# FOUNDATION INVESTIGATION AND DESIGN REPORT
# HIGHWAY 7289 EAST EMBANKMENT SLOPE
# STA. 11+400 TO 11+900 SEGUIN TOWNSHIP
# AGREEMENT NO. 5020-E-0010
# GWP 5252-21-00

THURBER ENGINEERING LTD.

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**GEOCRES NO.: 31E-419**

**Report**

**to**

**AECOM Canada Ltd.**

Latitude: 45.184091°
Longitude: -79.775059°

July 2024

Thurber File No.: 31334

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# PART 1. FACTUAL INFORMATION

## 1. INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed along the existing embankment slope to the east of Highway 7289, also known as Lake Joseph Road, 9 km south of the intersection with Highway 141 and approximately 35 km south of Parry Sound, Ontario. The site is in the Township of Seguin (formerly Township of Humphrey) within the District of Parry Sound, Ontario. Thurber Engineering Limited (Thurber) carried out the assignment as a sub-consultant to AECOM Canada Ltd. (AECOM) under Agreement No. 5020-E-0010.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results, and a written description of the subsurface conditions. A model of the subsurface conditions influencing assessment of the existing slope and retaining wall and remedial measures was developed as part of the assignment.

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

## 2. SITE DESCRIPTION

### 2.1 General

The existing embankment slope is located immediately east of Highway 7289 between Sta. 11+400 and Sta. 11+900, Seguin Township, approximately 9 km south of the intersection with Highway 141 and 13 km north of the junction with Highway 400. There is an existing timber retaining wall located at the south end of the site between about 11+465 and 11+490. For project purposes, Highway 7289, the embankment slope, and the timber retaining wall are herein described as oriented north-south.

At the site location, Highway 7289 is a two-lane, undivided highway and has a posted speed limit of 80 km/h. The highway centreline profile decreases from Elevation 240.8 m at Sta. 11+400 (south project limit) to Elevation 235.7 m at Sta. 11+900 (north project limit). The northbound shoulders have a width ranging from approximately 2.9 m to 3.5 m, with about 2.4 m to 2.8 m being paved. Traffic volumes on this section of Highway 7289 are understood to have been 2,400 AADT in 2018 as per the Project Assessment Report (PAR).

The site is in a rural setting and is located within a region that is commonly used for recreational activities. The areas adjacent to the highway are generally undeveloped and densely vegetated with deciduous and some coniferous trees and shrubs. The site is bounded to the east by a steep slope down to Lake Joseph, and to the west by a railway running approximately parallel to the highway. Two private residential properties are located west of the railway, and several more adjacent to the east embankment slope near the south end of the project limit. Based on AutoCAD drawings provided by AECOM, the east embankment slope height varies from about 7 m to 9 m. The inclination of the east embankment slope, down toward Lake Joseph, generally ranges between about 1.4H:1V to 1.6H:1V but is as steep as 1.2H:1.0V at Sta. 11+475, near the existing timber retaining wall.

The terrain generally slopes up to the west of the highway towards the railway. Between the highway and the railway to the west, a gabion wall is present from about Sta. 11+465 to Sta. 11+600 and a rock cut is present from about Sta. 11+600 to 11+700. Steel cable guiderails on wooden posts are present along the northbound shoulders, and overhead utility lines are located on the east embankment slope and crossing the highway at multiple locations.

Localized shallow failures of the east embankment due to the steep slope and surface water infiltration have been observed over the years. Photographs 1 and 2 in Appendix D show examples of local slope failures observed in September 2014 (photographs provided by MTO). In general, the disturbed zones originated through the highway shoulder at the crest of the slope and extend down toward Lake Joseph.

Susceptible portions and/or locations showing visible signs of local failures have received surface treatments in an attempt to manage potential future failures. Drawings from Contract 1995-0229 (Sheets 3 to 5) show remedial treatment measures that included subexcavation and replacement of the northbound shoulder with Granular B Type II fill and a subdrain from 11+275 to 11+375, and placement of Granular B Type II fill on the exposed slope from 11+475 to 11+550. As a result of the observed failures in 2014, rock protection has been placed in many segments along the east embankment slope (see Photographs 3 and 4 in Appendix D).

During a site reconnaissance conducted by Thurber on December 12, 2021, no tension cracks were observed to be present in the asphalt along the existing east embankment slope, but slight to moderate tilt of guide rail posts and hydro poles on the east slope were observed within the project limits (see Photograph 8 in Appendix D). At the toe of the embankment slope, near the timber retaining wall between approximate Sta. 11+440 and 11+470, an exposed vertical slope was observed, indicating either a cut soil slope or a removed retaining wall (see Photographs 5 to 7 in Appendix D). The remaining section of the timber wall was observed to be in poor condition with significant tilt downslope.

No visible signs of global instability were observed at the gabion wall and slope west of the highway alignment.

Additional photographs of the project area are included in Appendix D.

## 2.2 Site Geology

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies within the physiographic region known as the Georgian Bay Fringe. The Georgian Bay Fringe is characterized by very shallow soil deposits and bare rock knobs.

According to Crins et al. 2009[i] the project area is described as Ecoregion 5E (Georgian Bay Ecoregion) within the Ontario Shield Ecozone. According to Wester et al. 2018[ii] the ecoregion is subdivided into Ecodistrict 5E-8 (Huntsville Ecodistrict). The area is characterized by a shallow to moderately deep stratum of morainal material and Precambrian bedrock outcrops.

The Ontario Geological Survey maps suggest that the bedrock at the project area commonly comprises layered biotite gneisses and migmatites with quartzofeldspathic gneisses, orthogneisses, and paragneisses found locally. Map P. 3103 indicates that the project area is characterized by glaciolacustrine deposits of stratified deltaic, valley-fill sands and gravel.

## 2.3 Existing Subsurface Information

No information is available in the Geocres Library for the area within the project limits. However, the following contract was available for this site:

- Contract 1995-0229 (D.F. ELLIOTT, 1995) presents the results of pavement investigations carried out for the rehabilitation of the existing highway. The investigation indicates NFP on bedrock and rock fill at numerous stations located within the site of the current foundation investigation.

## 3. SITE INVESTIGATION AND FIELD TESTING

The site investigation and field-testing program was carried out between June 27 and July 13, and then again on December 12, 2022, and consisted of on-road boreholes put down at seven locations identified as 22-02A/B, 22-04, 22-06, 22-08, 22-10, 22-12, and 22-14 and off-road boreholes put down at seven locations identified as 22-01, 22-03, 22-05, 22-07, 22-09, 22-11, and 22-13.

The on-road boreholes were advanced with a CME 75 truck mounted drill rig utilizing HW casing and coring techniques. The off-road boreholes were advanced with portable drilling equipment using NW casing, except for Boreholes 22-01 and 22-03 which were advanced with a hydro excavator and Borehole 22-11 which was put down with a CME 75 truck mounted drill rig from the existing driveway. A half-weight hammer was used for SPT advancement in Boreholes 22-05 and 22-13. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

A summary of the borehole coordinates, elevations, and termination depths is provided in Table 3-1. The as-drilled borehole elevations were surveyed by Thurber with both a surveyor's level and a handheld laser-level relative to BM HCP 152 (Elevation 239.588 m). The elevations and borehole coordinates were reviewed and referenced to the survey provided by AECOM. Horizontal locations were measured by Thurber relative to existing site features. The borehole coordinates and elevations are shown on the Borehole Location and Soil Strata drawing included in Appendix A and on the individual Record of Borehole sheets included in Appendix B. The borehole coordinates are referenced to MTM Zone 10.

In the drilled and sampled boreholes, soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in general accordance with ASTM D 1586. A hammer weight correction has been applied for the N-values recorded for the SPTs carried out with the portable drill in Boreholes 22-05 and 22-13. It is noted that an automatic hammer could not be used with the portable drill at those boreholes thus the SPT N-values from the portable drilling equipment are less reliable.

The boreholes were advanced to depths ranging from 0.7 m to 13.7 m (base elev. 234.3 m to 225.5 m), and coring was required to advance the boreholes into the existing cobbles, boulders, and bedrock. Vibrating Wire Piezometers (VWPs) were installed in Boreholes 22-04, 22-08, and 22-12 to allow for measurements of the groundwater level after drilling. The details for the VWPs are illustrated on the respective Record of Borehole sheets provided in Appendix B. The VWPs were decommissioned in December 2022.

**Table 3-1: Borehole Summary**

| Borehole No. | Drilled Location (Station) | Northing (Latitude) | Easting (Longitude) | Ground Surface Elevation (m) | Termination Depth (m) |
|---|---|---|---|---|---|
| 22-01 | East Embankment Toe (Sta. 11+800) | 5 005 092.0 (45.185462) | 283 097.6 (-79.776167) | 229.6 | 1.1 |
| 22-02A | Northbound Shoulder (Sta. 11+800) | 5 005 084.5 (45.185394) | 283 087.6 (-79.776294) | 235.9 | 4.0 |
| 22-02B | Northbound Shoulder (Sta. 11+795) | 5 005 080.4 (45.185357) | 283 090.3 (-79.776259) | 235.9 | 3.9 |
| 22-03 | East Embankment Toe (Sta. 11+700) | 5 005 008.3 (45.184711) | 283 152.5 (-79.775450) | 230.3 | 0.7 |
| 22-04 | Northbound Shoulder (Sta. 11+700) | 5 005 001.8 (45.184652) | 283 142.7 (-79.775589) | 236.7 | 9.1 |
| 22-05 | East Embankment Toe (Sta. 11+625) | 5 004 945.4 (45.184146) | 283 193.2 (-79.774945) | 231.4 | 1.0 |
| 22-06 | Northbound Shoulder (Sta. 11+625) | 5 004 939.3 (45.184091) | 283 184.2 (-79.775059) | 237.5 | 6.1 |
| 22-07 | East Embankment Toe (Sta. 11+550) | 5 004 883.6 (45.183591) | 283 238.3 (-79.774368) | 230.6 | 1.4 |
| 22-08 | Northbound Shoulder (Sta. 11+550) | 5 004 877.3 (45.183534) | 283 226.4 (-79.774520) | 238.6 | 12.2 |
| 22-09 | East Embankment Toe (Sta. 11+510) | 5 004 853.4 (45.183320) | 283 261.0 (-79.774078) | 231.3 | 1.7 |
| 22-10 | Northbound Shoulder (Sta. 11+510) | 5 004 845.1 (45.183245) | 283 249.9 (-79.774219) | 239.2 | 13.7 |
| 22-11 | East Embankment Toe (Sta. 11+475) | 5 004 826.5 (45.183079) | 283 283.4 (-79.773792) | 231.4 | 0.9 |
| 22-12 | Northbound Shoulder (Sta. 11+475) | 5 004 817.5 (45.182997) | 283 270.9 (-79.773950) | 239.7 | 9.0 |
| 22-13 | East Embankment Toe (Sta. 11+440) | 5 004 796.9 (45.182813) | 283 301.7 (-79.773558) | 235.9 | 1.6 |
| 22-14 | Northbound Shoulder (Sta. 11+440) | 5 004 789.1 (45.182742) | 283 291.3 (-79.773689) | 240.3 | 9.1 |

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

Following completion of the field investigation, the boreholes without a VWP were decommissioned in general accordance with O.Reg. 903, as amended. Boreholes 22-02A, 22-02B, 22-04, 22-06, 22-10, and 22-14 were capped with cold patch asphalt to reinstate the pavement surface.

## 4. LABORATORY TESTING

Laboratory testing was selected in general accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing included natural moisture content determination and visual identification of all retained soil samples. Selected soil samples were submitted for grain size distribution and tested in accordance with MTO and ASTM standards. All rock cores were photographed, their total core recovery (TCR), solid core recovery (SCR), and rock quality designation (RQD) were measured, and Unconfined Compressive Strength (UCS) testing was carried out on three selected rock samples. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B and are included in Appendix C.

Two soil samples were selected and submitted to Paracel Laboratories Ltd. in Ottawa for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are provided in Appendix C.

## 5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and on the Borehole Location and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following sections. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions will vary between and beyond borehole locations. Soil classification is in accordance with ASTM D2487. Description of cohesive soils and secondary components are described as outlined in the MTO Guideline for Foundation Engineering Services Manual (April 2022).

In general, the encountered stratigraphy consists of silty sand embankment fill overlying a native deposit of silty sand and gravel which is, in turn, underlain by gneissic bedrock.

### 5.1 Asphalt/Topsoil

Asphalt was encountered at the ground surface in all the on-road boreholes with a recorded thickness of 150 mm to 200 mm.

Approximately 100 mm to 150 mm of topsoil was encountered in Boreholes 22-01, 22-03, 22-05, 22-07, and 22-09.

### 5.2 Fill

Fill consisting of silty sand to sand, some silt was encountered beneath the asphalt in all the on-road boreholes, below the topsoil in Boreholes 22-05 and 22-07, and below the ground surface in Boreholes 22-11 and 22-13. Varying amounts of gravel were encountered within the layer. The fill was fully penetrated in all the on-road boreholes and in Borehole 22-07 with a recorded thickness ranging from 0.9 m to 3.5 m (base elev. 238.8 m to 229.2 m). SPT N-values in the fill ranged from 4 to 44 blows per 0.3 m of penetration, but generally between about 10 to 30 blows, indicating a compact relative density. Refusal blows counts were also observed which could represent a cobble or a boulder within the fill.

The recorded moisture contents ranged from 2 to 18%. The results of gradation analyses completed on thirteen samples of the layer are illustrated in Figure C1, C2, and C3 in Appendix C. The results of the tests are summarized below and on the Record of Borehole sheets in Appendix B.

<table>
<tr><th>Soil Particle</th><th colspan="2">Percentage (%)</th></tr>
<tr><td>Gravel</td><td colspan="2">0 to 46</td></tr>
<tr><td>Sand</td><td colspan="2">47 to 91</td></tr>
<tr><td>Silt</td><td rowspan="2">6 to 30</td><td>24</td></tr>
<tr><td>Clay</td><td>1</td></tr>
</table>

### 5.3 Silty Sand (SM)

A native layer of silty sand was encountered below the fill in all the on-road boreholes and in Borehole 22-07 and below the topsoil in Borehole 22-09. The deposit contains organics, and cobbles and boulders were encountered within the layer. The layer was fully penetrated in all the on-road boreholes with a recorded thickness ranging from 0.2 m to 6.4 m (base elev. 235.6 m to 229.1 m). SPT N-values in the layer ranged from 4 to 136 blows but were typically greater than 18 blows, indicating a compact to very dense relative density. Refusal blow counts were encountered within the layer, but these are likely indicative of the presence of a cobble or a boulder or the bedrock surface. Coring was required to penetrate the cobbles and boulders at some locations.

The recorded moisture content ranged from 6 to 38% but was typically less than about 24%. The results of gradation analyses completed on nine samples of the silty sand are summarized below and are illustrated on Figures C4 and C5 of Appendix C.

| Soil Particle | Percentage (%) |
|---|---|
| Gravel | 2 to 19 |
| Sand | 62 to 79 |
| Silt | 14 to 22 |
| Clay | 0 to 5 |

A sample from the layer in Borehole 22-04 and two samples from the lower portion of the deposit in Borehole 22-14 had a higher gravel content and a lower fines content. The results of gradation analyses completed on those samples are summarized below and are illustrated on Figure C6 of Appendix C.

<table>
<tr><th>Soil Particle</th><th colspan="2">Percentage (%)</th></tr>
<tr><td>Gravel</td><td colspan="2">26 to 54</td></tr>
<tr><td>Sand</td><td colspan="2">41 to 59</td></tr>
<tr><td>Silt</td><td rowspan="2">5 to 10</td><td>12</td></tr>
<tr><td>Clay</td><td>3</td></tr>
</table>

The results of the grainsize carried out on samples of this deposit are also summarized on the Record of Borehole sheets in Appendix B.

### 5.4 Cobbles and Boulders

A layer of cobbles and boulders was encountered below the topsoil in Boreholes 22-01 and 22-03 and inferred below the silty sand in Borehole 22-08. A layer of cobbles and boulders is inferred to be present below the silty sand in Borehole 22-04. The layer was fully penetrated in Boreholes 22-04 and 22-08 with a recorded thickness of 3.0 m and 4.5 m (base elev. 231.1 m and 229.5 m) at those locations.

Rotary diamond drilling and coring techniques were required to advance the boreholes past the cobbles and boulders layer in Boreholes 22-04 and 22-08. At Boreholes 22-01 and 22-03, advanced with a hydro excavator, samples of the silty sand present within the cobbles and boulders were obtained from the sidewall of the excavations. The recorded moisture content of those samples ranged from 15 to 24%. The results of gradation analyses completed on two of the samples of the silty sand portion of the deposit are illustrated in Figure C7 in Appendix C. The results of the tests are summarized below and on the Record of Borehole sheets in Appendix B.

| Soil Particle | Percentage (%) |
|---|---|
| Gravel | 2 to 15 |
| Sand | 74 to 76 |
| Silt | 11 to 22 |
| Clay | |

### 5.5 Bedrock

Bedrock was proven in Boreholes 22-02 A/B, 22-04, 22-06, 22-08, 22-10, 22-12, and 22-14. The depth to bedrock from the existing road grade ranged from 1.9 m to 10.1 m (elev. 235.6 m to 229.1 m, summarized in the table below) and indicates a variable bedrock surface.

| Borehole | Bedrock Surface | |
|---|---|---|
| | Depth (m) | Elevation (m) |
| 22-02A/B | 3.2 | 232.7 |
| 22-04 | 5.6 | 231.1 |
| 22-06 | 1.9 | 235.6 |
| 22-08 | 9.1 | 229.5 |
| 22-10 | 10.1 | 229.1 |
| 22-12 | 5.5 | 234.2 |
| 22-14 | 6.2 | 234.1 |

Bedrock was not proven in the boreholes put down at the toe of the slope but refusals at those locations (either at the inferred bedrock surface or cobbles and boulders) were at elevations ranging from 0.2 m to 5.2 m below the bedrock surface at the associated borehole put down from the top of the slope, indicating that the bedrock surface is variable and generally slopes down toward Lake Joseph.

The bedrock encountered consisted of moderately weathered to fresh, coarse-grained texture, gneiss that is pinkish grey in colour. In general, the discontinuities were rough, undulating cross joints. Bedrock logs are provided in Appendix B, and photographs of the bedrock cores are provided in Appendix C. The rock core quality and strength are summarized in the table below.

| Parameter | Range |
|---|---|
| Total Core Recovery (TCR), % | 42 to 100 |
| Solid Core Recovery (SCR), % | 30 to 97 |
| Rock Quality Designation (RQD), % | 15 to 81 |
| Fracture Index (fractures per 0.3 m)(1) | 0 to >10 |
| Unconfined Compressive Strength (UCS)(2), MPa | 103 to 115 |

Notes: (1) Indicated as "FI" on Borehole Logs
(2) Samples tested from Boreholes 22-04, 22-08, and 22-12

Based on the RQD, the bedrock quality is classified as very poor to excellent (CFEM, 2006). The results of unconfined compressive strength testing ranged from 103 MPa to 115 MPa, and indicate the bedrock is very strong (CFEM, 2006).

### 5.6 Groundwater Level

Observations for water levels were completed in the open boreholes during and upon completion of drilling. A vibrating wire piezometer (VWP) was installed in three boreholes to observe the piezometric pressure within the native deposits. The measured groundwater levels are summarized in Table 5-1 below.

**Table 5-1. Measured Groundwater Levels**

| Borehole | VWP Tip Elevation (m) | Screened Unit | Groundwater Level | | Date |
|---|---|---|---|---|---|
| | | | Depth (m) | Elevation (m) | |
| 22-04 | 233.0 | Cobbles and Boulders | Dry | - | 2022-07-08 |
| | | | Dry | - | 2022-07-14 |
| | | | 3.7 | 233.0 | 2022-12-12 |
| 22-08 | 230.2 | Cobbles and Boulders | 7.7 | 230.9 | 2022-07-06 |
| | | | 7.8 | 230.8 | 2022-07-14 |
| | | | 7.3 | 231.3 | 2022-12-12 |
| 22-12 | 233.6 | Bedrock | Dry | - | 2022-07-06 |
| | | | Dry | - | 2022-07-14 |
| | | | 5.8 | 233.9 | 2022-12-12 |

The surface of Lake Joseph was surveyed to be at Elevation 228.6 m on July 13, 2022.

It should be noted that the values shown above are considered short-term readings and may not reflect groundwater levels at the time of construction, and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

### 5.7 Analytical Testing

Two soil samples were submitted for analytical testing. The analysis results are included in Appendix C and are summarized in Table 5-2 below.

**Table 5-2: Summary of Analytical Test Results**

| Borehole | Sample (Soil Type) | Depth (m) | Chloride (μg/g) | Sulphate (μg/g) | Sulphide (%) | pH (-) | Resistivity (Ohm-cm) |
|---|---|---|---|---|---|---|---|
| 22-06 | SS3 (Silty Sand) | 1.5 – 2.1 | 43 | 136 | < 0.04 | 6.54 | 3,220 |
| 22-12 | SS3 (Sand Fill) | 1.5 – 2.1 | 31 | 16 | < 0.04 | 7.11 | 5,330 |

## 6. MISCELLANEOUS

The borehole locations were selected relative to existing site features and were influenced by access constraints. The as-drilled locations and ground surface elevations were measured by Thurber. DrillTech Drilling Ltd. of Newmarket, Ontario, and Walker Drilling of Utopia, Ontario, supplied and operated the drill rigs used to drill, test, and sample, and decommission the boreholes. The hydrovacuum truck was supplied and operated by Badger Daylighting Ltd. of Seguin, Ontario. The field work was supervised on a full-time basis by A. Simpson, E.I.T., and M. I. Khan, E.I.T., under the direction of S. Peters, P.Eng.

Geotechnical laboratory testing was carried out by Thurber's geotechnical laboratory in Ottawa, Ontario. Analytical laboratory testing was carried out by Paracel Laboratories Ltd. in Ottawa, Ontario. Unconfined Compressive Strength testing was carried out by Stantec in Ottawa, Ontario.

Interpretation of the data and preparation of this report were carried out by A. de Oliveira, E.I.T, and M. Kennedy, P.Eng. The report was reviewed by F. Griffiths, P.Eng., and P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

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# PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

## 7. GENERAL

This section of the report provides an interpretation of the factual data from Part 1 of this report and presents foundation design recommendations to assist the project team in the assessment and remediation of the existing east embankment slope between Sta. 11+400 and Sta. 11+900 on Highway 7289 in Seguin Township, Ontario. Thurber Engineering Limited (Thurber) carried out the current field investigation as a sub-consultant to AECOM Canada Ltd. (AECOM) under Agreement No. 5020-E-0010. The discussion and recommendations presented in this report are based on information provided by AECOM and the factual data obtained during the current field investigation.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation (MTO) and AECOM and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

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

### 7.1 Background Information

Highway 7289, also known as Lake Joseph Road, runs roughly parallel to and east of Highway 400, and to the west of Lake Joseph. The study area is located between Sta. 11+400 and Sta. 11+900 on Highway 7289 and is in close proximity to the shoreline of Lake Joseph.

Highway 7289 is a two-lane, undivided highway with a posted speed limit of 80 km/h. The highway profile decreases from Elevation 240.8 m at Sta. 11+400 (south project limit) to Elevation 235.7 m at Sta. 11+900 (north project limit). The northbound shoulders have a width ranging from approximately 2.9 m to 3.5 m, with about 2.4 m to 2.8 m being paved.

The existing terrain generally slopes down to the east. To the west of the highway, a gabion wall is present from about Sta. 11+465 to Sta. 11+600 and a rock cut is present from about Sta. 11+600 to 11+700. To the east, the highway embankment slope ranges from about 7 m to 9 m high and is steeply inclined, with inclination ranging between about 1.4H:1V to 1.6H:1V but as steep as 1.2H:1.0V at about Sta. 11+475, near an existing timber retaining wall.

Instability and movements of the east embankment slope due to the steepness and flow of surface water creating erosion have been observed. Photographs in Appendix D show visible signs of slope movement recorded over the years. Remedial treatment consisting of sub-excavation and replacement with Granular B Type II fill on portions of the east embankment slope was carried out in 1995, as part of Contract 1995-0229, and placement of rock protection along portions was carried out in 2014.

In general, the encountered stratigraphy consists of silty sand embankment fill overlying a native deposit of compact to very dense, till-like silty sand and gravel, cobbles and boulders which are, in turn, underlain by gneissic bedrock. Bedrock, with a variable and sloping surface profile, was encountered or inferred at relatively shallow depth in all boreholes below the fill or native soil layers. The groundwater level was generally encountered within about 2 metres of the bedrock surface. The water level in Lake Joseph was surveyed to be at Elevation 228.6 m on July 13, 2022.

## 7.2 Proposed Work

The Terms of Reference for this project require an assessment of the stability of the east embankment slope between Sta. 11+400 and 11+900 and recommendation for slope remediation, as necessary. A driveway and associated residential properties are present between the east embankment slope and Lake Joseph between approximate Sta. 11+400 and Sta. 11+490 near the southern extent of the site. The Terms of Reference outline the need for assessment and design of a retaining wall in this area. The east embankment slope toe abuts Lake Joseph from about Sta 11+490 to 11+720. Private onshore recreational facilities are present at the toe of the slope from approximate Sta. 11+720 to 11+900.

THURBER

## 7.3 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed work, existing ground conditions, and in accordance with the Canadian Highway Bridge Design Code (CHBDC), version CSA S6-19 and MTO policy MERO #2020-01 (dated March 23, 2020).

It is understood that the site has a consequence classification of *Typical Consequence*, in accordance with Section 6.5.1 of the CHBDC. Accordingly, a consequence factor ($\Psi$) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing factored geotechnical resistances. If this consequence classification changes, the geotechnical assessment and recommendations provided within this report will need to be reviewed and revised.

As per Section 6.5.3.2 of the CHBDC, the degree of site prediction model understanding is considered to be *Typical* based on the current information.

# 8. SEISMIC CONSIDERATIONS

## 8.1 Spectral and peak Acceleration Hazard Values

The seismic hazard data for the CHBDC is based on the fifth-generation seismic model developed by the Geological Survey of Canada (GSC)[iii]. The GSC seismic hazard calculation data sheet for this site for the *reference* ground condition (Site Class C) is presented in Appendix E. The site coefficients used to determine the design spectral acceleration values are a function of the Site Class, PGA and Sa(0.2). The PGA value for this location, as provided by GSC for a *reference* Site Class C with a 2% probability of exceedance in 50 years (2475-year event), is 0.064 g. This value is to be scaled by the F(PGA) based on the *site-specific* Site Class, as discussed in Section 8.2.

## 8.2 CHBDC Seismic Site Classification

In accordance with the CHBDC, the selection of the seismic site classification is based on the nature of the soil deposits within the upper 30 m of the stratigraphy. The site has been classified as a Seismic Site Class D based on the standard penetration resistance values in the overburden.

## 8.3 Liquefaction Potential

The susceptibility of the cohesionless soils at the site to experience liquefaction was assessed using the SPT data following the simplified method for cohesionless soil as outlined in Boulanger and Idriss (2014)[iv] and Section C6.14.8 of the Commentary to the CHBDC. Based on the relative density of the soils below the measured groundwater levels at the site, the site soils are considered to be non-liquefiable for design.

## 9. DISCUSSION

As described in Section 7.1 above, surficial failures and instability of the existing slope have been observed as illustrated by shallow slides, leaning guide rails/poles, and inclined and/or pistol-butted trees.

### 9.1 Existing Conditions

Slope stability assessments of the Highway 7289 east embankment under the existing conditions were carried out using GeoStudio 2021 Slope/W software for limit equilibrium analysis. Input parameters for the embankment fill and native soils for the analysis are based on the SPT N-values, observations in the field, and the results of laboratory testing.

Table 6.2 of Section 6.9.1 of the CHBDC requires minimum Factors of Safety of 1.5 and 1.3 for embankments in permanent and temporary static conditions, respectively, for a typical degree of understanding and a consequence factor, $\Psi$, of 1.0. However, based on MTO policy MERO #2020-01 and consideration of the nature of the highway and existing slopes, reduced target Factors of Safety for this site of 1.35 and 1.25 for permanent and temporary conditions, respectively, were recommended by MTO.

For seismic analysis, Table 6.3 in Section 6.14.4.1 of the CHBDC indicates a minimum resistance factor of 0.95 ($\varphi_{gu,\ static(temporary)}$ = 0.75 + 0.2) for force-based design and 1.0 for performance-based design. Based on these values and $\Psi$ of 1.0, a target Factor of Safety of 1.1 for this temporary condition with a typical degree of understanding is appropriate for the pseudo-static seismic analysis. The stability analyses considered a Site Class D PGA value of 0.083 g for ground motions with a return period of 2,475 years, as per Section 4.4.3.2 of the CHBDC.

The embankment slope was assessed at the three representative locations shown on Drawing 2 in Appendix A and as summarized below:

- South Segment (Sta. 11+400 to 11+550) as represented by Section A-A’ (approx. Sta. 11+475, approximate height 8.3 m) – near southern extent of site, adjacent to driveway and existing timber retaining wall;
- Central Segment (Sta. 11+550 to 11+740) as represented by Section B-B’ (approx. Sta. 11+625, approximate height 9m) – middle of site, adjacent to edge of Lake Joseph;

- North Segment (Sta. 11+740 to 11+900) as represented by Section C-C' (approx. Sta. 11+770, approximate height 7 m) – northern extent of site, near private recreational lands.

The soil stratigraphy was based on, and interpolated between, the nearest boreholes. The existing ground surface profiles were developed based on the available ground contours, provided by AECOM. A traffic surcharge of 17 kPa has been applied as a temporary load, where appropriate. Site-adjusted horizontal PGA value of 0.042 g, equal to ½ of the site-adjusted horizontal PGA value was used for the 2,475-year seismic analyses, as per Section 4.4.3.3 of the CHBDC and outlined in Sections 8.1 and 8.2 above. In order to assess the potential impact on highway operations the slip surfaces were constrained on the up slope side to daylight no further east than the edge of pavement (EP).

Copies of the output from the stability analyses are provided on the figures presented in Appendix F. Each output figure shows the slope geometry, groundwater conditions, soil stratigraphy and soil strength parameters utilized in the analysis. The stability analyses modelling slope failure at the edge of pavement (EP) under existing conditions generated the following Factors of Safety.

**Table 9-1 Slope Stability Anaysis Results – Existing East Embankment Slope**

| Condition | Case | Factor of Safety for Slips Reaching EP | | |
|---|---|---|---|---|
| | | **Section A-A'** Sta. 11+475 | **Section B-B'** Sta. 11+625 | **Section C-C'** Sta. 11+770 |
| Permanent | Long Term (Drained) | 1.2 (Fig F1.1a) | 1.4 (Fig F2.1a) | 1.2 (Fig F3.1a) |
| Temporary (traffic loading) | Short Term (Undrained) | 1.2 (Fig F1.1b) | 1.4 (Fig F2.1b) | 1.2 (Fig F3.1b) |
| Temporary (seismic loading) | Pseudo-Static (Undrained) 2,475-year | 1.1 (Fig F1.1c) | 1.2 (Fig F2.1c) | 1.1 (Fig F3.1c) |

The results of the slope stability analyses support the historical and recent site observations that stability of the steep slope does not meet the target Factors of Safety at Section A-A' and Section C-C'. The results for Section B-B' indicate acceptable Factors of Safety for the driving lanes.

It is noted that shallower failures which affect only the material on the slope face, beyond the highway platform have a lower Factor of Safety than those indicated in Table 9-1. These small, shallow failures are frequently associated with erosion from overland storm water flow. Where left unremedied, such shallow failures could progress in subsequent retrogressive failures that could eventually impact the highway itself.

### 9.2 Remedial Options

The following design options have been considered to address the marginal stability of the east embankment slope:

- Reconstruct embankment slope with rockfill
  The slope could be stabilized by removal of existing marginally stable granular fill and replacement with rockfill, placed at 1.25H:1V with a mid-height bench where required to provide suitable stability. A minimum width of 5 m of rockfill is preferred for constructability purposes. A reduced width of removal and rockfall placement has been considered however the wider treatment is required to intersect the deep critical failure surfaces that extend to the edge of the existing highway. This option may require temporary closure of the highway for construction and/or temporary roadway protection during construction. Access to the toe of the slope is required and is feasible in the south and north segments of the site.
- Realignment of Highway 7289 with slope flattening
  The existing embankment slope could be flattened by excavating. Alterations to the Highway 7289 alignment (lowering of the grade and/or realignment to the west) will be necessary. Very shallow bedrock at the site would influence the limits of excavation. Realignment to the west may also encounter bedrock outcrops requiring excavation, as well as property acquisition requirements, depending on the magnitude of alignment shift and available space on the west side of the existing highway right-of-way.
- RSS wall at toe of the slope
  An RSS wall constructed at the toe of the slope is considered feasible at the existing driveway at the southern extent of the site where reasonable access to the slope toe is available. Since construction of an RSS wall would require some excavation into the existing slope, its feasibility would also be influenced by the depth to bedrock within the proposed footprint.
- Buttress embankment slope with a toe berm
  The stability of the slope could be improved with construction of a rockfill toe berm where space permits. The toe berm would be constructed from the bottom of the slope and would require sufficient room at the existing toe to provide access for construction. This option is considered feasible in the northern portion of the site where the eastern property line of the highway right-of-way is sufficiently offset. Subexcavation at the toe may be required to provide sufficient width to construct a functional rockfill berm.

- Retaining wall with deep foundations
  The slope could be stabilized with the construction of a structural cutoff/retaining wall along the full length of the slope. However, construction of a retaining wall with deep foundations would be challenging due to the presence of cobbles and boulders, and shallow bedrock at the site. Installation of sheet piles would not be feasible. Soldier piles and lagging may be considered but would require pre-drilling of the bedrock for socketing of the soldier piles to provide fixity. This retaining wall option for the full length of the slope is considered to be cost prohibitive in comparison to other options described herein and is, therefore, not addressed further in this report.
- Monitor and localized repairs
  For the central segment of the project length, where the existing slope meets the target Factors of Safety for stability, monitoring and ongoing localized repair may be a suitable solution. Historical observations and the results of the preliminary slope stability assessment of the existing conditions described above (see Section 9.1) indicate that the critical failures are generally shallow in nature. Periodic monitoring would allow identification of minor slope movements before they transition to a larger, retrogressive failure that may impact the highway.

Soil Nailing was considered infeasible as the shallow and erratic bedrock would result in shallow nail refusal and preclude generation of sufficient resistance. The application of light weight fills (LWF) at the top of the slope was also considered infeasible as it would require erosion protection on the full area of the slope below the LWF or loss of material over time would undermine the LWF. Treatments that move the toe of slope to the east have been considered only in areas that are not restricted by potential property and/or environmental impacts (e.g., outward onto the driveway near the south end of the site or into the lake in the central portion). Given the current slope stability concerns, treatment options requiring excavations should include limits to temporary slope cut inclinations as described in the sections below.

A summary table comparing the feasible remedial options described above is included in Appendix G. The results of slope stability models analyzing the proposed remedial options are described below. Further discussion of the preferred remedial options is provided in Section 10.

### 9.3 Global Stability of Remedial Options

Slope stability analyses of the representative cross-sections described in Section 9.1 were carried out to assess the global stability of the various feasible remedial options. The embankment slope stability was evaluated using GeoStudio 2021 Slope/W software, as described in Section 9.1. The analyses considered the following additional assumptions:

- Side slopes of 1.25H:1V for rockfill, 2.0H:1V for Granular B Type II, and 1.9H:1V for the flattened existing slope were modelled.
- Mid-height 1 m wide benches were used for rockfill slopes where required to achieve suitable Factors of Safety.
- The retained soil at the RSS wall will consist of OPSS Granular B Type II and is supported on a 300 mm thick Granular A bedding layer or the exposed bedrock.

Copies of the output from the stability analyses are provided on the Figures in Appendix F and the results are summarized in Table 9-2 and Table 9-3 below.

The stratigraphy considered in the slope stability models is based on interpolation of the soil and bedrock stratigraphy between the boreholes put down at the slope crest and the slope toe. The results of the stability analyses were influenced by the soil stratigraphy and, in particular, the reinforced soil mass of the RSS wall being “keyed-in” to the glacial till. Variation of the soil and bedrock stratigraphy between boreholes not captured in the stability models may influence the successful design of the slope treatment.

### 9.3.1 Section A-A’

The results of the static stability analyses of the slope at Section A-A’ (temporary/traffic and permanent conditions) considering construction of a 1.25H:1V rockfill embankment or flattening of the east embankment slope with highway realignment meet the target Factors of Safety. The feasible rockfill embankment option considered temporary cut slopes in the upper portion (above Elevation 235.5 m) inclined at no steeper than 1H:1V, and no steeper than 1.25H:1V in the lower portion.

The results of all associated seismic analyses also meet the target Factor of Safety for seismic design for the 2475-year seismic event.

The results of the static slope stability analyses also indicate that an RSS wall 2.3 m high with a reinforced block extending a minimum of 1.9 m into the slope and a 2H:1V backslope meet the target Factors of Safety for global stability (Figures F1.4a-c). However, it should be noted that the width of the reinforced block required to satisfy the ultimate design of the RSS wall (to be carried out by others) may be larger than 1.9 m since it will be supporting an approximately 6 m high 2H:1V slope and could influence the design and feasibility. Note that the temporary cut slope required to place the Granular B Type II backfill behind the RSS wall should be sloped no steeper than 1.25H:1V. The design should include benching of the native earth slopes prior to placement of fill behind the wall (OPSD 208.010).

**Table 9-2 Slope Stability Anaysis Results – Section A-A' (Sta. 11+475)**

| Condition | Case | Factor of Safety | | |
|---|---|---|---|---|
| | | **Rockfill** 1.25H:1V | **Flattened Slope**[1] 1.9H:1V | **RSS Wall** 2.0H:1V |
| Permanent | Long Term (Drained) | 1.4 (Fig F1.2a) | 1.4 (Fig F1.3a) | 1.5 (Fig F1.4a) |
| Temporary (traffic loading) | Short Term (Undrained) | 1.4 (Fig F1.2b) | 1.4 (Fig F1.3b) | 1.5 (Fig F1.4b) |
| Temporary (seismic loading) | Pseudo-Static (Undrained) 2,475-year | 1.2 (Fig F1.2c) | 1.2 (Fig F1.3c) | 1.4 (Fig F1.4c) |

Note: 1) requires highway realignment ~3.4 m to the west.

Rockfill may be considered during detailed design for backfill behind the RSS wall to optimize the stability and inclination of the back slope. However, the 1.25H:1V rockfill slope solution would need only a minor increase in rockfill volume and is much simpler as it does not require the retaining wall.

### 9.3.2 Section B-B'

The results of the slope stability analyses of the existing slope at Section B-B' meet the target Factors of Safety (see Section 9.1). Remedial slope stabilizing measures are not required.

### 9.3.3 Section C-C'

The results of the static stability analyses of the slope at Section C-C' (temporary/traffic and permanent conditions) considering construction of a 1.25H:1V rockfill embankment or flattening of the east embankment slope with highway realignment meet the target Factors of Safety. However, these options necessitate undesirable design and/or construction requirements including significant disruption during construction for embankment reconstruction and/or highway realignment.

**Table 9-3 Slope Stability Anaysis Results – Section C-C' (Sta. 11+770)**

| Condition | Case | Factor of Safety | | |
|---|---|---|---|---|
| | | **Rockfill** 1.25H:1V | **Flattened Slope[1]** 1.9H:1V | **Rockfill Toe Berm** |
| Permanent | Long Term (Drained) | 1.4 (Fig F3.2a) | 1.4 (Fig F3.3a) | 1.4 (Fig F3.4a) |
| Temporary (traffic loading) | Short Term (Undrained) | 1.4 (Fig F3.2b) | 1.3 (Fig F3.3b) | 1.4 (Fig F3.4b) |
| Temporary (seismic loading) | Pseudo-Static (Undrained) 2,475-year | 1.3 (Fig F3.2c) | 1.3 (Fig F3.3c) | 1.3 (Fig F3.4c) |

Note: 1) requires highway realignment ~1.5 m to the west.

Construction of a toe berm at the base of the existing slope was also examined. The results of the slope stability analyses indicate that a 1.25H:1V rockfill toe berm, a minimum of 2 m wide, constructed with top surface at Elevation 232.5 m meets the target static Factors of Safety. However, it should be noted that subexcavation at the toe may be required to provide sufficient width to construct a functional rockfill berm. To this end, consideration could be given to instead using rock protection material to construct the toe berm which would eliminate the requirement for compaction after placement and would allow feasible placement by smaller equipment where construction area/access is restricted. In this case, a contract provision should be included to provide direction on maximum allowable particle size for rock protection material (see Appendix H).

The results of the associated seismic analyses also meet the target Factor of Safety for seismic design for the 2475-year seismic event.

## 10. DESIGN RECOMMENDATIONS

Based on the foundation investigation observations, analytic results, and project-specific design requirements (including the preference to maintain the current highway alignment), the following list of treatment approaches for the Highway 7289 east embankment slope within the study area is recommended:

1. The south (Sta. 11+460 to 11+500) portion of the east embankment slope be reconstructed by removing existing materials and placing rockfill at 1.25H:1V, with 1.0 m mid-height benches where rockfill slope height exceeds 8 m. Rockfill slope construction must be carried out from the bottom of the slope and, therefore, would require suitable access along the slope toe. Excavation of the existing materials will require partial or full highway closures, roadway protection, or a combination thereof.

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2. It is understood that the portion of the section of east embankment slope between Sta. 11+500 and 11+550 received remedial repairs in 2014 that consisted of reconstruction with Granular B Type II capped with 500 mm of rip rap. Per MTO direction, this section is to receive minor erosion treatment and localized repairs, as needed. The central (Sta. 11+500 to 11+740) portion of the east embankment should receive minor erosion treatment and localized repairs, as needed.

3. The north (Sta. 11+740 to 11+900) portion of the east embankment should be buttressed by construction of a minimum 2 m wide rockfill or rock protection toe berm constructed with the top surface at Elevation 232.5 m. Construction should be carried out from the bottom of the slope and may require some subexcavation at the existing toe to construct a berm with sufficient width with rock fill. The use of rock protection material to construct the toe berm would permit the use of smaller construction equipment and could reduce the impact on the surrounding area.

A summary table comparing the feasible remedial options described above is included in Appendix G.

### 10.1 Rockfill Embankment/Berm

For the rockfill treatment (either full slope reconstruction or toe berm construction), the existing materials must be removed to the design cut line. Temporary excavations of the existing slope should be inclined no steeper than 1.25H:1V, except for the upper portion of Section A-A' (above Elevation 235.5 m) that may be excavated as steeply as 1H:1V. Any topsoil, organics, soft or loose deposits, disturbed soils, and deleterious materials exposed on the excavated face must be removed and replaced with rockfill. A mid-height bench into the existing slope should be included where the rockfill slope height exceeds 8 m. Benching into the existing slope as per OPSD 208.010 should not be carried out.

Embankment and/or toe berm construction should be carried out in accordance with OPSS.PROV 206. Rock size should be controlled in accordance with OPSS.PROV 206 (modified as suggested in Appendix H). The reconstruction of the embankment and/or of the toe berm should be carried out with rock fill and a 1.25H:1V slope, constructed starting from the base of the embankment. Rock fill should not be placed by dumping from the top of the slope. Rock fill should be placed in a controlled manner (not end dumped) including blading, dozing and chinking of the rock to minimize voids and bridging. Rock fill must be compacted as per OPSS.PROV 206.

For embankment reconstruction, at the pavement subgrade level or where granular fill is to be placed over rock fill, the rock fill subgrade must be blinded with spall material and rock fill chinking shall be in accordance with OPSS.PROV 206. This treatment could also be considered at the location of the bench. All granular fill must be compacted as per OPSS 501. Granular fill should not be used as part of the rock fill widening.

The rock fill should consist of 100% crushed bedrock with angular particles and have a well graded particle distribution. Additional material requirements are provided in Appendix H.

As noted above, the use of rock protection material to construct the toe berm in the north (Sta. 11+740 to 11+900) portion would permit the use of smaller construction equipment and could reduce the impact on the surrounding area. The rock protection material should be in accordance with OPSS.PROV 1004. A modification to the gradation requirements is recommended; suggested wording is provided in Appendix H. Rock protection should be placed as per OPSS.PROV 511.

### 10.2 Slope Flattening to 1.9H:1V

If the slope flattening treatment is to be used, the existing overburden materials must be removed to the design cut line and carried out from the top of the slope. Excavation or removal of bedrock exposed above the design cut line is not required. Any topsoil, organics, soft or loose deposits, disturbed soils, and deleterious materials exposed on the excavated face must be removed and replaced with granular fill. Fill placement, where needed, should be carried out in accordance with OPSS.PROV 206 and compacted as per OPSS.PROV 501. The fill should consist of OPSS Granular B Type II. The exposed, flattened slope should be covered with gravel sheeting as soon as is practical to minimize erosion potential. Where excavation is not required, the existing vegetation should not be disturbed.

### 10.3 Erosion Protection Enhancement

In the central portion of the site, the east embankment slope flattens slightly and the toe of the slope nears the edge of Lake Joseph. The existing slope in this area, along Section B-B', meets the target Factors of Safety.

Since the stability of the existing slope in this area is acceptable, significant construction of a retaining wall, rockfill slope, or highway realignment and slope flattening in the central portion of the site is not required. Where significant slope modification is not carried out, enhancing the erosion protection measures and providing regular slope monitoring to identify where additional erosion protection or localized repair is required, should be undertaken.

The granular fill that comprises the upper portion of the existing embankment has shown signs of erosion due to surface water runoff and raveling. Infiltration of significant surface water in the granular embankment slope will decrease the overall stability.

To protect the embankment from flowing surface water on the existing slope, consideration may be given to construction of a curb along the northbound shoulder to direct surface runoff to defined rock lined drainage channels (see OPSD 601.010). The location and frequency of the drainage channels along the slope must consider the hydraulic implications of the surface water flow to reduce the potential for additional erosion issues.

However, considering the satisfactory global stability of the slope along Section B-B' and the presence of ditches above the highway along the southbound lanes that would intercept any overland flow, the impact of the anticipated nominal surface water flow over the east embankment slope is expected to be minimal, provided that regular slope monitoring with localized repair is undertaken.

Where water flow has resulted in gullies or in ravelling of material on the existing slopes, rock protection should be placed (OPSS.PROV 1004 and 511) to re-establish the embankment slope.

### 10.4 RSS Wall Design

The assessment of global stability of an RSS wall as presented in Section 9.3.1 considered the reinforced soil mass of the RSS wall being "keyed-in" to the glacial till. Variation of the soil and bedrock stratigraphy between boreholes not captured in the stability models may influence the successful design of the slope treatment. If an RSS wall is preferred, it is recommended that additional probe holes be drilled within the anticipated footprint to verify the bedrock surface.

If the actual bedrock surface profile within the slope and/or the required width of the reinforced RSS wall block required to retain the reconstructed slope that is determined during detailed design significantly influences the feasibility of an RSS wall, a rockfill slope may be preferred or consideration may need to be given to a wall supported by solider piles socketed into the bedrock.

The design of proprietary RSS walls is the responsibility of the supplier. The depth of frost penetration at this site is estimated to be 1.7 m (as per OPSD 3090.101) and should be considered in the design of conventional retaining walls, as required. Typically, RSS walls do not require full frost protection as they are able to tolerate some movement due to frost heave. The RSS system should be designed in accordance with the MTO RSS Design Guidelines. It is anticipated that the Performance, Appearance and Acceptance attributes will be L, M and A; these should be confirmed once the location and height of the wall is established. Subgrade preparation should be as described below. Surface water diversion and dewatering may be required to prepare the subgrade and install the engineered fill pad in the dry (Section 11.2).

The lateral pressure comments provided Section 10.4.3 may be used in RSS design. Please also refer to Section 9.3.1 for comments on global stability. The RSS wall must be designed to support the 2H:1V slope above the wall.

### 10.4.1 RSS Subgrade Preparation

All organics, soft or loose deposits, disturbed soils, and deleterious materials must be stripped from the footprint of the retaining wall to expose competent subgrade at or below the desired founding elevations. The fill or other deleterious material is considered unsuitable to support the retaining wall and should be sub-excavated within the foundation footprints and replaced with OPSS.PROV 1010 Granular A or Granular B Type II that is placed and compacted up to the bedding level as per OPSS.PROV 501. The exposed final subgrade must be inspected to confirm that the subgrade is suitable and uniformly competent.

To provide a more uniform foundation subgrade condition for the retaining wall foundation, a minimum 300 mm thick layer of well compacted bedding material conforming to OPSS.PROV 1010 Granular A requirements must be provided under the base of the foundations.

Based on the encountered groundwater levels, it is noted that construction is expected to extend near the groundwater elevation during subgrade preparation. Excavation dewatering may be required to control groundwater, surface water, any perched water and precipitation runoff. Refer to Section 11.2 for additional comments on water control.

### 10.4.2 RSS Retaining Wall Foundations

A minimum 300 mm thick engineered fill pad constructed on the underlying undisturbed native soils or bedrock should be provided below the reinforced retained soil. The engineered fill pad is required to provide a leveling pad and uniform bearing surface. The thickness of the engineered pad may be reduced where bedrock is within 300 mm of the underside of the retained soil. The engineered fill pads should consist of OPSS Granular A or Granular B Type II placed and compacted in accordance with OPSS.PROV 501. Engineered fill pads should be constructed with

1H:1V sides slopes with the crest of slope a minimum of 1 m from the edge of footing and reinforced retained soil on all sides.

RSS walls with a minimum embedment of 0.8 m and bearing on an engineered fill pad as described above may be designed based on the following factored geotechnical:

- Factored geotechnical resistance at ULS 400 kPa
- Factored geotechnical resistance at SLS 210 kPa

The factored geotechnical resistances include the following factors:

- Consequence factor ($\Psi$) of 1.0 (as per CHBDC Table 6.1)
- Geotechnical resistance factors (as per CHBDC Table 6.2):
    - $\phi_{gu}$ = 0.5 (static analysis; typical degree of understanding)
    - $\phi_{gs}$ = 0.8 (static analysis; typical degree of understanding)

### 10.4.3 RSS Backfill and Lateral Earth Pressure

Where excavation for construction of a retaining wall is carried out, structural backfill material should consist of Granular A or Granular B Type II meeting the OPSS.PROV 1010 specifications and SP110S06. The backfill must be in accordance with OPSS 902 and placed and compacted in accordance with OPSS.PROV 501. Backfill should be compacted and compaction equipment to be used adjacent to the structure must be restricted in accordance with OPSS.PROV 501.07.02.

Lateral earth pressure provided in the equations in the sections below are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. Drains should be included through the retaining wall. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in wall design.

#### 10.4.3.1 Static Lateral Earth Pressure

Lateral earth pressures acting on vertical structures should be computed in accordance with the Section 6.12 of the CHBDC but under fully drained conditions, the lateral pressures are generally given by the following expression:

$$\sigma_h = K * (\gamma d + q)$$

where:

| | | |
|---|---|---|
| $\sigma_h$ | = | static lateral earth pressure on the wall at depth d (kPa) |
| K | = | static earth pressure coefficient (see table below) |
| $\gamma$ | = | unit weight of retained soil (see table below) adjusted below water level |
| d | = | depth below top of fill where pressure is computed (m) |
| q | = | value of any surcharge (kPa) |

A lateral earth pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Clause 6.12.3 of the CHBDC. Typical earth pressure coefficients for vertical walls for backfill material are shown in Table 10-1.

**Table 10-1. Static Earth Pressure Coefficients**

| Condition | OPSS Granular A and Granular B Type II<br>$\phi$ = 35°, $\gamma$ = 21 kN/m³ | | Existing Silty Sand Fill<br>$\phi$ = 32°, $\gamma$ = 21 kN/m³ | |
|---|---|---|---|---|
| | Horizontal Surface Behind Wall | 2H:1V Slope Behind Wall | Horizontal Surface Behind Wall | 2H:1V Slope Behind Wall |
| Coefficient of at Rest Earth Pressure, $K_o$ (Restrained Wall) | 0.43 | 0.62 | 0.47 | 0.68 |
| Coefficient of Active Earth Pressure, $K_A$ (Unrestrained Wall) | 0.27 | 0.39 | 0.31 | 0.47 |

The parameters in the table correspond to full mobilization of active and passive earth pressures and require certain relative movements between the wall and adjacent soil to produce these conditions. Figure C6.27 and Table C6.12 of the Commentary to the CHBDC indicates the relative movement required to fully mobilize the active earth pressure.

#### 10.4.3.2 Combined Static and Seismic Lateral Earth Pressure

In accordance with Clause 6.14 of the CHBDC, structures should be designed using dynamic earth pressure coefficients that incorporate the effects of earthquake loading. The following recommendations are per Section C6.14.7.2 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using Mononobe Okabe Method with:

- $k_h$ = ½ * F(PGA) * PGA, for structures that allow 25 to 50 mm of movement, and
- $k_h$ = F(PGA) * PGA, for non-yielding walls

The coefficients of horizontal earth pressure for seismic loading presented in Table 10 2 may be used for vertical walls. The provided earth pressure coefficients are based on a Seismic Site

Class C and a PGA with a 2% probability of exceedance in 50 years of 0.064 g (Geological Survey of Canada – Fifth Generation).

**Table 10-2. Combined Static and Seismic Earth Pressure Coefficients**

| Condition | OPSS Granular A and Granular B Type II $\phi = 35^{o}$, $\gamma = 21$ kN/m$^3$ | | Existing Silty Sand Fill $\phi = 32^{o}$, $\gamma = 20$ kN/m$^3$ | |
|---|---|---|---|---|
| | Horizontal Surface Behind Wall | 2H:1V Slope Behind Wall | Horizontal Surface Behind Wall | 2H:1V Slope Behind Wall |
| Coefficient of Active Earth Pressure, $K_{AE}$ (Restrained Wall) | 0.32 | 0.52 | 0.36 | 0.68 |
| Coefficient of Active Earth Pressure, $K_{AE}$ (Unrestrained Wall) | 0.29 | 0.45 | 0.33 | 0.55 |

The total pressure due to combined static and seismic loads acting at a specific depth below the top of the wall/soil may be determined using the following equation that includes consideration of material properties and the soils profile.

$$\sigma_{hAE} = K * \gamma * d + (K_{AE} - K_A) * \gamma * (H - d)$$

where:

$\sigma_{hAE}$ = combined static and seismic lateral earth pressure on wall at depth d (kPa)
d = depth below the top of the wall where pressure is computed (m)
K = static earth pressure coefficient
($K_A$ for yielding walls, $K_o$ for non-yielding walls)
$\gamma$ = unit weight of retained soil, adjusted below water level
$K_{AE}$ = combined static and seismic earth pressure coefficient
H = total height of the wall (m)

# 11. CONSTRUCTION CONSIDERATIONS

## 11.1 Excavation and Staging

All excavation must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects as a minimum. For this project, although the existing fill materials could be classified as Type 3 soil, **it is recommended that temporary cut slopes be no steeper than 1.25H:1V** based on the stability of the existing slopes (unless otherwise noted). Although temporary embankment and cut slope stability is the responsibility of the Contractor, a provision should be included in the contract concerning the maximum steepness of temporary cut slopes.

Excavations must be planned and carried out in a manner that does not impact on the stability of the existing roadway. The duration of temporary open excavations and cut slopes should be minimized to reduce the likelihood of causing instability concerns. Selection of the equipment and methodology to excavate and backfill is the responsibility of the Contractor. Material stockpiling is a temporary construction measure and the associated stability implications are the responsibility of the Contractor. The selection and placement of construction equipment (such as cranes) and construction of temporary construction access roads are also the Contractor's responsibility. Placement of equipment or temporary stockpiling must not destabilize the embankment. The cut slopes may have to be protected from precipitation and runoff to avoid surficial instabilities.

If full embankment slope reconstruction with rockfill is to be carried out or if the existing slopes are to be flattened to 1.9H:1V, it is anticipated that the northbound lane would be directly affected by the work, and that a partial or full highway closure may be required.

Although the current expectation is that the temporary excavation required to install an RSS wall in Section A-A' would not extend to the northbound lane of the highway, it is recommended that this lane be closed during construction and traffic flow be constrained to the existing southbound lane and controlled by temporary signals or flaggers.

The excavated soils could be considered for use in landscaped areas away from the east embankment slopes.

### 11.2 Surface and Groundwater Control

It is anticipated that the proposed excavations for a RSS wall in the south segment of the project at the toe of the embankment slope will be near the groundwater level. Surface water will tend to seep into and accumulate in excavations. Water from surface flow and from within the slope must always be diverted away from the excavation. Construction, subgrade preparation and placement and compaction of granular materials must be carried out in the dry. The Contractor must be prepared to control groundwater and surface water at the site. Dewatering and surface water diversion must remain operational and effective until the temporary excavations are backfilled.

The design of dewatering and diversion systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the dewatering systems in accordance with OPSS.PROV 517 as amended by SP517F01. The design Engineer and design-checking Engineer do not need a minimum of 5 years of experience in designing similar dewatering systems and the associated Designer Fill-In in SP517F01 Table 1 should be "No". Based on the proximity to existing dwellings, preconstruction surveys are recommended, and the associated Designer Fill-In for Preconstruction Survey Distance should be 100 m.

It is anticipated that dewatering of the RSS Wall excavations should generally be feasible using sumps and pumps.

Assessment of the dewatering requirements and the need for registration on the Environmental Activity and Sector Registry (EASR) or a Permit to take Water (PTTW) should be carried out by specialists experienced in this field.

### 11.3 Scour and Erosion Protection

The Contractor should provide silt fences and erosion control blankets as per OPSS.PROV 805 and OPSD 219.110 throughout the duration of construction to prevent transport of silt/sediment.

Given the relatively steep inclination and height of the existing embankment slope, as well as the impact of removal of the existing vegetation on the slope during construction, the earth cut slope should be considered erodible.

Erosion protection measures for the existing slopes are discussed in Section 10.3.

In areas where the slopes are reconstructed or flattened, slope protection and drainage measures will be required to ensure the long-term surficial stability of the cut slopes. Slope vegetation should be established as soon as possible after completion of the embankment fills to limit surficial erosion. A vegetation cover should be established on all exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

Where construction alters areas in proximity to the existing Lake Joseph shoreline, design of the protection measure must consider hydrologic and hydraulic factors and shall be carried out by specialists experienced in this field. Typically, rock protection should be provided over all earth surface subjected to flowing water in accordance with OPSS.PROV 511.

## 12. CONSTRUCTION CONCERNS

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

- Obstructions (ie: cobbles, boulders, buried debris, bedrock)

  Buried obstructions, such as cobbles & boulders, will be encountered during construction and interfere with excavations and installation of deep foundations. The bedrock surface is variable and may be higher than expected. The Contractor must be prepared to dislodge or penetrate obstructions. Where obstructions are encountered near the surface, the Contractor may choose to remove such obstructions, provided it does not destabilize the existing earth slope.

- Equipment Selection

  The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing soils to support the proposed construction equipment and supplies. If highway realignment and slope flattening is selected as the preferred remedial option, a long-reach excavator may be required to complete the required excavation from the top of the slope. The contact documents should include an NSSP to alert the contractor to this requirement.

- Temporary Excavations

  Due to the height of the proposed excavation (7 m to 9 m) and the existing slope condition, constructing to OHSA requirements alone are not sufficient for this site; the contract provisions should include notification to the contractor. The contract drawings should include temporary excavation slopes at 1.25H:1V unless otherwise noted (e.g. the upper portion of the cut slope at Section A-A').

The successful performance of the project will depend largely upon good workmanship and quality control during construction. Observation of the excavation and backfilling operations will be required during construction as per OPSS.PROV 902 to confirm that the foundation recommendations are correctly implemented, and material specifications are met.

## 13. ADDITIONAL INVESTIGATIONS

If an RSS wall is selected as the preferred option for the south segment of the project, it is recommended that additional probe holes be drilled within the anticipated footprint to verify the bedrock surface. The probe holes should be nominally located at the four corners of the footprint of the proposed RSS wall. Each probe hole should prove bedrock by coring 3 m.

## 14. CLOSURE

Engineering analysis and preparation of this report were carried out by Mr. Matt Kennedy, P.Eng. The report was reviewed Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.
Report Prepared By:


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Designated Principal Contact
Senior Geotechnical Engineer

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## REFERENCES

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[ii] https://files.ontario.ca/ecosystems-ontario-part2-03262019.pdf

[iii] https://earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/calc-en.php

[iv] Boulanger, R. W., and Idriss, I. M. (2014). CPT and SPT based liquefaction triggering procedures, Report No. UCD/CGM-14/01, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, CA, 134 pp.

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# STATEMENT OF LIMITATIONS AND CONDITIONS

## 1. STANDARD OF CARE

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

## 2. COMPLETE REPORT

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

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

## 3. BASIS OF REPORT

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

## 4. USE OF THE REPORT

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

## 5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

## 6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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

## 7. INDEPENDENT JUDGEMENTS OF CLIENT

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

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## Appendix A Drawings

Borehole Locations and Strata Drawings

CONT No GWP 5252-21-00

HIGHWAY 7289
EAST EMBANKMENT SLOPE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 1

Ontario

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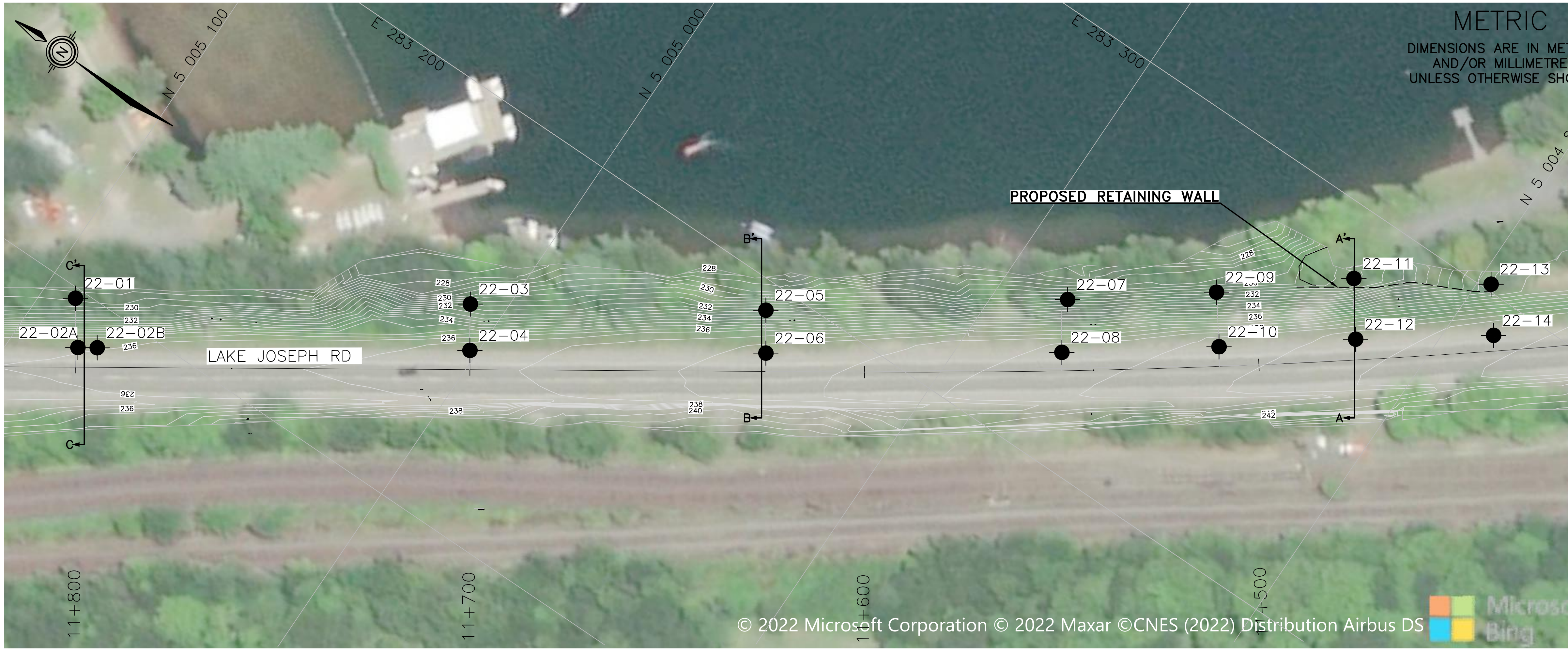
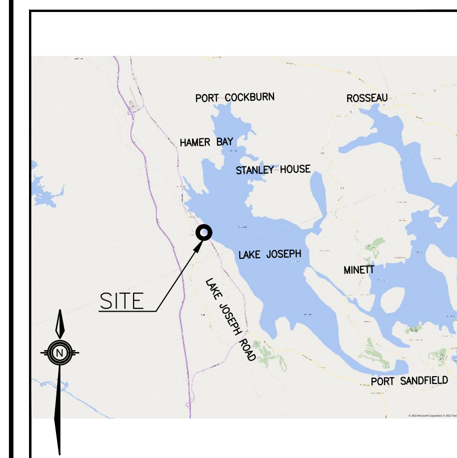
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN




PLAN

25 0 25 50m
SCALE 1:1250

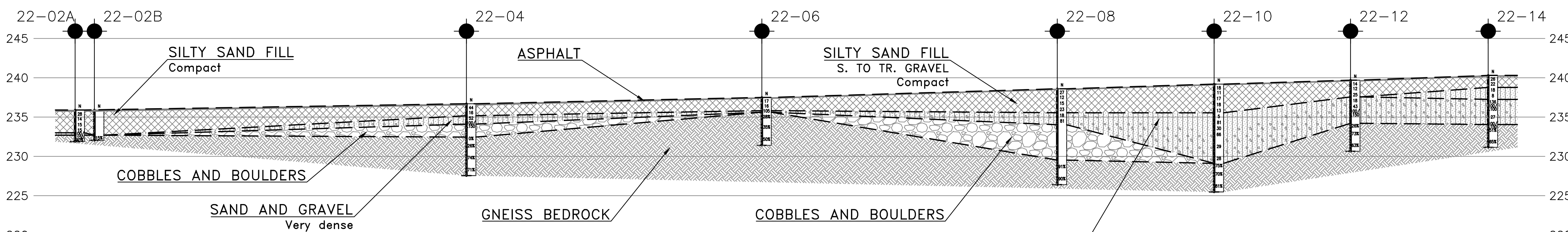



KEYPLAN

## LEGEND

- Borehole
- Borehole and Cone
- N — Blows /0.3m (Std Pen Test, 475J/blow)
- CONE — Blows /0.3m (60° Cone, 475J/blow)
- PH — Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% — Rock Quality Designation (RQD)
- A/R — Auger Refusal

| NO | ELEVATION | NORTHING | EASTING |
|---|---|---|---|
| 22-01 | 229.6 | 5 005 092.0 | 283 097.6 |
| 22-02A | 235.9 | 5 005 084.5 | 283 087.6 |
| 22-02B | 235.9 | 5 005 080.4 | 283 090.3 |
| 22-03 | 230.3 | 5 005 008.3 | 283 152.5 |
| 22-04 | 236.7 | 5 005 001.8 | 283 142.7 |
| 22-05 | 231.4 | 5 004 945.4 | 283 193.2 |
| 22-06 | 237.5 | 5 004 939.3 | 283 184.2 |
| 22-07 | 230.6 | 5 004 883.6 | 283 238.3 |
| 22-08 | 238.6 | 5 004 877.3 | 283 226.4 |
| 22-09 | 231.3 | 5 004 853.4 | 283 261.0 |
| 22-10 | 239.2 | 5 004 845.1 | 283 249.9 |
| 22-11 | 231.4 | 5 004 826.5 | 283 283.4 |
| 22-12 | 239.7 | 5 004 817.5 | 283 270.9 |
| 22-13 | 235.9 | 5 004 796.9 | 283 301.7 |
| 22-14 | 240.3 | 5 004 789.1 | 283 291.3 |




PROFILE ALONG HWY 7289,
NORTHBOUND SHOULDER

H 1:1250: 25 0 25 50m
V 1:300: 6 0 6 12m

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## -NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 31E-419

| REVISIONS | DATE | BY | DESCRIPTION |
|---|---|---|---|

DESIGN | CHK | CODE | LOAD | DATE JAN 2023
DRAWN MC | CHK | SITE | STRUCT | DWG 1

MINISTRY OF TRANSPORTATION, ONTARIO

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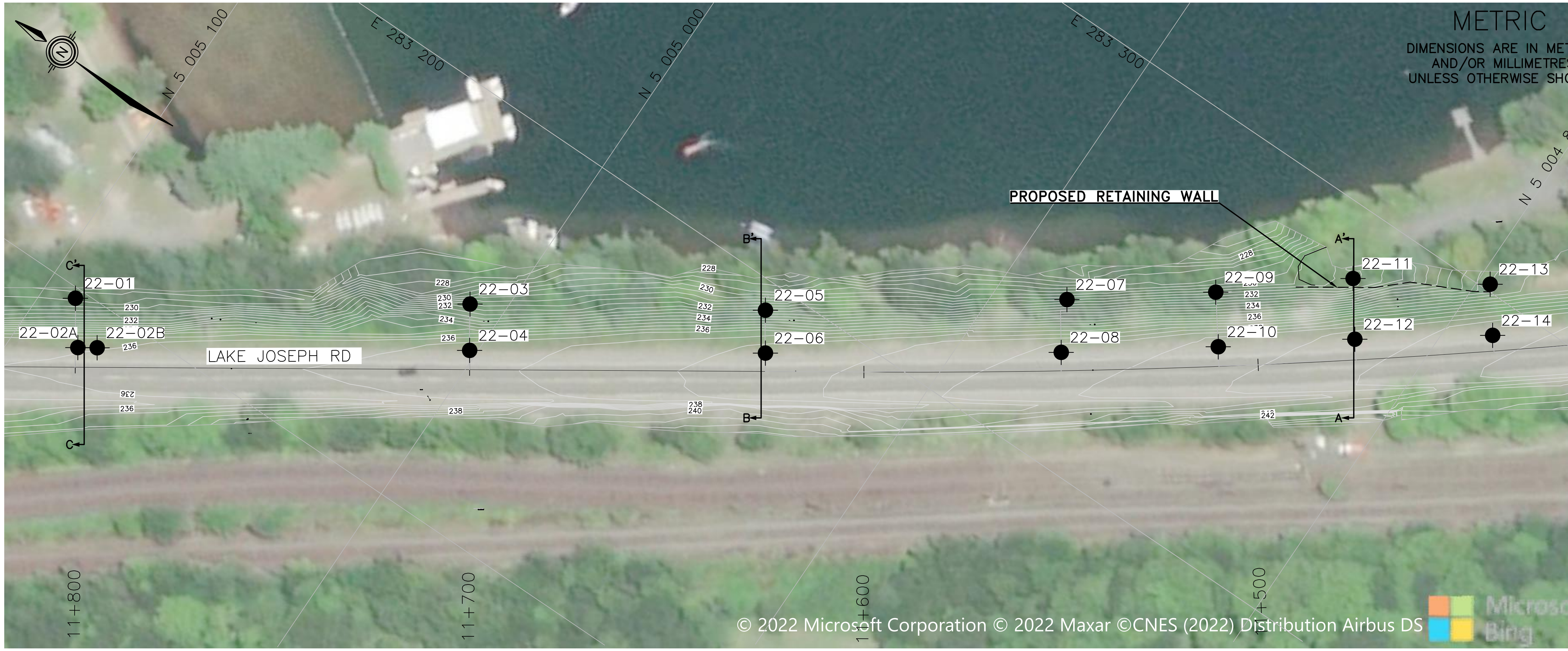
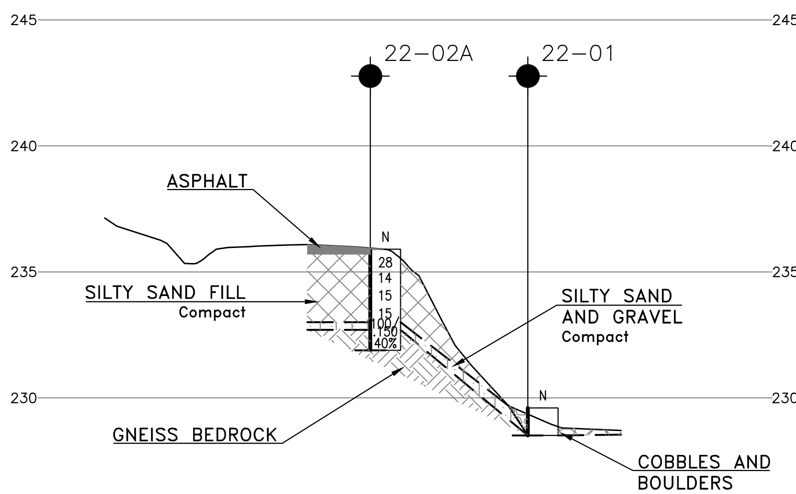



PLAN

SCALE 1:1250 (25 0 25 50m)




SECTION C–C'

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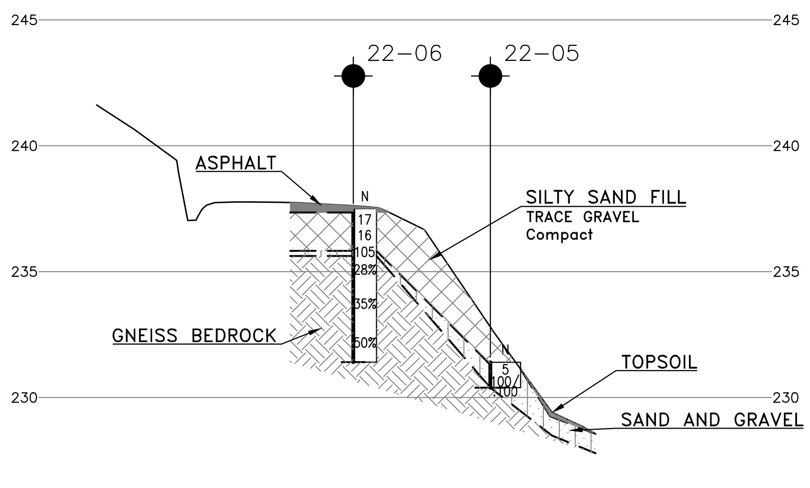


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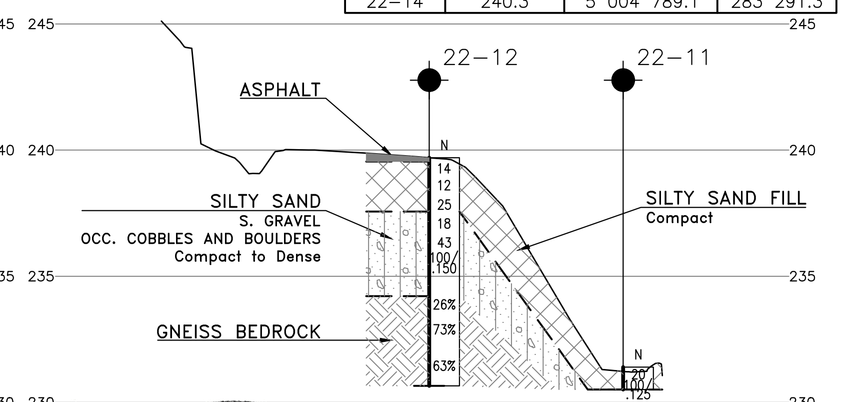


SECTION A–A'

H 1:600 V 1:300

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CONT No
GWP 5252–21–00

HIGHWAY 7289
EAST EMBANKMENT SLOPE

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
2

Ontario

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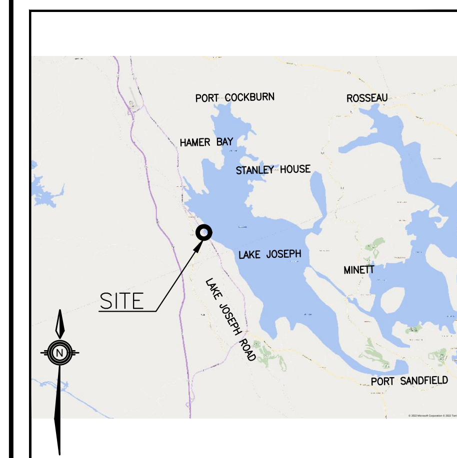


KEYPLAN

LEGEND

| | |
|---|---|
| | Borehole |
| | Borehole and Cone |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
| | Water Level |
| | Head Artesian Water |
| | Piezometer |
| 90% | Rock Quality Designation (RQD) |
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|---|---|---|---|
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| 22–11 | 231.4 | 5 004 826.5 | 283 283.4 |
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| 22–13 | 235.9 | 5 004 796.9 | 283 301.7 |
| 22–14 | 240.3 | 5 004 789.1 | 283 291.3 |

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1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 31E-419

| REVISIONS | DATE | BY | DESCRIPTION |
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| | | | | |
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| DESIGN | CHK | CODE | LOAD | DATE JAN 2023 |
| DRAWN MC | CHK | SITE | STRUCT | DWG 2 |

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## Appendix B Record of Borehole Sheets

Symbols, Abbreviations, and and Terms Used on Test Hole Records
Record of Borehole Sheets

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## SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

### TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

| | |
|---|---|
| Topsoil | mixture of soil and humus capable of supporting vegetative growth |
| Peat | mixture of fragments of decayed organic matter |
| Till | unstratified glacial deposit which may include particles ranging in sizes from clay to boulder |
| Fill | material below the surface identified as placed by humans (excluding buried services) |

### TERMINOLOGY DESCRIBING SOIL STRUCTURE:

| | |
|---|---|
| Desiccated | having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc. |
| Fissured | having cracks, and hence a blocky structure |
| Varved | composed of alternating layers of silt and clay |
| Stratified | composed of alternating successions of different soil types, e.g. silt and sand |
| Layer | > 75 mm in thickness |
| Seam | 2 mm to 75 mm in thickness |
| Parting | < 2 mm in thickness |

### RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

### N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

### DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.

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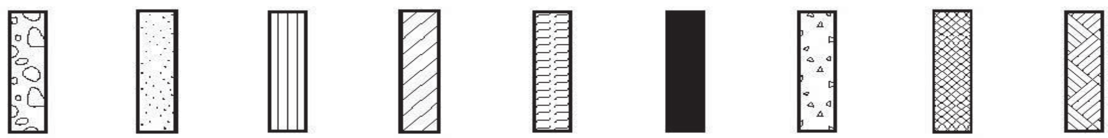
**STRATA PLOT:**
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders Cobbles Gravel | Sand | Silt | Clay | Organics | Asphalt | Concrete | Fill | Bedrock

**TEXTURING CLASSIFICATION OF SOILS**

| Classification | Particle Size |
|---|---|
| Boulders | Greater than 200 mm |
| Cobbles | 75 – 200 mm |
| Gravel | 4.75 – 75 mm |
| Sand | 0.075 – 4.75 mm |
| Silt | 0.002 – 0.075 mm |
| Clay | Less than 0.002 mm |

**TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)**

| Descriptive Term | Undrained Shear Strength (kPa) |
|---|---|
| Very Soft | 12 or less |
| Soft | 12 – 25 |
| Firm | 25 – 50 |
| Stiff | 50 – 100 |
| Very Stiff | 100 – 200 |
| Hard | Greater than 200 |

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

**SAMPLE TYPES**

| | |
|---|---|
| SS | Split spoon samples |
| ST | Shelby tube or thin wall tube |
| DP | Direct push sample |
| PS | Piston sample |
| BS | Bulk sample |
| WS | Wash sample |
| HQ, NQ, BQ etc. | Rock core sample obtained with the use of standard size diamond coring equipment |

**TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)**

| Descriptive Term | SPT “N” Value |
|---|---|
| Very Loose | Less than 4 |
| Loose | 4 – 10 |
| Compact | 10 – 30 |
| Dense | 30 – 50 |
| Very Dense | Greater than 50 |

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## MODIFIED UNIFIED SOIL CLASSIFICATION

| Major Divisions | | Group Symbol | Typical Description |
|---|---|---|---|
| **COARSE GRAINED SOIL** | GRAVEL AND GRAVELLY SOILS | GW | Well-graded gravels or gravel-sand mixtures, little or no fines. |
| | | GP | Poorly-graded gravels or gravel-sand mixtures, little or no fines. |
| | | GM | Silty gravels, gravel-sand-silt mixtures. |
| | | GC | Clayey gravels, gravel-sand-clay mixtures. |
| | SAND AND SANDY SOILS | SW | Well-graded sands or gravelly sands, little or no fines. |
| | | SP | Poorly-graded sands or gravelly sands, little or no fines. |
| | | SM | Silty sands, sand-silt mixtures. |
| | | SC | Clayey sands, sand-clay mixtures. |
| **FINE GRAINED SOILS** | SILT AND CLAY SOILS $W_L < 35\%$ | ML | Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. |
| | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. |
| | | OL | Organic silts and organic silty-clays of low plasticity. |
| | SILT AND CLAY SOILS $35\% < W_L < 50\%$ | MI | Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts. |
| | | CI | Inorganic clays of medium plasticity, silty clays. |
| | | OI | Organic silty clays of medium plasticity. |
| | SILT AND CLAY SOILS $W_L > 50\%$ | MH | Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts. |
| | | CH | Inorganic clays of high plasticity, fat clays. |
| | | OH | Organic clays of high plasticity, organic silts. |
| **HIGHLY ORGANIC SOILS** | | Pt | Peat and other organic soils. |

Note - $W_L$= Liquid Limit

THURBER

# EXPLANATION OF ROCK LOGGING TERMS

## ROCK WEATHERING CLASSIFICATION

| | |
|---|---|
| Fresh (FR) | No visible signs of weathering. |
| Fresh Jointed (FJ) | Weathering limited to surface of major discontinuities. |
| Slightly Weathered (SW) | Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials. |
| Moderately Weathered (MW) | Weathering extends throughout the rock mass, but the rock material is not friable. |
| Highly Weathered (HW) | Weathering extends throughout the rock mass and the rock is partly friable. |
| Completely Weathered (CW) | Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved. |

## TERMS

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

## DISCONTINUITY SPACING

| Bedding | Bedding Plane Spacing |
|---|---|
| Very thickly bedded | Greater than 2 m |
| Thickly bedded | 0.6 to 2 m |
| Medium bedded | 0.2 to 0.6 m |
| Thinly bedded | 60 mm to 0.2 m |
| Very thinly bedded | 20 to 60 mm |
| Laminated | 6 to 20 mm |
| Thinly laminated | Less than 6 mm |

## STRENGTH CLASSIFICATION

| Rock Strength | Approximate Uniaxial Compressive Strength (MPa) |
|---|---|
| Extremely Strong | Greater than 250 |
| Very Strong | 100 – 250 |
| Strong | 50 – 100 |
| Medium Strong | 25 – 50 |
| Weak | 5 – 25 |
| Very Weak | 1 – 5 |
| Extremely Weak | 0.25 – 1 |

# RECORD OF BOREHOLE No 22-01



**METRIC**

GWP# 5252-21-00
LOCATION Lat: 45.185462°, Long: -79.776167° Sta. 11+800, Seguin Township, MTM z10: N 5 005 092.0 E 283 097.6
ORIGINATED BY MIK
HWY 7289
BOREHOLE TYPE Hydrovac Excavation
COMPILED BY AO
DATUM Geodetic
DATE 2022.12.12 - 2022.12.12
CHECKED BY MJK

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100) | WATER CONTENT (%) (20 40 60) | UNIT WEIGHT kN/m³ | GR | SA | SI | CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 229.6 | Ground Surface | | | | | | | | | | | | | |
| 0.0 | **TOPSOIL (150 mm)** | | | | | | | | | | | | | |
| 0.2 | **COBBLES and BOULDERS** Infilled with brown-grey Silty Sand, contains Roots<br>- Boulders larger than 450 mm | | 1 | GS | - | ∇ | 229 | | o | | 2 | 76 | 22 (SI+CL) | |
| 228.5 / 1.1 | **End of Borehole** - Hydrovac refusal<br>Unstabilized water lever at a depth of 0.9 m upon completion of drilling. | | | | | | | | | | | | | |

SHEAR STRENGTH legend: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE

WATER CONTENT legend: PLASTIC LIMIT $w_P$; NATURAL MOISTURE CONTENT $w$; LIQUID LIMIT $w_L$

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 - 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No 22-02A



**METRIC**

GWP# 5252-21-00

LOCATION: Lat: 45.185394°, Long: -79.776294°; Sta. 11+800, Seguin Township, MTM z10: N 5 005 084.5 E 283 087.6

ORIGINATED BY APS

HWY 7289

BOREHOLE TYPE CME 75 Truck Mounted / HW casing / HQ Coring

COMPILED BY AO

DATUM Geodetic

DATE 2022.07.07 - 2022.07.07

CHECKED BY MJK

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | WATER CONTENT (%) | UNIT WEIGHT kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| 235.9 | Asphalt Surface | | | | | | | |
| 0.0 | **ASPHALT (200 mm)** | | | | | | | |
| 0.2 | SILTY SAND, Compact, Light brown, **FILL** | 1 | SS | 28 | | ~3 | | |
| | | 2 | SS | 14 | 235 | ~4 | | 0 80 20 (SI+CL) |
| | | 3 | SS | 15 | 234 | ~7 | | |
| | | 4 | SS | 15 | | ~8 | | |
| 233.0 / 2.9 | **SILTY SAND (SM)** some Gravel, Compact, Dark brown | 5 | SS | 100/150mm | 233 | ~9 | | 11 68 16 5 |
| 232.7 / 3.2 | **Inferred GNEISS BEDROCK**, Fresh, Pinkish grey, Coarse grained, Very strong | 1 | RUN | - | 232 | | FI: 2, 2 | RUN #1 TCR=53% SCR=53% RQD=40% |
| 231.9 / 4.0 | **End of Borehole** - Borehole terminated at a depth of 4.0 m due to no flush water return. See Borehole 22-02B for continuation. | | | | | | | |

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60; GROUND WATER CONDITIONS; STRAT PLOT.

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 22-02B



**METRIC**

GWP# 5252-21-00 | LOCATION Lat: 45.185357°, Long: -79.776259° Sta. 11+795, Seguin Township, MTM z10: N 5 005 080.4 E 283 090.3 | ORIGINATED BY APS

HWY 7289 | BOREHOLE TYPE CME 75 Truck Mounted / HW casing / HQ Coring | COMPILED BY AO

DATUM Geodetic | DATE 2022.06.27 - 2022.07.07 | CHECKED BY MJK

| ELEV / DEPTH | SOIL PROFILE: DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100) | PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT w, LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 235.9 | **Asphalt Surface** | | | | | | | | | | |
| 0.0 | Refer to Borehole 22-02A for stratigraphy. | | | | | | 235 | | | | |
| | | | | | | | 234 | | | | |
| | | | | | | | 233 | | | | |
| 232.7 / 3.2 | **Inferred GNEISS BEDROCK** Fresh Pinkish grey Coarse grained Very strong | | 1 | RUN | - | | | | | FI 1 2 | RUN #1 TCR=42% SCR=36% RQD=15% |
| 232.0 / 3.9 | **End of Borehole** - Borehole terminated at a depth of 4.0 m due to no flush water return. | | | | | | | | | | |

$+^3$, $\times^3$: Numbers refer to Sensitivity; 20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No 22-03



**METRIC**

GWP# 5252-21-00

LOCATION Lat: 45.184711°, Long: -79.7754501° Sta. 11+700, Seguin Township, MTM z10: N 5 005 008.3 E 283 152.5

ORIGINATED BY MIK

HWY 7289

BOREHOLE TYPE Hydrovac Excavation

COMPILED BY AO

DATUM Geodetic

DATE 2022.12.12 - 2022.12.12

CHECKED BY MJK

| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT w / LIQUID LIMIT $w_L$ — WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 230.3 | Ground Surface | | | | | | | | | | |
| 0.0 | **TOPSOIL (150 mm)** | | 1 | GS | - | | | | | | |
| 0.2 | **COBBLES and BOULDERS** Infilled with dark brown Sand, some Gravel and Fines, contains Organics - Boulders larger than 450 mm | | 2 | GS | - | | 230 | | ○ (approx. 24) | | 15 74 11 (SI+CL) |
| 229.6 / 0.7 | **End of Borehole** - Hydrovac refusal<br><br>Borehole dry upon completion of drilling. | | | | | | | | | | |

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No 22-04



METRIC

| | | | |
|---|---|---|---|
| GWP# 5252-21-00 | LOCATION Lat: 45.184652°, Long: -79.775589° Sta. 11+700, Seguin Township, MTM z10: N 5 005 001.8 E 283 142.7 | | ORIGINATED BY APS |
| HWY 7289 | BOREHOLE TYPE CME 75 Truck Mounted / HW casing / HQ Coring | | COMPILED BY AO |
| DATUM Geodetic | DATE 2022.07.06 - 2022.07.06 | | CHECKED BY MJK |

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | UNIT WEIGHT / FI | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|
| 236.7 | Asphalt Surface | | | | | | |
| 0.0 | **ASPHALT (200 mm)** | | | | | | |
| 0.2 | SAND some Gravel and Fines, Dense to Compact, Light brown, **FILL** | 1 | SS | 44 | 236 | | 17 72 11 (SI+CL) |
| | | 2 | SS | 16 | | | |
| 235.2 / 1.5 | **SAND and GRAVEL (SW)** Some Fines, Very dense, Brown to grey brown | 3 | SS | 52 | 235 | | 42 48 10 (SI+CL) |
| | | 4 | SS | 100/150mm | | | |
| 234.1 / 2.6 | **COBBLES and BOULDERS** | 1 | HQ | - | 234 | | |
| | - 420 mm Boulder at a depth of 3.8 m | 2 | HQ | - | 233 | | |
| | | 3 | HQ | - | 232 | | |
| 231.1 / 5.6 | **GNEISS BEDROCK** Slightly weathered to fresh, Pinkish grey, Coarse grained, Very strong | 3 | RUN | - | 231 | FI: 1, 1 | RUN #3 TCR=100% SCR=70% RQD=100% |
| | | 4 | RUN | - | 230 | 1, 0, 2, >10 | RUN #4 TCR=90% SCR=63% RQD=74% |
| | | 5 | RUN | - | 229, 228 | 3, 1, 0, 1, 0 | RUN #5 TCR=86% SCR=64% RQD=71% UCS=114MPa |
| 227.6 / 9.1 | **End of Borehole** Vibrating Wire Peizometer Installed at a depth of 3.7 m. | | | | | | |

Groundwater level symbol at elevation approx. 233.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE: 20 40 60 80 100

PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No 22-04



**METRIC**

| | | | |
|---|---|---|---|
| GWP# 5252-21-00 | LOCATION Lat: 45.184652°, Long: -79.775589° Sta. 11+700, Seguin Township, MTM z10: N 5 005 001.8 E 283 142.7 | | ORIGINATED BY APS |
| HWY 7289 | BOREHOLE TYPE CME 75 Truck Mounted / HW casing / HQ Coring | | COMPILED BY AO |
| DATUM Geodetic | DATE 2022.07.06 - 2022.07.06 | | CHECKED BY MJK |

| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100 | PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Continued From Previous Page | | | | | | | | | | |
| | **Water Level Readings:**<br>DATE DEPTH (m) ELEV. (m)<br>2022/07/14 dry -<br>2022/12/12 3.7 233.0 | | | | | | | | | | |

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

DOUBLE LINE 31334 LAKE JOSEPH GINT 2022.GPJ 2012TEMPLATE(MTO).GDT 4-11-23

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No 22-05



**METRIC**

GWP# 5252-21-00

LOCATION Lat: 45.184146°, Long: -79.774945° Sta. 11+625, Seguin Township, MTM z10: N 5 004 945.4 E 283 193.2

ORIGINATED BY APS

HWY 7289

BOREHOLE TYPE Portable / NW Casing

COMPILED BY AO

DATUM Geodetic

DATE 2022.07.13 - 2022.07.13

CHECKED BY MJK

| ELEV DEPTH | DESCRIPTION | SAMPLES NUMBER | SAMPLES TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|
| 231.4 | Ground Surface | | | | | | |
| 0.0 | **TOPSOIL (100 mm)** | | | | | | |
| 0.1 | SAND and GRAVEL<br>Contains Rootlets<br>Compact<br>Black brown<br>**FILL** | 1 | SS | 10 | | 231 | 46 47 7 (SI+CL) |
| | | 2 | SS | 100/ 100mm | | | |
| 230.4<br>1.0 | **End of Borehole**<br>Spoon refusal on inferred boulder.<br>Borehole dry upon completion of drilling.<br>**Note:** A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer. | | | | | | |

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT $\gamma$ kN/m$^3$

+ $^3$, × $^3$: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

DOUBLE LINE 31334 LAKE JOSEPH GINT 2022.GPJ 2012TEMPLATE(MTO).GDT 4-11-23

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No 22-06



**METRIC**

GWP# 5252-21-00

LOCATION Lat: 45.184091°, Long: -79.775059° Sta. 11+625, Seguin Township, MTM z10: N 5 004 939.3 E 283 184.2

ORIGINATED BY APS

HWY 7289

BOREHOLE TYPE CME 75 Truck Mounted / HW casing / HQ Coring

COMPILED BY AO

DATUM Geodetic

DATE 2022.07.04 - 2022.07.04

CHECKED BY MJK

| ELEV DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | WATER CONTENT (%) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| 237.5 | Asphalt Surface | | | | | | | |
| 0.0 | **ASPHALT (150 mm)** | | | | | | | |
| 0.2 | SILTY SAND trace Gravel, Compact, Light brown, **FILL** | 1 | SS | 17 | 237 | o | | |
| | | 2 | SS | 16 | | o | | 9 71 20 (SI+CL) |
| | | | | | 236 | | | |
| 235.8 / 1.7 | **SILTY SAND (SM)** trace Gravel, Contains Organics, Very dense, Dark Brown | 3 | SS | 100/200mm | | o o | FI | |
| 235.6 / 1.9 | **GNEISS BEDROCK**, Moderately weathered to fresh, Pinkish grey, Coarse grained, Very strong | 1 | RUN | - | 235 | | >10, 1, 5, 4 | RUN #1 TCR=54% SCR=30% RQD=28% |
| | | 2 | RUN | - | 234, 233 | | >10, >10, 3, 1, 2 | RUN #2 TCR=58% SCR=33% RQD=35% |
| | | 3 | RUN | - | 232 | | 2, 4, 3, 3, 3 | RUN #3 TCR=100% SCR=90% RQD=50% |
| 231.4 / 6.1 | **End of Borehole** Borehole dry upon completion of drilling. | | | | | | | |

Column headings also include: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$.

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No 22-07



**METRIC**

GWP# 5252-21-00

LOCATION Lat: 45.183591°, Long: -79.774368° Sta. 11+550, Seguin Township, MTM z10: N 5 004 883.6 E 283 238.3

ORIGINATED BY APS

HWY 7289

BOREHOLE TYPE Portable / NW Casing

COMPILED BY AO

DATUM Geodetic

DATE 2022.07.12 - 2022.07.12

CHECKED BY MJK

| ELEV DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | WATER CONTENT (%) | UNIT WEIGHT kN/m³ | GR | SA | SI | CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 230.6 | Ground Surface | | | | | | | | | | | |
| 0.0 / 0.1 | **TOPSOIL (100 mm)** | | | | | | | | | | | |
| | GRAVELLY SAND some Fines, Occasional Wood fragments, Loose, Brown, **FILL** | 1 | SS | 5 | | | o | | | | | |
| | | | | | | 230 | | | | | | |
| | | 2 | SS | 4 | | | o | | 23 | 63 | 14 (SI+CL) | |
| 229.2 / 1.4 | | | | | ▽ | | | | | | | |
| 229.2 / 1.4 | **SILT SAND (SM)** trace Gravel, Contains Organics, Loose, Dark brown | 3 | SS | 100/ 75mm | | | o | | 4 | 72 | 21 | 3 |
| | **End of Borehole** Spoon refusal on inferred boulder | | | | | | | | | | | |
| | Unstabilized water lever at a depth of 1.3 m upon completion of drilling. | | | | | | | | | | | |

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT $w_P$ — NATURAL MOISTURE CONTENT $w$ — LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity

15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

DOUBLE LINE 31334 LAKE JOSEPH GINT 2022.GPJ 2012TEMPLATE(MTO).GDT 4-11-23

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No 22-08



**METRIC**

| | | | | | |
|---|---|---|---|---|---|
| GWP# | 5252-21-00 | LOCATION | Lat: 45.183534°, Long: -79.7745196° Sta. 11+550, Seguin Township, MTM z10: N 5 004 877.3 E 283 226.4 | ORIGINATED BY | APS |
| HWY | 7289 | BOREHOLE TYPE | CME 75 Truck Mounted / HW casing / HQ Coring | COMPILED BY | AO |
| DATUM | Geodetic | DATE | 2022.06.29 - 2022.06.29 | CHECKED BY | MJK |

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|
| 238.6 | Asphalt Surface | | | | | |
| 0.0 | **ASPHALT (150 mm)** | | | | | |
| 0.2 | SAND some Fines, Some to trace Gravel, Compact, Light Brown, **FILL** | 1 | SS | 27 | 238 | |
| | | 2 | SS | 12 | | 1 86 13 (SI+CL) |
| | | 3 | SS | 15 | 237 | |
| | | 4 | SS | 23 | 236 | |
| 235.6 / 3.0 | **SILTY SAND (SM)** some Gravel, Occasional Wood fragments, Compact to loose, Dark to light brown | 5 | SS | 18 | 235 | |
| | | 6 | SS | 7 | | 16 62 19 3 |
| 234.0 / 4.6 | **Inferred COBBLES and BOULDERS** | 1 | HQ | - | 234, 233 | |
| | | 2 | HQ | - | 232, 231 | |
| | | 3 | HQ | - | 230 | |
| 229.5 / 9.1 | **GNEISS BEDROCK** Fresh, Pinkish grey, Coarse grained, Very strong | 4 | RUN | - | 229 | FI: 2, 2, 0; RUN #4 TCR=91% SCR=89% RQD=91% |

Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100

Shear Strength kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

Plastic Limit $w_P$, Natural Moisture Content $w$, Liquid Limit $w_L$; Water Content (%): 20 40 60

Unit Weight γ kN/m³

Ground water level indicated at approx. elev. 231.4.

Continued Next Page

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

DOUBLE LINE 31334 LAKE JOSEPH GINT 2022.GPJ 2012TEMPLATE(MTO).GDT 4-11-23

# RECORD OF BOREHOLE No 22-08

 **METRIC**

| | | | |
|---|---|---|---|
| GWP# 5252-21-00 | LOCATION Lat: 45.183534°, Long: -79.7745196° Sta. 11+550, Seguin Township, MTM z10: N 5 004 877.3 E 283 226.4 | ORIGINATED BY APS |
| HWY 7289 | BOREHOLE TYPE CME 75 Truck Mounted / HW casing / HQ Coring | COMPILED BY AO |
| DATUM Geodetic | DATE 2022.06.29 - 2022.06.29 | CHECKED BY MJK |

Continued From Previous Page

| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|
| | **GNEISS BEDROCK**<br>Fresh<br>Pinkish grey<br>Coarse grained<br>Very strong | | | | 228 | 0<br>1<br>1 | |
| 226.4 | | 5 | RUN | - | 227 | 3<br>1<br>1<br>0 | RUN #5<br>TCR=96%<br>SCR=93%<br>RQD=90%<br>UCS=115MPa |
| 12.2 | **End of Borehole** | | | | | | |

Vibrating Wire Peizometer Installed at a depth of 8.4 m

**Water Level Readings:**

| DATE | DEPTH (m) | ELEV. (m) |
|---|---|---|
| 2022/07/06 | 7.7 | 230.9 |
| 2022/07/14 | 7.8 | 230.8 |
| 2022/12/12 | 7.3 | 231.3 |

Column headers: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100; PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT w, LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60; GR SA SI CL

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

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No 22-09



**METRIC**

GWP# 5252-21-00

LOCATION Lat: 45.1833196°, Long: -79.774078° Sta. 11+510, Seguin Township, MTM z10: N 5 004 853.4 E 283 261.0

ORIGINATED BY APS

HWY 7289

BOREHOLE TYPE Portable / NW Casing

COMPILED BY AO

DATUM Geodetic

DATE 2022.07.12 - 2022.07.12

CHECKED BY MJK

| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | WATER CONTENT (%) | UNIT WEIGHT kN/m³ | GR | SA | SI | CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 231.3 | Ground Surface | | | | | | | | | | | |
| 0.0 / 0.1 | **TOPSOIL (100 mm)** | | | | | | | | | | | |
| | **SILTY SAND (SM)** some Gravel, Contains Organics, Loose, Dark brown | 1 | SS | 4 | | 231 | | | | | | |
| | | 2 | SS | 5 | | 230 | | | | | | |
| | | | | | ∇ | | | | | | | |
| 229.6 / 1.7 | | 3 | SS | 100/50mm | | | | | 10 | 69 | 18 | 3 |
| | **End of Borehole** Spoon refusal on inferred boulder. Unstabilized water lever at a depth of 1.5 m upon completion of drilling. | | | | | | | | | | | |

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT $w_P$ — NATURAL MOISTURE CONTENT $w$ — LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60

+³, ×³: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No 22-10



METRIC

GWP# 5252-21-00
LOCATION Lat: 45.183245°, Long: -79.774219° Sta. 11+510, Seguin Township, MTM z10: N 5 004 845.1 E 283 249.9
ORIGINATED BY APS
HWY 7289
BOREHOLE TYPE CME 75 Truck Mounted / HW casing / HQ Coring
COMPILED BY AO
DATUM Geodetic
DATE 2022.06.30 - 2022.06.30
CHECKED BY MJK

| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|
| 239.2 | Asphalt Surface | | | | | |
| 0.0 | **ASPHALT (150 mm)** | | | | 239 | |
| 0.2 | SILTY SAND Compact Light Brown **FILL** | 1 | SS | 18 | | |
| | | 2 | SS | 11 | 238 | 1 69 30 (SI+CL) |
| | | 3 | SS | 17 | | |
| 237.1 / 2.1 | SAND some Gravel and Fines Compact Grey brown **FILL** | 4 | SS | 18 | 237 | 13 68 19 (SI+CL) |
| | | 5 | SS | 13 | 236 | |
| 235.5 / 3.7 | **SILTY SAND (SM)** Trace to some Gravel Contains Organics Occasional Cobbles and Boulders Loose to very dense Dark grey brown to light grey brown | 6 | SS | 5 | 235 | 2 73 22 3 |
| | | 7 | SS | 81 | 234 | 19 63 15 3 |
| | | 8 | SS | 30 | | |
| | | 9 | SS | 66 | 233 | |
| | - Coring of Cobbles and Boulders from a depth of 6.7 m to 7.6 m | 1 | HQ | - | 232 | |
| | | 10 | SS | 29 | 231 | 13 73 14 0 |
| | - Coring of Cobbles and Boulders from a depth of 8.2 m to 9.1 m | 2 | HQ | - | 230 | |
| | | 11 | SS | 28 | | |

Other columns: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

DOUBLE LINE 31334 LAKE JOSEPH GINT 2022.GPJ 2012TEMPLATE(MTO).GDT 4-11-23

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No 22-10



**METRIC**

| | | | | | |
|---|---|---|---|---|---|
| GWP# | 5252-21-00 | LOCATION | Lat: 45.183245°, Long: -79.774219° Sta. 11+510, Seguin Township, MTM z10: N 5 004 845.1 E 283 249.9 | ORIGINATED BY | APS |
| HWY | 7289 | BOREHOLE TYPE | CME 75 Truck Mounted / HW casing / HQ Coring | COMPILED BY | AO |
| DATUM | Geodetic | DATE | 2022.06.30 - 2022.06.30 | CHECKED BY | MJK |

Continued From Previous Page

| ELEV DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | UNIT WEIGHT FI | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|
| 229.1 10.1 | **GNEISS BEDROCK** Slightly weathered to fresh Pinkish grey Coarse grained Very strong | 1 | RUN | - | 229 | 2, 1 | RUN #1 TCR=100% SCR=97% RQD=75% |
| | | 2 | RUN | - | 228 | 2, 0, 1, 3 | RUN #2 TCR=96% SCR=70% RQD=70% |
| | | 3 | RUN | - | 227, 226 | 2, 0, 4, 1, 2, 3 | RUN #3 TCR=98% SCR=89% RQD=81% |
| 225.5 13.7 | **End of Borehole** | | | | | | |

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT w, LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; GR SA SI CL

+ ³, × ³ : Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

DOUBLE LINE 31334 LAKE JOSEPH GINT 2022.GPJ 2012TEMPLATE(MTO).GDT 4-11-23

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No 22-11



**METRIC**

GWP# 5252-21-00
LOCATION Lat: 45.183079°, Long: -79.773792° Sta. 11+475, Seguin Township, MTM z10: N 5 004 826.5 E 283 283.4
ORIGINATED BY APS
HWY 7289
BOREHOLE TYPE CME 75 Truck Mounted / HW casing
COMPILED BY AO
DATUM Geodetic
DATE 2022.07.08 - 2022.07.08
CHECKED BY MJK

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | WATER CONTENT (%) | UNIT WEIGHT γ kN/m3 | GR | SA | SI | CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 231.4 | Ground Surface | | | | | | | | | | | | | |
| 0.0 | SAND and GRAVEL some Fines<br>Compact<br>Brown<br>**FILL** | | 1 | SS | 20 | | 231 | | o | | 36 | 52 | 12 (SI+CL) | |
| 230.5 | | | 2 | SS | 100/ 125mm | | | | o | | | | | |
| 0.9 | **End of Borehole**<br><br>Borehole dry upon completion of drilling. | | | | | | | | | | | | | |

Legend: SHEAR STRENGTH kPa: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE. Scales 20, 40, 60, 80, 100. WATER CONTENT: PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$; 20, 40, 60. REMARKS & GRAIN SIZE DISTRIBUTION (%).

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No 22-12



**METRIC**

GWP# 5252-21-00

LOCATION Lat: 45.182997°, Long: -79.7739501° Sta. 11+475, Seguin Township, MTM z10: N 5 004 817.5 E 283 270.9

ORIGINATED BY APS

HWY 7289

BOREHOLE TYPE CME 75 Truck Mounted / HW casing / HQ Coring

COMPILED BY AO

DATUM Geodetic

DATE 2022.06.28 - 2022.06.28

CHECKED BY MJK

| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | WATER CONTENT (%) | UNIT WEIGHT | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| 239.7 | Asphalt Surface | | | | | | | |
| 0.0 | **ASPHALT (150 mm)** | | | | | | | |
| 0.2 | SILTY SAND<br>Compact<br>Light Brown<br>**FILL** | 1 | SS | 14 | | | | |
| | | 2 | SS | 12 | 239 | | | |
| | | 3 | SS | 25 | 238 | | | 1 76 23 (SI+CL) |
| 237.6<br>2.1 | **SILTY SAND (SM)** some Gravel<br>Occasional Cobbles and Boulders<br>Compact to dense<br>Dark brown to light brown grey | 4 | SS | 18 | 237 | | | 11 70 15 4 |
| | | 5 | SS | 43 | 236 | | | |
| | | 6 | SS | 100/ 150mm | | | | |
| | - Coring of Cobbles and Boulders from a depth of 4.5 m to 5.5 m | 1 | HQ | - | 235 | | FI | |
| 234.2<br>5.5 | **GNEISS BEDROCK**<br>Moderately weathered to fresh<br>Pinkish grey<br>Coarse grained<br>Very strong | 1 | RUN | - | 234 | | 2<br>5<br>4 | RUN #1<br>TCR=68%<br>SCR=44%<br>RQD=26% |
| | | 2 | RUN | - | 233 | | 3<br>1<br>2<br>3 | RUN #2<br>TCR=100%<br>SCR=94%<br>RQD=73% |
| | | 3 | RUN | - | 232<br>231 | | 2<br>3<br>3<br>3<br>2 | RUN #3<br>TCR=83%<br>SCR=72%<br>RQD=63%<br>UCS=103MPa |
| 230.7<br>9.0 | **End of Borehole**<br><br>Vibrating Wire Peizometer installed at a depth of 6.1 m. | | | | | | | |

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT $w_P$ — NATURAL MOISTURE CONTENT w — LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No 22-12



METRIC

| | | | |
|---|---|---|---|
| GWP# 5252-21-00 | LOCATION Lat: 45.182997°, Long: -79.7739501° Sta. 11+475, Seguin Township, MTM z10: N 5 004 817.5 E 283 270.9 | ORIGINATED BY APS |
| HWY 7289 | BOREHOLE TYPE CME 75 Truck Mounted / HW casing / HQ Coring | COMPILED BY AO |
| DATUM Geodetic | DATE 2022.06.28 - 2022.06.28 | CHECKED BY MJK |

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT w / LIQUID LIMIT $w_L$ — WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| | Continued From Previous Page | | | | | | | | | | |
| | **Water Level Readings:** | | | | | | | | | | |

| DATE | DEPTH (m) | ELEV. (m) |
|---|---|---|
| 2022/07/06 | dry | - |
| 2022/07/14 | dry | - |
| 2022/12/12 | 5.8 | 233.9 |

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No 22-13



**METRIC**

| | | | |
|---|---|---|---|
| GWP# 5252-21-00 | LOCATION | Lat: 45.182813°, Long: -79.773558° Sta. 11+440, Seguin Township, MTM z10: N 5 004 796.9 E 283 301.7 | ORIGINATED BY APS |
| HWY 7289 | BOREHOLE TYPE | Portable / NW Casing | COMPILED BY AO |
| DATUM Geodetic | DATE | 2022.07.13 - 2022.07.13 | CHECKED BY MJK |

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | WATER CONTENT (%) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 235.9 | Ground Surface | | | | | | | | | | |
| 0.0 | GRAVELLY SAND some Fines, Compact, Brown, **FILL** | | 1 | SS | 23 | | | | o | | 25 61 14 (SI+CL) |
| | | | 2 | SS | 23 | | 235 | | o | | |
| 234.3 / 1.6 | **End of Borehole** | | 3 | SS | 100/100mm | | | | o | | 2 73 24 1 |

Shear strength legend: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE. Scales: 20 40 60 80 100. Water content: PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT w, LIQUID LIMIT $w_L$; 20 40 60.

**Note:** A half-weight hammer was used to advance the split-spoon sampler. The "N" values presented above have been adjusted to provide an estimate of the "N" value that would have been obtained with a standard hammer.

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

DOUBLE LINE 31334 LAKE JOSEPH GINT 2022.GPJ 2012TEMPLATE(MTO).GDT 4-11-23

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No 22-14



**METRIC**

GWP# 5252-21-00
LOCATION Lat: 45.182742°, Long: -79.773689° Sta. 11+440, Seguin Township, MTM z10: N 5 004 789.1 E 283 291.3
ORIGINATED BY APS
HWY 7289
BOREHOLE TYPE CME 75 Truck Mounted / HW casing / HQ Coring
COMPILED BY AO
DATUM Geodetic
DATE 2022.06.27 - 2022.06.27
CHECKED BY MJK

| ELEV DEPTH (m) | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | WATER CONTENT (%) | UNIT WEIGHT | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| 240.3 | Asphalt Surface | | | | | | | |
| 0.0 | **ASPHALT (150 mm)** | | | | | | | |
| 0.2 | SAND Compact Light brown **FILL** | 1 | SS | 26 | | | | |
| | | 2 | SS | 22 | | | | 3 91 6 (SI+CL) |
| 238.8 / 1.5 | **SAND** some Silt Contains Organics Compact to loose Dark brownish grey | 3 | SS | 18 | | | | 2 79 17 2 |
| | | 4 | SS | 8 | Water level at approx. El. 237.9 | | | |
| 237.3 / 3.0 | **SILTY SAND (SM)** with Gravel to **GRAVEL (GP-GM)** with Silt and Sand Frequent Cobbles and Boulders Compact to very dense Brown to light brown grey | 5 | SS | 136 | | | | 26 59 12 3 |
| | | 6 | SS | 100/ 100mm | | | | |
| | - Coring of Cobbles and Boulders from a depth of 4.0 m to 5.0 m | 1 | HQ | - | | | | |
| | | 7 | SS | 27 | | | | 54 41 5 (SI+CL) |
| | | 8 | SS | 100/ 150mm | | | FI | |
| 234.1 / 6.2 | **GNEISS BEDROCK** Slightly weathered to fresh Pinkish grey Coarse grained Very strong | 1 | RUN | - | | | 9, 1, 2, 3, 2 | RUN #1 TCR=100% SCR=82% RQD=51% |
| | | 2 | RUN | - | | | 1, 2, 2, 3, 2 | RUN #2 TCR=100% SCR=81% RQD=65% |
| 231.2 / 9.1 | **End of Borehole** Unstabilized water lever at a depth of 2.4 m upon completion of drilling. | | | | | | | |

Plot legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100; PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT w, LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; ELEVATION SCALE 240 – 232.

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

THURBER

## Appendix C Laboratory Testing

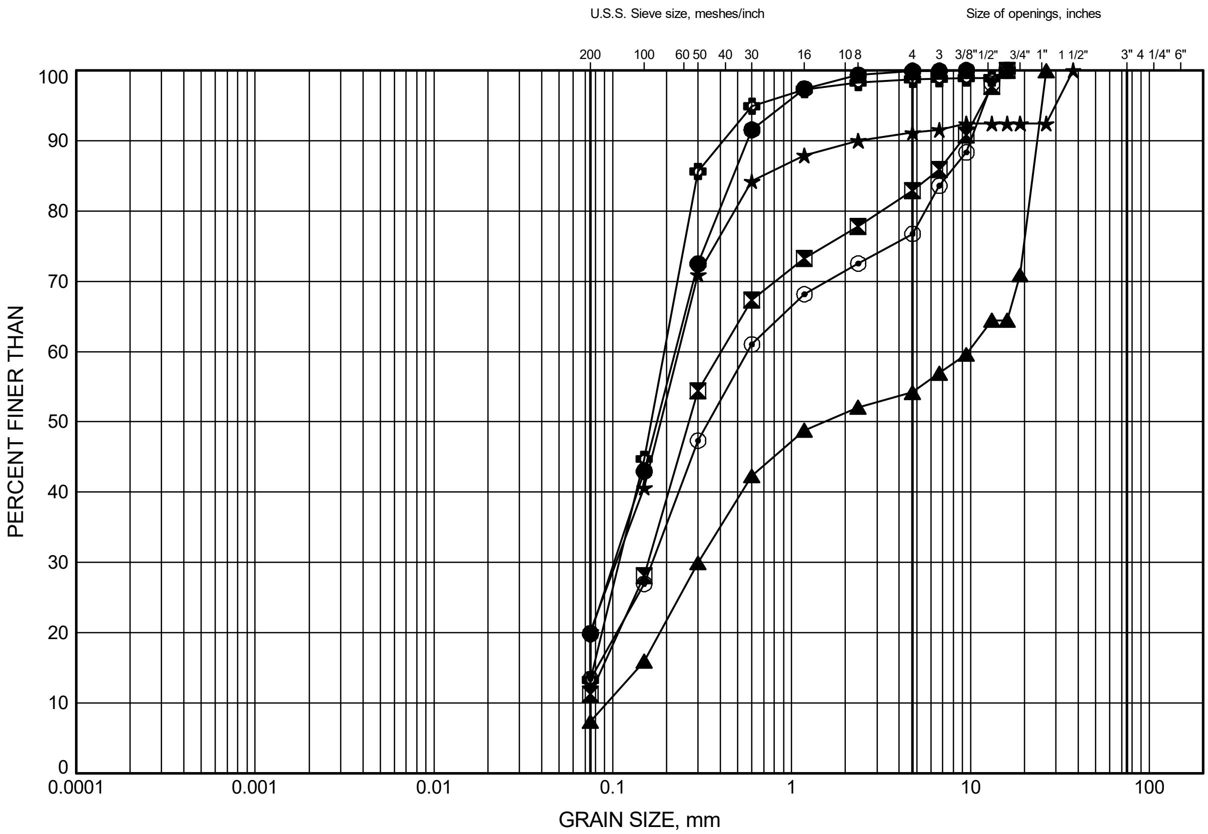
Particle Size Analysis Figures
Unconfined Compressive Strength Testing Results
Rock Core Photographs
Analytical Testing Results

Hwy 7289 East Embankment Slope (Sta. 11+400 to 11+900)

# GRAIN SIZE DISTRIBUTION

FIGURE C1

## FILL: Silty Sand to Sand




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | 22-02A | 1.1 | 234.8 |
| ⧗ | 22-04 | 0.5 | 236.2 |
| ▲ | 22-05 | 0.4 | 231.0 |
| ★ | 22-06 | 1.1 | 236.4 |
| ⊙ | 22-07 | 1.1 | 229.5 |
| ✿ | 22-08 | 1.1 | 237.5 |

Date January 2023

GWP# 5162-18-00

THURBER

Prep'd RH

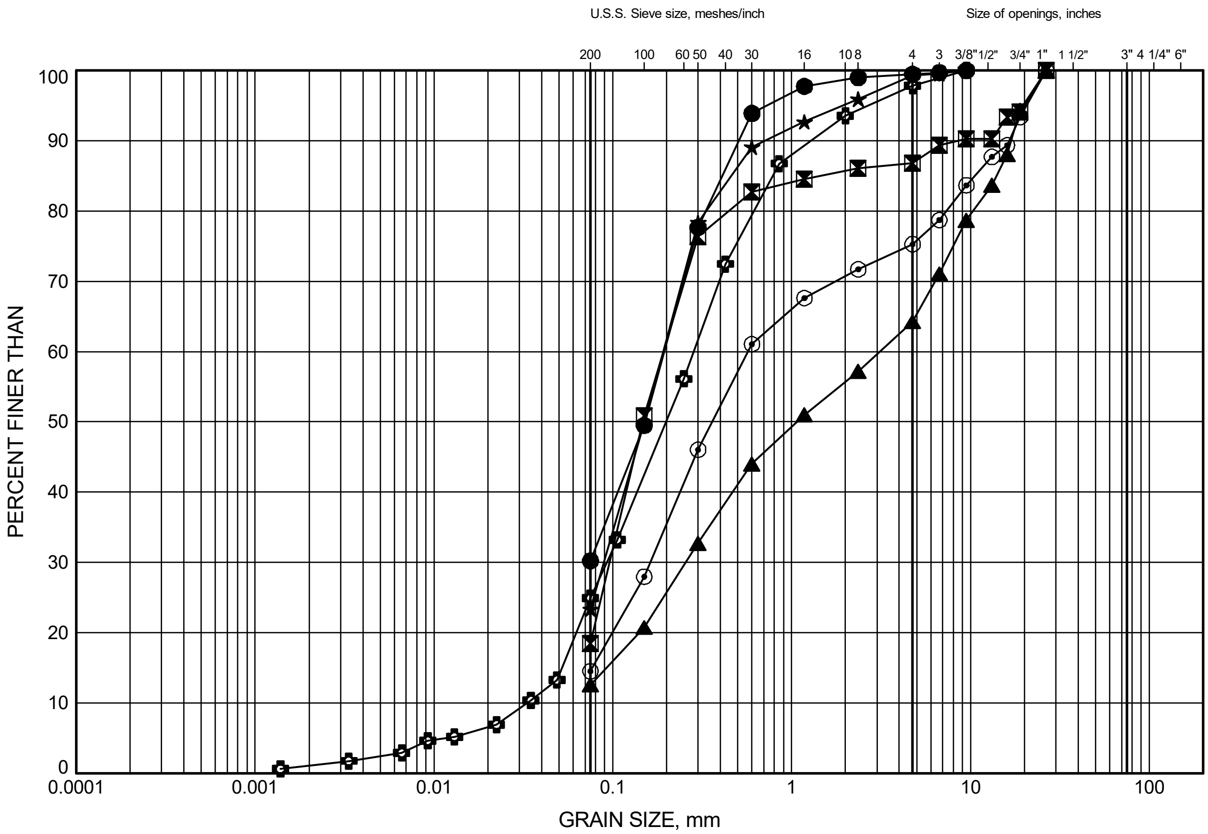
Chkd. AO

Hwy 7289 East Embankment Slope (Sta. 11+400 to 11+900)

# GRAIN SIZE DISTRIBUTION

FIGURE C2

## FILL: Silty Sand to Sand




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | 22-10 | 1.1 | 238.1 |
| ⧗ | 22-10 | 2.6 | 236.6 |
| ▲ | 22-11 | 0.3 | 231.1 |
| ★ | 22-12 | 1.8 | 237.9 |
| ⊙ | 22-13 | 0.3 | 235.6 |
| ✿ | 22-13 | 1.6 | 234.3 |

Date January 2023

GWP# 5162-18-00

THURBER

Prep'd RH

Chkd. AO

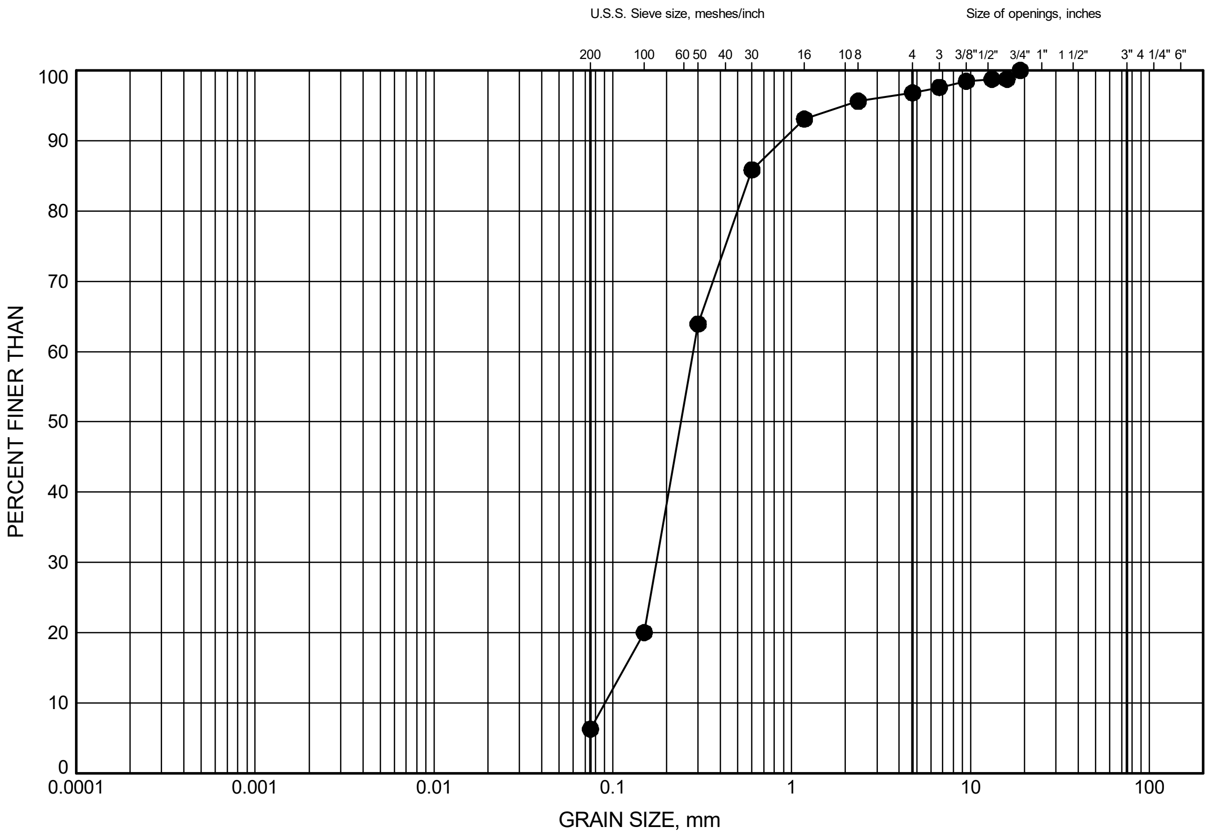
GRAIN SIZE DISTRIBUTION - THURBER 31334 LAKE JOSEPH GINT 2022.GPJ 1-30-23

Hwy 7289 East Embankment Slope (Sta. 11+400 to 11+900)

# GRAIN SIZE DISTRIBUTION

FIGURE C3

## FILL: Sand




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | 22-14 | 1.1 | 239.2 |

Date January 2023

GWP# 5162-18-00

THURBER

Prep'd RH

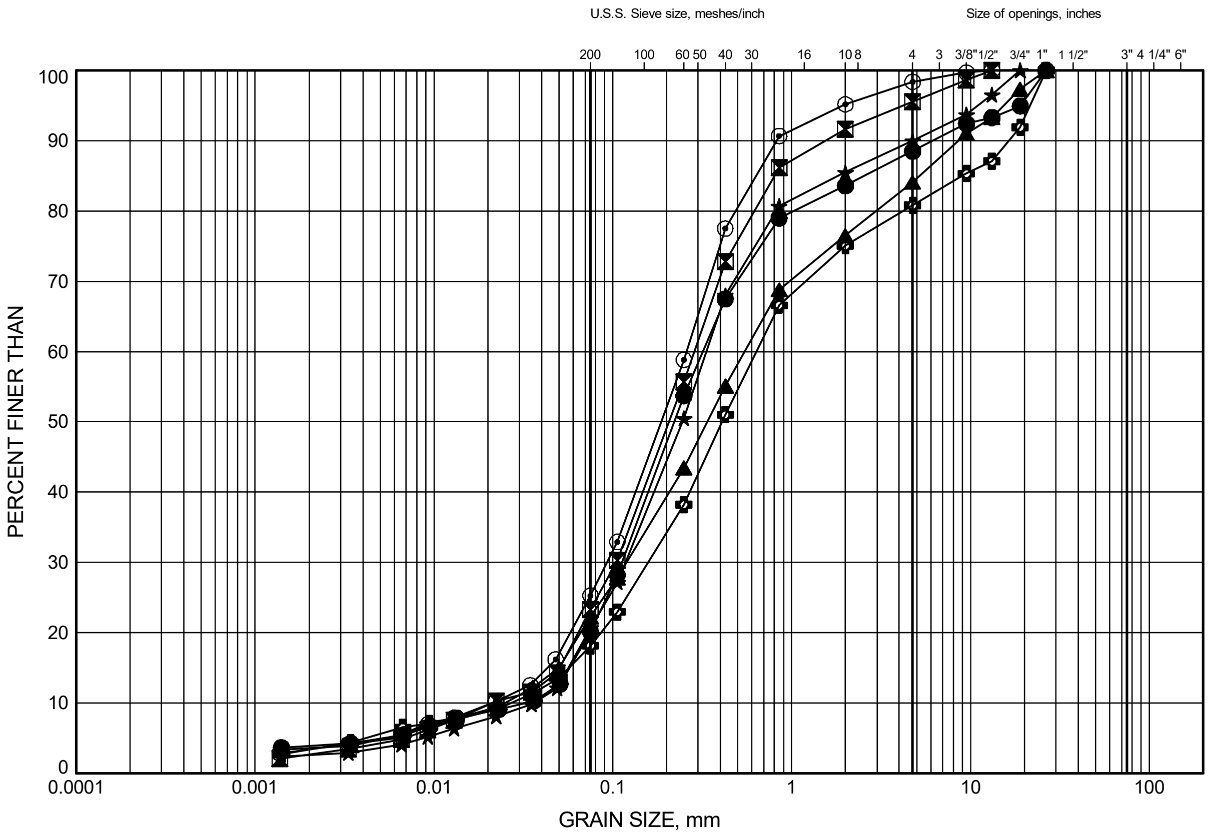
Chkd. AO

Hwy 7289 East Embankment Slope (Sta. 11+400 to 11+900)

# GRAIN SIZE DISTRIBUTION

FIGURE C4

## Silty Sand (SM)




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | 22-02A | 3.0 | 232.9 |
| ⧗ | 22-07 | 1.4 | 229.2 |
| ▲ | 22-08 | 4.1 | 234.5 |
| ★ | 22-09 | 1.6 | 229.7 |
| ⊙ | 22-10 | 4.1 | 235.1 |
| ✪ | 22-10 | 4.9 | 234.3 |

Date January 2023

GWP# 5162-18-00

THURBER

Prep'd RH

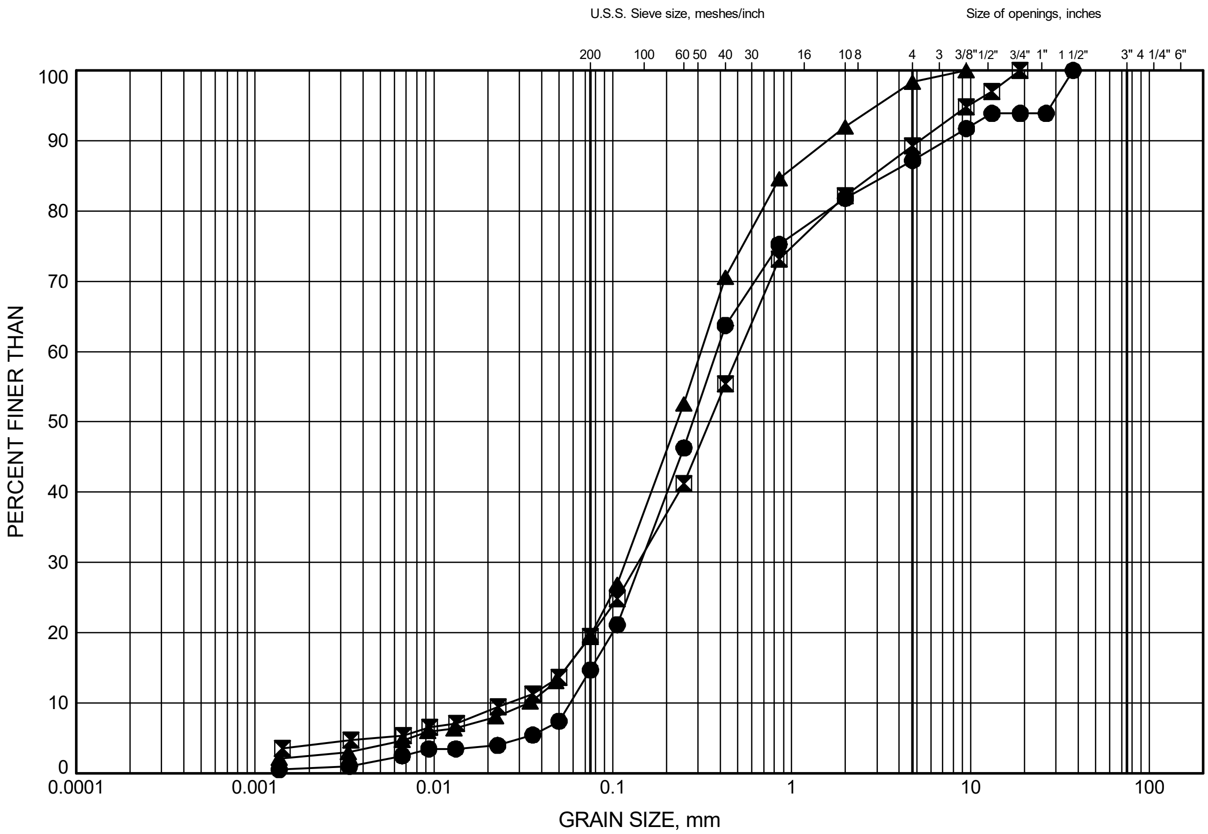
Chkd. AO

Hwy 7289 East Embankment Slope (Sta. 11+400 to 11+900)

# GRAIN SIZE DISTRIBUTION

FIGURE C5

## Silty Sand (SM)




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | 22-10 | 7.9 | 231.3 |
| ⧗ | 22-12 | 2.6 | 237.1 |
| ▲ | 22-14 | 1.8 | 238.5 |

Date January 2023

GWP# 5162-18-00

THURBER

Prep'd RH

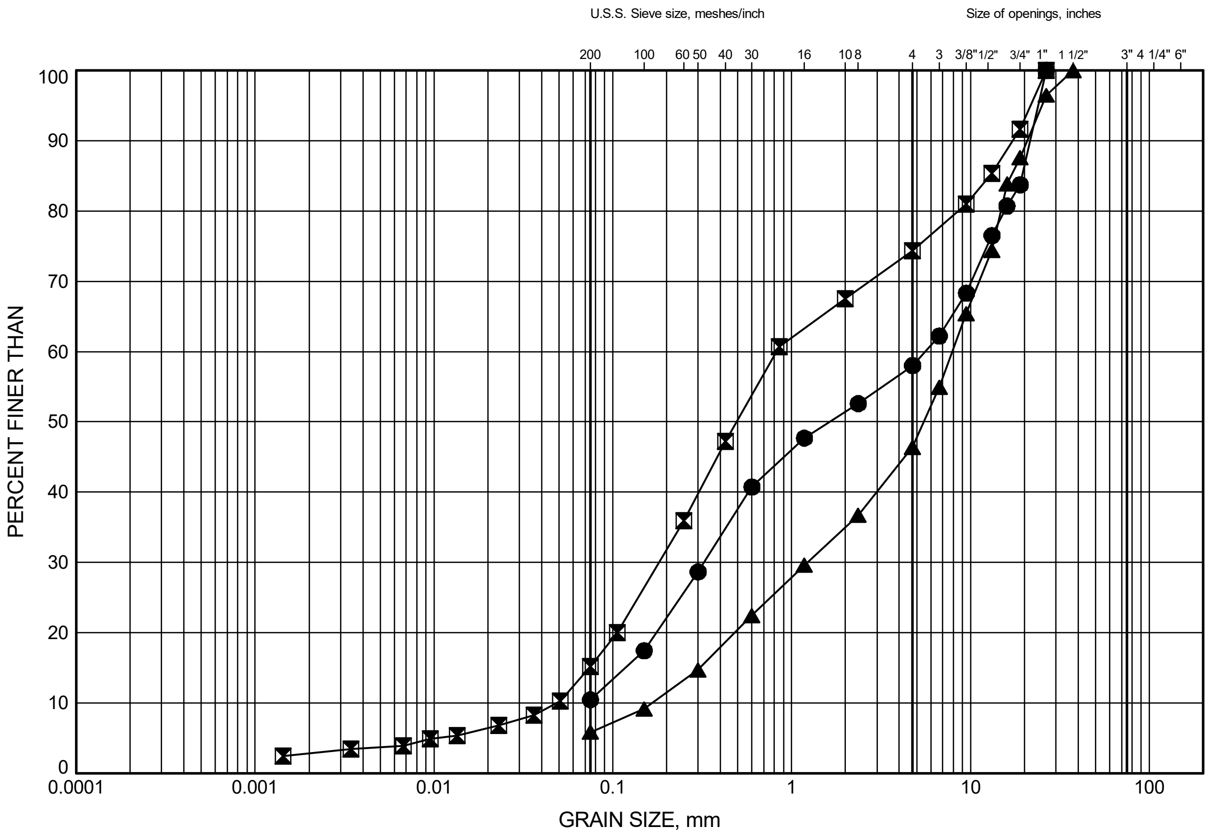
Chkd. AO

Hwy 7289 East Embankment Slope (Sta. 11+400 to 11+900)

# GRAIN SIZE DISTRIBUTION

FIGURE C6

## Sand and Gravel (SM-GM)




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | 22-04 | 1.8 | 234.9 |
| ⧗ | 22-14 | 3.4 | 236.9 |
| ▲ | 22-14 | 5.3 | 235.0 |

Date January 2023

GWP# 5162-18-00

THURBER

Prep'd RH

Chkd. AO

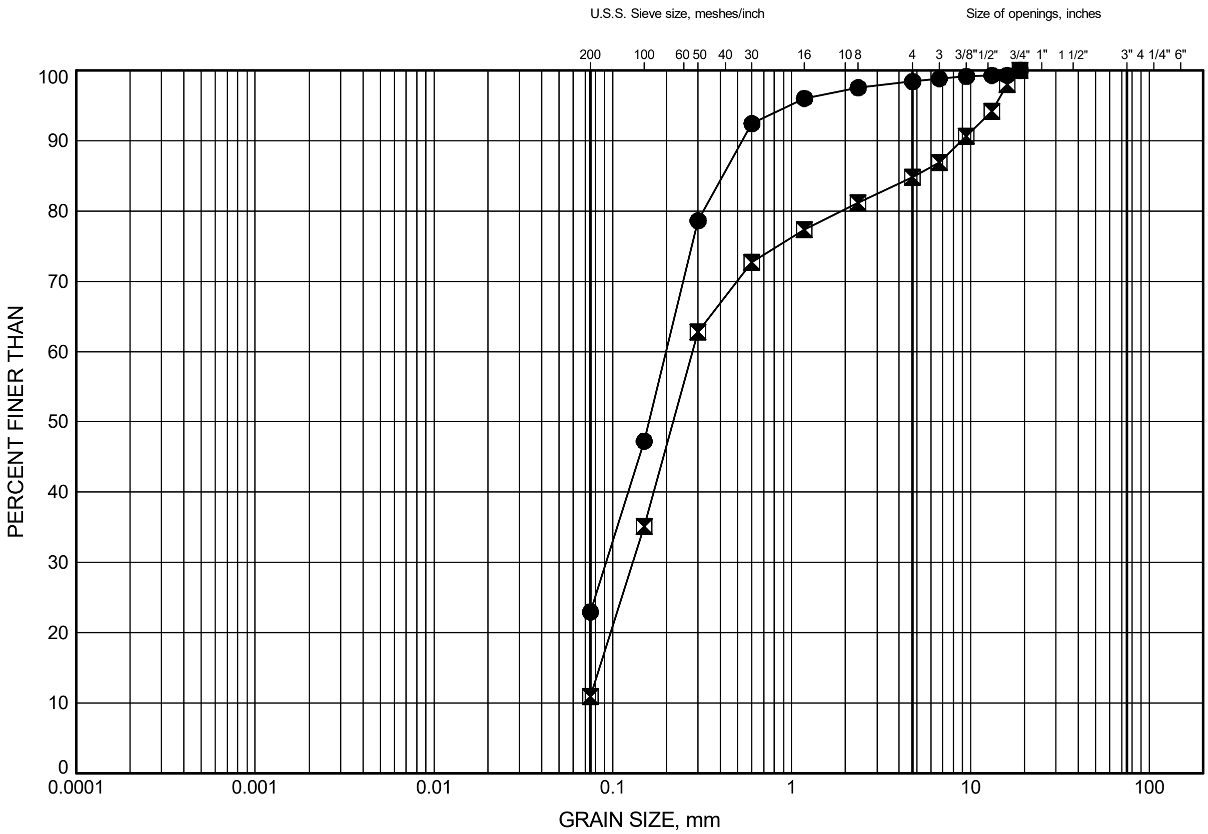
GRAIN SIZE DISTRIBUTION - THURBER 31334 LAKE JOSEPH GINT 2022.GPJ 1-30-23

Hwy 7289 East Embankment Slope (Sta. 11+400 to 11+900)

# GRAIN SIZE DISTRIBUTION

FIGURE C7

## Cobbles and Boulders




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | 22-01 | 0.6 | 229.0 |
| ⧗ | 22-03 | 0.4 | 229.9 |

Date January 2023

GWP# 5162-18-00

THURBER

Prep'd RH

Chkd. AO

**Stantec Consulting Ltd.**
2781 Lancaster Rd, Suite 100 A&B, Ottawa ON K1B 1A7

August 2, 2022
File: 122410864

Client: Thurber Engineering, File #31334

**Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core**
**Highways 7289, 7290 & 141**

The following table summarizes unconfined compressive strength results for three intact rock cores.

| Location | Sample Depth | Compressive Strength (MPa) | Description of Break |
|---|---|---|---|
| 22-04 Run-5 | 28'-29'4'' | 113.6 | Well-formed cone |
| 22-12 Run-3 | 26'4''27'3'' | 102.5 | End to end diagonal fracture |
| 22-08 Run-2 | 43'7''-44'5'' | 115.4 | Well-formed cone |

Sincerely,

**Stantec Consulting Ltd.**

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-722-2799
brian.prevost@stantec.com

# Borehole 22-02A

**Run 1**

**Depth 3.2 to 4.0 m**

**Elevation 232.7 to 231.9 m**

**Dry Sample**

Run 1 Start
elev. 232.7 m

Run 1 End
elev. 231.9 m

THURBER ENGINEERING LTD.

**Geotechnical Investigation**
**Highway 7289 East Embankment Slope**
**Sta. 11+400 to Sta. 11+900**
**Humphrey Township, ON**

**G.W.P. 5162-18-00**
**Project No.: 31334**

# Borehole 22-02A

**Run 1**
**Depth 3.2 to 4.0 m**
**Elevation 232.7 to 231.9 m**
**Wet Sample**

Run 1 Start
elev. 232.7 m

Run 1 End
elev. 231.9 m

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Geotechnical Investigation
Highway 7289 East Embankment Slope
Sta. 11+400 to Sta. 11+900
Humphrey Township, ON

G.W.P. 5162-18-00
Project No.: 31334

# Borehole 22-02B

## Run 1
## Depth 3.2 to 3.9 m
## Elevation 232.7 to 232.0 m
## Dry Sample

Run 1 Start
elev. 232.7 m

Run 1 End
elev. 232.0 m

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Geotechnical Investigation
Highway 7289 East Embankment Slope
Sta. 11+400 to Sta. 11+900
Humphrey Township, ON

G.W.P. 5162-18-00
Project No.: 31334

# Borehole 22-02B

**Run 1**
**Depth 3.2 to 3.9 m**
**Elevation 232.7 to 232.0 m**
**Wet Sample**

Run 1 Start
elev. 232.7 m

Run 1 End
elev. 232.0 m

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Highway 7289 East Embankment Slope
Sta. 11+400 to Sta. 11+900
Humphrey Township, ON

G.W.P. 5162-18-00
Project No.: 31334

# Borehole 22-04

## Runs 1 to 5
## Depth 5.6 to 9.1 m
## Elevation 234.1 to 227.6 m
## Dry Sample

HQ 1 to HQ 3 Start
Cobbles and Boulders

HQ 1 to HQ 3 End
Cobbles and Boulders

Run 3 Start
elev. 231.1 m

Run 3 End
elev. 230.6 m

Run 4 Start
elev. 230.6 m

Run 4 End
elev. 229.1 m

Run 5 Start
elev. 229.1 m

Run 5 End
elev. 227.6 m

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Geotechnical Investigation
Highway 7289 East Embankment Slope
Sta. 11+400 to Sta. 11+900
Humphrey Township, ON

G.W.P. 5162-18-00
Project No.: 31334

# Borehole 22-06

## Runs 1 to 3
## Depth 1.9 to 6.1 m
## Elevation 235.6 to 231.4 m
## Wet Sample

Run 1 Start
elev. 235.6 m

Run 1 End
elev. 234.5 m

Run 2 Start
elev. 234.5 m

Run 2 End
elev. 233.0 m

Run 3 Start
elev. 233.0 m

Run 3 End
elev. 231.4 m

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Highway 7289 East Embankment Slope
Sta. 11+400 to Sta. 11+900
Humphrey Township, ON

G.W.P. 5162-18-00
Project No.: 31334

# Borehole 22-08

## Runs 4 to 5
## Depth 9.1 to 12.2 m
## Elevation 229.5 to 226.4 m
## Dry Sample

Run 4 Start
elev. 229.5 m

Run 4 End
elev. 227.9 m

Run 5 Start
elev. 227.9 m

Run 5 End
elev. 226.4 m

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Geotechnical Investigation
Highway 7289 East Embankment Slope
Sta. 11+400 to Sta. 11+900
Humphrey Township, ON

G.W.P. 5162-18-00
Project No.: 31334

# Borehole 22-10

## Runs 1 to 3

## Depth 10.1 to 13.7 m

## Elevation 229.1 to 225.5 m

## Dry Sample

Run 1 Start elev. 229.1 m

Run 1 End elev. 228.5 m

Run 2 Start elev. 228.5 m

Run 2 End elev. 227.0 m

Run 3 Start elev. 227.0 m

Run 3 End elev. 225.5 m

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Geotechnical Investigation
Highway 7289 East Embankment Slope
Sta. 11+400 to Sta. 11+900
Humphrey Township, ON

G.W.P. 5162-18-00
Project No.: 31334

# Borehole 22-12

## Runs 1 to 3
## Depth 5.5 to 9.0 m
## Elevation 234.2 to 230.7 m
## Dry Sample

Run 1 Start
elev. 234.2 m

Run 1 End
elev. 233.6 m

Run 2 Start
elev. 233.6 m

Run 2 End
elev. 232.2 m

Run 3 Start
elev. 232.2 m

Run 3 End
elev. 230.7 m

THURBER ENGINEERING LTD.

Geotechnical Investigation
Highway 7289 East Embankment Slope
Sta. 11+400 to Sta. 11+900
Humphrey Township, ON

G.W.P. 5162-18-00
Project No.: 31334

# Borehole 22-14

## Runs 4 to 5
## Depth 6.2 to 9.1 m
## Elevation 234.1 to 231.2 m
## Dry Sample

Run 1 Start
elev. 234.1 m

Run 1 End
elev. 232.7 m

Run 2 Start
elev. 232.7 m

Run 2 End
elev. 231.2 m

THURBER ENGINEERING LTD.

Geotechnical Investigation
Highway 7289 East Embankment Slope
Sta. 11+400 to Sta. 11+900
Humphrey Township, ON

G.W.P. 5162-18-00
Project No.: 31334

Certificate of Analysis

**Client:** **Thurber Engineering Ltd.**

**Client PO:**

Report Date: 26-Jul-2022

Order Date: 13-Jul-2022

**Project Description: 31334 Lake Joseph**

| | | | | | |
|---|---|---|---|---|---|
| | **Client ID:** | 22-06 SS3 (5'-7') | 22-12 SS3 (5'-7') | - | - |
| | **Sample Date:** | 04-Jul-22 09:00 | 28-Jun-22 09:00 | - | - |
| | **Sample ID:** | 2229357-01 | 2229357-02 | - | - |
| | **MDL/Units** | Soil | Soil | - | - |
| **Physical Characteristics** | | | | | |
| % Solids | 0.1 % by Wt. | 84.7 | 87.5 | - | - |
| **General Inorganics** | | | | | |
| Conductivity | 5 uS/cm | 310 | 188 | - | - |
| pH | 0.05 pH Units | 6.54 | 7.11 | - | - |
| Resistivity | 0.10 Ohm.m | 32.2 | 53.3 | - | - |
| **Anions** | | | | | |
| Chloride | 5 ug/g dry | 43 | 31 | - | - |
| Sulphate | 5 ug/g dry | 136 | 16 | - | - |

**SGS Canada Inc.**
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

26-July-2022

**Paracel Laboratories**
Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

**Date Rec. :** 15 July 2022
**LR Report:** **CA12480-JUL22**
**Reference:** Project#: 2229357

**Copy:** #1

# CERTIFICATE OF ANALYSIS

## Final Report

| Sample ID | Sample Date & Time | Sulphide (Na2CO3) % |
|---|---|---|
| 1: Analysis Start Date | | 25-Jul-22 |
| 2: Analysis Start Time | | 20:35 |
| 3: Analysis Completed Date | | 26-Jul-22 |
| 4: Analysis Completed Time | | 09:56 |
| 5: QC - Blank | | < 0.04 |
| 6: QC - STD % Recovery | | 110% |
| 7: QC - DUP % RPD | | ND |
| 8: RL | | 0.02 |
| 9: 22-06 SS3 (5'-7') | 04-Jul-22 | < 0.04 |
| 10: 22-12 SS3 (5'-7') | 28-Jun-22 | < 0.04 |

RL - SGS Reporting Limit
ND - Not Detected

Note: Results may be unreliable if the standard holding time of 28 days was exceeded.

*Kimberley Didsbury*
*Project Specialist,*
*Environment, Health & Safety*

OnLine LIMS

0002989166

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# Appendix D Site Photographs

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Photograph 1: Highway 7289 and east slope showing failure near Sta. 11+510 (looking south)
*[taken Sept. 2014]*

Photograph 2: Highway 7289 and east slope showing failure (looking north)
*[taken Sept. 2014]*


Photograph 3: New slope treatment near Sta. 11+600 (looking south)
*[taken Apr. 2015]*


Photograph 4: New slope treatment near Sta. 11+770 (looking north)
*[taken Apr. 2015]*

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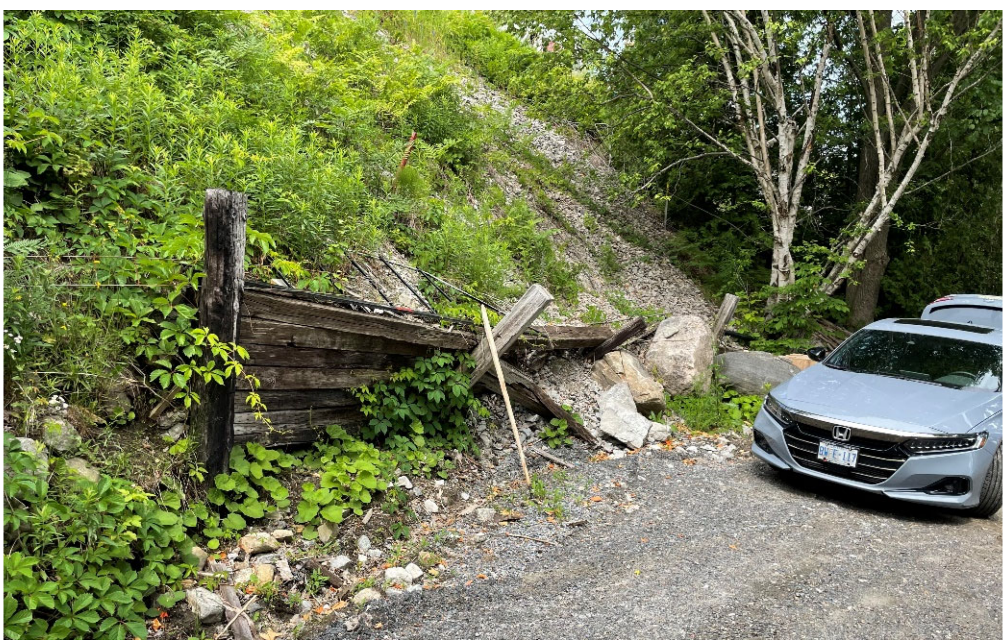
Photograph 5: Existing Timber Retaining Wall near Sta. 11+475 (looking north)
*[taken Sept. 2016]*



Photograph 6: Existing Timber Retaining Wall near Sta. 11+475 (looking north)
*[taken Jun. 2022]*

Photograph 7: Existing Timber Retaining Wall near Sta. 11+475 (looking north)
*[taken Mar. 2024]*

Photograph 8: Highway 7289 and east embankment slope near Sta. 11+515 (looking north)
*[taken Dec. 2021]*


Photograph 9: West of Highway 7289 and Gabion Wall near Sta. 11+500 (looking south)
*[taken Dec. 2021]*


Photograph 10: West of Highway 7289 and rock outcrop near Sta. 11+650 (looking south)
*[taken Dec. 2021]*

Photograph 11: Highway 7289 and west slope near Sta. 11+800 (looking south)
*[taken Dec. 2021]*

Photograph 12: Highway 7289 and driveway entrance near Sta. 11+400 (looking north)
*[taken Dec. 2021]*

# Appendix E GSC Seismic Hazard Calculation

# 2015 National Building Code Seismic Hazard Calculation

**INFORMATION:** **Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836**
**Western Canada English (250) 363-6500 Facsimile (250) 363-6565**

**Site:** 45.185N 79.776W **User File Reference:** Hwy 7289 - Sta 11+400 to Sta 11+800 2022-12-21 23:21 UT

| Probability of exceedance per annum | 0.000404 | 0.001 | 0.0021 | 0.01 |
|---|---|---|---|---|
| Probability of exceedance in 50 years | 2 % | 5 % | 10 % | 40 % |
| Sa (0.05) | 0.078 | 0.049 | 0.032 | 0.011 |
| Sa (0.1) | 0.110 | 0.071 | 0.048 | 0.018 |
| Sa (0.2) | 0.110 | 0.074 | 0.050 | 0.019 |
| Sa (0.3) | 0.096 | 0.065 | 0.045 | 0.017 |
| Sa (0.5) | 0.080 | 0.054 | 0.037 | 0.014 |
| Sa (1.0) | 0.049 | 0.032 | 0.022 | 0.007 |
| Sa (2.0) | 0.026 | 0.016 | 0.011 | 0.003 |
| Sa (5.0) | 0.006 | 0.004 | 0.002 | 0.001 |
| Sa (10.0) | 0.003 | 0.002 | 0.001 | 0.000 |
| PGA (g) | 0.064 | 0.041 | 0.027 | 0.010 |
| PGV (m/s) | 0.067 | 0.042 | 0.027 | 0.008 |

**Notes:** Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 $m/s^2$). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

---

## References


**National Building Code of Canada 2015 NRCC no. 56190;** Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

**Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)**
**Commentary J**: Design for Seismic Effects

**Geological Survey of Canada Open File 7893** Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada


See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

Natural Resources Canada Ressources naturelles Canada

Canada

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# Appendix F Slope Stability Analysis Figures

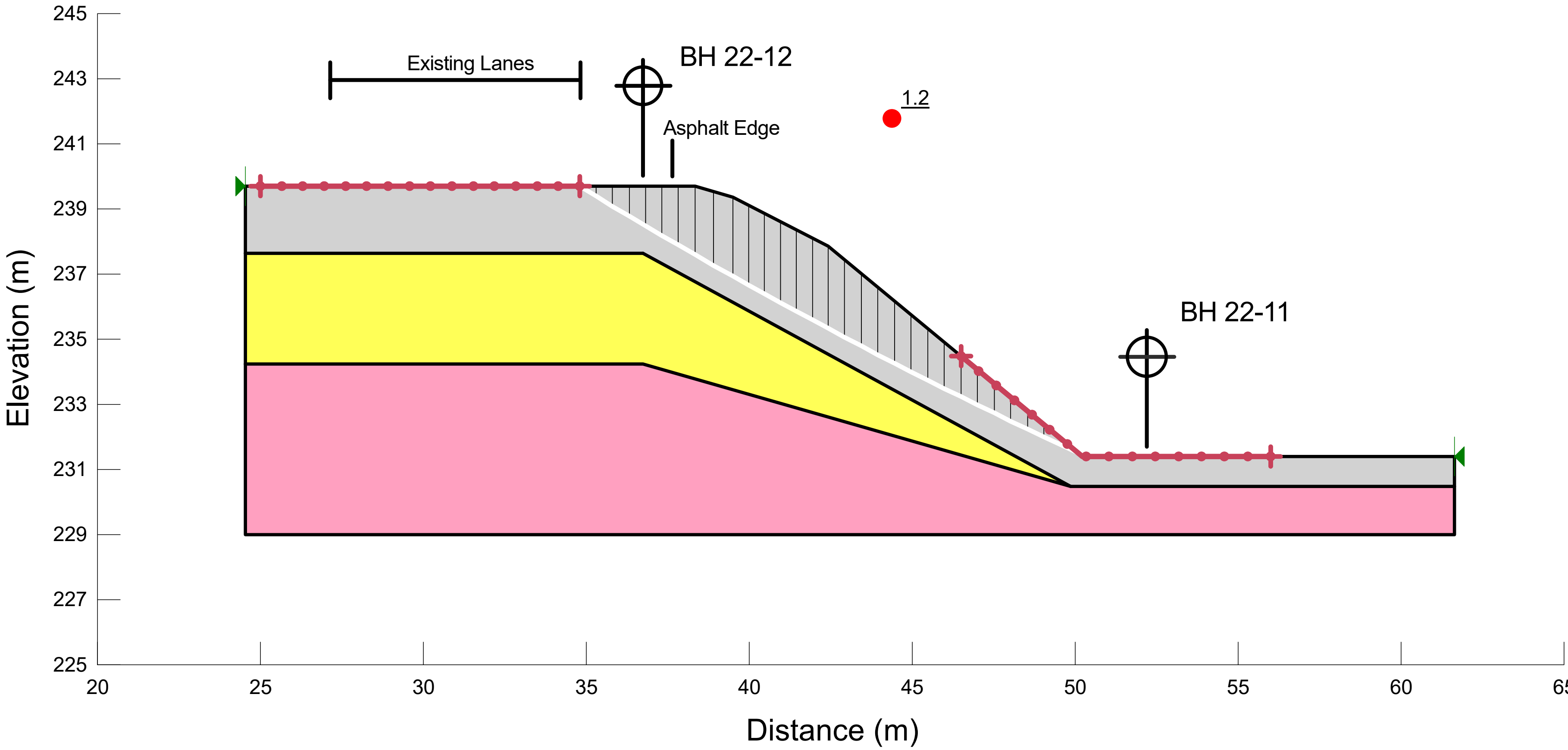
Client: AECOM Canada Ltd. July 2024
File No.: 31334

THURBER

## List of Slope Stability Analysis Figures

| | Figure No. | Scenario | Condition/Case | Factor of Safety |
|---|---|---|---|---|
| Section A-A' | F1.1a | Existing Profile | Static (Long Term) | 1.2 |
| | F1.1b | Existing Profile | Static, Traffic Loading | 1.2 |
| | F1.1c | Existing Profile | Pseudo-Static, Seismic Loading | 1.1 |
| | F1.2a | Rockfill (1.25H:1V) | Static (Long Term) | 1.4 |
| | F1.2b | Rockfill (1.25H:1V) | Static, Traffic Loading | 1.4 |
| | F1.2c | Rockfill (1.25H:1V) | Pseudo-Static, Seismic Loading | 1.2 |
| | F1.3a | Flattened Slope (1.9H:1V) | Static (Long Term) | 1.4 |
| | F1.3b | Flattened Slope (1.9H:1V) | Static, Traffic Loading | 1.4 |
| | F1.3c | Flattened Slope (1.9H:1V) | Pseudo-Static, Seismic Loading | 1.2 |
| | F1.4a | RSS Wall (2.0H:1V) | Static (Long Term) | 1.5 |
| | F1.4b | RSS Wall (2.0H:1V) | Static, Traffic Loading | 1.5 |
| | F1.4c | RSS Wall (2.0H:1V) | Pseudo-Static, Seismic Loading | 1.4 |
| Section B-B' | F2.1a | Existing Profile | Static (Long Term) | 1.4 |
| | F2.1b | Existing Profile | Static, Traffic Loading | 1.4 |
| | F2.1c | Existing Profile | Pseudo-Static, Seismic Loading | 1.2 |
| Section C-C' | F3.1a | Existing Profile | Static (Long Term) | 1.2 |
| | F3.1b | Existing Profile | Static, Traffic Loading | 1.2 |
| | F3.1c | Existing Profile | Pseudo-Static, Seismic Loading | 1.1 |
| | F3.2a | Rockfill (1.25H:1V) | Static (Long Term) | 1.4 |
| | F3.2b | Rockfill (1.25H:1V) | Static, Traffic Loading | 1.4 |
| | F3.2c | Rockfill (1.25H:1V) | Pseudo-Static, Seismic Loading | 1.3 |
| | F3.3a | Flattened Slope (1.9H:1V) | Static (Long Term) | 1.4 |
| | F3.3b | Flattened Slope (1.9H:1V) | Static, Traffic Loading | 1.3 |
| | F3.3c | Flattened Slope (1.9H:1V) | Pseudo-Static, Seismic Loading | 1.3 |
| | F3.4a | Rockfill Toe Berm | Static (Long Term) | 1.4 |
| | F3.4b | Rockfill Toe Berm | Static, Traffic Loading | 1.4 |
| | F3.4c | Rockfill Toe Berm | Pseudo-Static, Seismic Loading | 1.3 |

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|---|---|
| (grey) | e) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 |
| (yellow) | f) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 |
| (pink) | g) Bedrock | Bedrock (Impenetrable) | | | |




Project
31334 - Hwy 7289 Sta 11+475 (Section A-A')

Analysis
a1) Permanent – Long Term, static

Seismic Coefficient
H: g, V: g

Last Run
2024/04/11, 10:21:11 AM

Scale
1:200

Additional Details
Name: a) Existing Conditions
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (34.8, 239.7) m, Exit: (50.068106, 231.5258) m
Center: (111.7196, 365.02727) m, Radius: 147.04948 m

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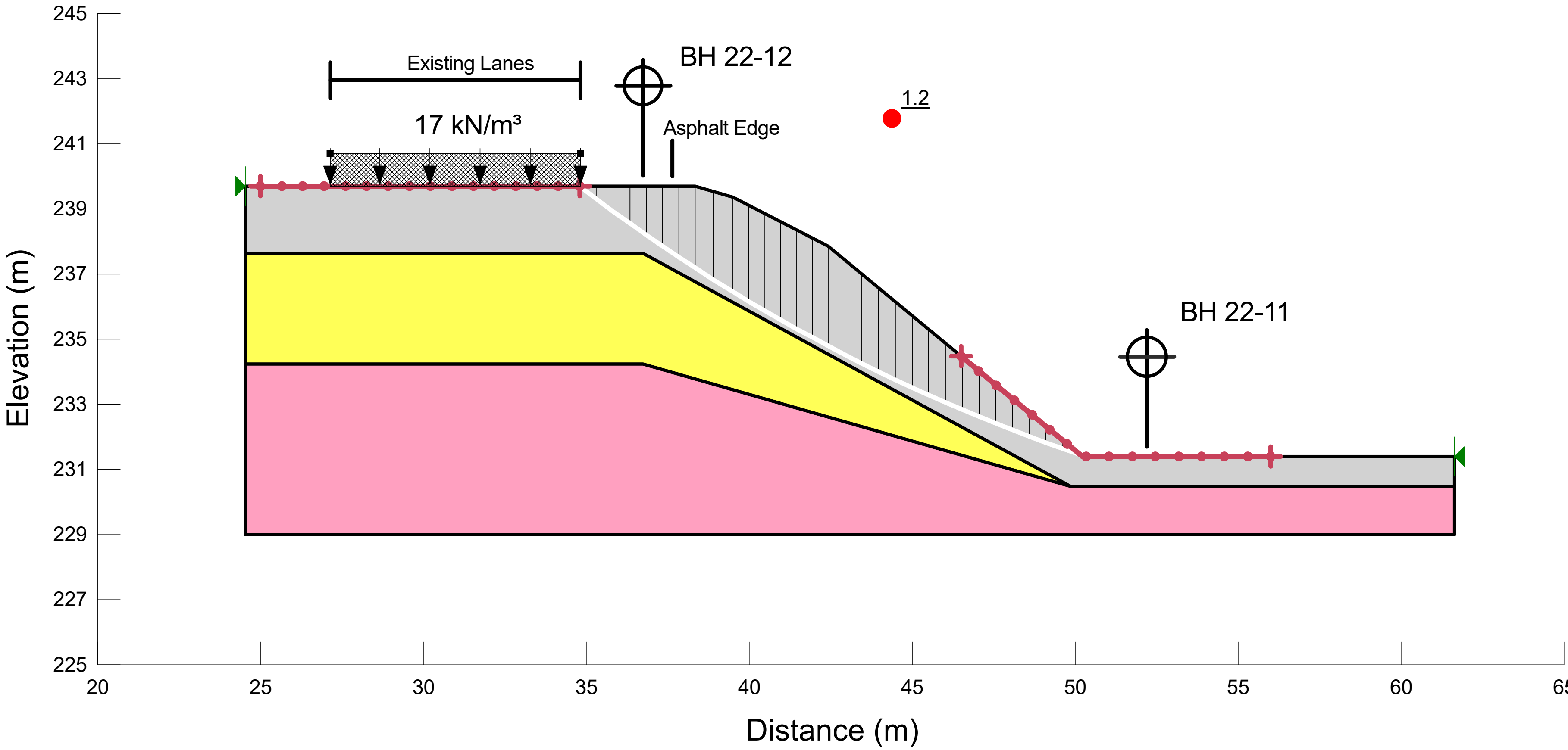
**Figure F1.1a**

O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+475 Timber Wall BHs 22-11 and 22-12\31334 - Hwy 7289 Sta 11+475 FIDR_post final modified_r3.gsz

Tool Version: 24.1.0.1406

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|---|---|
| | e) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 |
| | f) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 |
| | g) Bedrock | Bedrock (Impenetrable) | | | |




| Project | Analysis | Seismic Coefficient | Last Run | Scale |
|---|---|---|---|---|
| 31334 - Hwy 7289 Sta 11+475 (Section A-A') | a2) Temporary (traffic) – Short Term, static | H: g, V: g | 2024/04/11, 10:21:12 AM | 1:200 |

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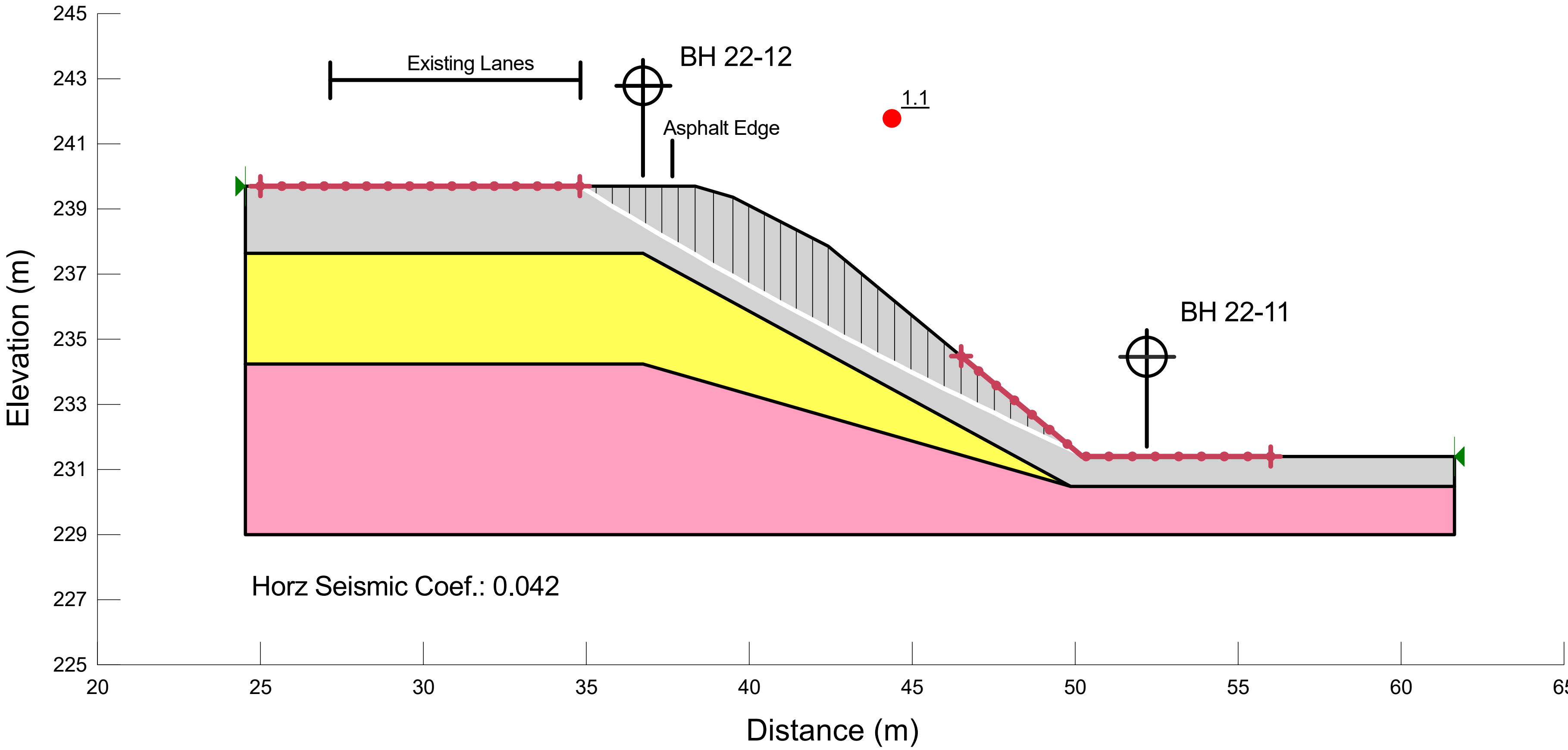
Additional Details
Name: a) Existing Conditions
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (34.8, 239.7) m, Exit: (50.136806, 231.4689) m
Center: (67.114716, 281.50733) m, Radius: 52.840264 m

**Figure F1.1b**

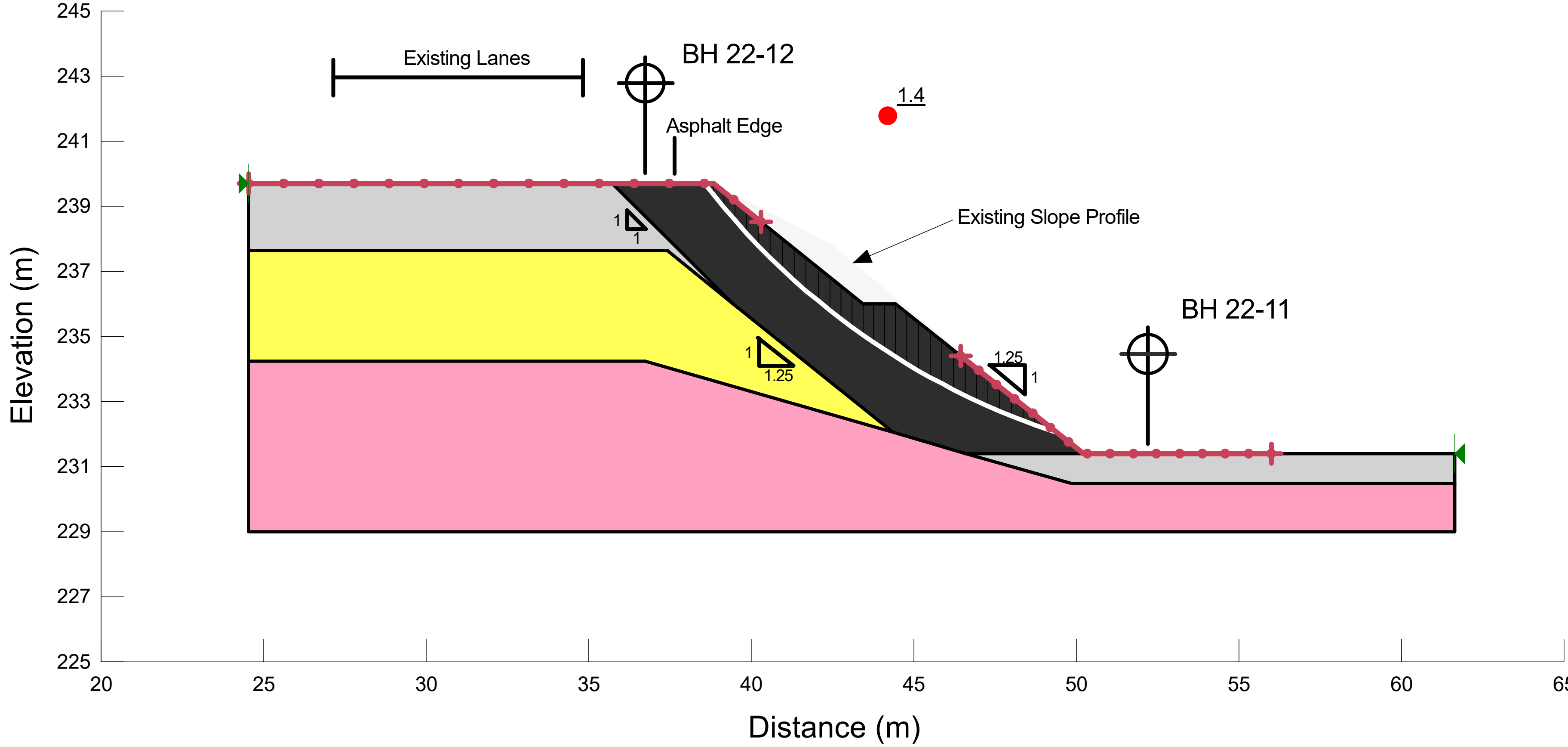
| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|---|---|
| (grey) | e) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 |
| (yellow) | f) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 |
| (pink) | g) Bedrock | Bedrock (Impenetrable) | | | |




| | | |
|---|---|---|
| THURBER | Project: 31334 - Hwy 7289 Sta 11+475 (Section A-A') | Additional Details |
| | Analysis: a3) Pseudo-static | Name: a) Existing Conditions<br>Comments:<br>Method: Morgenstern-Price, Half-Sine<br>Minimum Slip Surface Depth: 1.52 m<br>Entry: (34.8, 239.7) m, Exit: (50.068106, 231.5258) m<br>Center: (111.7196, 365.02727) m, Radius: 147.04948 m |
| | Seismic Coefficient: H: 0.042g, V: g; Last Run: 2024/04/11, 10:21:10 AM; Scale: 1:200 | |

**Figure F1.1c**

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|---|---|
| | d) Rockfill | Mohr-Coulomb | 18 | 0 | 42 |
| | e) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 |
| | f) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 |
| | g) Bedrock | Bedrock (Impenetrable) | | | |




| Project | Additional Details |
|---|---|
| 31334 - Hwy 7289 Sta 11+475 (Section A-A') | Name: b) Rockfill Slope 1.25H:1V w 1.0m Bench |
| Analysis: b1) Permanent – Long Term, static | Comments: |
| Seismic Coefficient: H: g, V: g | Method: Morgenstern-Price, Half-Sine |
| Last Run: 2024/04/11, 10:21:19 AM | Minimum Slip Surface Depth: 1.52 m |
| Scale: 1:200 | Entry: (38.554378, 239.7) m, Exit: (49.426018, 232.0308) m |
| | Center: (56.524585, 253.63378) m, Radius: 22.739364 m |

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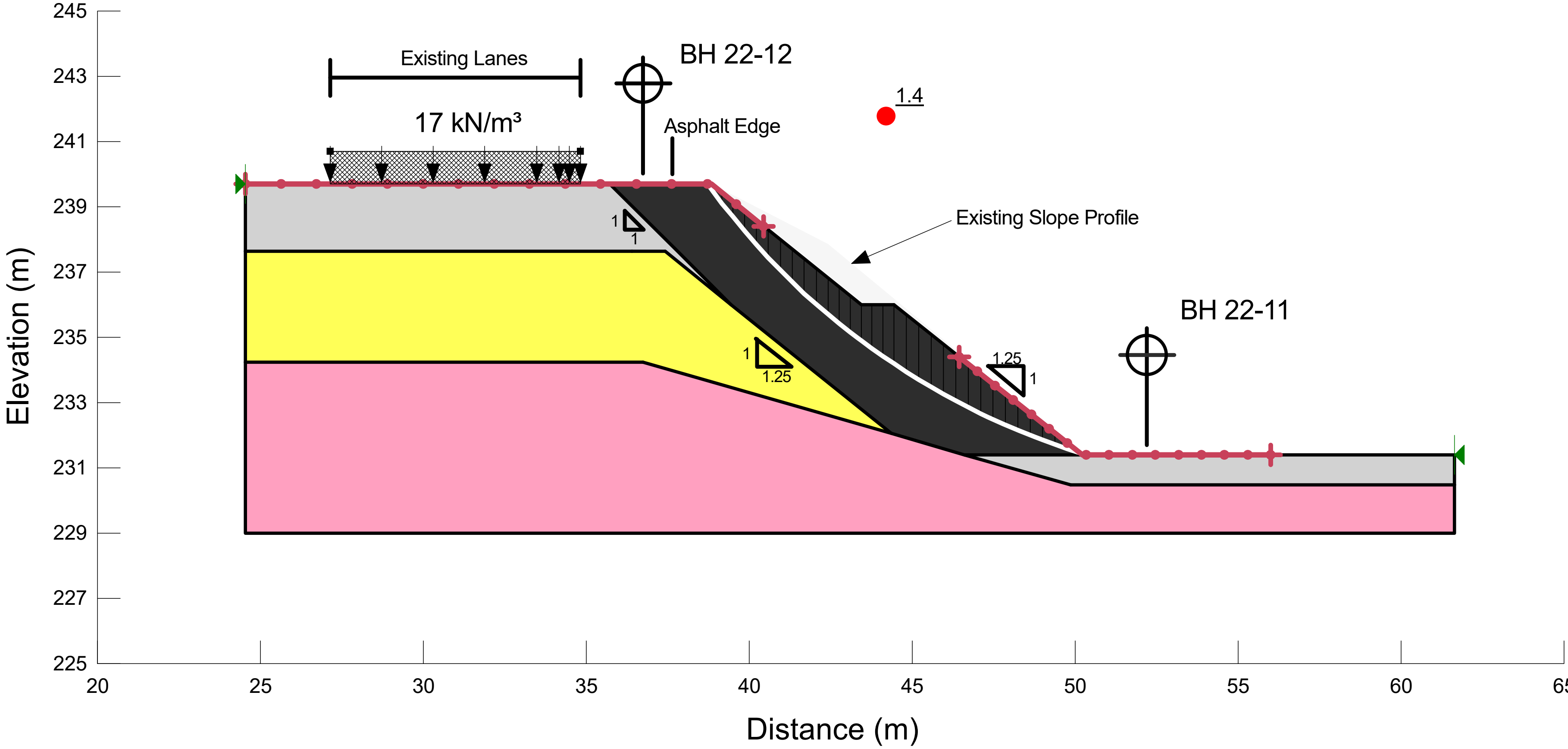
**Figure F1.2a**

O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+475 Timber Wall BHs 22-11 and 22-12\31334 - Hwy 7289 Sta 11+475 FIDR_post final modified_r3.gsz

Tool Version: 24.1.0.1406

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|---|---|
| (dark grey) | d) Rockfill | Mohr-Coulomb | 18 | 0 | 42 |
| (light grey) | e) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 |
| (yellow) | f) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 |
| (pink) | g) Bedrock | Bedrock (Impenetrable) | | | |

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Project
31334 - Hwy 7289 Sta 11+475 (Section A-A')

Analysis
b2) Temporary (traffic) – Short Term, static

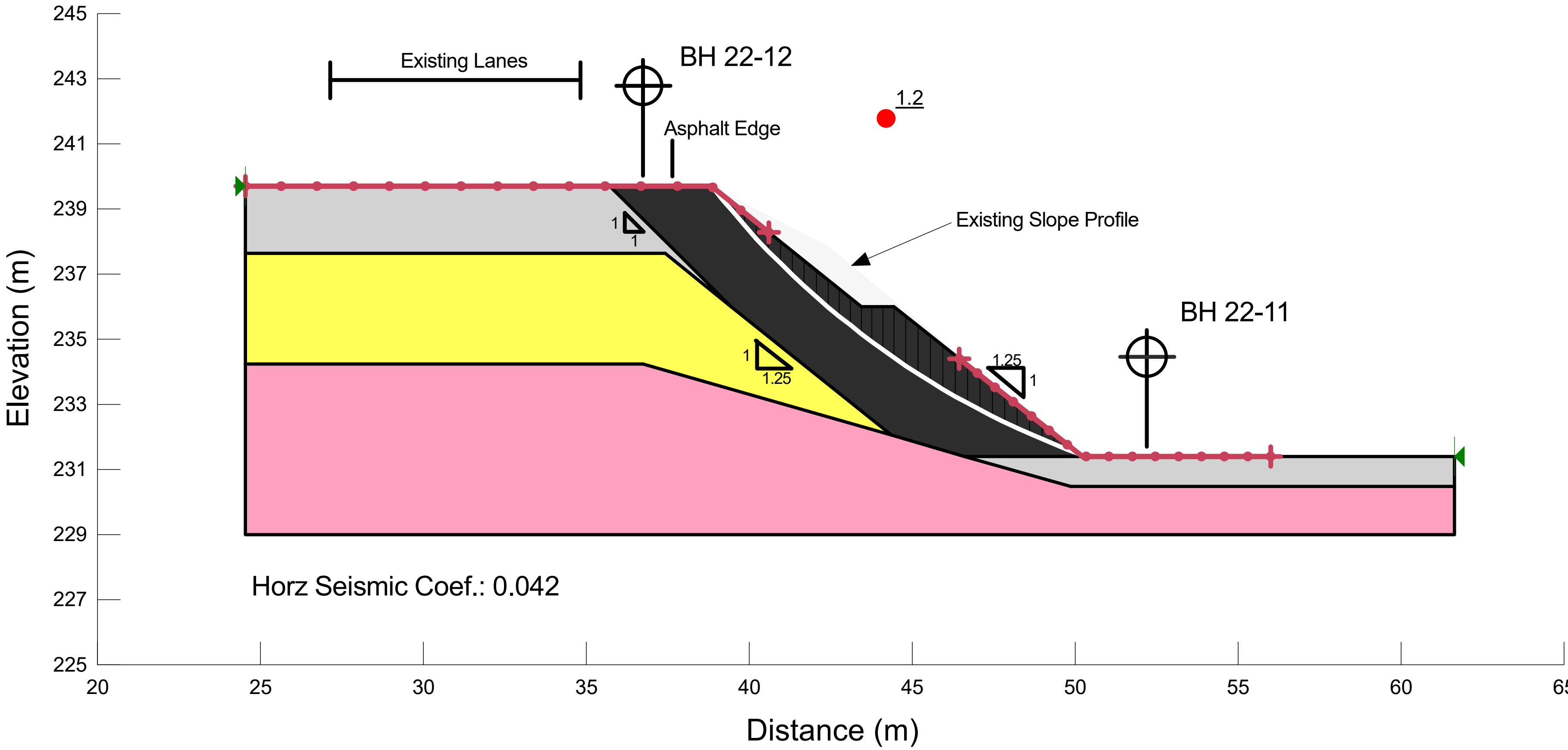
| Seismic Coefficient | Last Run | Scale |
|---|---|---|
| H: g, V: g | 2024/04/11, 10:21:20 AM | 1:200 |

Additional Details
Name: b) Rockfill Slope 1.25H:1V w 1.0m Bench
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (38.718528, 239.7) m, Exit: (50.143224, 231.461) m
Center: (56.786738, 252.71388) m, Radius: 22.267044 m

**Figure F1.2b**

*O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+475 Timber Wall BHs 22-11 and 22-12\31334 - Hwy 7289 Sta 11+475 FIDR_post final modified_r3.gsz*   *Tool Version: 24.1.0.1406*

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|---|---|
| (dark grey) | d) Rockfill | Mohr-Coulomb | 18 | 0 | 42 |
| (light grey) | e) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 |
| (yellow) | f) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 |
| (pink) | g) Bedrock | Bedrock (Impenetrable) | | | |




| Project | Additional Details |
|---|---|
| 31334 - Hwy 7289 Sta 11+475 (Section A-A') | Name: b) Rockfill Slope 1.25H:1V w 1.0m Bench |

Analysis: b3) Pseudo-static

Seismic Coefficient: H: 0.042g, V: g

Last Run: 2024/04/11, 10:21:21 AM

Scale: 1:200

Additional Details:
Name: b) Rockfill Slope 1.25H:1V w 1.0m Bench
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (38.882759, 239.65756) m, Exit: (50.117021, 231.48181) m
Center: (58.984178, 255.47249) m, Radius: 25.57692 m

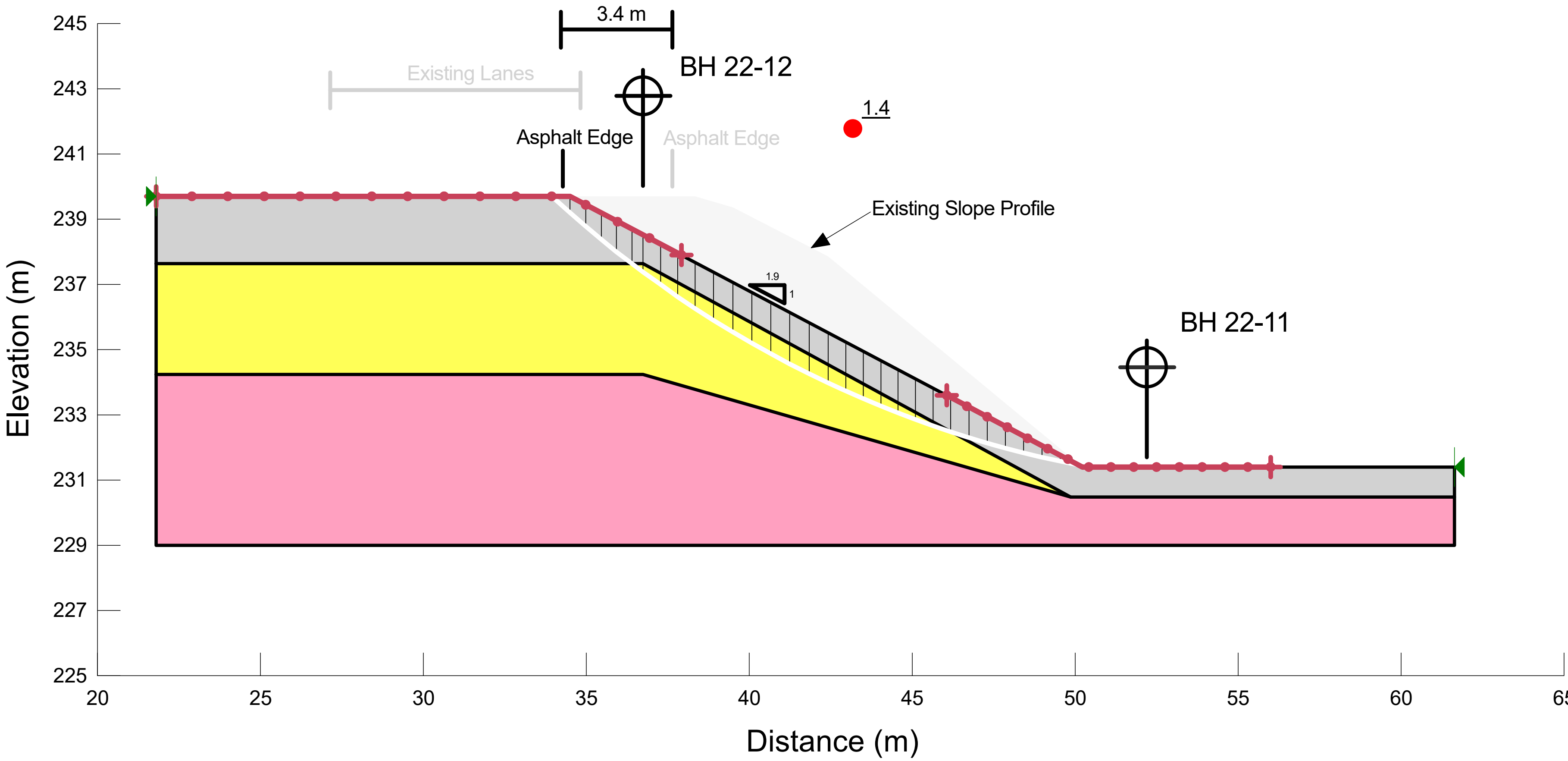
THURBER

**Figure F1.2c**

O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+475 Timber Wall BHs 22-11 and 22-12\31334 - Hwy 7289 Sta 11+475 FIDR_post final modified_r3.gsz

Tool Version: 24.1.0.1406

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|---|---|
| | e) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 |
| | f) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 |
| | g) Bedrock | Bedrock (Impenetrable) | | | |




THURBER

Project
31334 - Hwy 7289 Sta 11+475 (Section A-A')

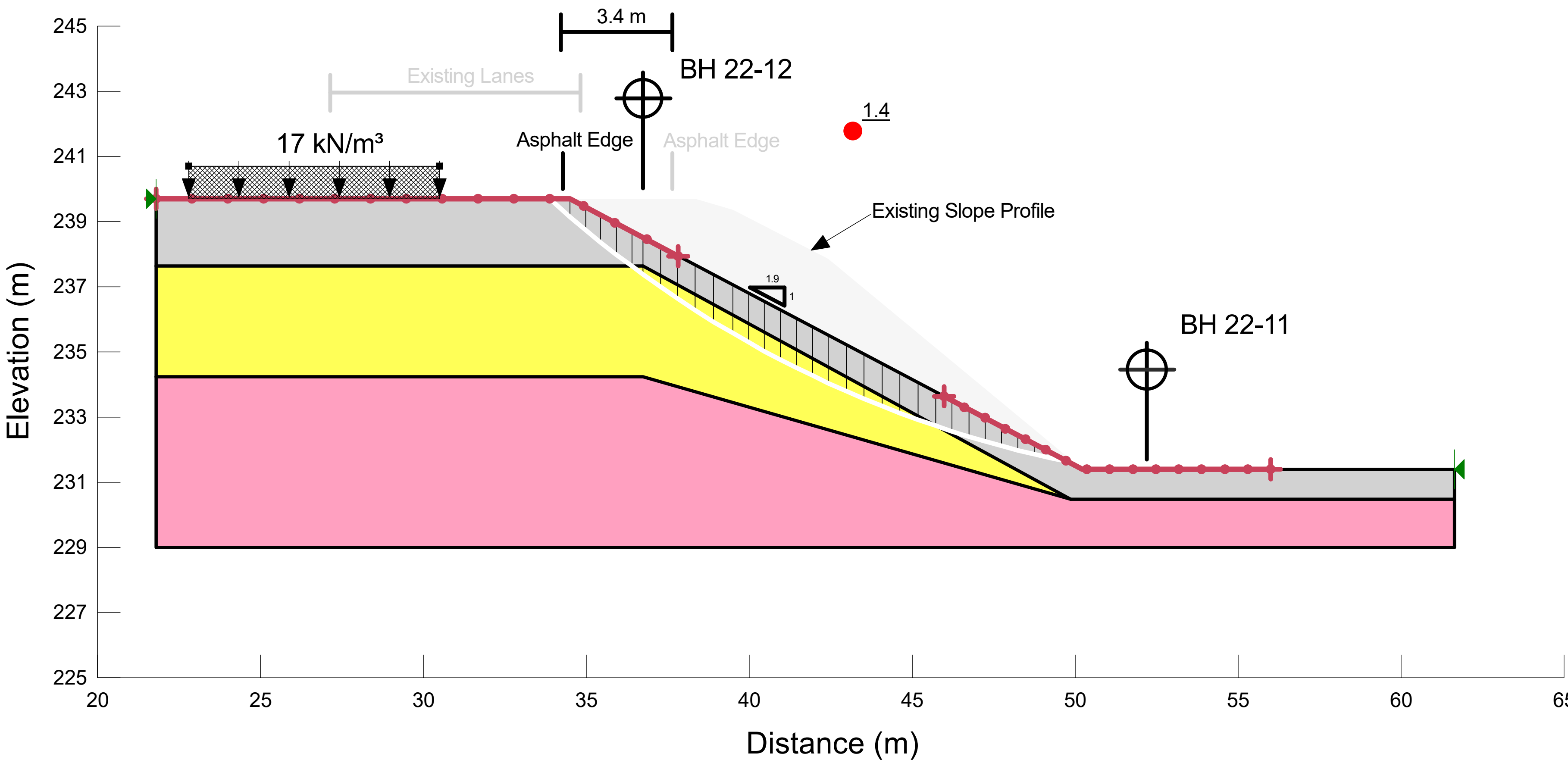
Analysis
c1) Permanent – Long Term, static

| Seismic Coefficient | Last Run | Scale |
|---|---|---|
| H: g, V: g | 2024/04/11, 10:21:13 AM | 1:200 |

Additional Details
Name: c) Slope Cut 1.9H:1V
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (33.944396, 239.7) m, Exit: (50.110811, 231.45765) m
Center: (56.534172, 264.03178) m, Radius: 33.201411 m

**Figure F1.3a**

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|---|---|
| (grey) | e) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 |
| (yellow) | f) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 |
| (pink) | g) Bedrock | Bedrock (Impenetrable) | | | |

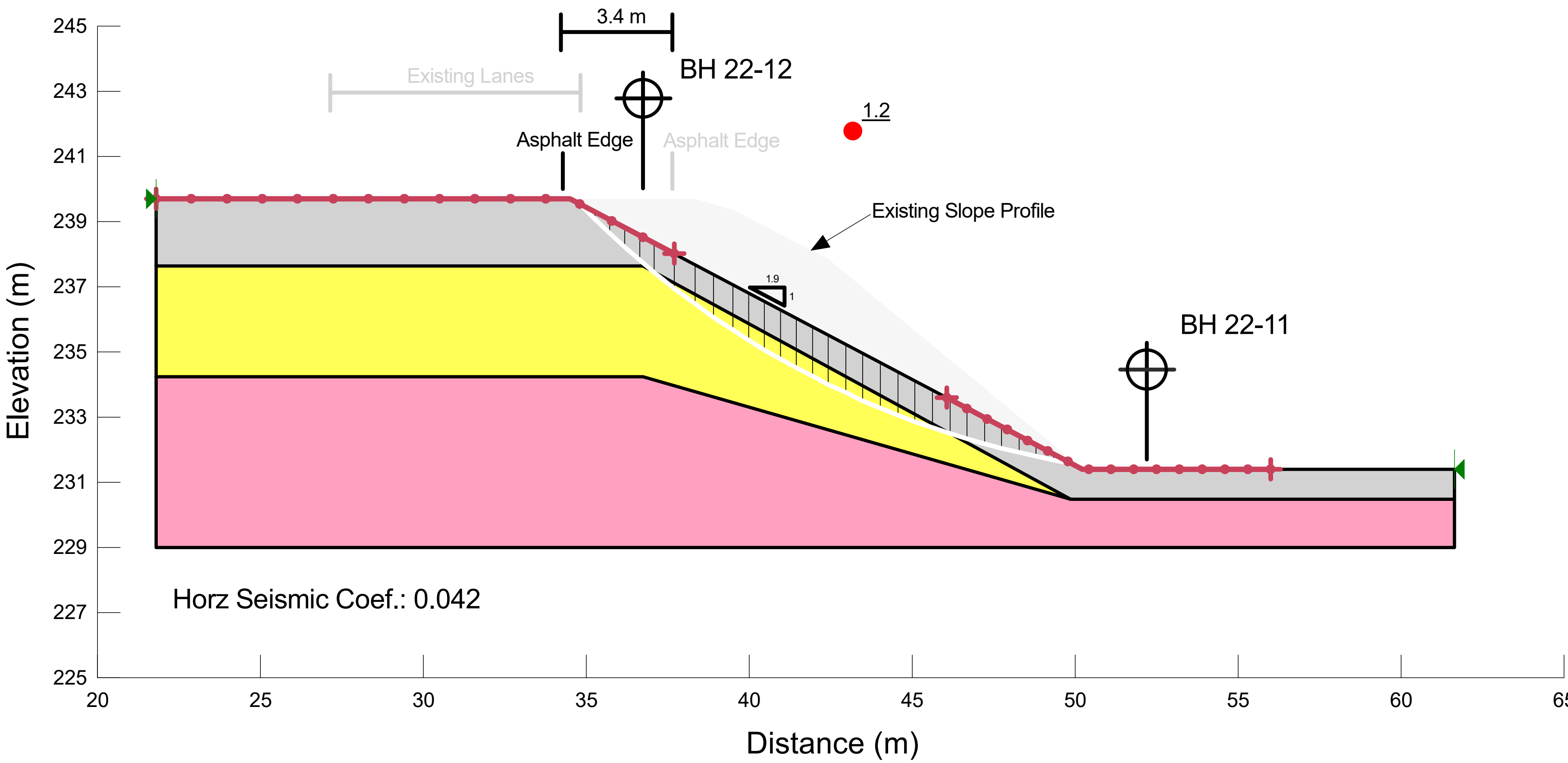



| | | |
|---|---|---|
| Project: 31334 - Hwy 7289 Sta 11+475 (Section A-A') | | Additional Details: Name: c) Slope Cut 1.9H:1V<br>Comments:<br>Method: Morgenstern-Price, Half-Sine<br>Minimum Slip Surface Depth: 1.52 m<br>Entry: (33.872963, 239.7) m, Exit: (49.764111, 231.64071) m<br>Center: (56.543411, 264.70455) m, Radius: 33.751695 m |
| Analysis: c2) Temporary (traffic) – Short Term, static | | |
| Seismic Coefficient: H: g, V: g | Last Run: 2024/04/11, 10:21:14 AM | Scale: 1:200 |

THURBER

**Figure F1.3b**

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|---|---|
| | e) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 |
| | f) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 |
| | g) Bedrock | Bedrock (Impenetrable) | | | |




THURBER

Project
31334 - Hwy 7289 Sta 11+475 (Section A-A')

Analysis
c3) Pseudo-static

Seismic Coefficient: H: 0.042g, V: g
Last Run: 2024/04/11, 10:21:15 AM
Scale: 1:200

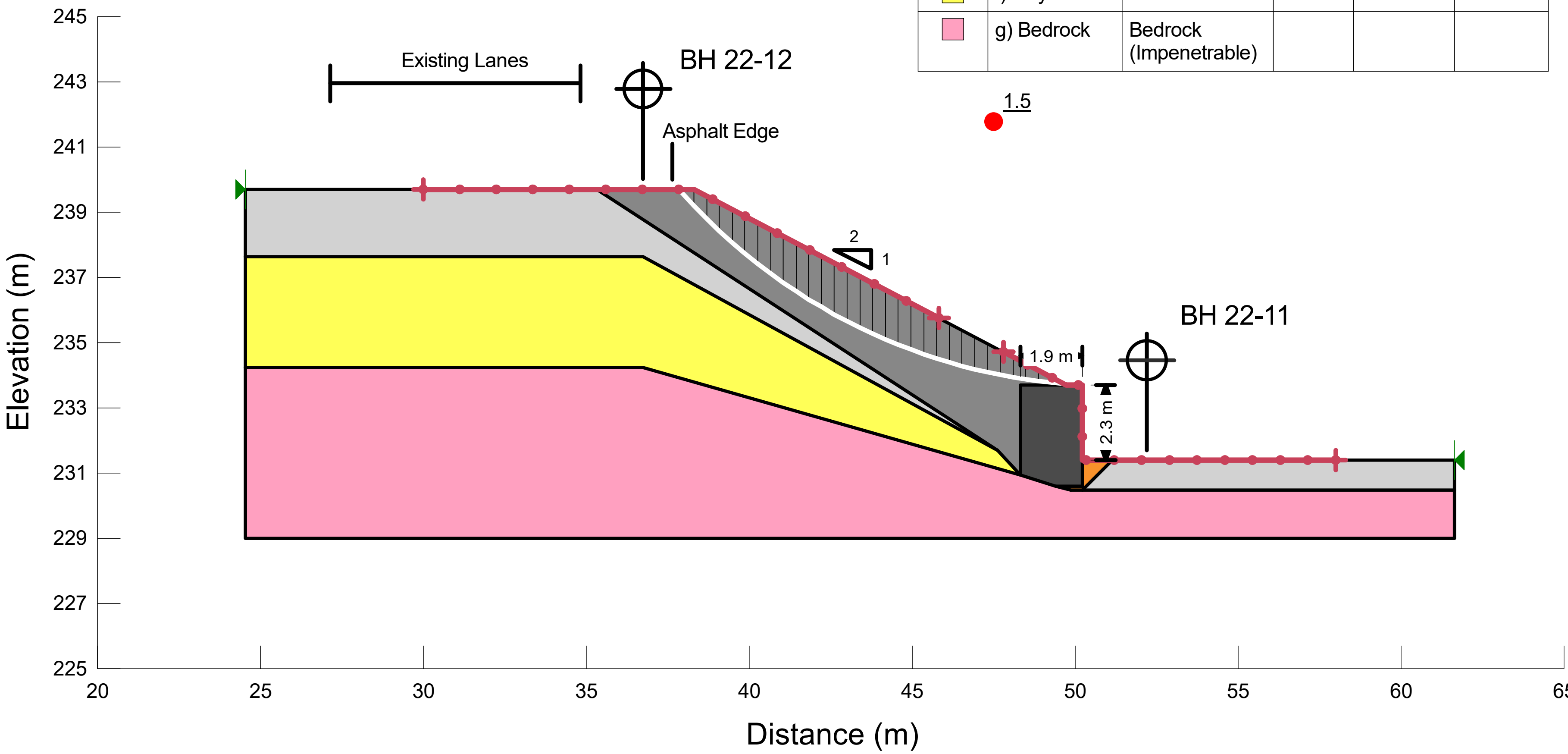
Additional Details
Name: c) Slope Cut 1.9H:1V
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (34.808895, 239.53694) m, Exit: (49.867305, 231.58622) m
Center: (54.573325, 258.7347) m, Radius: 27.553343 m

**Figure F1.3c**

O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+475 Timber Wall BHs 22-11 and 22-12\31334 - Hwy 7289 Sta 11+475 FIDR_post final modified_r3.gsz

Tool Version: 24.1.0.1406

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|---|---|
| | a) Gran A | Mohr-Coulomb | 21 | 0 | 35 |
| | b) RSS | Mohr-Coulomb | 21 | 250 | 42 |
| | c) Gran B II | Mohr-Coulomb | 22 | 0 | 35 |
| | e) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 |
| | f) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 |
| | g) Bedrock | Bedrock (Impenetrable) | | | |




THURBER

| | | |
|---|---|---|
| Project: 31334 - Hwy 7289 Sta 11+475 (Section A-A') | | |
| Analysis: d1) Permanent – Long Term, static. | | |
| Seismic Coefficient: H: g, V: g | Last Run: 2024/04/11, 10:21:16 AM | Scale: 1:200 |

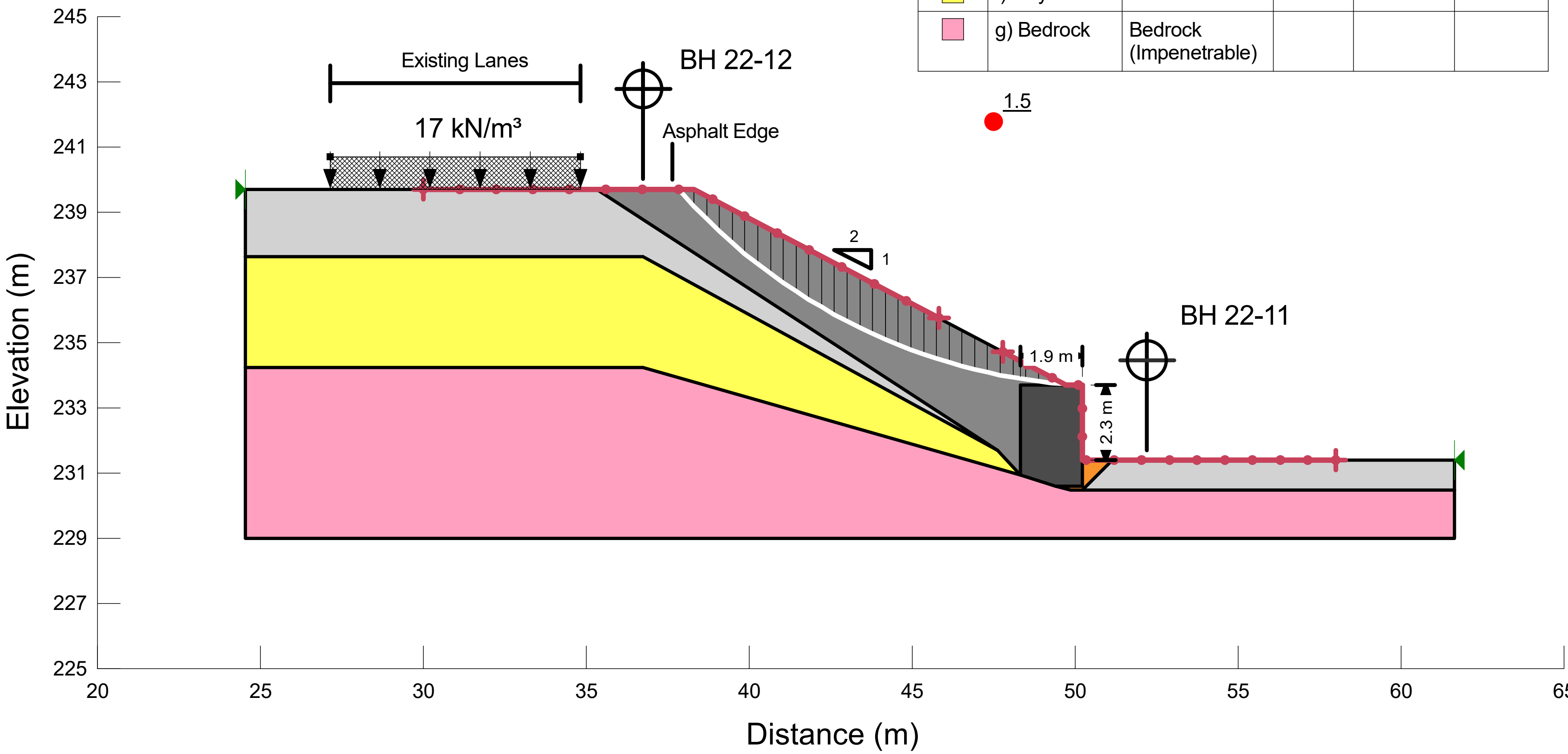
Additional Details
Name: d) RSS Wall (2.3 m x 1.9 m) Slope 2.0H:1.0V
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (37.835562, 239.7) m, Exit: (49.658941, 233.73208) m
Center: (51.178911, 251.43931) m, Radius: 17.77235 m

**Figure F1.4a**

O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+475 Timber Wall BHs 22-11 and 22-12\31334 - Hwy 7289 Sta 11+475 FIDR_post final modified_r3.gsz

Tool Version: 24.1.0.1406

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|---|---|
| (orange) | a) Gran A | Mohr-Coulomb | 21 | 0 | 35 |
| (dark grey) | b) RSS | Mohr-Coulomb | 21 | 250 | 42 |
| (grey) | c) Gran B II | Mohr-Coulomb | 22 | 0 | 35 |
| (light grey) | e) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 |
| (yellow) | f) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 |
| (pink) | g) Bedrock | Bedrock (Impenetrable) | | | |




Project
31334 - Hwy 7289 Sta 11+475 (Section A-A')

Analysis
d2) Temporary (traffic) – Short Term, static.

| Seismic Coefficient | Last Run | Scale |
|---|---|---|
| H: g, V: g | 2024/04/11, 10:21:17 AM | 1:200 |

Additional Details
Name: d) RSS Wall (2.3 m x 1.9 m) Slope 2.0H:1.0V
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (37.832963, 239.7) m, Exit: (49.659725, 233.73167) m
Center: (51.175903, 251.43814) m, Radius: 17.77127 m

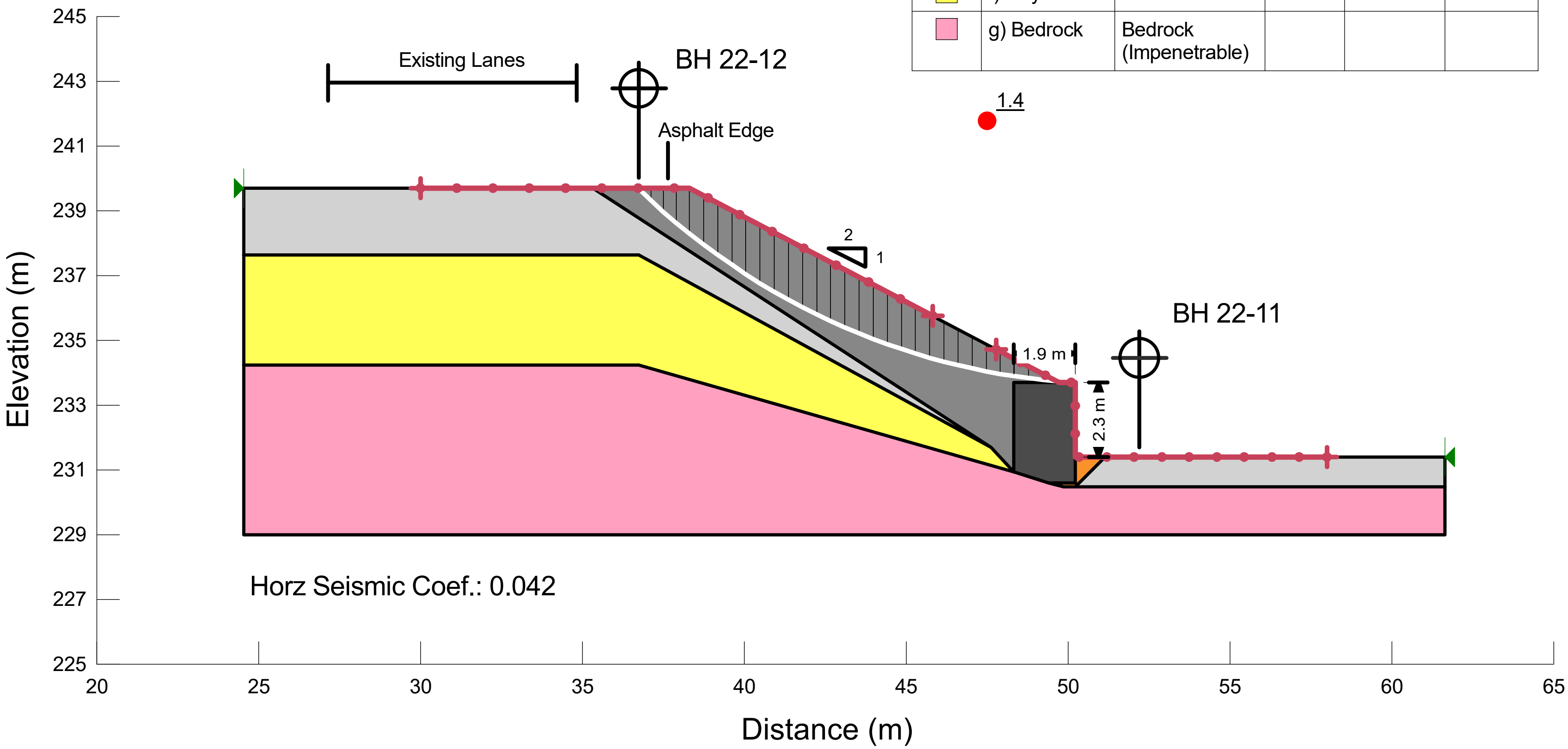
THURBER

**Figure F1.4b**

*O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+475 Timber Wall BHs 22-11 and 22-12\31334 - Hwy 7289 Sta 11+475 FIDR_post final modified_r3.gsz*

*Tool Version: 24.1.0.1406*

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|---|---|
| (orange) | a) Gran A | Mohr-Coulomb | 21 | 0 | 35 |
| (dark grey) | b) RSS | Mohr-Coulomb | 21 | 250 | 42 |
| (grey) | c) Gran B II | Mohr-Coulomb | 22 | 0 | 35 |
| (light grey) | e) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 |
| (yellow) | f) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 |
| (pink) | g) Bedrock | Bedrock (Impenetrable) | | | |




THURBER

Project
31334 - Hwy 7289 Sta 11+475 (Section A-A')

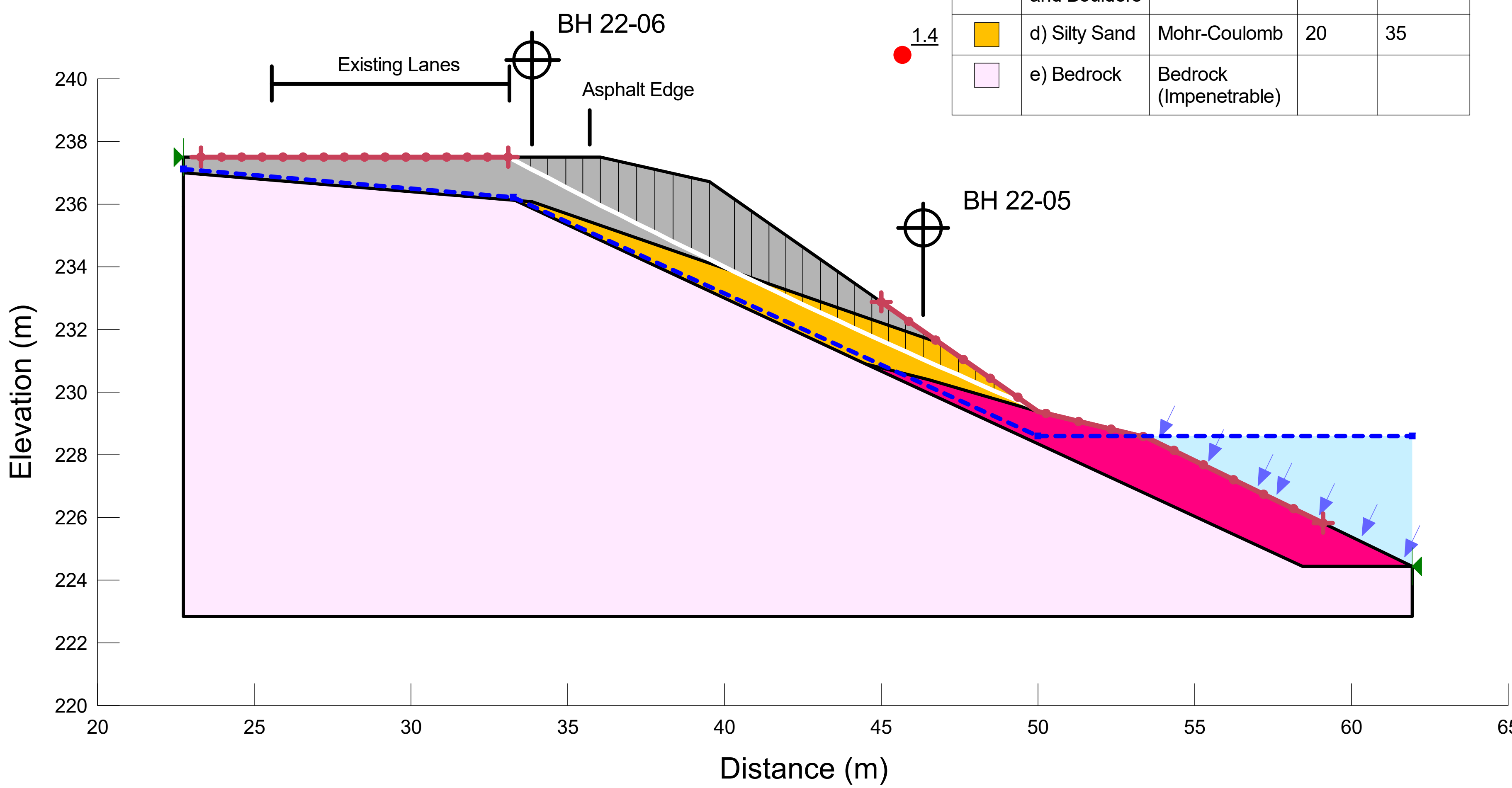
Analysis
d3) Pseudo-static.

| Seismic Coefficient | Last Run | Scale |
|---|---|---|
| H: 0.042g, V: g | 2024/04/11, 10:21:18 AM | 1:200 |

Additional Details
Name: d) RSS Wall (2.3 m x 1.9 m) Slope 2.0H:1.0V
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (36.713969, 239.7) m, Exit: (49.653582, 233.7349) m
Center: (51.560102, 254.88753) m, Radius: 21.238378 m

**Figure F1.4c**

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Friction Angle (°) |
|---|---|---|---|---|
| (grey) | b) FILL | Mohr-Coulomb | 20 | 32 |
| (magenta) | c) Cobbles and Boulders | Mohr-Coulomb | 22 | 45 |
| (orange) | d) Silty Sand | Mohr-Coulomb | 20 | 35 |
| (light pink) | e) Bedrock | Bedrock (Impenetrable) | | |




| Project | Additional Details |
|---|---|
| 31334 - Hwy 7289 Sta 11+625 (Section B-B') | Name: a) Existing Conditions<br>Comments:<br>Method: Morgenstern-Price, Half-Sine<br>Minimum Slip Surface Depth: 1 m<br>Entry: (33.1, 237.5) m, Exit: (49.747239, 229.55661) m<br>Center: (136.33994, 432.44772) m, Radius: 220.59714 m |

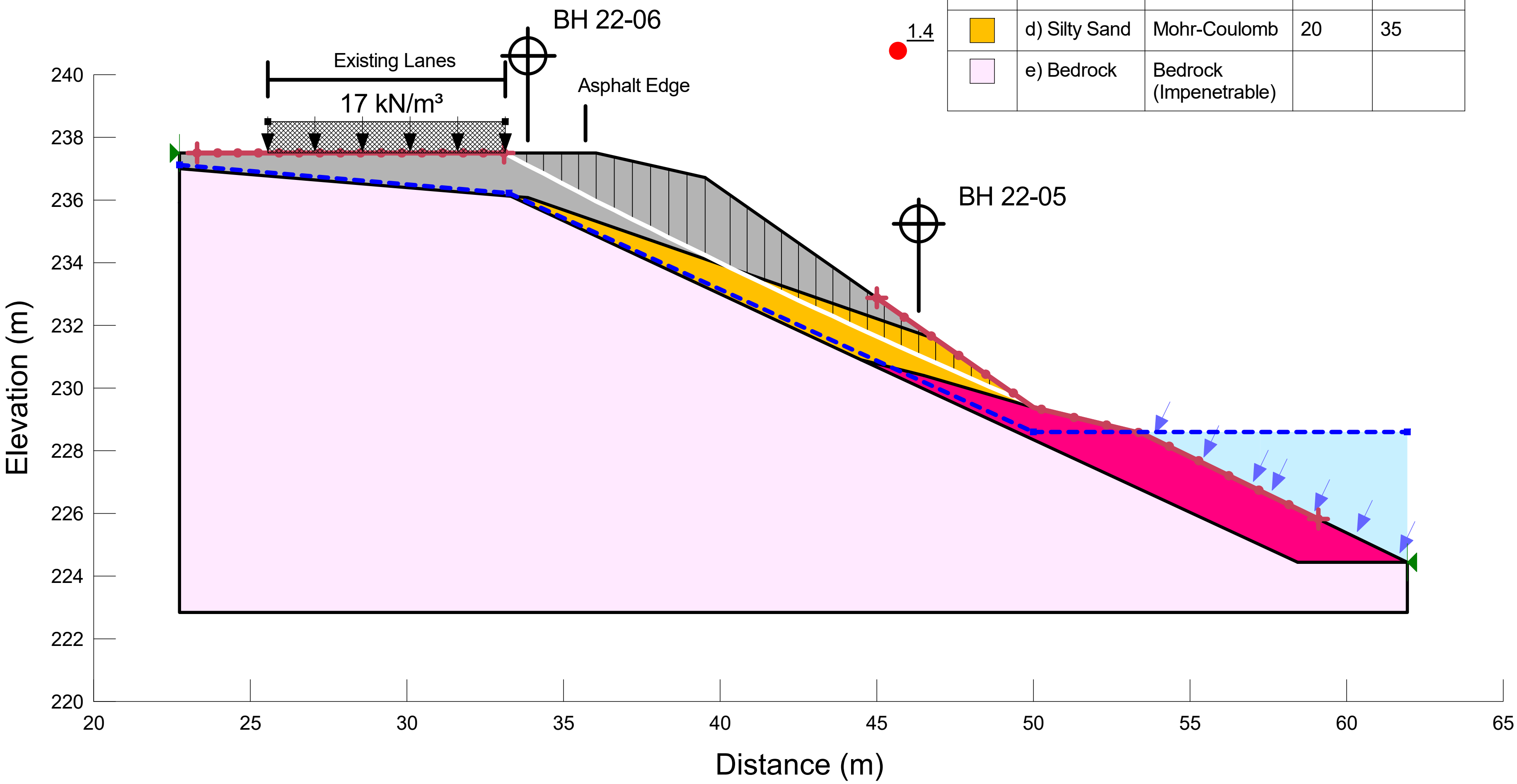
| Analysis | | |
|---|---|---|
| 01) Permanent – Long Term, static | | |
| **Seismic Coefficient** | **Last Run** | **Scale** |
| H: g, V: g | 2023/04/05, 04:56:37 PM | 1:200 |

THURBER

**Figure F2.1a**

H:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+625 Mid site BHs 22-05 and 22-06\31334 - Hwy 7289 Sta 11+625 Final FIDR.gsz

Tool Version: 11.3.1.23726




| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Friction Angle (°) |
|---|---|---|---|---|
| | b) FILL | Mohr-Coulomb | 20 | 32 |
| | c) Cobbles and Boulders | Mohr-Coulomb | 22 | 45 |
| | d) Silty Sand | Mohr-Coulomb | 20 | 35 |
| | e) Bedrock | Bedrock (Impenetrable) | | |

THURBER

Project
31334 - Hwy 7289 Sta 11+625 (Section B-B')

Analysis
02) Temporary (traffic) – Short Term, static

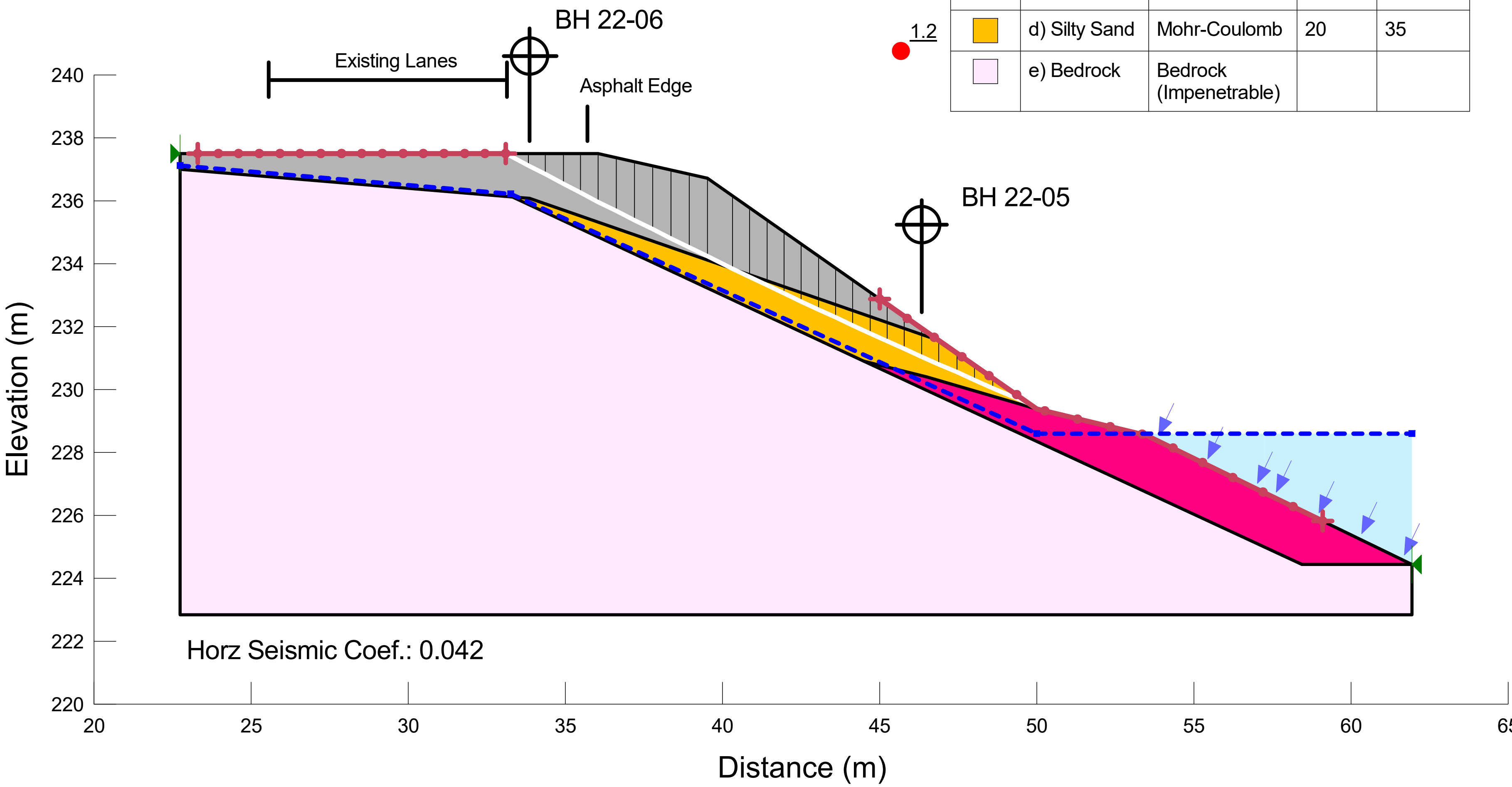
Seismic Coefficient: H: g, V: g
Last Run: 2023/04/05, 04:56:38 PM
Scale: 1:200

Additional Details
Name: a) Existing Conditions
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1 m
Entry: (33.1, 237.5) m, Exit: (49.747239, 229.55661) m
Center: (136.33994, 432.44772) m, Radius: 220.59714 m

**Figure F2.1b**

H:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+625 Mid site BHs 22-05 and 22-06\31334 - Hwy 7289 Sta 11+625 Final FIDR.gsz

Tool Version: 11.3.1.23726




| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Friction Angle (°) |
|---|---|---|---|---|
| | b) FILL | Mohr-Coulomb | 20 | 32 |
| | c) Cobbles and Boulders | Mohr-Coulomb | 22 | 45 |
| | d) Silty Sand | Mohr-Coulomb | 20 | 35 |
| | e) Bedrock | Bedrock (Impenetrable) | | |

THURBER

Project
31334 - Hwy 7289 Sta 11+625 (Section B-B')

Analysis
03) Pseudo-static

Seismic Coefficient
H: 0.042g, V: g

Last Run
2023/04/05, 04:56:39 PM

Scale
1:200

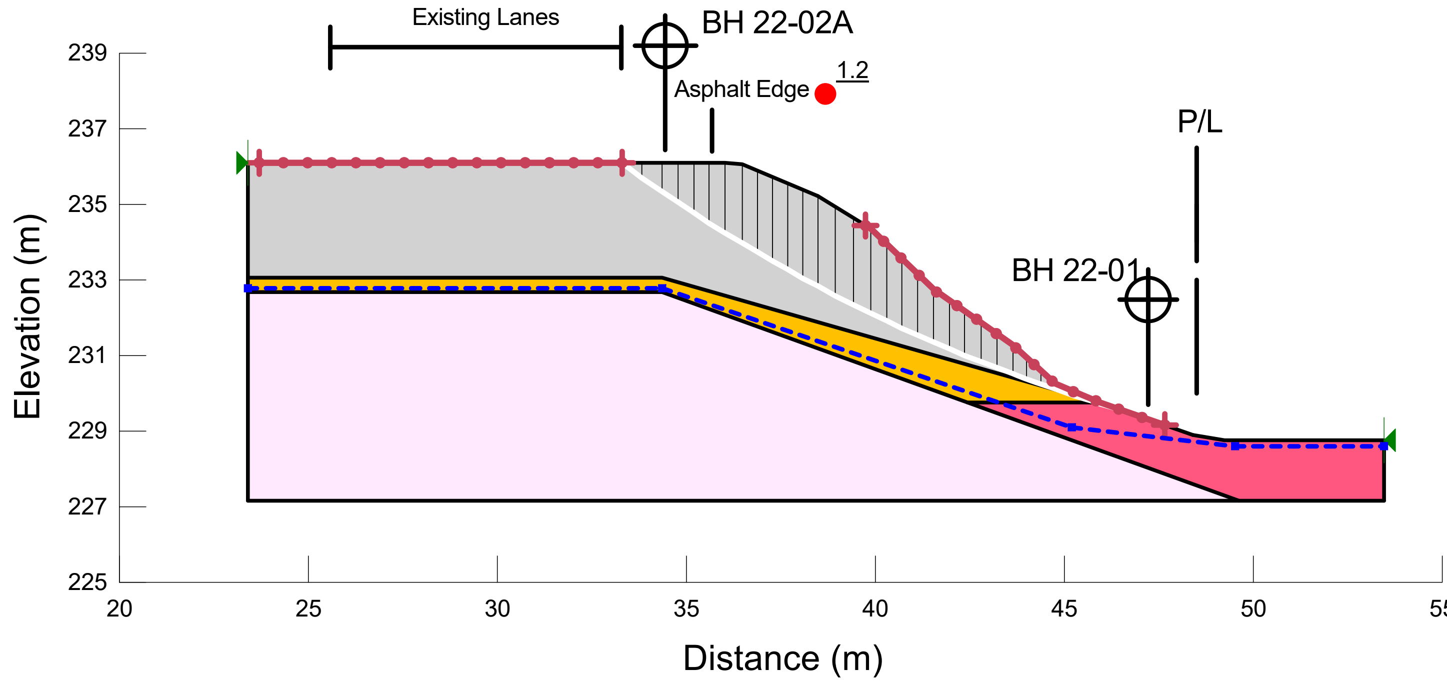
Additional Details
Name: a) Existing Conditions
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1 m
Entry: (33.1, 237.5) m, Exit: (49.747239, 229.55661) m
Center: (136.33994, 432.44772) m, Radius: 220.59714 m

**Figure F2.1c**

H:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+625 Mid site BHs 22-05 and 22-06\31334 - Hwy 7289 Sta 11+625 Final FIDR.gsz

Tool Version: 11.3.1.23726

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Piezometric Surface |
|---|---|---|---|---|---|---|
| (grey) | b) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 | 1 |
| (red) | d) Cobbles and Boulders | Mohr-Coulomb | 22 | 0 | 45 | 1 |
| (yellow) | e) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 | 1 |
| (pink) | f) Bedrock | Bedrock (Impenetrable) | | | | 1 |




| Project | Additional Details |
|---|---|
| 31334 - Hwy 7289 Sta 11+770 (Section C-C') | Name: a) Existing Conditions<br>Comments:<br>Method: Morgenstern-Price, Half-Sine<br>Minimum Slip Surface Depth: 1 m<br>Entry: (33.297723, 236.09) m, Exit: (46.443303, 229.57538) m<br>Center: (58.477591, 270.37917) m, Radius: 42.541424 m |

Analysis: a1) Permanent – Long Term, static

| Seismic Coefficient | Last Run | Scale |
|---|---|---|
| H: g, V: g | 2024/04/02, 01:37:49 PM | 1:200 |

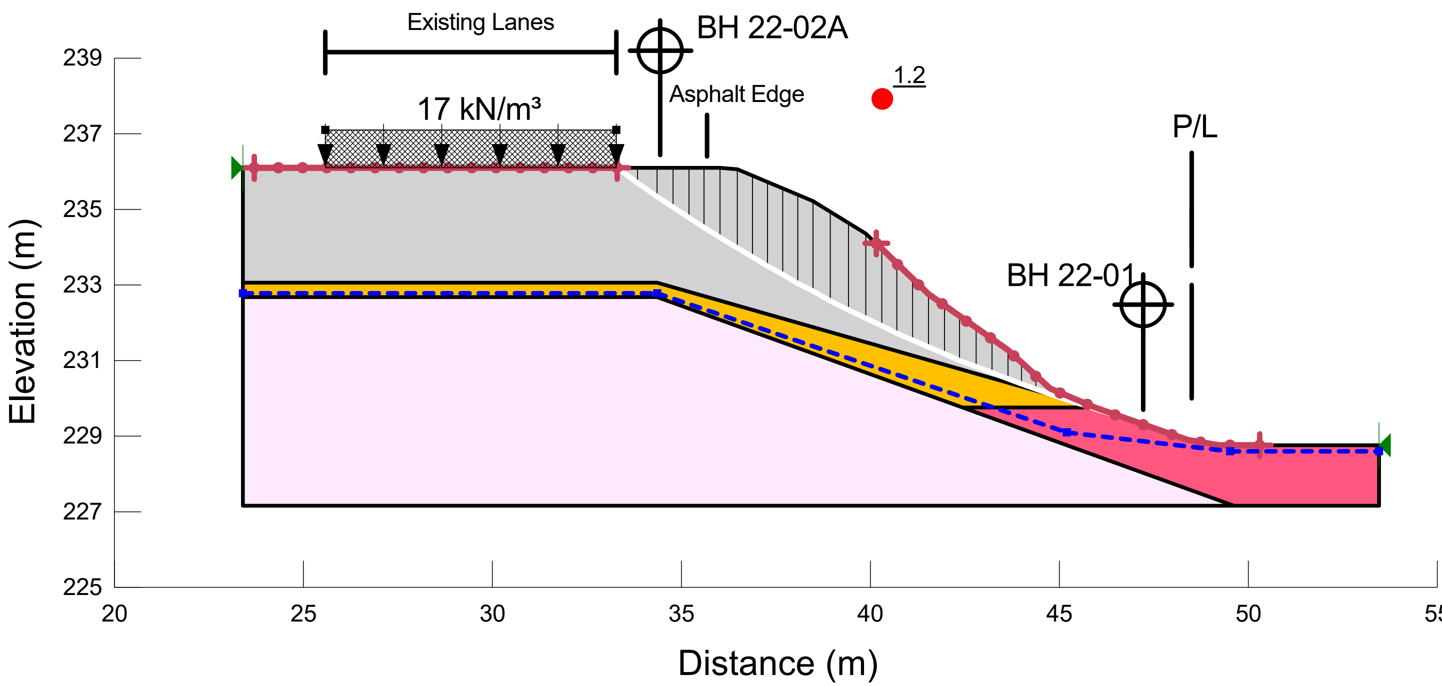
THURBER

**Figure F3.1a**

O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+770 North Section BHs 22-01 and 22-02\31334 - Hwy 7289 Sta 11+770 draft r2.gsz

Tool Version: 24.1.0.1406

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Piezometric Surface |
|---|---|---|---|---|---|---|
| (grey) | b) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 | 1 |
| (red) | d) Cobbles and Boulders | Mohr-Coulomb | 22 | 0 | 45 | 1 |
| (orange) | e) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 | 1 |
| (pink) | f) Bedrock | Bedrock (Impenetrable) | | | | 1 |




THURBER

Project
31334 - Hwy 7289 Sta 11+770 (Section C-C')

Analysis
a2) Temporary (traffic) – Short Term, static

| Seismic Coefficient | Last Run | Scale |
|---|---|---|
| H: g, V: g | 2024/04/02, 01:37:50 PM | 1:200 |

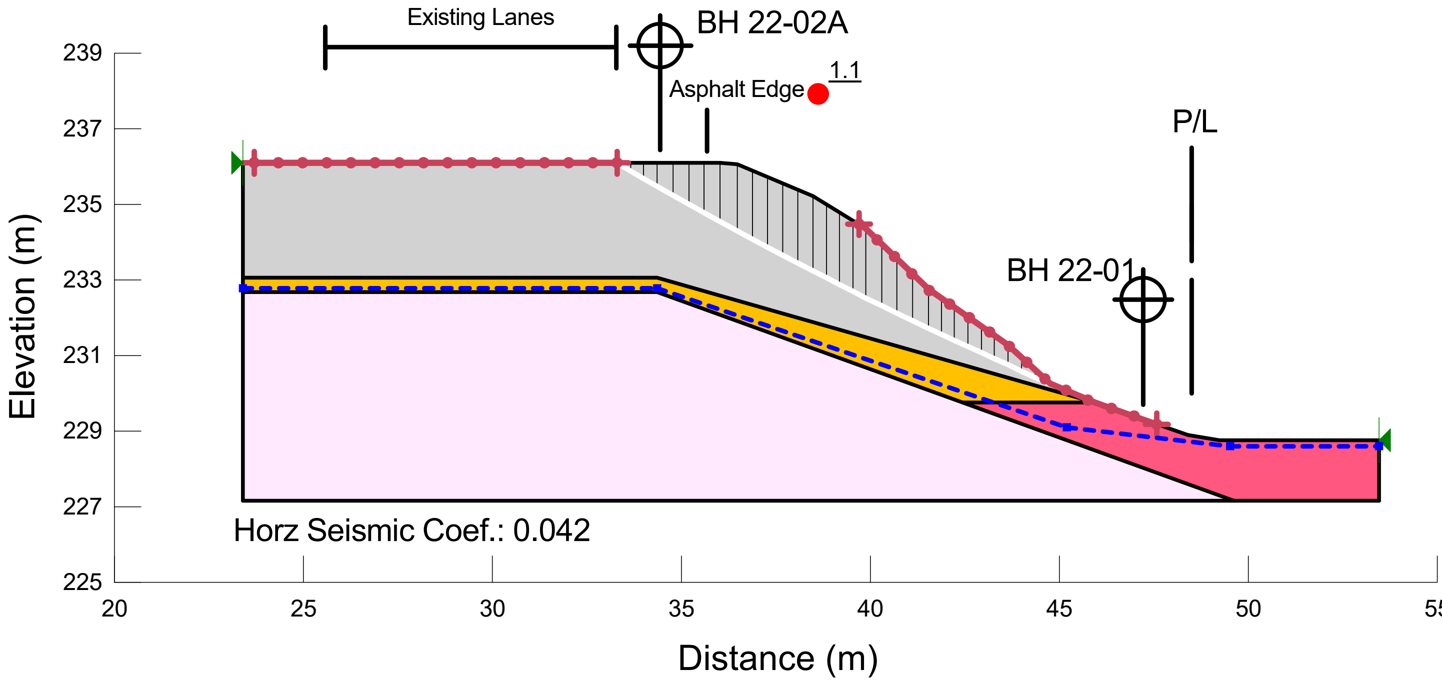
Additional Details
Name: a) Existing Conditions
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1 m
Entry: (33.3, 236.09) m, Exit: (46.484178, 229.5612) m
Center: (58.533308, 270.46947) m, Radius: 42.64584 m

**Figure F3.1b**

*O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+770 North Section BHs 22-01 and 22-02\31334 - Hwy 7289 Sta 11+770 draft r2.gsz*

*Tool Version: 24.1.0.1406*

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Piezometric Surface |
|---|---|---|---|---|---|---|
| | b) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 | 1 |
| | d) Cobbles and Boulders | Mohr-Coulomb | 22 | 0 | 45 | 1 |
| | e) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 | 1 |
| | f) Bedrock | Bedrock (Impenetrable) | | | | 1 |




THURBER

Project
31334 - Hwy 7289 Sta 11+770 (Section C-C')

Analysis
a3) Pseudo-static

| Seismic Coefficient | Last Run | Scale |
|---|---|---|
| H: 0.042g, V: g | 2024/04/02, 01:37:48 PM | 1:200 |

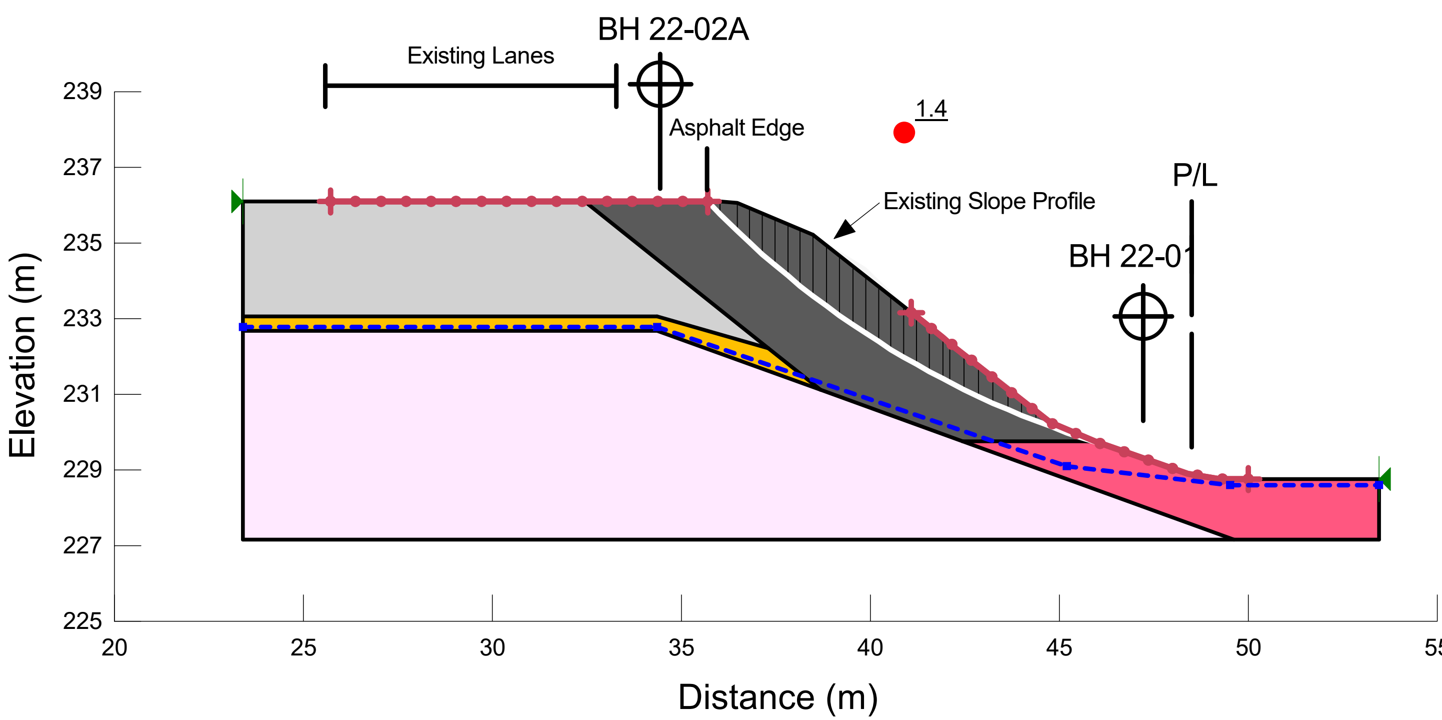
Additional Details
Name: a) Existing Conditions
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1 m
Entry: (33.3, 236.09) m, Exit: (44.737705, 230.26142) m
Center: (88.176809, 329.64069) m, Radius: 108.45827 m

**Figure F3.1c**

O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+770 North Section BHs 22-01 and 22-02\31334 - Hwy 7289 Sta 11+770 draft r2.gsz

Tool Version: 24.1.0.1406

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Piezometric Surface |
|---|---|---|---|---|---|---|
| | a) Rockfill | Mohr-Coulomb | 18 | 0 | 42 | 1 |
| | b) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 | 1 |
| | d) Cobbles and Boulders | Mohr-Coulomb | 22 | 0 | 45 | 1 |
| | e) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 | 1 |
| | f) Bedrock | Bedrock (Impenetrable) | | | | 1 |




THURBER

Project
31334 - Hwy 7289 Sta 11+770 (Section C-C')

Analysis
b1) Permanent – Long Term, static

Seismic Coefficient
H: g, V: g

Last Run
2024/04/02, 01:37:57 PM

Scale
1:200

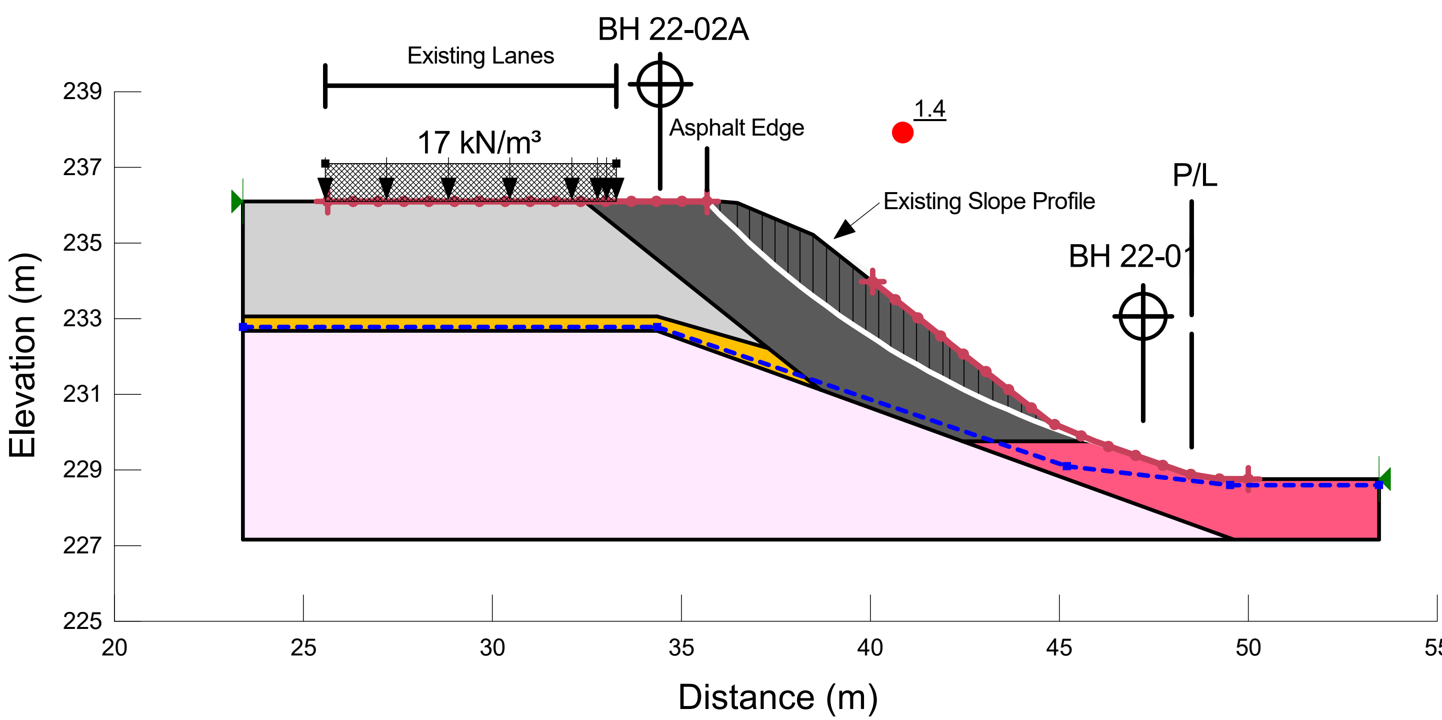
Additional Details
Name: b) Rockfill (1.25H:1V)
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (35.704032, 236.09) m, Exit: (46.074623, 229.70329) m
Center: (53.112385, 252.74418) m, Radius: 24.091748 m

**Figure F3.2a**

O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+770 North Section BHs 22-01 and 22-02\31334 - Hwy 7289 Sta 11+770 draft r2.gsz

Tool Version: 24.1.0.1406

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Piezometric Surface |
|---|---|---|---|---|---|---|
| | a) Rockfill | Mohr-Coulomb | 18 | 0 | 42 | 1 |
| | b) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 | 1 |
| | d) Cobbles and Boulders | Mohr-Coulomb | 22 | 0 | 45 | 1 |
| | e) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 | 1 |
| | f) Bedrock | Bedrock (Impenetrable) | | | | 1 |




THURBER

| Project | | |
|---|---|---|
| 31334 - Hwy 7289 Sta 11+770 (Section C-C') | | |
| Analysis: b2) Temporary (traffic) – Short Term, static | | |
| Seismic Coefficient: H: g, V: g | Last Run: 2024/04/02, 01:37:58 PM | Scale: 1:200 |

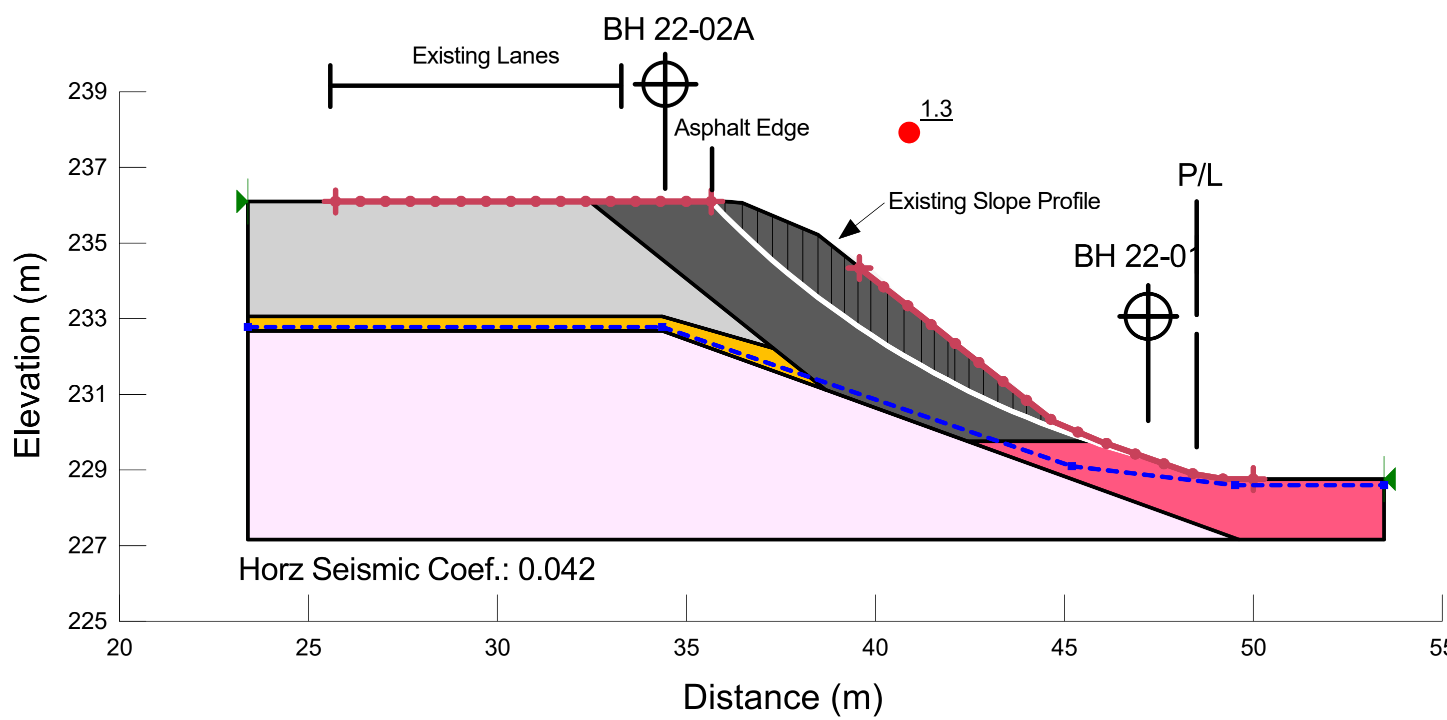
Additional Details
Name: b) Rockfill (1.25H:1V)
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (35.68419, 236.09) m, Exit: (46.301437, 229.6246) m
Center: (53.291479, 253.05374) m, Radius: 24.449644 m

**Figure F3.2b**

O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+770 North Section BHs 22-01 and 22-02\31334 - Hwy 7289 Sta 11+770 draft r2.gsz

Tool Version: 24.1.0.1406

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Piezometric Surface |
|---|---|---|---|---|---|---|
| | a) Rockfill | Mohr-Coulomb | 18 | 0 | 42 | 1 |
| | b) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 | 1 |
| | d) Cobbles and Boulders | Mohr-Coulomb | 22 | 0 | 45 | 1 |
| | e) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 | 1 |
| | f) Bedrock | Bedrock (Impenetrable) | | | | 1 |




| | |
|---|---|
| Project | 31334 - Hwy 7289 Sta 11+770 (Section C-C') |
| Analysis | b3) Pseudo-static |
| Seismic Coefficient | H: 0.042g, V: g |
| Last Run | 2024/04/02, 01:37:59 PM |
| Scale | 1:200 |

THURBER

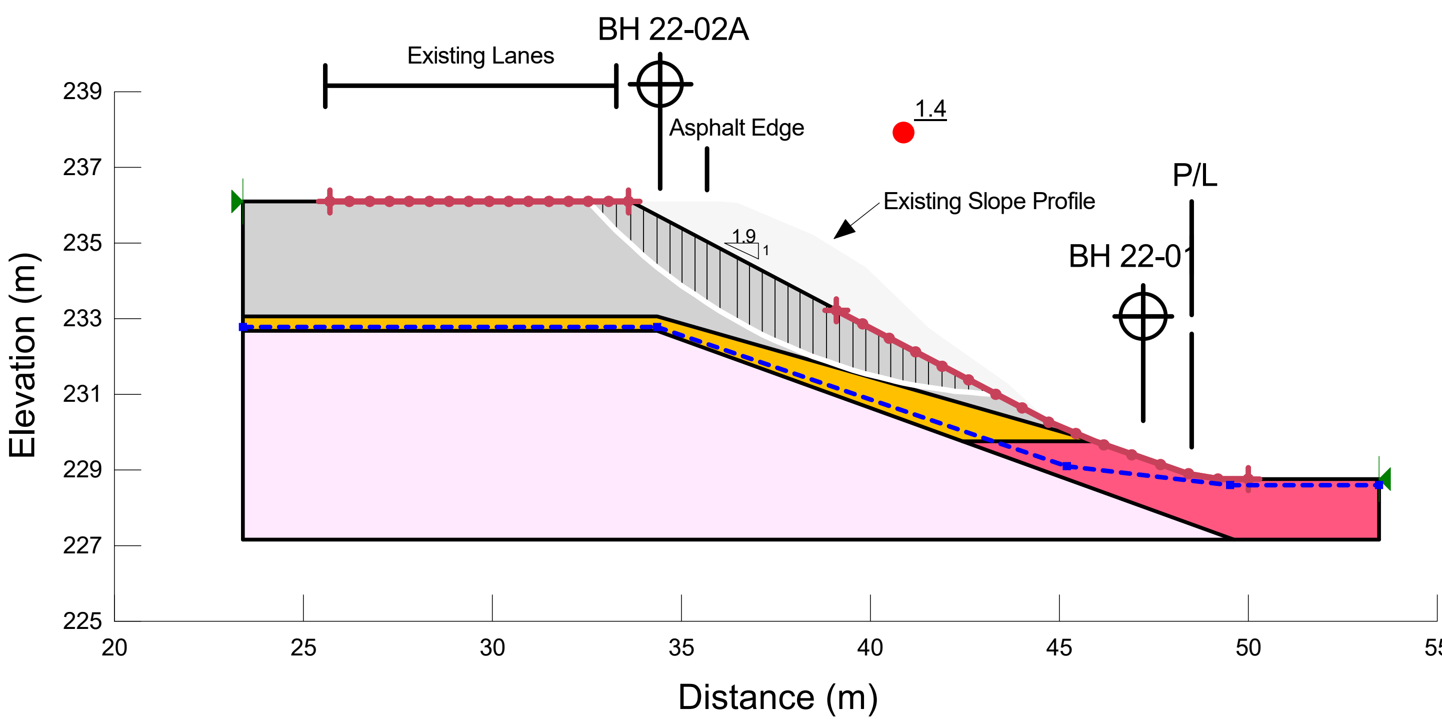
Additional Details
Name: b) Rockfill (1.25H:1V)
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (35.654429, 236.09) m, Exit: (47.131382, 229.33666) m
Center: (53.406757, 253.13026) m, Radius: 24.607228 m

**Figure F3.2c**

*O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+770 North Section BHs 22-01 and 22-02\31334 - Hwy 7289 Sta 11+770 draft r2.gsz*

*Tool Version: 24.1.0.1406*

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Piezometric Surface |
|---|---|---|---|---|---|---|
| (grey) | b) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 | 1 |
| (red) | d) Cobbles and Boulders | Mohr-Coulomb | 22 | 0 | 45 | 1 |
| (yellow) | e) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 | 1 |
| (pink) | f) Bedrock | Bedrock (Impenetrable) | | | | 1 |




| | | | |
|---|---|---|---|
| THURBER | Project: 31334 - Hwy 7289 Sta 11+770 (Section C-C') | | Additional Details |
| | Analysis: c1) Permanent – Long Term, static | | |
| | Seismic Coefficient: H: g, V: g | Last Run: 2024/04/02, 01:37:54 PM | Scale: 1:200 |

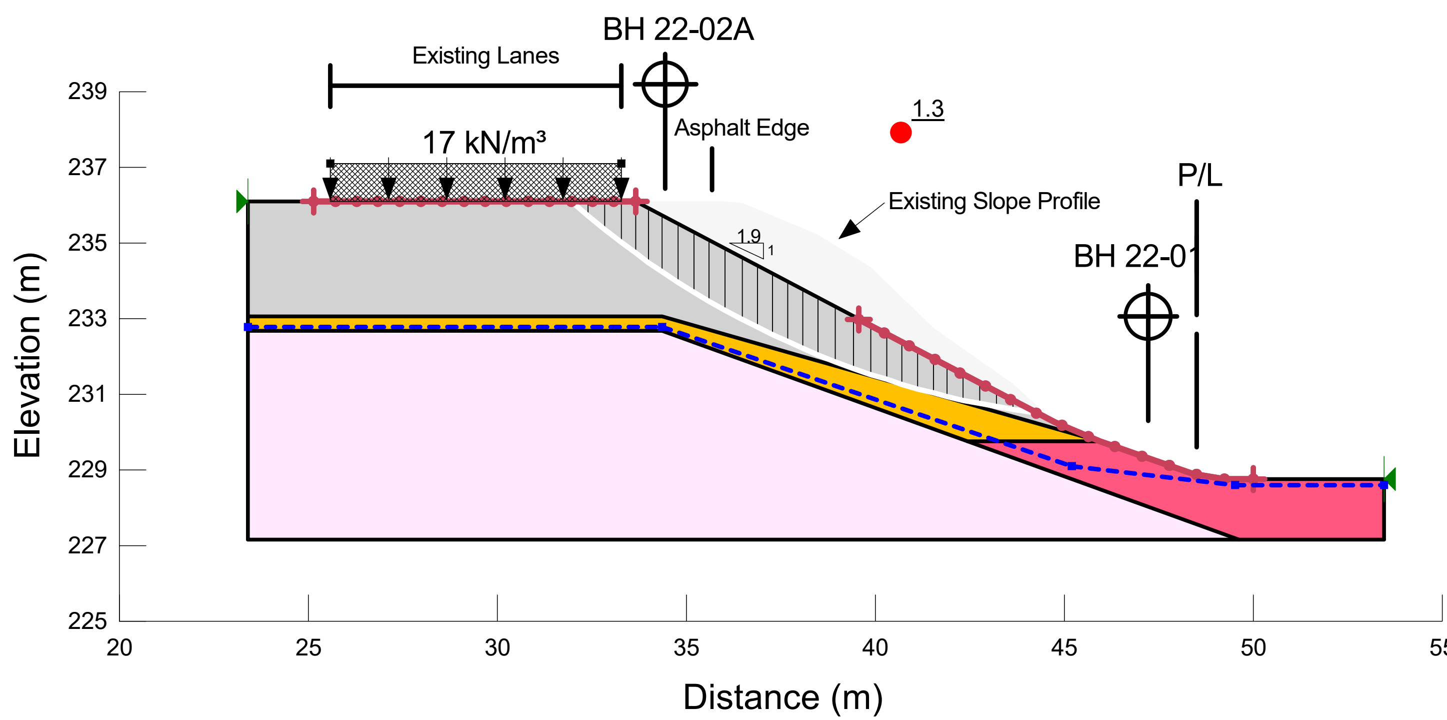
Additional Details
Name: c) Flattened Slope (1.9H:1.0V)
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.6 m
Entry: (32.546667, 236.09) m, Exit: (43.310819, 231.00737) m
Center: (43.937226, 246.27363) m, Radius: 15.279109 m

**Figure F3.3a**

O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+770 North Section BHs 22-01 and 22-02\31334 - Hwy 7289 Sta 11+770 draft r2.gsz

Tool Version: 24.1.0.1406

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Piezometric Surface |
|---|---|---|---|---|---|---|
| (grey) | b) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 | 1 |
| (pink) | d) Cobbles and Boulders | Mohr-Coulomb | 22 | 0 | 45 | 1 |
| (yellow) | e) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 | 1 |
| (light pink) | f) Bedrock | Bedrock (Impenetrable) | | | | 1 |




THURBER

Project
31334 - Hwy 7289 Sta 11+770 (Section C-C')

Analysis
c2) Temporary (traffic) – Short Term, static

| Seismic Coefficient | Last Run | Scale |
|---|---|---|
| H: g, V: g | 2024/04/02, 01:37:56 PM | 1:200 |

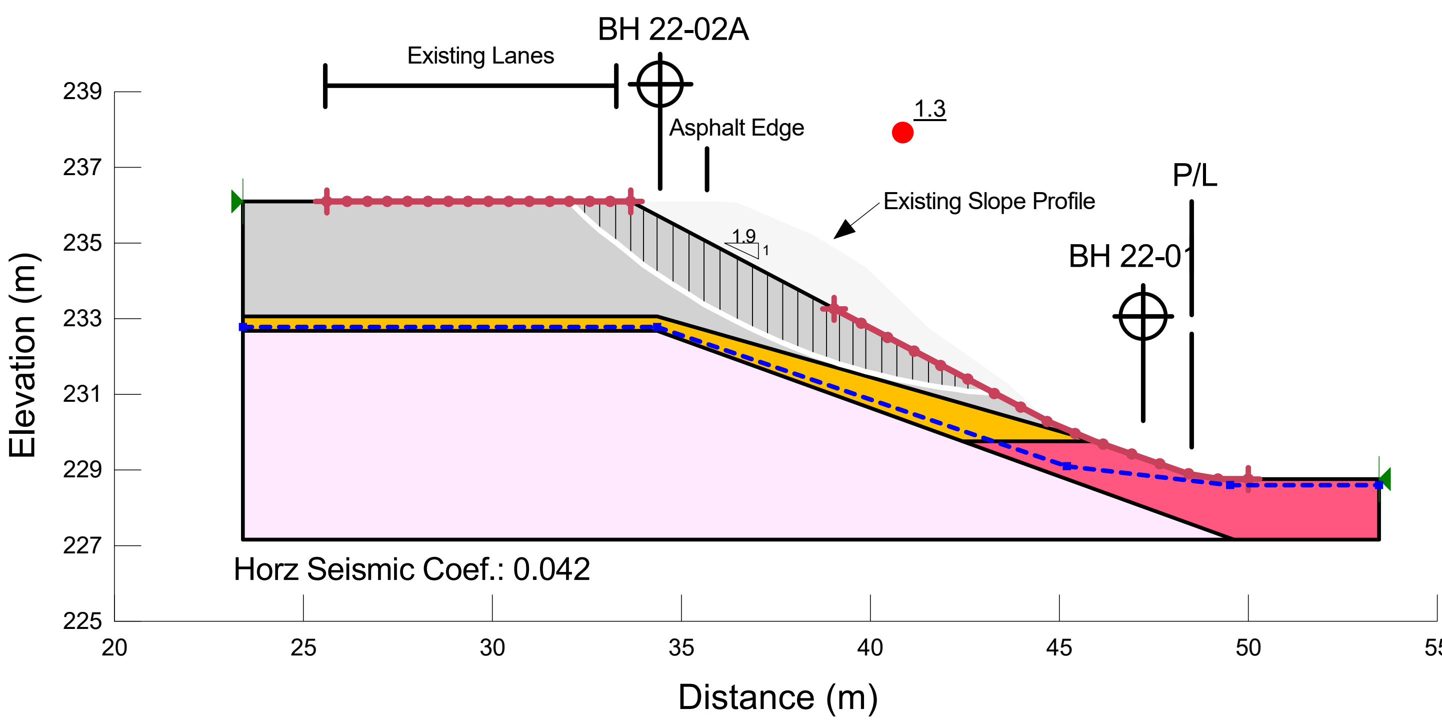
Additional Details
Name: c) Flattened Slope (1.9H:1.0V)
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.6 m
Entry: (31.950942, 236.09) m, Exit: (44.25848, 230.50866) m
Center: (47.310375, 253.59895) m, Radius: 23.291106 m

**Figure F3.3b**

O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+770 North Section BHs 22-01 and 22-02\31334 - Hwy 7289 Sta 11+770 draft r2.gsz

Tool Version: 24.1.0.1406

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Piezometric Surface |
|---|---|---|---|---|---|---|
| (grey) | b) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 | 1 |
| (red) | d) Cobbles and Boulders | Mohr-Coulomb | 22 | 0 | 45 | 1 |
| (yellow) | e) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 | 1 |
| (pink) | f) Bedrock | Bedrock (Impenetrable) | | | | 1 |

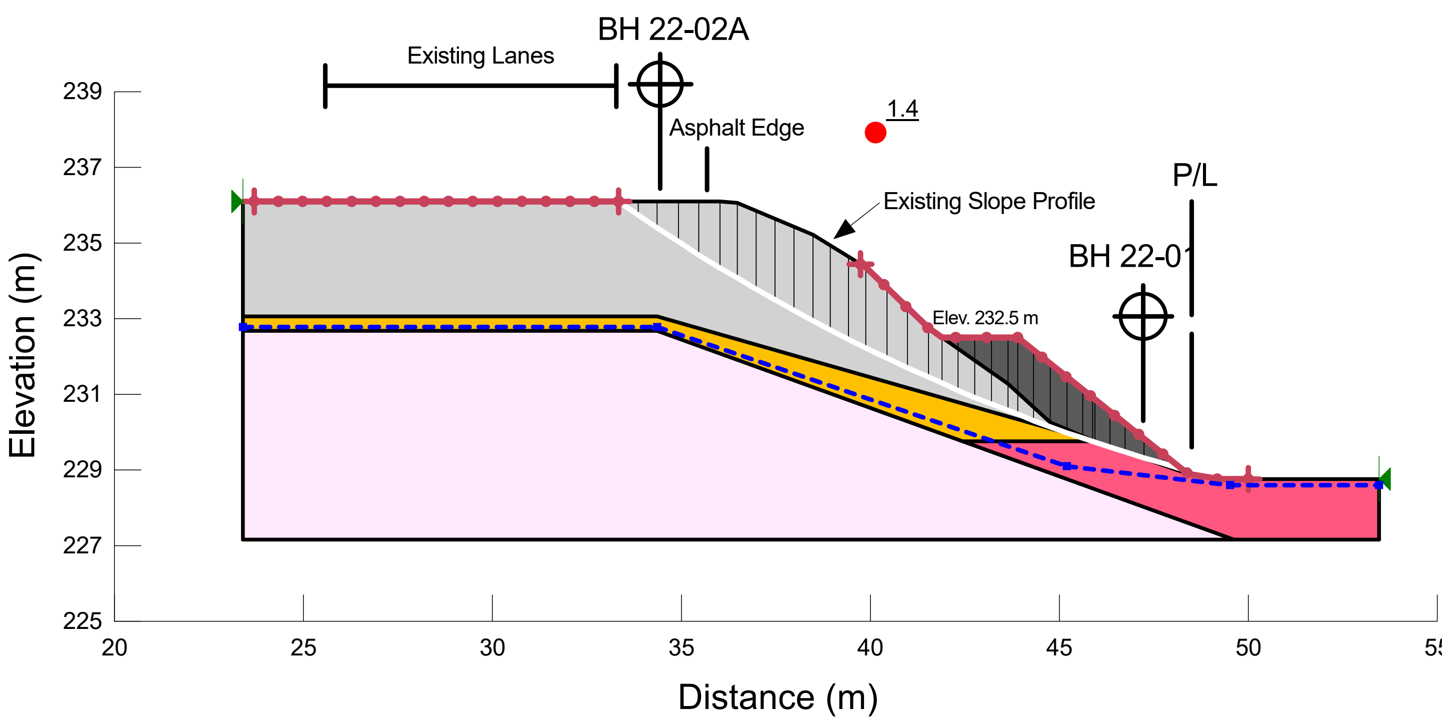



| | | | |
|---|---|---|---|
| THURBER | Project: 31334 - Hwy 7289 Sta 11+770 (Section C-C') | | |
| | Analysis: c3) Pseudo-static | | |
| | Seismic Coefficient: H: 0.042g, V: g | Last Run: 2024/04/02, 01:37:56 PM | Scale: 1:200 |

Additional Details
Name: c) Flattened Slope (1.9H:1.0V)
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.6 m
Entry: (32.046015, 236.09) m, Exit: (43.276785, 231.02528) m
Center: (44.563681, 248.8631) m, Radius: 17.884188 m

**Figure F3.3c**

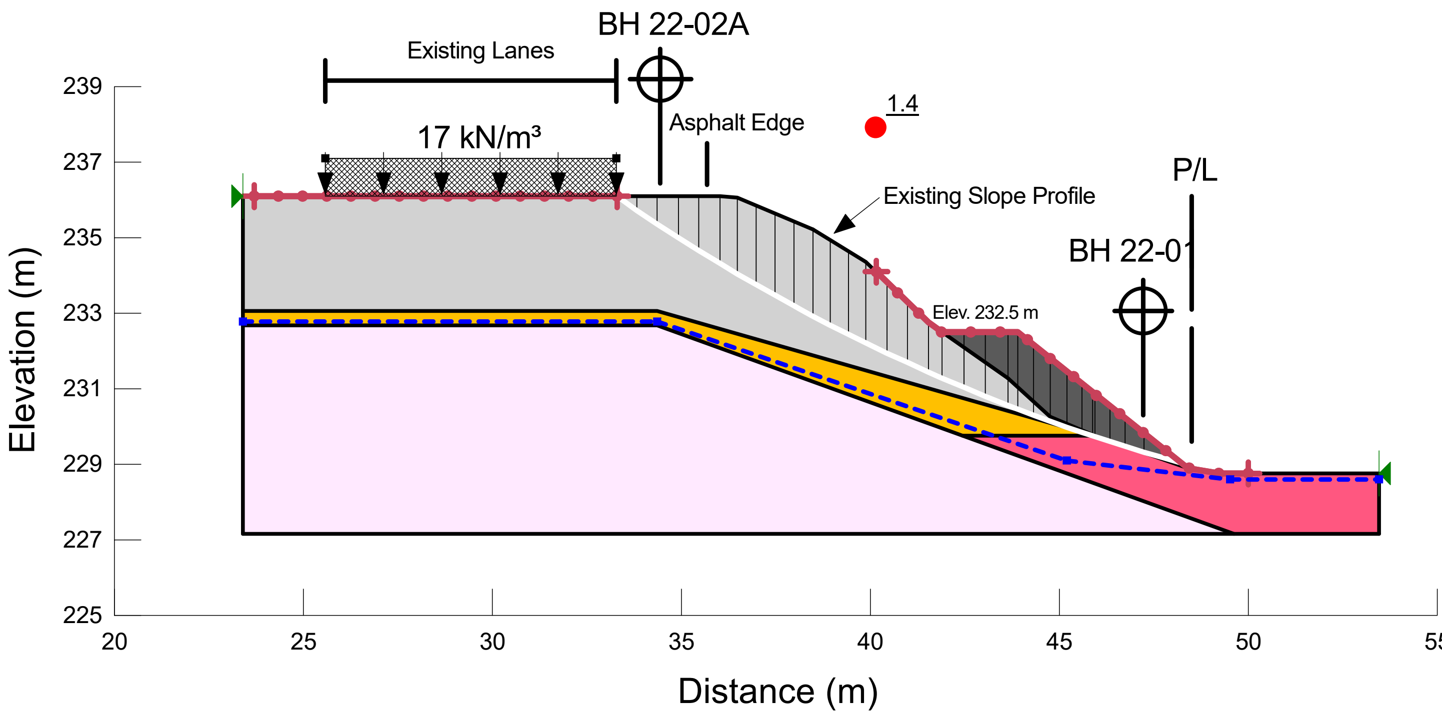
| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Piezometric Surface |
|---|---|---|---|---|---|---|
| | a) Rockfill | Mohr-Coulomb | 18 | 0 | 42 | 1 |
| | b) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 | 1 |
| | d) Cobbles and Boulders | Mohr-Coulomb | 22 | 0 | 45 | 1 |
| | e) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 | 1 |
| | f) Bedrock | Bedrock (Impenetrable) | | | | 1 |




| | | | |
|---|---|---|---|
| THURBER | Project: 31334 - Hwy 7289 Sta 11+770 (Section C-C') | | Additional Details: Name: d) Rockfill Berm (1.25H:1V) Comments: Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1 m Entry: (33.347286, 236.09) m, Exit: (48.231153, 229.02708) m Center: (61.545578, 276.29891) m, Radius: 49.111102 m |
| | Analysis: d1) Permanent – Long Term, static | | |
| | Seismic Coefficient: H: g, V: g | Last Run: 2024/04/02, 01:37:51 PM | Scale: 1:200 |

**Figure F3.4a**

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Piezometric Surface |
|---|---|---|---|---|---|---|
| | a) Rockfill | Mohr-Coulomb | 18 | 0 | 42 | 1 |
| | b) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 | 1 |
| | d) Cobbles and Boulders | Mohr-Coulomb | 22 | 0 | 45 | 1 |
| | e) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 | 1 |
| | f) Bedrock | Bedrock (Impenetrable) | | | | 1 |



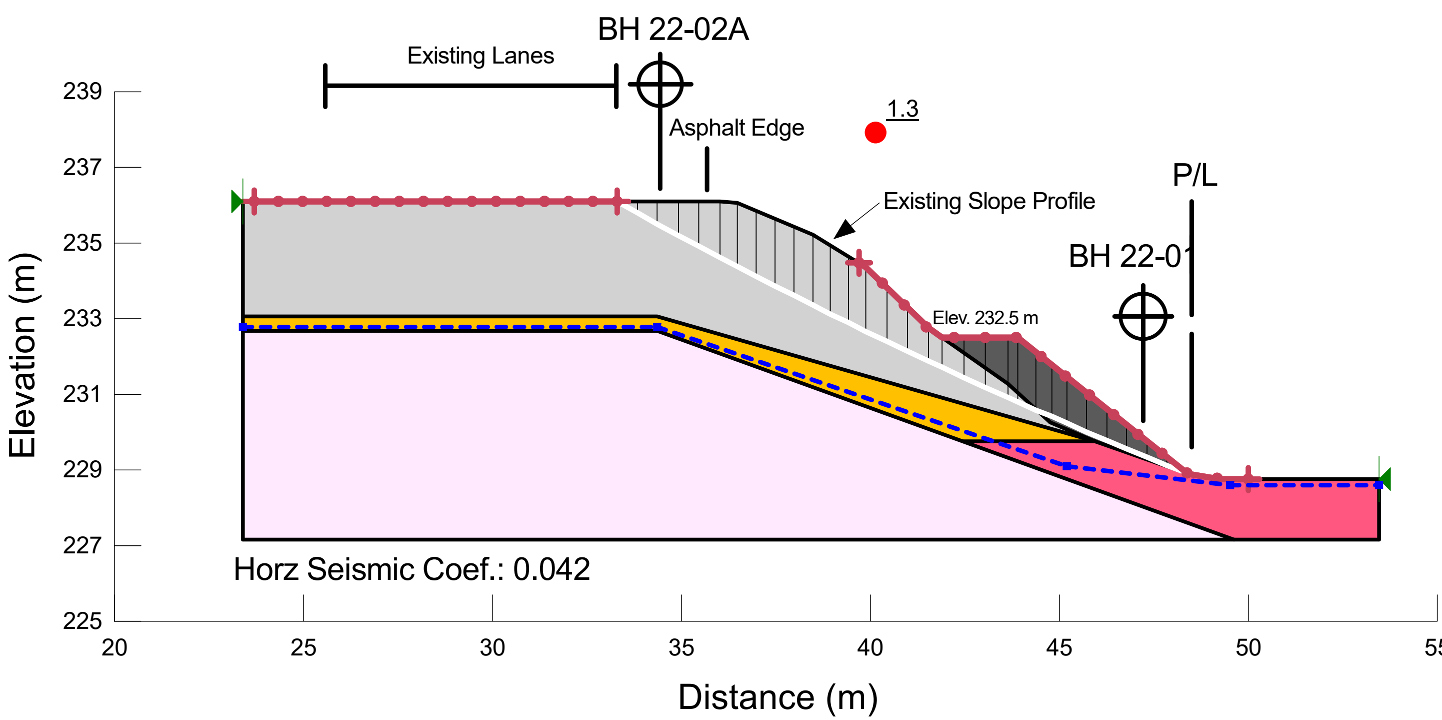

| | | | |
|---|---|---|---|
| THURBER | Project: 31334 - Hwy 7289 Sta 11+770 (Section C-C') | | Additional Details |
| | Analysis: d2) Temporary (traffic) – Short Term, static | | Name: d) Rockfill Berm (1.25H:1V)<br>Comments:<br>Method: Morgenstern-Price, Half-Sine<br>Minimum Slip Surface Depth: 1 m<br>Entry: (33.3, 236.09) m, Exit: (48.22731, 229.03015) m<br>Center: (61.51771, 276.44235) m, Radius: 49.239736 m |
| | Seismic Coefficient: H: g, V: g | Last Run: 2024/04/02, 01:37:53 PM | Scale: 1:200 |

**Figure F3.4b**

*O:\Projects\30001 to 40000\31334 - Hwys 7289, 7290 & 141\Analysis\Slope Models\Sta 11+770 North Section BHs 22-01 and 22-02\31334 - Hwy 7289 Sta 11+770 draft r2.gsz*

*Tool Version: 24.1.0.1406*

| Color | Name | Slope Stability Material Model | Unit Weight (kN/m³) | Effective Cohesion (kPa) | Effective Friction Angle (°) | Piezometric Surface |
|---|---|---|---|---|---|---|
| (dark grey) | a) Rockfill | Mohr-Coulomb | 18 | 0 | 42 | 1 |
| (light grey) | b) Existing Fill | Mohr-Coulomb | 20 | 0 | 32 | 1 |
| (pink) | d) Cobbles and Boulders | Mohr-Coulomb | 22 | 0 | 45 | 1 |
| (yellow) | e) Silty Sand | Mohr-Coulomb | 20 | 0 | 35 | 1 |
| (light pink) | f) Bedrock | Bedrock (Impenetrable) | | | | 1 |




THURBER

Project
31334 - Hwy 7289 Sta 11+770 (Section C-C')

Analysis
d3) Pseudo-static

| Seismic Coefficient | Last Run | Scale |
|---|---|---|
| H: 0.042g, V: g | 2024/04/02, 01:37:53 PM | 1:200 |

Additional Details
Name: d) Rockfill Berm (1.25H:1V)
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1 m
Entry: (33.3, 236.09) m, Exit: (48.370342, 228.91573) m
Center: (97.583866, 351.70967) m, Radius: 132.28879 m

**Figure F3.4c**

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# Appendix G Comparison of Slope Remediation Alternatives

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# COMPARISON OF SLOPE REMEDIATION ALTERNATIVES

| Rockfill Slope, 1.25H:1V | Rockfill Toe Berm | Slope Flattening, Highway Realignment | RSS Wall at Toe | Erosion Enhancement, Monitoring |
|---|---|---|---|---|
| ***Advantages*** | | | | |
| - Requires less specialized construction equipment | - Requires less specialized construction equipment<br>- Minimal impact on highway | - Top-down construction<br>- Minimizes encroachment/ impact on properties and lake shore at slope toe | - Requires less specialized construction equipment<br>- Wall facia options | - Minimal impact to highway |
| ***Disadvantages*** | | | | |
| - Bottom-up construction<br>- Construction will require access/encroachment onto properties and lake shore at slope toe<br>- Full or partial highway closure required<br>- Overhead utility conflicts | - Bottom-up construction<br>- Construction will require access/encroachment onto properties and lake shore at slope toe<br>- Overhead utility conflicts | - Possible bedrock removal<br>- Property acquisition may be required<br>- Highway alignment impacts beyond site<br>- Removal of existing trees/vegetation<br>- Full highway closures or more difficult staging<br>- Overhead utility conflicts | - Construction will require access/ encroachment onto properties and lake shore at slope toe<br>- Partial highway closure<br>- Possible overhead utility conflicts | - Ongoing monitoring program required |
| ***Risk/Consequences*** | | | | |
| - Variable bedrock surface | - Variable bedrock surface | - Full closure of highway for significant duration<br>- Variable bedrock surface | - Variable bedrock surface | - Potential for subsequent shallow failures not eliminated |
| ***Relative Cost*** | | | | |
| Moderate | Moderate | Moderate | Moderate-High | Low |
| ***Recommendation*** | | | | |
| **Recommended For Sections A-A', C-C'** | **Recommended For Section C-C'** | **Feasible but Not Recommended** | **Feasible For Section A-A'** | **Recommended For Section B-B'** |

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## Appendix H List of Referenced Specifications and Contract Provisions

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

| | |
|---|---|
| OPSD 208-010 | Benching of Earth Slopes |
| OPSD 219.010 | Light-Duty Silt Fence Barrier |
| OPSD 3090.101 | Foundation Frost Depths for Southern Ontario |
| OPSD 601.010 | Asphalt Curb and Asphalt Curb with Gutter |
| OPSS.PROV 1004 | Material Specification for Aggregates – Miscellaneous |
| OPSS.PROV 1010 | Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material |
| OPSS.PROV 206 | Construction Specification for Grading |
| OPSS.PROV 501 | Construction Specification for Compacting |
| OPSS.PROV 511 | Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting |
| OPSS.PROV 517 | Construction Specification for Dewatering and Temporary Flow Passages |
| OPSS.PROV 539 | Construction Specification for Temporary Protection Systems |
| OPSS.PROV 804 | Construction Specification for Seed and Cover |
| OPSS.PROV 805 | Construction Specification for Temporary Erosion and Sediment Control Measures |
| OPSS.PROV 902 | Construction Specification for Excavating and Backfilling Structures |
| SSP 105S09 | Amendment to OPSS 539 - Temporary Protection Systems |
| SSP 517F01 | Amendment to OPSS 517 - Construction Specification for Dewatering and Temporary Flow Passages |

2. Contract Provision – Obstructions

Buried obstructions, such as cobbles and/or boulders, will be encountered during construction and interfere with excavation and installation of deep foundations. The Contractor must be prepared to dislodge or penetrate obstructions. Where obstructions are encountered near the surface, the Contractor may choose to remove such obstruction, provided it does not destabilize the existing slope.

3. Rock Fill Provision

Paragraph 7 of OPSS.PROV 206.07.05.02.01 General should be replaced with the following:

Rock fill for embankment shall be produced in a quarry from crushed or fractured bedrock fragments with 100% fractured faces and shall not deteriorate when exposed to air and water and shall be resistant to deterioration by cycles of wetting, drying, freezing, and thawing. Rock fill shall not contain weak rocks such as shale or limestone.

The maximum particle size of the rock fill shall not be greater than 500 mm in any direction and the maximum percentage of particles passing the 75 μm sieve shall not be greater than 10%. The rock fill shall be well graded with the gradation determined as provided in Note 2 of Table 8 within OPSS.PROV 1004 (November 2012). The rock fill particles shall have a minimum unconfined compressive strength (UCS) of 100 MPa and meet the physical property requirements of "Rock Protection" as provided in Table 7 within OPSS.PROV 1004 (November 2012).

Rock fill for use on this contract shall meet the following requirements:

| Lab Test | MTO Test Number | Requirement |
|---|---|---|
| **Percent Crushed Particles, % minimum** | LS-607 | 100 |
| **2 or more Crushed Faces, % minimum** | LS-617 | 85 |
| **Asphalt Coated Particles, Coarse Aggregates, % maximum** | LS-621 | 0 |

Other requirements for producing this material are as follows:

- The material shall be 100% crushed and produced only from particles greater than 300 mm in diameter prior to crushing
- The resulting fill material shall be angular
- Material shall be free of organics and debris

4. Rock Protection

Where specified for toe berm construction between Station 11+740 and 11+900, rock protection shall meet the requirements of OPSS.PROV 1004 with the following modification.

Table 8 Gradation Requirements, Rock Protection: 100% of the particles shall be less than 75 kg.