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To: Ministry of Transportation	Date: October 16, 2024
Attn: Matthew Leavitt, P.Eng.	File: 48719
From: Michael Eastman, P.Eng.	
Reviewer: P.K. Chatterji, P.Eng.	

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**HIGHWAY 72 NON-STRUCTURAL HIGH FILL CULVERT AT STATION 12+270  
LAVAL TOWNSHIP, ONTARIO  
AGREEMENT # 6022-E-0038, ASSIGNMENT # 7  
GEOCRES NO. 52F16-009**

Dear Mr. Leavitt,

Thurber Engineering Ltd. (Thurber) was retained by the Ontario Ministry of Transportation (MTO) to provide Foundation Engineering services under Retainer Agreement No. 6022-E-0038 for Assignment No. 7 for the replacement of a non-structural high fill culvert on Highway 72 at Sta. 12+270 in Laval Township, Ontario.

This technical memorandum focuses on a slope stability analysis for the proposed temporary detour embankment staging including temporary cut slopes and embankment widening.

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

## **1. BACKGROUND**

This assessment was based on the following Draft Foundation Investigation Report (FIR) provided by MTO:

- Draft Preliminary Foundation Investigation Report, Culvert 51, 17.3 km North of the Corner of Hwy 17 and 72, Township of Laval, Station 12+270, by TBT Engineering Limited, dated December 22, 2023.

The investigation included two boreholes, one through the centre of the northbound lane and one at the west side embankment toe (i.e., culvert outlet). The borehole locations and strata drawing and borehole logs are attached to this technical memorandum.

The accuracy and quality of the data in the above report remains the responsibility of TBTE.

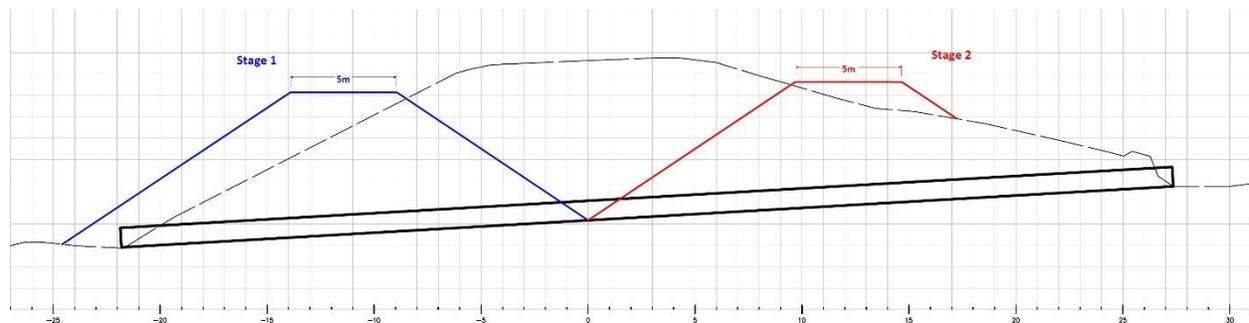
## 2. SUBSURFACE CONDITIONS

The subsurface conditions encountered in Boreholes BH 1 and BH 2 advanced by TBTE generally consisted of embankment fill material comprising very loose to compact sand, soft to firm clay and sand, and stiff clay overlying native loose to compact sand and compact silt. Both boreholes were noted to be dry upon completion and no monitoring wells or standpipe piezometers were installed.

## 3. TEMPORARY DETOUR EMBANKMENTS

### 3.1 Construction Staging

The following culvert construction staging sequence has been provided by MTO in an email dated February 7, 2024.



**Figure 3.1: Culvert construction staging sequence at Station 12+270 (provided by MTO).**

- **Stage 1:** Construct temporary embankment widening to the west of the existing highway alignment to facilitate one lane of traffic flow (i.e., platform width of 5 m) around the excavation for the construction of the new culvert east of the centreline. The temporary embankment will have a temporary cut slope at 2H:1V to the east (inside) and a widened slope to the west (outside) at 1.25H:1V or flatter. The temporary embankment will be widened to the west using OPSS Granular B Type II or rock fill. The maximum height of the new fill is on the order of 3 m.
- **Stage 2:** Construct temporary embankment to the east of the existing highway alignment to facilitate one lane of traffic flow (i.e., platform width of 5 m) around the excavation for the construction of the new culvert west of the centreline. The temporary embankment will have 1.25H:1V or flatter side slopes to the east (outside) and west (inside). The temporary embankment will be constructed using OPSS Granular B Type II or rock fill. The height of the temporary embankment is approximately 6 m.

### 3.2 Slope Stability Analysis

Stability analyses were carried out for the temporary detour embankments utilizing the commercially available computer program SLOPE/W of the GeoStudio software package with the option of Morgenstern-Price method of slices for limit equilibrium.

The input parameters used in the stability analyses, including soil stratigraphy, material properties, groundwater conditions and modeled geometry are shown in the figures attached to this technical memorandum. The material properties used in the analyses were determined from in-situ and laboratory testing as well as soil index correlations.

The stability analysis plots are attached to this technical memorandum. The results of the stability analyses are summarized in the table below.

*Table 3-1 Summary of Slope Stability Analyses*

Location	Cut or Fill	Side	Side Slope	Embank. Fill	Condition	Factor of Safety	Figure
Stage 1 West Temp. Embank.	Cut	East	2H:1V	Gran. B Type II	Drained	1.15	1
	Fill	West			Drained	1.44	2
	Cut	East	2H:1V	Rock Fill	Drained	1.15	3
	Fill	West	1.25H:1V		Drained	1.19	4
Stage 2 East Temp. Embank.	Fill	East	2H:1V	Gran. B Type II	Drained	1.48	5
		West			Drained	1.43	6
		East	1.25H:1V	Rock Fill	Drained	1.23	7
		West			Drained	1.20	8

For the Stage 1 temporary embankment to the west, the factor of safety is less than 1.3 for a temporary cut slope at 2H:1V (Figures 1 and 3). A factor of safety of greater than 1.3 is achieved for embankment widening with Granular B Type II at 2H:1V (Figure 2).

For the Stage 2 temporary embankment to the east, embankment construction with Granular B Type II at 2H:1V achieves a factor of safety of greater than 1.3 (Figures 5 and 6).



#### 4. CLOSURE

Engineering analysis and preparation of this technical memorandum were carried out by Mr. M. Eastman, P.Eng. The technical memorandum was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.

Report Prepared By:



Michael Eastman, P.Eng.  
Associate  
Geotechnical Engineer



P.K. Chatterji, Ph.D., P.Eng.  
Designated Principal Contact  
Senior Geotechnical Engineer

#### Attachments

- Borehole Locations and Strata Drawing and Borehole Logs (prepared by TBTE)
- Slope Stability Analysis



## 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.

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

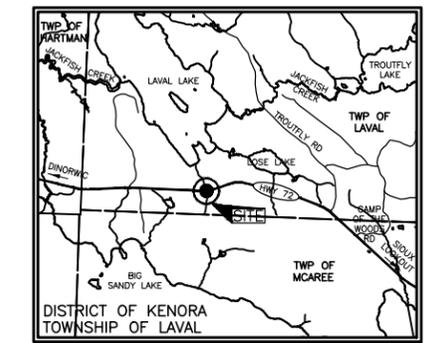
**Ontario** Ministry of Transportation

**GEOCRES** - - -  
**CONT** - - -  
**WP** - - -

SOIL STRATA  
STA 12+270 CULVERT 20  
HIGHWAY 72 TOWNSHIP OF LAVAL

SHEET  
1

**TBT ENGINEERING**  
CONSULTING GROUP



SOIL STRATA SYMBOLS

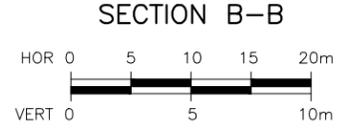
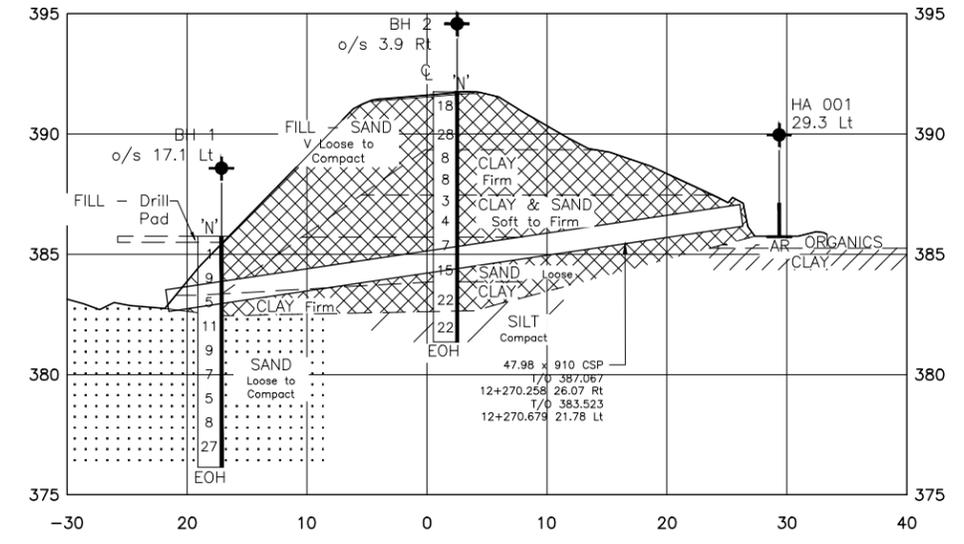
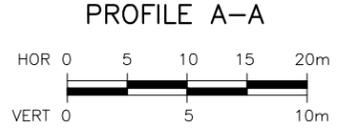
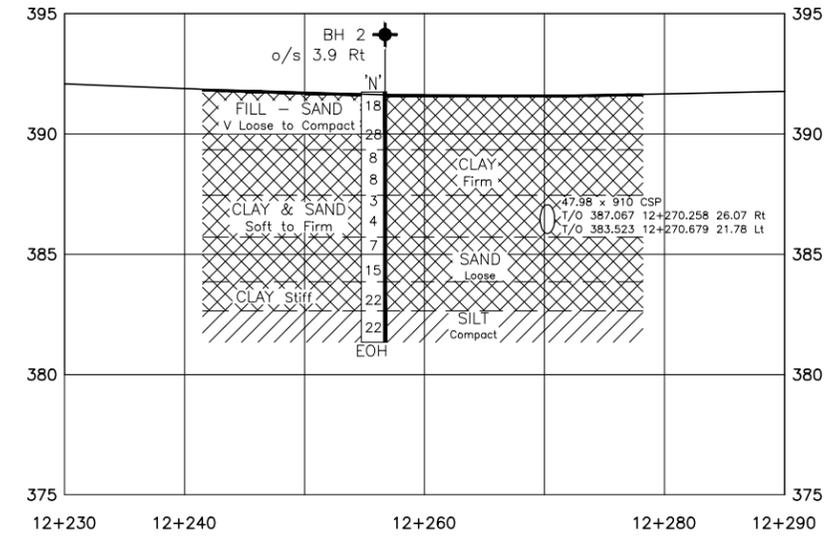
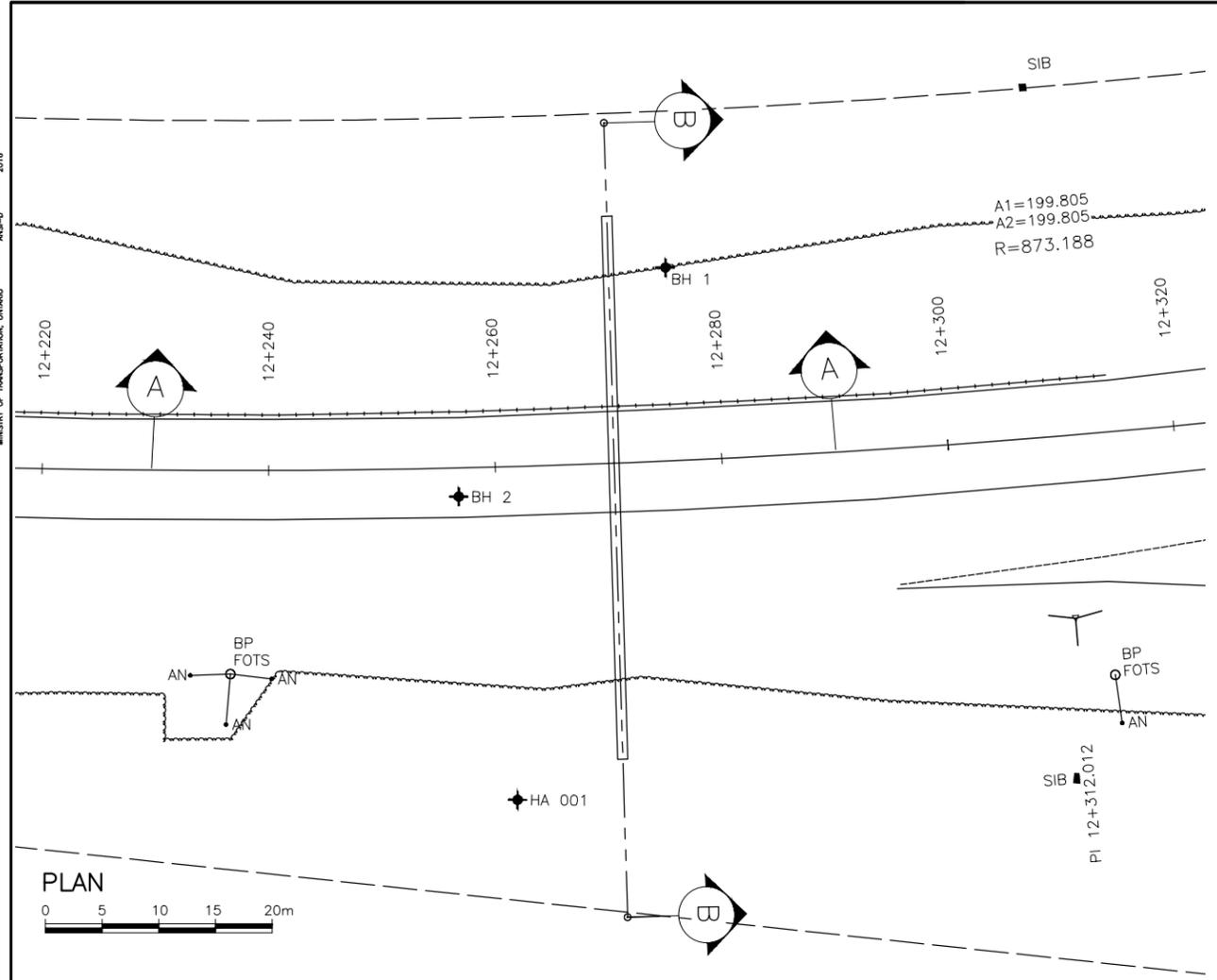
	ASPHALT		SAND
	FILL		SILT
	ORGANICS		GRAVEL
	SAND & CLAY		SAND & GRAVEL
	CLAY		

LEGEND

- BH Borehole
- HA Hand Auger
- 'N' Std Pen Test (Blows/0.3m)
- EOH End of Borehole
- AR Auger Refusal

No	ELEVATION	CO-ORDINATES (MTM)	
		NORTH	EAST
BH 1	386.0	15 5 520 338	346 694
BH 2	391.8	15 5 520 332	346 716
HA 001	387.1	15 5 520 330	346 742

NOTE  
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.



FILE NAME: Y:\Projects\2022\22-146 MTO, NMR Geotechnical Retainer\22-146-10 - Hwy 72 & 664 FND\Drawings\3\_Culvert 20 Laval 12+270 - to review\Laval 12+270 Culvert 20.dwg  
MODIFIED: 2023-12-22 11:38

REVISIONS

No	DATE	BY	CHK	DESCRIPTION
1	22/12/23	SS		ISSUED FOR REVIEW

DESIGN XX CHK XX CODE XXXXXX LOAD XXXX DATE 22/12/23  
DRAWN NB CHK SS SITE XXXXXX DWG 1

**RECORD OF BOREHOLE No 1**

1 OF 1

**METRIC**

W.P. 6033-19-00 LOCATION Station 12+276 o/s 17.7m Lt of C/L N:5520338.267; E:346693.569 MTM Zone:16 ORIGINATED BY AF  
 DIST NWR HWY 72 BOREHOLE TYPE Hollow Stem Auger COMPILED BY ZA/TG  
 DATUM \_\_\_\_\_ DATE 2023.09.22 - 2023.09.22 LATITUDE 49.8191153 LONGITUDE -92.4177971 CHECKED BY DV

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
386.0 0.0	FILL - Drill Pad - 0.5 m															
385.5 0.5	FILL - SAND - some silt, trace gravel, brown, very loose to loose		1	SS	1											
			2	SS	9										1 82 (17)	
	----- - CLAY - Sandy, trace organics, grey, firm		3	SS	5										0 34 (66)	
382.7 3.3	----- - wood debris, organics SAND - trace gravel, trace silt, loose to compact		4	SS	11											
			5	SS	9											
			6	SS	7											
			7	SS	5										0 96 (4)	
			8	SS	8											
	----- - trace gravel, occasional cobbles		9	SS	27										1 96 (3)	
376.4 9.6	End of Borehole @ 9.6 m.															

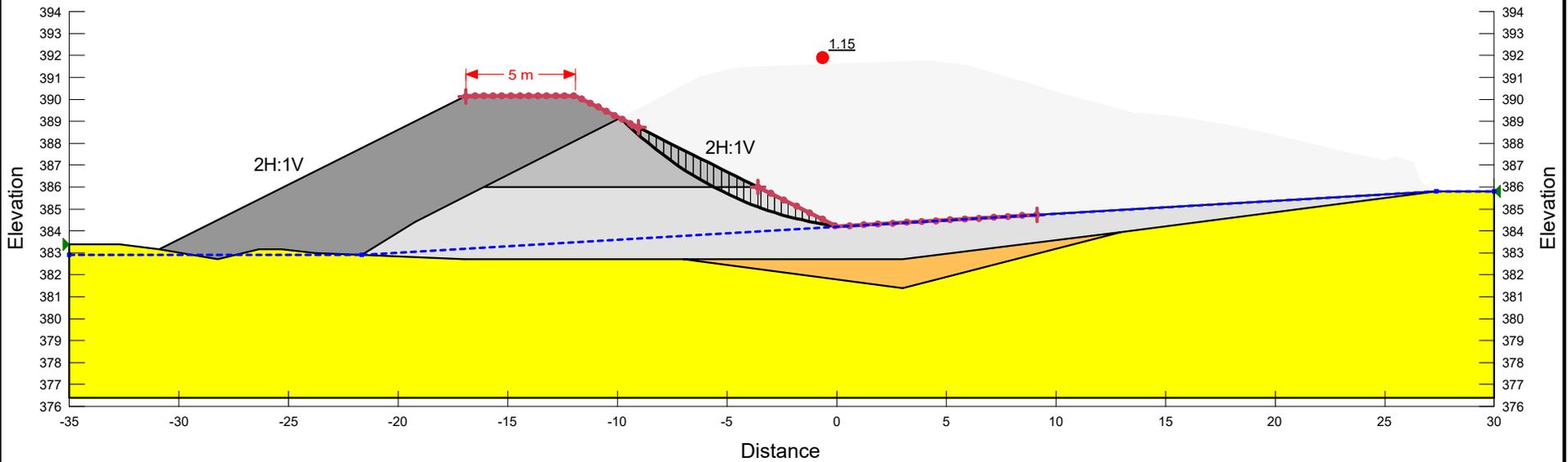
-DRAFT-

ONTARIO MTO MOD DRAFT LAVAL 12+270.GPJ ONTARIO MTO.GDT 12-22-23

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE      PP=Pocket Penetrometer (Kg/cm<sup>2</sup>)



Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)
Light Gray	Existing Fill - Lower	19	0	28
Medium Gray	Existing Fill - Upper	20.5	0	30
Dark Gray	OPSS Gran. B Type II	22	0	35
Yellow	Sand	21	0	30
Orange	Silt	20	0	33

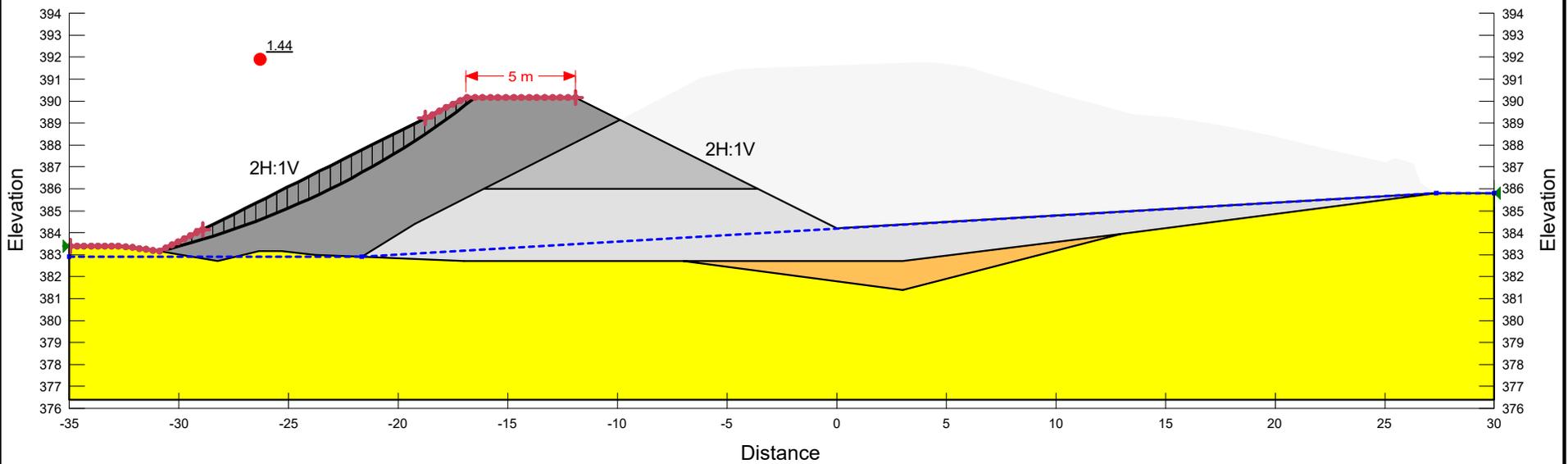


Project		Hwy 72 Non-Structural High Fill Culvert (Laval)	
Analysis		Stage 1 East Side Temp. Cut Slope at 2H:1V with Gran. B Type II (Drained)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	2024-03-08, 04:17:55 PM	1:281	

Additional Details	
Name: Stage 1 East Side Temp. Cut Slope at 2H:1V with Gran. B Type II	
Comments: Sta. 12+270	
Method: Morgenstern-Price, Half-Sine	
Min. Drainage Surface Depth: 1 m	
Entry: (-9.7834195, 389.08941) m, Exit: (-0.016876289, 384.20843) m	
Center: (2.2929966, 401.04198) m, Radius: 16.991289 m	

**Figure 1**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)
Light Gray	Existing Fill - Lower	19	0	28
Medium Gray	Existing Fill - Upper	20.5	0	30
Dark Gray	OPSS Gran. B Type II	22	0	35
Yellow	Sand	21	0	30
Orange	Silt	20	0	33

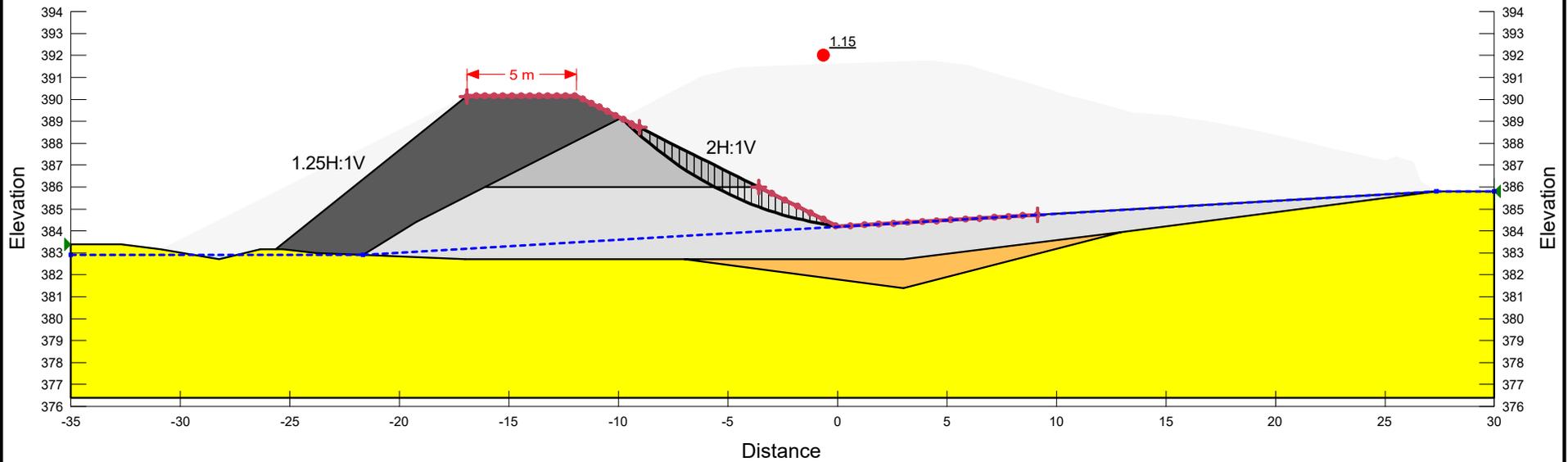


Project <b>Hwy 72 Non-Structural High Fill Culvert (Laval)</b>	
Analysis <b>Stage 1 West Side Embank. Widening at 2H:1V with Gran. B Type II (Dr. Sinec)</b>	
Seismic Coefficient H: 0g, V: 0g	Last Run 2024-03-08, 04:17:57 PM
Scale 1:281	

Additional Details  
 Name: Stage 1 West Side Embank. Widening at 2H:1V with Gran. B Type II  
 Comments: Sta. 12+270  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Dr. Sinec Depth: 1 m  
 Entry: (-30.880008, 383.16) m, Exit: (-16.499565, 390.15) m  
 Center: (-39.929916, 420.0656) m, Radius: 37.999008 m

**Figure 2**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)
Light Gray	Existing Fill - Lower	19	0	28
Medium Gray	Existing Fill - Upper	20.5	0	30
Dark Gray	Rock Fill	19	0	42
Yellow	Sand	21	0	30
Orange	Silt	20	0	33

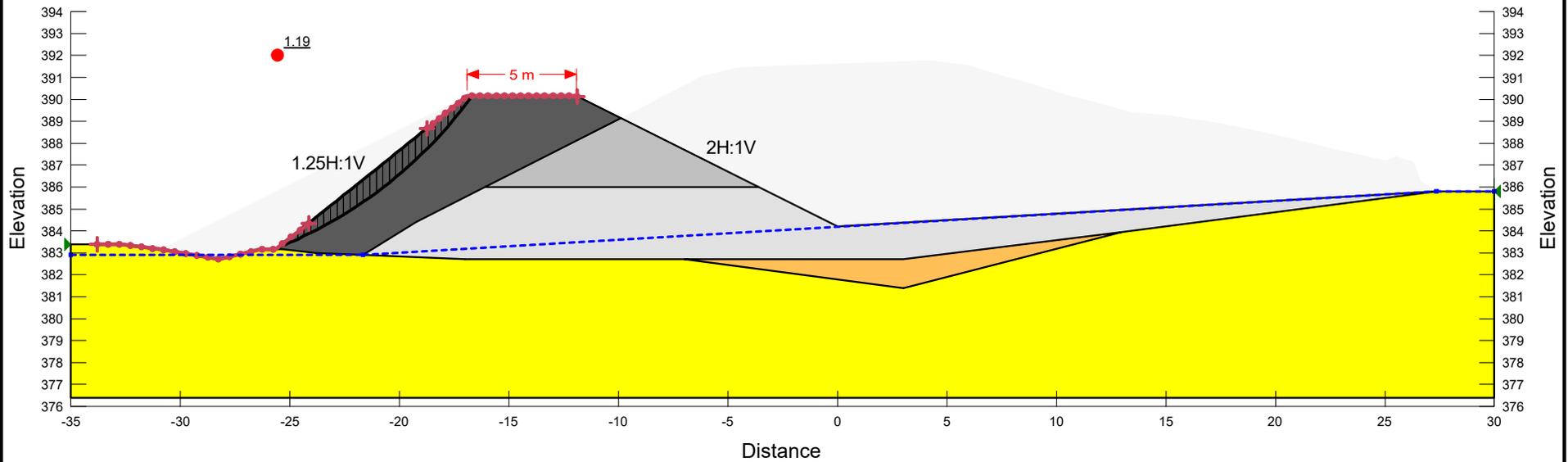


Project <b>Hwy 72 Non-Structural High Fill Culvert (Laval)</b>	
Analysis <b>Stage 1 East Side Temp. Cut Slope at 2H:1V with Rock Fill (Drained)</b>	
Seismic Coefficient H: 0g, V: 0g	Last Run 2024-03-08, 04:18:00 PM
Scale 1:281	

Additional Details Name: Stage 1 East Side Temp. Cut Slope at 2H:1V with Rock Fill Comments: Sta. 12+270 Method: Morgenstern-Price, Half-Sine Slip Surface Depth: 1 m Entry: (-9.7833958, 389.0894) m, Exit: (-0.016874459, 384.20843) m Center: (2.2929967, 401.04195) m, Radius: 16.991258 m
--

**Figure 3**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)
Light Gray	Existing Fill - Lower	19	0	28
Medium Gray	Existing Fill - Upper	20.5	0	30
Dark Gray	Rock Fill	19	0	42
Yellow	Sand	21	0	30
Orange	Silt	20	0	33

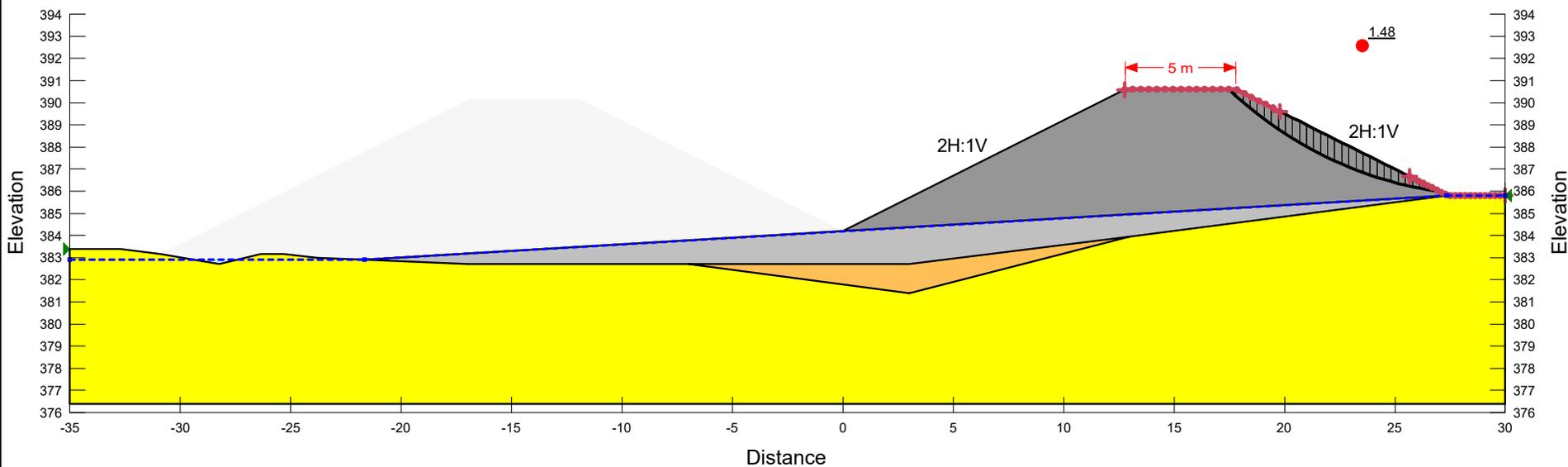


Project <b>Hwy 72 Non-Structural High Fill Culvert (Laval)</b>	
Analysis <b>Stage 1 West Side Embank. Widening at 1.25H:1V with Rock Fill (Drained)</b>	
Seismic Coefficient H: Og, V: Og	Last Run 2024-03-08, 04:18:02 PM
Scale 1:281	

Additional Details Name: Stage 1 West Side Embank. Widening at 1.25H:1V with Rock Fill Comments: Sta. 12+270 Method: Morgenstern-Price, Half-Sine Mill Surface Depth: 1 m Entry: (-25.543228, 383.23542) m, Exit: (-16.682789, 390.15) m Center: (-33.246741, 402.24104) m, Radius: 20.507504 m
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**Figure 4**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)
Light Gray	Existing Fill - Upper	20.5	0	30
Dark Gray	OPSS Gran. B Type II	22	0	35
Yellow	Sand	21	0	30
Orange	Silt	20	0	33

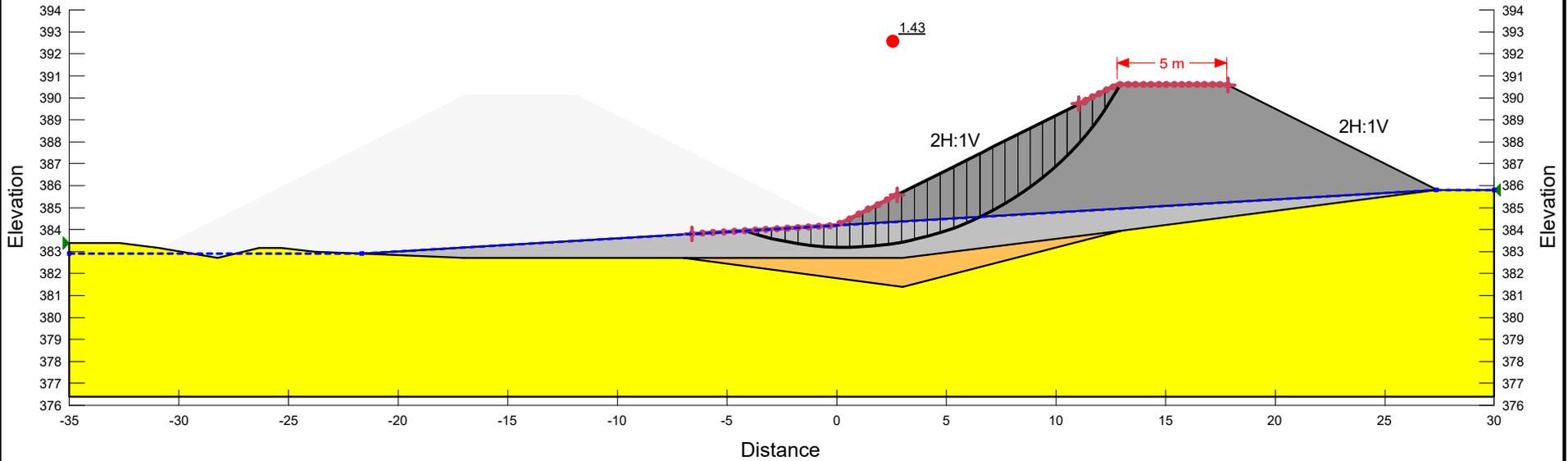


Project		Hwy 72 Non-Structural High Fill Culvert (Laval)	
Analysis		Stage 2 East Side New Embank. at 2H:1V with Gran. B Type II (Drained)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	2024-03-08, 04:18:07 PM	1:281	

Additional Details  
 Name: Stage 2 East Side New Embank. at 2H:1V with Gran. B Type II  
 Comments: Sta. 12+270  
 Method: Morgenstern-Price, Half-Sine  
 Min. Drainage Surface Depth: 1 m  
 Entry: (17.490117, 390.6) m, Exit: (27.06445, 385.96778) m  
 Center: (29.525633, 403.26548) m, Radius: 17.471924 m

**Figure 5**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)
Light Gray	Existing Fill - Upper	20.5	0	30
Dark Gray	OPSS Gran. B Type II	22	0	35
Yellow	Sand	21	0	30
Orange	Silt	20	0	33

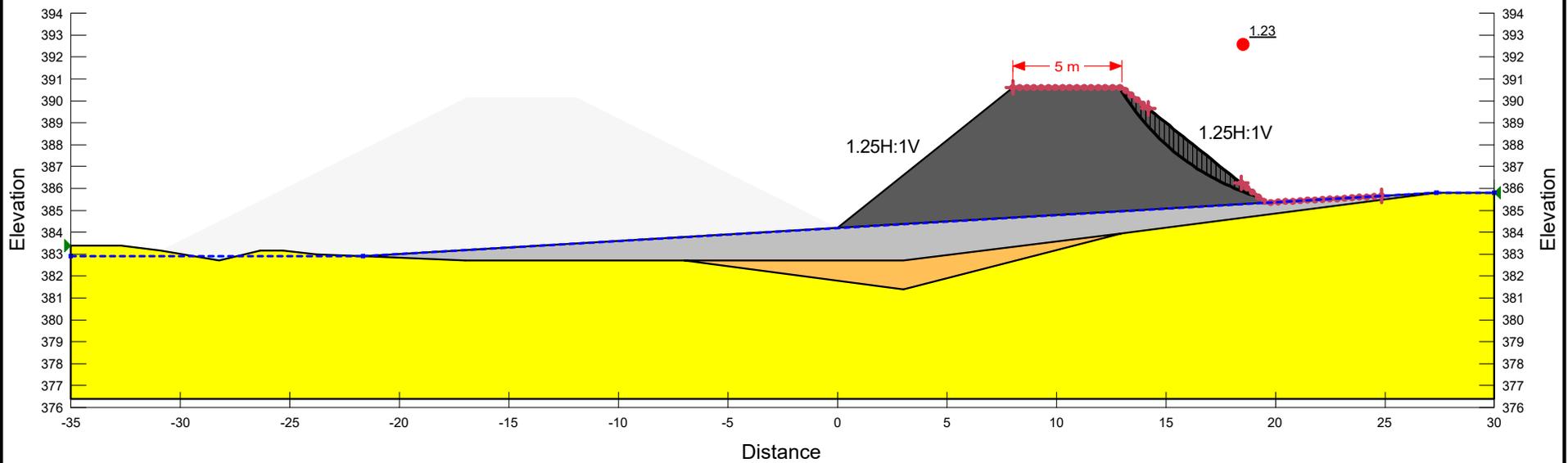


Project		Hwy 72 Non-Structural High Fill Culvert (Laval)	
Analysis		Stage 2 West Side New Embank. at 2H:1V with Gran. B Type II (Drained)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	2024-03-08, 04:18:05 PM	1:281	

Additional Details	
Name: Stage 2 West Side New Embank. at 2H:1V with Gran. B Type II	
Comments: Sta. 12+270	
Method: Morgenstern-Price, Half-Sine	
Minimum Drainage Surface Depth: 1 m	
Entry: (-4.1840228, 383.94877) m, Exit: (12.94255, 390.6) m	
Center: (0.39833786, 397.52505) m, Radius: 14.328768 m	

**Figure 6**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)
Light Gray	Existing Fill - Upper	20.5	0	30
Dark Gray	Rock Fill	19	0	42
Yellow	Sand	21	0	30
Orange	Silt	20	0	33

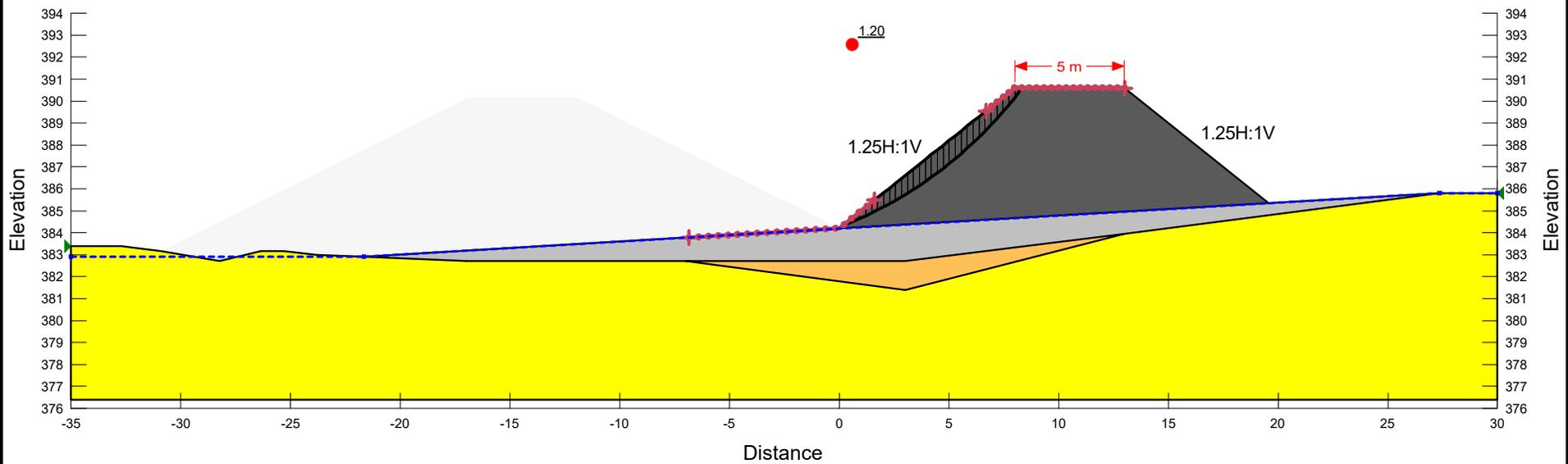


Project <b>Hwy 72 Non-Structural High Fill Culvert (Laval)</b>	
Analysis <b>Stage 2 East Side New Embank. at 1.25H:1V with Rock Fill (Drained)</b>	
Seismic Coefficient H: 0g, V: 0g	Last Run 2024-03-08, 04:18:11 PM
Scale 1:281	

Additional Details  
 Name: Stage 2 East Side New Embank. at 1.25H:1V with Rock Fill  
 Comments: Sta. 12+270  
 Method: Morgenstern-Price, Half-Sine  
 (Drained) Slip Surface Depth: 1 m  
 Entry: (12.8884, 390.6) m, Exit: (19.208626, 385.61764) m  
 Center: (22.45737, 396.23859) m, Radius: 11.106702 m

**Figure 7**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)
Grey	Existing Fill - Upper	20.5	0	30
Dark Grey	Rock Fill	19	0	42
Yellow	Sand	21	0	30
Orange	Silt	20	0	33



	Project <b>Hwy 72 Non-Structural High Fill Culvert (Laval)</b>	Additional Details Name: Stage 2 West Side New Embank. at 1.25H:1V with Rock Fill Comments: Sta. 12+270 Method: Morgenstern-Price, Half-Sine (Drained) Slip Surface Depth: 1 m Entry: (0.12933613, 384.30347) m, Exit: (8.3266803, 390.6) m Center: (-6.7821998, 401.78573) m, Radius: 18.798906 m	
	Analysis <b>Stage 2 West Side New Embank. at 1.25H:1V with Rock Fill</b>	Seismic Coefficient H: 0g, V: 0g	Last Run 2024-03-08, 04:18:10 PM
			Scale 1:281

**Figure 8**