
APPENDIX C

Laboratory Test Results





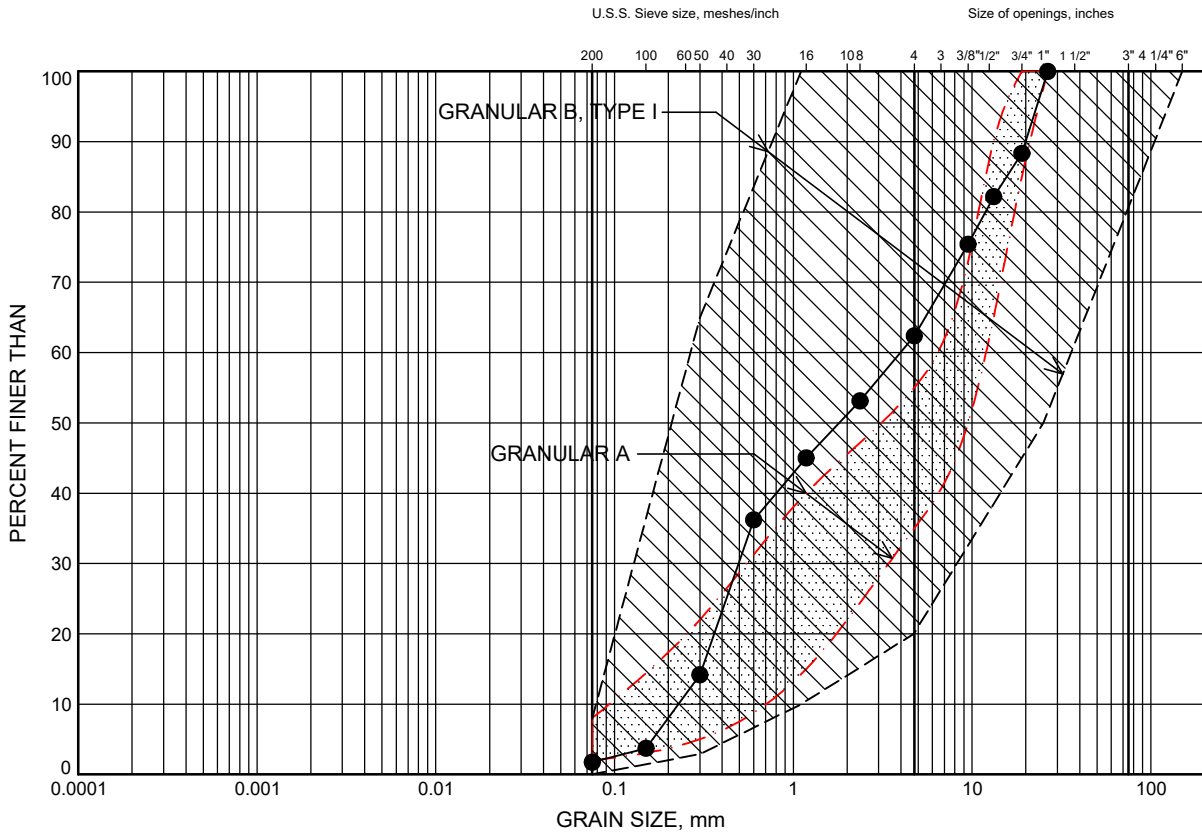




Fort Severn MTO Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C5



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BAND PIT	0.00	

Date September 2024
Project 50440

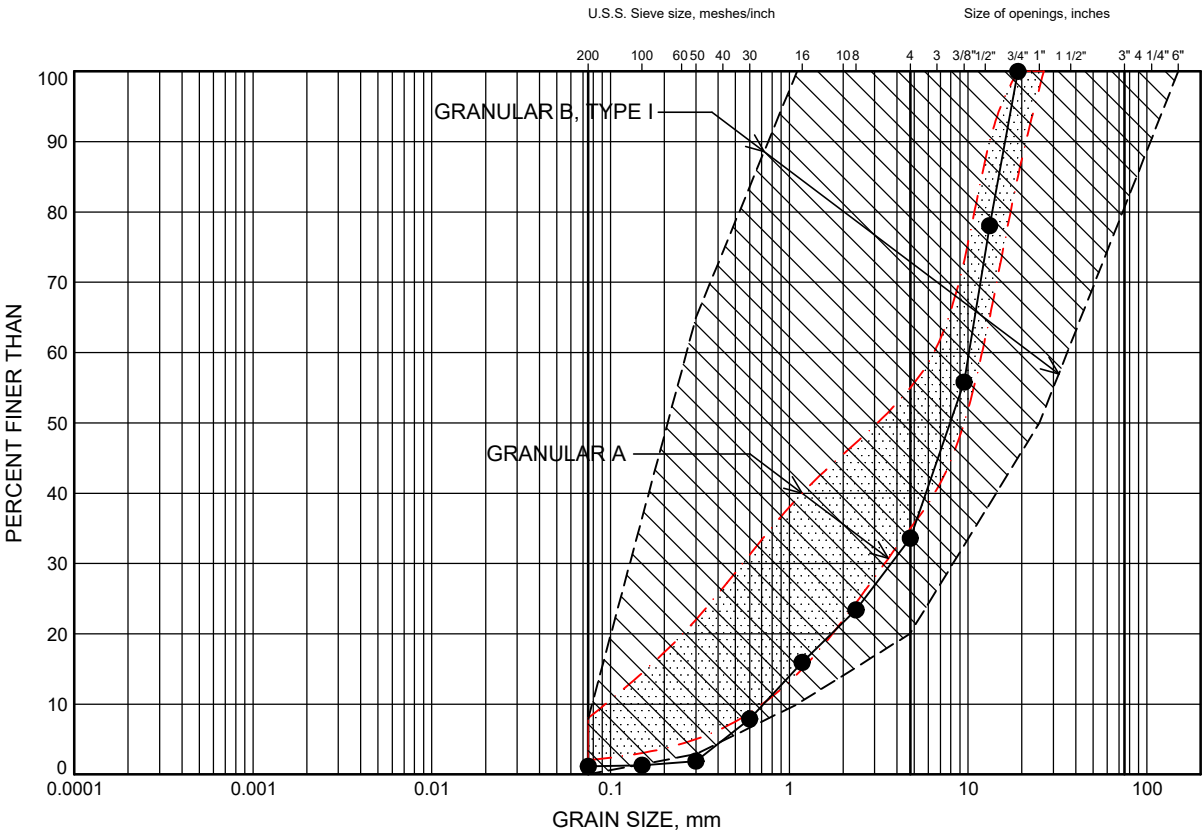


Prep'd AN
Chkd. JA

Fort Severn MTO Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C6



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MTO PIT	0.00	

Date September 2024

Project 50440



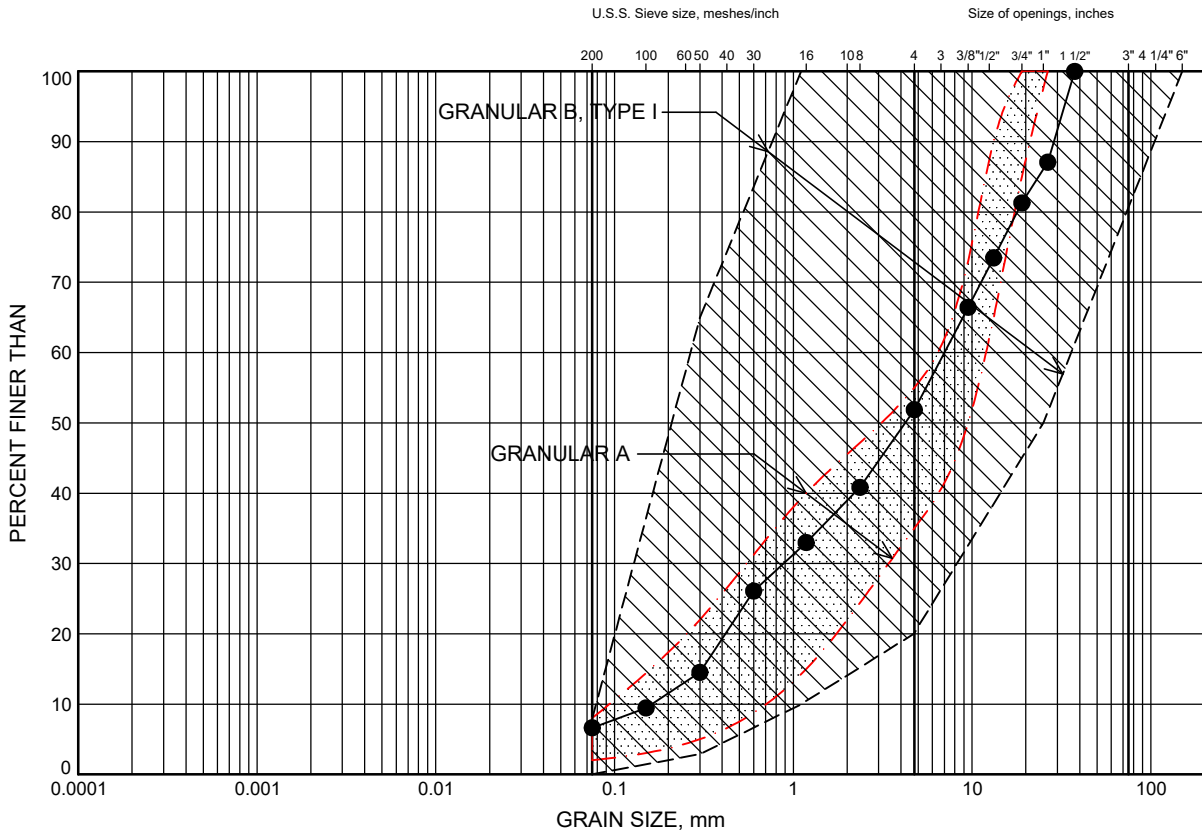
Prep'd AN

Chkd. JA

Fort Severn MTO Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C7



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	RIVER PIT	0.00	

Date September 2024
Project 50440



Prep'd AN
Chkd. JA



FINAL REPORT

CA40005-AUG24 R1

50440, Metrolinx Ontario Line-Package 3B

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

Address 1908 Ironoak Way, Suite 202
Oakville, ON
L6H 0N1, Canada

Contact Joshua Alexander

Telephone 613-606-7303

Facsimile

Email jalexander@thurber.ca

Project 50440, Metrolinx Ontario Line-Package 3B

Order Number

Samples Soil (2)

LABORATORY DETAILS

Project Specialist Jill Campbell, B.Sc.,GISAS

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 2165

Facsimile 705-652-6365

Email jill.campbell@sgs.com

SGS Reference CA40005-AUG24

Received 08/01/2024

Approved 08/12/2024

Report Number CA40005-AUG24 R1

Date Reported 08/12/2024

COMMENTS

Temperature of Sample upon Receipt: 7 degrees C

Cooling Agent Present: yes

Custody Seal Present: yes

Chain of Custody Number: 1

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Jill Campbell, B.Sc.,GISAS





TABLE OF CONTENTS

First Page..... 1-2

Index..... 3

Results..... 4

QC Summary..... 5-6

Legend..... 7

Annexes..... 8



FINAL REPORT

CA40005-AUG24 R1

Client: Thurber Engineering Ltd.
Project: 50440, Metrolinx Ontario Line-Package 3B
Project Manager: Joshua Alexander
Samplers: Joshua Alexander

MATRIX: SOIL

Sample Number	5	6
Sample Name	24-01 - SS2 4-6'	24-05 - SS1&2 6-10'
Sample Matrix	Soil	Soil
Sample Date	14/07/2024	17/07/2024

Parameter	Units	RL		Result	Result
Corrosivity Index					
Corrosivity Index	none	1		1	8
Soil Redox Potential	mV	no		343	332
Sulphide (Na2CO3)	%	0.01		< 0.01	0.01
pH	pH Units	0.05		8.32	8.63
Resistivity (calculated)	ohms.cm	-9999		29400	52600
General Chemistry					
Conductivity	uS/cm	2		34	19
Metals and Inorganics					
Moisture Content	%	0.1		18.5	19.4
Sulphate	µg/g	0.4		5.5	19
Other (ORP)					
Chloride	µg/g	0.4		660	15



FINAL REPORT

CA40005-AUG24 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0131-AUG24	µg/g	0.4	<0.4	NV	35	102	80	120	92	75	125
Sulphate	DIO0131-AUG24	µg/g	0.4	<0.4	6	35	95	80	120	94	75	125

Carbon/Sulphur
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0016-AUG24	%	0.01	< 0.01								

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0075-AUG24	uS/cm	2	< 2	1	20	99	90	110	NA		



FINAL REPORT

CA40005-AUG24 R1

QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-|ENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0075-AUG24	pH Units	0.05	NA	0		99			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

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

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Results relate only to the sample tested.

Data reported represent the sample as submitted to SGS. Solid samples expressed on a dry weight basis.

"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act and Excess Soil Quality" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm.

The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents. Reproduction of this analytical report in full or in part is prohibited.

This report supersedes all previous versions.

-- End of Analytical Report --

Laboratory Information Section - Lab use only

Received By: CD
Received Date: 9/11/04 (mm/dd/yy)
Received Time: 14:15 (hr : min)Received by (signature): [Signature]
Custody Seal Present: Yes ☒ No ☐
Custody Seal Intact: Yes ☐ No ☐Cooling Agent Present: Yes ☒ No ☐ Type: ICE
Temperature Upon Receipt (°C): 2.2LAB LIMS: CA 40005 - AUG 24

REPORT INFORMATION

Company: Thurber Engineering Ltd.Contact: Joshua AlexanderAddress: 202-1908 Ironoak Way,
Oakville, ON L6H 7G4Phone: 613-606-7303

Fax: _____

Email: jalexander@thurber.ca

INVOICE INFORMATION

☒ (same as Report Information)

Company: _____

Contact: _____

Address: _____

Phone: _____

Email: accountingON@thurber.caQuotation #: _____
Project #: 50440P.O. #: 50440
Site Location/ID: Metrolinx Ontario Line - Package 3B

TURNAROUND TIME (TAT) REQUIRED

☒ Regular TAT (5-7 days)RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: _____

NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

REGULATIONS

Regulation 153/04:

☒ Table 1 ☒ Res/Park ☐ Soil Texture: _____
☐ Table 2 ☐ Ind/Com ☐ Coarse ☐ PWOC ☐ MMR ☐ CCME ☒ Other ☐ MISA ☐ Fine ☐ Municipality: _____
☐ Table 3 ☐ Agri/Other ☐ Fine ☐ MISA ☐ Other ☐ Municipality: _____

Sewer By-Law:

☐ Sanitary ☐ Storm

RECORD OF SITE CONDITION (RSC)

☒ YES ☐ NO

ANALYSIS REQUESTED

M & I

SVOC

PCB

PHC

VOC

Pest

Other (please specify)

TCLP

SAMPLE IDENTIFICATION

DATE SAMPLED

TIME SAMPLED

OF BOTTLES

MATRIX

Field Filtered (Y/N)

Metals & Inorganics

Full Metals Suite

ICP Metals only

PAHs

SVOCs

PCBs

F1-F4 + BTEX

F1-F4 only

VOCs

BTEX only

Pesticides

Corrosivity Suite

1,4-dioxane

Dioxins and furans

PHC F1

HOLD SAMPLE for potential D&Fs analysis

Sewer Use:

Water Characterization Pkg

General

Extended

TCLP

tests

MLL

BiolP

ABN

gnt.

COMMENTS:

Observations/Comments/Special Instructions

Sampled By (NAME):

Joshua Alexander

Signature:

Joshua Alexander

Date:

07/17/24

(mm/dd/yy)

Pink Copy - Client

Relinquished by (NAME):

Joshua Alexander

Signature:

Joshua Alexander

Date:

08/01/24

(mm/dd/yy)

Yellow & White Copy - SGS

Revision # 1.3
Date of Issue 13 Oct. 2019Note: Submission of samples to SGS is acknowledgement that you have been provided direction on sample collection/handling and transportation of samples. [2] Submission of samples to SGS is considered authorization for completion of work. Signatures may appear on this form or be retained on file in the contract, or in an alternative format (e.g. shipping documents). [3] Results may be sent by email to an unlimited number of addresses for no additional cost. This document is issued by the Company under its General Conditions of Service accessible at http://www.sgs.com/terms_and_conditions.htm. (Printed copies are available upon request). Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.

APPENDIX D

Site Photographs



Photo 1: Looking east at each abutment on Wapusk Road (July 2024)



Photo 2: Looking west at west abutment on Wapusk Road (July 2024)



Photo 3: Existing culvert and local Band Road (July 2024)



Photo 4: General Site Setup and Underside of Modular Bridge (July 2024)

APPENDIX E

List of OPSS and OPSD Documents and Suggested Wording for NSSPs

1. The following Special Provisions and OPSS Documents are referenced in this report:

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 209	Embankments over Swamps in Compressible Soils
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheetting
OPSS.PROV 517	Construction Specification for Dewatering and Temporary Flow Passage Systems
SP 517F01	Amendment to OPSS 517, Dewatering System – Temporary Flow Passage System
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS.PROV 902	Construction Specification for Excavating and Backfilling Structures
SP 109S61	Amendment to OPSS 902, Dewatering and Protection Systems
OPSS.PROV 903	Construction Specification for Deep Foundations
OPSS.PROV 1004	Material Specification for Aggregates - Miscellaneous
OPSS.PROV 1005	Material Specification for Aggregates – Streambed Material
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
OPSS.PROV 1205	Material Specification for Clay Seal
OPSS.PROV 1860	Material Specification for Geotextiles
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m
OPSD 810.010	General Rip Rap Layout for Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Penetration Depths for Northern Ontario
OPSD 3101.150	Walls, Abutment, Backfill Minimum Granular Requirement

2. Suggested Wording for NSSPs

- **Suggested Text for NSSP on Obstructions**

Culvert excavation may encounter obstructions such as wood, cobbles and boulders embedded in the fill and native soils. Such obstructions may impede excavation progress. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths.

- **Suggested Text for NSSP on Dewatering**

The Contractor is notified that full dewatering of the temporary culvert excavation at this site may not be practical due to the highly permeable subgrade consisting of sand and gravel and silt. Attempting to fully dewater and lower the water table to below the final subgrade may not be possible.

The Contractor is permitted to dewater a maximum of 50,000 L/day in order to remove as much of the standing water in the temporary culvert excavation as possible. Water levels likely to prevail during construction will necessitate subgrade preparation, placement of bedding, culvert installation, and other works under standing water.

The dewatering system is to be designed in accordance with OPSS.PROV 517 and SP517F01. A preconstruction survey is not required.

- **Monitoring of Embankment Fill Compaction**

Embankment fill and bedding material placed below water level in the temporary excavation for culvert installation shall be obtained from the MTO pit at the airport. The fill placed below water level must be fully wrapped in geotextile. It will not be possible to compact the fill below water level. However, granular fill placed above water level must be placed in 300 mm lifts and thoroughly compacted with a minimum of 8 passes of a vibratory roller.

Fill compaction immediately above the culvert should be controlled so as not to damage the culverts. The compaction of each lift shall be visually examined to confirm that each lift is thoroughly compacted. A probe rod shall be used to assess compaction of each lift. Probing should be conducted at a number of locations of each lift. If the probe rod meets refusal within a couple of inches of the compacted lift, the lift will be deemed to be compacted.

APPENDIX F

Settlement Analysis Figures

Fort Severn Settlement Below the Culvert

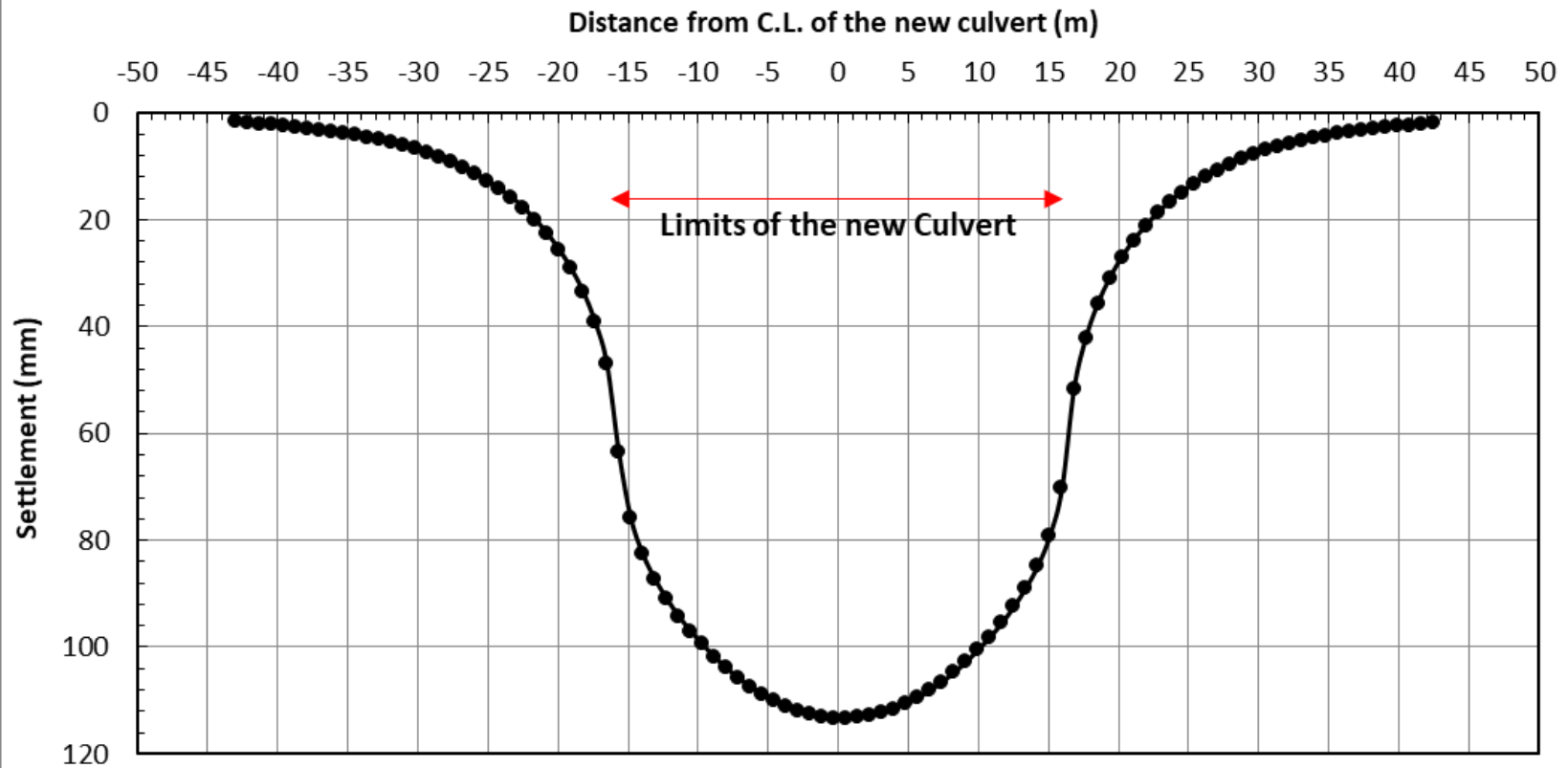


Figure F1

Fort Severn Settlement Below the Diversion Channel

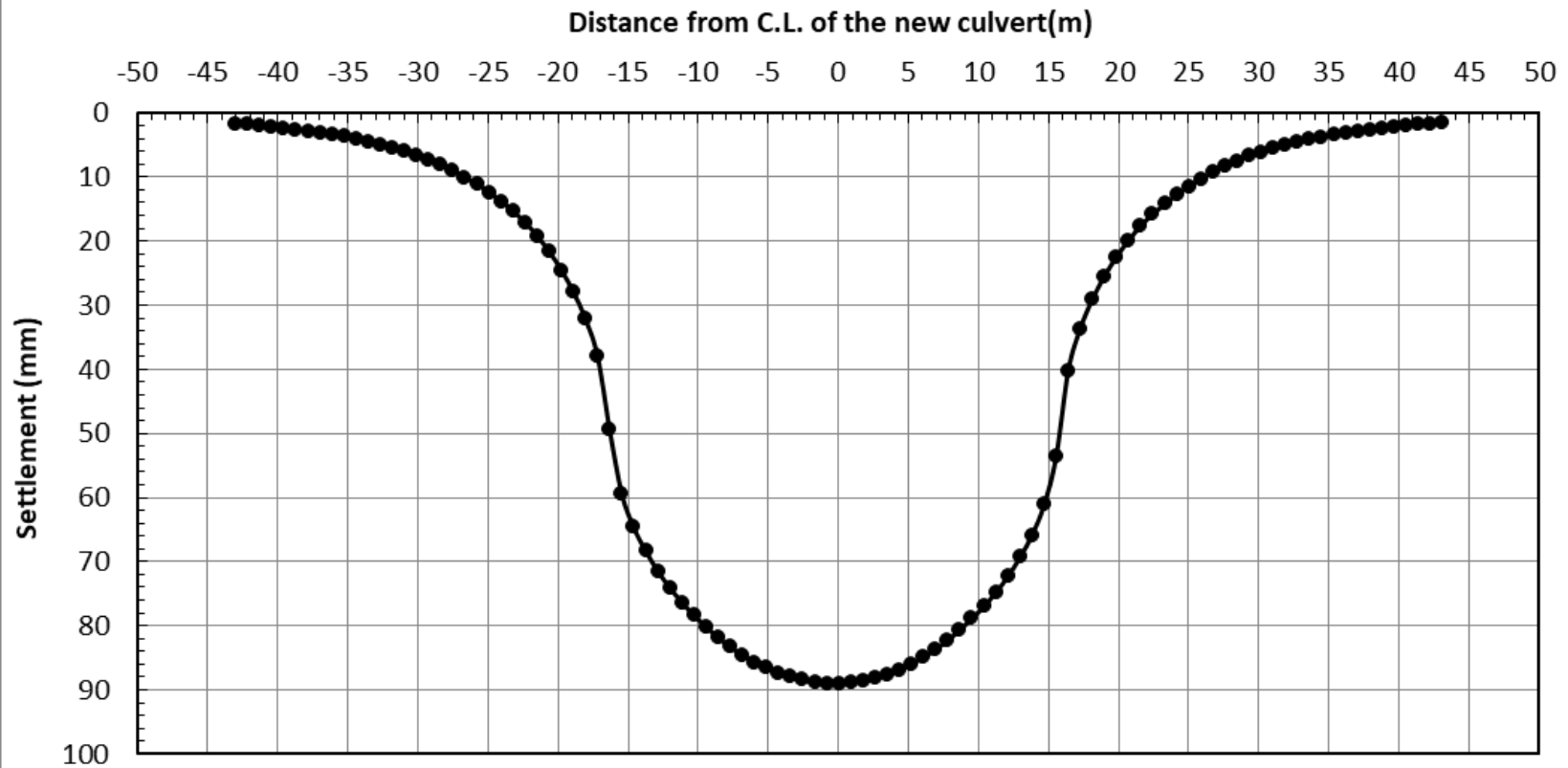
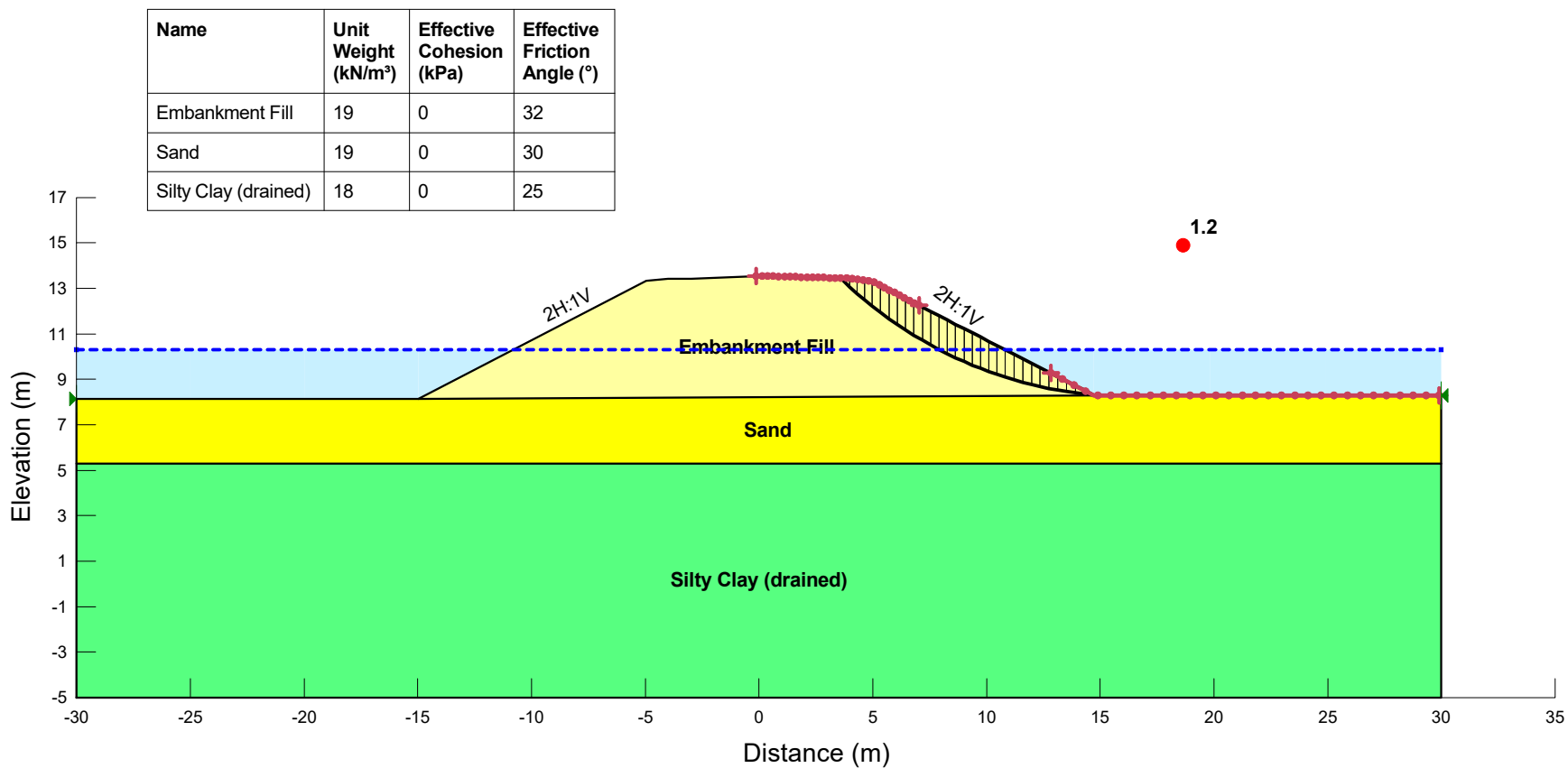


Figure F2

APPENDIX G

Slope Stability Analysis Figures

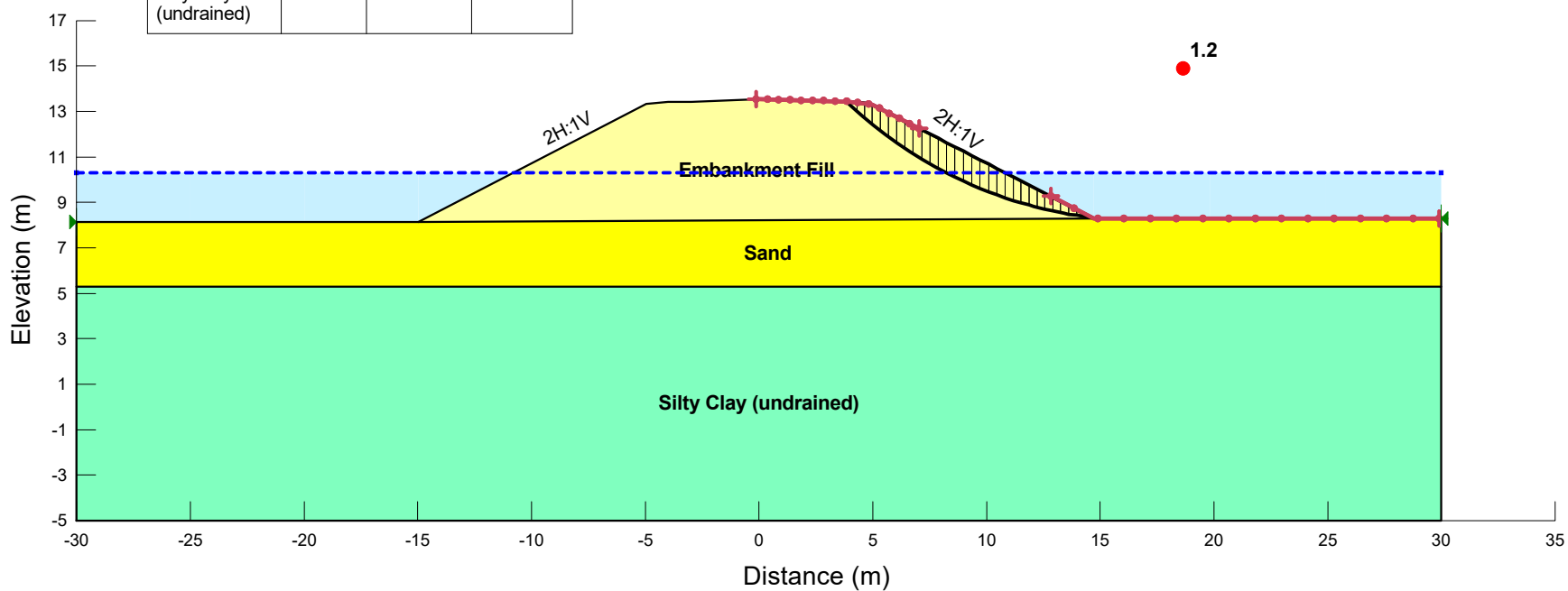


Project		
Fort Severn		
Analysis		
Fort Severn (Drained Analysis)		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	07/30/2024, 12:55:58 PM	1:300

Additional Details

Figure G1

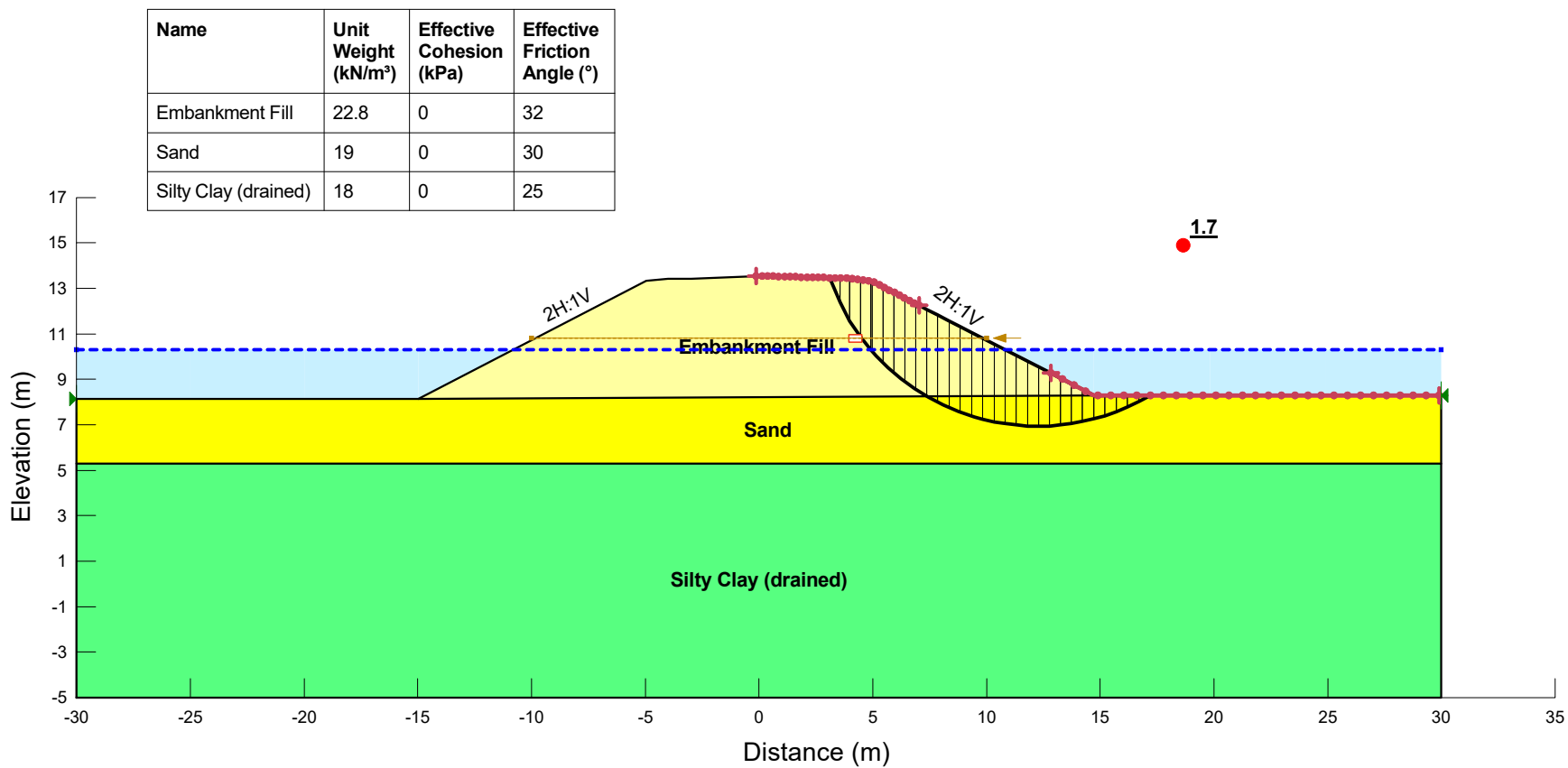
Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
Embankment Fill	19	0	32
Sand	19	0	30
Silty Clay (undrained)	18	36	0



Project Fort Severn		
Analysis Fort Severn (Undrained Analysis)		
Seismic Coefficient H: 0g, V: 0g	Last Run 07/30/2024, 12:56:00 PM	Scale 1:300

Additional Details

Figure G2

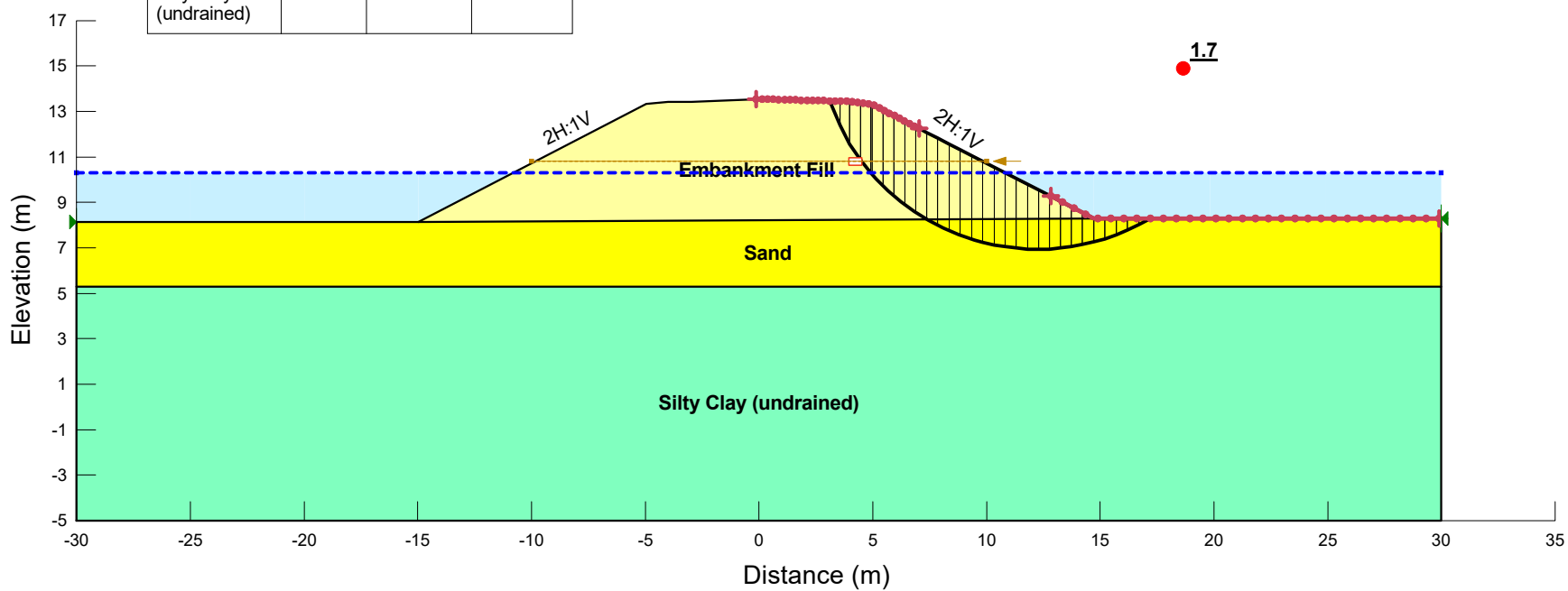


Project Fort Severn		
Analysis Fort Severn (Drained Analysis - with geogrid)		
Seismic Coefficient H: 0g, V: 0g	Last Run 08/11/2024, 08:39:08 AM	Scale 1:300

Additional Details

Figure G3

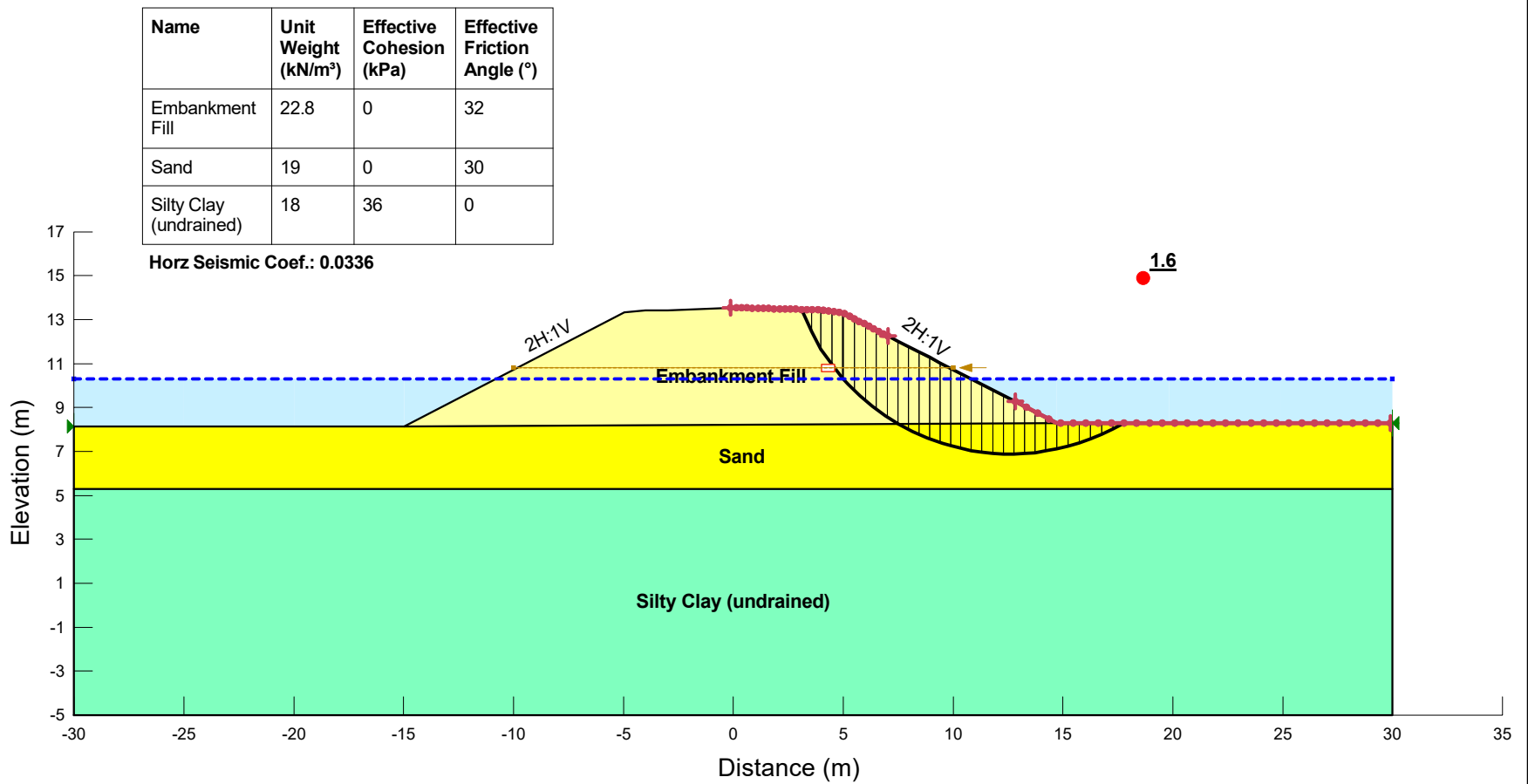
Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
Embankment Fill	22.8	0	32
Sand	19	0	30
Silty Clay (undrained)	18	36	0



Project Fort Severn		
Analysis Fort Severn (Undrained Analysis - with geogrid)		
Seismic Coefficient H: 0g, V: 0g	Last Run 08/11/2024, 08:41:06 AM	Scale 1:300

Additional Details

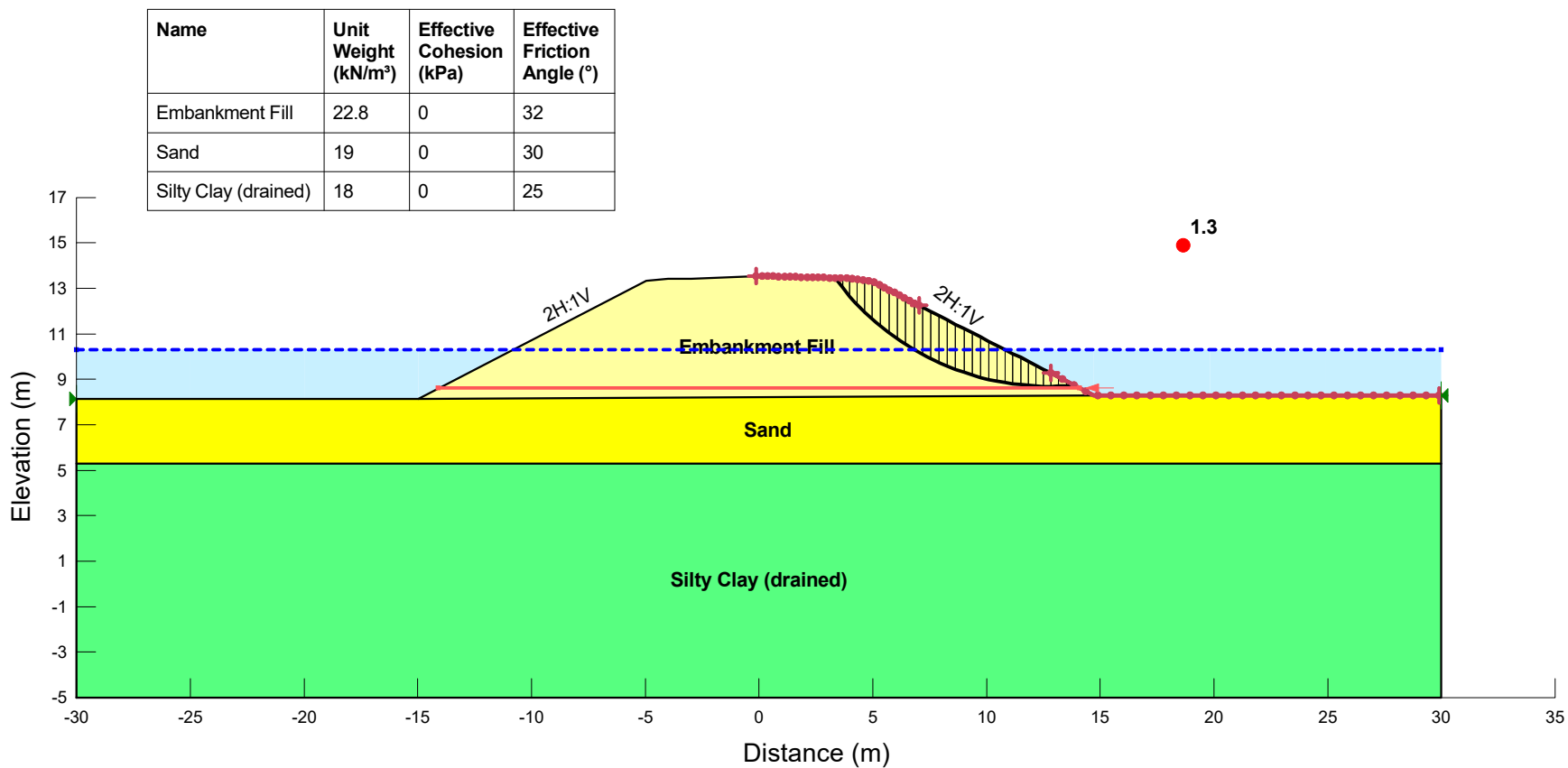
Figure G4



Project		
Fort Severn		
Analysis		
Fort Severn (Seismic Analysis - with geogrid above water)		
Seismic Coefficient	Last Run	Scale
H: 0.0336g, V: 0g	08/11/2024, 08:42:14 AM	1:300

Additional Details

Figure G5

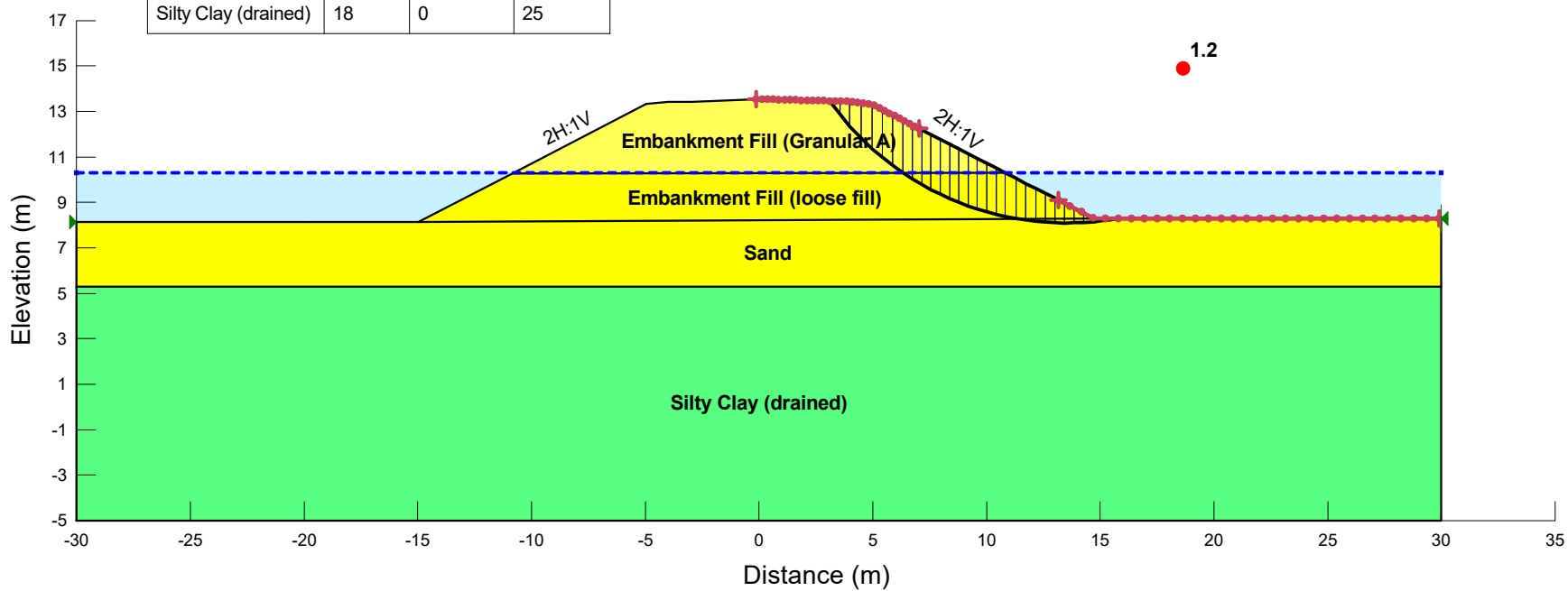


Project		
Fort Severn		
Analysis		
Fort Severn (Drained Analysis - with geogrid below water)		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	08/11/2024, 08:46:05 AM	1:300

Additional Details

Figure G6

Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
Embankment Fill (Granular A)	22.8	0	35
Embankment Fill (loose fill)	19	0	30
Sand	19	0	30
Silty Clay (drained)	18	0	25

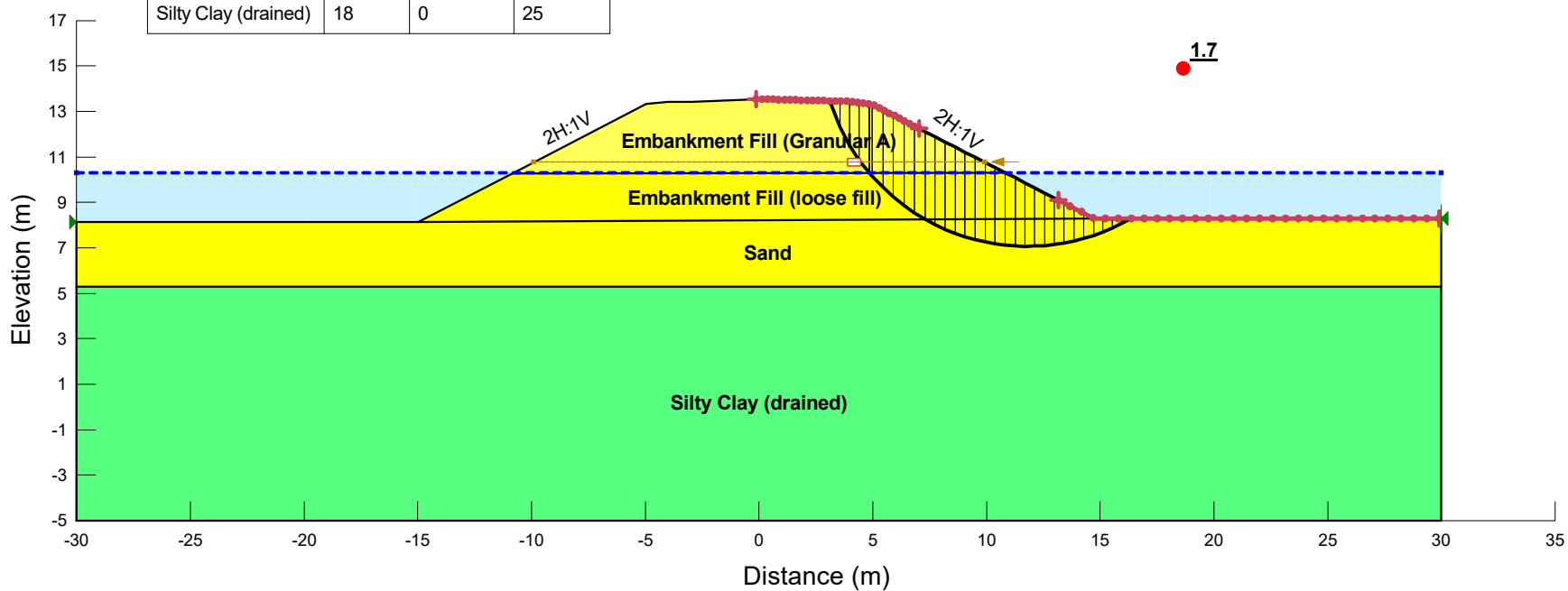


Project Fort Severn		
Analysis Fort Severn (Drained_Granular A fill_loose fill below water)		
Seismic Coefficient H: 0g, V: 0g	Last Run 08/09/2024, 07:22:13 AM	Scale 1:300

Additional Details

Figure G7

Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
Embankment Fill (Granular A)	22.8	0	35
Embankment Fill (loose fill)	19	0	30
Sand	19	0	30
Silty Clay (drained)	18	0	25

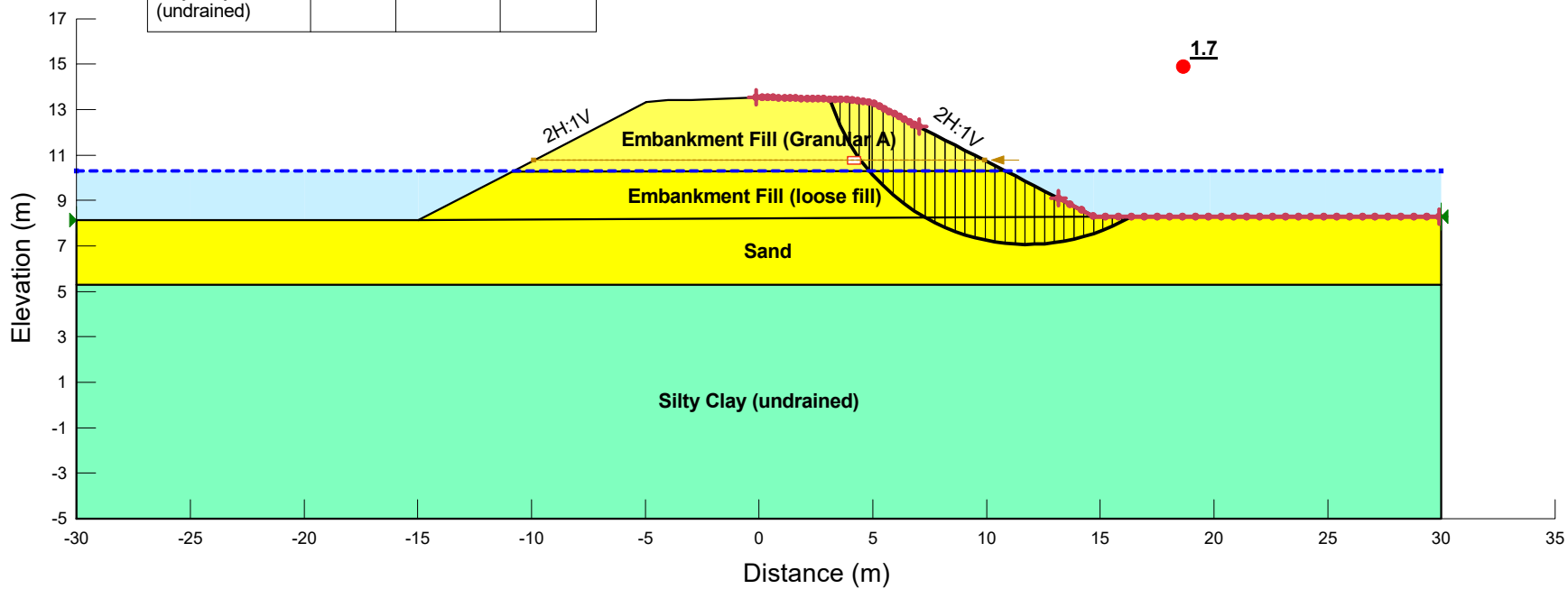


Project Fort Severn		
Analysis Fort Severn (Drained_Granular A fill_loose fill below water)		
Seismic Coefficient H: 0g, V: 0g	Last Run 08/11/2024, 08:00:00 AM	Scale 1:300

Additional Details - Geogrid above water level

Figure G8

Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
Embankment Fill (Granular A)	22.8	0	35
Embankment Fill (loose fill)	19	0	30
Sand	19	0	30
Silty Clay (undrained)	18	36	0

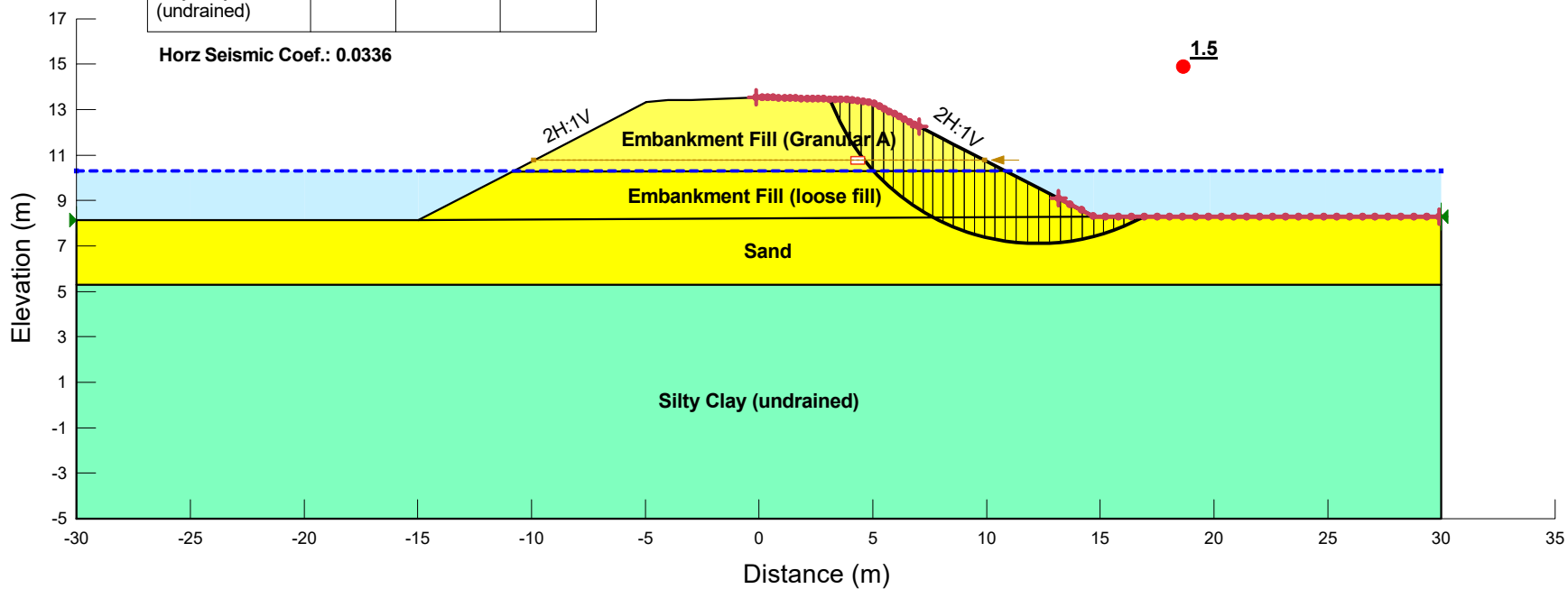


Project Fort Severn		
Analysis Fort Severn (Undrained_Granular A fill_loose fill below water)		
Seismic Coefficient H: 0g, V: 0g	Last Run 08/11/2024, 08:12:11 AM	Scale 1:300

Additional Details
- Geogrid above water level

Figure G9

Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
Embankment Fill (Granular A)	22.8	0	35
Embankment Fill (loose fill)	19	0	30
Sand	19	0	30
Silty Clay (undrained)	18	36	0



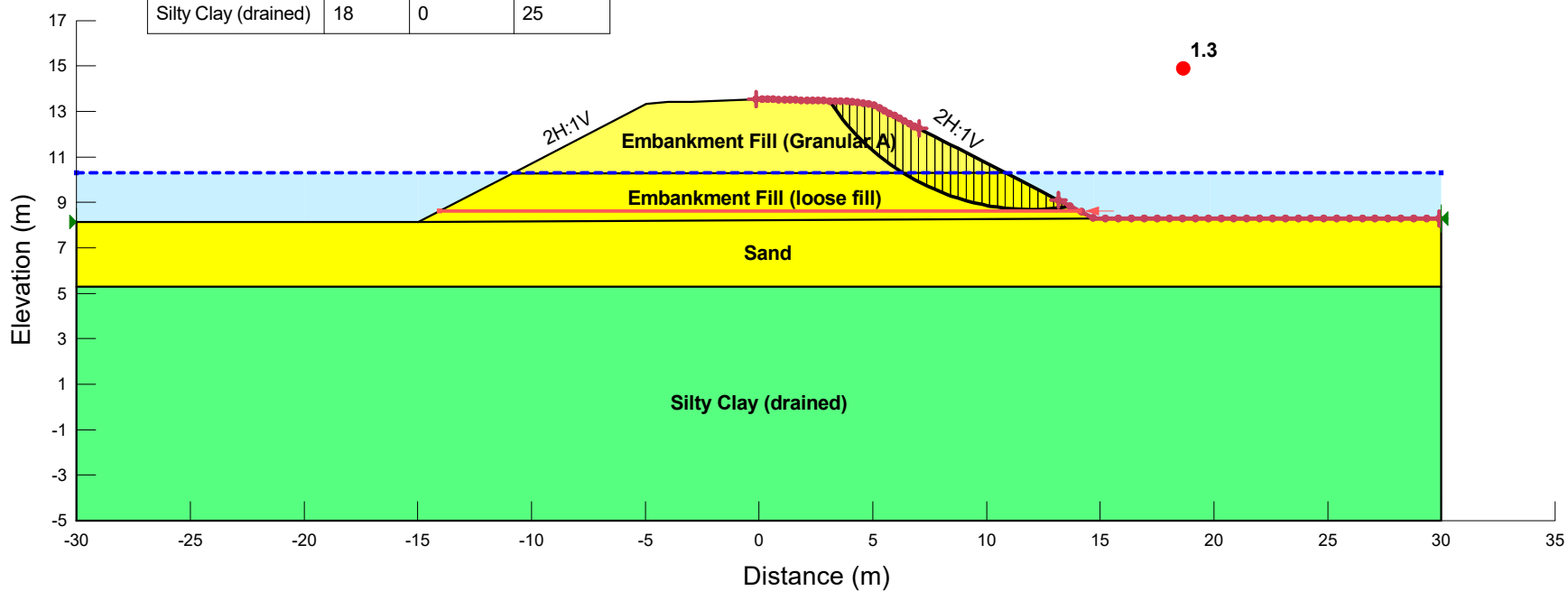
Project		
Fort Severn		
Analysis		
Fort Severn (Seismic_Granular A fill_loose fill below water)		
Seismic Coefficient	Last Run	Scale
H: 0.0336g, V: 0g	08/11/2024, 08:31:02 AM	1:300

Additional Details

- Geogrid above water level

Figure G10

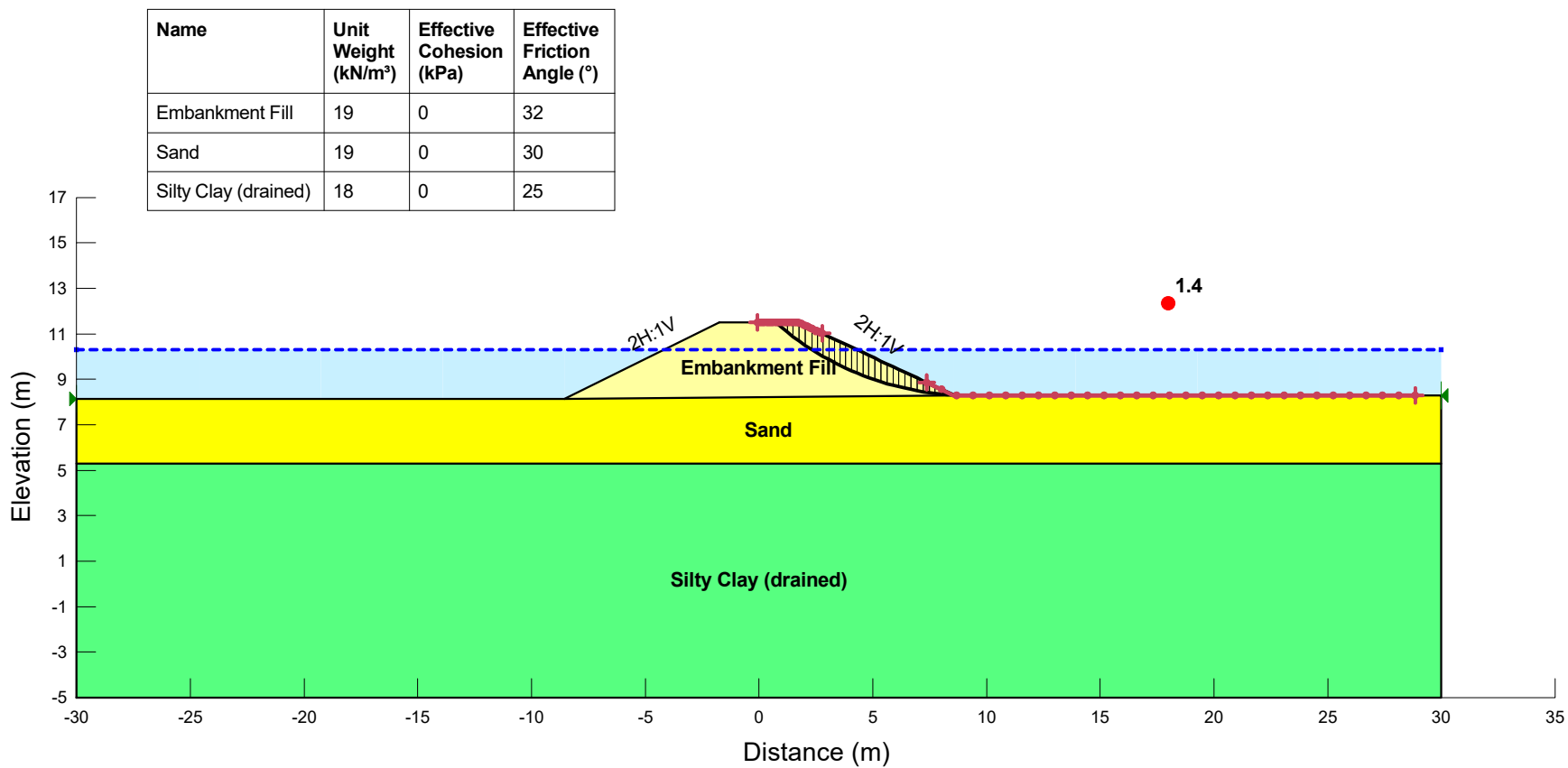
Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
Embankment Fill (Granular A)	22.8	0	35
Embankment Fill (loose fill)	19	0	30
Sand	19	0	30
Silty Clay (drained)	18	0	25



Project Fort Severn		
Analysis Fort Severn (Drained_Granular A fill_loose fill below water)		
Seismic Coefficient H: 0g, V: 0g	Last Run 08/11/2024, 08:07:27 AM	Scale 1:300

Additional Details
- Geogrid below water level

Figure G11



Project Fort Severn		
Analysis Fort Severn (Drained Analysis)		
Seismic Coefficient H: 0g, V: 0g	Last Run 07/30/2024, 01:01:54 PM	Scale 1:300

Additional Details

Figure G12

APPENDIX H

General Arrangement Drawing

