Guest Road and Shallow Bay Road Intersection Improvement
STA 100+75 to STA 112+31 Highway 16
Cluculz Lake, BC
Geotechnical Assessment Report

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1. Introduction

The BC Ministry of Transportation and Infrastructure (MoTI) retained Ecora Engineering & Resource Group Ltd. (Ecora) to carry out a geotechnical site assessment for the proposed road improvements along Highway 16 and the paralleling Frontage Road at the intersection of Guest Road and Shallow Bay Road north of Cluculz Lake, BC.

MoTI requested Ecora to undertake a detailed site assessment to gain an understanding of the soil properties, groundwater conditions and provide geotechnical recommendations for the proposed road widening. Preliminary embankment design including stability and settlement assessments are provided as part of the work.

Our services are being provided in accordance with the Northern Region MoTI, As-and-When contracts between Ecora and MoTI (MoTI Contract No. 863CS1092 and 863CS1149).

2. Project Description

It is Ecora's understanding that the MoTI intends to carry out road improvements along Highway 16 and the paralleling Frontage Road in the vicinity of the intersections at Guest Road and Shallow Bay Road. The total combined project length is approximately 1.55 km.

The project location is approximately 400 m north of Cluculz Lake and approximately 40 km east of Vanderhoof. Based on drawing package R3-375 from BINNIE and Associates Ltd. (BINNIE), the proposed project consists of eight alignments listed below. Proposed alignments and test hole locations are indicated in Figure 1.

- L100: 544 m of construction surrounding Guest Road, and an additional 440 m at Shallow Bay Road, with a total approximate length of 1 km in the east-west direction.
- L300: 70 m of roadway along Guest Road north of Highway 16.
- L400: 70 m of roadway along Guest Road south of Highway 16.
- L500: 100 m of roadway along Frontage Road, west of Guest Road.
- L600: 100 m of roadway along Frontage Road, east of Guest Road.
- L700: 60 m of roadway along Shallow Bay Road, to the south of Highway 16.
- L800: 65 m of roadway along Frontage Road, to the west of Shallow Bay Road.
- L900: 100 m of roadway along Frontage Road, to the east of Shallow Bay Road.

Project works will consist of road widening and construction of turning lanes at the two intersections along with grading, and drainage improvements. It also includes widening of the embankment surrounding an existing 2400 mm diameter steel jacked pipe culvert which crosses the road centerline on L100 at STA. 108+31, 150 m to the east of Guest Road. The existing culvert length is 70 m (DWG No. R3-375-102) which conveys flow from a catchment pond to the north into a creek to the south.

Based on sections provided in drawing package R3-375, proposed fill embankments are typically sloped at 4H:1V (~14°) with toe slopes of 2H:1V (~27°) up to 1 m. The exception is in the vicinity of the culvert between STA.104+80 to STA.105+40, where fill slopes are observed as 2H:1V for the full embankment height. The height of embankment in this section is up to 8 m. Proposed cut slopes are indicated as 2H:1V and are up to 3 m in height but generally less than 2 m.

3. Site Description

The project site is located approximately 40 km by road east of Vanderhoof along Highway 16 within the vicinity of the intersections of Guest Road and Shallow Bay Road including segments of Frontage Road, which parallels Highway 16 to the south. The existing intersection at Guest Road comprises a north and south segment which are paved in the immediate vicinity of the intersection with Highway 16. Frontage Road crosses Guest Road to the south and is an unpaved gravel road. Shallow Bay Road exists only to the south of Highway 16 and pavement does not extend beyond an area immediately adjacent to the highway. Frontage Road crosses Shallow Bay Road and is unpaved.

Existing topography at the site is undulating terrain with the road alignment constructed atop a fill embankment with variable side slopes. Current slopes are steeper along the north shoulder, with gentler gradients to the south. The current alignment appears to have been constructed on embankment fill with a footprint extending north of Highway 16 to south of Frontage Road. Existing embankment slopes range from 2H:1V (~27°) to 3H:1V (~18°) with heights of up to 4 m, and steeper slopes near the existing culvert. In this area, embankment slopes of 1.5H:1V (~34°) and heights of up to approximately 8 m were observed.

4. Background Review

4.1 Published Surficial and Bedrock Geology

The 1:100,000 scale surficial geology map of Cluculz Lake (Geological Survey of Canada Open File 3638) indicates that the area is underlain by a “veneer of glacial lake sediments” consisting of a thin cover of clay and silt with localized deposits of gravel and sand.

The bedrock geology for the site was determined from “MapPlace2” the BC Geological Society GIS. This indicates that the bedrock underlying the site comprises Cache Creek Complex of Permian to Triassic in age. These are described as “mafic volcanic breccia and flows; greenstone; minor limestone, argillite and chert”.

4.2 Water Well Logs

From review of the BC Provincial Groundwater Wells and Aquifers database, four wells were identified within a 200 m radius of the project area. The most proximal wells are concentrated on the west side of the project site with additional wells to the south closer to Cluculz Lake. The following list describes the location of the nearest water wells:

- Well ID 56111 – 100 m south of Highway 16 between Guest Road and Shallow Bay Road.
- Well ID 79203 – 90 m west of Guest Road and 90 m south of Frontage Road.
- Well ID 62927 – 55 m west of Guest Road and 50 m south of Frontage Road.
- Well ID 60057 – 90 m southwest of Frontage Road west of Guest Road.

Stratigraphy logs provided from drilling operations are summarized in the following tables with original water well logs provided in Appendix A. The inferred water table based on these logs was approximately 50 m below ground surface.

Table 1: Water Well ID: 56111

Depth Interval (m)	Thickness (m)	Drillers Description
0 to 18.3	18.3	*"Glacial Till"*
18.3 to 48.8	30.5	*"Dry gravel and till layers"*
48.8 to 54.9	6.1	*"Silty sand"*
54.9 to 65.5	10.7	*"Dirty gravel"*
65.5 to 67.1	1.6	*"Sand and gravel"*

Table 2: Water Well ID: 79203

Depth Interval (m)	Thickness (m)	Drillers Description
0 to 1.8	1.8	*"Mostly gravel"*
1.8 to 24.4	22.6	*"Mostly clay, some gravel"*
24.4 to 27.4	3.0	*"More gravel"*
27.4 to 34.7	7.3	*"Dark clay"*
34.7 to 37.2	2.5	*"Brown clay and grit"*
37.2 to 60.4	23.2	*"Sand and gravel to more gravel"*

Table 3: Water Well ID: 62927

Depth Interval (m)	Thickness (m)	Drillers Description
0	53.3	*"till"*
53.3	62.8	*"gravel"*

Table 4: Water Well ID: 60057

Depth Interval (m)	Thickness (m)	Drillers Description
0 – 38.7	38.7	*"Brown till"*
38.7 – 40.8	2.1	*"Cemented gravel"*
40.8 – 58.8	18.0	*"Gravel and sand"*

4.3 Historical Air Photos

Historical air photos were reviewed to gain an understanding of historical development at the site. This included the following:

- University of British Columbia air photos dated 1946, 1953, 1960, 1966, 1978, 1980, 1985, 1990, 1996, 2000 and 2006;
- Google Earth historical imagery dated 2002, 2018 and 2021.

The above air photos suggest that Guest Road existed as early as 1946 along with the section of Frontage Road to the east. At this time the surrounding area was heavily forested. By 1953 Shallow Bay Road was constructed and Frontage Road was extended to the west of Guest Road. From 1953 to 1960 it appears construction of Highway 16 had occurred. From 1960 to 2021 the project area has remained relatively unchanged with the exception of clear cutting the surrounding forested areas.

No significant geotechnical constraints were identified from a review of the air photos.

5. Geotechnical Investigation

5.1 Geotechnical Drilling and Excavation

Ecora conducted a geotechnical investigation between August 17 and August 20, 2021 which was coordinated by Teri Brito from Ecora's Vancouver Office. Drilling operations were carried out by Geotech Drilling Ltd. from Prince George, BC, on August 18 and 19, 2021 using both truck and track mounted drill rigs with solid stem auger drilling capabilities. Test pits were excavated by an independent contractor, Darcy Tiani, on August 20, 2021.

Ecora conducted an additional geotechnical investigation program on March 22, 2022, using a hand auger and a Scala penetrometer. The investigation was carried out by Mark-Antoine Berthiaume, from Ecora's Vancouver office, and by Darrel Norstrom from MoTI. The purpose of this additional investigation was to acquire additional geotechnical information on the wetland located on the culvert near STA 105+00.

Prior to both phases of drilling, a BC One Call ticket was reviewed to assess utilities in the region. For the first phase, First Call Locating & Underground Services from Prince George, BC (First Call) were engaged to carry out site identification of subsurface utilities. AccuMark Utility Locating were used for the second phase of locates.

Drilling and test pitting were supervised by Ecora personnel. The investigation comprised nine test holes (TH21-01 to TH21-09), six test pits (TP21-01 to TP21-06) and three hand auger holes (HA22-01 to HA22-03). Details of coordinates, completion depths, and test hole objective are provided in Table 5, with locations indicated on the site plan in the attached Figure 1. Detailed geotechnical logs for each test hole are provided in Appendix B.

Table 5: Test Hole Summary

Test Hole ID	Easting (m)	Northing (m)	Termination Depth (m)	Objectives
TH21-01	464811	5971633	12.2	Culvert wing wall design
TH21-02	464812	5971598	9.1	Culvert wing wall design
TH21-03	464565	5971696	1.5	Pavement characterization
TH21-04	464664	5971598	1.5	Pavement characterization
TH21-05	464676	5971693	1.5	Pavement characterization
TH21-06	465134	5971612	1.5	Pavement characterization
TH21-07	465255	5971608	1.5	Pavement characterization
TH21-08	465341	5971648	1.5	Pavement characterization
TH21-09	465396	5971654	1.5	Pavement characterization

Test Hole ID	Easting (m)	Northing (m)	Termination Depth (m)	Objectives
TP21-01	464572	5971701	3	Road improvements / embankment design
TP21-02	464723	5971634	2.4	Road improvements / embankment design
TP21-03	465027	5971589	3.4	Road improvements / embankment design
TP21-04	465154	5971604	3.5	Road improvements / embankment design
TP21-05	465296	5971632	3.6	Road improvements / embankment design
TP21-06	465428	5971672	3.4	Road improvements / embankment design
Surface Water Sample Collection	464824	5971637	N/A	Chemical testing of surface water
HA22-01	464833	5971636	2.1	Wetland characterization
HA22-02	464840	5971635	2.3	Wetland characterization
HA22-03	5971635	464847	1.6	Wetland characterization

5.2 Surface Water Sample Collection

Due to the existence of the water body north of the highway, chemical testing is required as stipulated in the MoTI document entitled “Environment Testing Requirements for Concrete Deterioration” dated October 19, 2018. Collection of water quality sampling was conducted in accordance with the United Stated Department of Agriculture (USDA) and Canadian Council of Ministers of the Environment (CCME) guidelines. Near bank samples were collected on August 20, 2021, from the northwest side of the culvert inlet.

5.3 Laboratory Testing

Laboratory testing was carried out on grab samples and SPT split spoon samples which were collected during the site investigation. Testing included:

- Geotechnical Index Testing at Ecora’s in-house geotechnical laboratory
- Chemical Testing in Native Soils at CARO Analytical Services laboratory
- Surface Water Sample Testing at CARO Analytical Services laboratory

Geotechnical index testing includes grain size analysis, hydrometer, natural moisture content, and Atterberg limits testing. Chemical testing on native soil material included sulphate content and chloride content. Surface water samples were tested for pH and water-soluble sulphates. Details of the testing are described herein.

5.3.1 Geotechnical Index Testing

Geotechnical index testing comprised of grain size analysis, hydrometer, natural water content, and Atterberg limits from grab samples and SPT split spoon samples collected during the site investigation. Index testing was carried out at Ecora’s geotechnical laboratory and undertaken in accordance with the ASTM standards outlined in Table 6.

Table 6: Geotechnical Index Testing ASTM Standards

Test type	ASTM standard used
Grain Size Analyses / Hydrometer	ASTM C136
Atterberg Limits	ASTM D4318
Natural Moisture Content	ASTM D2216

A summary of results from the suite of index testing carried out is provided in Table 8, with detailed laboratory results provided in Appendix C.

Table 7: Grain Size Analysis Results

Test Hole ID	Sample Depth Interval (m)	Moisture Content (%)	Gravel (%)	Sand (%)	Fines (%) (Silt / Clay)	Description
TH21-01	0.6 - 0.8	1.3	0.4	20.2	79.4	Sandy FINES; trace gravel
TH21-01	3.0 - 3.6	13.8	16.8	33.8	49.4	Sandy SILT; some gravel
TH21-01	9.1 - 9.3	7.5	36.3	36.7	27.0	Silty SAND and GRAVEL
TH21-02	2.5 - 2.7	9.7	22.6	38.6	38.8	Gravelly SILT and SAND
TH21-02	7.5 - 7.7	22.4	7.5	43.2	30.0 / 19.3	Silty SAND; some clay, trace gravel
TH21-03	0.5 - 0.7	5.7	38.9	53.0	8.1	SAND and GRAVEL; trace fines
TH21-04	1.0 - 1.2	8.9	25.1	45.4	29.5	Silty, gravelly SAND
TH21-05	0.8 - 1.0	14.1	2.1	36.2	61.7	SILT and SAND, trace gravel
TH21-06	0.3 - 0.5	2.0	46.9	48.1	5.0	SAND and GRAVEL; trace fines
TH21-06	1.3 - 1.5	13.5	14.1	39.1	46.8	SILT and SAND; some gravel
TH21-07	0.3 - 0.5	20.5	0.4	7.5	44.9 / 47.2	CLAY and SILT; trace sand, trace gravel
TH21-07	1.0 - 1.2	30.9	0	0.6	52.7 / 46.7	CLAY, medium plasticity
TH21-08	0.5 - 0.7	5.1	41.0	50.7	8.3	SAND and GRAVEL; trace fines
TH21-08	1.2 - 1.4	12.5	13.5	35.6	50.9	SILT and SAND; some gravel
TH21-09	0.4 - 1.0	3.3	37.8	51.6	10.6	SAND and GRAVEL; some fines
TH21-09	1.2 - 1.4	18.5	7.5	21.7	70.8	Sandy SILT; trace gravel
TP21-01	1.9 - 2.0	33.3	0	0.9	59.7 / 39.4	SILT and CLAY; trace sand
TP21-03	3.0 - 3.4	7.5	29.1	33.9	37.0	Sandy, gravelly FINES
TP21-04	0.6 - 0.8	5.3	31.4	61.1	7.5	Gravelly SAND; trace fines

Test Hole ID	Sample Depth Interval (m)	Moisture Content (%)	Gravel (%)	Sand (%)	Fines (%) (Silt / Clay)	Description
TP21-04	1.5 - 1.6	30.4	0	1.9	51.3 / 46.8	SILT and CLAY; trace sand
TP21-05	1.8 - 2.0	21.1	2.6	23.1	36.4 / 37.9	Sandy CLAY and SILT; trace gravel
TP21-05	0.8 - 1.0	5.7	32.3	62.0	5.7	Gravelly SAND; trace fines
TP21-06	1.9 - 2.0	10.1	26.1	40.1	33.8	Silty gravelly SAND
HA22-01	1.8 - 2.0	43.0	0	13.5	59.0 / 27.5	Clayey SILT; some sand
HA22-02	1.7 - 2.0	31.9	3.3	19.3	48.3 / 29.1	CLAY, medium plasticity
HA22-03	1.0 - 1.2	41.4	0	5.8	63.2 / 31.0	CLAY, medium plasticity

Table 8: Atterberg Limit Results

Test Hole ID	Sample Depth	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Description
TH21-02	7.3 - 7.5	14.8	31.8	15.1	16.7	CM - Medium Plastic Clay
TH21-04	1.5 - 1.6	21.1	40.8	21.7	19.1	CM - Medium Plastic Clay
TH21-07	1 - 1.2	30.9	40.9	21.4	19.4	CM - Medium Plasticity Clay
HA22-01	1.4 - 1.8	50.0	39.0	24.0	15.0	CM – Medium Plastic CLAY
HA22-02	1.2 - 1.7	48.5	38.0	24.0	14.0	CM – Medium Plastic CLAY
HA22-02	2.0 - 2.2	36.4	40.0	19.0	21.0	CM – Medium Plastic Clay
HA22-03	1.2 - 1.6	35.3	33.0	20.0	13.0	CM – Medium Plastic CLAY

5.3.2 Chemical Testing in Native Soils

Select samples were collected for chemical testing from locations and depths in accordance with the MoTI document entitled “Environment Testing Requirements for Concrete Deterioration” dated October 19, 2018. Material testing requirements from this document indicate water soluble sulphate and chloride content testing within native soil in accordance with CSA A23.2-3B and ASTM C1218. Samples were analyzed by Caro Analytical Services. Results are summarized in Table 9 below with the laboratory test report presented in Appendix C.

Table 9: Native Soil Chemical Test Results Summary

Test Hole ID	Depth (m)	Water Soluble Sulphate in Soil (%)	Soluble Chloride in Water (%)
TH21-02	2.70	< 0.05	< 0.002
	5.70	< 0.05	< 0.002

5.3.3 Surface Water Sample Testing

Surface water samples collected from the northern inlet of the existing culvert were sent to Caro Analytical Services for analysis. Testing was carried out in accordance with the MOTI test requirements document specified above including pH and water-soluble sulphate content in accordance with CSA A23.2-2B. Results of testing for surface water samples are summarized in Table 10 with the laboratory test report presented in Appendix C.

Table 10: Surface Water Test Results Summary

Surface Water Sample Ref.	Sample Type	pH	Soluble Sulphate in Water (mg/L)
SW21-01	Surface Water	7.14	-
SW21-03	Surface Water	7.21	<1.0
SW21-04	Surface Water	-	<1.0

6. Surface Conditions

6.1 Soil Conditions

Typical material types encountered throughout the site during the investigation are summarized in the following sections with detailed logs for each borehole provided in Appendix B.

6.1.1 Existing Pavement Structure

During the site investigation a total of 9 test holes were drilled, with 7 located within the existing road alignments including Highway 16 and side roads. Pavement structure was observed in 6 of the shallow test holes; TH21-03 to TH21-09 except for TH21-05, which was located in the unpaved section of Guest Road north of Highway 16. We could not decipher between crushed base course (CBC) and select granular subbase (SGSB) during the field investigation and is collectively referred to herein as “base”. Typical observations from the site investigation are listed below:

- Asphalt material ranged from 60 mm in thickness where present within side road and shoulder structure to 250 mm in thickness within the Highway 16 travel lanes. No asphalt was observed along the north segment of Guest Road or in the deep test holes within the embankment.
- Granular base thickness ranged from 100 mm to 900 mm and was described as dense, well graded, and grey to brown in colour.
- Sub-base material underlying the granular base was observed from 150 mm – 1200 mm and similarly described as dense, well graded, and grey to brown.

The total thickness of current pavement structure observed in test holes varied from 300 mm to 1520 mm including asphalt, base, and sub-base material summarized in Table 11.

Table 11: Existing Pavement Structure Summary

Test Hole ID	Thickness of Asphalt (mm)	Thickness of Base (mm)	Total Pav. Structure Thickness (mm)	Location
TH21-01	-	-	-	North Embankment at Culvert Outlet
TH21-02	-	-	-	South Embankment at Culvert Outlet
TH21-03	250	1270	1520	Westbound shoulder west of Guest Road
TH21-04	90	1430	1520	Center of Guest Road at Frontage Road
TH21-05	-	-	-	Center of Guest Road North of Highway 16
TH21-06	250	950	1200	Westbound travel lane between Guest Road and Shallow Bay Road
TH21-07	150	150	300	Center of Shallow Bay Road at Frontage Road.
TH21-08	60	940	1000	Eastbound shoulder east of Shallow Bay Road
TH21-09	240	1280	1520	Center of eastbound travel lane east of Shallow Bay Road.

Table 12: Existing Travel and Shoulder Lane Pavement Structure

	Travel Lane			Shoulder Lane		
	Asphalt	Base	Total	Asphalt	Base	Total
Minimum Thickness (mm)	240	950	1000	60	940	1000
Maximum Thickness (mm)	250	1280	1520	250	1250	1520
Average Thickness (mm)	245	1115	1260	155	1095	1260

6.1.2 Dense to Very Dense Sand and Gravel

Encountered immediately below pavement structure in the majority of holes, this layer comprised of granular material ranging from gravelly sand to sand and gravel, with some areas described as silty. Occasional cobbles were observed. Extending to depths ranging from 0.75 m 1.7 m this material was considered dense to very dense, moist, grey or brown in colour, well graded, and exhibited subrounded gravel. SPT N-values with this material ranged from 49 to over 100 blows per 300 mm.

Comprising of a gravel mass fraction ranging from 25% to 47% and sand from 45% to 62% based on laboratory results this material is inferred to be fill material.

6.1.3 Compact to Dense Sand and Silt

This material ranges from interlayered silty sand to sandy silt with trace to some gravel. It is described as dry to moist, well graded, and brown in colour and characterized as compact to dense. SPT N-values in the dense and very dense strata range from 37 to refusal (N>50) for 300 mm. This material was typically non-plastic to low plastic, with some regions of localized medium plasticity.

Within holes TH21-05, TH21-06, TH21-08, TH21-09, TP21-02, and TP21-03 this material was encountered at depths ranging from 1 m to 1.5 m below existing grade and extending to the full depth of the respective (shallow) test hole or test pit. At TH21-01 and TH21-02 this material is found at shallow depths and interlayered with sandier layers and clay layers.

6.1.4 Clay and Silt Mixtures

Material ranging from silty clay to clayey silt was encountered in TH21-02, TH21-07, TP21-01, TP21-04, and TP21-05. This material was described as medium plastic, and moist to wet, with moisture contents between 15% and 33% based on laboratory testing. The clays and silts are predominantly brown in colour with the exception of a blue-grey seam located at TP21-04.

Clay ranged from 19% - 47% of the material composition by mass, and silt ranged from 36% to 60% based on gradation results from laboratory testing. Atterberg limits carried out in this material showed PI values ranging from 16% to 19%.

6.2 Wetland Clay & Silt

The material encountered in the wetland near station 105+00 was mostly comprised of clayey silt with trace to some sand and increased in sand content with depth. Some organic material was present in the upper portion of the wetland. Silt content ranged from 48% to 63% and clay content ranged from 28% to 31%. The clayey silt material was medium plastic, with PI values ranging from 15% to 21%.

Scala penetrometer values ranged from 2 to 5 blows/50 mm. Hard material (Scala refusal) was encountered at depths between 2.69 m and 3.32 m. The hard material appeared shallower towards the eastern end of the wetland.

6.3 Groundwater

During site reconnaissance, an inferred water table was noted at 5.3 m depth in TH21-02 located in the embankment between Highway 16 and Frontage Road. Groundwater levels within the wetland are anticipated near surface.

7. Geotechnical Overview

Subsurface conditions observed during the site investigation comprise of silty sand to sandy silt underlying sand and gravel. Based on the encountered conditions and the proposed works associated with the project key geotechnical design considerations include:

- Stability: Including the roadway alignment, adjacent embankments, and area surrounding the culvert.

- Earthworks: Cuts and fills will be required to construct the works associated with road improvement and widening. Recommendations are provided to support the design and construction of these earthworks.
- Culvert Headwall: The road widening at the location of the existing culvert will require upgrades to the existing culvert configuration to accommodate the extended embankments associated with the road improvement and widening.
- Pavement Design: A pavement design assessment has been undertaken based on traffic data, frost considerations, and best practices of the Northern Region MoTI.

The above considerations are discussed in the following sections together with provisional geotechnical construction recommendations.

8. Consequence and Site Understanding Classification

8.1 Consequence Classification

Section 6.5.1 of the Canadian Highway Bridge Design Code (CHBDC) S6-14 specifies three failure consequence levels, namely:

- **High Consequence** – The foundations and/or geotechnical systems are designed for applications including bridges, essential to post disaster recovery (e.g., lifeline) and/or having large societal or economical impacts;
- **Typical Consequence** – The foundations and/or geotechnical systems are designed for applications including bridges, carrying medium to large volume of traffic and/or having potential impacts on alternative transportation corridors or structures; or,
- **Low Consequence** – The foundations and/or geotechnical systems that are designed for applications where life safety is not a concern. The use of low consequence for bridges requires approval.

It is assumed that a determination of the consequence classification has not been undertaken by the Regulatory Authority and that the area is not used for post disaster recovery, or wide reaching societal or economic impacts, thus the selected consequence classification for the project site is assumed to be “Typical”.

8.2 Site Understanding

According to Table 6.2c in the Supplement to the CHBDC S6-14, the three degrees making up the site and prediction model understanding are identified as:

- **High Understanding** – Extensive project-specific investigation procedures and/or knowledge are combined with prediction models of demonstrated quality to achieve a high level of confidence with performance predictions.
- **Typical Understanding** – Typical project-specific investigation procedures and/or knowledge are combined with conventional prediction models to achieve a typical level of confidence with performance predictions.

- **Low Understanding** – Limited representative information (e.g., previous experience, extrapolation from nearby and/or similar sites) combined with conventional prediction models to achieve a lower level of confidence with performance predictions.

Based on the site investigation program conducted, the site and prediction model are identified as “Typical Understanding”.

8.3 Geotechnical Factors of Safety for Global Slope Stability

Supplement to CHBDC (Table 6.2b) provides the minimum Factor of Safety (FoS) for global stability corresponding to the site consequence and degree of understanding summarized in Table 13 below. Based on a “Typical Consequence” and “Typical Understanding” the minimum design FoS used for global stability of permanent and temporary slopes are 1.54 and 1.33 respectively.

Table 13: Factors of Safety for Global Stability of Embankments (Supplement to CHBDC S6-14, 2016 – Table 6.2b)

Degree of Understanding	Low			Typical			High		
Consequence factor from S6-14	High	Typical	Low	High	Typical	Low	High	Typical	Low
FoS for Global Stability – Permanent	1.85	1.67	1.45	1.71	**1.54**	1.34	1.59	1.43	1.24
FoS for Global Stability – Temporary	1.59	1.43	1.24	1.48	**1.33**	1.16	1.39	1.25	1.09

9. Seismic Considerations

9.1 Seismic Hazard

Peak Ground Acceleration (PGA) and Spectral Accelerations (Sa(T)) for various return periods for a “Class C” site were obtained from the Earthquakes Canada website (http://earthquakescanada.nrcan.gc.ca) which is based on the 5th Generation Seismic Hazard Model for Canada (Adams et. al. 2015). The values for the project area are summarized in Table 14 below.

Table 14: Reference (Class C) Design PGA and Sa(T)

Annual Exceedance Probability (AEP)	PGA (g)	Sa(0.2) (g)	Sa(0.5) (g)	Sa(1.0) (g)	Sa(2.0) (g)	Sa(5.0) (g)	Sa(10.0) (g)
1/475	0.016	0.033	0.034	0.028	0.022	0.009	0.003
1/1,000	0.025	0.056	0.051	0.040	0.030	0.014	0.005
1/2,475	0.044	0.101	0.082	0.059	0.043	0.020	0.006

9.2 Seismic Site Classification

Based on Table 15 below (reproduction of Table 4.1 in CHBDC S6-14), and the SPTs recorded during the investigation, a seismic site classification of Class D “Stiff Soil” is recommended for the project area.

Table 15: Site Classification for Seismic Site Response (Table 4.1 CHBDC S6-14)

Site Class	Soil Profile Name	Average Properties in Top 30 m		
		Soil Shear Wave Average Velocity $\bar{V}_{s30}$ (m/s)	Standard Penetration Resistance, $\bar{N}_{60}$	Soil Undrained Shear Strength s_u (kPa)
A	Hard Rock	$\bar{V}_{s30}$ > 1500	Not Applicable	Not Applicable
B	Rock	760 < $\bar{V}_{s30}$ < 1500	Not Applicable	Not Applicable
C	Very Dense Soil and Soft Rock	360 < $\bar{V}_{s30}$ < 760	50 < $\bar{N}_{60}$	100 < s_u
D	Stiff Soil	180 < $\bar{V}_{s30}$ < 360	15 ≤ $\bar{N}_{60}$ ≤ 50	50 < s_u < 100
E	Soft Soil	$\bar{V}_{s30}$ < 180	$\bar{N}_{60}$ < 15	su < 50
		Any profile with more than 3 m of soil with the following characteristics: Plasticity Index, Ip > 20; Moisture Content, w ≥ 40%; and Undrained Shear Strength, s_u < 25 kPa		
F	Other Soils (1)	Site specific evaluation required		

(1) Other soils include:
a) liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils, and other soils susceptible to failure or collapse under seismic loading;
b) peat and/or highly organic clays greater than 3 m in thickness;
c) highly plastic clays (PI > 75) more than 8 m thick, and
d) soft to medium stiff clays more than 30 m thick

10. Slope Stability

Assessment of slope stability in cut slopes and fill embankments along the project alignment described in the following sections is based on the BINNIE drawing package R3-375 provided by MOTI with cross-sections at various stations. Evaluation of the sections provided was the basis of stability model development described herein.

10.1 Culvert Headwall

BINNIE cross-section drawings indicate that the majority of side slopes in the project area are moderately gentle with the exception of near the existing culvert (STA 105+00 to 105+17) where fill embankments will be as high as 8 m to match existing. Within this area, slope stabilization measures are required.

Slope stability was assessed by use of the RocScience software package Slide2 (V9.0.0.3), creating a model under static and seismic (pseudo-static) conditions. Geotechnical soil parameters used in the stability analysis are

summarized in Table 16 below. The soil parameters for existing material are based on subsurface conditions encountered in adjacent test holes (TH21-01 and TH21-02). Parameters for proposed engineered materials are assumed based on typical values.

Table 16: Soil Properties Used for Slide2 Analysis

Material	Unit Weight (kN/m^3)	Drained Analysis		Undrained Analysis
		Friction Angle (°)	Cohesion (kPa)	Undrained Cohesion (kPa)
Native Sand and Silt	20	33	2	-
Silt	20	30	0	-
Type D - Granular Fill	20	37	0	-
Engineered Fill	20	38	0	-
Rock Fill	21	46	0	-
Lock Block	24	0	365	-
Wetland – Very Soft Clay	16	19	1	5
Wetland – Firm Clay	18	26	5	30

Several remediation strategies were considered during preliminary design development. Of the proposed options, the MoTI has selected a 2H:1V fill extension with some sub-excavation and replacement of the wetland material. Other alternatives required displacement of the culvert or did not meet adequate Factor of Safety (FoS) requirements. These options included a Geosynthetic Reinforced Soil (GRS) wall, a 2.6H:1V fill extension without wetland material replacement and a slope with a rock toe buttress.

Culvert headwall retention works will be carried out approximately from STA 105+00 to STA 105+34. Design in this area has a targeted FoS of 1.54 as specified in the British Columbia Supplement to CHBDC S6. Current analysis for the selected option; results shown in Figure 2.0, calculates an FoS of 1.53.

The selected design consists of a granular fill slope of 2H:1V (27˚) extending from the proposed highway elevation. The wetland below the fill will be excavated to a depth of 1.5 m below mudline. The removal of the weak clay layer and replacement with a higher strength material increases the passive resistance of the soil and allows us to achieve a satisfactory FoS. Recommended construction sequencing involves a benched excavation with placement of fill in lifts meeting standard MoTI specifications. Earthworks construction recommendations are further described in Section 12.

Slide2 software was used to analyze a cross-section at STA 105+00 and STA 103 + 72.643 (see BINNIE Drawing R3-375-6XS). Model results from analysis of the selected option are presented in Figure 2.0 with supplementary preliminary design options shown in Appendix D. Model results for STA 103 + 72.643 slope stability analysis is presented in Figure 3.0.

10.2 Embankment Fill Stability

The fill slopes on Binnie cross sections typically consist of 4H:1V slopes (for the 9 m width from the through lane to meet the clear zone requirement). Beyond that 9 m offset, the embankments extend down at 2H:1V (i.e. near the toe of the embankment).

Where embankments are behind concrete roadside barriers (CRBs), they are 2H:1V as the CRBs satisfy clear zone requirements.

These 4H:1V sections and 2H:1V embankments are low in height and constructed in areas away from softer wetland soils. These embankment slopes are considered acceptable provided that the embankments are placed and compacted in in accordance with Section 201 of the MoTI Specifications for Highway Construction SS 202.

10.3 Cut Slope Stability

Cut slopes within the project extents are predominantly located along the side road alignments (L300 – L900) and are typically minimal in height. The most significant cut slopes proposed are located at the C20 curb section located at the northeast corner of the intersection between Highway 16 and Guest Road with a maximum height of approximately 3 m. This C20 curb section is shown in the BINNIE drawings as having a 2H:1V (27˚) slope. Ecora has completed slope stability analysis for the critical cut slope section at approximately STA 103+72.643. The cross section location and results of both the static and seismic stability analyses are presented as Figures 3.0 to 3.2 which indicate a low risk of instability of these cut slopes.

10.4 Embankment Settlement

Construction of the proposed road improvements will involve fill placement in sections of the alignment, which will impose loading on the subgrade soils with the potential to cause settlement. Based on sections provided by BINNIE, the maximum embankment height will be approximately 8 m, associated with the northern embankment in vicinity of the existing culvert from approximate station 105+00 to 105+30. Embankment fill placement is assumed to be granular fill with an approximate bulk density of 20 kN/m^3. Soils encountered during the site investigation were described as silty sands and sandy silts, with some areas containing some gravel. The wetland downstream of the culvert is comprised of clays, some silt and varying amounts of sand. Based on these parameters it is anticipated that in the area of the existing culvert post-construction settlement resulting from construction activities will be less than 75 mm, provided that the wetland material is excavated and replaced. Other locations within the project alignment are considered to have nominal settlement (< 50 mm). The majority of this is anticipated to occur during embankment construction, prior to the placement of asphalt.

Tolerances of the infrastructure in this zone to impacts of settlement should be considered during design. Utilities may require relocating.

10.5 Wetland Sub-excavation and Groundwater Control

As noted earlier, subexcavation is required within the wetland (near STA 105+00) to both improve the stability and improve the settlement of the embankment that would impact the culvert.

This will involve subexcavating to an inferred depth of 1.5 m (below mudline) within the wetland and replacement with compacted granular fill. The required width at the base of the granular fill replacement zone will be 6 m and it should be wrapped in non-woven geotextile up to Elevation 771.0 m. The finished embankment slope is to be constructed at 2H:1V and formed entirely in compacted granular fill.

The final elevation of the sub-excavation should be confirmed by a geotechnical representative from Ecora or MoTI during construction.

Dewatering will be needed during construction to facilitate embankment construction. The contractor shall allow for appropriate dewatering methods to enable the subexcavation works to be undertaken. This may entail the use of temporary sheet piling or other measures as determined by the Contractor. Construction during the summer is likely to reduce the groundwater control requirements.

11. Earthworks and Material Recommendations

11.1 Stripping

For stripping, we recommend utilizing a nominal allowance of 300 mm for the highway design.

11.2 Site Preparation

Prior to the placement of fill or pavement structure, the Contractor shall remove all topsoil, organics, and any other deleterious material to at least 1 m laterally past the edge of proposed fill. The stripped subgrade shall be reviewed by a geotechnical engineer prior to the placement of any fill. This review should include a “proof-roll” by completing several passes with approved heavy construction equipment for compaction. Any soft areas or areas showing poor performance (i.e., pumping, cracking, deflection etc.) should also be sub-excavated and replaced with structural fill to be placed in accordance with WorkSafe BC Occupation Health & Safety Regulations, Part 20.

11.3 Compaction Requirements

General embankment fill is subject to requirements of Section 201.37 of the MoTI Specifications for Highway Construction SS 202 (MoTI specifications), which defines “earth embankments” as embankments constructed from material containing less than 15% by volume of rock larger than 150 mm in diameter.

Requirements of section 201.37 are that earth embankments are constructed in successive horizontal lifts not exceeding 200 mm in loose thickness below the top 500 mm and in layers not exceeding 100 mm in loose thickness above 500 mm. Compaction efforts are required between each lift such that a minimum of 95% of the Standard Proctor Maximum Dry Density (SPMDD) determined in accordance with ASTM D698 with the exception of the top 300 mm of embankments which much meet a compaction standard of 100% of the SPMDD.

During tendering, we recommend that the Special Provisions require the Contractor to provide an earthworks management plan which addresses their strategy for quality control and quality assurance with respect to fill placement. This should address the construction equipment that will be used to compact fine grained soils (e.g., sheepsfoot rollers), measures for controlling moisture, and obtaining representative proctors for the various material types in use.

11.4 Cut and Fill Recommendations

Where fill thickness is small, design grade will be achieved with pavement structure i.e., designated base and subbase material. In areas of greater fill thickness, grade will be achieved through the placement of site grading fill followed by base and subbase material. In these areas, the site grading fill shall comprise of 75 mm minus sand and gravel with less than 5% fines.

All exposed cut slopes should be reviewed by a geotechnical engineer to verify the exposed soil and groundwater conditions are consistent with design assumptions and conducive to construction. Based on the site investigation it is assumed that the water table will not be encountered during excavation for road improvements for the majority of the alignment. Potential for groundwater may exist to the north of Highway 16, near the culvert inlet depending on final design of the headwall.

The establishment of vegetation on soil slopes assists with stabilization by root-binding, preventing erosion, and lowering soil moisture content. It is recommended that slopes should be vegetated soon after construction to minimize the potential for erosion.

11.5 Material Re-use

Material encountered during the site investigation exhibits a significant amount of fines. This material can be used as Type D borrow however limitations and risks associated with re-use should be appreciated. Fine grained fill requires additional moisture control, may be frost susceptible, has potential for expansion, has limitations on side slopes, and requires additional compaction efforts. Other considerations may be the experience of local contractors in working with fine grained materials. Specialized compaction equipment may be needed, such as a sheepsfoot roller.

Fine grained material encountered does not meet the BC MoTI specifications for CBC, SGSB or BEF.

Localized regions of more granular material were encountered, which may be considered for re-use. Quality of this material for use should be determined by confirmatory testing.

12. Frost Considerations

Design of the works associated with the road and intersection improvements in the project area should consider the susceptibility of material to frost effects such as heave.

Frost depth is defined as the maximum depth to which freezing temperatures penetrate the ground. Extent of subsurface freezing effects will vary depending on climate and material conditions. Penetration depth of freezing temperature is approximated based on frost probes through the MoTI Road Weather Information System (RWIS) online database. The most proximal frost probes from this repository are 27.2 km east and slightly south in a direct path (28 km along the highway). Two stations are installed at this location, including a frost probe, Tamarack FP (41961), and a climate station, Tamarac (41094). The next most proximal probes are located greater than 45 km away. Table 17 summarizes frost depth encountered at probes within 50 km of the subject site.

Table 17: MoTI Frost Probe Data (Northern Region)

Frost Probe ID	Latitude	Longitude	Elevation (m)	Proximity to Site (Approximate)	Maximum Freezing Depth < 0˚ (m)			
				Distance (km)	Elevation (m)	2021	2020	2019
Tamarack FP (41961)	53.83111	-123.13222	715	27.2 (SE)	- 65	1.7	1.6	1.7
Blackwater Road (41964)	53.75035	-122.87018	760	46.2 (SE)	- 20	1.6	1.45	-
Highway 27 (52362)	54.14944	-124.16306	840	49.8 (NW)	+ 60	1.8	1.95	2.4

Frost penetration over a 3-year period indicate an average freezing depth ranging from 1.45 m to 2.4 m. It is noted that the frost probe which registered deeper freezing penetration is located at an elevation 60 m higher than the project site.

Frost protection impacts on the pavement design are discussed in Section 13.

Works within the vicinity of the culvert should be carried out by use of non-frost susceptible material in accordance with Section 303 (Culverts) of the MoTI specifications.

13. Pavement Design

13.1 General

Pavement analysis and design has been conducted for the proposed alignment including Highway 16 and intersection improvements at Guest Road and Shallow Bay Road.

The following sources were used in the development of pavement design of the project site:

- Geotechnical data from 2021 site investigation including subsurface material observations and laboratory results.
- MoTI Pavement Structure Design Guidelines – Technical Circular T-01/15 (January 2015).
- AASHTO (1993) “Guide for Design of Pavement Structures”.
- Traffic volumes from the MoTI Traffic Data Program GIS application (www.th.gov.ca/trafficdata).

13.2 Pavement Structure and Type

Basis of the pavement design provided herein follows procedures outlined in the Technical Circular T-01/15 and relies upon vehicle volumes from the BC MoTI “Traffic Data Program” website. The most proximal traffic data locations were assessed to determine typical traffic volumes experienced by the road in this region. Three sites were reviewed located between 7 km and 17 km from the project site. Of the three sites located within the vicinity, only one, Bednesti (P-42-EW – N), is a permanent site having consistent data collection from 2009 to 2021.

Design inputs are based on the information collected from the Bednesti data collection station, located approximately 9.7 km east of the project site along Highway 16. Annual traffic volume data for this site is provided in Appendix E. Traffic growth rate is highly variable at this station as well as the temporary stations in the region, showing fluctuating growth rates. Due to this high variability the growth rate from data collection is considered unreliable and a standard growth of 2% is assumed for the project area per Technical Circular T-01/15. A summary of data inputs to determine service loading applicable to the roadway is provided in Table 18 based on procedures from AASHTO 1993 guidelines referenced in the MoTI Technical Circular T- 01/15.

Table 18: Summary of Traffic Data Design Inputs

Parameter	Description	Highway 16	Source
AADT	Annual average daily traffic (vehicles/day)	4,616	2021 data from Station 45-001EW-N
Directional Distribution	Distribution in POS and NEG direction	0.5	Data from Traffic Data Program website
Design Life in years	-	20	Recommended by Technical Circular T-01/15
Growth Factor	Traffic growth rate (%)	2 %	Standard value from Technical Circular T-01/15
HVP	Heavy vehicle percentage (%)	30 %	Data from Traffic Data Program website
HVDF	Heavy vehicle percentage in design lane (%)	100 %	Single lane per direction (all heavy vehicles in one lane)
NALV	Number of ESALs per heavy vehicle	6	Based on TAC Vehicle Weights and Dimensions Study Load Equivalency Factor plot interpolation
TDY	Traffic days per year	365	
Estimated ESALs	Current equivalent single axle loads (yearly)	1.5×10^6	Calculation based on Technical Circular T-01/15 for current conditions
20-year Estimated ESALs	20-year projected equivalent single axle loads (cumulative)	**37×10^6**	Calculation based on AASHTO formula and indicated growth rate

Of the four typical pavement structure types (A, B, C, D) provided in the MoTI Technical Circular T-01/15 – "Pavement Structure Design Guidelines", the applicable pavement type for this project based on traffic loading is Type A. The typical pavement types and their respective attributes as described in the above referenced document are shown in Table 19. Additional considerations should be made to confirm adequacy of design to meet northern conditions and impacts of frost penetration.

Traffic volume data is not available for the side roads in the project area including Guest Road, Shallow Bay Road, and Frontage Road. It is assumed that traffic volumes are significantly lower than the monitored sections along Highway 16 and will not require a Type A pavement design. In these sections, roadway improvements will only extend approximately 100 m or less along side roads at the intersections and it is assumed that a tapered pavement design would be adequate.

Table 19: Pavement Structure Type

Pavement Structure Type	Roadway Description	20 Year Deign ESAL Criteria	Typical Asphalt Concrete Pavement Thickness (mm)
A	High volume roads, truck lanes, specialty locations	>20,000,000	≥ 150
B	Medium to high volume roads	100,000 to 20,000,000	75 to 150
C	Low volume & subdivision roads	<100,000	50 to 75
D	Low volume sealcoat or gravel roads	<100,000	Graded aggregate sealcoat layer(s)

13.3 Pavement Design Thickness

Design of the pavement structure follows the methods outlined in the MoTI Technical Circular T-01/15 with reference to parameters from AASHTO 1993. Values used in the determination of minimum required structural Number (SN) are provided in Table 20. The calculated minimum structural number is based on reliability requirements, serviceability index, resilient modulus, structural layer coefficient, and drainage coefficient. Structural number used in design must meet or exceed the calculated minimum.

Table 20: Pavement Structure Properties

Parameter	Description	Highway 16	Notes
Pi	Initial serviceability index	4.2	Technical Circular T-01/15
P_t	Terminal serviceability index	2.5	Technical Circular T-01/15
R	Reliability	90	Technical Circular T-01/15
S_o	Standard Deviation	0.45	Technical Circular T-01/15
a_{ac}	Structural layer coefficient—AC	0.40	Technical Circular T-01/15
a_b	Structural layer coefficient—CBC	0.14	Technical Circular T-01/15
a_{sb}	Structural layer coefficient—SGSB	0.10	Technical Circular T-01/15
m_b	Drainage coefficient—CBC	0.95	Technical Circular T-01/15
m_{sb}	Drainage coefficient— SGSB	0.8	Technical Circular T-01/15
M_r (MPa)	Resilient modulus—subgrade	35	Estimated from SPT N-values and soil type
SN_R (mm)	**Structural Number Required**	**170**	**-**

Using a convergent numerical analysis, the minimum structural number is determined as 170 mm. Proposed pavement structure to achieve this SN requirement as well as minimum pavement requirements for a Class A roadway is provided in Table 21, resulting in a SN of 172 mm and a total depth of pavement structure of 1,350 mm.

Design thicknesses provided assume pavement structures are well drained, proper maintenance is performed, and that placement is conducted in accordance with the current MoTI Standard Specifications for Highway Construction (2020) unless otherwise approved by the MoTI.

Table 21: Pavement Structure Design Thickness (Highway 16)

Material	Thickness	Structural Number
Asphalt Pavement	150 mm	60 mm
Crushed Base Course (CBC)	300 mm	40 mm
Select Granular Subbase (SGSB)	900 mm	72 mm
TOTAL	**1,350 mm**	**172 mm**

As the total pavement depth exceeds 50% of assumed frost depth, further thickening of pavement structure layers is not deemed necessary to combat impacts of frost penetration.

Asphalt pavement construction shall follow Section 502 of the “Standard Specifications for Highway Construction” (MoTI, 2020).

Construction of granular surfacing, granular base, and SGSB shall follow Section 202 of the "Standard Specifications for Highway Construction" (MoTI 2020). Granular surface materials shall be placed in lifts with loose thickness of 300 mm (150 mm compact), adequately moisture conditioned, and compacted to 100% of the Standard Proctor Maximum Dry Density (SPMDD) per ASTM D698.

For the gravel frontage roads, we recommend the use of High Fines Surfacing Aggregate (HFSA) over 300 mm of CBC over 900 mm of SGSB.

14. Chemical Testing Interpretation

Laboratory testing to determine potential for chemical degradation was carried out in accordance with the MoTI "Environment Testing Requirements for Concrete Deterioration" document indicating testing requirements. Analytes tested include water-soluble sulphates and water-soluble chlorides with discussion of result interpretation provided in the following sections. Chemical testing was carried out by CARO Analytical Services.

14.1 Sulphates

Sulphate attack is defined as a chemical and/ or physical reaction between sulphates usually found in soil or groundwater and concrete or mortar in the built environment. Primarily the reaction in the mortar occurs with the calcium aluminate hydrates in the cement paste matrix, often causing deterioration. Table 3 of the CSA A23.3.1 provides exposure classification for various scenarios of concrete subjected to sulphate attack and is reproduced in Table 22.

Table 22: Additional Requirements for Concrete Subjected to Sulphate Attack (CSA A23.1 – Table 3)

Class of Exposure	Degree of Exposure	Water Soluble Sulphate (SO_4) in Soil Sample (%)	Sulphate (SO_4) in Groundwater Sample (mg/L)	Water Soluble Sulphate (SO_4) in Recycled Aggregate Sample (%)	Cementing Materials to Be Used
S-1	Very Severe	> 2.0	> 10,000	> 2.0	HS or HSb
S-2	Severe	0.20 – 2.0	1,500 – 10,000	0.6 – 2.0	HS or HSb
S-3	Moderate	0.10 – 0.20	150 – 1,500	0.20 – 0.60	MS, MSb, LH, HS, or HSb

Soil samples obtained during the site investigation with results provided in section 5.3.2 indicate a sulphate content of < 0.05% and are thus lower than the exceedance threshold provided by CSA A23.3 of 0.1% – 0.2%. As such, risk of sulphate attack on concrete structures or pavement due to contact with sulphate rich soil in the project is considered sufficiently low to not require sulphate-resistant cement material.

Surface water samples tested for soluble sulphate content indicated values of < 1.0 mg/L. Based on the threshold requirements from the CSA regulations for groundwater, it is assumed surface water specifications are comparable and the risk of sulphate attack due to contact with sulphate-laden surface water is considered low.

Use of sulphate-resistant cementitious material is not considered required at the project site.

14.2 Chlorides

Introduction of chloride ions may occur as contaminants from manufacturing or subsequent exposure to chloride-laden environments such as seawater or de-icing salts. Exposure to chlorides can cause corrosion problems adversely affecting reinforcing steel. A significant concentration of chloride ions in the alkaline electrolyte phase adjacent to the steel tends to cause a phenomenon termed “pitting” wherein localized breakdown of the passive film on the embedded metal. Pitting can result in a serious localized loss in cross section of the affected regions of bars.

The limits of water-soluble chloride ion contents by mass of cementitious material are provided in section 4.1.1.2 of CSA 23 A23.1 (Limits on chloride ion content) as presented below:

- for prestressed concrete: 0.06%;
- for reinforced concrete exposed to a moist environment or chlorides, or both: 0.15%; and
- for reinforced concrete exposed to neither a moist environment nor chlorides: 1.0%

Chloride test results from the project site indicate water soluble chloride content < 0.002%, which is below the lower chloride exposure threshold. Risk of chloride attack on reinforcing steel due to soil exposure to chloride containing soil is considered low.

14.3 pH Testing

Chemical pH testing in surface water at the project site indicate values of 7.14 and 7.21, which are considered to exhibit a neutral pH. Risk of concrete deterioration caused by contact with acidified fluids is considered to increase with pH values below 6.5. The encountered pH at the project site suggest that the pH is within an acceptable range and additional measures are not required to regulate pH.

15. Temporary Excavations

All work conducted in and around excavations should be carried out in accordance with requirements specified by the WorkSafe BC Occupation Health & Safety Regulations, Part 20.

To maintain the stability of trench excavations, all materials excavated from the trench shall be placed a minimum distance away form the excavations, equal to the depth of the excavation.

Temporary cut slopes/excavations formed within the native soils shall be graded no steeper than 1H:1V. When a temporary cut slope of 1H:1V cannot be achieved, temporary shoring will be required.

16. Geotechnical Construction Recommendations

Ecora should be given the opportunity to review Special Provisions, design drawings and any other specifications related to geotechnical aspects of this project, prior to construction.

All design recommendations presented in this report are based on the assumption that an adequate level of monitoring will be provided during construction, and that construction will be carried out by a suitably qualified Contractor, experienced in earthworks, culvert and roadway construction. One of the purposes of providing an adequate level of field review is to check that recommendations based on geotechnical data obtained at discrete test locations are relevant to other areas of the alignment. It is recommended that the following site reviews are carried out by a geotechnical representative on behalf of MoTI:

- Review of subgrade conditions prior to the placement of embankment fill to verify that subgrade conditions are in line with those anticipated in this report.
- Full-time monitoring and compaction testing for the placement of all engineered fill.
- Review of subgrade conditions for new culvert foundation.
- Review of permanent cut slopes.

17. Closure

We trust this report meets your requirements. Please contact us if you have any questions or comments.

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Figures

SITE PLAN

ecora™

GEOTECHNICAL ASSESSMENT
HIGHWAY 16
GUEST RD TO SHALLOW BAY RD
CLUCULZ LAKE, BC

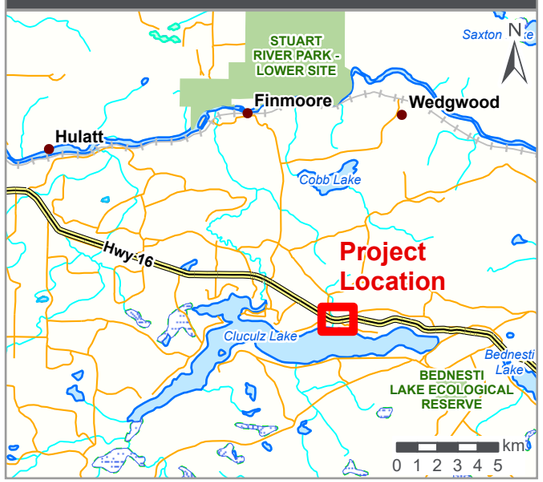
Legend

- 2022 Hand Auger Holes
- Test Hole Locations (Shallow)
- Test Hole Locations (Deep)
- Test Pit Locations
- 20m TRIM Contour Lines
- Fresh Water Atlas Streams
- Digital Atlas Roads
- Inferred Alignments
- Culvert Crossing
- PMBC Legal Parcels

References

Aerial Imagery: Vivid Maxar. Imagery Date: 7/24/2018

LOCATION MAP



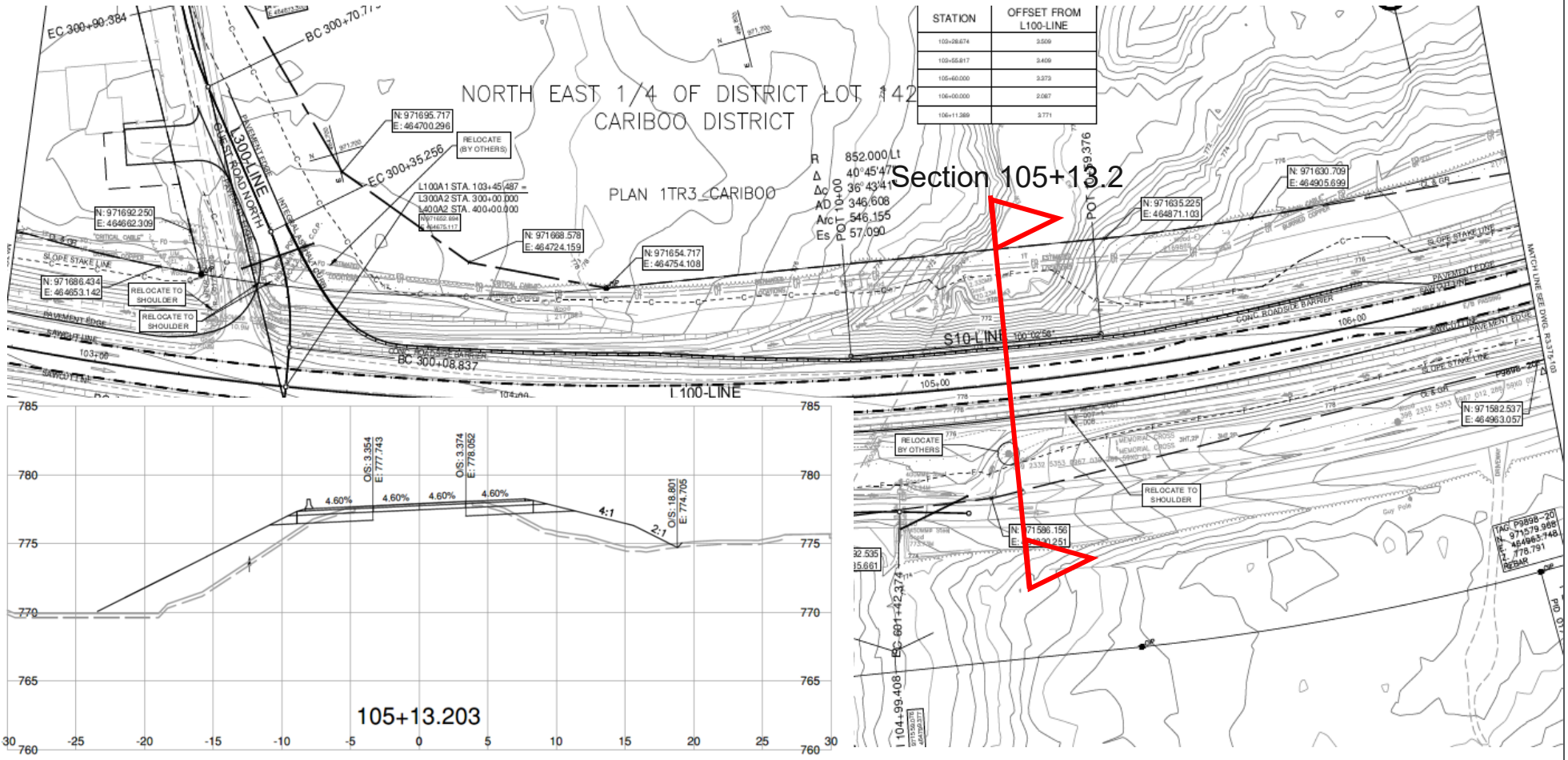
1:5,000

0 50 100 150 Meters

Project No.: 180750-13
Client: Ministry of Transportation & Infrastructure
NAD 1983 UTM Zone 10N

Date: 2022/05/25
Drawn: MT Check:MS

Figure 1.0



Notes:
Base plan provided by Binnie in drawing R3-375-102-1 dated March 18, 2021.

Cross-section provided by Binnie in drawing L100A1-8XS dated January 25, 2022.

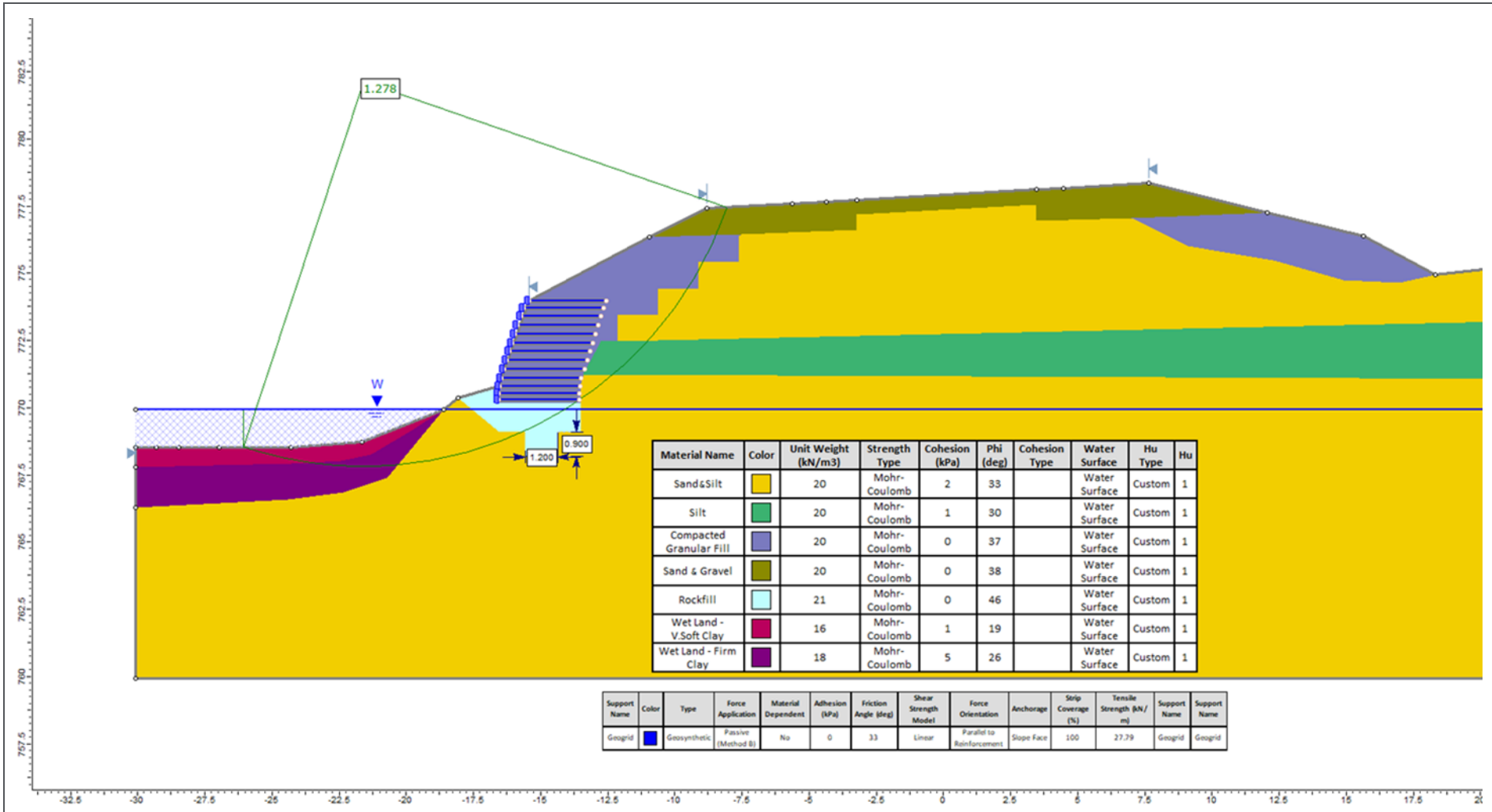
Guest Road to Shallow Bay Intersection Improvement STA100+75 to STA112+31 Highway 16

Slide2 Analysis Results – Section STA 105+13.2 Location

Project No.	212111-05
Client:	Ministry of Transportation and Infrastructure
Office:	Vancouver
Scale:	NTS
Date:	June 17, 2022
DWN:	MB CHK: DB

ecora

Figure 2.0



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu
Sand&Silt		20	Mohr-Coulomb	2	33		Water Surface	Custom	1
Silt		20	Mohr-Coulomb	1	30		Water Surface	Custom	1
Compacted Granular Fill		20	Mohr-Coulomb	0	37		Water Surface	Custom	1
Sand & Gravel		20	Mohr-Coulomb	0	38		Water Surface	Custom	1
Rockfill		21	Mohr-Coulomb	0	46		Water Surface	Custom	1
Wet Land - V.Soft Clay		16	Mohr-Coulomb	1	19		Water Surface	Custom	1
Wet Land - Firm Clay		18	Mohr-Coulomb	5	26		Water Surface	Custom	1

Support Name	Color	Type	Force Application	Material Dependent	Adhesion (kPa)	Friction Angle (deg)	Shear Strength Model	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (kN/m)	Support Name	Support Name
Geogrid		Geosynthetic	Passive (Method B)	No	0	33	Linear	Parallel to Reinforcement	Slope Face	100	27.79	Geogrid	Geogrid

Notes:
See figure 2.0 for cross-section location.

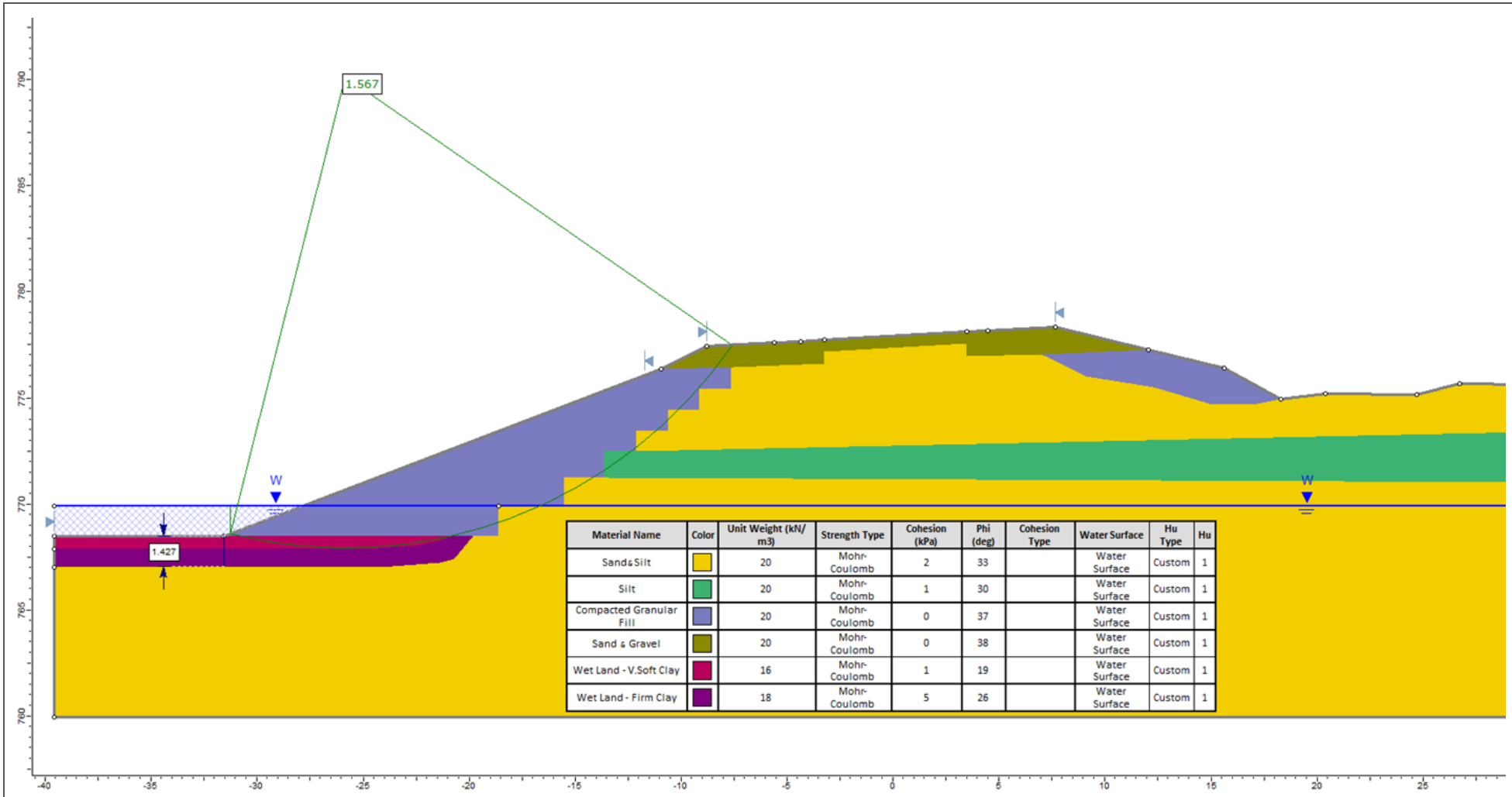
Guest Road to Shallow Bay Intersection Improvement STA100+75 to STA112+31 Highway 16

Slide2 Analysis Results – Section STA 105+13.2 – GRS Wall Option (Drained)

Project No. 212111-05
Client: Ministry of Transportation and Infrastructure
Office: Vancouver
Scale: NTS
Date: June 17, 2022
DWN: MB CHK: DB

ecora

Figure 2.0a



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu
Sand&Silt		20	Mohr-Coulomb	2	33		Water Surface	Custom	1
Silt		20	Mohr-Coulomb	1	30		Water Surface	Custom	1
Compacted Granular Fill		20	Mohr-Coulomb	0	37		Water Surface	Custom	1
Sand & Gravel		20	Mohr-Coulomb	0	38		Water Surface	Custom	1
Wet Land - V.Soft Clay		16	Mohr-Coulomb	1	19		Water Surface	Custom	1
Wet Land - Firm Clay		18	Mohr-Coulomb	5	26		Water Surface	Custom	1

Notes:
See figure 2.0 for cross-section location.

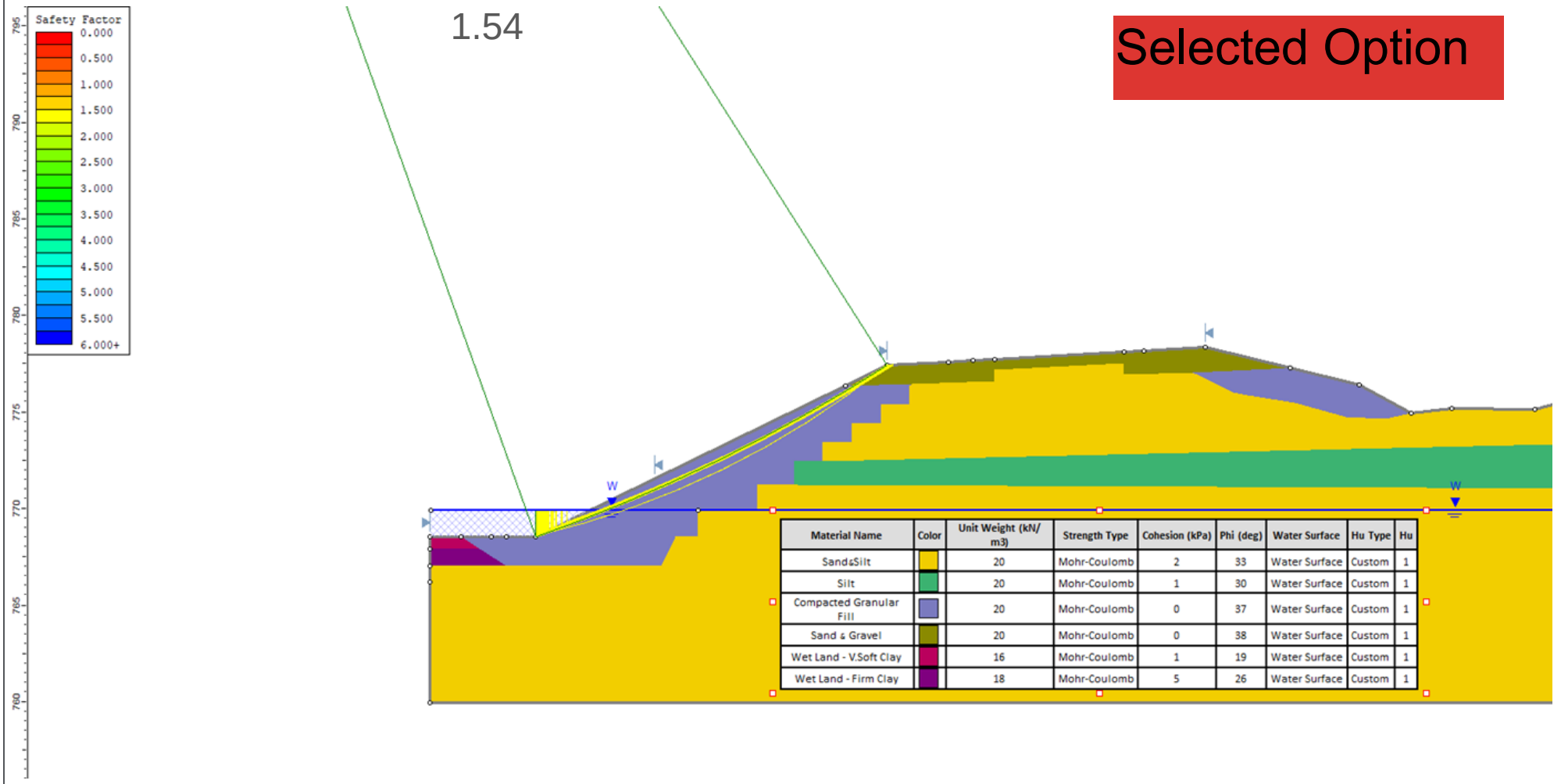
Guest Road to Shallow Bay Intersection Improvement STA100+75 to STA112+31 Highway 16

Slide2 Analysis Results– Section STA 105+13.2 – 2.6H:1V Slope (Drained)

Project No. 212111-05
Client: Ministry of Transportation and Infrastructure
Office: Vancouver
Scale: NTS
Date: June 17, 2022
DWN: MB CHK: DB

ecora

Figure 2.1a



Notes:
See figure 2.0 for cross-section location.

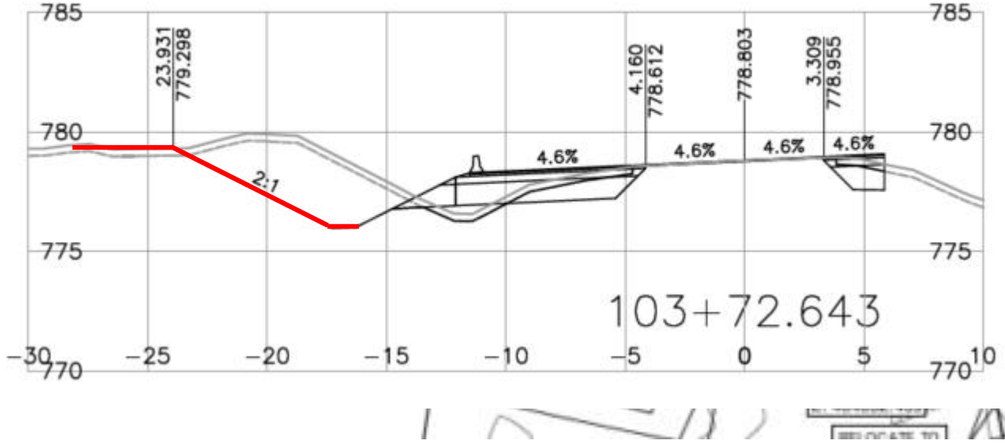
Guest Road to Shallow Bay Intersection Improvement
STA100+75 to STA112+31 Highway 16

Slide2 Analysis Results– Section STA 105+13.2 – 2H:1V Slope with Sub-Excavate & Replace (Drained)

Project No. 212111-05
Client: Ministry of Transportation and Infrastructure
Office: Vancouver
Scale: NTS
Date: June 17, 2022
DWN: MB CHK: DB

ecora

Figure 2.2a



Notes:

Plan view (drawing no. R3-375-104, dated 07/19/'22) and cross section (drawing no. -L100A1-5XS, dated 03/01/'23) provided by R.F. Binnie and Associates Ltd.

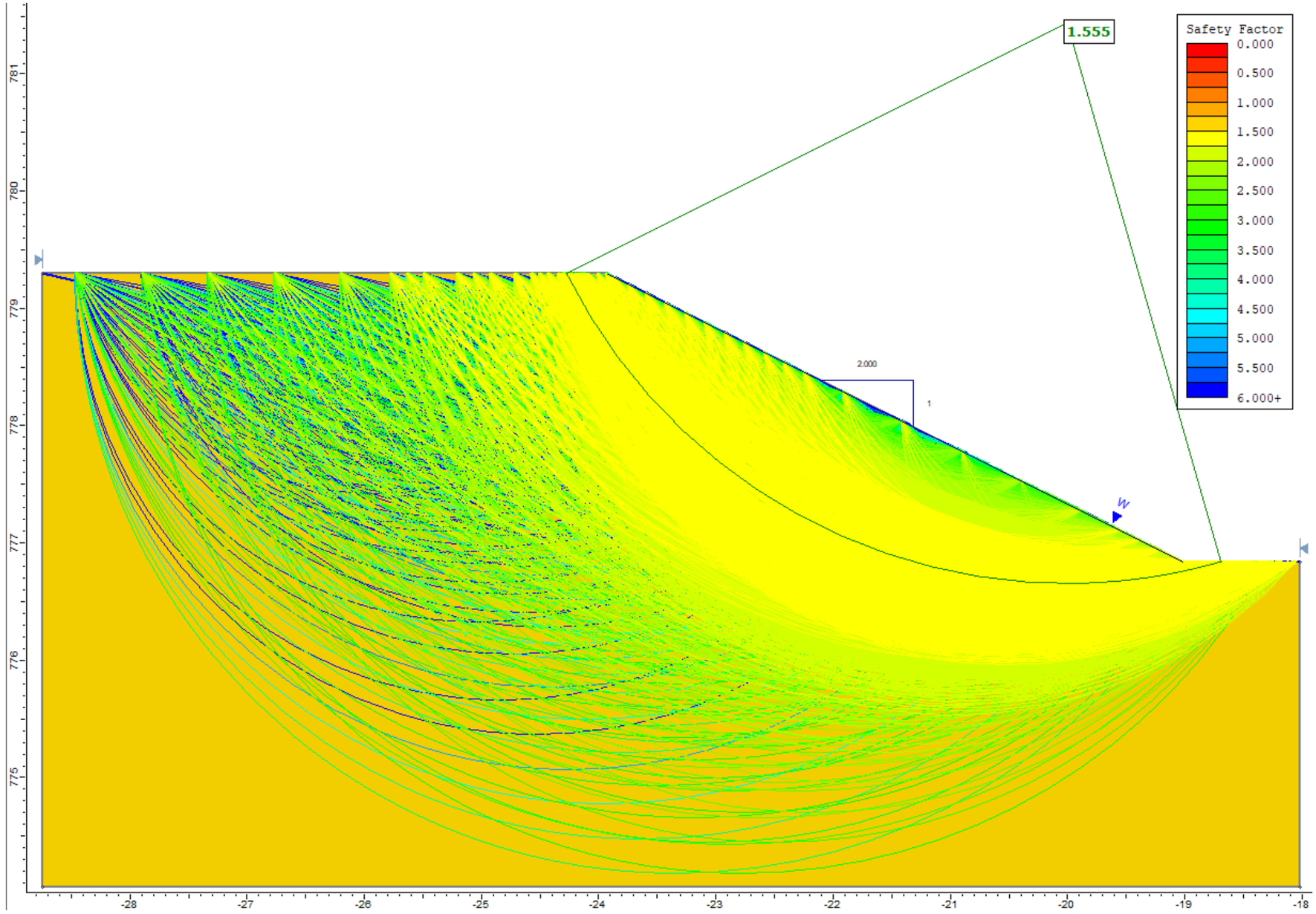
Guest Road to Shallow Bay Intersection Improvement
STA100+75 to STA112+31 Highway 16

Slide2 Analysis Section Location – ~STA103+72.643

Project No.	212111-05
Client:	Ministry of Transportation and Infrastructure
Office:	Vancouver
Scale:	NTS
Date:	April 28th, 2023
DWN:	BrS CHK: DB

ecora

Figure 3.0



Notes:

Cross section is shown on Figure 3.0.

FOS>1.54 therefore static slope stability is acceptable for the permanent condition.

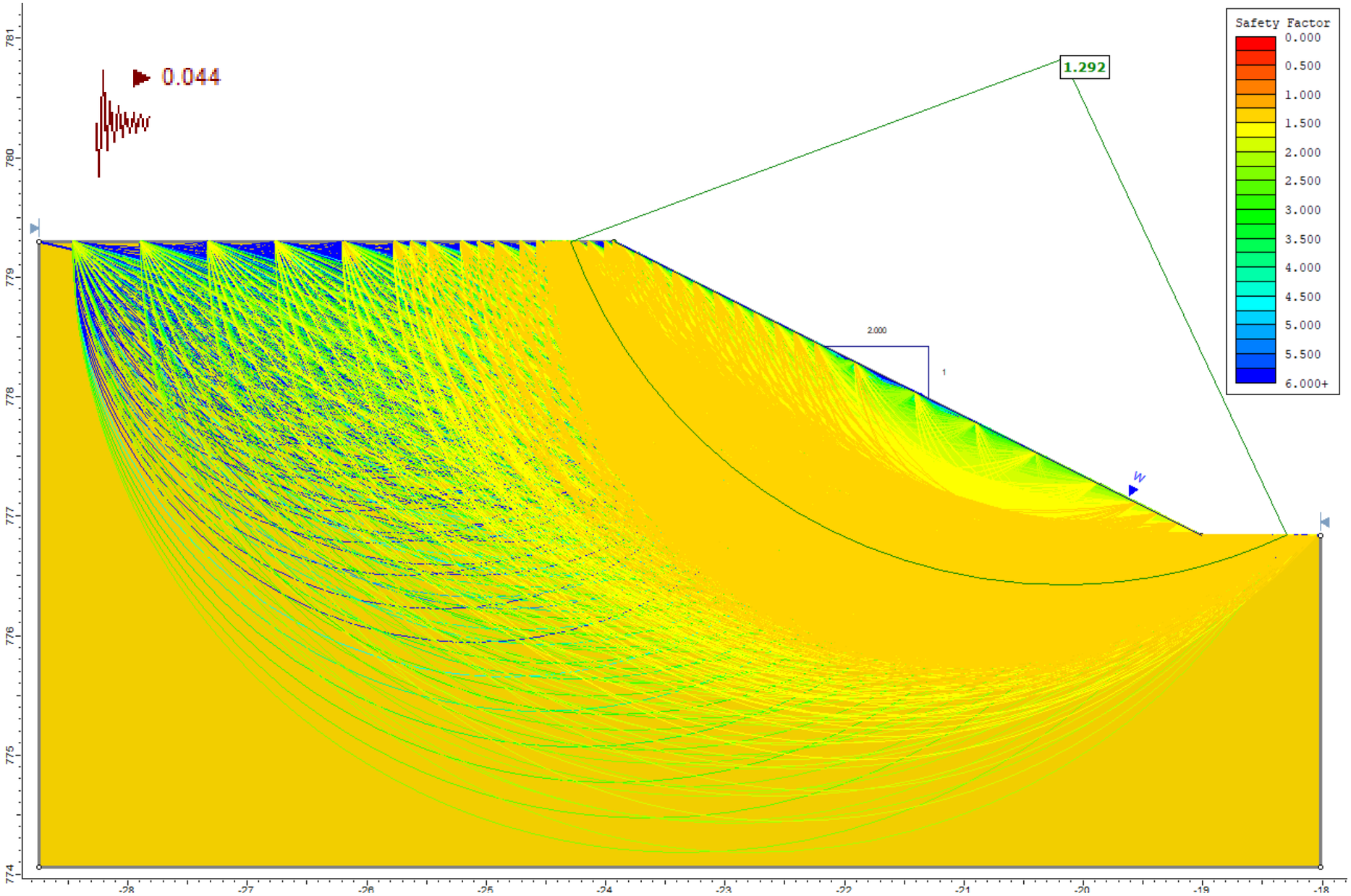
Guest Road to Shallow Bay Intersection Improvement
STA100+75 to STA112+31 Highway 16

Slide2 Analysis Results (Static) – ~STA103+72.643

Project No.	212111-05
Client:	Ministry of Transportation and Infrastructure
Office:	Vancouver
Scale:	NTS
Date:	April 28th, 2023
DWN:	BrS CHK: DB

ecora

Figure 3.1



Notes:

Cross section is shown on Figure 3.0.

k_{EH} taken as 100%PGA, normalized by g. FOS>1 therefore seismic slope stability is acceptable.

Guest Road to Shallow Bay Intersection Improvement
STA100+75 to STA112+31 Highway 16

Slide2 Analysis Results (Seismic) – ~STA103+72.643

Project No.	212111-05
Client:	Ministry of Transportation and Infrastructure
Office:	Vancouver
Scale:	NTS
Date:	April 28th, 2023
DWN:	BrS CHK: DB

ecora

Figure 3.2

Photographs

Photo 1 Facing east towards culvert inlet at northern embankment at Highway 16

Photo 2 Existing culvert internal baffles

Photo 3 Facing west towards south embankment between Highway 16 and Frontage Rad

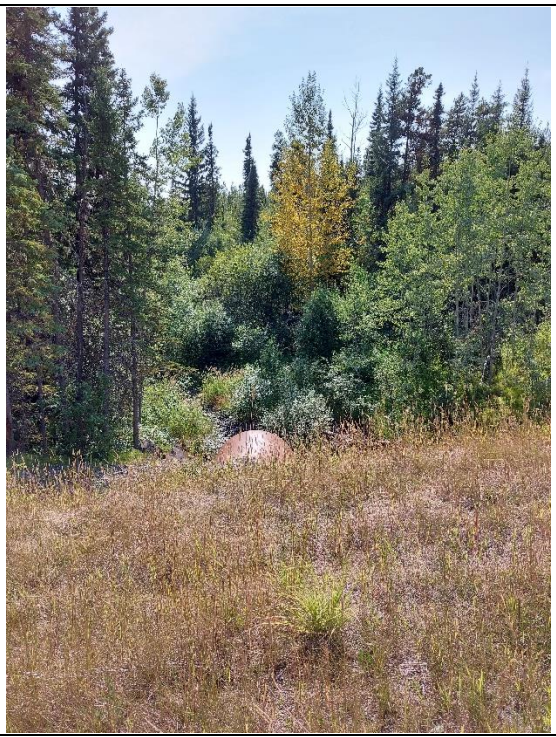


Photo 4 Facing south towards culvert outlet south of Frontage Road

Photo 5 Facing west along Frontage Road towards Guest Road

Photo 6 TH21-02 Drill set up facing south

Photo 7 TH21-02 – material at 2 m

Photo 8 TH21-02 material below water table

Photo 9 TH21-03 drill cuttings

Photo 10 TH21-03 road structure

Photo 11 TH21-04 material from 0 m – 1.5 m

Photo 12 SPT04-1 Material in split spoon

Photo 13 TH21-05 from 0 m – 1.5 m

Photo 14 TH21-06 pavement structure drill hole

Photo 15 TH21-06 drilled material

Photo 16 TH21-07 drilled material

Photo 17 Clay and Silt material at 0.3 m – 1.5 m

Photo 18 TH21-08 drilled material

Photo 19 TH21-08 – silty material

Photo 20 TH21-09 drilled material

Photo 21 TH21-09 SPT09-1 split spoon

Photo 22 TH21-01 drilled material at approximately 5 m

Photo 23 TH21-01 SPT01-3

Photo 24 TH21-01 drilled material at 12 m

Photo 25 TP21-01 Excavation

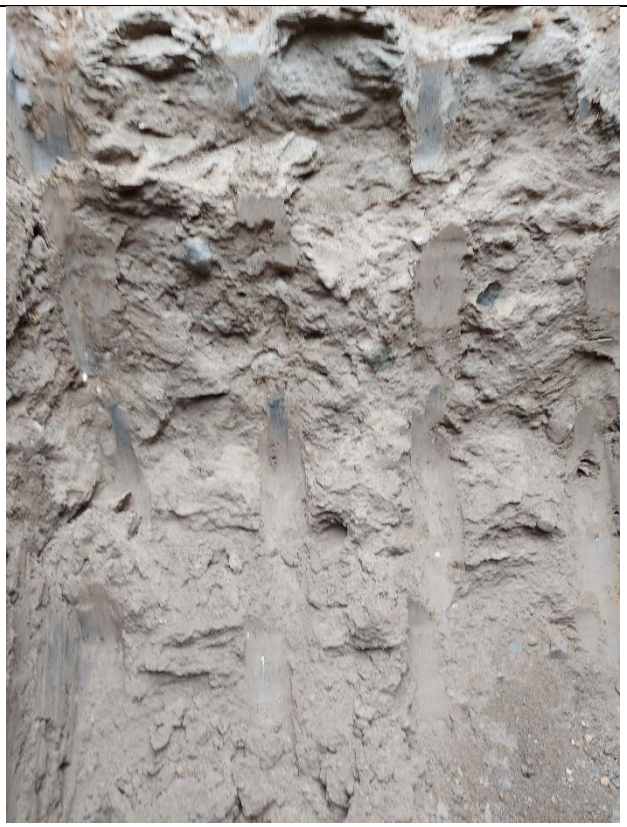


Photo 26 TP21-02 Excavation

Photo 27 TP21-03 Excavation

Photo 28 TP21-04 Excavation

Photo 29 TP21-05 Excavation

Photo 30 TP21-06 Excavation

Photo 31 Water Sampling Location

Photo 32 Excavation equipment used for test pits

Photo 33 Marked Utility line From Western Pole near STA 105+00

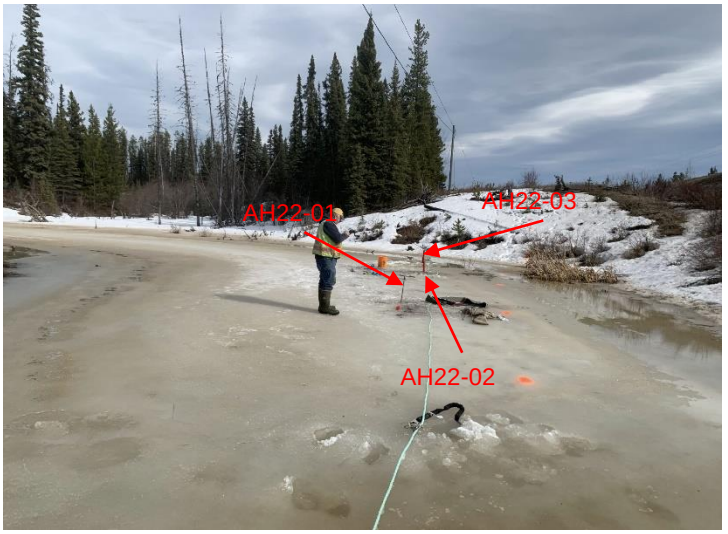


Photo 34 Hand Auger Hole Location

Photo 35 Culvert on the Northern Highway Side near STA 105+00

Photo 36 Excavation equipment used for test pits

Appendix A

Water Well Logs

Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 60057
Well Identification Plate Number:
Owner Name: RICK WARE
Intended Water Use: Private Domestic
Artesian Condition: No

Well Status: New
Well Class: Water Supply
Well Subclass:
Aquifer Number:

Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Alternative specs submitted: No

Licensing Information

Licensed Status: Unlicensed

Licence Number:

Location Information

Street Address: LEHMAN ROAD
Town/City: PRINCE GEORGE

Legal Description:

Lot	1
Plan	33469
District Lot	1421
Block	
Section	
Township	
Range	
Land District	05
Property Identification Description (PID)	

Description of Well Location:

Geographic Coordinates - North American Datum of 1983 (NAD 83)

Latitude: 53.891821 **Longitude:** -123.540437
UTM Easting: 464483 **UTM Northing:** 5971621
Zone: 10 **Coordinate Acquisition Code:** (50 m accuracy) Digitized from 1:20,000 mapping

Well Activity

Activity	Work Start Date	Work End Date	Drilling Company	Date Entered
Legacy record	1992-07-01		Pine Drilling	August 13th 2003 at 8:28 AM

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
1992-07-01					

Well Completion Data

Total Depth Drilled:
Finished Well Depth: 193 ft bgl
Final Casing Stick Up:
Depth to Bedrock:
Ground elevation:

Estimated Well Yield: 15 USgpm
Well Cap:
Well Disinfected Status: Not Disinfected
Drilling Method: Other
Method of determining elevation: Unknown

Static Water Level (BTOC): 162 feet btoc
Artesian Flow:
Artesian Pressure (head):
Artesian Pressure (PSI):
Orientation of Well: VERTICAL

Lithology

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Observations	Water Bearing Flow Estimate (USGPM)
0	127	BROWN TILL						
127	134	CEMENTED GRAVEL						
134	193	GRAVEL AND SAND						

Casing Details

From (ft bgl)	To (ft bgl)	Casing Type	Casing Material	Diameter (in)	Wall Thickness (in)	Drive Shoe
There are no records to show						

Surface Seal and Backfill Details

Surface Seal Material: Other
Surface Seal Installation Method:
Surface Seal Thickness:
Surface Seal Depth:

Backfill Material Above Surface Seal:
Backfill Depth:

Liner Details

Liner Material:
Liner Diameter:
Liner from:

Liner Thickness:
Liner to:

Liner perforations

From (ft bgl)	To (ft bgl)
There are no records to show	

Screen Details

Intake Method:
Type:
Material: Other
Opening:
Bottom:

Installed Screens

From (ft bgl)	To (ft bgl)	Diameter (in)	Assembly Type	Slot Size
There are no records to show				

Well Development

Developed by:

Development Total Duration:

Well Yield

Estimation Method:
Static Water Level Before Test:
Hydrofracturing Performed: No

Estimation Rate:
Drawdown:
Increase in Yield Due to Hydrofracturing:

Estimation Duration:

Well Decommission Information

Reason for Decommission:
Sealant Material:
Decommission Details:

Method of Decommission:
Backfill Material:

Comments

COMPLETION DAY NOT INCLUDED IN WELL DRILLERS LOG. METHOD OF DRILLING = DRILLED

Alternative Specs Submitted: Yes

Documents

- WTN 60057_Well Record.pdf

Disclaimer

The information provided should not be used as a basis for making financial or any other commitments. The Government of British Columbia accepts no liability for the accuracy, availability, suitability, reliability, usability, completeness or timeliness of the data or graphical depictions rendered from the data.

Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 62927
Well Identification Plate Number:
Owner Name: JIM TURCOTTE
Intended Water Use: Private Domestic
Artesian Condition: No

Well Status: New
Well Class: Water Supply
Well Subclass:
Aquifer Number:

Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Alternative specs submitted: No

Licensing Information

Licensed Status: Unlicensed

Licence Number:

Location Information

Street Address: SS#3,SITE18,COMP10 V2N 2S7
Town/City: PRINCE GEORGE, BC

Legal Description:

Lot	5
Plan	26667
District Lot	1421
Block	
Section	
Township	
Range	
Land District	05
Property Identification Description (PID)	

Description of Well Location:

Geographic Coordinates - North American Datum of 1983 (NAD 83)
Latitude: 53.891515 **Longitude:** -123.53847
UTM Easting: 464612 **UTM Northing:** 5971586
Zone: 10 **Coordinate Acquisition Code:** (50 m accuracy) Digitized from 1:20,000 mapping

Well Activity

Activity	Work Start Date	Work End Date	Drilling Company	Date Entered
Legacy record	1996-05-01		Pine Drilling	August 13th 2003 at 5:57 AM

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
1996-05-01					

Well Completion Data

Total Depth Drilled:
Finished Well Depth: 208 ft bgl
Final Casing Stick Up:
Depth to Bedrock:
Ground elevation:
Estimated Well Yield: 5 USgpm
Well Cap:
Well Disinfected Status: Not Disinfected
Drilling Method: Other
Method of determining elevation: Unknown
Static Water Level (BTOC): 175 feet btoc
Artesian Flow:
Artesian Pressure (head):
Artesian Pressure (PSI):
Orientation of Well: VERTICAL

Lithology

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Observations	Water Bearing Flow Estimate (USGPM)
0	175	till						
175	206	gravel						

Casing Details

From (ft bgl)	To (ft bgl)	Casing Type	Casing Material	Diameter (in)	Wall Thickness (in)	Drive Shoe
There are no records to show						

Surface Seal and Backfill Details

Surface Seal Material: Other
Surface Seal Installation Method:
Surface Seal Thickness:
Surface Seal Depth:
Backfill Material Above Surface Seal:
Backfill Depth:

Liner Details

Liner Material:
Liner Diameter:
Liner from:
Liner Thickness:
Liner to:

Liner perforations

From (ft bgl)	To (ft bgl)
There are no records to show	

Screen Details

Intake Method:
Type:
Material: Other
Opening:
Bottom:

Installed Screens

From (ft bgl)	To (ft bgl)	Diameter (in)	Assembly Type	Slot Size
There are no records to show				

Well Development

Developed by:
Development Total Duration:

Well Yield

Estimation Method:
Static Water Level Before Test:
Hydrofracturing Performed: No
Estimation Rate:
Drawdown:
Increase in Yield Due to Hydrofracturing:
Estimation Duration:

Well Decommission Information

Reason for Decommission:
Sealant Material:
Decommission Details:
Method of Decommission:
Backfill Material:

Comments

RECOMMENDED PUMP SETTING 200FT. METHOD OF DRILLING = DRILLED

Alternative Specs Submitted: Yes

Documents

- WTN 62927_Well Record.pdf

Disclaimer

The information provided should not be used as a basis for making financial or any other commitments. The Government of British Columbia accepts no liability for the accuracy, availability, suitability, reliability, usability, completeness or timeliness of the data or graphical depictions rendered from the data.

Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 79203
Well Identification Plate Number:
Owner Name: ALAN WILAMS
Intended Water Use: Private Domestic
Artesian Condition: No

Well Status: New
Well Class: Water Supply
Well Subclass:
Aquifer Number:

Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Alternative specs submitted: No

Licensing Information

Licensed Status: Unlicensed

Licence Number:

Location Information

Street Address: HWY 6 WEST & GUEST RD
Town/City:

Legal Description:

Lot	8
Plan	26667
District Lot	1421
Block	
Section	
Township	
Range	
Land District	
Property Identification Description (PID)	

Description of Well Location:

Geographic Coordinates - North American Datum of 1983 (NAD 83)
Latitude: 53.891036 **Longitude:** -123.539042
UTM Easting: 464574 **UTM Northing:** 5971533
Zone: 10
Coordinate Acquisition Code: unknown, accuracy based on parcel size) ICF cadastre, poor or no location sketch, arbitrarily located in center of parcel

Well Activity

Activity	Work Start Date	Work End Date	Drilling Company	Date Entered
Legacy record	1999-06-01	1999-06-01	Pine Drilling	August 13th 2003 at 9:31 AM

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
1999-06-01	1999-06-01				

Well Completion Data

Total Depth Drilled:
Finished Well Depth: 198 ft bgl
Final Casing Stick Up:
Depth to Bedrock:
Ground elevation:

Estimated Well Yield: 0 USgpm
Well Cap:
Well Disinfected Status: Not Disinfected
Drilling Method:
Method of determining elevation: Unknown

Static Water Level (BTOC): 162 feet btoc
Artesian Flow:
Artesian Pressure (head):
Artesian Pressure (PSI):
Orientation of Well: VERTICAL

Lithology

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Observations	Water Bearing Flow Estimate (USGPM)
0	6	MOSTLY GRAVEL						
6	80	MOSTLY CLAY SOME GRAVEL						
80	90	MORE GRAVEL						
90	114	DARK CLAY						
114	122	BROWN CLAY & GRIT						
122	198	SAND & GRAVEL TO MORE GRAVEL						

Casing Details

From (ft bgl)	To (ft bgl)	Casing Type	Casing Material	Diameter (in)	Wall Thickness (in)	Drive Shoe
				0		

Surface Seal and Backfill Details

Surface Seal Material:
Surface Seal Installation Method:
Surface Seal Thickness:
Surface Seal Depth:

Backfill Material Above Surface Seal:
Backfill Depth:

Liner Details

Liner Material:
Liner Diameter:
Liner from:

Liner Thickness:
Liner to:

Liner perforations

From (ft bgl)	To (ft bgl)
There are no records to show	

Screen Details

Intake Method:
Type:
Material:
Opening:
Bottom:

Installed Screens

From (ft bgl)	To (ft bgl)	Diameter (in)	Assembly Type	Slot Size
194.00	198.00			25.00

Well Development

Developed by:

Development Total Duration:

Well Yield

Estimation Method:
Static Water Level Before Test:
Hydrofracturing Performed: No

Estimation Rate:
Drawdown:
Increase in Yield Due to Hydrofracturing:

Estimation Duration:

Well Decommission Information

Reason for Decommission:
Sealant Material:
Decommission Details:

Method of Decommission:
Backfill Material:

Comments

SCREEN RISER & PARKER 6'2"

Alternative Specs Submitted: Yes

Documents

- WTN 79203_Well Record.pdf

Disclaimer

The information provided should not be used as a basis for making financial or any other commitments. The Government of British Columbia accepts no liability for the accuracy, availability, suitability, reliability, usability, completeness or timeliness of the data or graphical depictions rendered from the data.

Groundwater Wells and Aquifers

Well Summary

Well Tag Number: 56111
Well Identification Plate Number:
Owner Name: DAVE APPLETON
Intended Water Use: Private Domestic
Artesian Condition: No

Well Status: New
Well Class: Water Supply
Well Subclass:
Aquifer Number:

Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Alternative specs submitted: No

Licensing Information

Licensed Status: Unlicensed

Licence Number:

Location Information

Street Address: GUEST ROAD
Town/City: VANDERHOOF

Legal Description:

Lot	1
Plan	26667
District Lot	1421
Block	
Section	
Township	
Range	
Land District	05
Property Identification Description (PID)	

Description of Well Location:

Geographic Coordinates - North American Datum of 1983 (NAD 83)
Latitude: 53.890743 **Longitude:** -123.534199
UTM Easting: 464892 **UTM Northing:** 5971498
Zone: 10 **Coordinate Acquisition Code:** (50 m accuracy) Digitized from 1:20,000 mapping

Well Activity

Activity	Work Start Date	Work End Date	Drilling Company	Date Entered
Legacy record	1986-06-16		Cariboo Water Wells	August 13th 2003 at 8:28 AM

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
1986-06-16					

Well Completion Data

Total Depth Drilled:
Finished Well Depth: 220 ft bgl
Final Casing Stick Up:
Depth to Bedrock:
Ground elevation:

Estimated Well Yield: 10 USgpm
Well Cap:
Well Disinfected Status: Not Disinfected
Drilling Method: Other
Method of determining elevation: Unknown

Static Water Level (BTOC):
Artesian Flow:
Artesian Pressure (head):
Artesian Pressure (PSI):
Orientation of Well: VERTICAL

Lithology

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Observations	Water Bearing Flow Estimate (USGPM)
0	60	GLACIEL TILL						
60	160	DRY GRAVEL AND TILL LAYERS						
160	180	SILTY SAND						
180	215	DIRTY GRAVEL						
215	220	SAND AND GRAVELS						

Casing Details

From (ft bgl)	To (ft bgl)	Casing Type	Casing Material	Diameter (in)	Wall Thickness (in)	Drive Shoe
There are no records to show						

Surface Seal and Backfill Details

Surface Seal Material: Other
Surface Seal Installation Method:
Surface Seal Thickness:
Surface Seal Depth:

Backfill Material Above Surface Seal:
Backfill Depth:

Liner Details

Liner Material:
Liner Diameter:
Liner from:

Liner Thickness:
Liner to:

Liner perforations

From (ft bgl)	To (ft bgl)
There are no records to show	

Screen Details

Intake Method:
Type:
Material: Other
Opening:
Bottom:

Installed Screens

From (ft bgl)	To (ft bgl)	Diameter (in)	Assembly Type	Slot Size
There are no records to show				

Well Development

Developed by:

Development Total Duration:

Well Yield

Estimation Method:
Static Water Level Before Test:
Hydrofracturing Performed: No

Estimation Rate:
Drawdown:
Increase in Yield Due to Hydrofracturing:

Estimation Duration:

Well Decommission Information

Reason for Decommission:
Sealant Material:
Decommission Details:

Method of Decommission:
Backfill Material:

Comments

METHOD OF DRILLING = DRILLED

Alternative Specs Submitted: Yes

Documents

- WTN 56111_Well Record.pdf

Disclaimer

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Appendix B

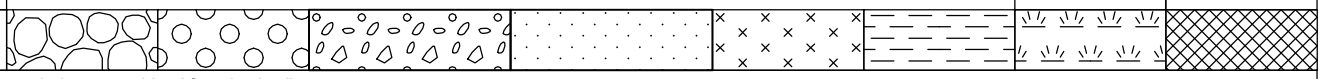
Ecora 2021 & 2022 Site Investigation Logs

TERMS, SYMBOLS AND ABBREVIATIONS USED ON BOREHOLE & TEST PIT LOGS

SOIL DESCRIPTION SEQUENCE OF TERMS - consistency - fraction - grading - moisture - plasticity - additional

The visual field description and classification of soils is made in accordance with the Canadian Foundation Engineering Manual 4th Edition (Canadian Geotechnical Society, 2006) and the International Association of Engineering Bulletin, Rock and Soil Description and Classification for Engineering Geological Mapping (1981) with the exception of particle size criteria which is made on the basis of ASTM D2487-06 Standard Practice for Classification of Soils for Engineering Purposes.

PARTICLE SIZE CRITERIA & GRAPHIC SYMBOL

TYPE	COARSE							FINE		ORGANIC	FILL
	Boulders	Cobbles	Gravel		Sand			Silt	Clay	Organic Soil	Fill
			coarse	fine	coarse	medium	fine				
Size Range (mm)	200	75	19		4.75	2	0.475	0.075	0.002		
Graphic Symbol											

Notes: 1.) Graphic symbols are combined for mixed soil types.
2.) The upper particle size for clay is as per the Canadian Foundation Engineering Manual.

PROPORTIONAL TERMS

FRACTION	TERM	% OF SOIL MASS	EXAMPLE
Major	(....) and (.....) (UPPER CASE)	35 to 50	GRAVEL
Subordinate	(....) y (lower case)	20 to 35	sandy
Minor	some (....) (lower case)	10 to 20	some clay
	trace (....) (lower case)	less than 10	trace silt

CONSISTENCY TERMS FOR GRANULAR SOILS

DESCRIPTIVE TERM	SPT 'N' VALUE (BLOWS / 300 mm)	DYNAMIC CONE (SCALA) (BLOWS / 100 mm)
very loose	< 4	0 to 2
loose	4 to 10	1 to 3
compact	10 to 30	3 to 7
dense	30 to 50	7 to 17
very dense	> 50	> 17

Notes: 1.) No correlation implied between the SPT and Scala Penetrometer.
2.) SPT 'N' values are uncorrected.

PLASTICITY TERMS FOR COHESIVE SOILS

TERM	DESCRIPTION
high plasticity	Can be moulded or deformed over a wide range of moisture contents without cracking or showing any tendancy to change volume.
medium plasticity	Can be moulded over a wide range of moisture contents however will crack at low moisture contents.
low plasticity	Can be moulded in fingers when moist however crumbles.
non plastic	Has no ability to be moulded at any moisture content, may show quick or dilatant behavior.

SENSITIVITY TERMS FOR COHESIVE SOILS

TERM	S_t RATIO OF PEAK/REMOULDED UNDRAINED SHEAR STRENGTH
quick clay	$S_t > 16$
extra sensitive	$8 < S_t < 16$
sensitive	$4 < S_t < 8$
medium sensitivity	$2 < S_t < 4$
low sensitivity	$S_t < 2$

CONSISTENCY TERMS FOR COHESIVE SOILS

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	FIELD DIAGNOSTIC CHARACTERISTICS
very soft	< 12	Easily exudes between fingers when squeezed.
soft	12 to 25	Easily indented by fingers.
firm	25 to 50	Can be indented by strong finger or thumb pressure.
stiff	50 to 100	Cannot be indented by thumb pressure.
very stiff	100 to 200	Can be indented by thumb nail.
hard	200 to 500	Difficult to indent by thumb nail.

MOISTURE CONDITION

DESCRIPTIVE TERM	CONDITION	FIELD DIAGNOSTIC CHARACTERISTICS	
		COHESIVE SOILS	GRANULAR SOILS
dry	Looks and feels dry.	Hard, powdery or friable.	Runs freely through hands.
moist	Feels cool, darkened in colour.	Weakened by moisture, but no free water on hands when remoulding.	Tend to cohere.
wet		Weakened by moisture, free forms water on hands when handling.	
saturated	Feels cool, darkened in colour and free water is present on the sample.		

GRADING TERMS FOR GRANULAR SOILS

TERM	DESCRIPTION	
well graded	Good representation of all particle sizes from largest to smallest.	
poorly graded	Limited representation of grain sizes - further divided into:	
	uniformly graded	Most particles about the same size.
	gap graded	Absence of one or more intermediate sizes.

SAMPLE TYPE

TERM	DESCRIPTION
B	Bulk disturbed sample.
C	Core sample obtained with the use of standard size coring bits.
D	Small disturbed sample.
P	Piston sampler
S	Split spoon sample (obtained by performing the Standard Penetration Test)
T	Shelby tube or thin wall tube.

WATER LEVEL

SYMBOL	DESCRIPTION
▼	Measured in a standpipe, piezometer, or well.
▽	Inferred.

SUMMARY LOG

Drill Hole #: **TH21-01**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13
Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971633 , 464811 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-19

Company: Geotech Drilling

Driller: Pat Ross

Drill Make/Model: Fraste MDXL

Drilling Method: Solid Stem Auger

DEPTH (m)	DRILLING DETAILS (T / G / S)	Pocket Penetrometer ✕ / Shear Strength (kPa) ✕ 100 200 300 400 ; ▲ SPT "N" (BLOWS/300 mm) ▲ ; W_P % 20 ; W% 40 60 ; W_L % 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							Topsoil, organics, rootlets. 0.1m			0
							Sandy SILT, trace gravel; fine grained sand, compact to very dense, light brown, dry.			
1		2		GS01-1					**Sieve** (Sa#GS01-1) G:1% S:20% F:79%	1
		8		GS01-2						
2										2
		10		GS01-3						
3		21 27 33 31 ; 14 ; 60		SPT01-1					**Sieve** (Sa#SPT01-1) G:17% S:34% F:49%	3
4		5		GS01-4			SAND and SILT; trace to some gravel, fine to coarse sand, rounded to subrounded gravel, brown, moist. 4.0m			4
5		19		GS01-5						5
6							Sandy SILT; some gravel, thinly layered fine grain sand lenses, rounded gravel, dense. 6.0m			6
7		7 14 23 41 ; 18 ; 37		SPT01-2 GS01-6						7
							Gravelly SILT and SAND; well graded, some organics, compact, brown, dry to moist. 7.5m			
8		6		GS01-7						8
9		R		SPT01-3			Silty SAND and GRAVEL; well graded, fine to coarse sand, rounded gravel, dense to very dense, brown, dry. 9.0m			9
		8		GS01-8					**Sieve** (Sa#GS01-8) G:36% S:37% F:27%	
10										

Legend
Sample Type: **A**-Auger **B**-Becker **C**-Core **G**-Grab **V**-Vane **L#**-Lab Sample **S**-Split Spoon **O**-Odex (air rotary) **W**-Wash (mud return) **T**-Shelby Tube

Final Depth of Hole: 12.2 m
Depth to Top of Rock:

SUMMARY LOG

Drill Hole #: **TH21-01**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971633 , 464811 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-19

Company: Geotech Drilling

Driller: Pat Ross

Drill Make/Model: Fraste MDXL

Drilling Method: Solid Stem Auger

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer ✕ Shear Strength (kPa) 100 200 300 400 / SPT "N" (BLOWS/300 mm) W P% 20 W% 40 60 W L% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
10			SPT	SPT01-4			Silty SAND and GRAVEL; well graded, fine to coarse sand, rounded gravel, dense to very dense, brown, dry. *(continued)*			10
11		60 for 60 mm	GS	GS01-9						11
12							12.2m End of hole at 12.19 m.			12
13										13
14										14
15										15
16										16
17										17
18										18
19										19
20										

Legend Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 12.2 m

Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

SUMMARY LOG

Drill Hole #: **TH21-02**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13
Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971598 , 464812 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-18

Company: Geotech Drilling

Driller: Pat Ross

Drill Make/Model: Fraste MDXL

Drilling Method: Solid Stem Auger

DEPTH (m)	DRILLING DETAILS (G S F T)	Pocket Penetrometer ✕ / Shear Strength (kPa) ✕ 100 200 300 400 ; ▲ SPT "N" (BLOWS/300 mm) ▲ ; W P% 20 ; W% 40 60 ; W L% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							SAND and GRAVEL; loose, brown, dry.			0
		5		GS02-1						
0.75m										
1		14		GS02-2			SAND and SILT; some gravel to gravelly, fine sand, rounded gravel, very dense, brown, dry.			1
2										2
		9		GS02-3					**Sieve** (Sa#GS02-3) G:23% S:39% F:39%	
3	34 38 67	12	>> ▲ 105	SPT02-1						3
4										4
4.5m							SAND and SILT to silty SAND; trace to some gravel, firm, non-plastic, brown, moist to wet.			
5										5
5.3m ▼							Inferred water table at 5.3 m depth.			
				GS02-4						
6.0m							Clayey SAND and SILT; trace gravel, hard, medium plastic, brown, wet.			
6										6
7	7 14 23 41	15 37 22		GS02-5					**Atterberg** (Sa#GS02-5): PL:15% LL:32% **Sieve** (Sa#GS02-5) G:8% S:43% F:49% Clay:19% Silt:30%	7
7.5m				SPT02-2			Silty SAND, some clay, trace gravel, dense, brown, moist to wet. Sand lens 20 mm thick at 7.8 m depth.			
8.0m							SILT and SAND; soft, brown, wet.			8
8										
		17		GS02-6						
9.1m							End of hole at 9.1 m.			9
9										
10										

Legend
Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 9.1 m
Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

SUMMARY LOG

Drill Hole #: **TH21-03**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971696 , 464565 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-18

Company: Geotech Drilling

Driller: Pat Ross

Drill Make/Model: Fraste MDXL

Drilling Method: Solid Stem Auger

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer ✕ / Shear Strength (kPa) 100 200 300 400 ▲ SPT "N" (BLOWS/300 mm) ▲ Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							Asphalt.			0
							0.25m			
		6		GS03-1			SAND and GRAVEL, trace fines; some cobbles, rounded gravel, well graded, loose to compact, brown, moist.		**Sieve** (Sa#GS03-1) G:39% S:53% F:8%	
1										1
2										2
3										3
4										4
							1.5m			
5							End of hole at 1.52 m.			

Legend Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 1.5 m

Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

Ministry of Transportation and Infrastructure

SUMMARY LOG

Drill Hole #: **TH21-04**

Project: **Guest and Shallow Bay**
Location: Highway 16
Datum: 10U, NAD83
Northing/Easting: 5971598 , 464664
Elevation:
Alignment:
Station/Offset:
Coordinates taken with GPS

Date(s) Drilled: 2021-08-18
Company: Geotech Drilling
Driller: Pat Ross
Drill Make/Model: Fraste MDXL
Drilling Method: Solid Stem Auger

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group
Logged by: TB Reviewed by: DB

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer ✕ / Shear Strength (kPa) 100 200 300 400 ▲ SPT "N" (BLOWS/300 mm) ▲ Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0		2		GS04-1			Asphalt. 0.09m Silty, gravelly SAND trace to some cobbles, well graded, very dense, brown, moist.			0
		30 34 29 31		SPT04-1						
		4 63 ▲								
1		9		GS04-2					**Sieve** (Sa#GS04-2) G:25% S:45% F:30%	1
							1.5m End of hole at 1.52 m.			
2										2
3										3
4										4
5										

Legend
Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 1.5 m
Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

SUMMARY LOG

Drill Hole #: **TH21-05**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971693 , 464676 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-18

Company: Geotech Drilling

Driller: Pat Ross

Drill Make/Model: Fraste MDXL

Drilling Method: Solid Stem Auger

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer ✕ / Shear Strength (kPa) ✕ 100 200 300 400 ; SPT "N" (BLOWS/300 mm) ▲ ; W P% 20 W% 40 60 W L% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							SILT and SAND, trace gravel; loose to compact, well graded, brown, moist.			0
1		14		GS05-1					**Sieve** (Sa#GS05-1) G:2% S:36% F:62%	1
							1.5m End of hole at 1.52 m.			
2										2
3										3
4										4
5										

Legend

Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 1.5 m

Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

SUMMARY LOG

Drill Hole #: **TH21-06**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971612 , 465134 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-18

Company: Geotech Drilling

Driller: Pat Ross

Drill Make/Model: Fraste MDXL

Drilling Method: Solid Stem Auger

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) / SPT "N" (BLOWS/300 mm) / W P% / W% / W L%	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							Asphalt.			0
							0.25m			
		2		GS06-1			SAND and GRAVEL; dense, well graded grey to brown. Inferred granular base.		**Sieve** (Sa#GS06-1) G:47% S:48% F:5%	
							0.35m			
							SAND and GRAVEL, trace fines; dense, well graded grey to brown. Inferred subbase.			
							0.45m			
							SAND and GRAVEL; dense to very dense, occasional silt pockets, non-plastic, grey, dry.			
1		39 42 52		SPT06-1						1
		6			94					
		14		GS06-2						
							1.2m			
							SILT and SAND; some gravel, fine grain sand, brown.			
		14		GS06-3					**Sieve** (Sa#GS06-3) G:14% S:39% F:47%	
							1.5m			
							End of hole at 1.52 m.			
2										2
3										3
4										4
5										

Legend

Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 1.5 m

Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

SUMMARY LOG

Drill Hole #: **TH21-07**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971608 , 465255 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-18

Company: Geotech Drilling

Driller: Pat Ross

Drill Make/Model: Fraste MDXL

Drilling Method: Solid Stem Auger

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); Wp % 20; W% 40 60; WL % 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							Asphalt.			0
							0.15m Cobbly SAND and SILT; some gravel, compact, brown.			
							0.3m CLAY and SILT to SILT and CLAY, trace sand, trace gravel; firm, medium plastic, brown.		**Sieve** (Sa#GS07-1) G:1% S:8% F:92% Clay:47% Silt:45%	
1		21		GS07-1						1
		31		GS07-2					**Atterberg** (Sa#GS07-2): PL:21% LL:41% **Sieve** (Sa#GS07-2) G:0% S:1% F:99% Clay:47% Silt:53%	
							1.5m End of hole at 1.52 m.			
2										2
3										3
4										4
5										

Legend

Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 1.5 m

Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

SUMMARY LOG

Drill Hole #: **TH21-08**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971648 , 465341 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-18

Company: Geotech Drilling

Driller: Pat Ross

Drill Make/Model: Fraste MDXL

Drilling Method: Solid Stem Auger

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer ✕ / Shear Strength (kPa) ✖ 100 200 300 400 ; SPT "N" (BLOWS/300 mm) ▲ ; W P % 20 W% 40 60 W L % 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							Asphalt. 0.06m			0
							SAND and GRAVEL; dense, well graded, brown, inferred granular base and subbase. 0.2m			
							SAND and GRAVEL, trace fines; rounded gravel, well graded, dense, brown.			
		5		GS08-1					**Sieve** (Sa#GS08-1) G:41% S:51% F:8%	
1							1.0m			1
		13		GS08-2			SILT and SAND; some gravel, compact, grey.		**Sieve** (Sa#GS08-2) G:14% S:36% F:51%	
							1.5m End of hole at 1.52 m.			
2										2
3										3
4										4
5										

Legend

Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 1.5 m

Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

SUMMARY LOG

Drill Hole #: **TH21-09**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971654 , 465396 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-18

Company: Geotech Drilling

Driller: Pat Ross

Drill Make/Model: Fraste MDXL

Drilling Method: Solid Stem Auger

DEPTH (m)	DRILLING DETAILS (G S F)	Pocket Penetrometer ✕ / Shear Strength (kPa) 100 200 300 400 ; ▲ SPT "N" (BLOWS/300 mm) ▲ ; W P % 20 W% 40 60 W L % 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							Asphalt.			0
							0.24m			
	22 25 24 18	3 49		SPT09-1			SAND and GRAVEL; some fines, well graded, subrounded gravel, dense, brown to grey.		**Sieve** (Sa#SPT09-1) G:38% S:52% F:11%	
1		7		GS09-1			0.95m Inferred cobble or boulder. 1.0m			1
		19		GS09-2			Sandy SILT, trace gravel; trace woody debris, rounded gravel, brown to grey.		**Sieve** (Sa#GS09-2) G:8% S:22% F:71%	
							1.5m End of hole at 1.52 m.			
2										2
3										3
4										4
5										

Legend Sample Type: **A**-Auger **B**-Becker **C**-Core **G**-Grab **V**-Vane **L#**-Lab Sample **S**-Split Spoon **O**-Odex (air rotary) **W**-Wash (mud return) **T**-Shelby Tube

Final Depth of Hole: 1.5 m

Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

TEST PIT LOG

Test Pit #: **TP21-01**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Datum: 10U, NAD83

Northing/Easting: 5971701 , 464572

Elevation:

Alignment:

Station/Offset:

Coordinates taken with GPS

Date(s) Drilled: 2021-08-20

Company: N/A

Operator: Darcy Tiani

Excavator: XCMG XE250UF

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer ✕ / Shear Strength (kPa) ✕ 100 200 300 400 ▲ SPT "N" (BLOWS/300 mm) ▲ Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							Gravelly SAND; some silt, trace cobbles, well graded, brown, moist.			0
1		7		GS01-1						1
							1.7m SILT and CLAY, trace sand, low plastic to medium plastic, firm, brown, moist.			
2		33		GS01-2					**Sieve** (Sa#GS01-2) G:0% S:1% F:99% Clay:39% Silt:60%	2
3							3.0m End of hole at 3 m.			3
4										4
5										

Legend

Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 3.0 m

Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

TEST PIT LOG

Test Pit #: **TP21-02**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971634 , 464723 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-20

Company: N/A

Operator: Darcy Tiani

Excavator: XCMG XE250UF

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer (kPa) / Shear Strength (kPa) / SPT "N" (BLOWS/300 mm) / W_P % / W% / W_L %	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							Gravelly SAND; some silt, well graded, subrounded to subangular gravel, brown, moist.			0
				GS02-1						
1										1
							1.7m SILT and SAND, some gravel, firm, brown, moist.			
2		46		GS02-2					**Sieve** (Sa#GS02-2) G:12% S:42% F:46%	2
							2.4m Excavator on slope, hole terminated at 2.4 m due to reach.			
3										3
4										4
5										

Legend

Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 2.4 m

Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

TEST PIT LOG

Test Pit #: **TP21-03**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971589 , 465027 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-20

Company: N/A

Operator: Darcy Tiani

Excavator: XCMG XE250UF

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer ✕ / Shear Strength (kPa) ✕ 100 200 300 400; SPT "N" (BLOWS/300 mm) ▲; W P% 20 W% 40 60 W L% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate *{G % S % F %}*	DEPTH (m)
0							Gravelly SAND; some silt, well graded, subrounded gravel, fine sand, brown, moist.			0
							0.45m Asphalt layer.			
				GS03-2			0.55m Gravelly SAND; some silt, well graded, subrounded gravel, fine sand, brown, moist.			
		5		GS03-1						
1							1.3m SILT; trace to some sand, interbedded fine grained sand layers, brown, moist.			1
							1.7m Sandy, gravelly SILT; brown, moist.			
2										2
3		8		GS03-3					**Sieve** (Sa#GS03-3) G:29% S:34% F:37%	3
							3.4m End of hole at 3.4 m.			
4										4
5										

Legend

Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 3.4 m

Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

TEST PIT LOG

Test Pit #: **TP21-04**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971604 , 465154 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-20

Company: N/A

Operator: Darcy Tiani

Excavator: XCMG XE250UF

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer (kPa) / Shear Strength (kPa) / SPT "N" (BLOWS/300 mm) / W_P % / W% / W_L %	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							Gravelly SAND, trace silt; medium to coarse grained sand, subrounded gravel, loose to compact, brown, moist.			0
		5		GS04-1					**Sieve** (Sa#GS04-1) G:31% S:61% F:8%	
1							1.1m SILT and CLAY; trace sand, flaky, medium plastic, brown, moist.			1
		30		GS04-2			Blue-grey layer from 1.5 m to 1.9 m depth.		**Atterberg** (Sa#GS04-2): PL:22% LL:41% **Sieve** (Sa#GS04-2) G:0% S:2% F:98% Clay:47% Silt:51%	
				GS04-3						
2										2
3							3.5m End of hole at 3.5 m.			3
4										4
5										

Legend

Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 3.5 m

Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

TEST PIT LOG

Test Pit #: **TP21-05**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Date(s) Drilled: 2021-08-20

Company: N/A

Operator: Darcy Tiani

Excavator: XCMG XE250UF

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971632 , 465296 Station/Offset:

Elevation: *Coordinates taken with GPS*

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer ✕ / Shear Strength (kPa) ✕ 100 200 300 400 ; SPT "N" (BLOWS/300 mm) ▲ ; W_P % 20 ; W% 40 60 ; W_L % 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							Gravelly SAND, trace silt; loose to compact, subrounded gravel, medium to coarse sand, brown, moist.			0
1		6		GS05-1					**Sieve** (Sa#GS05-1) G:32% S:62% F:6%	1
							1.2m Sandy CLAY and SILT, trace gravel, non-plastic, laminated, brown, moist.			
2		21		GS05-2					**Sieve** (Sa#GS05-2) G:3% S:23% F:74% Clay:38% Silt:36%	2
3							Cobbles up to 250 mm diameter below 2.5 m depth.			3
							3.6m End of hole at 3.6 m.			
4										4
5										

Legend Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 3.6 m

Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

TEST PIT LOG

Test Pit #: **TP21-06**

Ministry of Transportation and Infrastructure

Project: **Guest and Shallow Bay**

Location: Highway 16

Prepared by: GK-18-750-MOT-13 Ecora Engineering and Resource Group

Logged by: TB Reviewed by: DB

Datum: 10U, NAD83 Alignment:

Northing/Easting: 5971672 , 465428 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: 2021-08-20

Company: N/A

Operator: Darcy Tiani

Excavator: XCMG XE250UF

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer ✕ Shear Strength (kPa) 100 200 300 400 / SPT "N" (BLOWS/300 mm) ▲ W P% 20 W% 40 60 W L % 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate *{G % S % F %}*	DEPTH (m)
0							SAND; some gravel to gravelly, trace silt, medium to coarse sand, subangular gravel, occasional cobbles, brown, moist.			0
				GS06-1						
1										1
							1.7m			
							Silty, gravelly SAND; subangular gravel, brown, moist.			
2				GS06-2					**Sieve** (Sa#GS06-2) G:26% S:40% F:34%	2
3										3
							3.4m			
							End of hole at 3.4 m.			
4										4
5										

Legend Sample Type: **A**-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 3.4 m

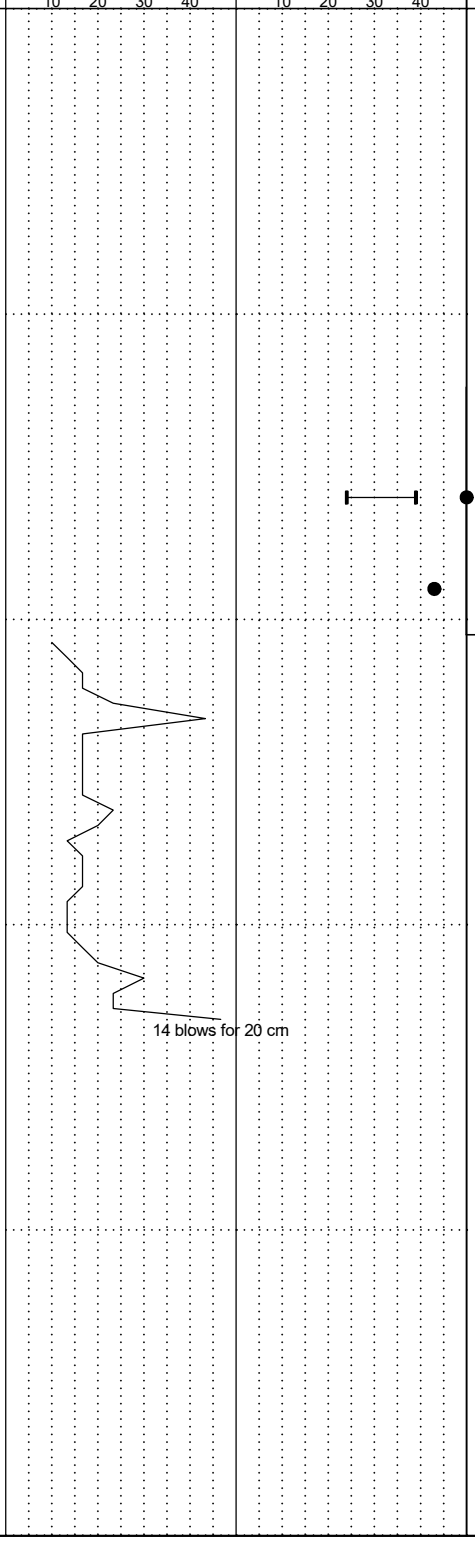
Depth to Top of Rock:

MOTI-SOIL-REV3 GK-18-750-MOT-13.GPJ MOTI_DATATEMPLATE_REV3.GDT 6/16/22

HAND AUGER: HA22-01

Project: HWY16 - Guest Road/Shallow Bay
Project No: 212111
Location: Highway 16
Client: MoTI
Zone: 10U Northing: 5971635.98 Easting: 464833.37 Elevation: 776 m

DEPTH (m)	DRILLING METHOD	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	SAMPLE TYPE	SAMPLE NUMBER	PARTICLE SIZE DISTRIBUTION GRAVEL (%)	SAND (%)	FINES (%)	STANDARD PENETRATION TEST (N)
			(ICE) (0 m to 0.59 m)						
			(WATER) (0.59 m to 1.2 m)						
1	Hand Auger		**CLAY (CH)** (1.2 m to 1.4 m) CLAY, very soft, no recovery.						
			CLAY (OH) (1.4 m to 1.8 m) CLAY, some silt, some organics, very soft, high plasticity, dark brown.	B	G1				
2			**CLAY (OH)** (1.8 m to 2.05 m) CLAY, some silt , trace organics, firm, medium to high plasticity, dark brown. Potential small gravel layer at end of hole.	B	G2	0.0	13.5	86.5	
			End of hole at 2.05 m depth. Scala from 2.05 m to 3.32 m depth.						



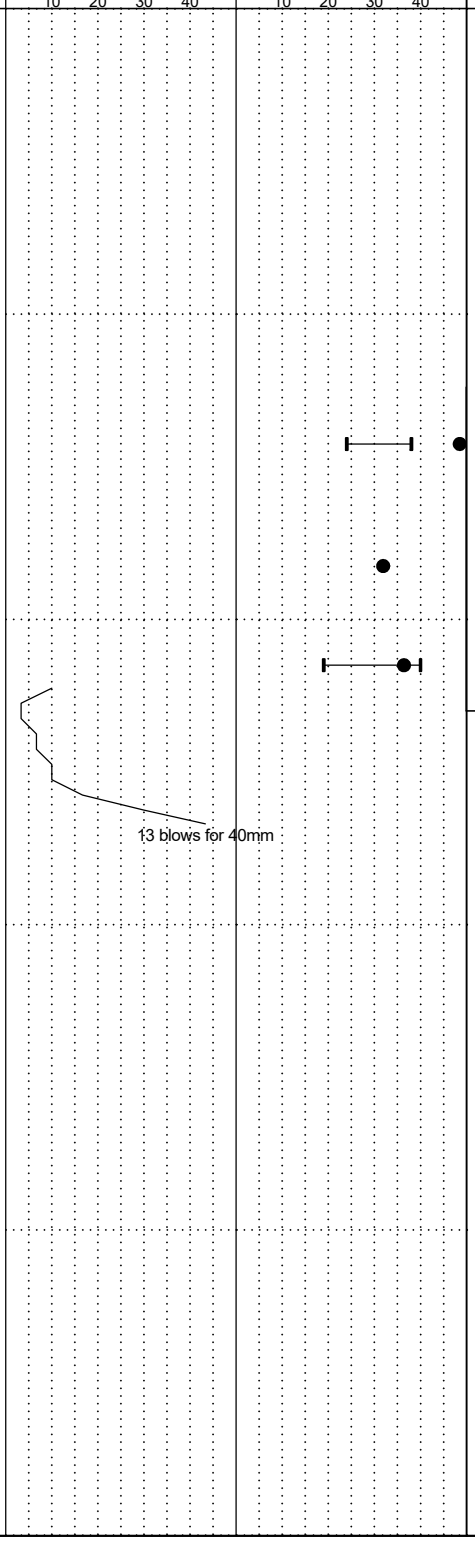
ELEVATION (m)

Contractor:
Drilling Rig Type: Hand Auger
Logged By: MB
Reviewed By: DB
Started: 2022-03-22
Completed: 2022-03-22
Hole Inclination: 90°
Hole Orientation: °
Completion Depth: 2.05m

HAND AUGER: HA22-02

Project: HWY16 - Guest Road/Shallow Bay
Project No: 212111
Location: Highway 16
Client: MoTI
Zone: 10U Northing: 5971635 Easting: 464840.12 Elevation: 776 m

DEPTH (m)	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	SAMPLE TYPE	SAMPLE NUMBER	GRAVEL (%)	SAND (%)	FINES (%)
	(ICE) (0 m to 0.54 m)					
	(WATER) (0.54 m to 1 m)					
1	**CLAY (CH)** (1 m to 1.2 m) CLAY, very soft, no recovery.					
	CLAY (OH) (1.2 m to 1.65 m) CLAY, some silt, some organics, soft, high plasticity, dark brown.	B	G1			
	CLAY (OH) (1.65 m to 2.3 m) CLAY, some silt , trace organics, firm, medium to high plasticity, dark brown.	B	G2	3.3	19.3	77.4
2		B	G3			
	End of hole at 2.3 m depth. Scala from 2.2 m to 2.69 m depth.					



Contractor: Logged By: MB Started: 2022-03-22 Hole Inclination: 90° Completion Depth: 2.3m
Drilling Rig Type: Hand Auger Reviewed By: DB Completed: 2022-03-22 Hole Orientation: ° Page 1 of 1

HAND AUGER: HA22-03

Project: HWY16 - Guest Road/Shallow Bay | Project No: 212111

Location: Highway 16 | Client: MoTI

Zone: 10U | Northing: 5971634.56 | Easting: 464846.61 | Elevation: 776 m

DEPTH (m)	DRILLING METHOD	GRAPHICAL LEGEND	DESCRIPTION (For Explanation of Terms, Symbols and Abbreviations See Attached Key Sheet)	SAMPLE TYPE	SAMPLE NUMBER	PARTICLE SIZE DISTRIBUTION GRAVEL (%)	SAND (%)	FINES (%)	STANDARD PENETRATION TEST (N)	ELEVATION (m)
			(ICE) (0 m to 0.47 m)							
			(WATER) (0.47 m to 0.64 m)							
			CLAY (OH) (0.64 m to 1 m) CLAY, very soft, no recovery.							
1			**CLAY (OH)** (1 m to 1.2 m) CLAY, some silt, some organics, soft, high plasticity, dark brown.	B	G1	0.0	5.8	94.2		
			CLAY (OH) (1.2 m to 1.6 m) CLAY, some silt , trace organics, firm, medium to high plasticity, dark brown.	B	G2					
			End of hole at 1.6 m depth.							

DYNAMIC CONE PENETRATION TEST (Blows/300mm): 10 20 30 40

SCALA PENETRATION TEST (Blows/50mm): 1 2 3 4

STANDARD PENETRATION TEST (N): 10 20 30 40

POCKET PEN. (kPa): 100 200 300 400

FIELD VANE (kPa): REMOULDED — PEAK; 40 80 120 160

PLASTIC — M.C. — LIQUID; 10 20 30 40

Contractor: | Logged By: MB | Started: 2022-03-22 | Hole Inclination: 90° | Completion Depth: 1.6m

Drilling Rig Type: Hand Auger | Reviewed By: DB | Completed: 2022-03-22 | Hole Orientation: ° | Page 1 of 1

Appendix C

Laboratory Test Results

Appendix C.1

Geotechnical Index Test Results

MOISTURE CONTENT TEST RESULTS

Project: Guest and Shallow Bay Road

Project Number: GK-18-750-MOT-13

Client: BC Ministry of Transportation & Infastructure

Sample No.: 21-350

Date Tested: Sept 20, 2021

Tested By: TB

B.H. Number	Sample Depth (m)	Tare Number	Tare Mass (g)	Mass of Wet Soil & Tare (g)	Mass of Dry Soil & Tare (g)	Moisture Content (%)	Additional Information
TH21-01	1.2 - 1.35	1	8.1	107.1	100.1	7.6%	
TH21-01	2.5 - 2.7	2	9.6	127.0	116.1	10.2%	
TH21-01	4 - 4.2	3	9.4	127.9	122.0	5.2%	
TH21-01	5.2 - 5.4	4	9.4	146.8	125.3	18.6%	
TH21-01	6.6 - 7.2	5	4.0	118.6	101.0	18.1%	
TH21-01	8.1 - 8.3	6	4.0	121.2	114.7	5.9%	
TH21-01	10.5 - 10.56	7	3.8	120.9	111.5	8.7%	
TH21-01	11 - 11.5	8	3.9	114.8	105.6	9.0%	
TH21-02	0.5 - 0.7	9	3.9	158.0	150.3	5.3%	
TH21-02	1 - 1.2	10	3.9	135.9	119.7	14.0%	
TH21-02	3 - 3.45	11	3.9	142.9	128.3	11.7%	
TH21-02	5.5 - 5.7	12	3.9	173.0	151.8	14.3%	
TH21-02	7.5 - 7.7	13	3.9	166.8	137.0	22.4%	
TH21-02	8.5 - 8.6	14	3.8	267.1	229.8	16.5%	
TH21-03	0.5 - 0.7	15	3.8	181.4	171.9	5.7%	
TH21-04	0 - 0.09	16	3.9	183.3	179.2	2.3%	
TH21-04	0.09 - 0.84	17	3.9	224.9	215.8	4.3%	
TH21-06	0.75 - 1.2	18	3.9	144.5	136.4	6.1%	
TH21-06	1 - 1.2	19	4.0	177.4	156.2	13.9%	
TH21-09	0.9 - 1.1	20	4.0	190.8	179.3	6.6%	
TP21-01	1 - 1.1	21	3.9	153.3	143.6	6.9%	
TP21-02	2 - 2.4	22	120.8	368.4	338.4	13.8%	
TP21-03	0.7 - 0.8	23	103.4	376.1	364.1	4.6%	

MOISTURE CONTENT TEST RESULTS

Project:	Hwy 16: Guest Raod & Shallow Bay	Sample No.:	22-194
Project Number:	212111	Date Tested:	April 11, 2022
Client:	British Columbia Ministry of	Tested By:	SQ
	Transportation and Infastructure	Page:	1 of 1

B.H. Number	Sample Depth (m)	Tare Number	Tare Mass (g)	Mass of Wet Soil & Tare (g)	Mass of Dry Soil & Tare (g)	Moisture Content (%)	Additional Information
HA22-01	1.4-1.8	1	369.4	1593.2	1185.2	50.0%	
HA22-01	1.8-2.0	2	390.1	1063.8	861.3	43.0%	
HA22-02	1.2-1.65	3	392.3	1430.5	1091.3	48.5%	
HA22-02	1.65-2.0	4	389.6	1930.9	1557.8	31.9%	
HA22-02	2.0-2.2	5	390.1	1528.8	1225.0	36.4%	
HA22-03	1.0-1.2	6	392.1	1282.0	1021.6	41.4%	
HA22-03	1.2-1.6	7	392.0	1350.9	1100.8	35.3%	

ATTERBERG LIMITS ASTM D4318

Project: Guest/Shallow Bay Intersection Improvements
Location: Guest Road at Highway 16
Sample Location/Source: TH21-02 at 7.3 - 7.5 m

Project No.: GK-18-750-MOT-13
Client: BC Minsitry of Trnsportation & Infastructure

LIQUID LIMIT (ASTM Designation D 423)

Trial Number	1	2	3
Tare Number	L1	L2	L3
Number of Blows	16	26	45
Mass of Wet Soil and Tare (g)	39.5	39.9	36.7
Mass of Dry Soil and Tare (g)	33.5	34.2	32.3
Mass of Tare (g)	15.8	15.8	16
Mass of Moisture (g)	6	5.7	4.4
Mass of Dry Soil (g)	17.7	18.4	16.3
Moisture Content(%)	33.9	31.0	27.0

PLASTIC LIMIT (ASTM Designation D 424)

Trial Number	1	2
Tare Number	P1	P2
Mass of Wet Soil and Tare (g)	21.3	21.4
Mass of Dry Soil and Tare (g)	20.6	20.7
Mass of Tare (g)	16.00	16
Mass of Moisture (g)	0.7	0.7
Mass of Dry Soil (g)	4.6	4.7
Moisture Content (%)	15.2	14.9

Test Results

Liquid Limit: **32**
Plastic Limit: **15**
Plasticity Index: 17

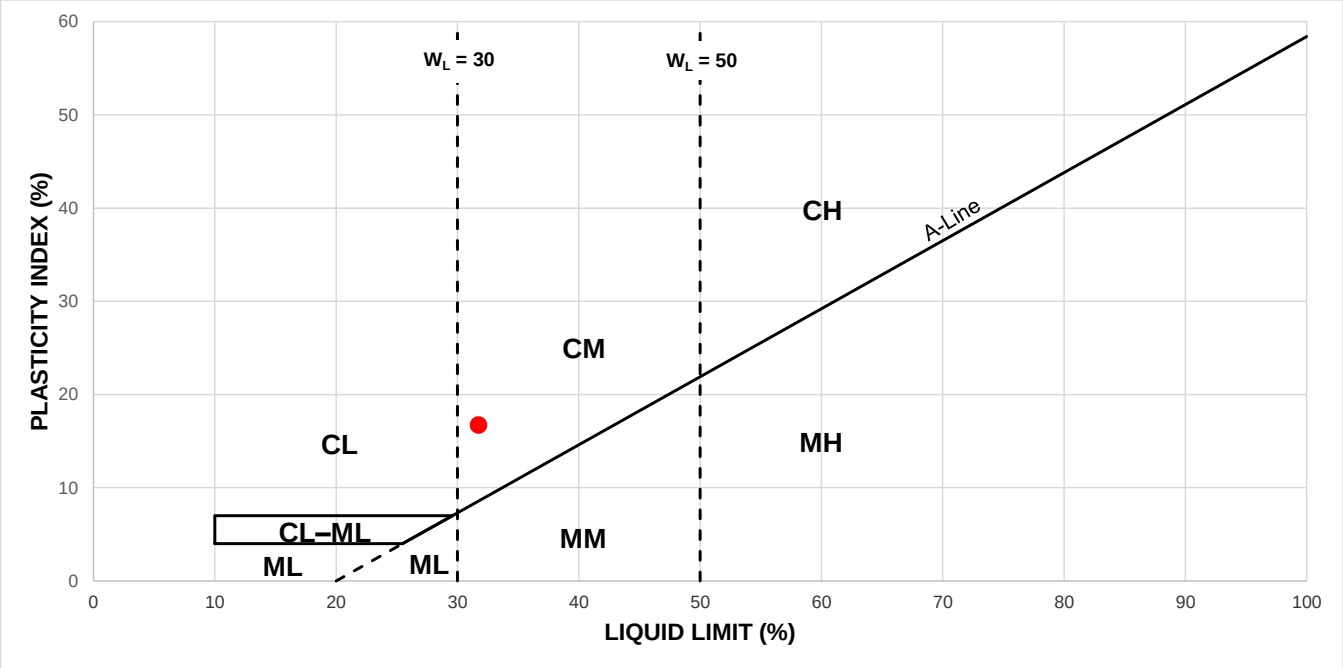
Plasticity Classification (based on Liquid Limit W_L)

0 to 30 Low Plasticity
30 to 50 Medium Plasticity
> 50 High Plasticity

Sample Description: CM - Medium Plastic Clay
Natural Moisture Content: 14.8%

Comments:

Sample Number: 21-355
Date Tested: 23-Sep-2021
Tested by: AE
Checked by: SK



ATTERBERG LIMITS ASTM D4318

Project: Guest/Shallow Bay Intersection Improvements
Location: Guest Road at Highway 16
Sample Location/Source: TH21-07 at 1.0 - 1.2 m

Project No.: GK-18-750-MOT-13
Client: BC Minsitry of Trnsportation & Infastructure

LIQUID LIMIT (ASTM Designation D 423)

Trial Number	1	2	3
Tare Number	L1	L2	L3
Number of Blows	31	25	17
Mass of Wet Soil and Tare (g)	24.96	26.29	27.59
Mass of Dry Soil and Tare (g)	18.98	19.83	20.54
Mass of Tare (g)	3.94	3.99	3.89
Mass of Moisture (g)	5.98	6.46	7.05
Mass of Dry Soil (g)	15.04	15.84	16.65
Moisture Content(%)	39.8	40.8	42.3

PLASTIC LIMIT (ASTM Designation D 424)

Trial Number	1	2
Tare Number	P1	P2
Mass of Wet Soil and Tare (g)	10.32	9.7
Mass of Dry Soil and Tare (g)	9.28	8.64
Mass of Tare (g)	4.21	3.9
Mass of Moisture (g)	5.07	4.74
Mass of Dry Soil (g)	1.04	1.06
Moisture Content (%)	20.5	22.4

Test Results

Liquid Limit: **41**
Plastic Limit: **21**
Plasticity Index: 19

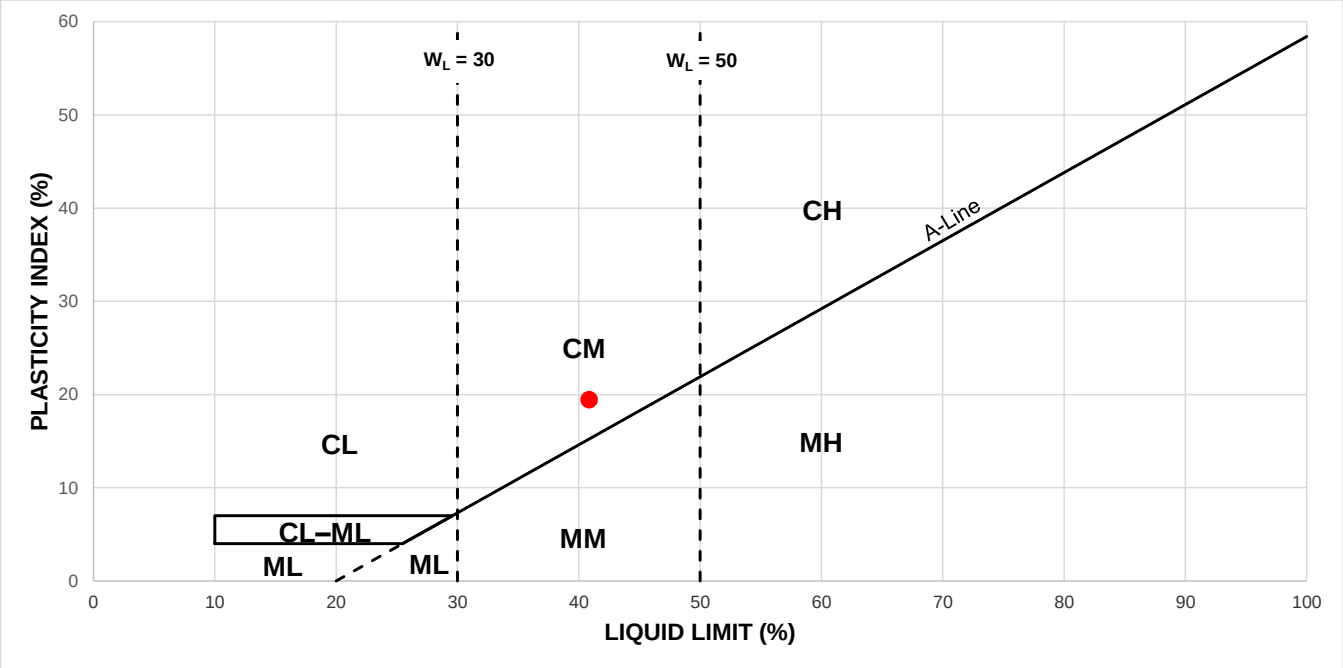
Plasticity Classification (based on Liquid Limit W_L)

0 to 30 Low Plasticity
30 to 50 Medium Plasticity
> 50 High Plasticity

Sample Description: CM - Medium Plasticity Clay
Natural Moisture Content: 30.9%

Comments:

Sample Number: 21-362
Date Tested: 23-Sep-2021
Tested by: AE
Checked by: SK



ATTERBERG LIMITS ASTM D4318

Project: Guest/Shallow Bay Intersection Improvements
Location: Guest Road at Highway 16
Sample Location/Source: TH21-04 at 1.5 - 1.6 m

Project No.: GK-18-750-MOT-13
Client: BC Minsitry of Trnsportation & Infastructure

LIQUID LIMIT (ASTM Designation D 423)

Trial Number	1	2	3
Tare Number	L1	L2	L3
Number of Blows	17	26	30
Mass of Wet Soil and Tare (g)	28.81	26.07	25.8
Mass of Dry Soil and Tare (g)	21.32	19.63	19.64
Mass of Tare (g)	3.86	3.92	4.04
Mass of Moisture (g)	7.49	6.44	6.16
Mass of Dry Soil (g)	17.46	15.71	15.6
Moisture Content(%)	42.9	41.0	39.5

PLASTIC LIMIT (ASTM Designation D 424)

Trial Number	1	2
Tare Number	P1	P2
Mass of Wet Soil and Tare (g)	9.87	10.76
Mass of Dry Soil and Tare (g)	8.82	9.52
Mass of Tare (g)	3.89	3.92
Mass of Moisture (g)	4.93	5.6
Mass of Dry Soil (g)	1.05	1.24
Moisture Content (%)	21.3	22.1

Test Results

Liquid Limit: **41**
Plastic Limit: **22**
Plasticity Index: 19

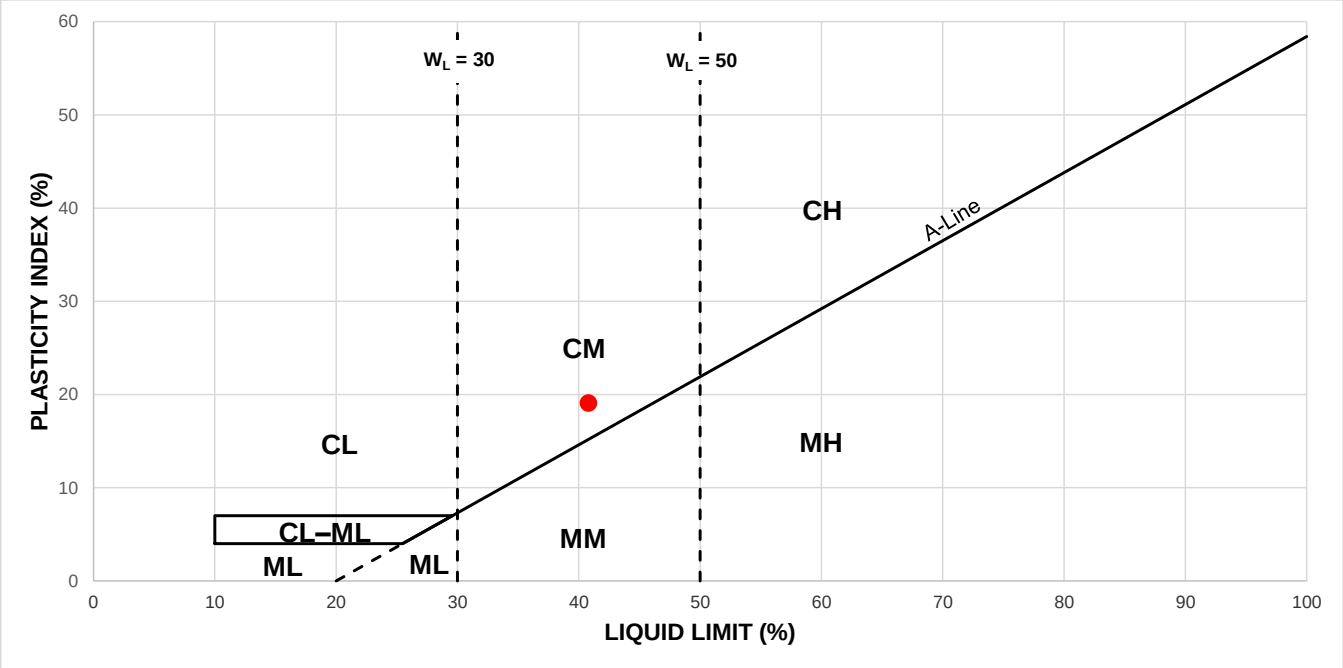
Plasticity Classification (based on Liquid Limit W_L)

0 to 30 Low Plasticity
30 to 50 Medium Plasticity
> 50 High Plasticity

Sample Description: CM - Medium Plasticity Clay
Natural Moisture Content: 21.1%

Comments:

Sample Number: 21-371
Date Tested: 23-Sep-2021
Tested by: AE
Checked by: SK



ATTERBERG LIMITS ASTM D4318

Project: Highway 16: Guest Road & Shallow Bay
Location: Vanderhoof, BC
Sample Location/Source: HA22-01 @ 1.4 - 1.8 m

Project No.: 212111
Client: BC Ministry of Transportation & Infastructure

LIQUID LIMIT (ASTM Designation D 423)

Trial Number	1	2	3
Tare Number	L1	L2	L3
Number of Blows	17	23	33
Mass of Wet Soil and Tare (g)	36.31	32.48	35.17
Mass of Dry Soil and Tare (g)	30.85	27.72	29.80
Mass of Tare (g)	17.36	15.75	15.71
Mass of Moisture (g)	5.46	4.76	5.37
Mass of Dry Soil (g)	13.49	11.97	14.09
Moisture Content(%)	40.5	39.8	38.1

PLASTIC LIMIT (ASTM Designation D 424)

Trial Number	1	2
Tare Number	P1	P2
Mass of Wet Soil and Tare (g)	21.09	21.34
Mass of Dry Soil and Tare (g)	20.10	20.35
Mass of Tare (g)	16.11	16.22
Mass of Moisture (g)	0.99	0.99
Mass of Dry Soil (g)	3.99	4.13
Moisture Content (%)	24.8	24.0

Test Results

Liquid Limit: **39**
Plastic Limit: **24**
Plasticity Index: 15

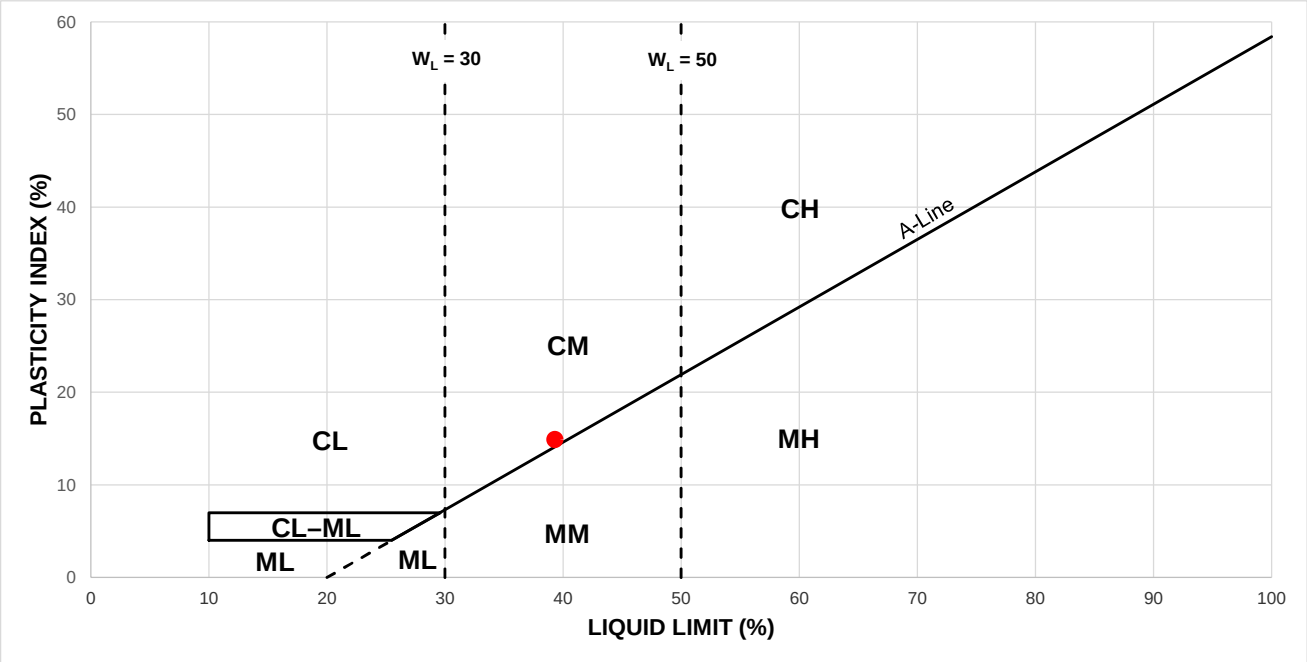
Plasticity Classification (based on Liquid Limit W_L)

0 to 30 Low Plasticity
30 to 50 Medium Plasticity
> 50 High Plasticity

Sample Description: CM - Medium Plastic Clay
Natural Moisture Content: 50.0%

Comments:

Sample Number: 22-198
Date Tested: 11-Apr-2022
Tested by: SQ
Checked by: SK



ATTERBERG LIMITS ASTM D4318

Project: Highway 16: Guest Road & Shallow Bay
Location: Vanderhoof, BC
Sample Location/Source: HA22-02 @ 1.2 - 1.65 m

Project No.: 212111
Client: BC Ministry of Transportation & Infastructure

LIQUID LIMIT (ASTM Designation D 423)

Trial Number	1	2	3
Tare Number	L1	L2	L3
Number of Blows	10	25	45
Mass of Wet Soil and Tare (g)	33.91	28.77	32.42
Mass of Dry Soil and Tare (g)	28.62	25.18	28.04
Mass of Tare (g)	16.11	15.76	15.91
Mass of Moisture (g)	5.29	3.59	4.38
Mass of Dry Soil (g)	12.51	9.42	12.13
Moisture Content(%)	42.3	38.1	36.1

PLASTIC LIMIT (ASTM Designation D 424)

Trial Number	1	2
Tare Number	P1	P2
Mass of Wet Soil and Tare (g)	23.07	21.60
Mass of Dry Soil and Tare (g)	21.90	20.42
Mass of Tare (g)	17.01	15.63
Mass of Moisture (g)	1.17	1.18
Mass of Dry Soil (g)	4.89	4.79
Moisture Content (%)	23.9	24.6

Test Results

Liquid Limit: **38**
Plastic Limit: **24**
Plasticity Index: 14

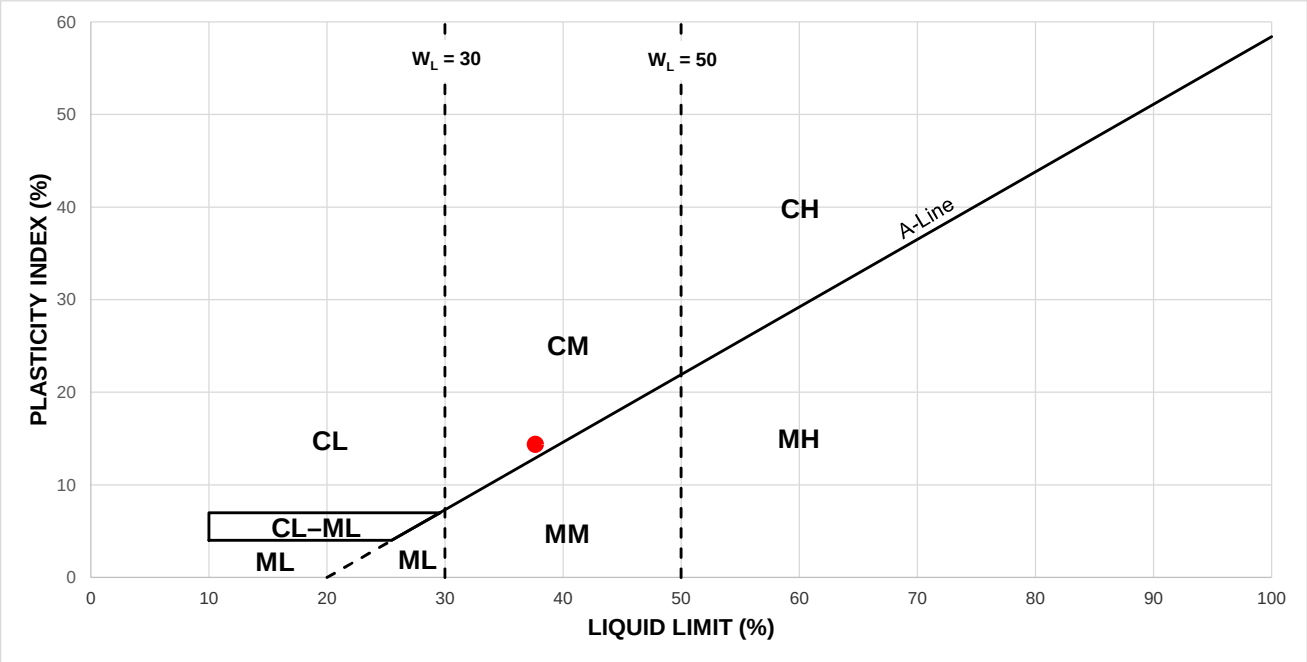
Plasticity Classification (based on Liquid Limit W_L)

0 to 30 Low Plasticity
30 to 50 Medium Plasticity
> 50 High Plasticity

Sample Description: CM - Medium Plastic Clay
Natural Moisture Content: 48.5%

Comments:

Sample Number: 22-199
Date Tested: 11-Apr-2022
Tested by: SQ
Checked by: SK



ATTERBERG LIMITS ASTM D4318

Project: Highway 16: Guest Road & Shallow Bay
Location: Vanderhoof, BC
Sample Location/Source: HA22-02 @ 2.0 - 2.2 m

Project No.: 212111
Client: BC Ministry of Transportation & Infastructure

LIQUID LIMIT (ASTM Designation D 423)

Trial Number	1	2	3
Tare Number	L1	L2	L3
Number of Blows	10	21	39
Mass of Wet Soil and Tare (g)	36.64	30.41	37.38
Mass of Dry Soil and Tare (g)	30.44	26.23	31.42
Mass of Tare (g)	15.86	15.91	15.73
Mass of Moisture (g)	6.20	4.18	5.96
Mass of Dry Soil (g)	14.58	10.32	15.69
Moisture Content(%)	42.5	40.5	38.0

PLASTIC LIMIT (ASTM Designation D 424)

Trial Number	1	2
Tare Number	P1	P2
Mass of Wet Soil and Tare (g)	21.04	21.00
Mass of Dry Soil and Tare (g)	20.28	20.15
Mass of Tare (g)	16.00	15.79
Mass of Moisture (g)	0.76	0.85
Mass of Dry Soil (g)	4.28	4.36
Moisture Content (%)	17.8	19.5

Test Results

Liquid Limit: **40**
Plastic Limit: **19**
Plasticity Index: 21

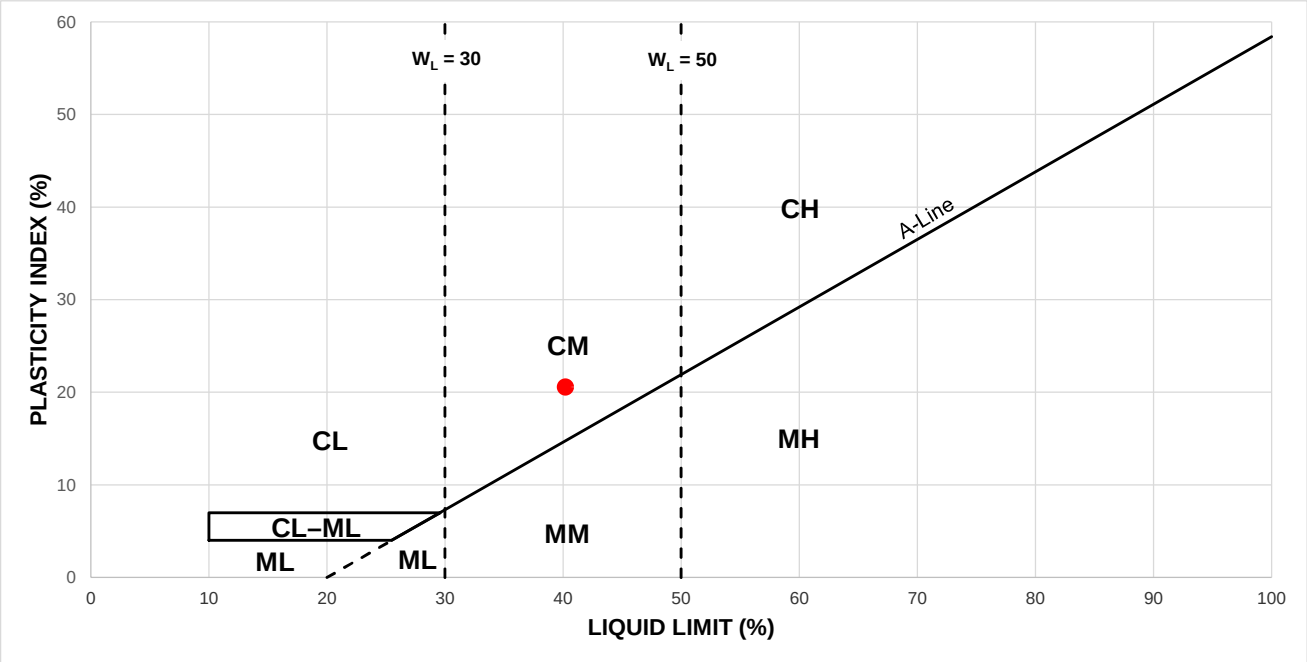
Plasticity Classification (based on Liquid Limit W_L)

0 to 30	Low Plasticity
30 to 50	Medium Plasticity
> 50	High Plasticity

Sample Description: CM - Medium Plastic Clay
Natural Moisture Content: 36.4%

Comments:

Sample Number: 22-200
Date Tested: 11-Apr-2022
Tested by: SQ
Checked by: SK



ATTERBERG LIMITS ASTM D4318

Project: Highway 16: Guest Road & Shallow Bay
Location: Vanderhoof, BC
Sample Location/Source: HA22-03 @ 1.2 - 1.6 m

Project No.: 212111
Client: BC Ministry of Transportation & Infastructure

LIQUID LIMIT (ASTM Designation D 423)

Trial Number	1	2	3
Tare Number	L1	L2	L3
Number of Blows	15	28	40
Mass of Wet Soil and Tare (g)	37.83	28.07	29.05
Mass of Dry Soil and Tare (g)	32.30	25.02	26.18
Mass of Tare (g)	15.72	15.69	17.28
Mass of Moisture (g)	5.53	3.05	2.87
Mass of Dry Soil (g)	16.58	9.33	8.90
Moisture Content(%)	33.4	32.7	32.2

PLASTIC LIMIT (ASTM Designation D 424)

Trial Number	1	2
Tare Number	P1	P2
Mass of Wet Soil and Tare (g)	20.36	21.18
Mass of Dry Soil and Tare (g)	19.62	20.28
Mass of Tare (g)	15.89	15.80
Mass of Moisture (g)	0.74	0.90
Mass of Dry Soil (g)	3.73	4.48
Moisture Content (%)	19.8	20.1

Test Results

Liquid Limit: **33**
Plastic Limit: **20**
Plasticity Index: 13

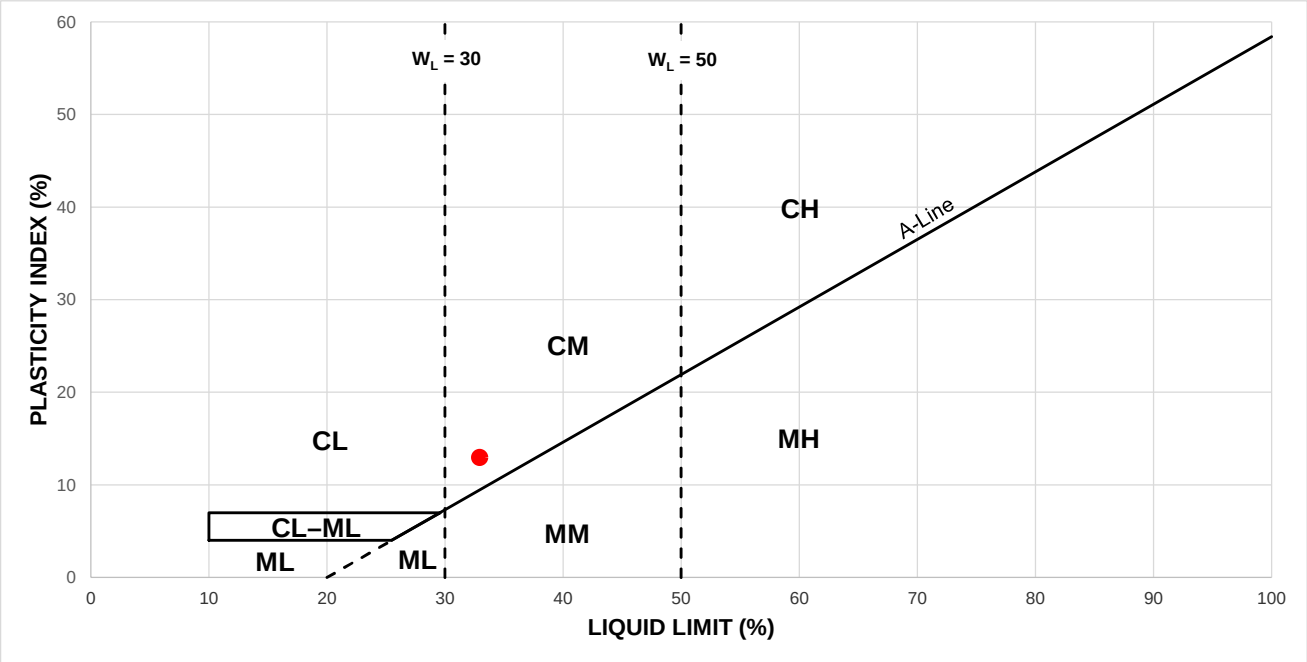
Plasticity Classification (based on Liquid Limit W_L)

0 to 30 Low Plasticity
30 to 50 Medium Plasticity
> 50 High Plasticity

Sample Description: CM - Medium Plastic Clay
Natural Moisture Content: 35.3%

Comments:

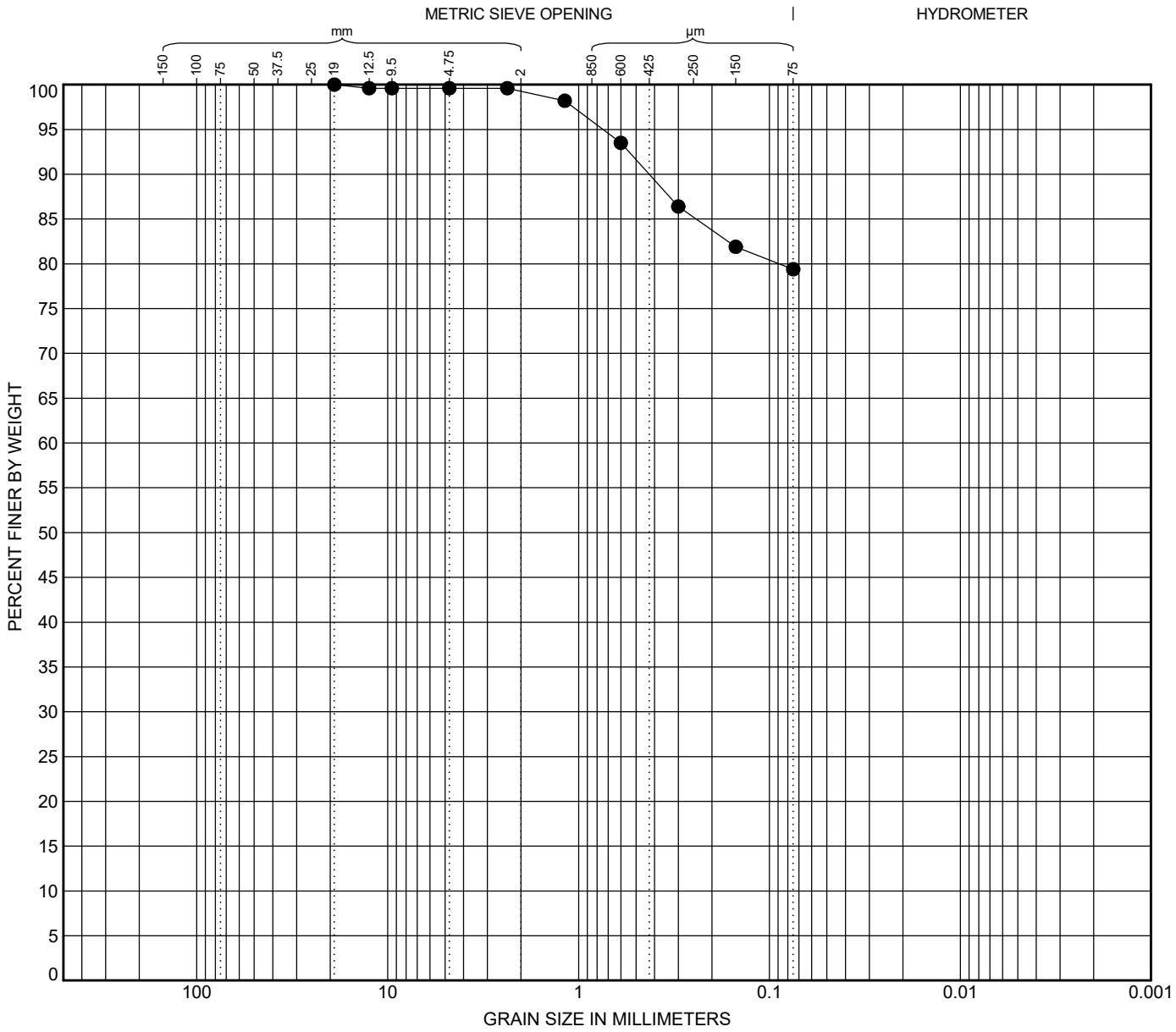
Sample Number: 22-201
Date Tested: 11-Apr-2022
Tested by: SQ
Checked by: SK



GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-01

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 0.6 m to 0.75 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
19	**0.242**							**0.4**	**20.2**	**79.4**	

Description: Sandy FINES, trace gravel
Natural Moisture Content: 1.3 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

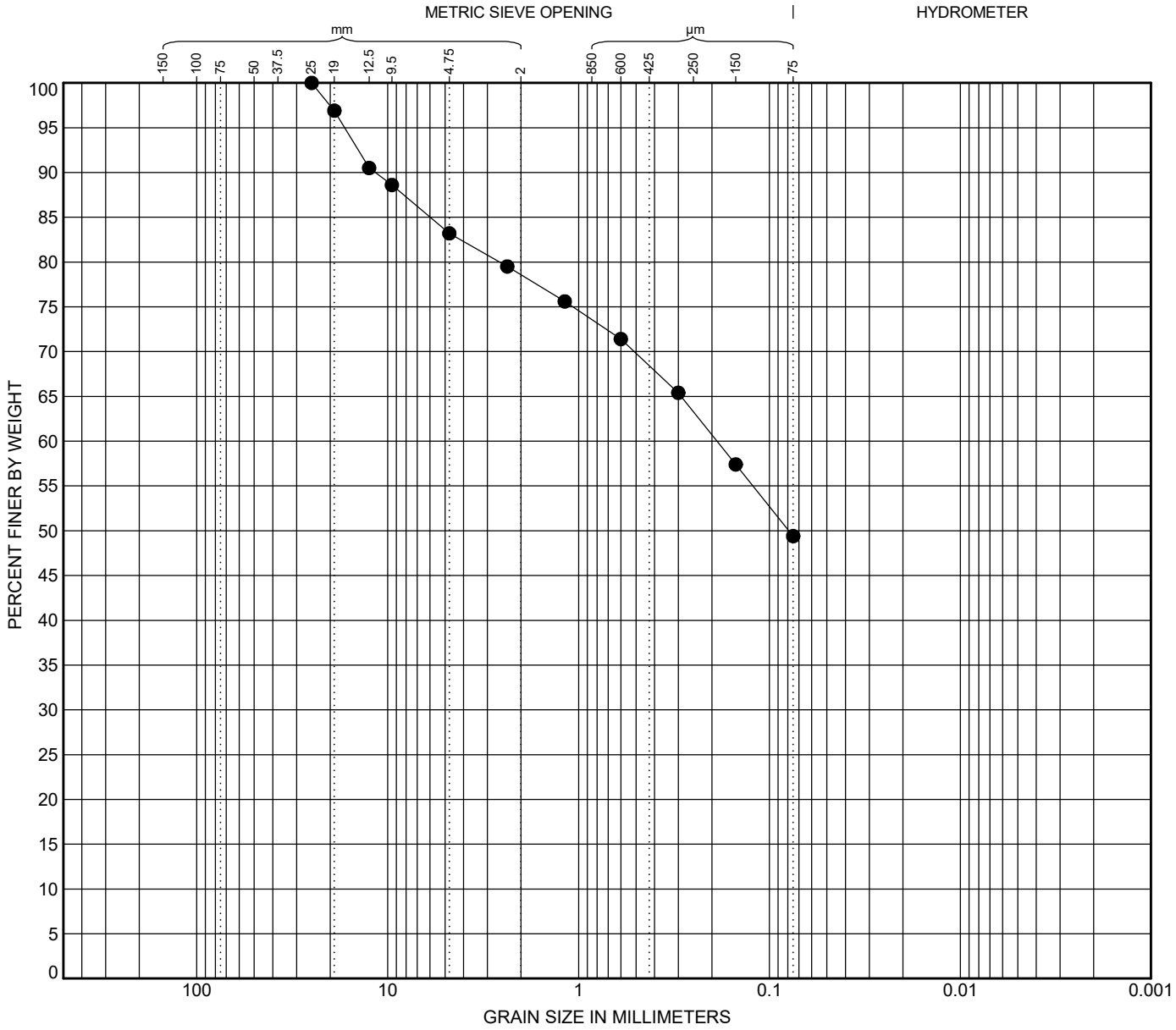
Sample Number: 21-351
Date Tested: 2021-09-09
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-01

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 3 m to 3.6 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
25	**5.985**	**0.188**						**16.8**	**33.8**	**49.4**	

Description: Sandy FINES, some gravel
Natural Moisture Content: 13.8 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

Sample Number: 21-352
Date Tested: 2021-09-09
Tested By: TB

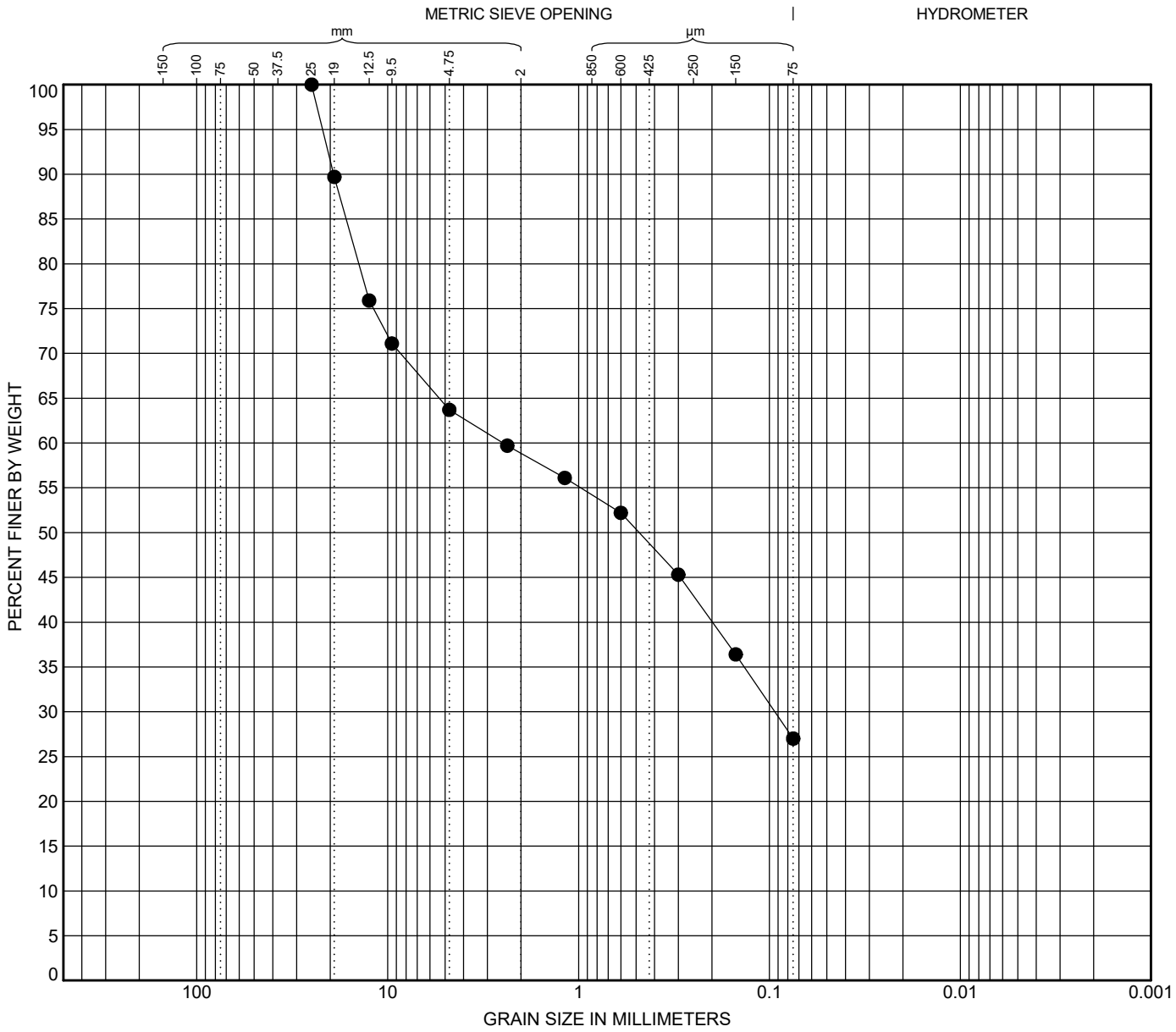
Checked By: _____

GRAIN SIZE DISTRIBUTION GK-18-750-MOT-13 LAB.GPJ DATAECORA2018.GDT 21-11-10

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-01

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 9.1 m to 9.3 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
25	**16.475**	**2.487**	**0.094**					**36.3**	**36.7**	**27.0**	

Description: Silty SAND and GRAVEL
Natural Moisture Content: 7.5 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

Sample Number: 21-353
Date Tested: 2021-09-09
Tested By: TB

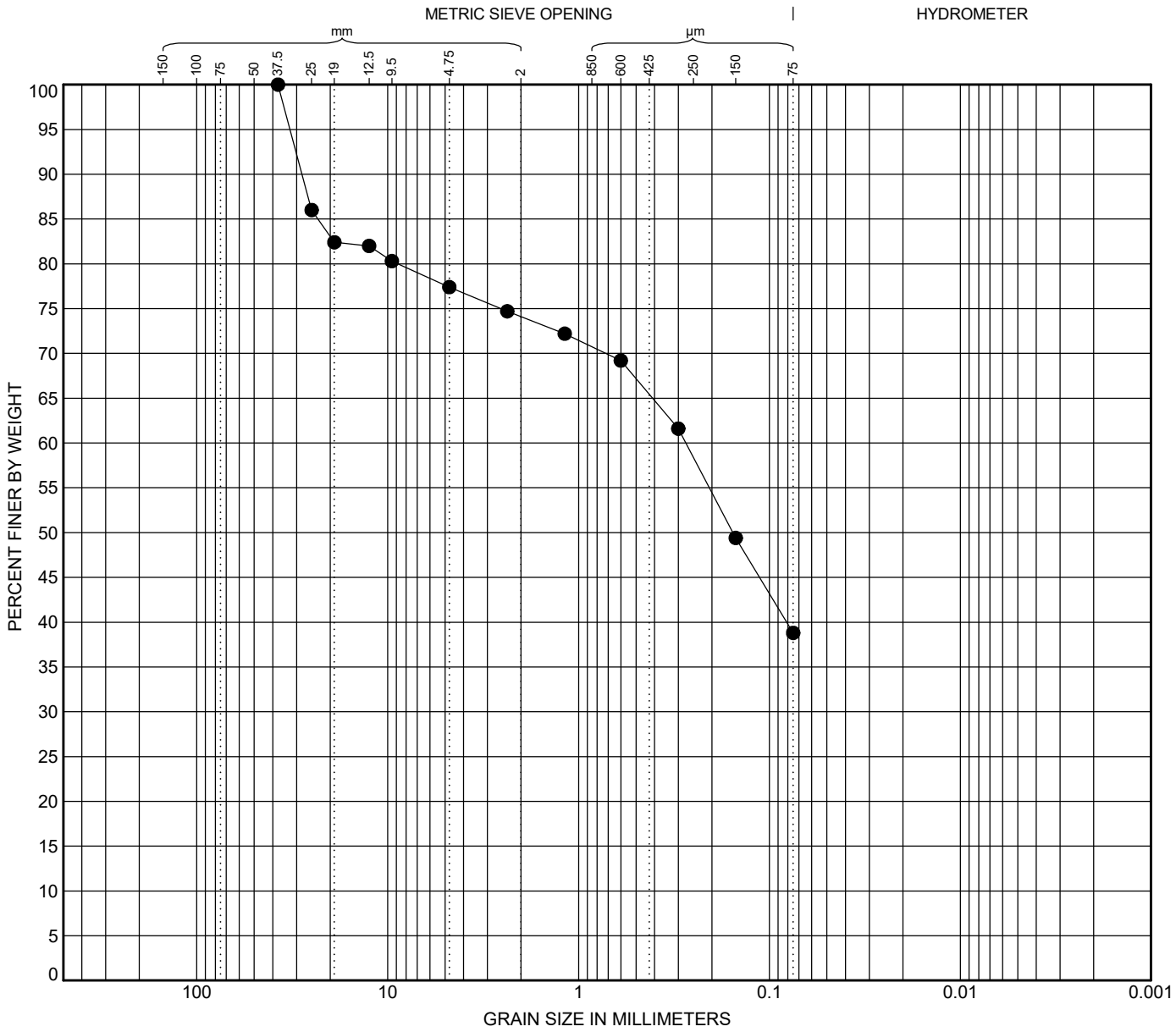
Checked By: _____

GRAIN SIZE DISTRIBUTION GK-18-750-MOT-13 LAB.GPJ DATAECORA2018.GDT 21-11-10

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-02

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 2.5 m to 2.7 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
37.5	**23.165**	**0.274**						**22.6**	**38.6**	**38.8**	

Description: Gravelly FINES and SAND
Natural Moisture Content: 9.7 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

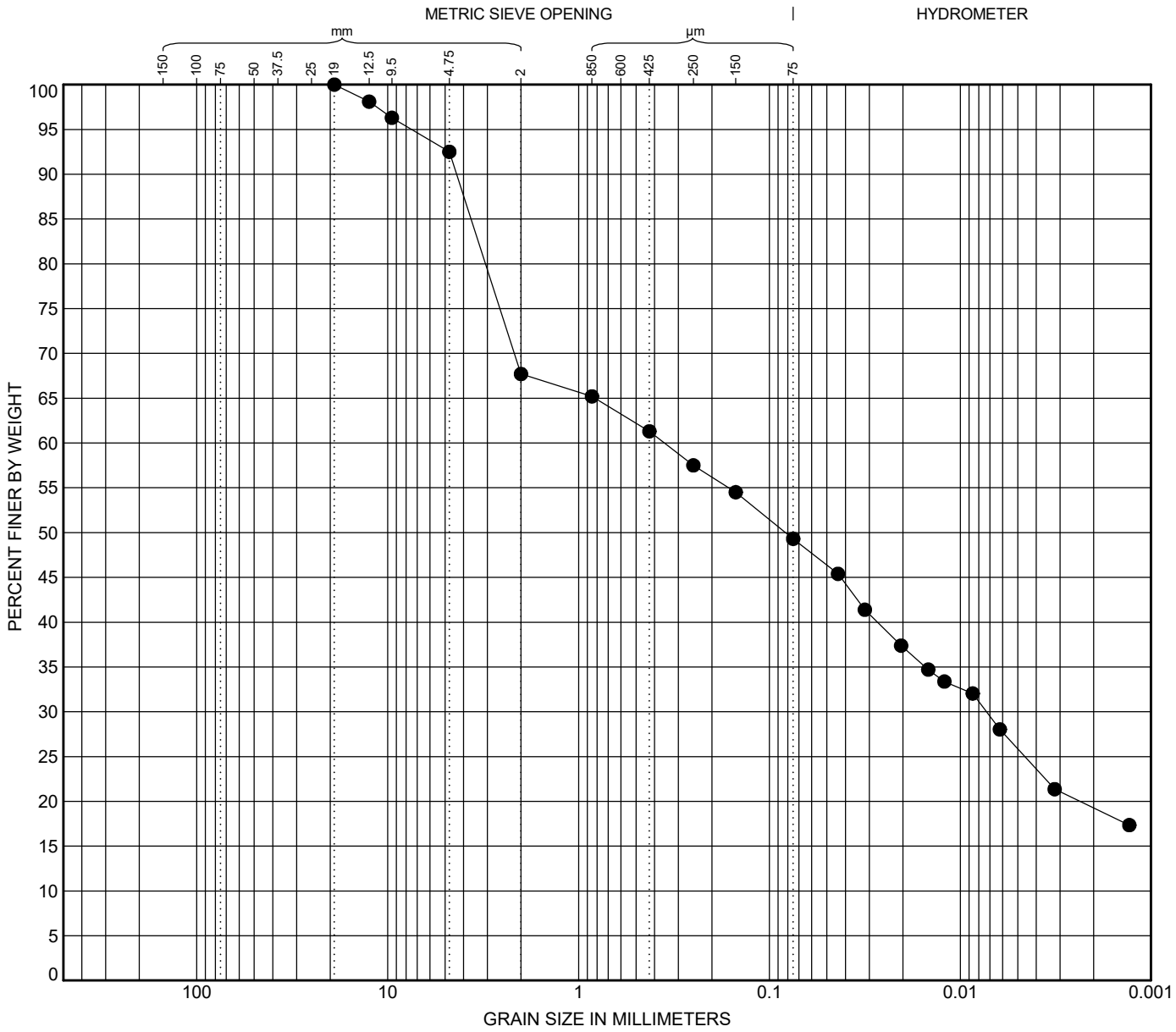
Sample Number: 21-354
Date Tested: 2021-09-09
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM D422

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-02

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 7.5 m to 7.7 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
19	**3.657**	**0.354**	**0.007**					**7.5**	**43.2**	**30.0**	**19.3**

Description: Silty SAND, some clay, trace gravel
Natural Moisture Content: 14.8 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

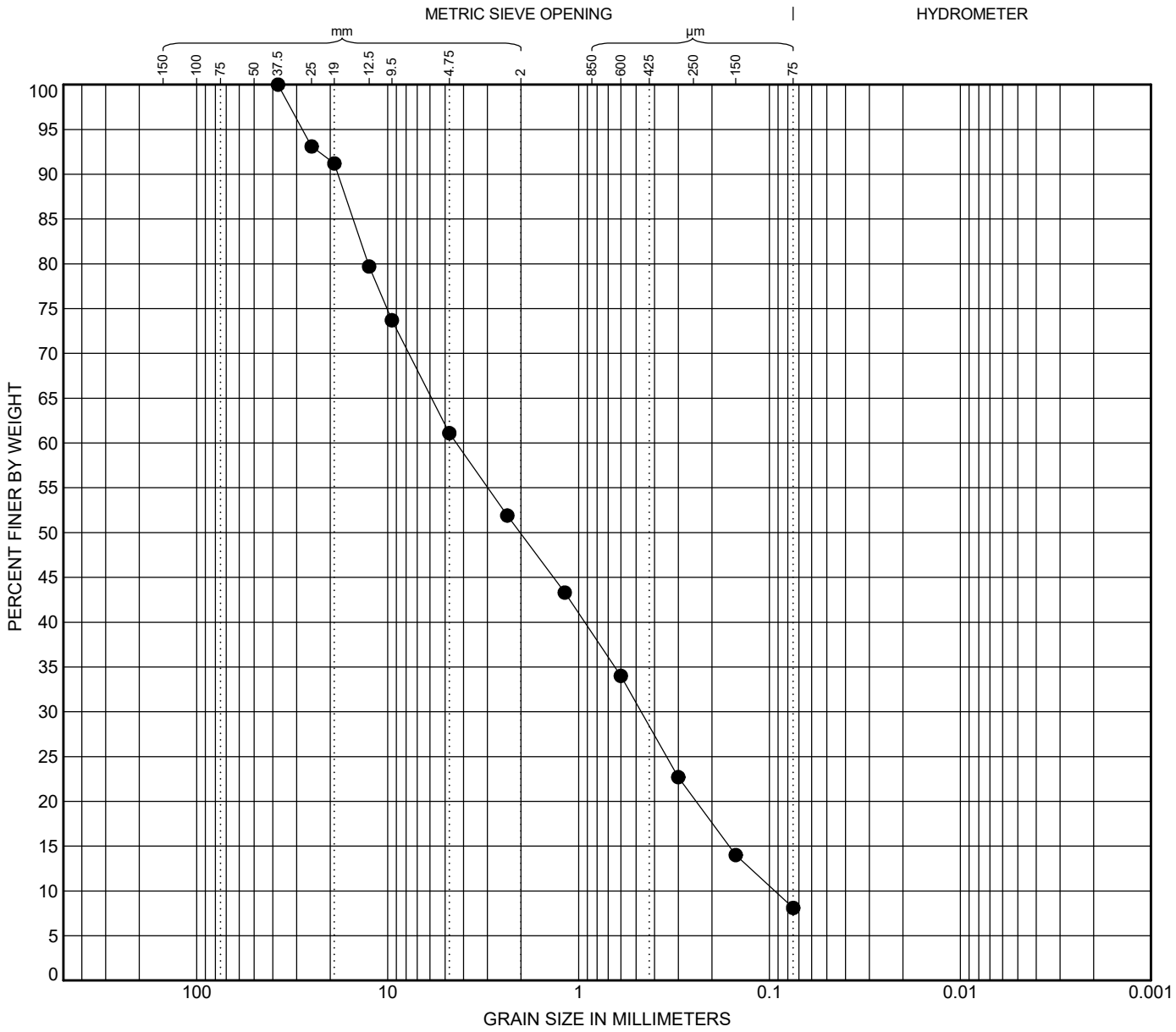
Sample Number: 21-355
Date Tested: 2021-09-27
Tested By: SK

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-03

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 0.5 m to 0.7 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
37.5	**15.161**	**4.369**	**0.469**	**0.162**	**0.094**	**0.54**	**46.60**	**38.9**	**53.0**	**8.1**	

Description: SAND and GRAVEL, trace fines
Natural Moisture Content: 5.6 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

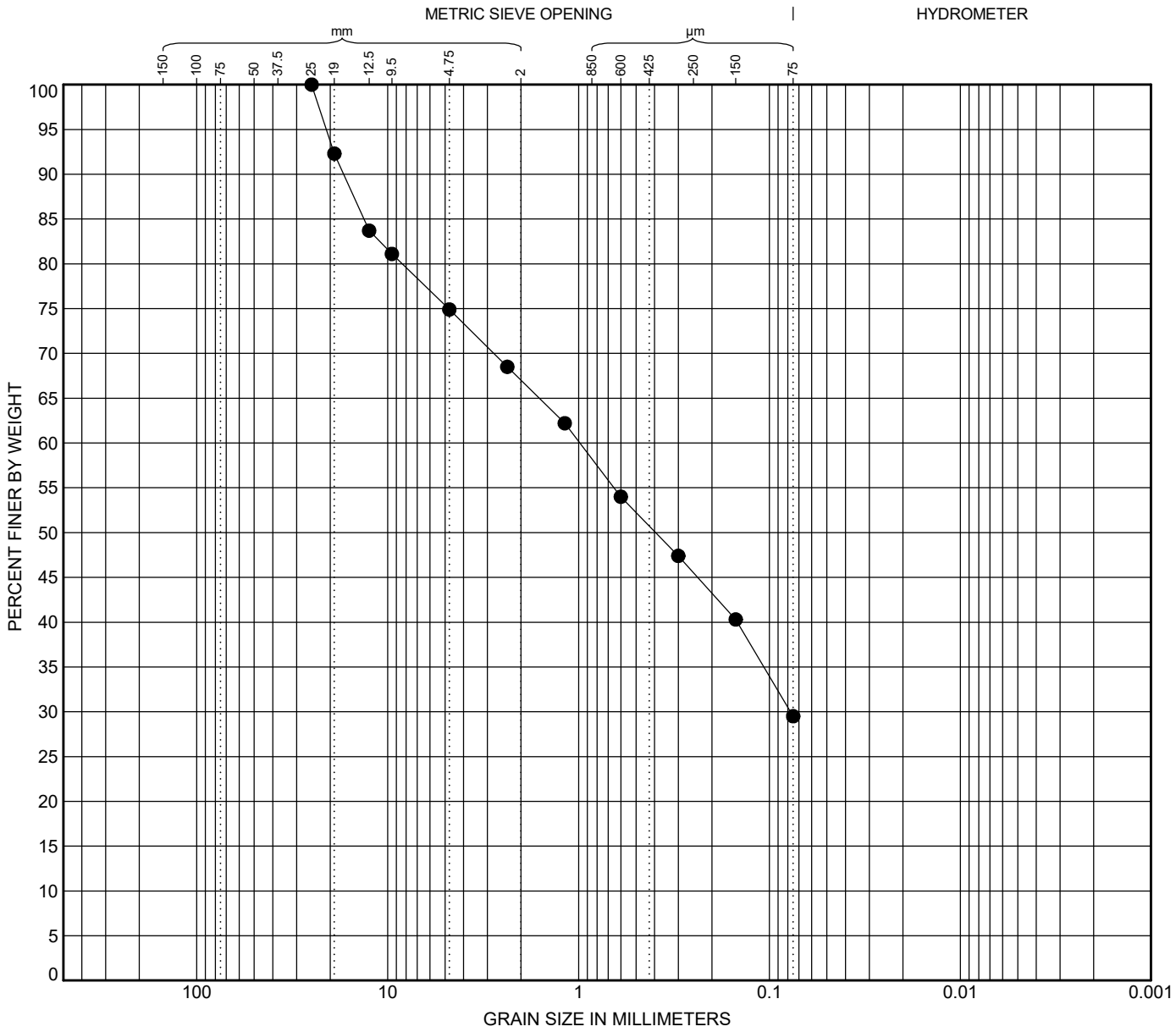
Sample Number: 21-356
Date Tested: 2021-09-09
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-04

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 1 m to 1.2 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
25	**13.317**	**0.984**	**0.077**					**25.1**	**45.4**	**29.5**	

Description: Silty, gravelly SAND
Natural Moisture Content: 8.9 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

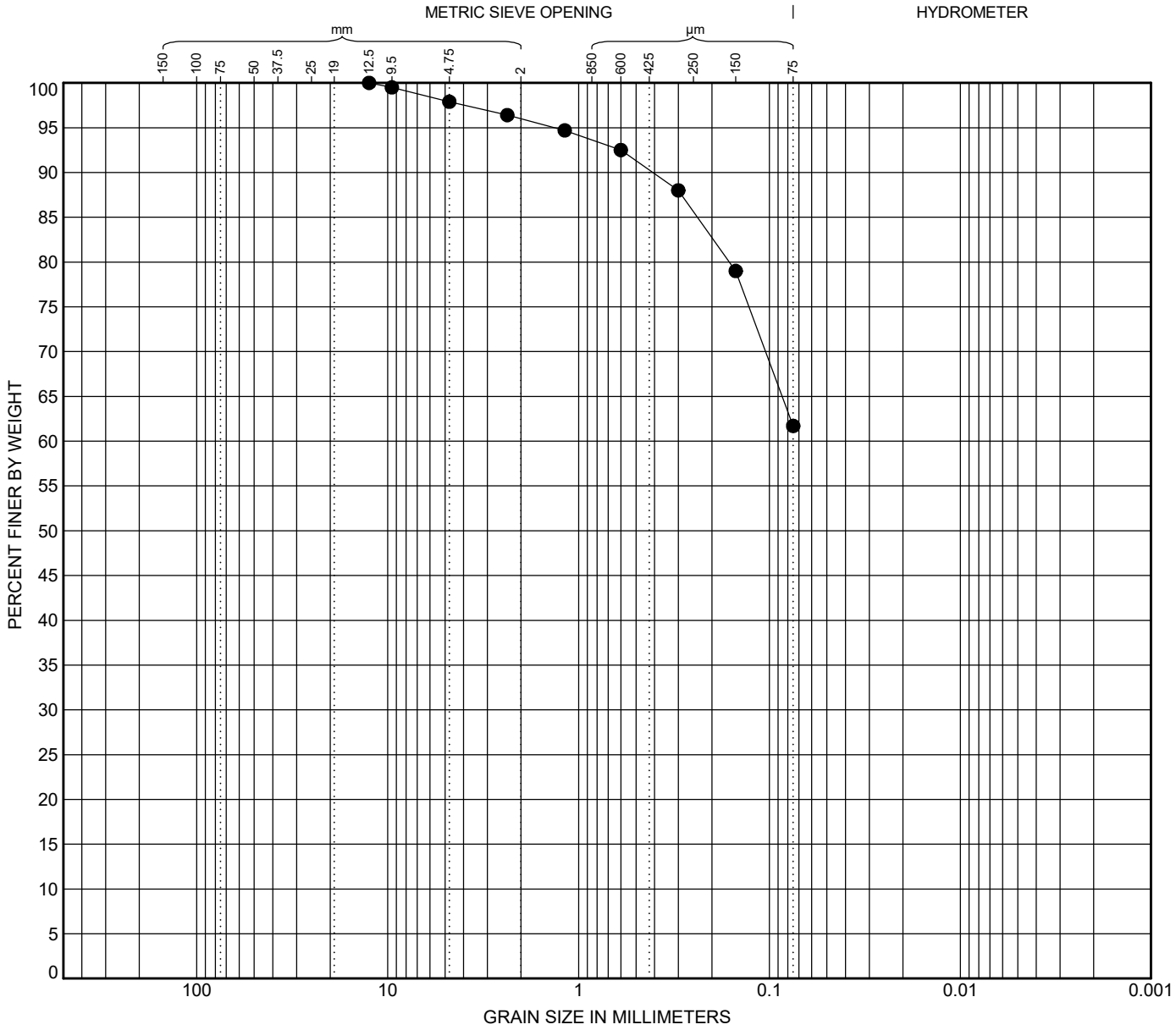
Sample Number: 21-357
Date Tested: 2021-09-09
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-05

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 0.75 m to 1 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
12.5	**0.238**							**2.1**	**36.2**	**61.7**	

Description: FINES and SAND, trace gravel
Natural Moisture Content: 14.1 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

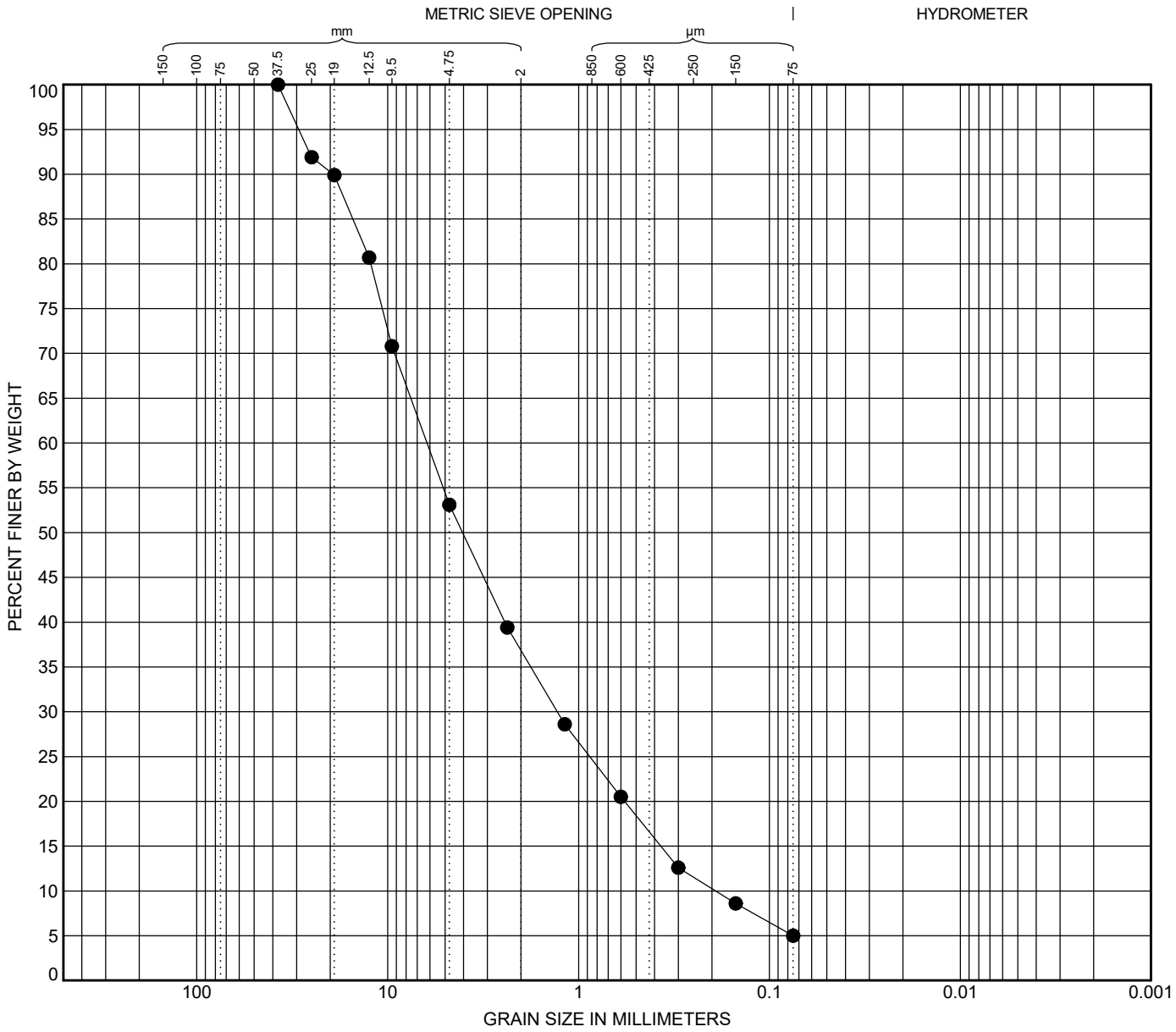
Sample Number: 21-358
Date Tested: 2021-09-09
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-06

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 0.3 m to 0.45 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
37.5	**15.202**	**6.224**	**1.291**	**0.37**	**0.191**	**1.40**	**32.55**	**46.9**	**48.1**	**5.0**	

Description: SAND and GRAVEL, trace fines
Natural Moisture Content: 2 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

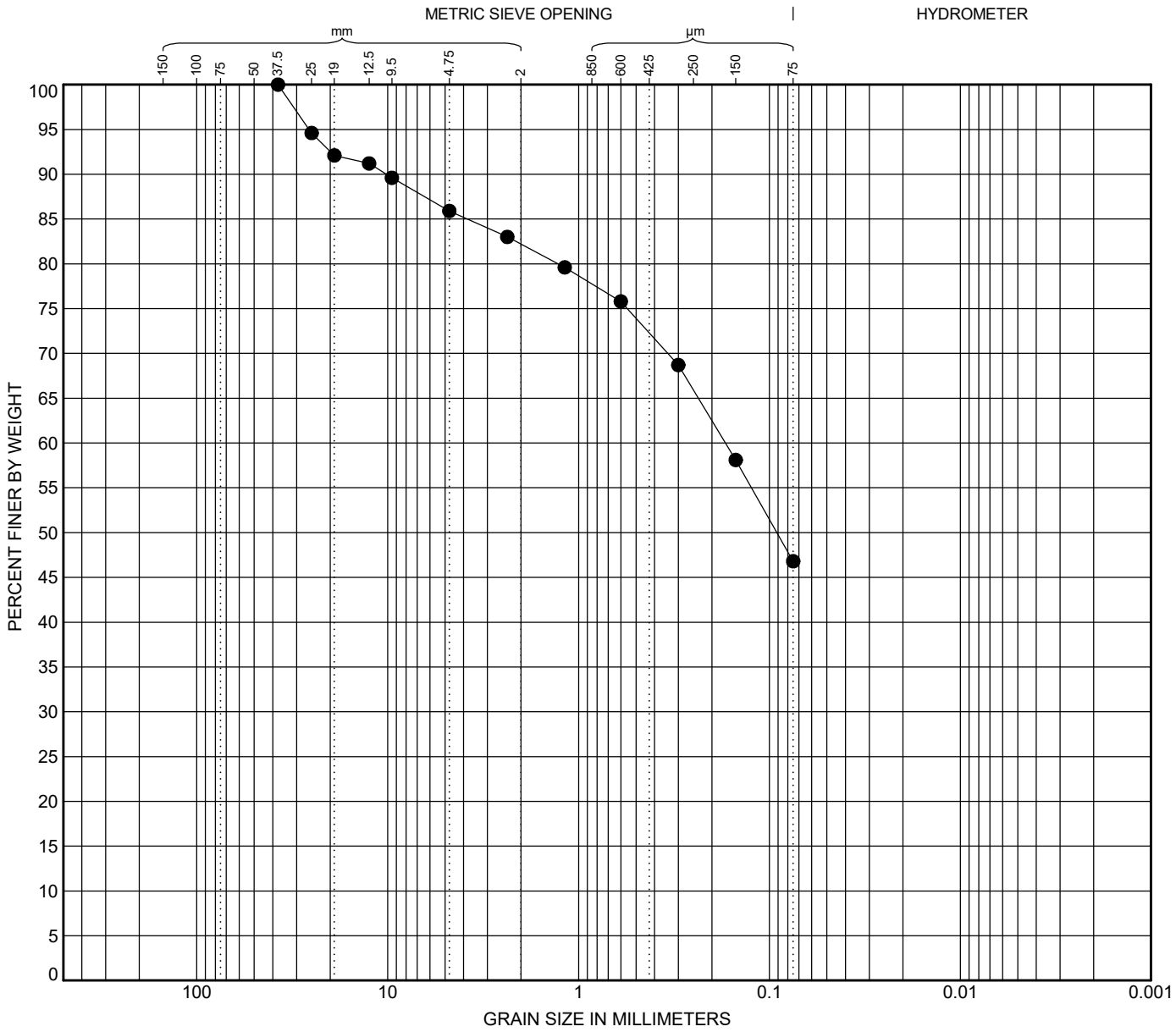
Sample Number: 21-359
Date Tested: 2021-09-09
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-06

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 1.3 m to 1.5 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
37.5	**3.823**	**0.17**						**14.1**	**39.1**	**46.8**	

Description: FINES and SAND, some gravel
Natural Moisture Content: 13.5 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

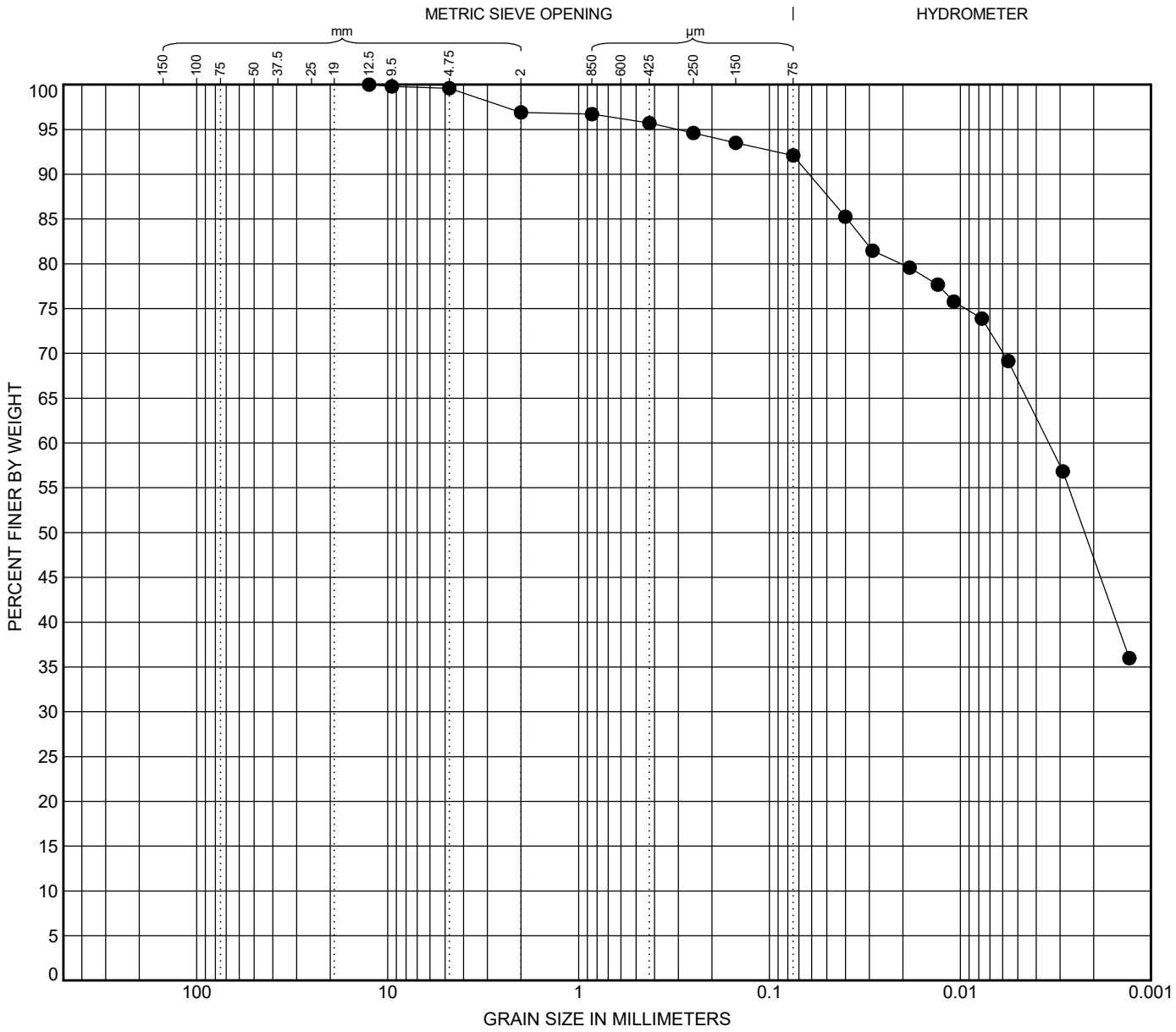
Sample Number: 21-360
Date Tested: 2021-09-09
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM D422

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-07

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 0.3 m to 0.5 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
12.5	**0.039**	**0.003**						**0.4**	**7.5**	**44.9**	**47.2**

Description: CLAY and SILT, trace sand, trace gravel
Natural Moisture Content: 20.5 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

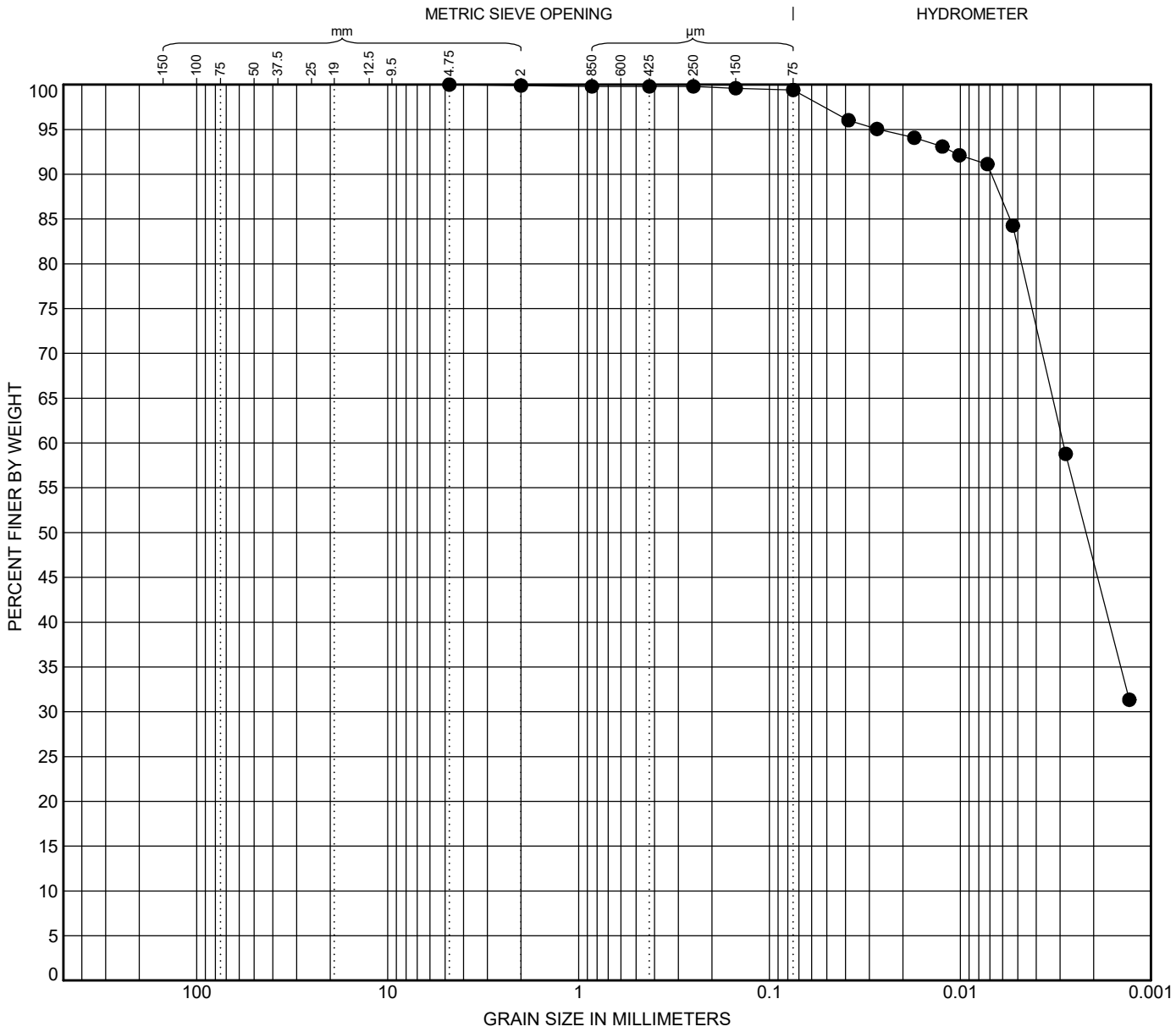
Sample Number: 21-361
Date Tested: 2021-09-27
Tested By: SK

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM D422

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-07

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 1 m to 1.2 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
4.75	**0.005**	**0.003**						**0.0**	**0.6**	**52.7**	**46.7**

Description: SILT and CLAY, trace sand
Natural Moisture Content: 30.9 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

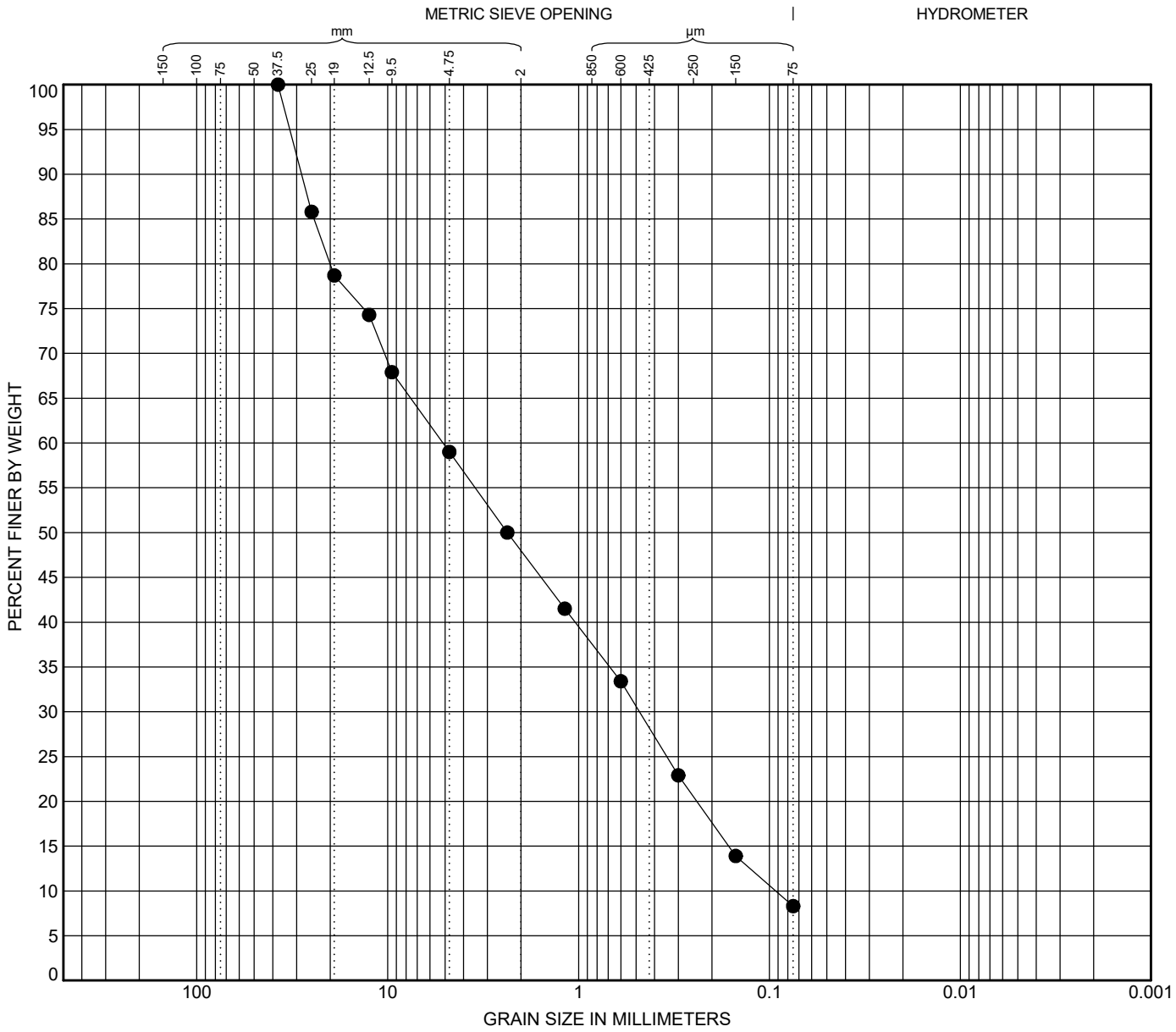
Sample Number: 21-362
Date Tested: 2021-09-27
Tested By: SK

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-08

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 0.5 m to 0.7 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
37.5	**24.239**	**5.135**	**0.479**	**0.163**	**0.093**	**0.48**	**55.47**	**41.0**	**50.7**	**8.3**	

Description: SAND and GRAVEL, trace fines
Natural Moisture Content: 5.1 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

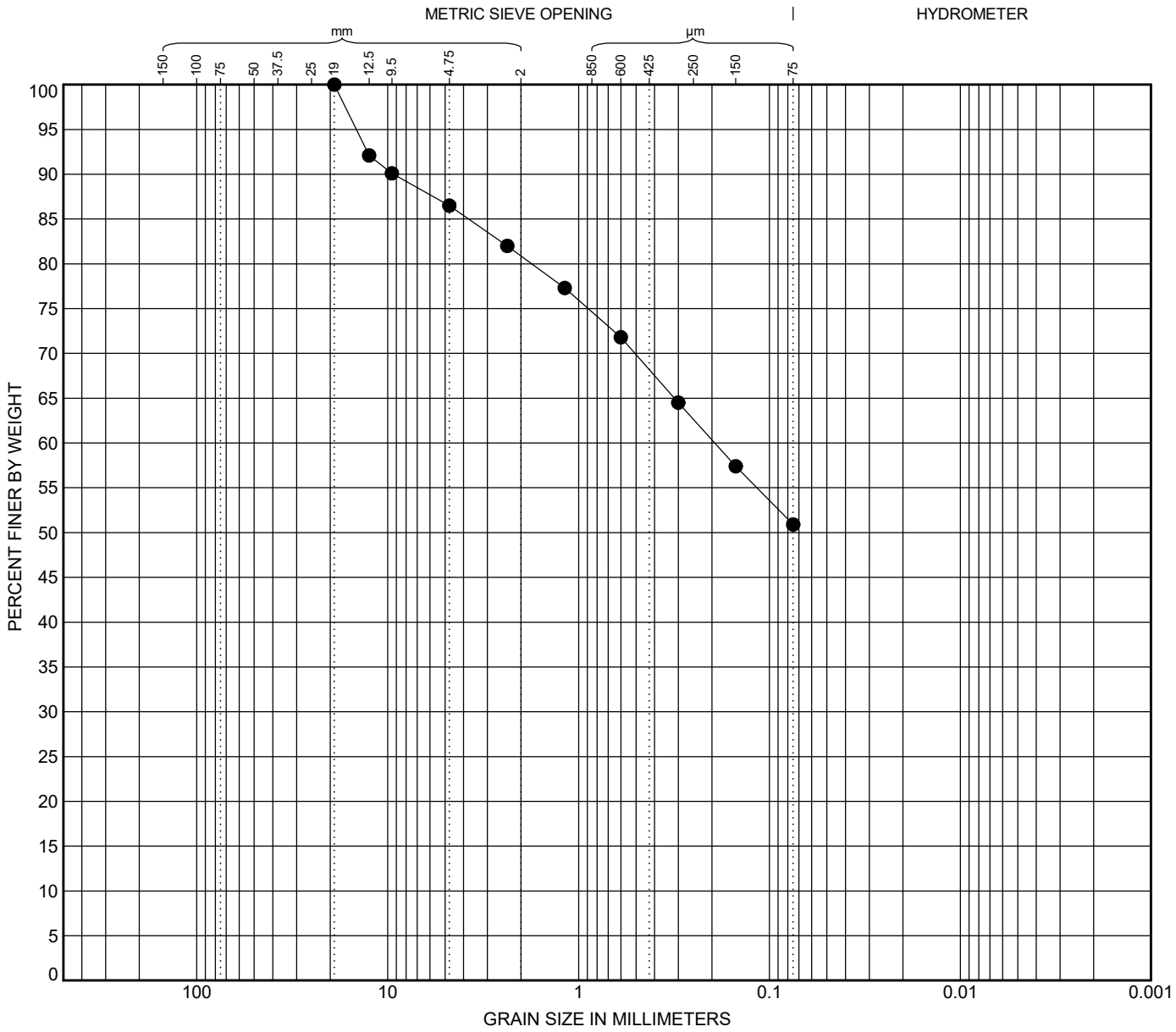
Sample Number: 21-363
Date Tested: 2021-09-09
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-08

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 1.2 m to 1.4 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
19	**3.762**	**0.193**						**13.5**	**35.6**	**50.9**	

Description: Sandy FINES, some gravel
Natural Moisture Content: 12.5 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

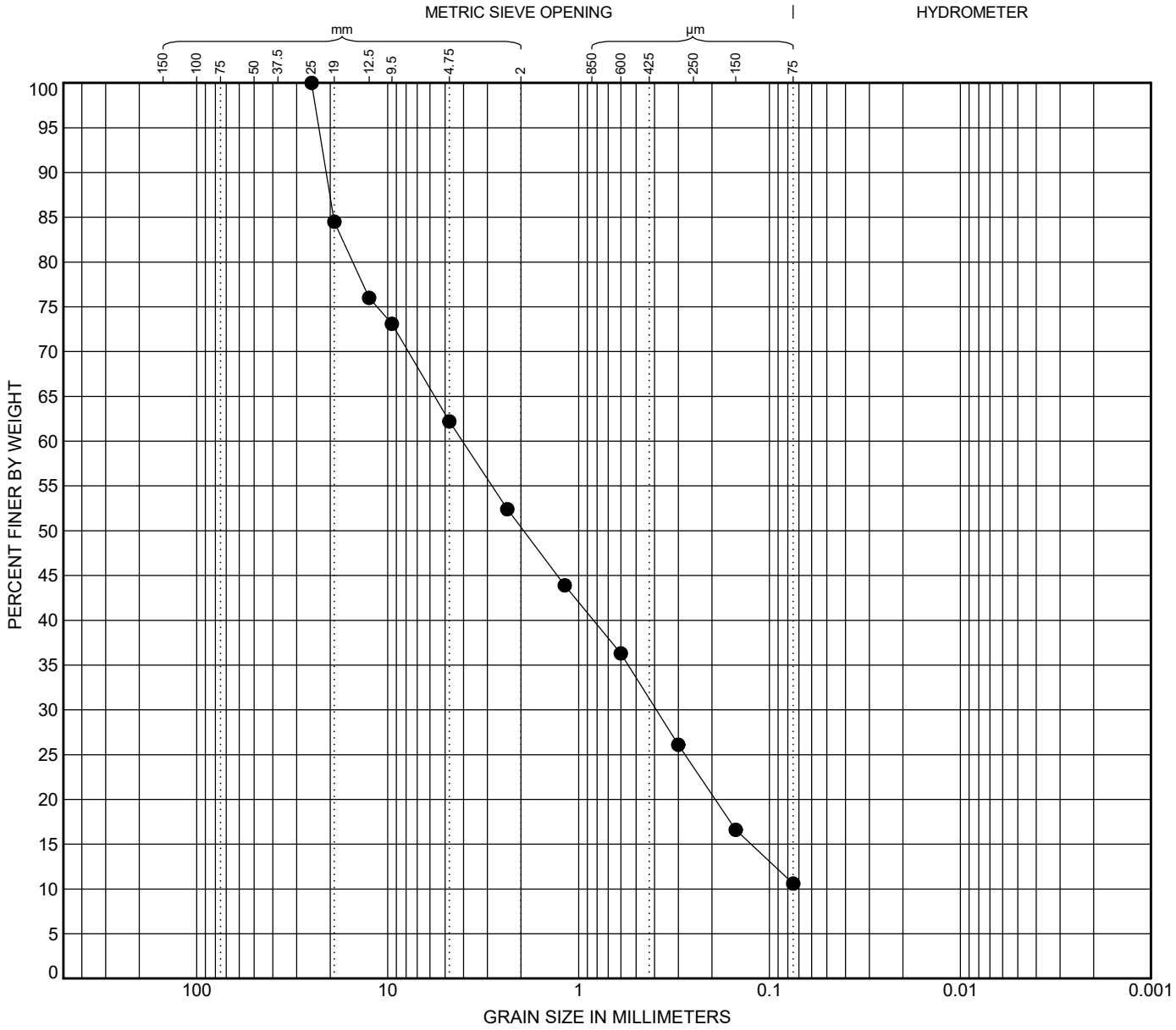
Sample Number: 21-364
Date Tested: 2021-09-09
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-09

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 0.35 m to 0.95 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
25	**19.169**	**4.06**	**0.391**	**0.125**		**0.54**	**58.01**	**37.8**	**51.6**	**10.6**	

Description: SAND and GRAVEL, some fines
Natural Moisture Content: 3.3 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

Sample Number: 21-365
Date Tested: 2021-09-09
Tested By: TB

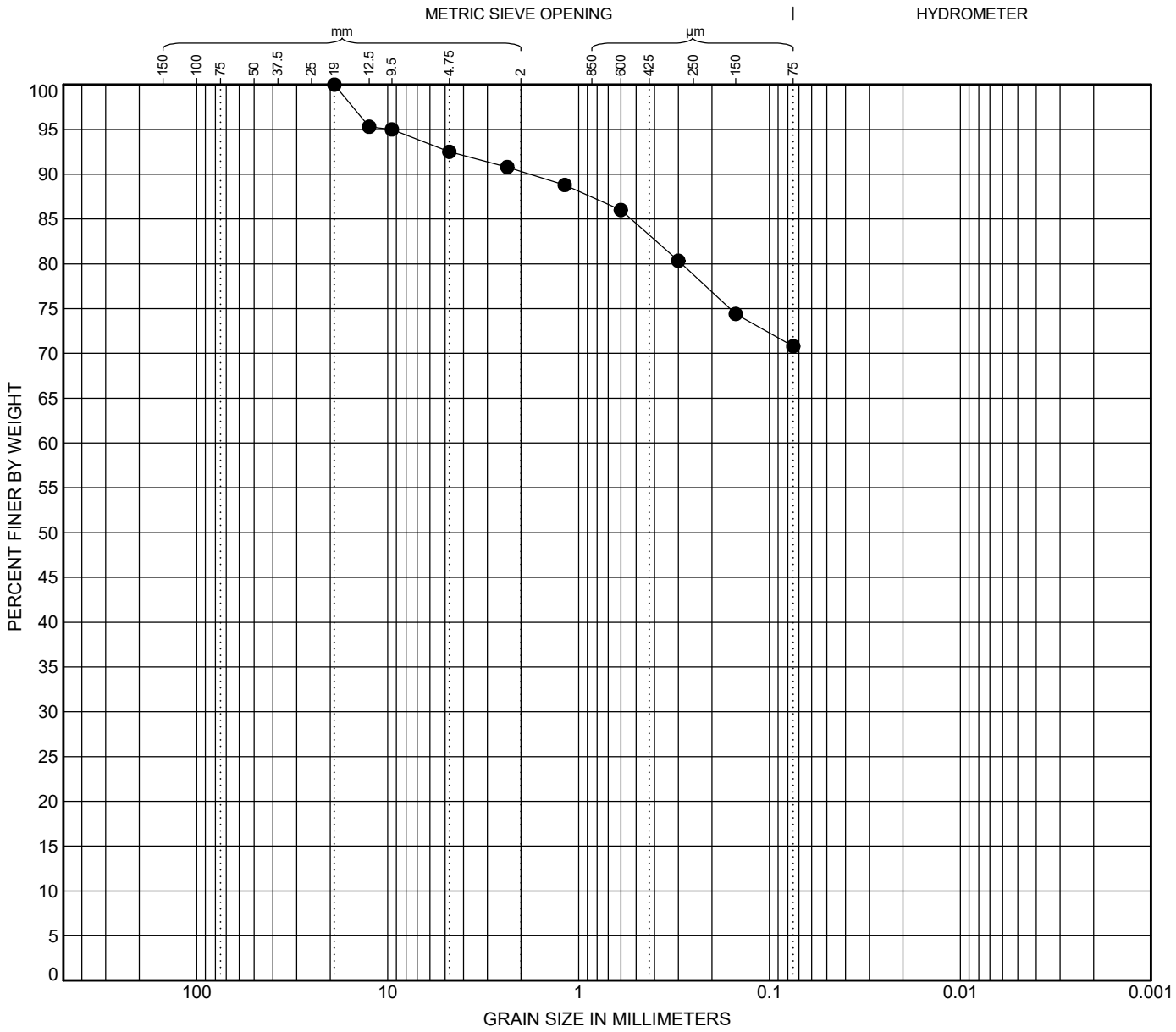
Checked By: _____

GRAIN SIZE DISTRIBUTION GK-18-750-MOT-13 LAB.GPJ DATAECORA2018.GDT 21-11-10

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TH21-09

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 1.2 m to 1.4 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
19	**0.531**							**7.5**	**21.7**	**70.8**	

Description: Sandy FINES, trace gravel
Natural Moisture Content: 18.5 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

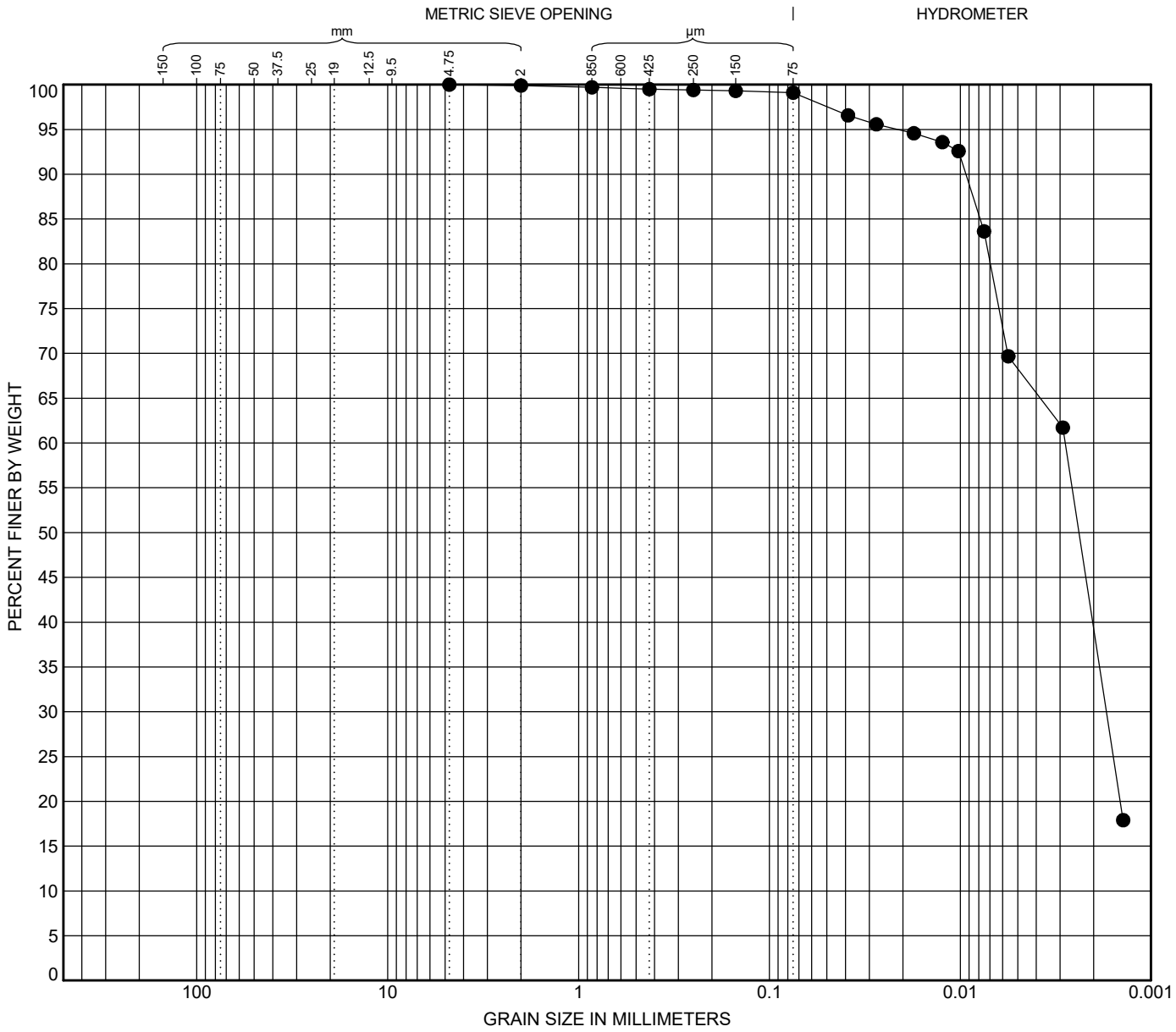
Sample Number: 21-366
Date Tested: 2021-09-09
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM D422

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TP21-01

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 1.9 m to 2 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
4.75	**0.008**	**0.003**	**0.002**					**0.0**	**0.9**	**59.7**	**39.4**

Description: SILT and CLAY, trace sand
Natural Moisture Content: 33.3 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

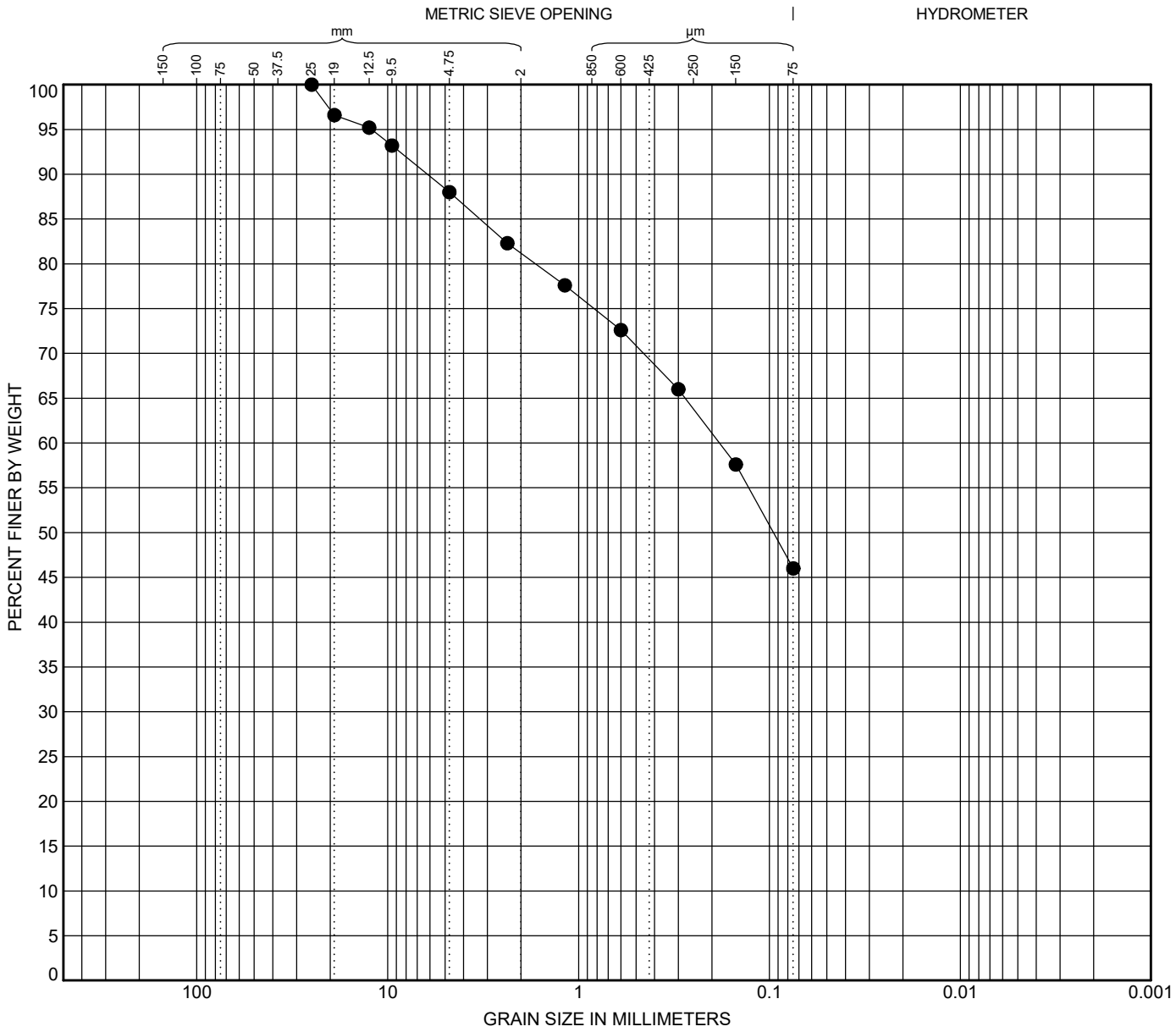
Sample Number: 21-367
Date Tested: 2021-09-27
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TP21-02

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 2 m to 2.4 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
25	**3.287**	**0.183**						**12.0**	**42.0**	**46.0**	

Description: FINES and SAND, some grave
INatural Moisture Content: 13.8 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

Sample Number: 21-368
Date Tested: 2021-09-09
Tested By: TB

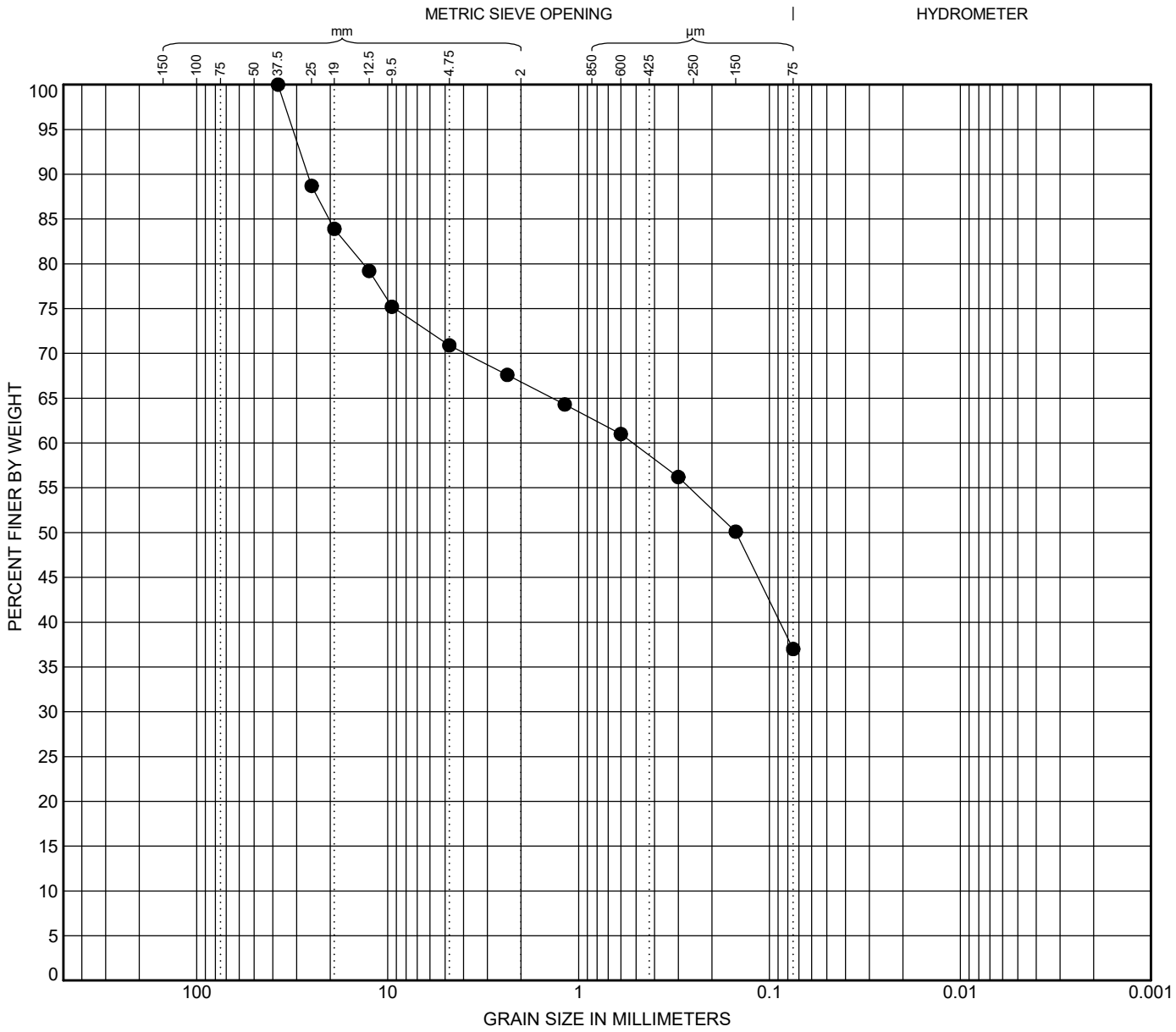
Checked By: _____

GRAIN SIZE DISTRIBUTION GK-18-750-MOT-13 LAB.GPJ DATAECORA2018.GDT 21-11-10

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TP21-03

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 3 m to 3.4 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
37.5	**20.233**	**0.519**						**29.1**	**33.9**	**37.0**	

Description: Sandy, gravelly FINES
Natural Moisture Content: 7.5 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

Sample Number: 21-369
Date Tested: 2021-09-09
Tested By: TB

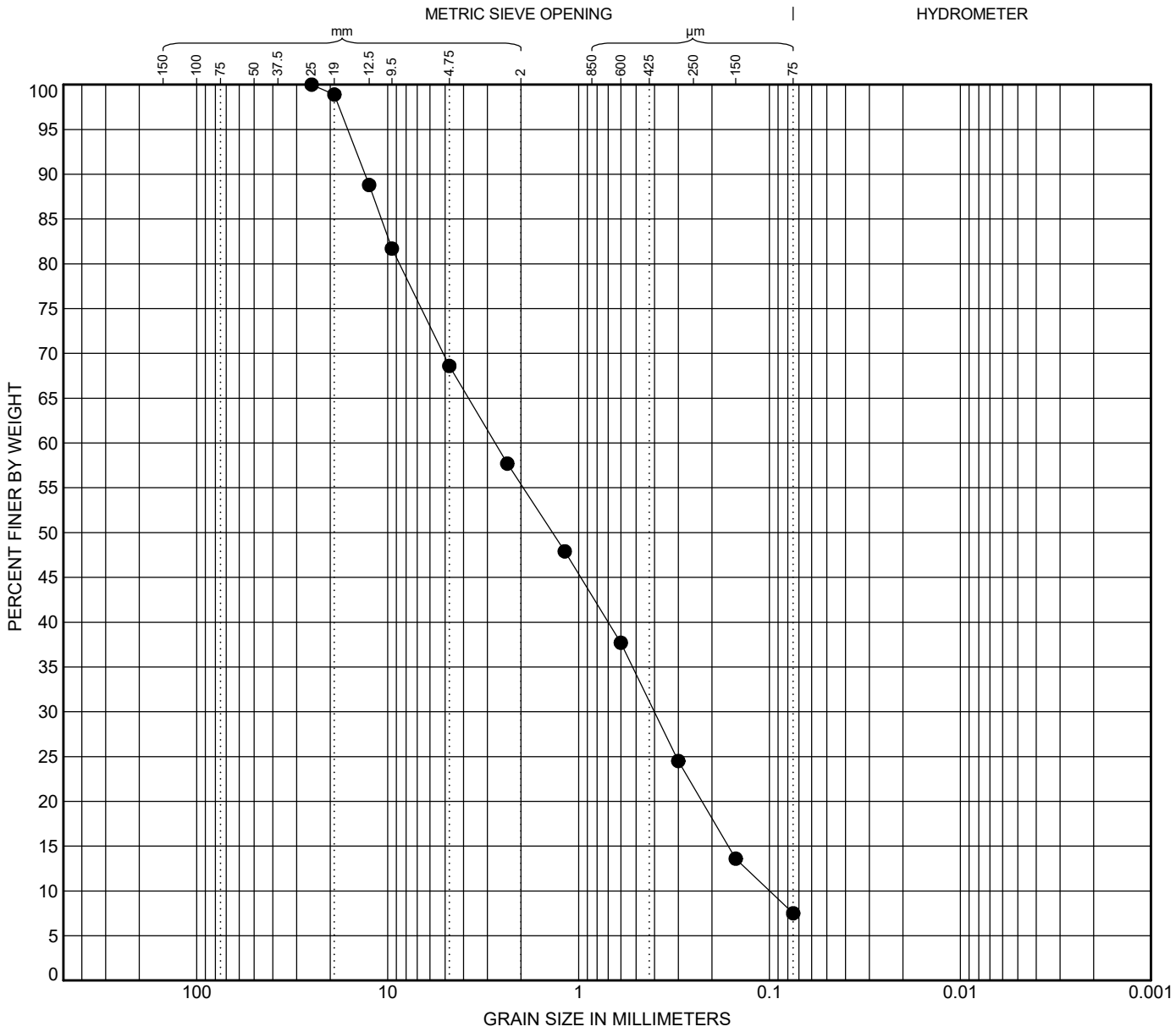
Checked By: _____

GRAIN SIZE DISTRIBUTION GK-18-750-MOT-13 LAB.GPJ DATAECORA2018.GDT 21-11-10

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TP21-04

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 0.6 m to 0.8 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
25	**10.792**	**2.735**	**0.4**	**0.164**	**0.1**	**0.59**	**27.45**	**31.4**	**61.1**	**7.5**	

Description: Gravelly SAND, trace fines
Natural Moisture Content: 5.3 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

Sample Number: 21-370
Date Tested: 2021-09-09
Tested By: TB

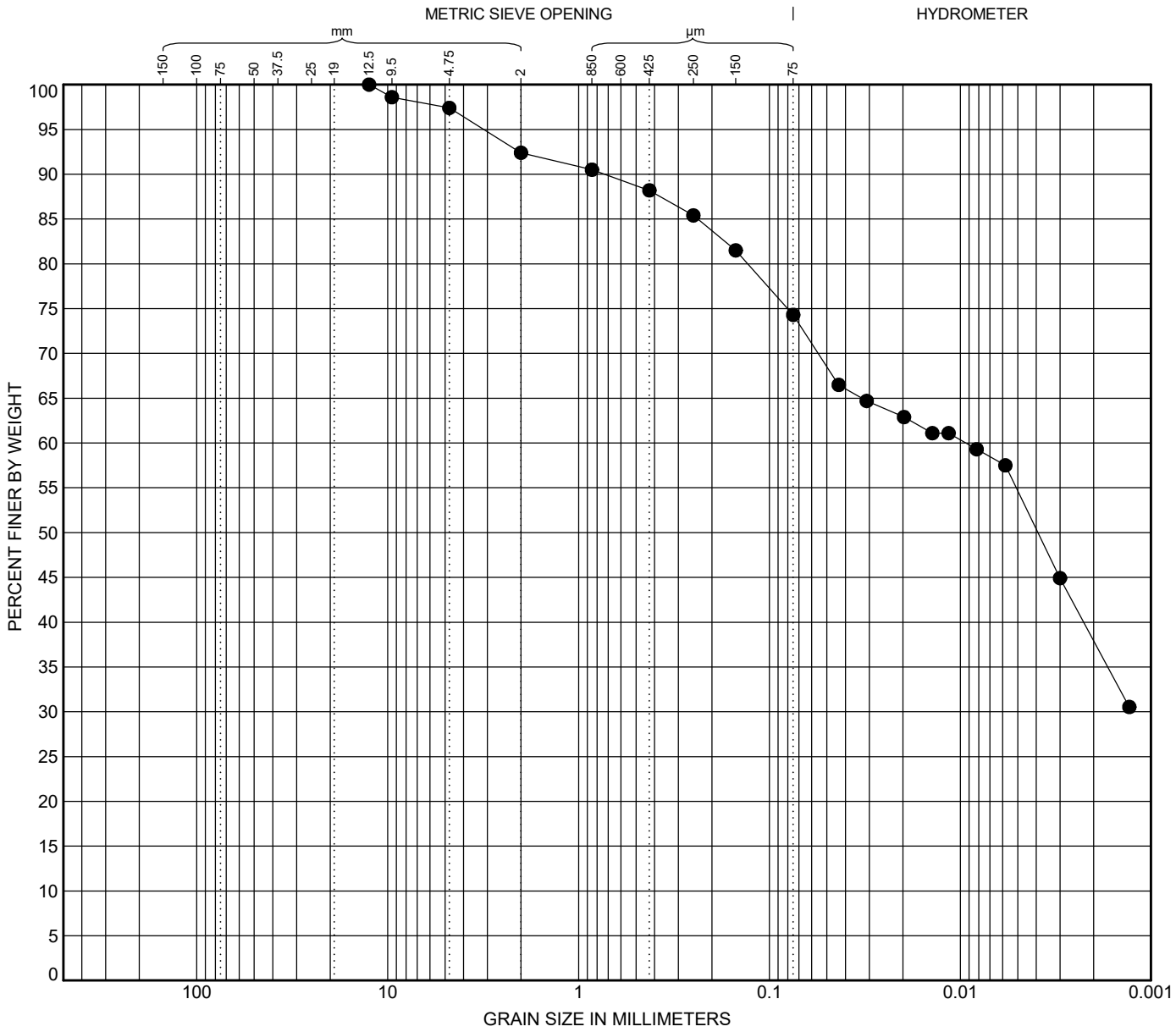
Checked By: _____

GRAIN SIZE DISTRIBUTION GK-18-750-MOT-13 LAB.GPJ DATAECORA2018.GDT 21-11-10

GRAIN SIZE DISTRIBUTION ASTM D422

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TP21-05

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 1.8 m to 2 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
12.5	**0.237**	**0.009**						**2.6**	**23.1**	**36.4**	**37.9**

Description: Sandy CLAY and SILT, trace gravel
Natural Moisture Content: 21.1 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

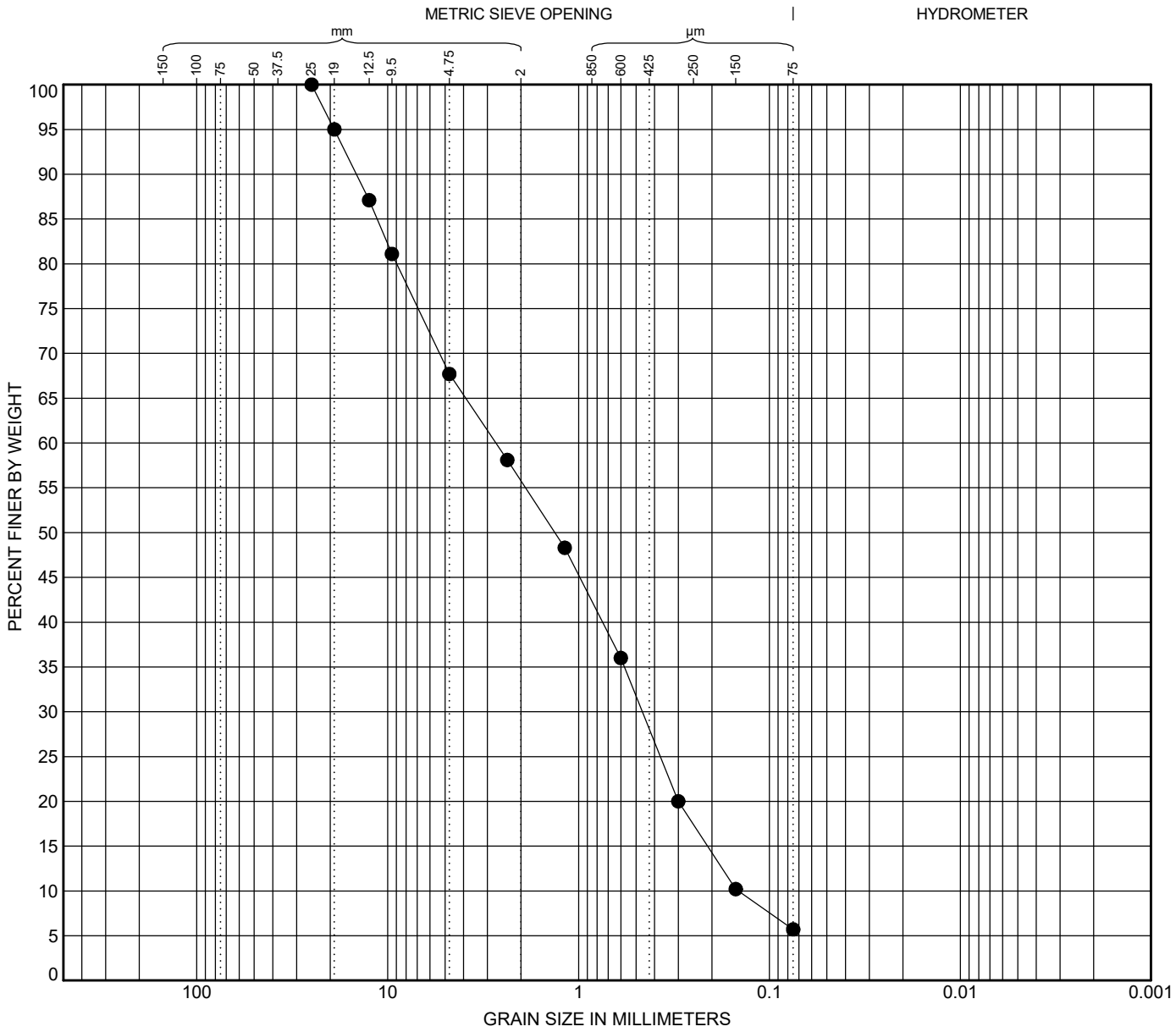
Sample Number: 21-371
Date Tested: 2021-09-27
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TP21-05

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 0.8 m to 1 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
25	**11.355**	**2.71**	**0.463**	**0.211**	**0.145**	**0.54**	**18.63**	**32.3**	**62.0**	**5.7**	

Description: Gravelly SAND, trace fines
Natural Moisture Content: 5.7 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

Sample Number: 21-372
Date Tested: 2021-09-09
Tested By: TB

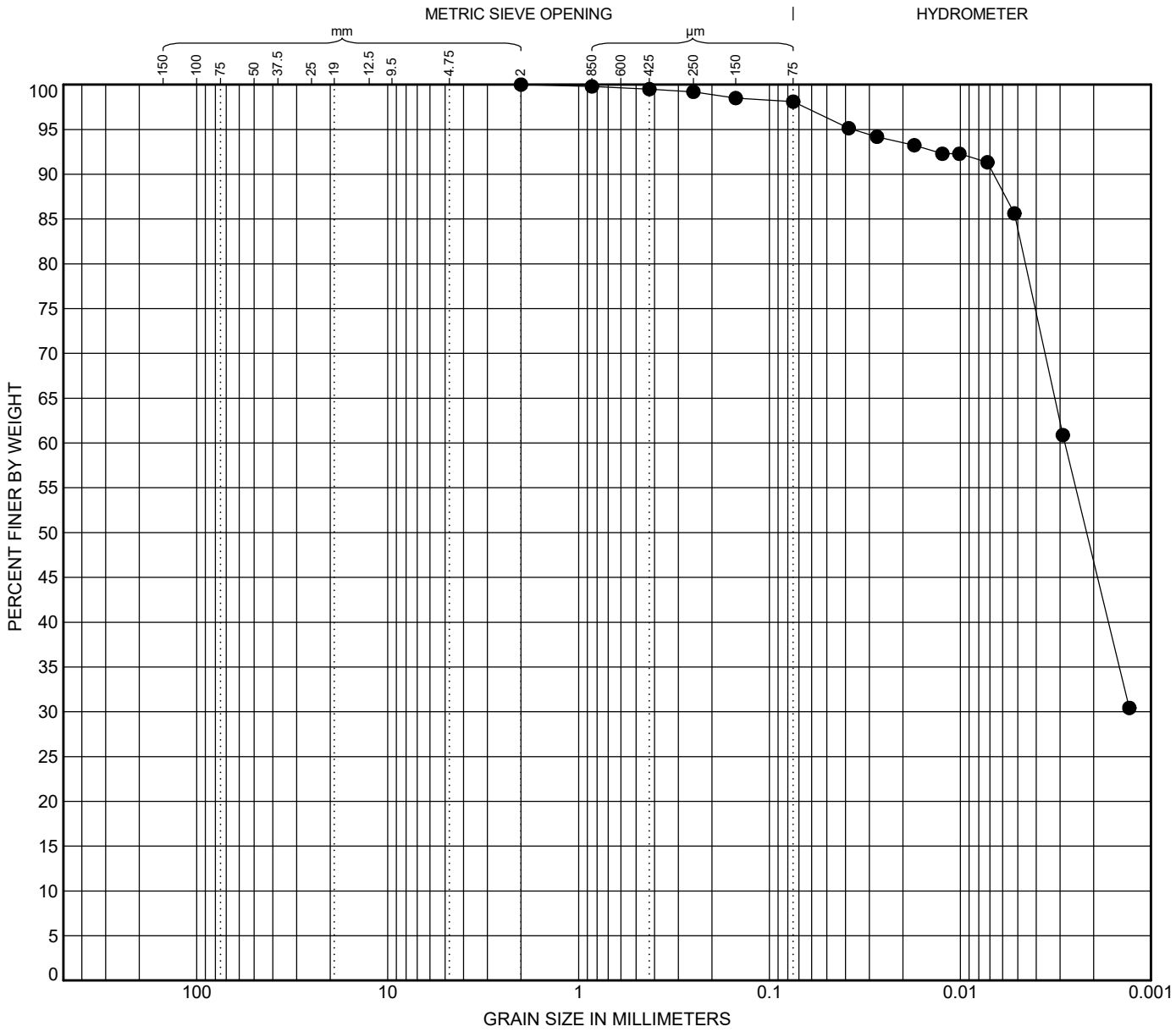
Checked By: _____

GRAIN SIZE DISTRIBUTION GK-18-750-MOT-13 LAB.GPJ DATAECORA2018.GDT 21-11-10

GRAIN SIZE DISTRIBUTION ASTM D422

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TP21-04

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 1.5 m to 1.6 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
2	**0.005**	**0.003**						**0.0**	**1.9**	**51.3**	**46.8**

Description: SILT and CLAY, trace sand
Natural Moisture Content: 30.4 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

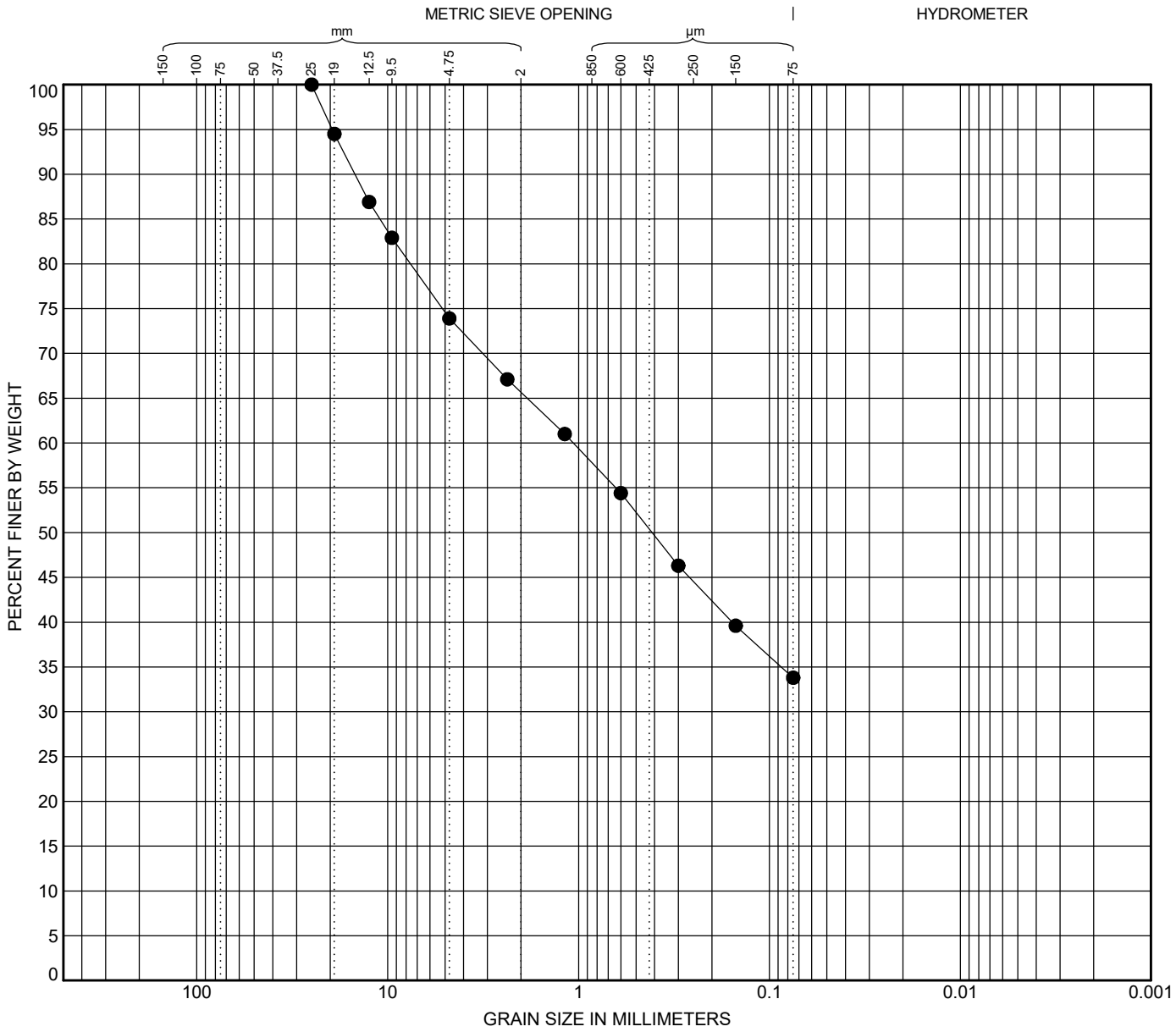
Sample Number: 21-373
Date Tested: 2021-09-27
Tested By: TB

Checked By: _____

GRAIN SIZE DISTRIBUTION ASTM C136

Project: Guest and Shallow Bay
Location: Guest Road at Highway 16
Sample Location/Source: TP21-06

Project No: GK-18-750-MOT-13
Client: Ministry of Transportation
Depth: 1.9 m to 2 m



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

D_{100}	D_{85}	D_{60}	D_{30}	D_{15}	D_{10}	C_c	C_u	%Gravel	%Sand	%Silt	%Clay
25	**10.972**	**1.065**						**26.1**	**40.1**	**33.8**	

Description: Silty, gravelly SAND
Natural Moisture Content: 10.1 %
Material Specification: N/A
Intended Use: N/A
Comments: N/A

Sample Number: 21-374
Date Tested: 2021-09-09
Tested By: TB

Checked By: _____

Appendix C.2

Native Soil Chemical Test Results

CERTIFICATE OF ANALYSIS

REPORTED TO	Ecora (Kelowna) 200 - 2045 Enterprise Way Kelowna, BC V1Y 6L8		
ATTENTION	Teri Brito	**WORK ORDER**	21K3052
PO NUMBER		**RECEIVED / TEMP**	2021-11-22 13:25 / 19.1°C
PROJECT	180750-13	**REPORTED**	2021-11-29 14:55
PROJECT INFO		**COC NUMBER**	No Number

Introduction:

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Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

If you have any questions or concerns, please contact me at bwhitehead@caro.ca

Authorized By:

Brent Whitehead
Client Scientist - Team Lead

TEST RESULTS

REPORTED TO	Ecora (Kelowna)	**WORK ORDER**	21K3052
PROJECT	180750-13	**REPORTED**	2021-11-29 14:55

Analyte	Result	RL	Units	Analyzed	Qualifier
TH21-02 @ 2.5 - 2.7m (21K3052-01) | Matrix: Solid | Sampled: 2021-08-23					
General Parameters					
Sulfate, Water-Soluble	< 0.050	0.050	%	2021-11-29	
Chloride, Water-Soluble	< 0.002	0.002	%	2021-11-29	
TH21-02 @ 5.5 - 5.7m (21K3052-02) | Matrix: Solid | Sampled: 2021-08-23					
General Parameters					
Sulfate, Water-Soluble	< 0.050	0.050	%	2021-11-29	
Chloride, Water-Soluble	< 0.002	0.002	%	2021-11-29	

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Ecora (Kelowna)	**WORK ORDER**	21K3052
PROJECT	180750-13	**REPORTED**	2021-11-29 14:55

Analysis Description	Method Ref.	Technique	Accredited	Location
Chloride, Water Soluble in Solid	ASTM C1218-97 / ASTM C1218-17	Hot Water Extraction / Hot Water Extraction		Richmond
Sulfate, Water-Soluble in Solid	CSA A23.2-3B / CSA A23.2-2B	Extraction (HCl) / Gravimetry (Barium Sulfate Precipitation)		Richmond

Glossary of Terms:

RL	Reporting Limit (default)
%	Percent
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
ASTM	ASTM International Test Methods
CSA	Canadian Standards Association Chemical Test Methods

General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:bwhitehead@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline(s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Ecora (Kelowna)	**WORK ORDER**	21K3052
PROJECT	180750-13	**REPORTED**	2021-11-29 14:55

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in “batches” and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B1K2530										
Blank (B1K2530-BLK1)				Prepared: 2021-11-23, Analyzed: 2021-11-24						
Sulfate, Water-Soluble	< 0.050	0.050	%							
General Parameters, Batch B1K3064										
Blank (B1K3064-BLK1)				Prepared: 2021-11-28, Analyzed: 2021-11-29						
Chloride, Water-Soluble	< 0.002	0.002	%							

Appendix C.3

Surface Water Chemical Test Results

CERTIFICATE OF ANALYSIS

REPORTED TO	Ecora (Vancouver) #300 - 638 Smithe Street Vancouver, BC V6B 1E3		
ATTENTION	Teri Brito	**WORK ORDER**	21K2619
PO NUMBER		**RECEIVED / TEMP**	2021-11-18 10:15 / 18.0°C
PROJECT	Culvert Outlet	**REPORTED**	2021-11-23 11:01
PROJECT INFO		**COC NUMBER**	No Number

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Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

If you have any questions or concerns, please contact me at bwhitehead@caro.ca

Authorized By:

Brent Whitehead
Client Scientist - Team Lead

TEST RESULTS

REPORTED TO	Ecora (Vancouver)	**WORK ORDER**	21K2619
PROJECT	Culvert Outlet	**REPORTED**	2021-11-23 11:01

Analyte	Result	RL	Units	Analyzed	Qualifier
SW21-01 (21K2619-01) | Matrix: Water | Sampled: 2021-08-20 16:00					CT1
General Parameters					
pH	**7.14**	0.10	pH units	2021-11-21	HT2
SW21-02 (21K2619-02) | Matrix: Water | Sampled: 2021-08-20 16:00					CT1
General Parameters					
pH	**7.21**	0.10	pH units	2021-11-21	HT2
SW21-03 (21K2619-03) | Matrix: Water | Sampled: 2021-08-20 16:00					CT1a
Anions					
Sulfate	< 1.0	1.0	mg/L	2021-11-20	HT1
SW21-04 (21K2619-04) | Matrix: Water | Sampled: 2021-08-20 16:00					CT1a
Anions					
Sulfate	< 1.0	1.0	mg/L	2021-11-20	HT1

Sample Qualifiers:

CT1	Incorrect Container(s) supplied for ph analysis
CT1a	Incorrect Container(s) supplied for sulfate analysis
HT1	The sample was prepared and/or analyzed past the recommended holding time.
HT2	The 15 minute recommended holding time (from sampling to analysis) has been exceeded - field analysis is recommended.

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Ecora (Vancouver)	**WORK ORDER**	21K2619
PROJECT	Culvert Outlet	**REPORTED**	2021-11-23 11:01

Analysis Description	Method Ref.	Technique	Accredited	Location
Anions in Water	SM 4110 B (2017)	Ion Chromatography	✓	Kelowna
pH in Water	SM 4500-H+ B (2017)	Electrometry	✓	Kelowna

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
mg/L	Milligrams per litre
pH units	pH < 7 = acidic, ph > 7 = basic
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:bwhitehead@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline(s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Ecora (Vancouver)	**WORK ORDER**	21K2619
PROJECT	Culvert Outlet	**REPORTED**	2021-11-23 11:01

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in "batches" and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

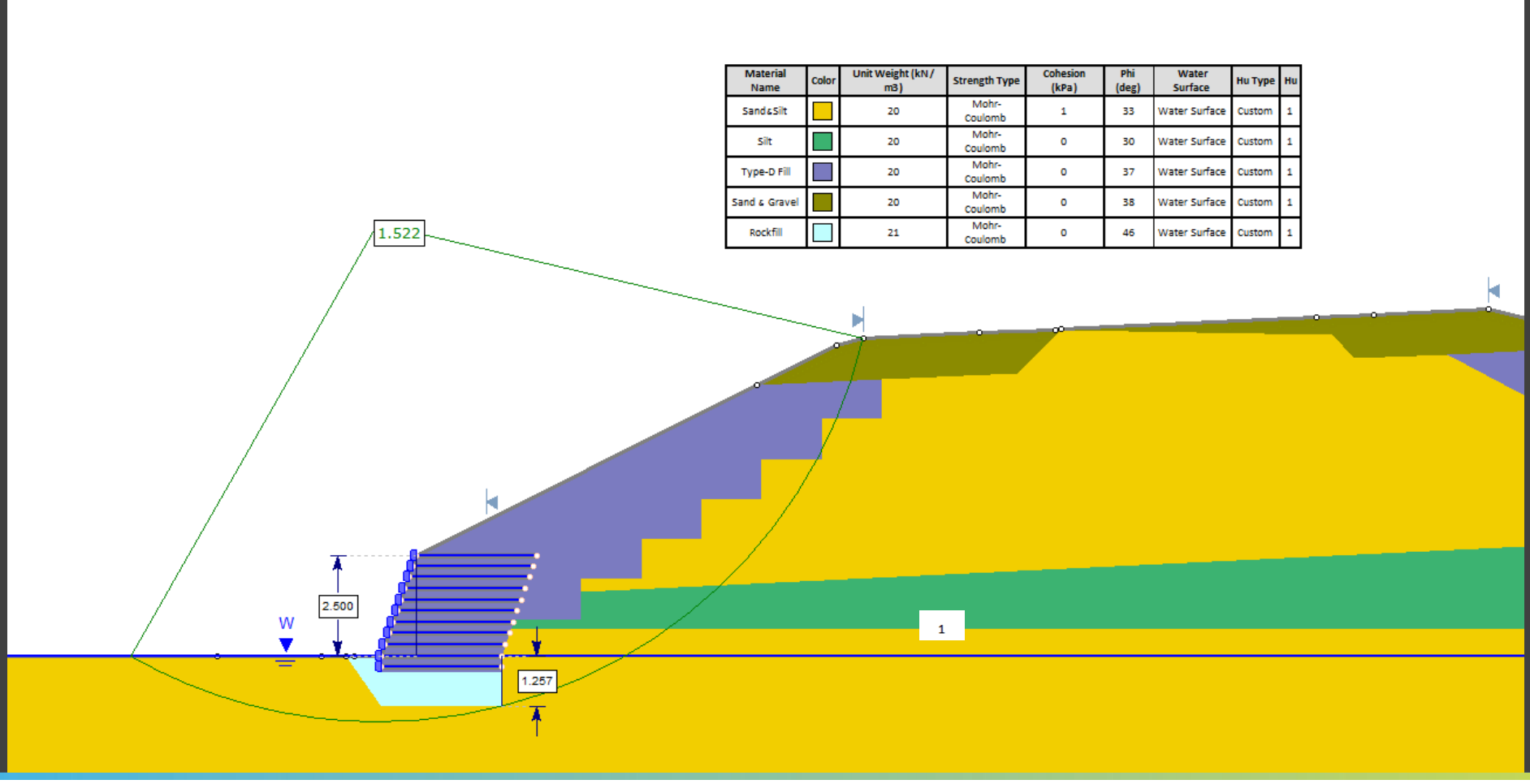
- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Anions, Batch B1K2285										
Blank (B1K2285-BLK1)				Prepared: 2021-11-20, Analyzed: 2021-11-20						
Sulfate	< 1.0	1.0	mg/L							
LCS (B1K2285-BS1)				Prepared: 2021-11-20, Analyzed: 2021-11-20						
Sulfate	16.1	1.0	mg/L	16.0		101	90-110			
Duplicate (B1K2285-DUP1)		**Source: 21K2619-04**		Prepared: 2021-11-20, Analyzed: 2021-11-20						
Sulfate	< 1.0	1.0	mg/L		< 1.0				10	
Matrix Spike (B1K2285-MS1)		**Source: 21K2619-04**		Prepared: 2021-11-20, Analyzed: 2021-11-20						
Sulfate	16.4	1.0	mg/L	16.0	< 1.0	102	75-125			
General Parameters, Batch B1K2348										
Reference (B1K2348-SRM1)				Prepared: 2021-11-21, Analyzed: 2021-11-21						
pH	6.99	0.10	pH units	7.01		100	98-102			
Reference (B1K2348-SRM2)				Prepared: 2021-11-21, Analyzed: 2021-11-21						
pH	6.99	0.10	pH units	7.01		100	98-102			

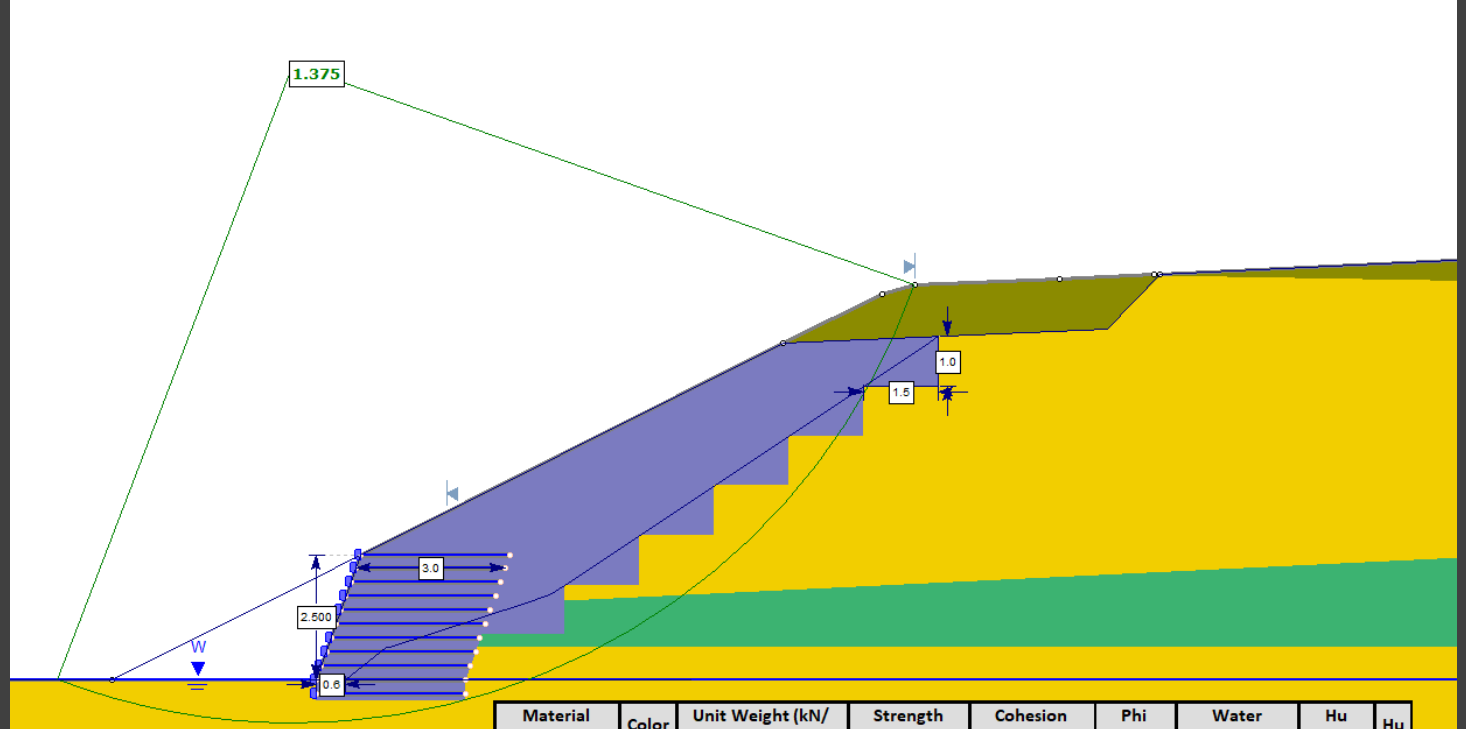
Appendix D

Option Analysis SLIDE2 Model Results



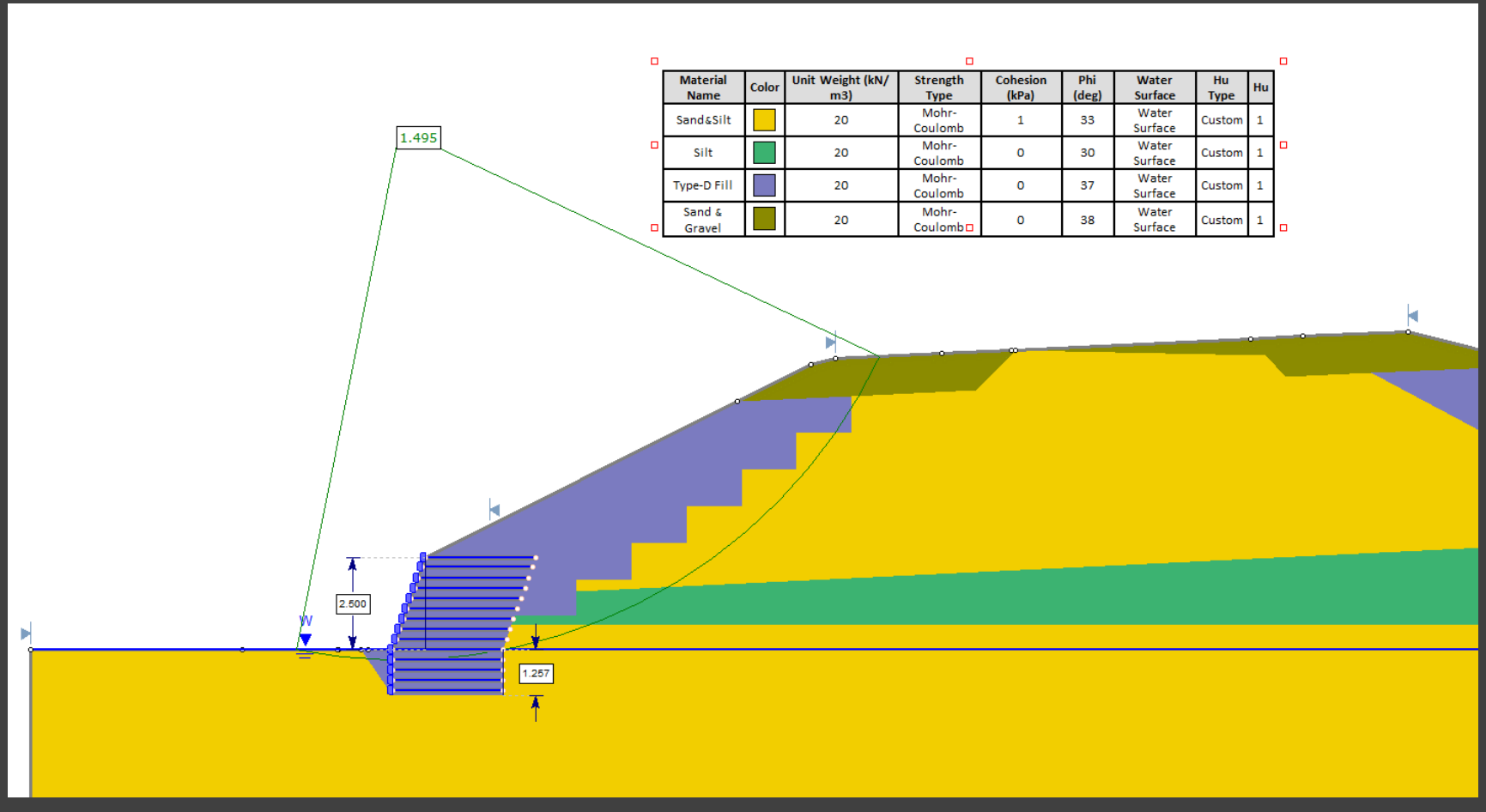
GRS Wall – With Rockfill

Selected Option



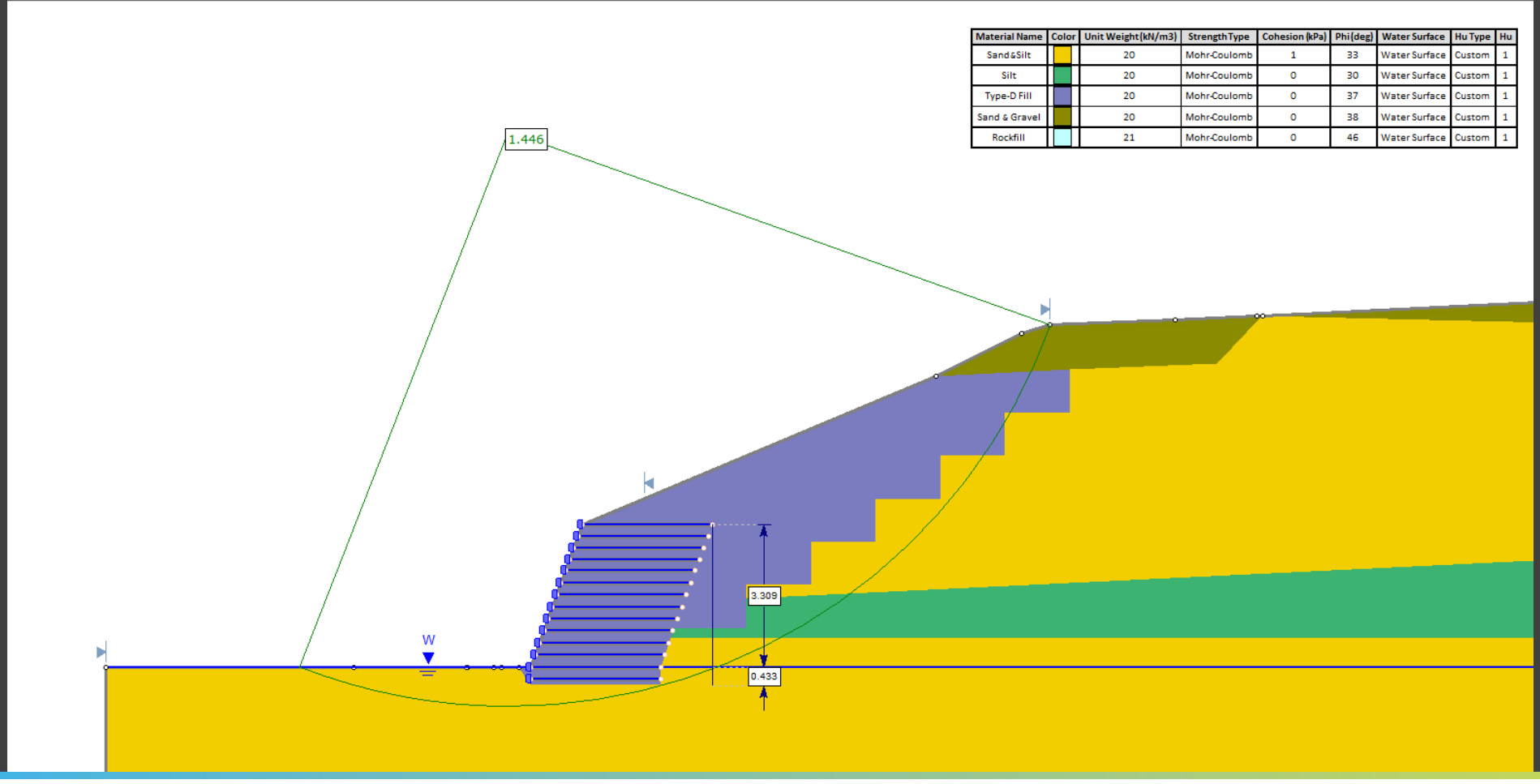
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Sand&Silt		20	Mohr-Coulomb	1	33	Water Surface	Custom	1
Silt		20	Mohr-Coulomb	0	30	Water Surface	Custom	1
Type-D Fill		20	Mohr-Coulomb	0	37	Water Surface	Custom	1
Sand & Gravel		20	Mohr-Coulomb	0	38	Water Surface	Custom	1

GRS Wall
Insufficient FoS



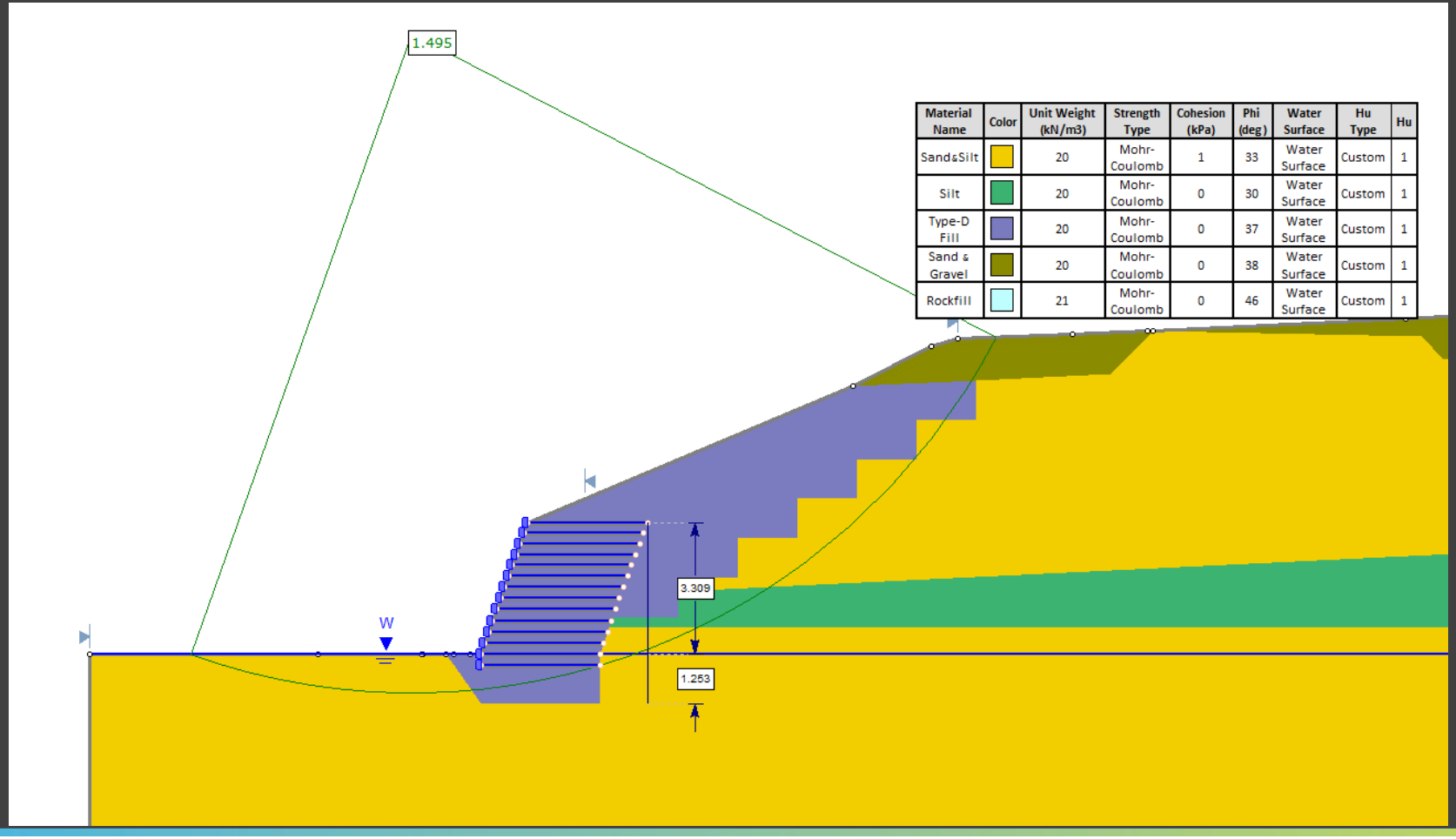
GRS Wall – Deeper

Insufficient FoS



GRS Wall – High (No Fill)

Insufficient FoS

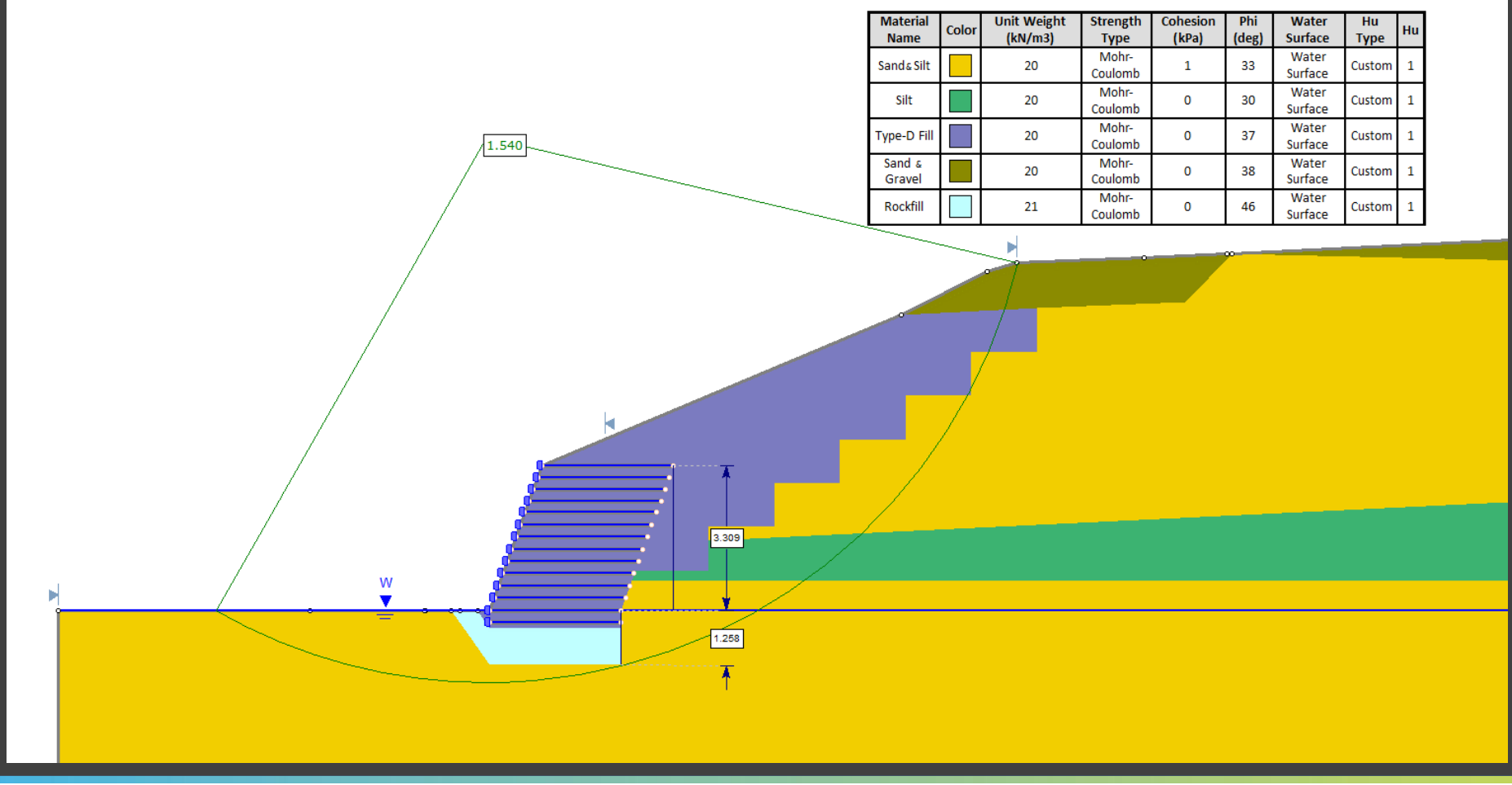


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Sand&Silt		20	Mohr-Coulomb	1	33	Water Surface	Custom	1
Silt		20	Mohr-Coulomb	0	30	Water Surface	Custom	1
Type-D Fill		20	Mohr-Coulomb	0	37	Water Surface	Custom	1
Sand & Gravel		20	Mohr-Coulomb	0	38	Water Surface	Custom	1
Rockfill		21	Mohr-Coulomb	0	46	Water Surface	Custom	1

GRS Wall – High (D-Type Fill)

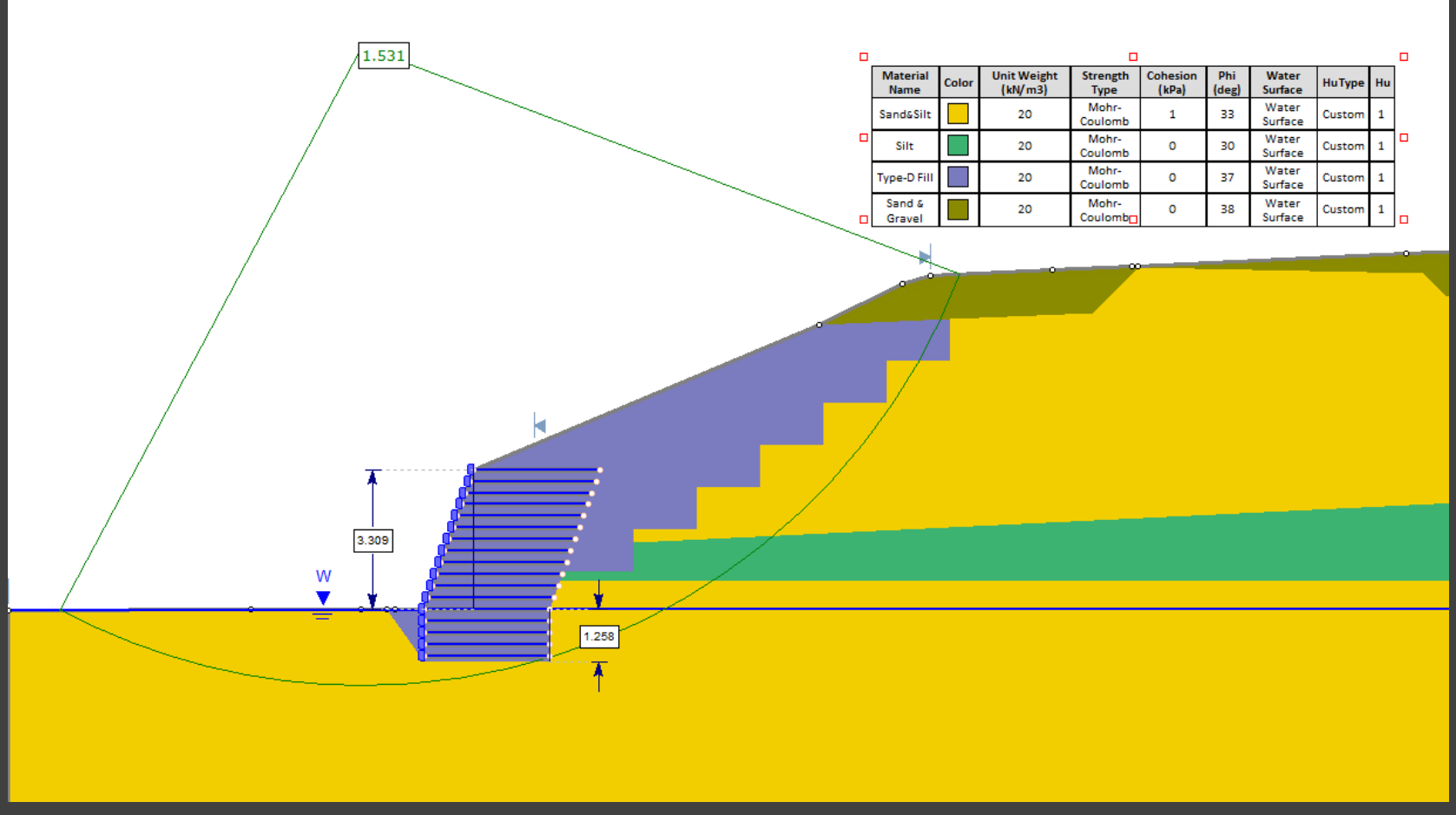
Insufficient FoS

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Sand & Silt		20	Mohr-Coulomb	1	33	Water Surface	Custom	1
Silt		20	Mohr-Coulomb	0	30	Water Surface	Custom	1
Type-D Fill		20	Mohr-Coulomb	0	37	Water Surface	Custom	1
Sand & Gravel		20	Mohr-Coulomb	0	38	Water Surface	Custom	1
Rockfill		21	Mohr-Coulomb	0	46	Water Surface	Custom	1



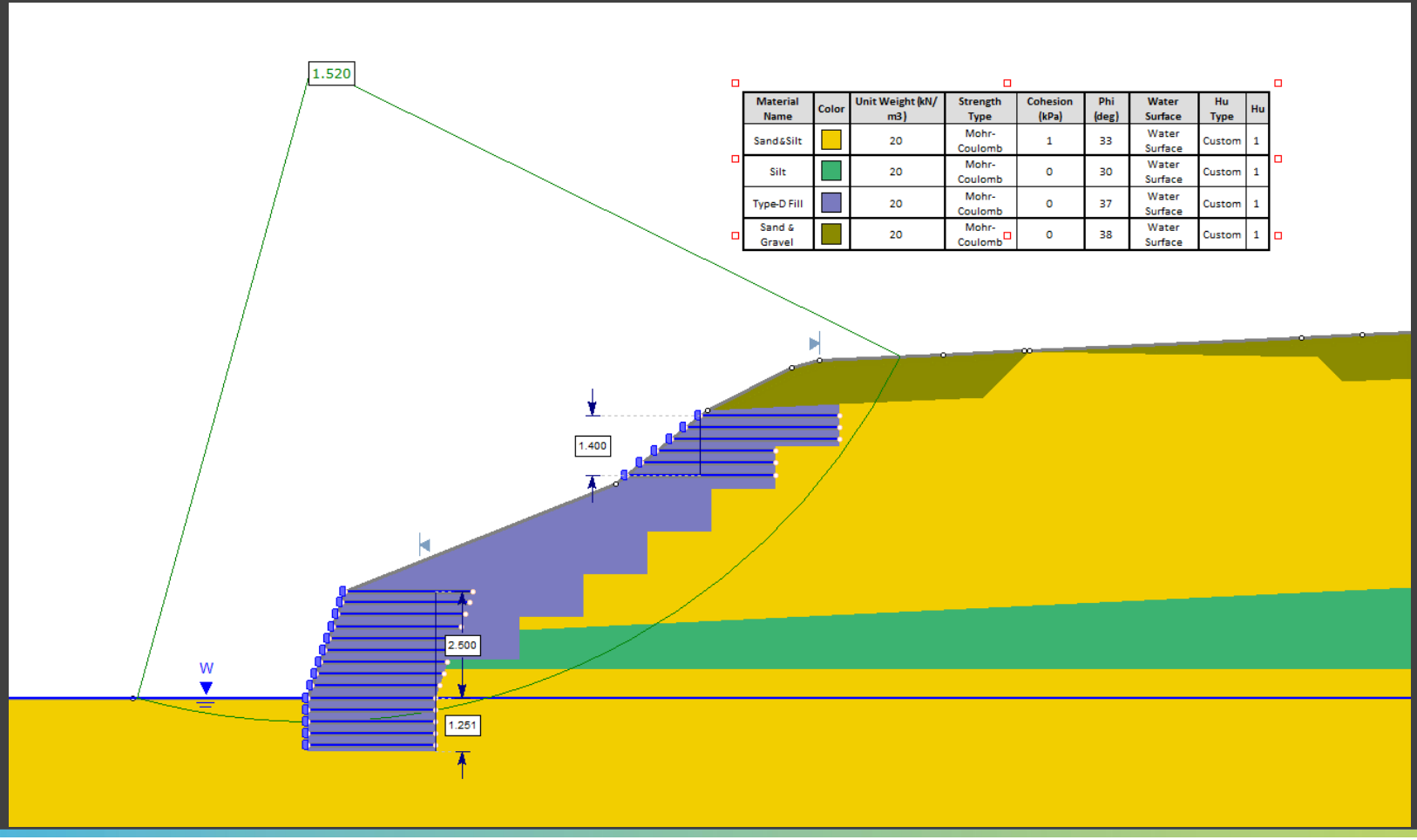
GRS Wall – High (Rockfill)

Requires Culvert Displacement



GRS Wall - High & Deep

Requires Culvert Displacement



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Sand&Silt		20	Mohr-Coulomb	1	33	Water Surface	Custom	1
Silt		20	Mohr-Coulomb	0	30	Water Surface	Custom	1
Type-D Fill		20	Mohr-Coulomb	0	37	Water Surface	Custom	1
Sand & Gravel		20	Mohr-Coulomb	0	38	Water Surface	Custom	1

GRS Wall – Above

Requires Culvert Displacement

Appendix E

Traffic Volume Data – Bednesti (P-42-2EW)

Ministry of Transportation and Infrastructure

Traffic Data

10 Year Annual Summary for 2020

TM Site ID: **P-42-2EW**

TM Site Name: **Bednesti - P-42-2EW, Yellowhead Trans-Canada**

Location: Route 16, 49.4 km west of Route 97, west of Prince George

Posted Speed: **100 kph**

Report Run on: Friday October 1 2021 09:17 AM

Traffic Data in this report

AADT — **Annual Average Daily Traffic**
A calculated daily estimate of the number of vehicles passing this site.

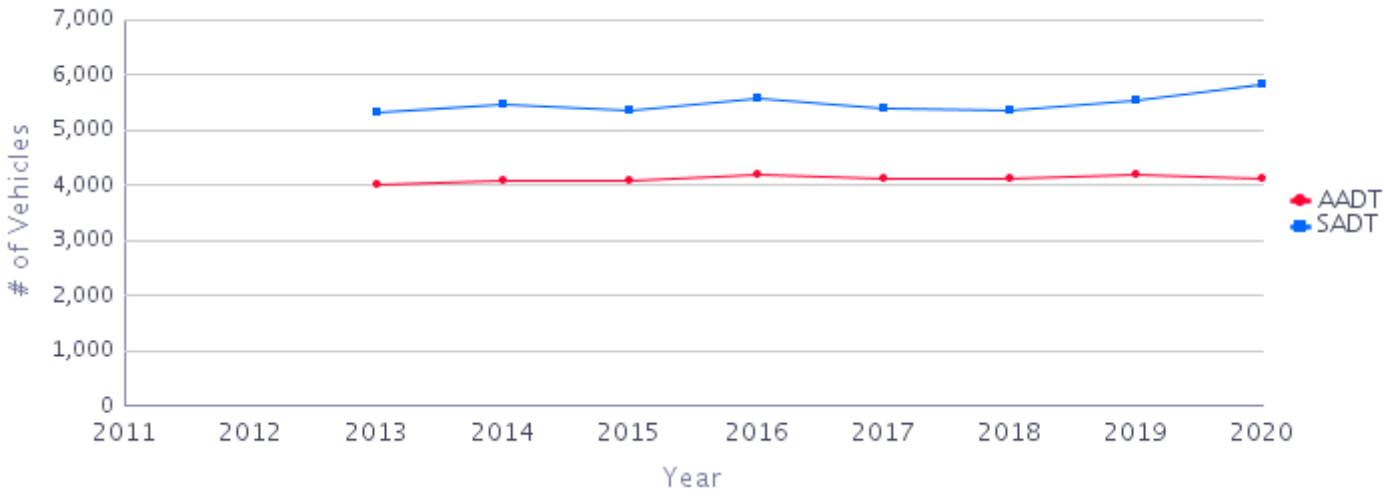
SADT — **Summer Average Daily Traffic**
(for the months of July and August)

Class — **Vehicle Length**
Types of vehicles traveling through this site.

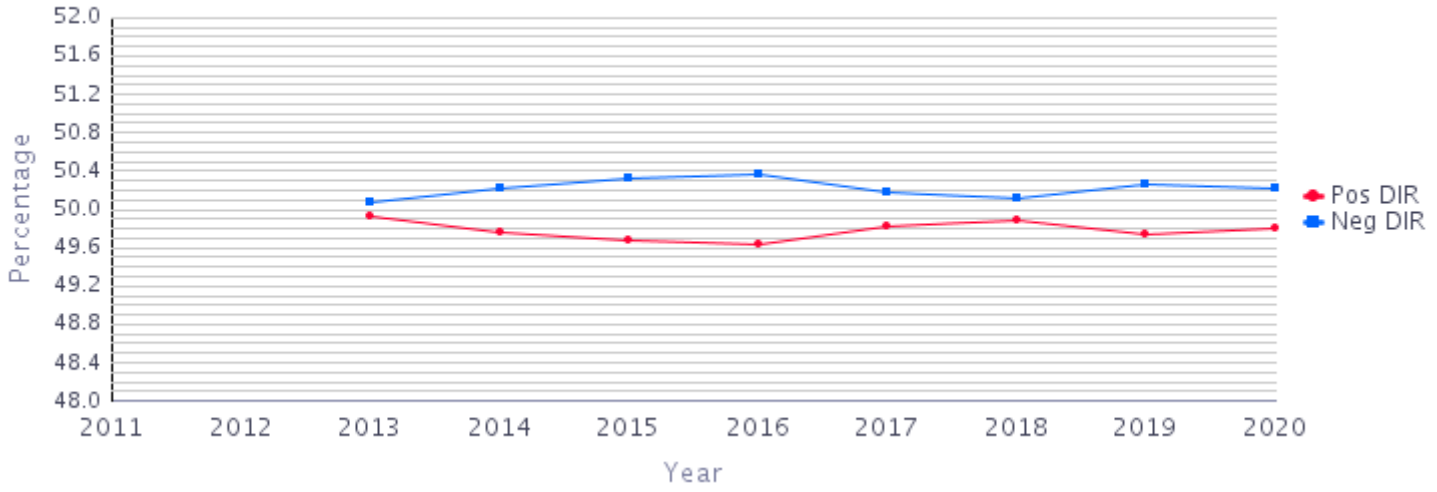
Average Daily Traffic Volumes

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
AADT			3,998	4,086	4,065	4,191	4,132	4,127	4,180	4,118
SADT			5,327	5,449	5,364	5,579	5,405	5,368	5,535	5,846

10 Year Annual Statistics



10 Years % AADT by Direction



Traffic Data

10 Year Annual Summary for 2020

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Location: Route 16, 49.4 km west of Route 97, west of Prince George

Posted Speed: **100 kph**

Report Run on: Friday October 1 2021 9:17 AM

10 Year Annual Average Daily Length Distribution Summary for 2020

Length	Vehicle Type	Road	% of Roadway	% Pos	% Neg
0 - 6 metres		24,121	73	50	50
6 - 12.5 metres		2,991	9	50	50
12.5 - 22.5 metres		2,881	9	48	52
22.5 - 35 metres		3,022	9	51	49
35 - 999 metres		15	<1	38	62

Disclaimer information and the most current traffic data may be found at: http://www.th.gov.bc.ca/trafficData