



**THURBER** ENGINEERING LTD.

**Foundation Investigation and Design Report  
Highway 9 Otter Creek Culvert Replacement  
Township of Carrick, Ontario  
G.W.P. 3076-14-00, Site No. 02X-0466/C0  
Latitude: 44.028747°, Longitude: -81.093200°  
GEOCRES No. 41A03-001**

**Client Name:** R.V. Anderson Associates Limited

**Date:** April 26, 2024

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**FOUNDATION INVESTIGATION AND DESIGN REPORT  
HIGHWAY 9 OTTER CREEK CULVERT REPLACEMENT  
TOWNSHIP OF CARRICK, ONTARIO  
G.W.P. 3076-14-00, SITE NO. 02X-0466/C0  
LATITUDE: 44.028747°, LONGITUDE: -81.093200°  
GEOGRES No. 41A03-001**

**PART 1: FACTUAL INFORMATION**

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## **1. INTRODUCTION**

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This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for design of the proposed Otter Creek Culvert (Site No. 02X-0466/C0) replacement. The Otter Creek Culvert is located on Highway 9, between Mildmay and Clifford, in Carrick Township, Ontario. This site is part of an overall detailed design project for improvements to Highway 9 between Mildmay and Clifford.

The purpose of this investigation was to explore the subsurface conditions at the 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 R.V. Anderson Associates Limited (RVA), under the Ministry of Transportation Ontario (MTO) West Region, Retainer Agreement Number 3020-E-0004, Work Item No. 23.

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.

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## **2. SITE DESCRIPTION**

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The site is located on Highway 9, approximately 500 m southeast of Side Road 30, near Mildmay, Ontario. The centreline of the existing culvert is located at approximate Highway 9 Station 20+247. Locally, Otter Creek flows under Highway 9 from northeast to southwest through the culvert, however the creek generally flows in an overall southeast to northwest direction. Highway 9 is a two-lane road with an asphalt paved surface and gravel shoulders, which is aligned in a northwest / southeast direction at the culvert site.

Existing site information provided by RVA and MTO, includes a 2021 Structure Inspection Report (OSIM report) for the culvert, a structural design drawing for a previous 2001 rehabilitation of the

culvert, and in progress drawings for the current Highway 9 project. The information indicates that the existing structure is an approximately 18.6 m long, open-footing, concrete box culvert, with a height of 1.5 m and a span of 4.9 m, except at the outlet, where the culvert alignment shifts and has a span of 6.3 m. The estimated culvert invert (top of existing concrete footings) is at approximate Elevation 317.5 m at both the inlet (northeast) and the outlet (southwest). The streambed level within the culvert is at approximate Elevation 317.6 m. The existing road grade at the culvert location is at approximate Elev. 320.3 m, and there is approximately 0.7 m of fill above the culvert. The local creek water level was reportedly measured at Elev. 317.93 m on November 3, 2022. The site topography within the culvert area is relatively flat, with agricultural open fields surrounding the culvert site on both sides of Highway 9.

The Highway 9 embankment is approximately 1.7 to 2 m high near the culvert, with side slopes beyond the culvert structure ranging in inclination from approximately 2H:1V to 2.5H:1V or flatter, except where the existing creek is close to the embankment toe. On the southwest side of Highway 9, the creek alignment closely follows the embankment toe from the culvert outlet for approximately 100 m towards the northwest. A small wood crib retaining wall (approximately 1.6 m long and 0.3 m high) in poor condition is located at the southwest quadrant of the culvert. Erosion of the embankment toe was observed in the vicinity of the existing retaining wall.

Photographs in Appendix E show the general nature of the site and the existing culvert.

Based on published geological mapping, the quaternary geology in the area of the culvert site typically consists of glaciofluvial ice-contact deposits including gravel, sand and minor till. The bedrock in the area typically consists of dolostone of the Bass Islands Formation.

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### **3. SITE INVESTIGATION AND FIELD TESTING**

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The site investigation and field-testing program for this project was carried out between September 25 and October 31, 2023. The field program consisted of drilling and sampling six (6) boreholes (CULV1-01 to CULV1-06) to depths from 4.0 to 15.2 m below the ground surface (Elev. 314.7 to 304.7 m).

Boreholes CULV1-03 and CULV1-04 were drilled through the gravel shoulders on Highway 9. Boreholes CULV1-01, CULV1-02, CULV1-05 and CULV1-06 were drilled off-road near the inlet and outlet of the existing culvert. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix A.

Utility clearances were obtained prior to the start of drilling. The horizontal coordinates and ground surface elevations at the boreholes were obtained by Thurber using a Trimble R12i GNSS system. The coordinate system MTM NAD 83, Zone 11 was used for the boreholes.

The boreholes through the road shoulders were advanced using a rubber track-mounted D-50 drill rig, using hollow stem augers and wash boring techniques. The off-road boreholes were advanced using a portable 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 in conjunction with the Standard Penetration Test (SPT). HQ rock coring methods were used at boreholes CULV1-03 and CULV1-04 to collect core samples of the bedrock.

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

The rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Groundwater conditions were observed in the open boreholes throughout the drilling operation. Monitoring wells were installed in Boreholes CULV1-04 and CULV1-06 to permit additional measurement of the groundwater level. The wells consisted of 50 and 32 mm diameter Schedule 40 PVC pipes with 3.0 m long slotted screens, enclosed in columns of filter sand. Monitoring well installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets in Appendix B.

Details of the drilling program, including drilling depths, monitoring well installation and completion details are summarized in Table 3.1.

**Table 3.1 Borehole Completion Details**

<b>Borehole Number</b>	<b>Borehole Depth / Base Elevation (m)</b>	<b>Monitoring Well Tip Depth / Elevation (m)</b>	<b>Completion Details</b>
CULV1-01	9.8 / 308.8	-	Backfilled with bentonite holeplug from 9.8 m to ground surface.
CULV1-02	6.1 / 312.4	-	Backfilled with bentonite holeplug from 6.1 m to ground surface.
CULV1-03	14.3 / 305.7	-	Backfilled with bentonite grout from 14.3 m to 1.8 m, bentonite holeplug to



Borehole Number	Borehole Depth / Base Elevation (m)	Monitoring Well Tip Depth / Elevation (m)	Completion Details
			0.2 m, and cold patch asphalt to ground surface.
CULV1-04	15.2 / 304.7	11.3 / 308.7	Backfilled with bentonite grout from 15.2 m to 11.6 m, coated bentonite pellets to 11.3 m, filter sand to 7.9 m, bentonite holeplug to 7.6 m, bentonite mixed with cuttings to 0.2 m, and cold patch asphalt to ground surface.
CULV1-05	4.0 / 314.7	-	Backfilled with bentonite holeplug from 4.0 m to ground surface.
CULV1-06	5.7 / 312.8	5.7 / 312.8	Backfilled with filter sand from 5.7 m to 2.1 m and bentonite holeplug to ground surface.

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#### 4. LABORATORY TESTING

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

In order to assess the potential for sulphate attack on buried concrete elements, as well as the potential for corrosion associated with the potential culverts, selected samples of the native soil from two boreholes were collected for analytical testing. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix D.

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#### 5. DESCRIPTION OF SUBSURFACE CONDITIONS

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Details of the subsurface conditions encountered during the foundation investigation are presented in the Record of Borehole sheets and the Borehole Locations and Soil Strata Drawing included in Appendices A and B.

A general description of the soil stratigraphy is given below. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It should be recognized and expected that soil and

rock conditions may vary between and beyond borehole locations.

In general, the subsurface stratigraphy below the asphalt typically consists of embankment fill comprised of silty sand and gravel fill to silty clay fill, underlain by layers of native silt, clayey silt and silty sand, as well as sand and gravel. The overburden soils were underlain by dolostone bedrock. The travelled portion of Highway 9 is paved with asphalt, however the boreholes on the road at this site were drilled through the gravel shoulders. More detailed descriptions of the individual strata are presented below.

### 5.1 Silty Sand and Gravel Fill

Embankment fill was encountered at the ground surface in Boreholes CULV1-03 and CULV1-04, which were drilled on Highway 9 through the gravel shoulders. The fill consisted of silty sand and gravel with trace clay.

The silty sand and gravel fill extended to 1.4 to 2.2 m below the ground surface (Elev. 318.5 to 317.8 m).

SPT 'N' values in the silty sand and gravel fill ranged from 5 to 46 blows per 0.3 m penetration, with dense to very dense conditions at the ground surface, and loose density below.

The measured moisture contents generally ranged from 4 to 20%.

The results of a grain size analysis conducted on a sample of the silty sand and gravel fill 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	34
Sand	32
Silt	28
Clay	6

### 5.2 Silty Clay Fill

A 0.8 m thick layer of silty clay fill with trace sand and trace gravel was encountered below the silty sand and gravel fill in Borehole CULV1-03. The silty clay fill extended to a depth of 2.2 m (Elev. 317.8 m).

The silty clay fill was soft, based on an SPT 'N' value of 4 blows per 0.3 m penetration. The moisture content of a sample of the silty clay fill was 20%.



### 5.3 Silty Sand to Sand and Silt Fill

A layer of fill ranging from silty sand to sand and silt was encountered below the silty sand and gravel and silty clay fill layers in Boreholes CULV1-03 and CULV1-04. The silty sand to sand and silt fill also contained trace to some gravel, trace clay and trace to some organic material.

The silty sand to sand and silt fill was 0.8 m thick and extended to a depth of 3.0 m below the ground surface (Elev. 317.0 m).

SPT 'N' values in the fill ranged from 2 to 11 blows per 0.3 m penetration, indicating a very loose to compact relative density.

The measured moisture contents generally ranged from 33 to 64%. The higher moisture content may represent the presence of organics in the fill.

The results of a grain size analysis conducted on a sample of the silty sand to sand and silt fill 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	6
Sand	49
Silt	39
Clay	6

### 5.4 Topsoil

Beyond the Highway 9 embankment, a layer of topsoil was encountered at the ground surface in Boreholes CULV1-01, CULV1-02, CULV1-05 and CULV1-06. The topsoil contained trace to some rootlets and ranged in thickness from 30 to 50 mm in Boreholes CULV1-01 and CULV1-05 and from 800 to 900 mm in Boreholes CULV1-02 and CULV1-06.

SPT 'N' values of 2 blows per 0.3 m penetration were recorded in the topsoil in Boreholes CULV1-02 and CULV1-06, indicating a very soft consistency.

The measured moisture contents in the topsoil ranged from 41 to 76%.

### 5.5 Silty Clay

A 1.2 m thick deposit of silty clay with trace to some sand, trace gravel and occasional organics was encountered below the topsoil in Borehole CULV1-01. The silty clay extended to a depth of

1.2 m below the ground surface (Elev. 317.3 m).

SPT 'N' values of 2 to 4 blows per 0.3 m penetration were recorded within the silty clay, indicating that the deposit is very soft to soft.

The moisture content of samples of the silty clay ranged from 43 to 58%.

## 5.6 Silty Sand

A native deposit of silty sand with trace clay and trace organics was encountered below the topsoil in Boreholes CULV1-02, CULV1-05 and CULV1-06. The silty sand deposit ranged in thickness from 0.4 to 1.1 m and extended to depths of 1.2 to 1.4 m (Elev. 317.4 to 317.2 m).

SPT 'N' values recorded within the silty sand deposit ranged from 3 to 16 blows per 0.3 m penetration, indicating that the density ranges from very loose to compact.

The moisture content of samples of the silty sand ranged from 13 to 69%. The higher moisture contents may represent the presence of organics in the relatively shallow soil deposit.

The results of a grain size analysis conducted on a sample of the silty sand are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C3 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	67
Silt	30
Clay	3

## 5.7 Silt

A layer of silt with trace to some sand and clay was encountered below the fill, silty clay and silty sand layers in all of the boreholes except for Borehole CULV1-06. The silt layer ranged in thickness from 1.0 to 2.6 m and extended to depths from 2.4 to 5.6 m (Elev. 316.1 to 314.3 m).

SPT 'N' values recorded within the silt layer ranged from 5 to 23 blows per 0.3 m penetration, indicating that the density ranges from loose to compact.

The moisture content of samples of the silt ranged from 9 to 24%.

The results of grain size analyses conducted on samples of the silt are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C4 of Appendix C. The results are

summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	1 to 13
Silt	77 to 86
Clay	10 to 15

The results of Atterberg Limits tests conducted on samples of the silt are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C8 of Appendix C. The results are summarized in the table below. The results indicate that the silt is typically non-plastic to low plasticity, with group symbols of ML to CL-ML.

Parameter	Percentage (%)
Liquid Limit	18 to 23
Plastic Limit	14 to 17
Plasticity Index	2 to 7

## 5.8 Clayey Silt

A layer of clayey silt with trace sand was encountered below the silty sand and silt layers in Boreholes CULV1-02, CULV1-03, CULV1-04 and CULV1-06, and below a 0.7 m thick deposit of sand and gravel in Borehole CULV-01. The clayey silt layer ranged in thickness from 1.5 to 3.5 m and extended to depths from 2.7 to 7.6 m (Elev. 315.8 to 311.4 m).

SPT 'N' values recorded within the clayey silt layer ranged from 6 to 18 blows per 0.3 m penetration, and a field vane shear test in Borehole CULV1-03 measured an undrained shear strength of 40 kPa. The SPT 'N' values and undrained shear strength value indicate that the clayey silt has a firm to very stiff consistency.

The moisture content of samples of the clayey silt ranged from 19 to 54%.

A 2 m thick lower pocket of clayey silt was encountered in Borehole CULV1-03 from a depth of 10.2 to 12.2 m below the ground surface (Elev. 309.8 to 307.8 m) within the underlying silty sand to sand and silt layer (refer to Section 5.9). The lower clayey silt was hard, based on SPT 'N' values of 37 to 47 blows per 0.3 m penetration. The moisture content of the lower clayey silt was approximately 13%.

The results of grain size analyses conducted on samples of the clayey silt are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C5 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	4 to 7
Silt	73 to 79
Clay	16 to 23

The results of Atterberg Limits tests conducted on samples of the clayey silt are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C9 of Appendix C. The results are summarized in the table below. The results indicate that the clayey silt typically has low plasticity, with group symbols of CL to CL-ML.

Parameter	Percentage (%)
Liquid Limit	21 to 24
Plastic Limit	13 to 16
Plasticity Index	7 to 9

## 5.9 Silty Sand to Sand and Silt

A layer of silty sand to sand and silt was encountered below the clayey silt in Boreholes CULV1-01, CULV1-02, CULV1-03 and CULV1-04. The silty sand to sand and silt also contained some gravel and trace to some clay. Where fully penetrated, the layer ranged in overall thickness from 3.0 to 5.4 m (including a clayey silt pocket noted in Section 5.8) and extended to depths from 10.2 to 13.0 m (Elev. 309.8 to 307.0 m). Boreholes CULV1-02 and CULV1-01 were terminated within the silty sand to sand and silt layer at depths of 6.1 and 9.8 m (Elev. 312.4 to 308.8 m) respectively. Slight artesian groundwater pressure of 0.25 m above the ground surface was encountered within the deposit at 6.1 m depth (Elev. 312.4 m) in Borehole CULV1-02.

SPT 'N' values recorded within the silty sand to sand and silt layer ranged from 13 to greater than 50 blows per 0.3 m penetration, indicating that the density ranges from compact to very dense. The SPT 'N' values of greater than 50 blows per 0.3 m of penetration at the base of Borehole CULV1-03 may be due to split spoon refusal on the underlying bedrock.

The moisture content of samples of the silty sand to sand and silt ranged from 10 to 13%.

The results of grain size analyses conducted on samples of the deposit are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C6 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	12 to 18
Sand	34 to 59
Silt	28 to 46
Clay	5 to 8
Silt & Clay	24

The results of an Atterberg Limits test conducted on a sample of the silt and sand are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C8 of Appendix C. The results are summarized in the table below. The results indicate that the silt and sand is non-plastic, with a group symbol of ML.

Parameter	Percentage (%)
Liquid Limit	16
Plastic Limit	11
Plasticity Index	5

## 5.10 Sand and Gravel

In Boreholes CULV1-04, CULV1-05 and CULV1-06, a 1.1 to 3.0 m thick layer of sand and gravel with trace to some silt was encountered below the above silt layers. The boreholes encountered bedrock or refusal to advance at depths of 4.0 to 11.3 m (Elev. 314.7 to 308.7 m).

SPT 'N' values ranging from 12 to greater than 50 blows per 0.3 m penetration were recorded in the sand and gravel, indicating that the density ranges from compact to very dense. The SPT 'N' values of greater than 50 blows per 0.3 m of penetration at the base of the deposit may be due to split spoon refusal on the underlying bedrock.

The measured natural moisture content of the sand and gravel ranged from 5 to 20%.

The results of a grain size analysis conducted on a sample of the sand and gravel are provided



on the Record of Borehole sheets in Appendix B and illustrated in Figure C7 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	60
Sand	36
Silt & Clay	4

### 5.11 Bedrock

Bedrock was encountered below the overburden soils in Boreholes CULV1-03 and CULV1-04 at depths of 11.3 to 13.0 m below the ground surface (Elev. 308.7 to 307.0 m). The bedrock was confirmed by coring 1.3 m in Borehole CULV1-03, and 3.9 m in Borehole CULV1-04.

The bedrock was described as Dolostone, which was typically light grey with brown interbeds and moderately weathered with occasional rubble zones.

The Fracture index (FI), measured as the total number of fractures per 0.3 m of rock core length, was typically between 1 and 6, and greater than 10 in localized rubble zones. Total Core Recovery (TCR) values measured on the recovered bedrock samples was 100%, and Solid Core Recovery (SCR) values ranged from 40 to 89%. Rock Quality Designation (RQD) values ranged from 13 to 70%, indicating that the bedrock ranges from very poor to fair quality.

Photographs of the rock core samples are presented in Appendix C.

### 5.12 Groundwater Conditions

Monitoring wells were installed in Boreholes CULV1-04 and CULV1-06 for measurement of the groundwater level. Groundwater conditions were also observed in the open boreholes throughout the drilling operation. The measured groundwater levels are summarized in Table 5.1 below.

**Table 5.1 Groundwater Measurements**

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
CULV1-01	October 30, 2023	1.0	317.5	Open Borehole
CULV1-02	October 14, 2023	- 0.25	318.8	Open Borehole
CULV1-03	September 28, 2023	3.7	316.3	Open Borehole
CULV1-04	September 26, 2023	4.3	315.7	Monitoring Well
	December 1, 2023	1.1	318.8	
	January 31, 2024	0.3	319.7	
CULV1-05	October 31, 2023	0.9	317.8	Open Borehole

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
CULV1-06	December 1, 2023	0.0	318.5	Monitoring Well
	January 31, 2024	- 0.2	318.7	

Slight artesian pressure was noted in Boreholes CULV1-02 and CULV1-06, resulting in water level measurements that were slightly above the ground surface (measured inside the drilling casing and monitoring well).

The groundwater levels above are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation. The local creek water level was reportedly measured at Elev. 317.93 m on November 3, 2022.

## 6. CORROSIVITY AND SULPHATE TEST RESULTS

Samples of the native silty sand and clayey silt from Boreholes CUL1-02 and CULV1-06 respectively were submitted for analytical testing of corrosivity parameters and sulphate. The laboratory certificates of analysis are presented in Appendix D. The results of the analytical tests are summarized below in Table 6.1.

**Table 6.1: Analytical Test Results**

Parameter	Units	Test Results	
		CULV1-02, SS2 2.5'-4.5' (0.8 – 1.4 m)	CULV1-06, SS4 7.5 – 9.5' (2.3 – 2.9 m)
		(Native Silty Sand)	(Native Clayey Silt)
Redox Potential	mV	294	271
Sulphide	%	0.09	0.08
pH	-	8.11	8.40
Chloride	µg/g	17	20
Sulphate	µg/g	400	190
Conductivity	µS/cm	438	287
Resistivity*	ohm-cm	2280	3480

\* Calculated based on conductivity result



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## 7. CLOSURE

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The field investigation was supervised on a full-time basis by Mr. Sergey Gladkiy and Mr. Jakob Flood of Thurber. Overall supervision of the field program was provided by Mr. Rod de Castro, P.Eng. Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory.

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

Thurber Engineering Ltd.



Mark Farrant, P.Eng.  
Associate, Senior Geotechnical Engineer



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

Date: April 26, 2024

File: 34935

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
HIGHWAY 9 OTTER CREEK CULVERT REPLACEMENT  
TOWNSHIP OF CARRICK, ONTARIO  
G.W.P. 3076-14-00, SITE NO. 02X-0466/C0  
LATITUDE: 44.028747°, LONGITUDE: -81.093200°  
GEOGRES NO. 41A03-001**

**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

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**8. GENERAL**

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This report provides an interpretation of the factual data from Part 1 of the report and presents detailed design foundation recommendations for the proposed replacement of the existing Otter Creek culvert crossing Highway 9. The discussion and recommendations presented in this report are based on the information provided by R.V. Anderson (RVA), the structural designer Doug Dixon and Associates Inc. (DDA), 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 their designers, 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.

Existing site information provided by RVA, DDA and MTO indicates that the existing structure is an approximately 18.6 m long, open-footing, concrete box culvert, with a height of 1.5 m and a span of 4.9 m, except at the outlet, where the culvert alignment shifts and has a span of 6.3 m. The estimated culvert invert (top of existing concrete footings) is at approximate Elevation 317.5 m at both the inlet (northeast) and the outlet (southwest). The streambed level within the culvert is at approximate Elevation 317.6 m. The existing road grade at the culvert location is at approximate Elev. 320.3 m, and there is approximately 0.7 m of fill above the culvert. The local creek water level was reportedly measured at Elev. 317.93 m on November 3, 2022. The site

topography within the culvert area is relatively flat, with agricultural open fields surrounding the culvert site on both sides of Highway 9.

The Highway 9 embankment is approximately 1.7 to 2 m high near the culvert, with side slopes beyond the culvert structure ranging in inclination from approximately 2H:1V to 2.5H:1V or flatter, except where the existing creek is close to the embankment toe. On the southwest side of Highway 9, the creek alignment closely follows the embankment toe from the culvert outlet for approximately 100 m towards the northwest. A small wood crib retaining wall (approximately 1.6 m long and 0.3 m high) in poor condition is located at the southwest quadrant of the culvert. Erosion of the embankment toe was observed in the vicinity of the existing retaining wall.

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## **9. CULVERT DESIGN**

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### **9.1 Culvert Alternatives**

This section presents discussions on various options for replacement of the existing culvert. Foundation recommendations for the preferred culvert type are provided.

Several culvert options that may be considered for this site are listed below:

- Concrete box (closed) culvert composed of pre-cast segments
- Corrugated steel pipe (CSP), structural plate corrugated steel pipe (SPCSP) or multiple pipes
- Cast in place open footing culvert

From a foundations and constructability perspective, use of a pre-cast concrete closed box culvert is preferred over the steel pipe or open footing culvert options, based on the following considerations:

- Pre-cast concrete closed box culverts require shallower depth of excavation compared with open footing concrete culverts, which require sufficient cover for frost protection of the footings;
- Pre-cast concrete box culverts can often be installed more expeditiously than cast in place open footing culverts, resulting in shorter durations for dewatering and construction;
- A segmental box culvert can accommodate some potential differential settlement along the culvert axis, unlike a cast in place open footing culvert; and
- Steel pipe culverts may be a viable alternative provided there is sufficient cover; however a larger diameter pipe or multiple pipes may be required to accommodate the creek flow



compared to a single-cell closed bottom box culvert, which is likely to satisfy the hydraulic requirements.

Accordingly,

- The closed bottom concrete box culvert option is preferred over the steel pipe option because it accommodates the creek flow within a single structure.
- The open footing culvert is not recommended at this site since it would involve deeper excavation in cohesionless soils to provide adequate frost protection. More dewatering effort will be required for this option.

Based on discussions with RVA and the structural designer DDA, it is understood that a precast concrete closed box culvert is preferred at this site. A Preliminary draft General Arrangement (GA) drawing was provided by DDA for the concrete box culvert for reference. The preliminary GA drawing is included in Appendix H for reference.

The preliminary GA drawing indicates that the proposed box culvert will be installed on a skewed and partially shifted alignment from the existing culvert, which allows for maintaining the existing creek alignment without significant modification of the creek channel. The proposed new culvert is a 23.9 m long precast concrete box, with an opening size of 4.8 m wide by 2.1 m high (exterior dimensions of 5.4 m wide by 2.8 m high). The invert level (bottom of concrete box) is at approximate Elev. 316.7 m. New gabion retaining walls (3 to 4 m long) are proposed at the southeast and southwest corners of the culvert, adjacent to the culvert outlet. It is understood that the concrete footings for the existing culvert will likely be removed down to their base level (approximate Elev. 316.5 m) to facilitate construction of the new box culvert and minimize impact of a hard-point effect from the existing footing below the base of the new box culvert. Please note that the existing footing depth (1 m) and base elevation are based on the 2001 rehabilitation drawing and may not reflect the actual footing dimensions. If the existing footings extend deeper than this level, it may be necessary to pulverize the remaining portion of the footings or deepen the excavations to remove them. Portions of the existing west footing where not in close proximity to the new culvert may remain in place and be cut off below the ground surface.

No significant grade raise is anticipated for Highway 9 after installation of the culvert.

It is understood that Highway 9 will be closed to traffic during construction of the replacement culvert, and therefore staged construction and temporary roadway protection systems will not be required.

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

## **9.2 Summary of Subsurface Conditions**

In general, the subsurface stratigraphy encountered in the boreholes consists of asphalt and embankment fill (silty sand and gravel fill to silty clay fill), underlain by layers of native silt, clayey silt and silty sand, as well as sand and gravel. The overburden soils were underlain by dolostone bedrock at depths ranging from 11.3 to 13.0 m below the ground surface where encountered.

The groundwater level in the open boreholes and monitoring wells ranged from approximate Elevation 315.7 to 319.7 m. The local creek surface water level was measured at an Elevation of 317.93 m in November 2022. Slight artesian groundwater pressure was noted at the site, indicating the possible presence of an upward gradient from the deeper cohesionless soils.

## **9.3 Foundation Design for Concrete Box Culvert**

The base of the existing culvert footings is at approximate Elev. 316.5 m, and the underside of the proposed concrete culvert is at approximate Elev. 316.7 m. This corresponds to a culvert subgrade consisting of loose silt below the groundwater table.

Foundation design aspects for the replacement culvert include subgrade conditions and preparation, geotechnical capacities, settlement of foundation soils, lateral earth pressures, gabion retaining walls, groundwater control, and restoration of the roadway embankment.

Replacement of the culvert with a concrete box culvert is considered to be a viable option for this site. Construction of the replacement concrete box culvert should be in accordance with OPSS 422.

### **9.3.1 Culvert Bedding and Subgrade Preparation**

In order to provide a uniform foundation subgrade, a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements should be provided under the base of the box culvert, similar to as shown on OPSD 803.010. The bedding material should be placed on the prepared subgrade as soon as practicable following its inspection and approval. The underside of the bedding layer should be placed on the native silt at or below Elev. 316.4 m. The bedding material should be placed and compacted in accordance with OPSS 422 and OPSS.PROV 501.

Adequate preparation of the subgrade will be essential for performance of the culvert. Due to the loose nature of the subgrade silt and the possible presence of upward groundwater pressure from the lower cohesionless soils, it is important that adequate dewatering be in place prior to excavation to the subgrade level, and that subgrade preparation and placement and compaction

of the bedding material are carried out in the dry to prevent disturbance of the silt. Further discussion on excavation and dewatering is included in Section 11.

Any buried topsoil, excessively soft soil, large cobbles and boulders, and any soft, very loose organic or other deleterious material encountered during subgrade preparation should be sub-excavated and replaced with compacted granular material to provide a uniformly competent subgrade condition. In the event that sub-excavation is required, the width of sub-excavation should be defined by a line extending from 0.3 m beyond the outside edge of the proposed culvert, outward and downward at 1H:1V. The sub-excavated area should then be backfilled with granular material meeting OPSS.PROV 1010 Granular A or Granular B Type II requirements and be compacted as per OPSS.PROV 501. The existing concrete culvert footings should also be removed from within the new culvert footprint and anywhere they impede with the preparation of the subgrade, bedding and backfilling for the new culvert. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction. Suggested wording for an NSSP on subgrade preparation is included in Appendix G.

A separation layer consisting of a non-woven geotextile should be placed between the subgrade soils and the minimum 300 mm thick layer of bedding material. The geotextile should meet the specifications for the OPSS Class II, and have a fabric opening size (FOS) not greater than 212  $\mu$ m. The subgrade surface prepared to support the box units should have a minimum 75 mm thick top levelling course consisting of uncompacted Granular A as per OPSS 422.

### 9.3.2 Geotechnical Resistances

The following geotechnical resistances are recommended for the design of a box culvert with an approximately 5 to 6 m bearing width founded at or below Elevation 316.4 m on the loose silt:

Geotechnical Resistance	Approx. 5 to 6 m Wide Culvert
Factored Geotechnical Resistance at ULS	150 kPa
Geotechnical Resistance at SLS (for up to 25 mm settlement)	100 kPa

A consequence factor of 1.0 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per Canadian Highway Bridge Design Code (CHBDC) 2019, Section 6.9.

The factored ultimate resistance and settlement are dependent on the culvert size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the culvert width or founding/invert elevation differs significantly from that given above.

The above geotechnical resistances are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with CHBDC 2019, Clause 6.10.5.3.

Resistance to sliding should be calculated assuming ultimate coefficients of friction of 0.45 between the concrete and the underlying Granular A or B Type II bedding material, and 0.35 between the bedding material and the native silt. A resistance factor of 0.8 should be applied to these ultimate values.

The culvert should be designed to resist external loadings including frost forces, lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment.

### 9.3.3 Frost Cover

The depth of frost penetration at this site is approximately 1.4 m based on OPSD 3090.101. The base of any concrete footings if employed should be provided with a minimum of 1.4 m of earth cover as protection against frost action. The frost cover requirement does not apply to the closed box concrete culvert.

Since the gabion walls are greater than 2.0 m in height, frost protection must follow the MTO RSS Design Guidelines, which state that minimum soil cover of the greater of 800 mm or 40% of the frost depth at the site (560 mm) must be provided above the base of the RSS leveling pad. Therefore, the base of the gabion walls must be provided with a minimum soil cover of 800 mm. The burial depth in front of the walls should also be deep enough to resist the effects of scour and erosion, and to meet lateral stability requirements. This is critical wherever the watercourse is in close proximity to the gabion walls.

### 9.3.4 Settlement

The replacement culvert is anticipated to be constructed with a similar or larger opening size as the existing culvert with no significant grade raise on the overlying embankment. A skewed alignment is proposed in order to maintain the existing creek alignment. Provided that all topsoil, very loose organic or other deleterious material, and any excessively soft or loose soil encountered is removed from below the new culvert and any new fill areas, the foundation

settlement is anticipated to be less than 25 mm, which would be completed by the end of construction.

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## 10. GABION RETAINING WALLS

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Due to property restrictions and the proximity to the creek channel on the south side of Highway 9, gabion retaining walls are proposed to retain the embankment fill at both the southeast and southwest corners of the new culvert outlet. Based on the preliminary GA drawing, the southeast gabion wall is approximately 3 m long and 2.35 m high, and the southwest gabion wall is approximately 4 m long and 2.8 m high. The walls are founded at the same elevation as the base of the new box culvert (approximate Elev. 316.7 m).

It is recommended that the gabion walls be supported on minimum 300 mm thick engineered granular fill pads to provide subgrade uniformity along the gabion wall alignments. The granular fill pads should consist of OPSS.PROV 1010 Granular A or Granular B Type II and be compacted as per OPSS.PROV 501. The granular fill pads should be founded on the native silt at or below Elev. 316.4 m.

The following geotechnical resistances are recommended for the design of gabion walls founded on 300 mm thick granular fill pads at or below Elevation 316.4 m on the loose silt:

Geotechnical Resistance	Approx. 2 m Wide Gabion Wall
Factored Geotechnical Resistance at ULS	150 kPa
Geotechnical Resistance at SLS (for up to 25 mm settlement)	100 kPa

A consequence factor of 1.0 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per Canadian Highway Bridge Design Code (CHBDC) 2019, Section 6.9.

The factored ultimate resistance and settlement are dependent on the gabion wall footing size (base width), configuration and applied loads; the geotechnical resistances should therefore be reviewed if the wall width or founding elevation differs significantly from that given above.

It should be noted that the embankment fill to be retained by the gabion walls is sloping with an inclination of approximately 2H:1V. The design of the gabion walls must include the appropriate



higher coefficient of earth pressure for the sloping fill being retained by the walls (refer to Section 13).

To satisfy global slope stability of the highway embankment, the minimum width of the base of the gabion walls should be 2 m (refer to Section 15). However, the internal stability of the gabion walls must be checked against various modes of failure including but not limited to sliding and overturning. In addition, the gabion walls should be designed to resist external loadings including frost forces, lateral earth pressures, hydrostatic pressure, weight of backfill, and surcharge due to construction equipment.

Resistance to lateral forces / sliding should be calculated assuming ultimate coefficients of friction of 0.60 between the gabion basket and the underlying granular pad material and 0.35 between the bedding material and the native silt. A resistance factor of 0.8 should be applied to these ultimate values.

Prior to constructing the engineered fill pads, the subgrade should be inspected, and any surficial or buried topsoil, loose, soft soils or otherwise disturbed materials should be removed. The exposed silt subgrade must be properly prepared and be carried out in the dry. Preparation of the subgrade should be carried out as described in Section 9.3.1. A geotextile should be placed on the native subgrade soil as a separation layer prior to granular fill placement, and placed on the back face of the gabion walls as a separation layer prior to backfilling.

Excavation and backfilling for gabion wall construction should be carried out with reference to the requirements in OPSS.PROV 902. Special attention and care should be given to excavation operations in order not to destabilize the existing slopes.

Material specifications for components used for the construction of the gabion walls (e.g., durable hard aggregates, wire mesh, PVC coating, fasteners, etc.) should meet the requirements of OPSS.PROV 1430 and OPSS.PROV 1004.

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## **11. EXCAVATION AND GROUNDWATER CONTROL**

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### **11.1 Excavations**

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the silty sand and gravel and silty sand to sand and silt fills 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), the fill soils would be classified as Type 4 soils. The silty clay fill and native soils within the excavation depth including silty clay, silty sand, silt, and sand

and gravel below the water table should be classified as Type 4 soils. Topsoil or other surficial alluvial deposits that are anticipated in the inlet and outlet areas are also classified as Type 4 soils.

Excavation and backfilling for culvert and gabion wall construction should be carried out in accordance with OPSS.PROV 902. Excavations are anticipated to be carried out through the existing fill, shallow silty sand and silty clay, and into the native silt.

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.

## **11.2 Groundwater Control and Dewatering**

Installation of the culvert and gabion walls should be carried out in the dry. As the excavations for culvert replacement and gabion wall construction will be carried out below the creek water level and the groundwater level, diversion of the creek water flow and adequate dewatering will be required. Surface water runoff and groundwater seepage from the embankment fill and native soils should also be anticipated and will accumulate into the excavations if not controlled. Due to the loose nature of the subgrade silt and the possible presence of upward groundwater pressure from the lower cohesionless soils, the creek should be diverted and full dewatering should be in place prior to commencement of excavation. To minimize disturbance of the subgrade silt, excavations for subgrade preparation and removal of the existing culvert footings should not commence until effective dewatering is in place and the groundwater level has been lowered to a minimum depth of 1 m below the final subgrade level. The dewatering system must be effective to maintain the water level at this depth throughout construction.

Dewatering methods including wellpoints and watertight sheet pile enclosures driven sufficiently deep to form a groundwater cut-off may be necessary, however additional assessment would be required to design the appropriate system. The design of any dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP FOUN0003 and OPSS.PROV 517. If a wellpoint system will be used, a preconstruction survey will be required. Further hydrogeological investigation is necessary for assessment of the required preconstruction survey distance for Designer Fill-In \*\* in SP FOUN0003.

Dewatering must remain operational and effective until the culvert and gabion wall foundations are constructed. An NSSP on dewatering is included in Appendix G.

Due to the high groundwater table, presence of artesian groundwater pressure, and the typically cohesionless soils that exist at the site, it is anticipated that dewatering activities will result in water taking flow rates that exceed 50,000 L/day. Further investigation and analysis would be required for assessment of dewatering flow rates, as in situ hydraulic conductivity testing data was not available.

If the water taking rate will be greater than 50,000 L/day and less than 400,000 L/day, then registration on the Environmental Activity and Sector Registry (EASR) will be required. If the water taking rate will be greater than 400,000 L/day, then a Category 3 Permit to Take Water (PTTW) will be required. Further investigation and a hydrogeological study would be required to provide the necessary data and analysis to the Ministry of the Environment, Conservation and Parks (MECP) for either EASR registration or a PTTW application.

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## **12. COFFERDAMS AND CHANNEL DIVERSION**

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Construction of cofferdams will be required to divert the creek channel and facilitate construction of the culvert and gabion walls. The design and selection of the cofferdam system is the responsibility of the Contractor. The Contractor should consider the ground conditions in selecting the type of cofferdam system for this site.

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## **13. CULVERT BACKFILL AND LATERAL EARTH PRESSURES**

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Backfill to the culvert and retaining walls should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS.PROV 1010. Backfilling for the culvert and gabion walls should be in accordance with OPSS.PROV 902, reference to the backfill arrangements stipulated in OPSD 803.010, as appropriate for the box culvert. All fills should be placed in regular lifts and be compacted in accordance with OPSS.PROV 501. The culvert 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 walls and roof 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 and gabion 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)
$\gamma$	=	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 behind the culvert and gabion walls are dependent on the material used as backfill. Recommended unfactored values are shown in Table 13.1 below.

**Table 13.1 Lateral Earth Pressure Coefficients (K)**

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ$ ; $\gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I (modified) or Type III $\phi = 32^\circ$ ; $\gamma = 21.2 \text{ kN/m}^3$	
	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	-	0.47	-
Passive, $K_P$ (Movement towards soil mass)	3.7	-	3.2	-

\* For 2H:1V backfill slope behind proposed gabion walls

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

For rigid structures such as concrete box culverts, at-rest horizontal earth pressures should be used for design. If the gabion walls are permitted to yield (unrestrained system), active horizontal earth pressure may be used in the geotechnical design of the wall. If the walls are not allowed to yield (restrained system), at-rest horizontal earth pressures should be used.

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the walls.

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 Granular B Type I, or at a depth of 2.0 m for Granular A or B Type II.

## 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 loose to compact or firm to very stiff fill and native soils, underlain by relatively shallow bedrock, the site is classified as Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. 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 0.111 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 D, and a reference PGA of 0.111 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 ( $K_{AE}$ )	
		OPSS Granular A or Granular B Type II $\phi = 35^\circ$ , $\gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I (modified) or Type III $\phi = 32^\circ$ , $\gamma = 21.2 \text{ kN/m}^3$
Active (Unrestrained Wall)	0.056	0.30	0.34
Active (Restrained Wall)	0.111	0.33	0.38

In view of the low potential for seismic activity in the area and the high fine content of the loose materials at the site, liquefaction is not considered to be a concern at this site.

## 15. SLOPE STABILITY

Based on slope configurations on cross-sections provided by RVA, slope stability analysis was conducted to assess the reinstated embankment slopes and global stability of the gabion retaining walls. A critical section at Station 20+243 through the south slope of Highway 9 and the southwest gabion wall adjacent to the creek was selected for analysis. The stability assessments assume the embankment fill will consist of Granular A or Granular B Type II, and a minimum gabion wall base of 2 m wide will be used.

Minimum Factors of Safety (F.S.) of 1.3 and 1.5 are considered to be acceptable for temporary and permanent conditions for the embankment slopes at this site.



The results of the analyses for temporary (undrained) and permanent (drained) conditions are presented in Figures F1 and F2 respectively in Appendix F. Figures 1 and 2 show the F.S. to be acceptable, with an F.S. of 1.8 for each condition.

A stability analysis under seismic loading was also performed using a pseudo-static slope stability analysis. For CHBDC 2019 Site Class D (see Section 14), a horizontal seismic coefficient,  $k_h$ , of 0.056g (one-half of the corresponding site peak ground acceleration) was used for the seismic stability analysis. To account for the softening of clays due to seismic loading, the undrained shear strength of the cohesive materials (clay soils) was reduced by a conservative estimate of 20% in accordance with Hynes-Griffin and Franklin (1984) in the slope stability analysis. The results of the analysis under seismic loading show the F.S. to be 1.55 (Figure F3 in Appendix F), which is greater than the minimum F.S. of 1.1 required by CHBDC 2019 for a typical degree of understanding.

Based on the results of the stability analyses, minimum 2 m wide gabion walls with the base founded at Elev. 316.7 m on minimum 300 mm thick granular fill pads are expected to be stable at this site.

Minimum 2 m wide gabion walls are recommended from a global stability perspective; however the dimensions of the gabion walls, including the width, will be governed by the lateral earth pressures imposed on the walls. As noted in Section 10, the internal stability of the gabion walls must be checked by the designer. The design should also include appropriate erosion protection measures where the gabion walls are in close proximity to the creek; for example at the southwest corner of the culvert (refer to Section 17).

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## **16. EMBANKMENT RESTORATION**

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Embankment restoration after completion of the culvert replacement should be carried out in accordance with OPSS.PROV 206. The embankment reconstruction material should consist of imported Granular A or Granular B Type II material. The restored embankment beyond the culvert should be reinstated at the existing slope inclination, but no steeper than 2H:1V. Earth fill or soils generated from the culvert excavation should not be used for reinstatement of the embankment at the culvert location.

In general, surface vegetation, peat, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the areas around the culvert inlets and outlets, and within the embankment footprints. Inspection and approval of the foundation surfaces by qualified geotechnical personnel should be conducted.

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## **17. SCOUR AND EROSION PROTECTION**

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Erosion protection should be provided at the culvert inlet and outlet and at the gabion walls. 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 OPSS 810.010, OPSS 511 and OPSS.PROV 1004.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. In particular, additional erosion protection measures may be required at the southwest gabion wall to prevent future loss of material where the wall is in close proximity to the creek. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

A concrete cut-off wall and a clay seal (only required 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 1005.

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## **18. CORROSION AND SULPHATE ATTACK POTENTIAL**

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

- The potential for corrosion of metal foundation elements from the surrounding native soils is considered to be moderate, based on the moderately low resistivity of the samples tested.
- The potential for corrosion of concrete foundation elements from the surrounding native soils is considered to be low, based on the low concentrations of chloride and sulphate in the samples tested. The effect of road deicing salt should be considering while selecting the class of concrete.
- The potential for sulphate attack on concrete from the surrounding native soil is considered to be negligible due to the low sulphate concentration in the samples tested.



- Appropriate protection measures are recommended for metal or concrete structural elements. The effect of road deicing salt should be considered while selecting the corrosion protection measures.

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## 19. CONSTRUCTION CONCERNS

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During construction, the Contract Administrator should employ experienced foundation / geotechnical staff to observe construction activities.

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

- Creek diversion and dewatering to lower the groundwater level to below the base of the culvert and gabion wall excavations must be carried out in advance to avoid disturbance of the sensitive silt subgrade. No excavation should occur until effective dewatering is in place. Suggested wording for an NSSP on dewatering is attached in Appendix G.
- Care must be exercised during excavation to avoid disturbing the founding subgrade for the culvert and gabion walls. When the excavation reaches the required elevation, the subgrade should be inspected and approved by qualified geotechnical personnel. Suggested wording for an NSSP on subgrade preparation is attached in Appendix G.
- The water level in the watercourse may fluctuate and be at a higher elevation at the time of construction than indicated in the report.



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## 20. CLOSURE

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

Thurber Engineering Ltd.



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Principal, Designated MTO Contact

Date: April 26, 2024

File: 34935

## **STATEMENT OF LIMITATIONS AND CONDITIONS**

### **1. STANDARD OF CARE**

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

### **2. COMPLETE REPORT**

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

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

### **3. BASIS OF REPORT**

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

### **4. USE OF THE REPORT**

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

### **5. INTERPRETATION OF THE REPORT**

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

### **6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES**

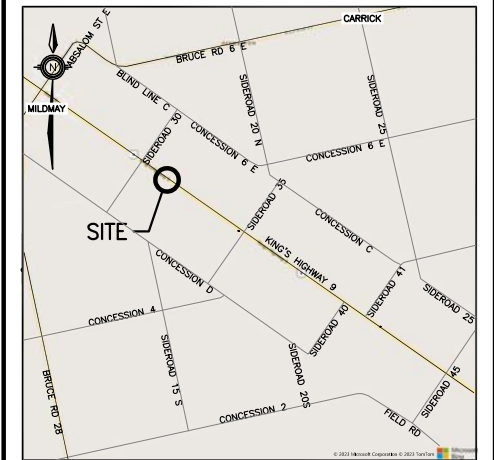
Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape,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

### **7. INDEPENDENT JUDGEMENTS OF CLIENT**






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

## **APPENDIX A**

### Borehole Locations and Soil Strata Drawings



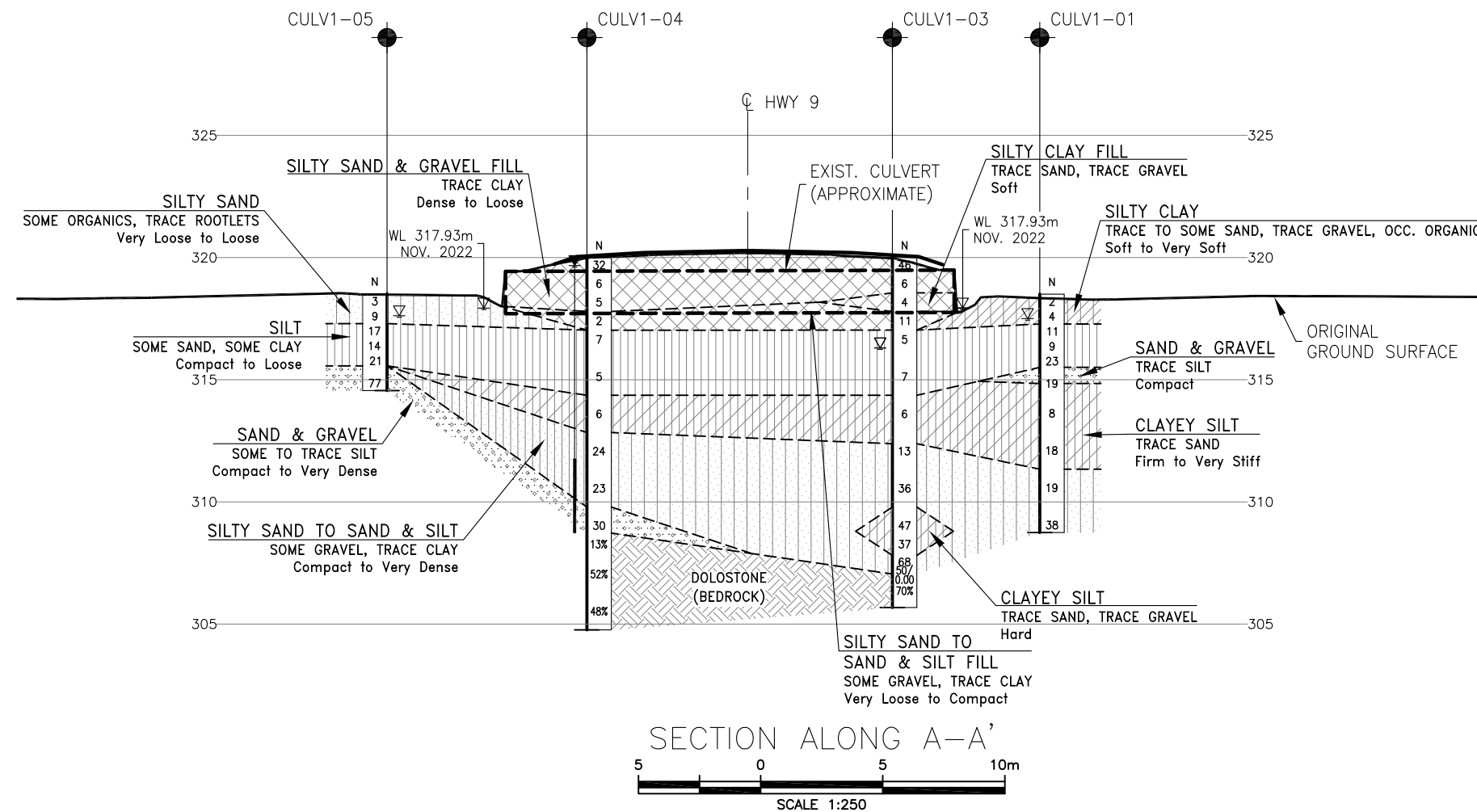
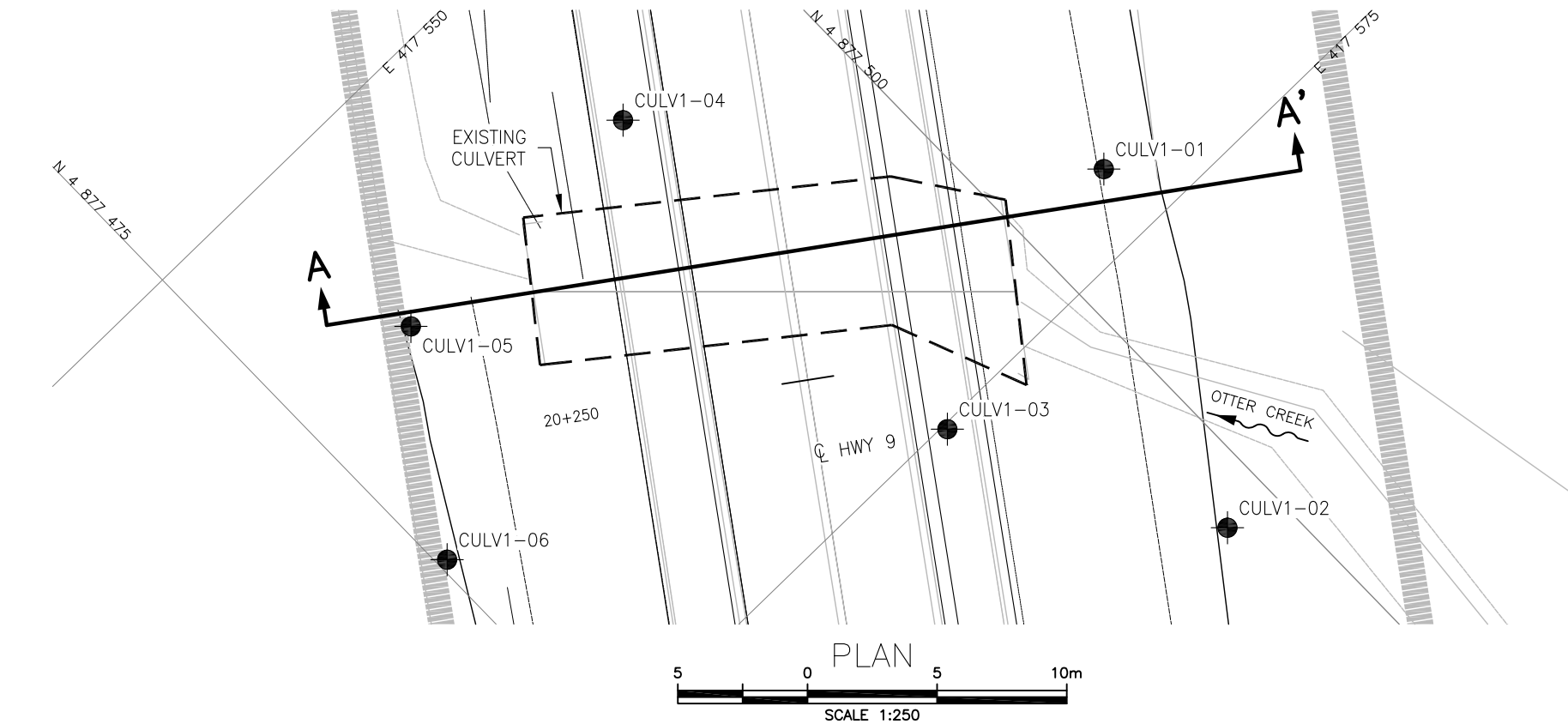
## LEGEND

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

[illegible]

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

REVISIONS										
	DATE	BY	DESCRIPTION							
DESIGN	MEF	CHK	PKC	CODE		LOAD		DATE	APR 2024	
DRAWN	AN	CHK	MEF	SITE 02X-0466/c0	STRUCT		DWG 1			







**THURBER** ENGINEERING LTD.

## **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 <sup>(1)</sup> '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

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


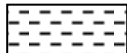



 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (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			

## EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
<b>Fresh (FR)</b>	No visible signs of weathering.		
<b>Fresh Jointed (FJ)</b>	Weathering limited to the surface of major discontinuities.		CLAYSTONE
<b>Slightly Weathered (SW)</b>	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
<b>Moderately Weathered (MW)</b>	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
<b>Highly Weathered (HW)</b>	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
<b>Completely Weathered (CW)</b>	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

<u>TERMS</u>	
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

# RECORD OF BOREHOLE No CULV1-01

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 877 504.0 E 417 572.2 ORIGINATED BY SG  
DIST West HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Rig COMPILED BY RdC  
DATUM Geodetic DATE 2023.10.30 - 2023.10.30 LATITUDE 44.028863 LONGITUDE -81.093154 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
318.5	GROUND SURFACE											GR SA SI CL			
0.8	<b>TOPSOIL</b> (30mm) Silty <b>CLAY</b> , trace to some sand, trace gravel, occasional organics Very Soft to Soft Dark Brown to Brown Moist to Wet		1	SS	2										
			2	SS	4										
317.3															
1.2	<b>SILT</b> , some clay, trace sand Compact to Loose Brown Wet (ML)		3	SS	11										
			4	SS	9										0 3 86 11
			5	SS	23										
315.5															
3.0	<b>SAND</b> and <b>GRAVEL</b> , trace silt Compact Brown Wet														
314.9			6	SS	19										
3.7	Clayey <b>SILT</b> , trace sand Stiff to Very Stiff Brown Moist to Wet (CL-ML)										0 5 75 20				
			7	SS	8										
			8	SS	18										
311.4															
7.2	Silty <b>SAND</b> , some gravel Compact to Dense Brown Wet										17 59 24 (SI+CL)				
			9	SS	19										
			10	SS	38										
308.8															
9.8	END OF BOREHOLE AT 9.8m.														

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

## METRIC

[illegible]

# RECORD OF BOREHOLE No CULV1-02

1 OF 1

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 877 497.8 E 417 585.4 ORIGINATED BY JF  
DIST West HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Rig COMPILED BY RdC  
DATUM Geodetic DATE 2023.10.14 - 2023.10.14 LATITUDE 44.028805 LONGITUDE -81.092990 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						
318.5	GROUND SURFACE													
0.0	TOPSOIL, some rootlets Very Soft Dark Brown Moist		1	SS	2									
317.6			2	SS	5									
0.9	Silty SAND, trace clay, some organics Loose Dark Brown Moist		3	SS	12									
317.2			4	SS	18									
1.4	SILT, some sand, some clay Compact Brown Moist to wet (ML)		5	SS	17									
316.1														
2.4	Clayey SILT, trace sand Very Stiff Brown Moist to wet (CL-ML)		6	SS	16									
313.7														
4.9	Silty SAND, some gravel, trace clay Compact Brown Wet													
312.4														
6.1	END OF BOREHOLE AT 6.1m. * ARTESIAN CONDITION ENCOUNTERED AT 6.1m. WATER LEVEL APPROXIMATELY 0.25m ABOVE EXISITING GRADE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

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







# RECORD OF BOREHOLE No CULV1-03

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 877 492.7 E 417 575.2 ORIGINATED BY SG  
DIST West HWY 9 BOREHOLE TYPE Hollow Stem Augers / Wash Boring / HQ Core Barrel COMPILED BY RdC  
DATUM Geodetic DATE 2023.09.26 - 2023.09.28 LATITUDE 44.028760 LONGITUDE -81.093119 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
320.0	GROUND SURFACE							20 40 60 80 100													
0.0	Silty <b>SAND</b> and <b>GRAVEL</b> , trace clay Dense to Loose Brown Dry (FILL)		1	SS	46		319														
			2	SS	6		318														
318.5			3	SS	4		317														
1.4	Silty <b>CLAY</b> , trace sand, trace gravel Soft Dark Brown Moist (FILL)		4	SS	11		316														
317.8							315														
2.2	Silty <b>SAND</b> , some gravel, trace clay, some organics Compact Dark Brown Moist to Wet (FILL)						314														
317.0							313														
3.0	<b>SILT</b> , some clay, trace sand Loose Brown Wet		5	SS	5		312														
			6	SS	7		311														
								310													
314.4							309														
5.6	Clayey <b>SILT</b> , trace sand Firm Brown Wet (CL-ML)		7	SS	6																
312.4																					
7.6	Silty <b>SAND</b> , some gravel, some clay Compact to Dense Brown Wet		8	SS	13																
				9	SS	36															

Continued Next Page

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

# RECORD OF BOREHOLE No CULV1-03

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 877 492.7 E 417 575.2 ORIGINATED BY SG  
 DIST West HWY 9 BOREHOLE TYPE Hollow Stem Augers / Wash Boring / HQ Core Barrel COMPILED BY RdC  
 DATUM Geodetic DATE 2023.09.26 - 2023.09.28 LATITUDE 44.028760 LONGITUDE -81.093119 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE									
	Continued From Previous Page						20   40   60   80   100						W P      W      W L				
309.8																	
10.2	Clayey <b>SILT</b> , trace sand, trace gravel Hard Brown Wet (CL-ML)		10	SS	47		309								0   4   76   20		
			11	SS	37		308										
307.8																	
12.2	Silty <b>SAND</b> , some gravel, trace clay Very Dense Grey Wet		12	SS	68										18   49   28   5		
307.0			13	SS	50/												
13.0	<b>BEDROCK (DOLOSTONE)</b> , moderately weathered, grey with brown interbeds  Rubble zone zone from 13.0m to 13.1m				0.000		307							F1  2  5  6	RUN #1 TCR=100% SCR=89% RQD=70%		
305.7			1	RUN			306										
14.3	END OF BOREHOLE AT 14.3m. WATER LEVEL AT 3.7m IN OPEN BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE GROUT TO 1.8m, BENTONITE HOLEPLUG TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.																

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No CULV1-04

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 877 492.0 E 417 557.9 ORIGINATED BY SG  
DIST West HWY 9 BOREHOLE TYPE Hollow Stem Augers / Wash Boring / HQ Core Barrel COMPILED BY RdC  
DATUM Geodetic DATE 2023.09.25 - 2023.09.26 LATITUDE 44.028757 LONGITUDE -81.093334 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE		WATER CONTENT (%) w <sub>p</sub> w      w <sub>L</sub>					
320.0	GROUND SURFACE							20   40   60   80   100						GR   SA   SI   CL	
0.0	Silty <b>SAND</b> and <b>GRAVEL</b> , trace clay Dense to Loose Brown Dry (FILL)		1	SS	32										
			2	SS	6		319								
			3	SS	5		318								
317.8															
2.2	<b>SAND</b> and <b>SILT</b> , trace clay, trace gravel, trace organics Very Loose Brown Moist (FILL)		4	SS	2										6   49   39   6
317.0			5	SS	7		317								0   1   84   15
3.0	<b>SILT</b> , some clay, trace sand Loose Brown Wet (CL-ML)		6	SS	5		316								
314.3															
5.6	Clayey <b>SILT</b> , trace sand Firm Brown Wet (CL-ML)		7	SS	6	314								0   4   73   23	
							313								
312.8															
7.2	<b>SILT</b> and <b>SAND</b> , some gravel, trace clay Compact Brown Wet (ML)		8	SS	24	312									
							311								12   34   46   8
			9	SS	23										

Continued Next Page

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

# RECORD OF BOREHOLE No CULV1-04

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 877 492.0 E 417 557.9 ORIGINATED BY SG  
 DIST West HWY 9 BOREHOLE TYPE Hollow Stem Augers / Wash Boring / HQ Core Barrel COMPILED BY RdC  
 DATUM Geodetic DATE 2023.09.25 - 2023.09.26 LATITUDE 44.028757 LONGITUDE -81.093334 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
Continued From Previous Page							<div><div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></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# RECORD OF BOREHOLE No CULV1-05

1 OF 1

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 877 480.6 E 417 558.0 ORIGINATED BY SG  
 DIST West HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Rig COMPILED BY RdC  
 DATUM Geodetic DATE 2023.10.31 - 2023.10.31 LATITUDE 44.028654 LONGITUDE -81.093336 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE							WATER CONTENT (%) w <sub>P</sub> w                      w <sub>L</sub>				
318.7	GROUND SURFACE							20	40	60	80	100							
0.9	<b>TOPSOIL:</b> (50mm)  Silty <b>SAND</b> , trace clay, some organics, trace rootlets Very Loose to Loose Dark Brown Wet		1	SS	3	▽	318											○	
317.4			2	SS	9														○
1.2	<b>SILT</b> , some clay, trace sand Compact Brown Wet (CL-ML)		3	SS	17			317											○
			4	SS	14														○
315.7			5	SS	21				316										○
2.9	<b>SAND</b> and <b>GRAVEL</b> , trace silt Very Dense Brown Wet																	○	
314.7			6	SS	77	315											○		
4.0	END OF BOREHOLE AT 4.0m UPON REFUSAL. WATER LEVEL AT 0.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																		

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CULV1-06

1 OF 1

METRIC

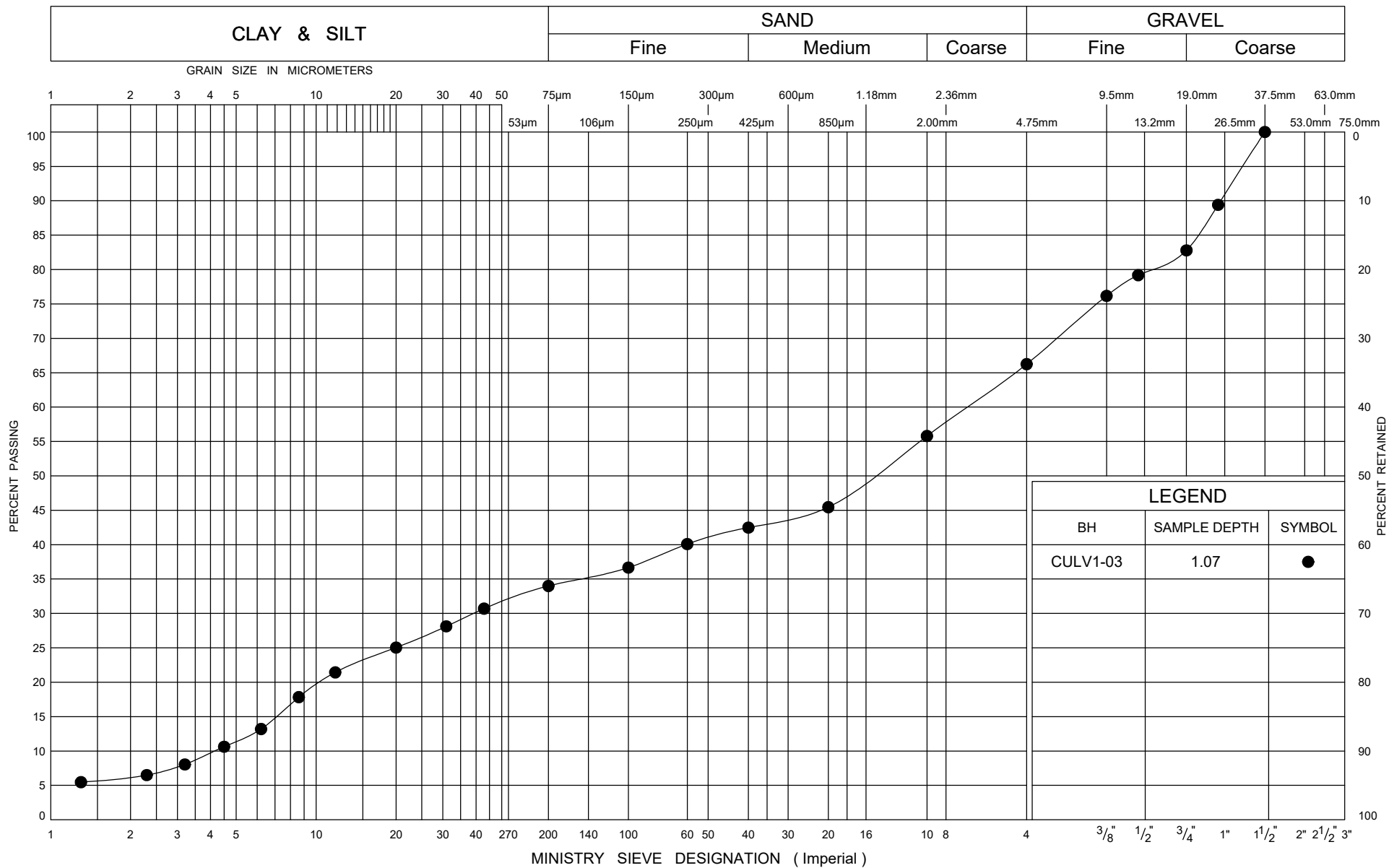
GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 877 475.4 E 417 565.4 ORIGINATED BY JF  
DIST West HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Rig COMPILED BY RdC  
DATUM Geodetic DATE 2023.10.13 - 2023.10.13 LATITUDE 44.028606 LONGITUDE -81.093245 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	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 (%)			
318.5	GROUND SURFACE							20	40	60	80	100	20	40	60					
0.0	<b>TOPSOIL</b> , trace silt, trace rootlets Very Soft Dark Brown Moist to Wet		1	SS	2		318													
317.8																				
0.8	Silty <b>SAND</b> , trace gravel, trace clay Compact Dark Brown Moist		2	SS	16															
317.3																				
1.2	Clayey <b>SILT</b> , trace sand Stiff to Very Stiff Brown Wet (CL)		3	SS	10		317									0	7	75	18	
			4	SS	14												0	5	79	16
315.8							316													
2.7	<b>SAND</b> and <b>GRAVEL</b> , trace silt Compact to Very Dense Brown Wet		5	SS	30															
							315													
							314													
			6	SS	12															
312.8							313													
5.7	END OF BOREHOLE AT 5.7m UPON REFUSAL. Piezometer installation consists of 32mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.  WATER LEVEL READINGS DATE            DEPTH(m)    ELEV.(m) 2023.12.01        0.0            318.5 2024.01.31       -0.2            318.7  "-" Above ground surface		7	SS	100/-	0.050														

## **APPENDIX C**

### Geotechnical Laboratory Test Results







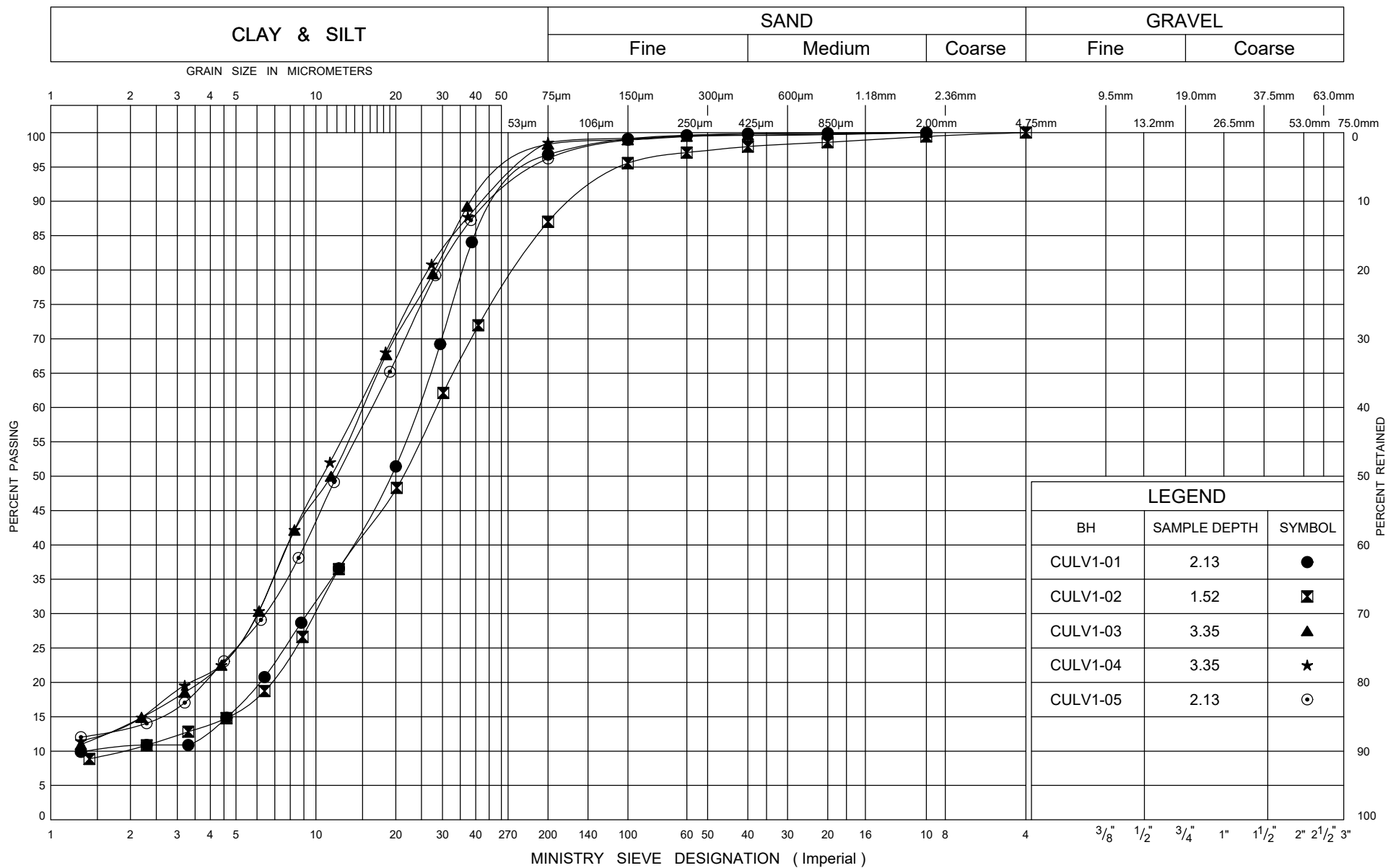
## FIG No C2

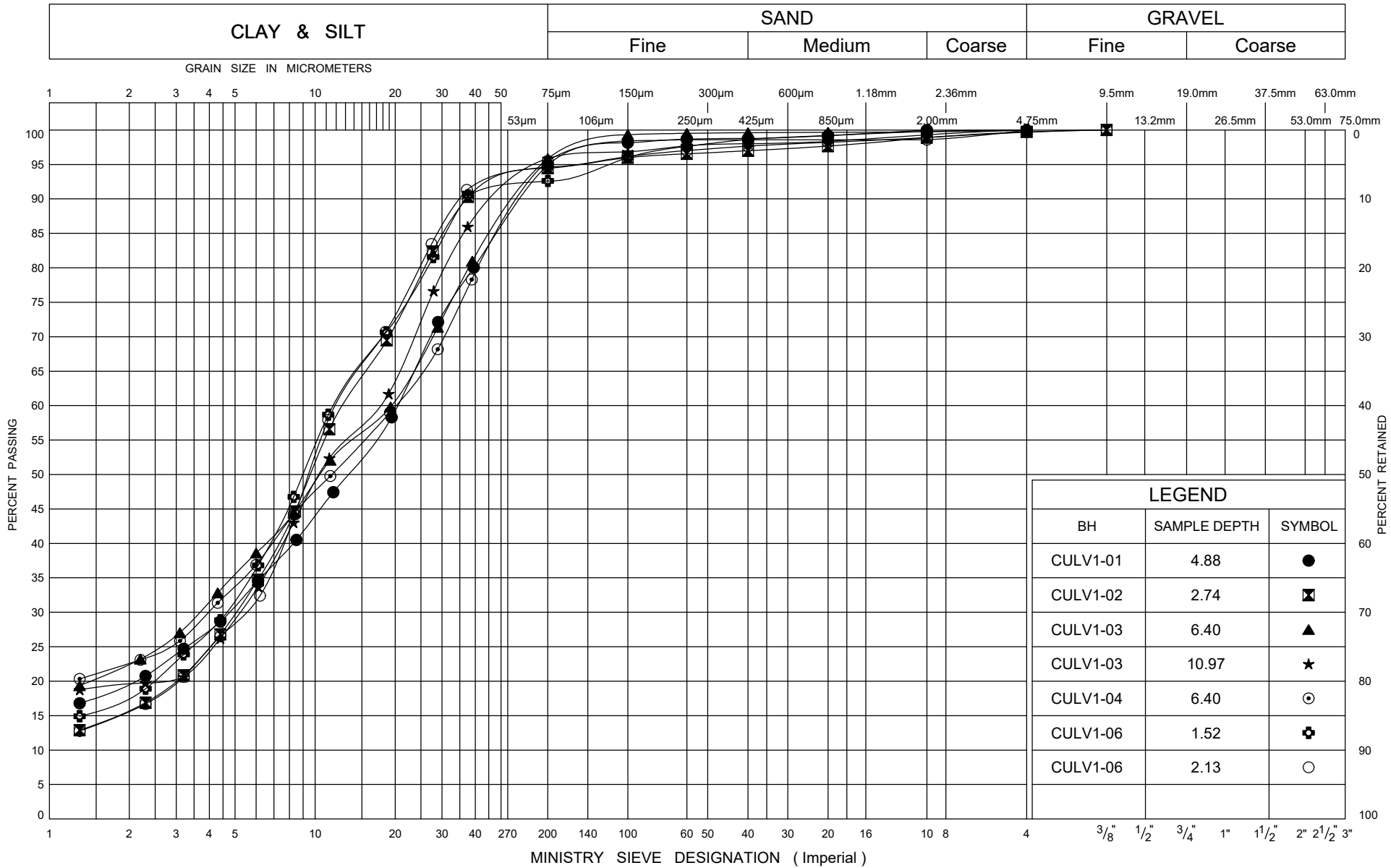
GWP# 3076-14-00

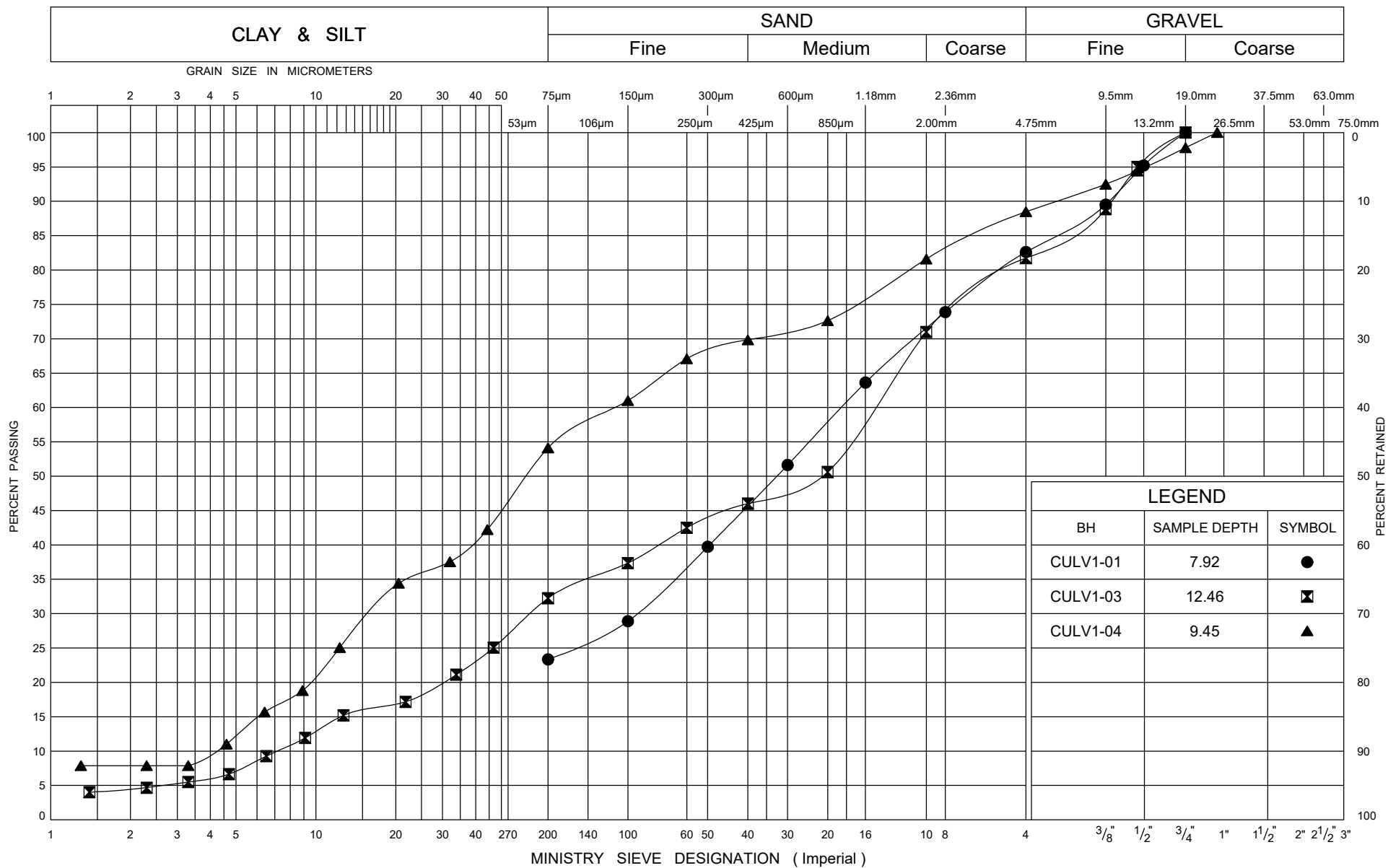
Highway 9

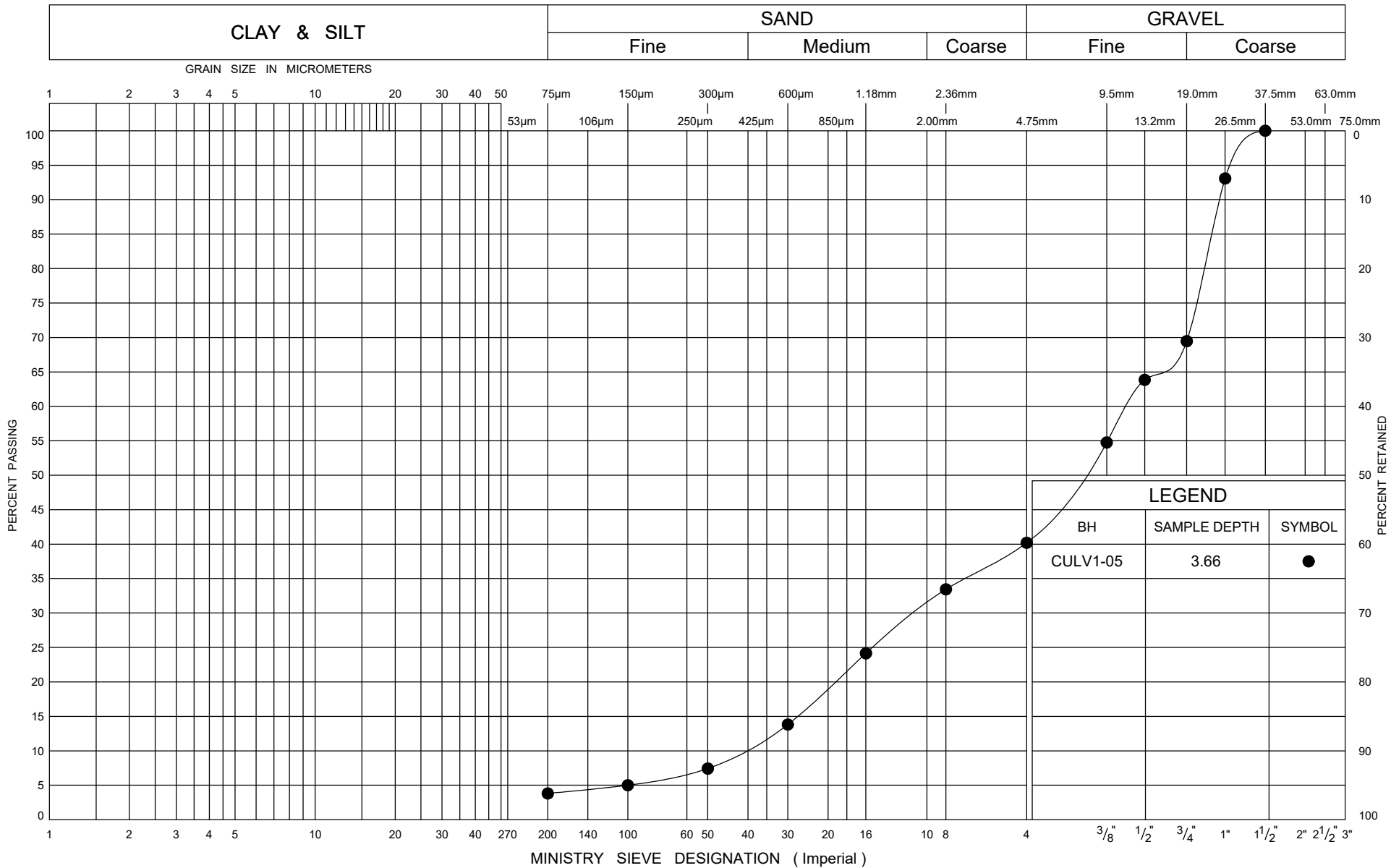


FIG No C3
GWP# 3076-14-00
Highway 9

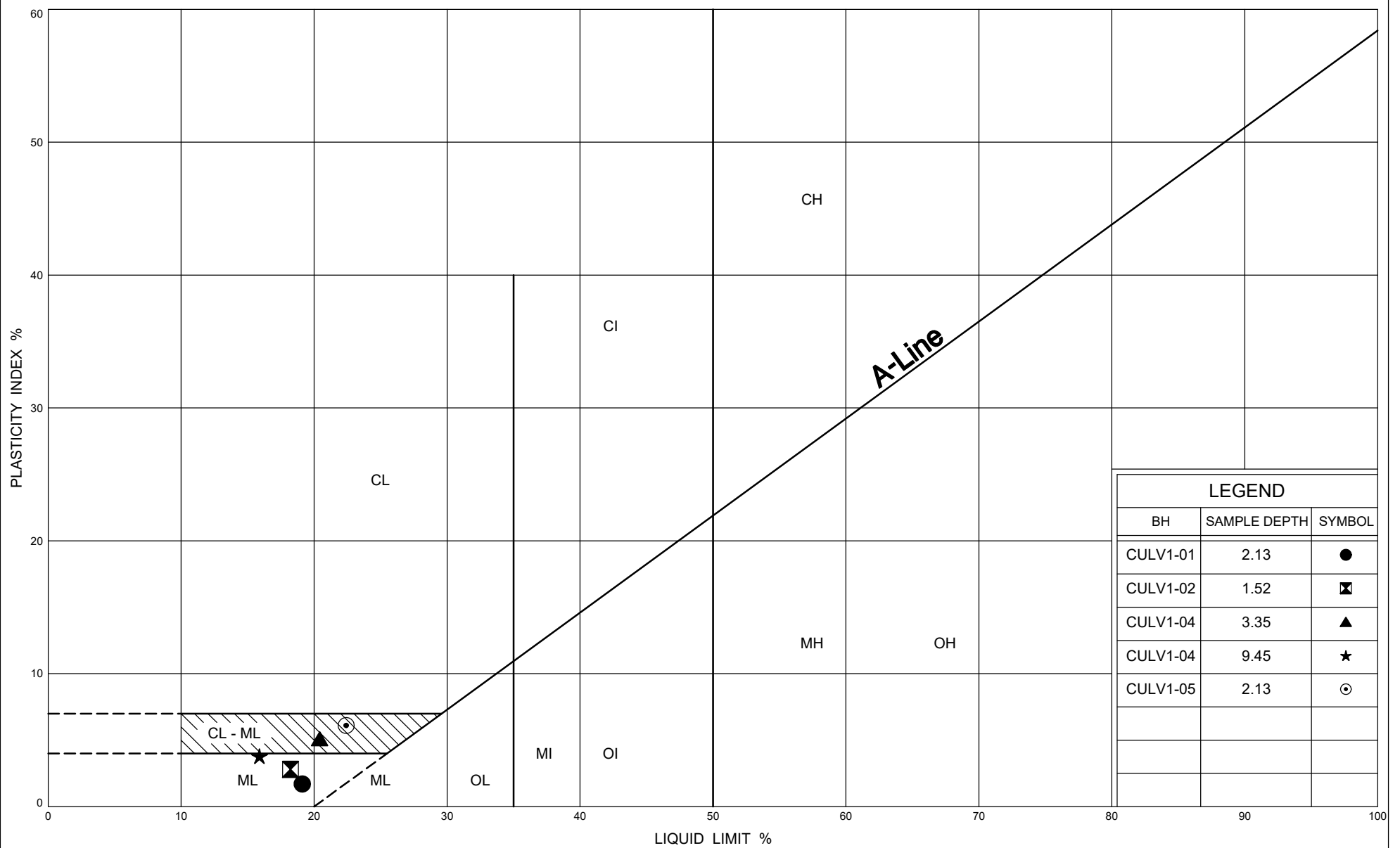












Ministry of  
Transportation

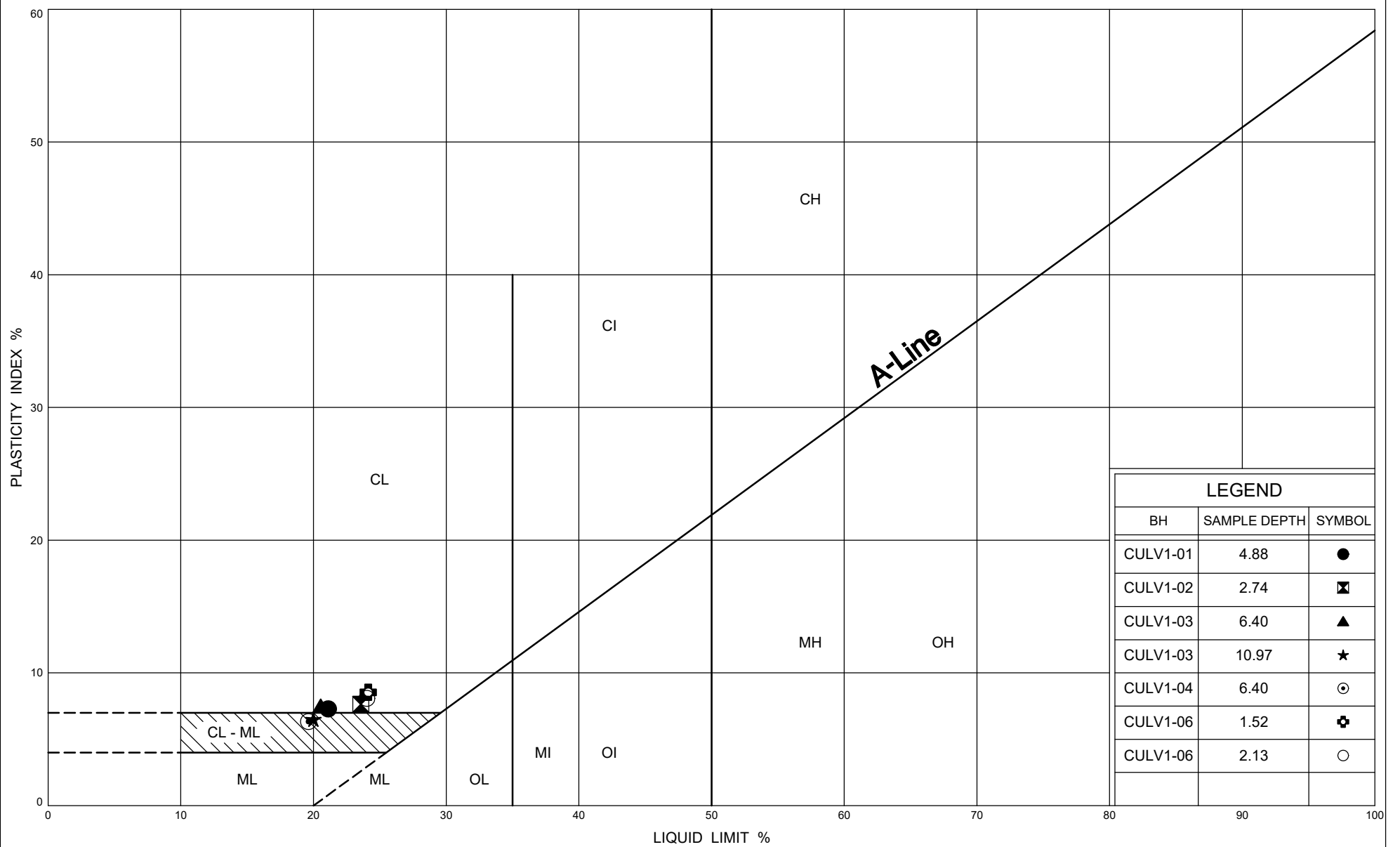
## PLASTICITY CHART

SILT / SAND and SILT

FIG No C8

GWP# 3076-14-00

Highway 9



Ministry of  
Transportation

## PLASTICITY CHART

Clayey SILT

FIG No C9

GWP# 3076-14-00

Highway 9

## Photographs of Rock Core

**Borehole CULV1-03– Run 1 – 13.0 to 14.3 m (Elev. 307.0 to 305.7 m)**



Note: top of core at right side of photo

**Borehole CULV1-04 – Runs 1 and 2 – 11.3 to 13.7 m (Elev. 308.7 to 306.3 m)**



Note: top of core at right side of photo



THURBER ENGINEERING LTD.

**Borehole CULV1-04 – Run 3 – 13.7 to 15.2 m (Elev. 306.3 to 304.7 m)**



Note: top of core at right side of photo

## **APPENDIX D**

### Analytical Laboratory Test Results



## FINAL REPORT

CA40030-JAN24 R1

34935, West Region MTO

Prepared for

**Thurber Engineering Ltd.**



# FINAL REPORT

CA40030-JAN24 R1

## First Page

### CLIENT DETAILS

Client                   Thurber Engineering Ltd.

Address                103, 2010 Winston Park Drive  
Oakville, ON  
L6H 5R7, Canada

Contact                Rod de Castro

Telephone

Facsimile

Email                   rdecastro@thurber.ca

Project                34935, West Region MTO

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         CA40030-JAN24

Received               01/09/2024

Approved              01/15/2024

Report Number         CA40030-JAN24 R1

Date Reported         01/15/2024

### COMMENTS

Temperature of Sample upon Receipt: 9 degrees C

Cooling Agent Present: Yes

Custody Seal Present: Yes

Chain of Custody Number: 009839

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







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Legend..... 7

Annexes..... 8



# FINAL REPORT

CA40030-JAN24 R1

**Client:** Thurber Engineering Ltd.

**Project:** 34935, West Region MTO

**Project Manager:** Rod de Castro

**Samplers:** Rod De Castro

MATRIX: SOIL

<b>Sample Number</b>	5	6
<b>Sample Name</b>	CULV1-02 SS2 2.5'-4.5'	CULV1-06 SS4 7'5-9'5
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	14/10/2023	13/10/2023

Parameter	Units	RL		Result	Result
<b>Corrosivity Index</b>					
Corrosivity Index	none	1		6	4
Soil Redox Potential	mV	no		294	271
Sulphide (Na <sub>2</sub> CO <sub>3</sub> )	%	0.01		0.09	0.08
pH	pH Units	0.05		8.11	8.40
Resistivity (calculated)	ohms.cm	-9999		2280	3480
<b>General Chemistry</b>					
Conductivity	uS/cm	2		438	287
<b>Metals and Inorganics</b>					
Moisture Content	%	0.1		11.1	14.7
Sulphate	µg/g	0.4		400	190
<b>Other (ORP)</b>					
Chloride	µg/g	0.4		17	20



FINAL REPORT

CA40030-JAN24 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	DIO0310-JAN24	µg/g	0.4	<0.4	2	35	100	80	120	99	75	125
Sulphate	DIO0310-JAN24	µg/g	0.4	<0.4	2	35	98	80	120	96	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)	ECS0024-JAN24	%	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	EWL0215-JAN24	uS/cm	2	< 2	2	20	104	90	110	NA		



FINAL REPORT

CA40030-JAN24 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	EWL0215-JAN24	pH Units	0.05	NA	0		100			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](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 --

Environment, Health & Safety - Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Fax: 705-652-6365 Web: www.sgs.com/environment  
- London: 857 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

## Laboratory Information Section - Lab use only

Received By: <u>EO</u>	Received By (signature): <u>[Signature]</u>	Cooling Agent Present: <input checked="" type="checkbox"/>	Temperature Upon Receipt (°C): <u>23.3</u>	LAB LIMS #: <u>QA-L10030-Jan24</u>
Received Date (mm/dd/yyyy): <u>19-08-24</u> (mm/dd/yyyy)	Custody Seal Present: <input checked="" type="checkbox"/>	Custody Seal Intact: <input checked="" type="checkbox"/>		
Received Time: <u>9:47</u>				
<b>REPORT INFORMATION</b>				
Company: <u>Truist Engineering Ltd</u> (same as Report Information)				
Contact: <u>Rod de Castro</u>				
Address: <u>103-2010 Winston Park</u>				
<u>Dr. de Castro</u>				
Phone: <u>647-525-3710</u>				
Email: <u>rod.decastro@truisteng.com</u>				
Email:				
<b>INVOICE INFORMATION</b>				
Quotation #: <u>34935</u>				
Project #: <u>34935</u>				
Site Location/ID: <u>West Region MTO</u>				
<b>TURNAROUND TIME (TAT) REQUIRED</b>				
<input type="checkbox"/> Regular TAT (5-7days)				
TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 6pm or on weekends: TAT begins next business day				
RUSH TAT (Additional Charges May Apply): <input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3 Days <input type="checkbox"/> 4 Days				
PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION				
Specify Due Date:				
Rush Confirmation ID:				

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

REGULATIONS				ANALYSIS REQUESTED										COMMENTS:
Regulation 153/04:				Use:										
Other Regulations:				Sewer										
Reg 347/558 (3 Day min TAT)				Water Pkg Gen. <input type="checkbox"/> Ext. <input type="checkbox"/>										
PWQO <input type="checkbox"/> MMER <input type="checkbox"/> Other: <input type="checkbox"/>				B(a)P <input type="checkbox"/> ABN <input type="checkbox"/> Ignit. <input type="checkbox"/>										
CCME <input type="checkbox"/> MISA <input type="checkbox"/>				TCLP M&I <input type="checkbox"/> VOC <input type="checkbox"/> PCB <input type="checkbox"/>										
				Pesticides OC <input type="checkbox"/> OP <input type="checkbox"/>										
				VOC <input type="checkbox"/> BTEX <input type="checkbox"/> THM <input type="checkbox"/>										
				BTEX <input type="checkbox"/> BTEX/F1 <input type="checkbox"/> F2-F4 <input type="checkbox"/>										
				PHC F1-F4 <input type="checkbox"/> VOC <input type="checkbox"/>										
				PCB Total <input type="checkbox"/> Aroclor <input type="checkbox"/>										
				PAH <input type="checkbox"/> ABN <input type="checkbox"/> SVOC(all) <input type="checkbox"/>										
				Metals & Inorganics										
				Field Filtered (Y/N)										
1. <u>QULV1-02 SS2 25-48'</u>				1 jar										
2. <u>QULV1-06 SS4 78-98'</u>				1 jar										
3.														
4.														
5.														
6.														
7.														
8.														
9.														
10.														
11.														
12.														

Observations/Comments/Special Instructions	
Sampled By (NAME): <u>ROD DE CASTRO</u>	Signature: <u>[Signature]</u>
Relinquished by (NAME):	Signature:

Date: <u>2024/09/24</u> (mm/dd/yyyy)	Pink Copy - Client
Date: <u>2024/09/24</u> (mm/dd/yyyy)	Yellow & White Copy - SGS

## **APPENDIX E**

### Site Photographs





**Photo 1: Looking west towards southwest corner of culvert outlet and along south slope of Highway 9 embankment. Photo taken Oct. 13, 2023**



**Photo 2: Looking east towards culvert outlet and along south slope of Highway 9 embankment. Photo taken June 23, 2023**





**Photo 3: Looking west at culvert inlet and along north slope of Highway 9 embankment. Photo taken June 23, 2023**



**Photo 4: Looking east at culvert inlet and along north slope of Highway 9 embankment. Photo taken June 23, 2023**





**Photo 5: Looking west along Highway 9 and north shoulder  
from near culvert inlet. Photo taken Sept. 13, 2023**



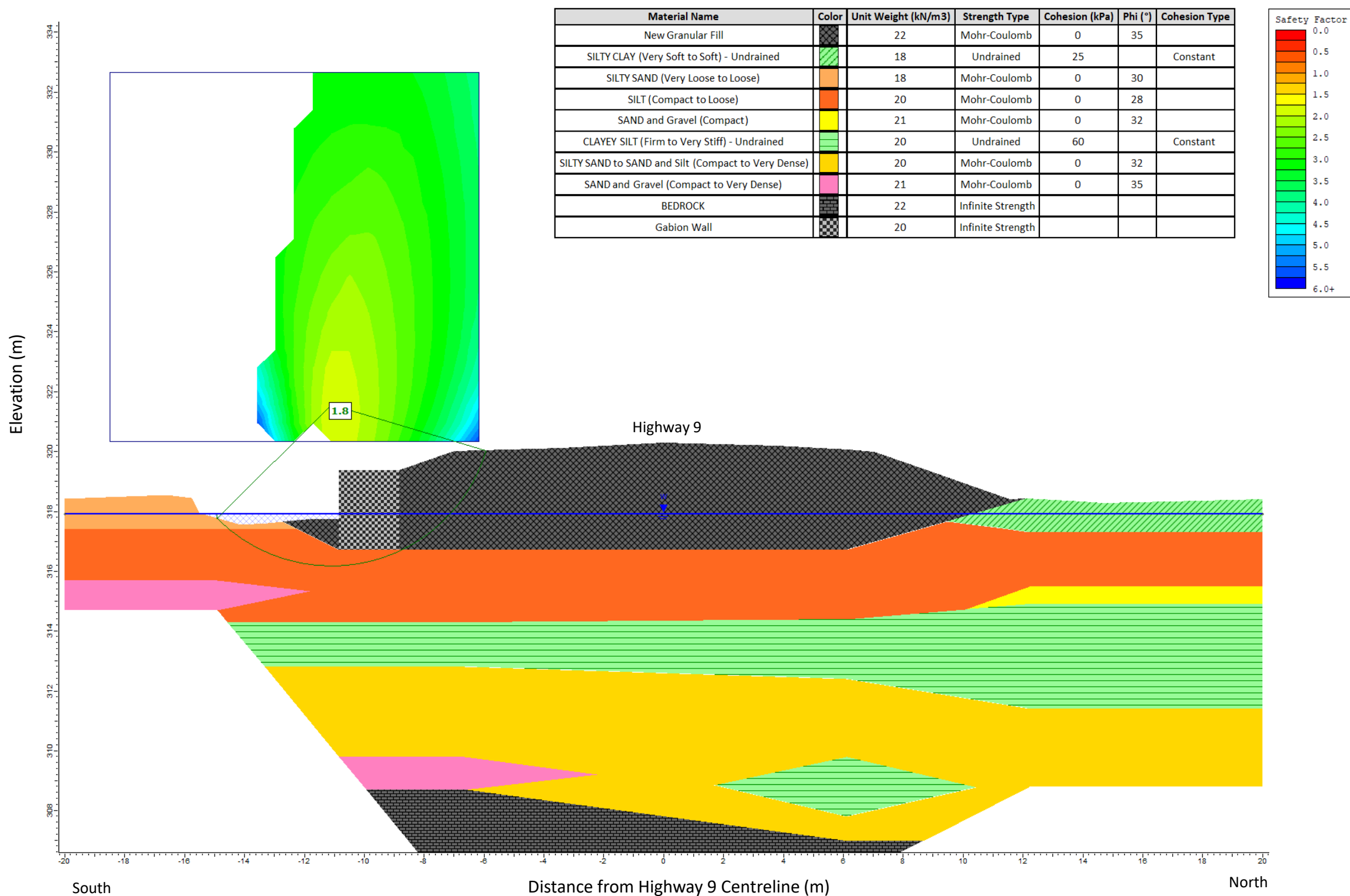
**Photo 6: Looking east along Highway 9 and south shoulder  
from near culvert outlet. Photo taken Sept. 13, 2023**

## **APPENDIX F**

### Slope Stability Analysis Figures

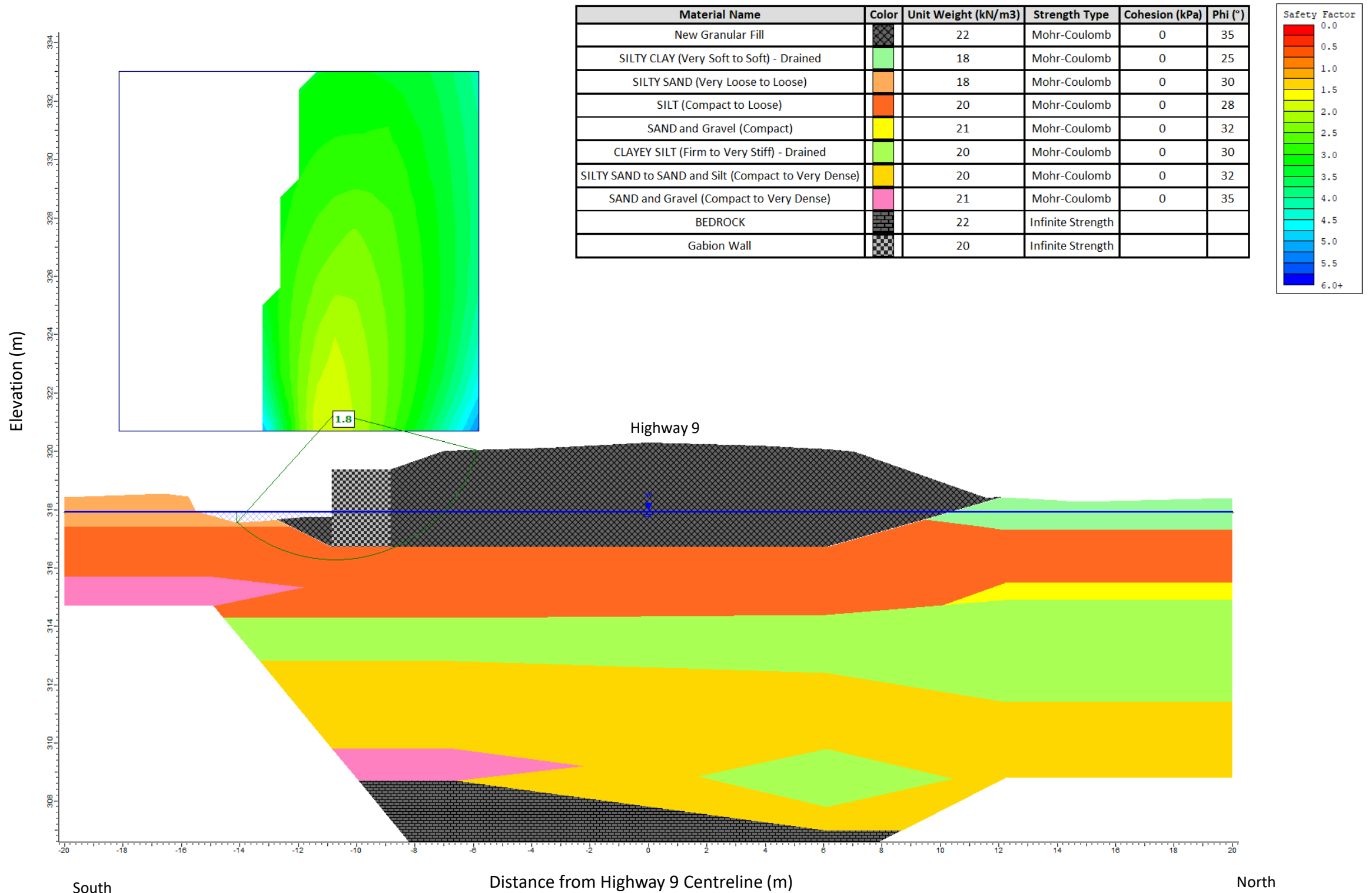
# Culvert 1 – Global Stability (STA 20+243) Temporary Conditions (Short Term) – South Slope with Gabion Wall

Figure F1



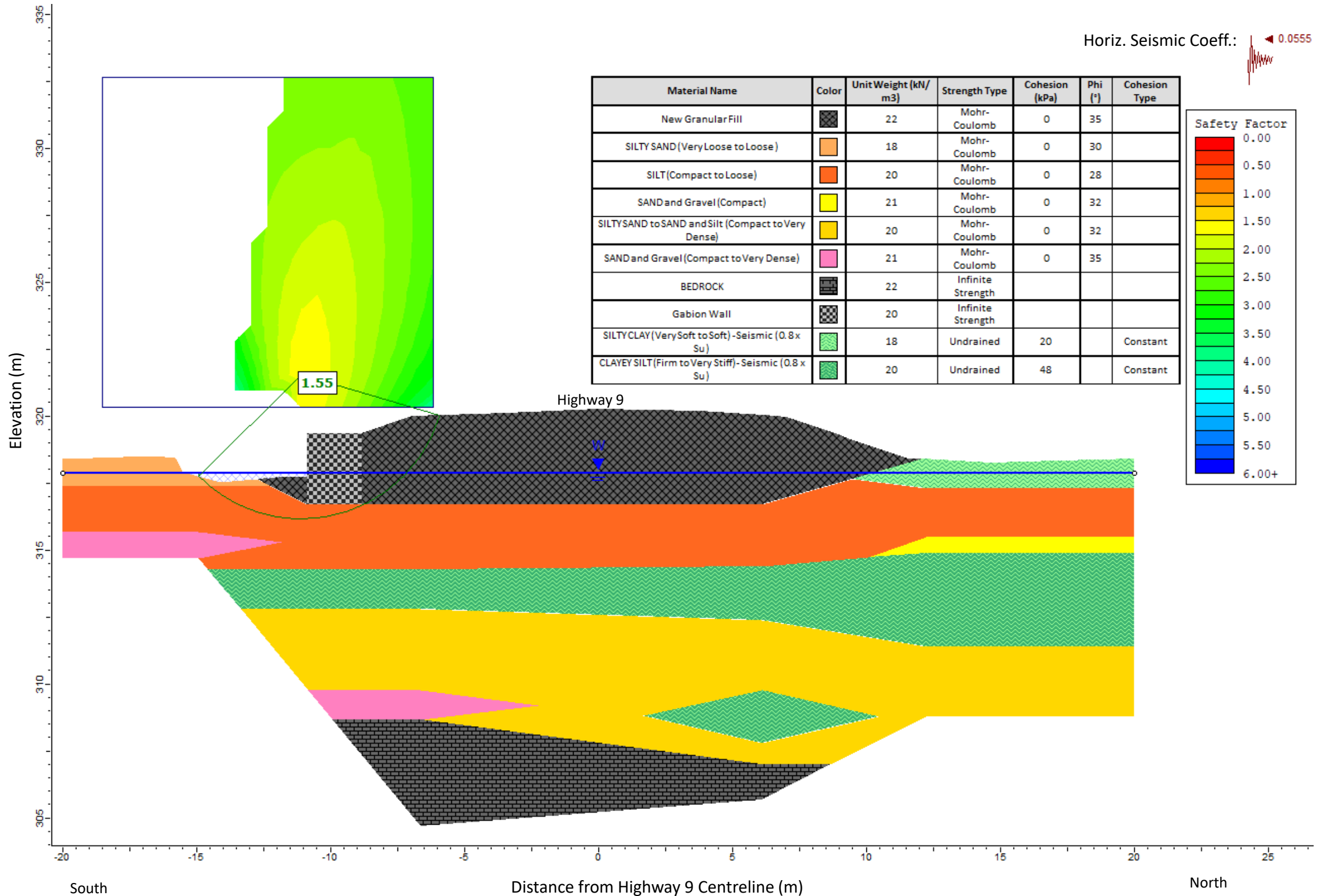
# Culvert 1 – Global Stability (STA 20+243) Permanent Conditions (Long Term) – South Slope with Gabion Wall

Figure F2



# Culvert 1 – Global Stability (STA 20+243) Seismic Conditions – South Slope with Gabion Wall

Figure F3



## **APPENDIX G**

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 422	Construction Specification for Precast Reinforced Concrete Box Culverts in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheetting
OPSS.PROV 517	Construction Specification for Dewatering
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS.PROV 902	Construction Specification for Excavating and Backfilling Structures
SP FOUN0003	Dewatering Structure Excavations
OPSS.PROV 1004	Material Specification for Aggregates - Miscellaneous
OPSS 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 1430	Material Specification for Gabion Baskets and Mats
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 3090.101	Foundation Frost Penetration Depths for Southern Ontario

**2. Suggested Wording for NSSPs**

- Suggested Text for NSSP on Subgrade Preparation**

The Contractor is advised that the soil that will be exposed at the culvert subgrade level is silt, which is moisture sensitive and may become disturbed or otherwise negatively impacted when subjected to construction or personnel traffic, freeze-thaw actions, ingress or ponding water. The Contractor shall be responsible for protecting the subgrade by implementing adequate



groundwater control measures and minimizing construction and personnel traffic on the founding subgrade.

The subgrade preparation and placement and compaction of the bedding material must be carried out in the dry.

Any buried topsoil, excessively soft soil, large cobbles and boulders, and any soft, very loose organic or other deleterious material encountered during subgrade preparation should be sub-excavated and replaced with compacted granular material to provide a uniformly competent subgrade condition.

Immediately following excavation, the base should be inspected by the foundation engineering specialist to confirm that the exposed subgrade surface conforms to the design requirements.

- **Suggested Text for NSSP on Dewatering**

Creek diversion and effective dewatering shall be designed and provided by the Contractor prior to and during structure excavation, subgrade preparation, bedding placement and backfilling to allow the work to proceed in the dry. Excavations conducted without prior dewatering will lead to loosening and disturbance of the subgrade. The dewatering system must be effective to maintain the water level at a minimum depth of 1 m below the final subgrade level throughout construction. Although the Contractor is responsible for designing and implementing dewatering measures, the Contractor is advised that conventional pumping from sumps will not be effective to dewater the silt at this site. A combination of properly designed watertight sheet pile enclosures and / or wellpoints may be required to dewater this site.

The dewatering system is to be designed in accordance with SP FOUN0003 and OPSS.PROV.517.



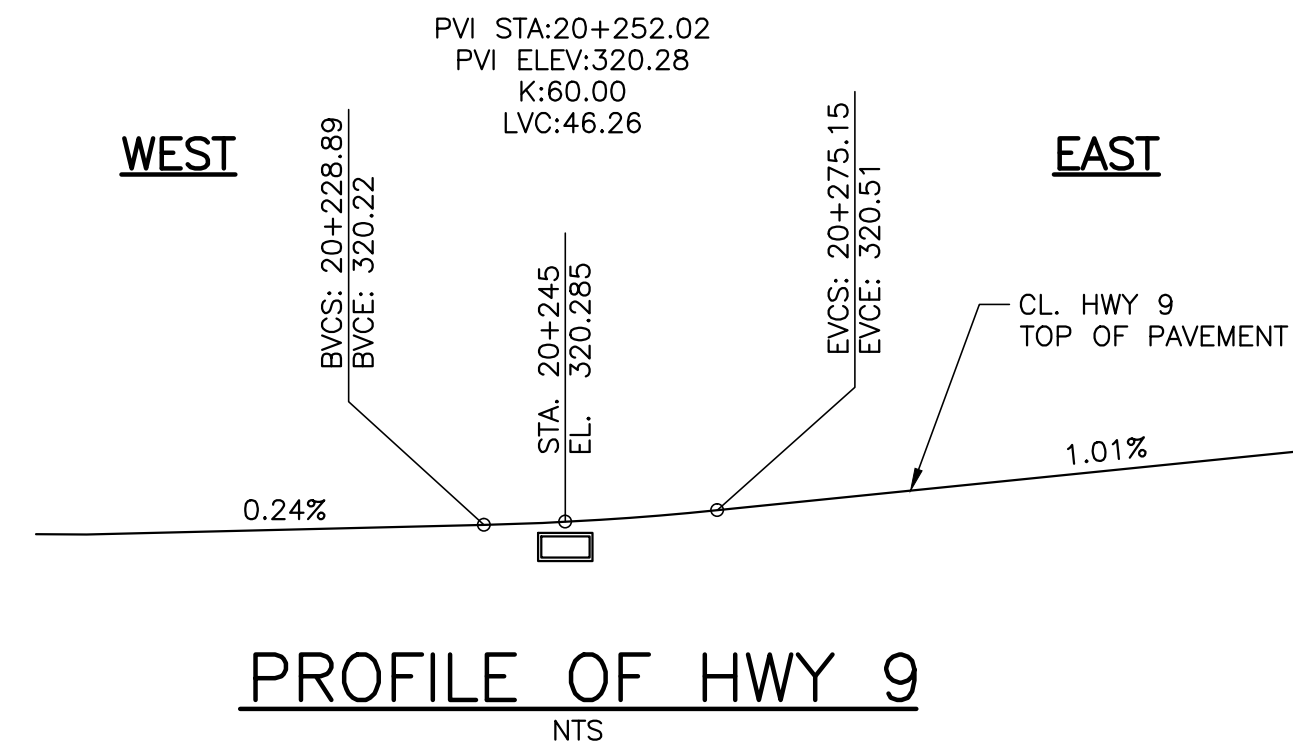
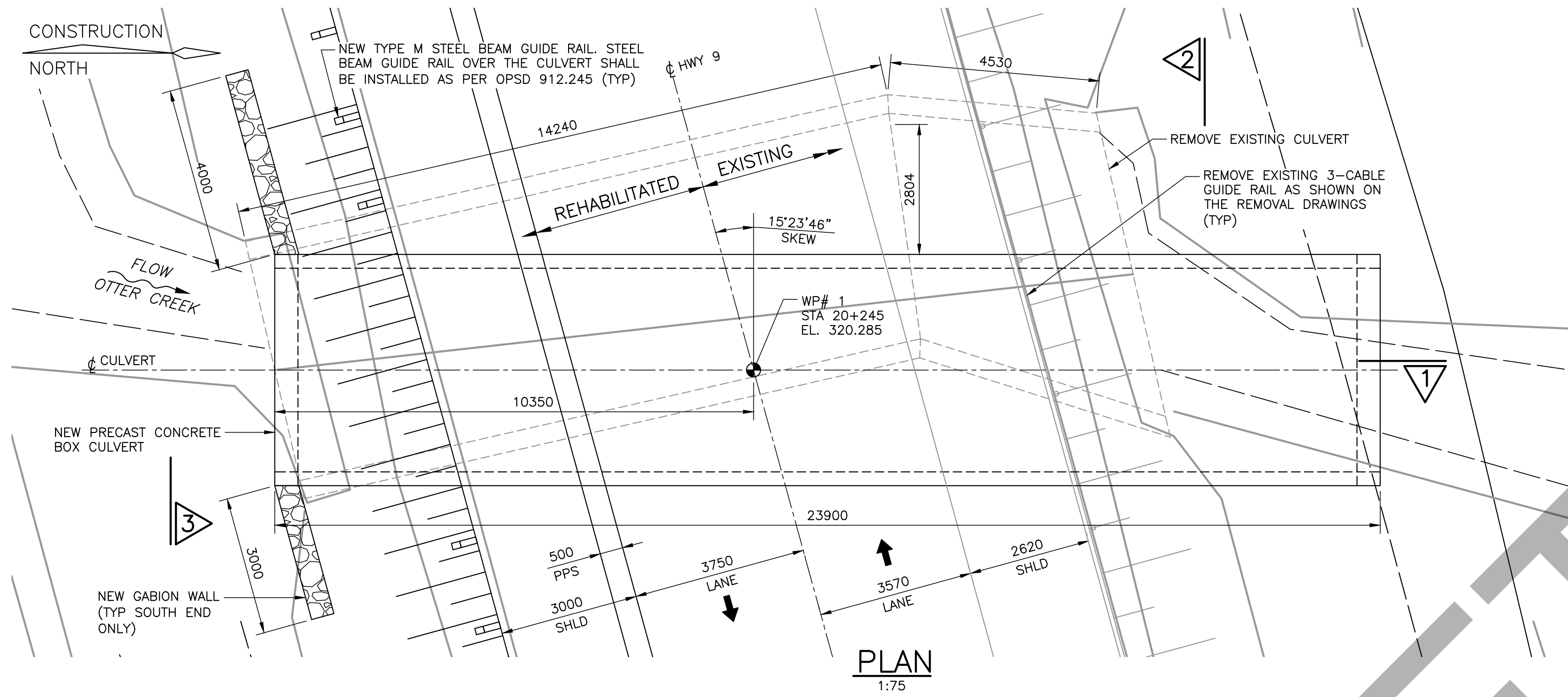
**THURBER** ENGINEERING LTD.

## **APPENDIX H**

Preliminary Draft General Arrangement Drawing

CAD FILE: X:\Projects\21-113 Highway 9 Greenock Creek Bridge DB Ready GHD\113E Hwy 9 Culverts\DDA CAD files\2-466\21-113E-466-0010A.dwg  
MODIFIED: 2024-01-11 3:21:14 PM azhang  
PLOTTED: 2024-01-11 3:21:24 PM AZhang

PR-D-707 88-05  
MINISTRY OF TRANSPORTATION, ONTARIO



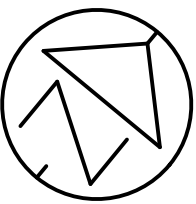
METRIC

DISTRICT  
CONT. No.  
WP No. 3102-21-01

CONCRETE CULVERT  
02X-0466/CO

PRELIMINARY GENERAL ARRANGEMENT

**DOUG DIXON & ASSOCIATES INC**



SHEET

### GENERAL NOTES

#### SPECIFIED 28-DAY COMPRESSIVE STRENGTH

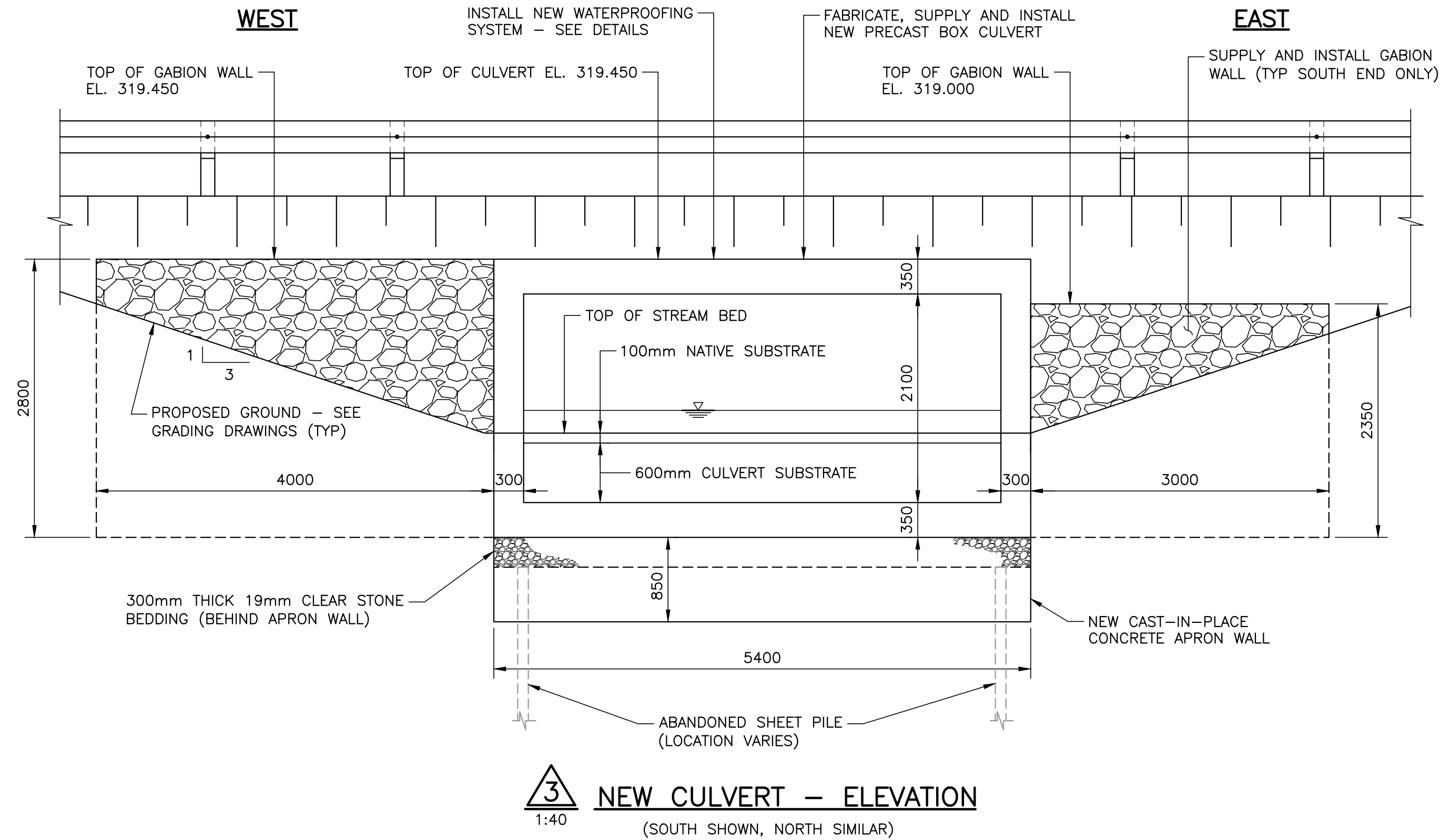
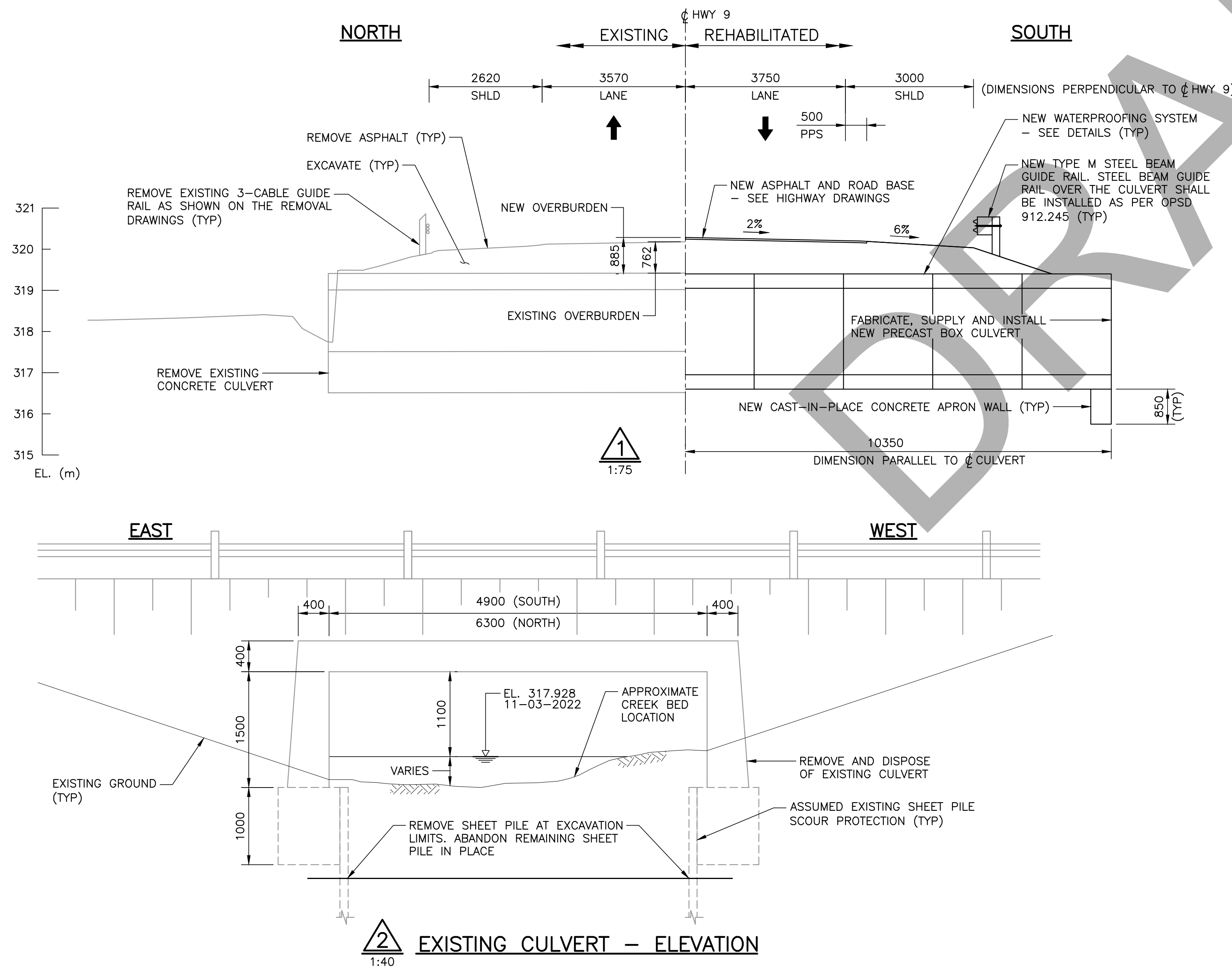
PRECAST CULVERT 45MPa  
ALL OTHER CONCRETE 30MPa

#### CLEAR COVER TO REINFORCING STEEL

UNLESS OTHERWISE NOTED 50±10mm

#### REINFORCING STEEL

1. REINFORCING STEEL SHALL BE GRADE 500W.



REVISIONS		DESCRIPTION				
DESIGN	HK	CHK	DD	CODE	CHBDC 2019	LOAD
DRAWN	AZ	CHK	HK	SITE	2-466/CO	STRUCT
		SCHEME		DATE JAN/24		
				DWG 1		