



**THURBER** ENGINEERING LTD.

**FINAL REV.2  
FOUNDATION INVESTIGATION AND DESIGN REPORT  
HIGHWAY 401 PALACE ROAD UNDERPASS  
GREATER NAPANEE, ONTARIO  
AGREEMENT NO. 4016-E-0014, ASSIGNMENTS 55 & 60  
GWP 4197-13-00**

**SITE NO. 17X-0063/BO**

**GEOCRES NO.: 31C-305**

Report to:

**McIntosh Perry Consulting Engineers**

Latitude: 44.269342°  
Longitude: -76.926641°

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**GEOCRES NO.: 31C-305**

**PART 1. FACTUAL INFORMATION**

**1 INTRODUCTION**

This section of the report presents the factual findings obtained from foundation investigations completed at the Highway 401 Palace Road Interchange in Greater Napanee, Ontario. Palace Road is to be realigned to cross over Highway 401 approximately 200 m west of its current crossing. Four new on/off ramps will also be constructed. The new E-N/S off ramp will be within a cut section to the northeast of the existing interchange. Thurber Engineering Limited (Thurber) carried out the current field investigation as a sub-consultant to McIntosh Perry Consulting Engineers (MPCE) under Agreement No. 4016-E-0014, Assignments 55 and 60.

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 design and construction was developed in the course of the current investigation.

**2 EXISTING INFORMATION**

During preparation of this report, Thurber reviewed the following historical foundation report and preliminary desktop study that are available within the online Geocres Library:

*Report on Foundation Investigation, Proposed Crossing Highway 401 – Line “C”, Township of Fredericksburgh, Counties of Lennox & Addington, Ontario Department of Highways, W.P. 33-59, dated December 1959, Universal Geotechnique Limited, Report No. T.411/59. [Geocres 31C00-063]*

*Foundation Report for Desktop Study, Highway 401/Palace Road Interchange (IC582), Interchange and Median Improvements, Greater Napanee, Ontario, Site No. 17-063.1/2, GWP 4197-13-00, dated August 7, 2018, Thurber Engineering Limited, File: 10035. [Geocres 31C00-276]*

The investigation for the existing Palace Road Overpass was carried out in 1959 prior to the construction of Highway 401 and the investigation included five boreholes, two at each abutment and one at the intersecting centerlines of Palace Road and Highway 401. Based on these historic boreholes, the subsurface conditions consisted of surficial topsoil up to

1.1 m thick overlying glacial till over limestone bedrock. All boreholes were terminated within the limestone bedrock. The depth to bedrock ranged from approximately 4.6 m to 6.9 m below the ground surface (elev. 101.5 to 94.9 m). The historical Geocres information indicates that for the construction of an overpass, bedrock excavation was necessary for more than half of the site and it is likely that the existing Highway 401 eastbound structure is supported by spread footings on bedrock and the existing Highway 401 westbound structure may be supported by spread footings on glacial till.

### 3 SITE DESCRIPTION

The existing Highway 401 Palace Road Interchange (IC582) is located 3.5 km north east of Napanee and 0.7 km east of the Napanee River crossing of Highway 401. For project purposes, Highway 401 will be considered to be oriented east-west and Palace Road/County Road 5 will be called Palace Road and considered to be oriented north-south.

The existing overpass consists of twin single-span I-girder bridge structures with a thin slab concrete deck supported on concrete retaining wall type abutments. Both structures have a total span length of about 11.6 m and a width of about 13.7 m. Each structure accommodates two traffic lanes, one speed change lane, and narrow shoulders. Steel guiderails are present on all sides of the two structures with the exception of the southeast quadrant of the eastbound structure. The Highway 401 structures span over two traffic lanes on Palace Road. Cut bedrock faces are visible along Palace Road to the south of Highway 401.

The section of Highway 401 within this project area generally runs in an east to west orientation along relatively flat terrain. The Highway 401 embankment slopes are grass covered and appeared to be stable with no visible signs of recent distress. Ditches are present along the outside toes of the embankments. A concrete barrier wall is present within the median leading up to the structures. Traffic volumes on this section of Highway 401 are understood to be 37,700 AADT (2016).

The lands adjacent to the Highway 401 Palace Road Interchange are mainly undeveloped and forested. Residential/agricultural properties are present within 200 m to the northeast. A commercial property is located within 200 m to the southwest. Approximately 200 m northwest of the interchange, the Napanee River runs near parallel to the north side of Highway 401 and then turns northward to run near parallel to the west side of Palace Road. A hydro corridor with transmission towers is present and crosses over the Highway 401 median approximately 250 m to the west of the existing interchange.

The project area is situated within the physiographic region known as the Napanee Plain (Chapman & Putnam, 1984). The Napanee Plain is characterized by a thin veneer of glacial till underlain at relatively shallow depths by limestone bedrock of the Bobcaygeon Formation. Thick glacial sediments are present in the deep river and stream valleys in the region.

Photographs showing the existing conditions at the site at the time of the current field investigation are included in Appendix D for reference.

#### 4 SITE INVESTIGATION AND FIELD TESTING

The 2020 site investigation and field testing program was carried out based on a Preliminary General Arrangement (GA) drawing received from MPCE dated September 2020 which indicates that the proposed new Highway 401 Underpass beneath Palace Road is to be located approximately 200 m west of the existing Highway 401 structures. The field investigation was undertaken to investigate the subsurface condition for the new underpass structure foundations as well as for the high fill embankments to be constructed on either side of the structure. *It is noted that the historic boreholes from Geocres 31C00-063 were drilled at the location of the existing structures and are therefore considered too far from the proposed alignment to provide anything but general information on subsurface conditions.*

The site investigation and field-testing program was carried out between October 18th and October 28th, 2020 and comprised both on-road and off-road drilling components. Seven on-road boreholes identified as 20-03, 20-04, 20-05, 20-06, 20-10, 20-12 and 20-15 were advanced with a truck-mounted CME-75 drill rig during night shifts. Eight off-road boreholes, identified as 20-01, 20-02, 20-07, 20-08, 20-09, 20-11, 20-13 and 20-14, were advanced using a track mounted CME-55 drill rig. The drill rigs were equipped with Hollow Stem Augurs, NW casing, and NQ coring equipment. Casing and rock coring techniques were required to advance past cobbles and boulders within the fill and to core bedrock in the foundation boreholes.

Two multi-channel analysis of surface waves (MASW) tests, identified as MASW #1 and MASW #2, were carried out on October 26<sup>th</sup> within the MTO right-of-way. The investigated locations were parallel to Highway 401 within the grassed ditch areas immediately south and north of the Highway 401. Additional details regarding the MASW testing equipment and methodology as well as a test location drawing are provided in Appendix E.

The 2021 site investigation and field testing program was carried out based on a GA drawing received from MPCE dated August 2021 which indicates that the north bridge span was lengthened by moving the north abutment approximately 7 m north from that shown on the September 2020 GA drawing. Two boreholes were drilled on August 23, 2021 in the vicinity of the proposed north abutment with the same procedures as the 2020 investigation described above. The new boreholes are identified as 21-16 and 21-17.

The 2021 site investigation and field testing program also addressed the new E N/S ramp and was based on a plan view drawing received from MPCE in July 2021. The field program consisted of advancing four boreholes, identified as 21-20, 21-21, 21-22 and 21-24 as well as four unsampled boreholes to probe for bedrock elevation, identified as 21-18, 21-19, 21-23 and 21-25, along the proposed ramp alignment. These boreholes were drilled on August 23 to 25, 2021.

Prior to commencement of the field investigation, utility clearances were obtained in the vicinity of the borehole locations.

The approximate locations of the boreholes and MASW test lines are shown on the Borehole Locations and Soil Strata Drawing included in Appendix A. The coordinates and elevation of the boreholes are provided on this drawing and on the Record of Borehole sheets included in Appendix B. The as-drilled locations of the boreholes and ground surface

elevations at the borehole locations were surveyed by Thurber on using a Trimble Catalyst DA5 GPS antenna with a reported accuracy of 1 cm. The benchmark labeled as horizontal control point (HCP) 103 (geodetic elevation of 103.768 m), HCP 104 (geodetic elevation of 107.492 m) and the top of bolt on the northwest corner of the closest hydro tower (geodetic elevation 99.760 m) identified on the base plans provided by MPCE were used as checks for the GPS survey. The borehole locations, ground surface elevations and termination depths are summarized in Table 4-1 and Table 4-2 for the 2020 and 2021 field investigation, respectively. The site is within MTM Zone 9.

**Table 4-1: Borehole Summary for 2020 Field Investigation**

Borehole No.	Proposed Foundation Element	Northing (m) (Latitude°)	Easting (m) (Longitude°)	Existing Ground Surface Elevation (m)	Termination Elevation (m)
20-01	South High Fill	4 903 249.1 (44.268446°)	270 699.3 (-76.927135°)	96.0	90.7
20-02	South Approach Embankment (near culvert)	4 903 280.9 (44.268734°)	270 715.0 (-76.926942°)	94.9	89.7
20-03	South Abutment	4 903 303.2 (44.268934°)	270 718.0 (-76.926906°)	98.7	86.7
20-04	South Abutment	4 903 300.5 (44.268910°)	270 729.8 (-76.926757°)	99.2	87.4
20-05	Pier	4 903 347.8 (44.269336°)	270 732.5 (-76.926727°)	98.9	85.0
20-06	Pier	4 903 354.4 (44.269396°)	270 747.3 (-76.926541°)	99.5	87.2
20-07	North Abutment (2020 GA)	4 903 382.4 (44.269648°)	270 745.6 (-76.926565°)	98.5	84.7
20-08	North Abutment (2020 GA)	4 903 387.7 (44.269697°)	270 760.1 (-76.926384°)	98.4	84.5
20-09	North Approach Embankment	4 903 404.5 (44.269848°)	270 760.1 (-76.926384°)	97.8	87.2
20-10	North High Fill	4 903 435.3 (44.270125°)	270 774.0 (-76.926212°)	99.6	87.7
20-11	North High Fill (near culvert)	4 903 493.0 (44.270647°)	270 819.7 (-76.925644°)	95.7	88.4
20-12	North High Fill	4 903 518.1 (44.270875°)	270 852.4 (-76.925236°)	99.1	90.3

Borehole No.	Proposed Foundation Element	Northing (m) (Latitude°)	Easting (m) (Longitude°)	Existing Ground Surface Elevation (m)	Termination Elevation (m)
20-13	North High Fill	4 903 549.5 (44.271159°)	270 903.1 (-76.924603°)	97.1	92.7
20-14	North High Fill	4 903 573.5 (44.271378°)	270 952.1 (-76.923991°)	98.1	92.2
20-15	North High Fill	4 903 594.6 (44.271570°)	271 011.1 (-76.923253°)	100.1	94.1

**Table 4-2 Borehole Summary for 2021 Field Investigation**

Borehole No.	Proposed Foundation Element	Northing (m) (Latitude°)	Easting (m) (Longitude°)	Existing Ground Surface Elevation (m)	Termination Elevation (m)
21-16	North Abutment (2021 GA)	4 903 395.7 (44.269768)	270 750.8 (-76.926501)	98.1	84.2
21-17	North Abutment (2021 GA)	4 903 400.6 (44.269813)	270 766.3 (-76.926307)	97.9	84.0
21-18 (Probe)	Cut Slope E-N/S Ramp	4 903 605.0 (44.271666)	271 055.4 (-76.922699)	102.8	93.1
21-19 (Probe)	Cut Slope E-N/S Ramp	4 903 585.8 (44.271494)	271 073.3 (-76.922473)	105.8	92.9
21-20	Cut Slope E-N/S Ramp	4 903 580.8 (44.271449)	271 086.3 (-76.922310)	106.8	96.5
21-21	Cut Slope E-N/S Ramp	4 903 563.7 (44.271297)	271 121.0 (-76.921874)	111.9	102.1
21-22	Cut Slope E-N/S Ramp	4 903 572.2 (44.271376)	271 157.5 (-76.921418)	111.2	100.4
21-23 (Probe)	Cut Slope E-N/S Ramp	4 903 563.5 (44.271297)	271 157.7 (-76.921415)	111.5	105.0
21-24	Cut Slope E-N/S Ramp	4 903 568.3 (44.271342)	271 194.7 (-76.920952)	111.9	104.3
21-25 (Probe)	Cut Slope E-N/S Ramp	4 903 591.3 (44.271551)	271 240.6 (-76.920378)	114.5	113.3

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in accordance with ASTM D 1586. Sampling with thin walled (Shelby) tube samples was attempted in the cohesive materials but samples were not recovered due to the stiffness of the cohesive soil encountered. In-situ vane shear testing was conducted within the cohesive deposits with an MTO N-sized vane. At several locations the ground conditions did not allow for penetration of the vane and readings could not be obtained. Bedrock was cored in Boreholes 20-03, 20-04, 20-05, 20-06, 20-07, 20-08, 21-16 and 21-17 along the proposed Palace Road structure alignment. Bedrock was cored in Boreholes 21-21, 21-22 and 21-24 along the proposed E-N/S ramp alignment.

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

Standpipe piezometers, consisting of 19 mm diameter PVC pipe with a 1.5 m long slotted screens, were installed in Borehole 20-02, 20-08, 20-11 and 20-14 to allow for measurements of the groundwater levels. The standpipe piezometer details are illustrated in the corresponding Record of Borehole sheets, provided in Appendix B. The standpipe piezometers were decommissioned in general accordance with MOE requirements (O.Reg. 903 as amended) as part of the August 2021 field investigation.

The boreholes without a standpipe installation were decommissioned in general accordance with MOE requirements (O.Reg. 903 as amended). The on-road boreholes were capped with granular fill and cold patch asphalt to reinstate the pavement surface.

## **5 LABORATORY TESTING**

The recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were subjected to Atterberg Limit testing and gradation analyses (hydrometer and/or sieve). All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured. Six samples of the bedrock were selected and submitted for Unconfined Compressive Strength testing (UCS) of intact rock core in accordance with ASTM D7012, Method C. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B. Three soil samples were selected and submitted for analytical testing of corrosivity parameters and sulphate content. All laboratory test results from the field investigation are provided in Appendix C.

## **6 DESCRIPTION OF SUBSURFACE CONDITIONS**

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. The MASW testing results are provided in Appendix E. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented 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, bedrock and groundwater conditions will vary between and beyond borehole locations.

Soil classification is in accordance with ASTM D2487 with cohesive soils described as per current MTO terminology.

## **6.1 Palace Road Alignment**

In general terms, the encountered stratigraphy along the proposed Palace Road alignment consisted of roadway embankment fill overlying stiff clay to clayey silt, overlying loose to dense layers of sandy silt to silty sand. Eight boreholes (20-03 through 20-08, 21-16 and 21-17) were cored and terminated in strong to very strong limestone bedrock. The boreholes not advanced into bedrock were terminated at auger refusal on inferred bedrock.

### **6.1.1 Topsoil**

Topsoil was encountered in off-road Boreholes 20-01, 20-02, 20-07, 20-08, 20-09, 20-11, 20-13, 20-14, 21-16 and 21-17 and ranged in thickness from 100 mm to 200 mm. Where recorded, the moisture contents varied from 13 to 47%.

### **6.1.2 Fill**

#### **Asphalt**

On-road Boreholes 20-03 and 20-04 through the existing W-N/S Ramp, Boreholes 20-05 and 20-06 through the Highway 401 median, Boreholes 20-10 and 20-12 through the E-N/S Ramp and Borehole 20-15 through Palace Road encountered an asphalt layer with thickness ranging from 100 mm to 150 mm.

#### **Fill: Gravel to Sand and Gravel**

A fill layer varying from gravel with silt and sand to sand and gravel was encountered below the asphalt in Boreholes 20-03, 20-04 and 20-15, below sand fill in Borehole 20-06 and below the topsoil in Boreholes 20-08, 20-09, 21-16 and 21-17. Frequent cobbles and boulders were noted in this layer in Boreholes 20-06, 20-09, 21-16 and 21-17. Trace RAP and concrete was encountered in Borehole 21-17. The gravel fill varied in thickness from 150 mm to 3.6 m and extended to base depths of 0.3 to 4.0 m (base elev. 99.8 to 94.2 m).

SPT N-values in the gravel fill typically ranged from 3 to 51 blows indicating a vary loose to dense relative density. Refusal blow counts were encountered in Boreholes 20-06, 20-09 and 21-16. Coring techniques were required to advance through the gravel fill in Borehole 20-06. The recorded moisture contents ranged from 1 to 12%.

The results of gradation analyses completed on 6 samples of the gravel fill are illustrated in Figure C1 of Appendix C. The results of the tests are summarized below and are presented on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	45 to 64
Sand	32 to 46
Silt	4 to 11
Clay	

**Fill: Sand to Silty Sand**

A fill layer varying from sand with silt to sand with silt and gravel to silty sand some to with gravel was encountered below the topsoil in Boreholes 20-01, 20-11 and 20-14, below the asphalt in Boreholes 20-05, 20-06, 20-10 and 20-12 and below the gravel fill layer in Boreholes 20-08 and 20-15. The sand fill typically varied in thickness from 0.4 to 1.7 m and extended to base depths ranging from 0.6 to 1.8 m (base elev. 98.6 to 94.2 m). The sand fill in Borehole 20-08 had a thickness of 2.1 m and a base depth of 4.6 m (base elev. 93.8 m).

SPT N-values in the sand fill typically ranged from 3 to 43 blows indicating a loose to dense relative density. SPT N-values of 61 and greater were recorded in Borehole 20-15. The recorded moisture contents ranged from 2 to 21%.

Gradation analyses completed on 9 samples of the sand fill are illustrated in Figures C2 and C3 of Appendix C. The results of the tests are summarized below and are presented on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)	
Gravel	2 to 45	
Sand	46 to 86	
Silt	9 to 28	27
Clay		9

**Fill: Clayey Sand to Silty Clayey Sand**

A fill layer varying from clayey sand some gravel to silty clayey sand trace to with gravel was encountered below the gravel fill layers in Boreholes 20-03, 20-04, 20-06, 20-09 and 21-16, below the sand fill layers in Borehole 20-05, 20-10 and 20-12 and below the topsoil in Borehole 20-07.

The clayey sand fill varied in thickness from 0.8 to 4.4 m and extended to base depths of 3.8 to 5.8 m (base elev. 94.6 to 93.7 m).

SPT N-values in the clayey sand fill typically ranged from weight of hammer (WH) to 33 blows indicating a very loose to dense relative density. A blow counts of 52 and 57 were recorded in Boreholes 20-12 and 20-05, respectively. The recorded moisture contents ranged from 6 to 23%

Gradation curves from analyses completed on 12 samples of the sand fill are illustrated in Figures C4 and C5 of Appendix C. The results of the tests are summarized below and are presented on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	5 to 21
Sand	37 to 51
Silt	25 to 35
Clay	9 to 21

Atterberg limit testing was completed on 12 samples of the fill layer. The results are illustrated in Figures C6 and C7 in Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B. The laboratory results indicate the fill layer exhibits non-plastic to low plasticity (ML/CL-ML to CL).

Parameter	Value
Liquid Limit	17 to 31
Plastic Limit	13 to 18
Plasticity Index	4 to 15

### 6.1.3 Silt

A deposit of silt was encountered below the topsoil in Borehole 20-02. The deposit was 1.4 m thick with an underside depth of 1.5 m (base elev. 93.4 m). SPT N-values of 5 and 19 blows were recorded in this deposit indicating a loose to compact relative density. Recorded moisture contents ranged from 21 to 29%.

The results of a gradation analysis completed on 1 sample in this deposit are illustrated in Figure C8 in Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	0
Sand	2
Silt	34
Clay	64

Atterberg limit testing was completed on one sample of the deposit. The results are illustrated in Figure C9 in Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B. The laboratory results indicate the deposit exhibits high plasticity (MH).

Parameter	Value
Liquid Limit	57
Plastic Limit	31
Plasticity Index	26

#### 6.1.4 Sandy Clay

A deposit varying from sandy clay to clay with to trace sand was encountered below the gravel fill in Borehole 21-17, below the sand fill in Boreholes 20-01, 20-08, 20-11 and 20-14, below the clayey sand fill in Boreholes 20-03, 20-04, 20-05, 20-07, 20-09, 20-10, 20-12 and 21-16 and below the surficial topsoil in Borehole 20-13. Cobbles were noted in this layer in Borehole 21-16. The deposit varied in thickness from 0.6 to 3.5 m and extended to base depths ranging from 2.3 to 7.2 m (elev. 95.8 to 91.5 m).

SPT N-values in this deposit ranged from 7 to 37 blows indicating a firm to very stiff consistency. A limited number of field vanes were able to penetrate into the layer but were unable to be sheared indicating an undrained shear strength in excess of 100 kPa. Recorded moisture contents ranged from 9 to 42%

The results of gradation analyses completed on 13 samples in this deposit are illustrated in Figures C10, C11 and C12 in Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	0 to 14
Sand	4 to 32
Silt	28 to 46
Clay	23 to 60

Atterberg limit testing was completed on 13 samples of the deposit. The results are illustrated in Figures C13, C14 and C15 in Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B. The laboratory results indicate the deposit exhibits intermediate to high plasticity (CI to CH).

Parameter	Value
Liquid Limit	36 to 62
Plastic Limit	19 to 29
Plasticity Index	17 to 34

### 6.1.5 Sandy, Clayey Silt to Silty, Clayey Sand

A deposit of sandy, clayey silt to silty, clayey sand trace to some gravel was encountered below the clay in Boreholes 20-05, 20-08, 20-10, 20-11 and 20-12 and inferred below the clayey sand fill in Borehole 20-06. The deposit varied in thickness from 0.9 to 2.6 m and extended to a base depth of 6.1 to 9.1 m (base elev. 92.3 to 89.3 m).

SPT N-values in this deposit ranged from 7 to 31 blows indicating a loose to dense relative density. Coring was required to penetrate through the inferred layer within Borehole 20-06. Recorded moisture contents ranged from 9 to 34%.

The results of gradation analyses completed on 5 samples in this deposit are illustrated in Figure C16 in Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	5 to 13
Sand	32 to 49
Silt	27 to 36
Clay	11 to 27

Atterberg limit testing was completed on 5 samples of the deposit. The results are illustrated in Figure C17 in Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B. The laboratory results indicate the deposit exhibits non-plastic to low plastic behaviour (ML/CL-ML to CL).

Parameter	Value
Liquid Limit	16 to 27
Plastic Limit	11 to 14
Plasticity Index	3 to 13

### 6.1.6 Gravel with Sand and Silt

A deposit of gravel with sand and silt was encountered below the clay in Boreholes 20-13 and 20-14. Both boreholes were terminated within this layer at auger refusal depths of 4.4 and 5.9 m respectively (elev. 92.7 to 92.2 m) indicating an estimated deposit thickness of 1.9 to 3.6 m.

One of the SPT N-values was recorded at 44 blows with the remainder of the recorded blows counts in excess of 100 blows indicating that the deposit is very dense. Recorded moisture contents ranged from 5 to 10%.

The results of gradation analyses completed on 3 samples in this deposit are illustrated in Figure C18 of Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	48 to 57
Sand	34 to 42
Silt	9 to 11
Clay	

#### 6.1.7 Silty Sand to Sand with Silt to Sandy Silt

A deposit varying from silty sand to sandy silt to sand with silt was encountered below the silty sand fill in Borehole 20-15, below the silt in Borehole 20-02, below the clay in Borehole 20-01, 20-03, 20-04, 20-07, 20-09, 21-16 and 21-17, below the sandy, clayey silt in Borehole 20-05 and 20-06 and below the silty, clayey sand in Borehole 20-08, 20-10, 20-11 and 20-12. Boreholes 20-01, 20-02, 20-09, 20-10, 20-11, 20-12 and 20-15 were terminated within this deposit upon auger refusal. Boreholes 20-03, 20-04, 20-05, 20-06, 20-07, 20-08, 21-16 and 21-17 encountered a deposit thickness of 2.2 to 5.5 m with an underside depth of 9.4 to 10.9 m (elev. 89.8 to 87.1 m).

SPT N-values in this deposit typically ranged from 3 to 33 blows indicating very loose to dense relative density. Refusal blow counts (>100 blows) were obtained near the base of the deposit but are expected to be the result of the underlying bedrock. Recorded moisture contents typically ranged from 6 to 24%. A single moisture content of 35% was recorded near the surface of this layer in Borehole 21-16.

The results of gradation analyses completed on 19 samples in this deposit are illustrated in Figures C19, C20, C21 and C22 in Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)	
Gravel	0 to 16	
Sand	41 to 87	
Silt	8 to 51	35 to 48
Clay		5 to 8

#### 6.1.8 Bedrock and Refusal

Boreholes 20-01, 20-02 and 20-09 through 20-15 were terminated at drill rig auger refusal on probable bedrock. Boreholes 20-03 through 20-08, 20-16 and 20-17 were cored and terminated within bedrock. A summary of the borehole termination information is presented in Table 6-1 below.

**Table 6-1. Summary of Refusal Depths/Bedrock Surface**

Borehole ID	Ground Surface Elevation (m)	Depth Below Existing Grade (m)	Top of Bedrock Elevation (m)
20-01	96.0	5.3	90.7*
20-02	94.9	5.2	89.7*
20-03	98.7	9.4	89.3
20-04	99.2	9.4	89.8
20-05	98.9	10.9	88.0
20-06	99.5	9.8	89.7
20-07	98.5	10.8	87.7
20-08	98.4	10.8	87.6
20-09	97.8	10.6	87.2*
20-10	99.6	11.9	87.7*
20-11	95.7	7.3	88.4*
20-12	99.1	8.8	90.3*
20-13	97.1	4.4	92.7*
20-14	98.1	5.9	92.2*
20-15	100.1	6.0	94.1*
21-16	98.1	10.8	87.3
21-17	97.9	10.8	87.1

\* Inferred Bedrock by auger refusal

The bedrock encountered in Boreholes 20-03 through 20-08, 21-16 and 21-17 consisted of grey slightly weathered to fresh limestone. The Total Core Recovery (TCR) measured on the recovered bedrock cores ranged from 95 to 100%, the Solid Core Recovery (SCR) ranged from 77 to 100% and the Rock Quality Designation (RQD) typically ranged from 59 to 100% with one value of 23% for Run 1 in Borehole 20-06. Based on the typical RQD values, the bedrock is classified as fair to excellent quality in accordance with CFEM (2006).

Unconfined Compressive Strength (UCS) testing was carried out on seven samples of the bedrock core with results ranging from about 111 to 228 MPa, indicating the bedrock to be very strong.

Photographs of the bedrock cores are provided in Appendix C.

#### 6.1.9 Groundwater

Standpipe piezometers were installed in Boreholes 20-02, 20-08, 20-11 and 20-14. The short-term groundwater level measurements are summarized in the table below.

**Table 6-2. Groundwater Level Observations**

Borehole (screen tip elevation)	Groundwater Level		Date of Measurement
	Depth (mbgs*)	Elevation (m)	
20-02 (89.7 m)	2.6	92.3	October 23, 2020
	2.6	92.3	October 28, 2020
	1.9	93.0	December 8, 2020
	2.3	92.6	August 25, 2021
20-08 (87.7 m)	5.8	92.6	October 28, 2020
	9.4	89.0	December 8, 2020
	5.7	92.7	August 25, 2021
20-11 (88.4 m)	3.1	92.6	October 23, 2020
	2.6	93.1	October 28, 2020
	2.3	93.4	December 8, 2020
	2.6	93.1	August 25, 2021
20-14 (92.2 m)	4.4	93.7	October 23, 2020
	4.4	93.7	October 28, 2020
	3.0	95.1	December 8, 2020
	4.2	93.9	August 25, 2021

\*mbgs = metres below ground surface

These observations are considered short term and it should be noted that the groundwater level at the time of construction may be different 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.

#### 6.1.10 Analytical Testing

Three soil samples were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity and conductivity. The analysis results are included in Appendix C and are summarized in the following table.

**Table 6-3. Summary of Analytical Test Results**

Borehole	20-04	20-05	20-07
Sample	SS7	SS4	SS5
Depth (m)	4.6 - 5.2	2.3 - 2.9	3.1 - 3.7
Elevation (m)	94.6 - 94.0	96.6 – 96.0	95.4 - 94.8
Material	Clay	Fill	Fill
Conductivity (μS/cm)	472	309	830
pH ( - )	7.6	7.8	7.3
Resistivity (Ohm-cm)	2,120	3,240	1,200
Chloride (μg/g)	187	131	422
Sulphate (μg/g)	17	29	29
Sulphide (%)	<0.04	<0.04	<0.04

## 6.2 E-N/S Ramp Alignment

In general terms, the encountered stratigraphy consisted of a surficial layer of topsoil, overlying loose to dense layers varying from sandy clayey silt and silty sand. A layer of sandy, clayey silt was encountered below the topsoil in Borehole 21-22. Bedrock was cored in three boreholes (21-21, 21-22 and 21-24) and terminated in strong to very strong limestone bedrock.

### 6.2.1 Topsoil

Topsoil was measured in Boreholes 21-20, 21-21, 21-22 and 21-24 and ranged in thickness from 50 to 100 mm.

### 6.2.2 Sandy, Clayey Silt

A deposit of sandy, clayey silt was encountered below the topsoil in Borehole 21-22. The deposit was 1.4 m thick and an underside elevation of 109.7 m. SPT N-values of 7 and 15 were recorded in this deposit indicating a loose to compact relative density. A moisture content of 17% was recorded in this layer.

The results of a gradation analysis completed on one sample in this deposit are illustrated in Figure C23 in Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	5
Sand	45
Silt	30
Clay	20

Atterberg limit testing was completed on one sample of the deposit. The results are illustrated in Figure C24 in Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B. The laboratory results indicate the deposit exhibits low plasticity (CL).

Parameter	Value
Liquid Limit	29
Plastic Limit	15
Plasticity Index	14

### 6.2.3 Silty Sand to Sand with Silt to Sandy Silt

A deposit varying from silty sand to sandy silt was encountered below the surficial topsoil in Boreholes 21-20, 21-21 and 21-24 and below the sandy, clayey silt in Borehole 21-22. Cobbles and boulders were noted within this deposit in Boreholes 21-21. The deposit was 3.8 to 10.2 m thick with an underside depth of 3.9 to 10.3 m (elev. 108.0 to 96.5 m). SPT N-values in this deposit typically ranged from 5 to 35 blows indicating a loose to dense relative density. Higher blow counts were obtained within the deposit on suspected boulders and near the base of the deposit near the bedrock interface. Recorded moisture contents ranged from 7 to 17%.

The results of gradation analyses completed on eleven samples in this deposit are illustrated in Figure C25 and 26 in Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)	
Gravel	3 to 24	
Sand	38 to 67	
Silt	28 to 35	9 to 25
Clay	9 to 21	

Atterberg limit testing was completed on the fines portion of two samples of the deposit. The results are illustrated in Figure C27 in Appendix C. The results are summarized below and are presented on the Record of Borehole sheets in Appendix B. The laboratory results indicate the deposit exhibits non-plastic to low plasticity (ML).

Parameter	Value
Liquid Limit	15 to 16
Plastic Limit	12
Plasticity Index	3 to 4

#### 6.2.4 Bedrock and Refusal

Boreholes 21-18, 21-19, 21-20, 21-23 and 21-25 were terminated at auger refusal on inferred bedrock. Boreholes 21-21, 21-22 and 21-24 were cored and terminated in bedrock. A summary of the borehole termination is presented in Table 6-4

**Table 6-4. Summary of Refusal Depths/Bedrock Surface**

Borehole ID	Ground Surface Elevation (m)	Depth Below Existing Grade (m)	Top of Bedrock Elevation (m)
21-18	102.8	9.7	93.1*
21-19	105.8	12.9	92.9*
21-20	106.8	10.3	96.5*
21-21	111.9	6.6	105.3
21-22	111.2	7.8	103.4
21-23	111.5	6.5	105.0*
21-24	111.9	3.9	108.0
21-25	114.5	1.2	113.3*

\* Inferred Bedrock by auger refusal

The bedrock encountered Boreholes 21-21, 21-22 and 21-24 consisted of grey slightly weathered to fresh limestone. The Total Core Recovery (TCR) measured on the recovered bedrock cores ranged from 97 to 100%, the Solid Core Recovery (SCR) ranged from 35 to 96% and the Rock Quality Designation (RQD) typically ranged from 46 to 89% with one value of 19% in Run 1 in Boreholes 21-24. Based on the typical RQD values, the bedrock is classified as poor to excellent quality in accordance with CFEM (2006)

Unconfined Compression Strength (UCS) testing was carried out on three samples of the bedrock core with results of 63, 75 and 127 MPa, indicating the bedrock to be strong to very strong.

Photographs of the bedrock cores are provided in Appendix C.

#### 6.2.5 Groundwater

The short-term groundwater level measurements within the open boreholes are summarized in the table below.

**Table 6-5. Groundwater Level Observations**

Borehole (screen tip elevation)	Groundwater Level		Date of Measurement
	Depth (mbgs*)	Elevation (m)	
21-18 (open borehole)	9.7	93.1	August 24, 2021
21-19 (open borehole)	11.8	94.0	August 24, 2021
21-20 (open borehole)	Dry	<96.5	August 25, 2021
21-23 (open borehole)	Dry	<105.0	August 24, 2021
21-25 (open borehole)	Dry	<113.3	August 25, 2021

\*mbgs = metres below ground surface

These observations are considered short term and it should be noted that the groundwater level at the time of construction may be different 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.

## **7 MISCELLANEOUS**

Borehole locations were selected based on proposed locations of the underpass foundations and high fill embankment alignment. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the field program.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario supplied and operated the CME drill rigs to carry out the drilling, sampling, in-situ testing, standpipe piezometer installation and decommissioning of the boreholes. Traffic control was performed per Ontario Book 7 by Beacon Lite Ltd. of Kingston, Ontario. Potable water required was provided by Montgomery Water Service of Napanee, Ontario. MASW testing was performed by Geophysics GPR International Inc. of Longueuil, Quebec. The 2020 field investigations were supervised on a full-time basis by Mr. R. Howarth, C. Tech. and Ms. S. Harrold, E.I.T. Supervision of the field investigation program was provided by Mr. C. Murray, P.Eng. The 2021 field investigation was supervised on a full-time basis by Mr. A. de Oliveira, E.I.T. and supervision of the field investigation program was provided by Mr. S. Peters, P.Eng.

Routine geotechnical laboratory testing was carried out by Thurber's geotechnical laboratory in Ottawa, Ontario. UCS testing on rock cores was completed by Stantec's laboratory in Ottawa, Ontario. Analytical testing was carried out by Paracel Laboratories Ltd. in Ottawa, Ontario. Interpretation of the data and preparation of this report were carried out by Christopher Murray, P.Eng. and Stephen Peters, P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundation Projects.

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**FINAL REV.2**  
**FOUNDATION INVESTIGATION AND DESIGN REPORT**  
**HIGHWAY 401 PALACE ROAD UNDERPASS**  
**GREATER NAPANEE, ONTARIO**  
**AGREEMENT NO. 4016-E-0014, ASSIGNMENTS 55 & 60**  
**GWP 4197-13-00**

**GEOCRES NO.: 31C-305**

**PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**8 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 design of the Palace Road Interchange in Greater Napanee, Ontario. Palace Road is to be realigned to cross over Highway 401 approximately 200 m west of its current crossing with new on/off ramps. The discussion and recommendations presented in this report are based on the information provided by McIntosh Perry Consulting Engineers (MPCE) and on the factual data obtained during the course of the investigation. Thurber Engineering Limited (Thurber) carried out the current field investigation as a sub-consultant to MPCE under Agreement No. 4016-E-0014.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation and McIntosh Perry Consulting Engineers 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.

In general terms, the encountered stratigraphy along the proposed Palace Road alignment consisted of roadway embankment fill overlying stiff clay to clayey silt, overlying loose to dense layers of sandy silt to silty sand. Eight boreholes (20-03 through 20-08, 21-16 and 21-17) were cored and terminated in strong to very strong limestone bedrock. The boreholes not advanced by coring were terminated at auger refusal on inferred bedrock. The groundwater elevation was measured in the standpipe piezometers and has ranged between elev. 95.1 m and 89.0 m as summarized in Table 6-2.

The stratigraphy encountered along the proposed E-N/S ramp consisted of loose to dense layers of sandy clayey silt and silty sand overlying strong to very strong limestone bedrock. Short term groundwater levels of elev. 93.1 and 94.0 m were recorded within two open boreholes as summarized in Table 6-5.

The existing Highway 401 Palace Road Interchange (IC582) is located 3.5 km northeast of Napanee and 0.7 km east of the Napanee River crossing of Highway 401. It is understood that the structure was constructed after 1959. The historical Geocres information indicates that for the construction of the overpass, bedrock excavation was necessary for more than half of the site and it is likely that the existing Highway 401 eastbound structure is supported by spread footings on bedrock and the existing Highway 401 westbound structure may be supported by spread footings on glacial till.

The existing overpass consists of twin single-span I-girder bridge structures with a thin slab concrete deck supported on concrete retaining wall type abutments. Both structures have a total span length of about 11.6 m and a width of about 13.7 m. Each structure accommodates two traffic lanes, one speed change lane, and narrow shoulders. Steel guiderails are present on all sides of the two structures with the exception of the southeast quadrant of the eastbound lane structure. The Highway 401 structures span over two traffic lanes on Palace Road. Cut bedrock faces are visible along Palace Road to the south of Highway 401.

The existing embankment slopes are grass covered and appear to be stable with no visible signs of recent distress.

## **8.1 Proposed Structure**

The General Arrangement (GA) drawing received from MPCE and dated September 2020 indicated that the proposed new Highway 401 Underpass beneath Palace Road is to be a two-span structure with a north and south span of 40.0 m and 47.0 m, respectively. The structure will accommodate two 3.75 m wide lanes and 2.5 m wide shoulders with a total structure width of 13.5 m. The structure is shown at an approximate 42 degree skew to Highway 401. The more recent GA drawing received from MPCE and dated August 2021 indicates that the north span is lengthened to 47.0 m and the overall structure width has been reduced to 13.2 m.

An existing Hydro One corridor crosses over Highway 401 near the location of the new Palace Road alignment. It is understood that relocation of the hydro alignment may be included as part of the current project.

The north abutment (Sta. 9+953) will be directly east of the existing N/S-W ramp and the south abutment (Sta. 10+047) will be at the location of the existing W-N/S ramp. The underside of the abutments/pile caps are schematically shown near elevations 100.4, 97.0 and 98.4 m for the north abutment, pier and south abutment, respectively.

The north approach fill at the abutment is indicated to be in the order of 11 m above the existing grades. The south approach fill at the abutment is in the order of 8.5 m and increases in height to approximately 12.5 m near the end of the wing walls. Cantilevered wingwalls are shown to support the approach fills at all four quadrants.

Based on the proposed profile of the realigned Palace Road (received from MPCE on August 2020), high fill embankments will extend approximately 350 m north and 95 m south of the abutments. Fill heights will reach a maximum of approximately 16.0 m above the existing grade at 80 m north of the north abutment (near Sta. 9+870).

Non-structural drainage culverts crossing under the new Palace Road high fill embankment are shown approximately 130 m north of the north abutment (near Sta. 9+830) and 25 m south of the south abutment (near Sta. 10+075). It is understood that culvert bedding and backfill recommendations will be provided by the Pavement Design Engineer.

## 8.2 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed foundations and existing ground conditions and in accordance with the Canadian Highway Bridge Design Code (CHBDC), version CSA S6-19. In accordance with CHBDC, the analysis and design of structures takes into consideration the importance of the structure and the consequences associated with exceeding limit states. The importance category and consequence classification are defined by the Regulatory Authority, which in this case is the Ministry of Transportation, Ontario (MTO).

It is understood that the MTO has designated this bridge structure as *Major-Route Bridge* with a *Typical Consequence*. 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.

The frost penetration depth and associated recommendations are provided in Section 11.6.

## 9 SEISMIC CONSIDERATIONS

### 9.1 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). Seismic hazard data for this site has been obtained from the GSC's seismic hazard calculator. The data includes peak ground acceleration (PGA), peak ground velocity (PGV), and the 5% damped spectral response acceleration values ( $S_a(T)$ ) for the *reference* ground condition (Site Class C) for a range of periods (T) and for a range of return periods including the 475-year, 975-year and 2475-year events. The GSC seismic hazard calculation data sheet for this site for the *reference* ground condition (Site Class C) is presented in Appendix F.

The site coefficients used to determine the design spectral acceleration values are a function of the Site Class, PGA and  $S_a(0.2)$ . The PGA value at this site provided by GSC for a *reference* Site Class C with a 2% probability of exceedance in 50 years (2475-year event) is 0.095 g. This value is to be scaled by the  $F(PGA)$  based on the site-specific Site Class, as discussed below.

### 9.2 Liquefaction Potential

The susceptibility of the cohesive soils at this site to experience liquefaction/cyclic softening was assessed following the Bray et al. (2004)<sup>1</sup> criteria using index properties. The results

of the analysis indicate the cohesive material is not susceptible to cyclic mobility under the design earthquake.

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)<sup>2</sup>. The cohesionless foundation soils are not considered to be susceptible to liquefaction under the design earthquake.

### 9.3 CHBDC Seismic Site Classification and Performance Category

In accordance with the CHBDC, the selection of the seismic site classification is based on the soil within the upper 30 m of the stratigraphy. The shear wave velocity,  $V_{s30}$ , was measured during the geophysical investigation using Multi-Channel Analysis of Surface Waves (MASW). The results of the testing conducted in the vicinity of the north and south abutments are provided in Appendix E and indicate  $V_s$  values in the overburden ranging from about 125 m/s to about 400 m/s. As per Table 4.1 within Section 4.4.3.2 of the CHBDC, the foundations soils have been classified as a Seismic Site Class C based on the measured shear wave velocities.

The  $F(PGA)$  as per Table 4.8 within Section 4.4.3.3 of the CHBDC is equal to 1.0 for this site yielding a Site Class C PGA of 0.095g.

It is anticipated that this bridge has an importance category of “major-route”. As per Section 4.4.4 of the CHBDC, a seismic performance category 1 is applicable at this site for all structural periods (T).

## 10 STRUCTURE FOUNDATION ALTERNATIVES

The table below provides a brief summary of the soil conditions encountered near the proposed elevation of the undersides of the abutments and pier. The groundwater readings presented in Table 6-2 were generally below the founding elevations (August 2021 GA) presented in Table 10-1.

**Table 10-1 Boreholes at Bridge Foundations**

Location	Estimated Base Elevation of Abutment <sup>(*)</sup>	Relevant Boreholes	Bedrock Elevation
North Abutment	100.4	21-17	87.1 m
		21-16	87.3 m
Pier	97.0	20-06	89.7 m
		20-05	88.0 m
South Abutment	98.4	20-04	89.8 m
		20-03	89.3 m

*Note: (\*) elevation estimated from General Arrangement drawing dated August 2021*

Given the soil stratigraphy and groundwater conditions encountered, the following options have been considered from a foundation's perspective for the support of the new bridge:

- Spread footings,
- Caissons (drilled shafts), and
- Steel piles (H-piles, pipe piles)

The foundation alternatives are presented below and evaluated from a foundation's perspective in terms of their respective advantages, disadvantages, risks and consequences. The evaluation is provided in the table provided in Appendix G.

- Spread Footings

The soils expected to be encountered at the founding elevation for spread footings would typically consist of existing fills underlain by native stiff to very stiff clay over compact to dense sandy clayey silt over loose to dense silty sand to sandy silt. It is not considered suitable to support foundations on existing fill; excavation and construction of an engineered pad of Granular A at least 1.0 m thick would be required. The underlying stiff to very stiff native clay would offer moderate bearing resistance. The spread footing for the pier would likely be significantly wider than a pile cap thus would likely have a greater impact on Highway 401 traffic during construction. Spread footings do not allow for construction of integral abutments.

In light of the above, it is not recommended to support the new bridge on spread footings. It may be possible to support wingwalls on spread footings; this would need to be confirmed once the highway profile and wall geometry has been established.

- Caissons/Drilled Shafts

Caisson foundations, particularly when they are socketed into bedrock, offer high geotechnical resistance. The high lateral stiffness of caissons is not compatible or suitable for integral abutments. The drilling methods would need to take into account the potential for unbalanced pressure heads and caisson base boiling while drilling through the loose to dense cohesionless soils.

Caissons are considered feasible but are not the preferred option from a foundations perspective to support the new bridge.

- Steel Piles

Based on the foundation soils encountered as part of the current investigation, driven steel piles are considered feasible for the support of the new abutments and pier. Driven steel piles could allow for the use of integral abutments provided other design constraints are met. Driven piles will typically reduce the volumes of excavation required when compared to shallow foundations which may be beneficial given the proximity of the foundation construction to Highway 401.

**Recommended Foundation Design Approach:**

It is recommended from a foundation’s perspective that the new structure be supported on driven steel piles. The underside of abutments/pile caps should follow the recommendations for frost depth, see Section 11.6.

Caissons could also be considered a viable foundation option for the support of the bridge and foundation design recommendations have been provided in the sections to follow.

Although not recommended from a foundation perspective, recommendations have been provided for spread footings to allow for structural evaluations.

**11 FOUNDATION DESIGN RECOMMENDATIONS**

**11.1 Driven Steel Piles**

11.1.1 Axial Geotechnical Resistance and Founding Elevation

Bedrock was proven by coring in all eight foundation Boreholes (20-03 through 20-08, 21-16 and 21-17), with bedrock surface elevations ranging from 89.8 to 87.1 m. The geotechnical axial resistances for HP310x110 piles bearing on bedrock are provide in Table 11-1 and may be used in design. A heavier section pile could be considered.

**Table 11-1 Axial Geotechnical Resistances for HP310x110**

Foundation Element	Estimated Pile Tip Elevation (m)	Factored Geotechnical Compression Resistance		Factored Tension Resistance
		ULS (kN)	SLS (kN)	ULS (kN)
North Abutment	87.1	2,250	will not govern	215
Pier	88.0			
South Abutment	89.3			

The pile capacities include a resistance factor of 0.4 ( $\phi_{gu}$ ), 0.8 ( $\phi_{gs}$ ) and 0.3 ( $\phi_{gt}$ ) for ULS compression, SLS compression and ULS tension values, respectively, as per Table 6.2 of the CHBDC (static analysis – typical understanding).

*The structural resistance of the pile must be checked by the structural engineer and may govern the design and the structural capacity of the pile may govern the design.*

11.1.2 Downdrag

Time dependant settlement of the cohesive foundation soils will occur due to the proposed approach embankments (see Section 11.8). As a result, deep foundations at the abutments will need to be designed to carry the additional static downdrag loads developed along the

length of the piles embedded in the cohesive layers and overlying materials. The *unfactored* static downdrag load for HP 310x110 is estimated to be up to 300 kN.

This downdrag load should be factored in accordance with the CHBDC. In accordance with Section 6.11.4.10 of the CHBDC and Clause C6.11.4.10 of the Commentary, in the structural design of a pile, the factored downdrag load should be added to the factored permanent loads to assess the effects of downdrag. In geotechnical analysis of downdrag, live load effects should not be considered.

The neutral plane for static downdrag calculations can be taken as the base of the cohesive deposits.

### 11.1.3 Lateral Geotechnical Resistance and Group Effects

Piles can be installed with a batter to resist lateral loads for a semi-integral abutment or at the pier. During a seismic event, a battered pile foundation may become too rigid, therefore the structural engineer should review.

The lateral resistance for the soil adjacent to a vertical pile is developed on the face of the pile embedded in the foundation soils and estimated using p-y curves.

The p-y curves for static conditions are shown in Appendix H to allow for calculation of the *ultimate* lateral capacity of an individual vertical pile. A geotechnical resistance factor of 0.5 ( $\phi_{gu}$ ) and 0.8 ( $\phi_{gs}$ ) as per Table 6.2 of the CHBDC (static analysis – typical understanding) should be applied to the *ultimate* ULS and SLS values, respectively. Note that the information provided in Appendix H is based on the pile cap elevation shown on the August 2021 GA Drawing and will need to be reviewed if the pile caps are modified.

Where lateral spacing between an adjacent pile or another structural element is less than four equivalent pile diameters, the lateral resistance will also need to be further reduced based on the center-to-center spacing. The reduction factors to be used can be obtained from Figures C6.22, C6.23 and C6.24 of the CHBDC.

### 11.1.4 Pile Tips

It is expected the pile installation may encounter cobbles and boulders. Care must also be exercised while driving to bedrock.

The tips of all piles must be protected from damage when driving and should be fitted with a Titus HD Rock Injector or approved equal as per Section 6.11.4.8 of the CHBDC.

### 11.1.5 Pile Driving

Pile driving must be carried out in accordance with OPSS 903 and Special Provision 109F57. For piles driven to refusal on bedrock, OPSS 903.07.02.07.03 shall apply. Care must be exercised if driving inclined piles or piles near sloping bedrock.

Vibration monitoring of newly constructed foundations should be considered. It is understood that the existing overhead Hydro lines are to be moved in advance of bridge construction. Hydro should locate new tower footings a sufficient distance from the site to prevent vibration impacts. It is not considered necessary to monitor vibrations of the existing Palace Road Overpass structures.

### 11.1.6 Abutment Type

Although the subsurface conditions at this site are considered suitable for integral abutments, the proposed abutment height (greater than 6 m) is problematic. It is noted that the structure skew angle (greater than 35 degrees) is also problematic to the use of integral abutments. Semi-Integral abutments should be considered.

## 11.2 Caissons

### 11.2.1 Axial Geotechnical Resistance

Drilled-in caissons are considered feasible at this site. At the pier, caissons could be extended up to the underside of the bridge to eliminate the need for a pile cap. It is recommended that the design use rock socketed caissons with a minimum bedrock socket length of 2B or 3 m, whichever is greater. Construction of caissons will require steel casing to support the sidewalls through native soils. The steel liners must be continuous and form a tight seal at the bedrock surface to minimize the ingress of soils and to facilitate machine-cleaning of the socket base. Care should be taken during coring and grouting/concreting to not create additional fractures within the bedrock.

The axial geotechnical capacity at factored ULS, for caissons, is given in the table below. The caisson capacities include a resistance factor of 0.4 ( $\phi_{gu}$ ) ULS as per Table 6.2 of the CHBDC (static analysis – typical understanding). The SLS condition will not govern for a caisson socketed into sound bedrock. The structural resistance of the caissons must be checked by the structural designer. The actual socketed length required should be lengthened, if required, based on the lateral capacity, moment capacity and seismic analysis to satisfy the structural assessment.

**Table 11-2 Axial Geotechnical Resistances for Rock Socketed Caissons**

Diameter (m)	Minimum Socket Depth (m)	Factored ULS <sub>f</sub> (MN)
1.2	3.0	9
1.5	3.0	13
1.8	3.6	19

### 11.2.2 Downdrag

It is understood that there will be no grade changes to the median of the existing Highway 401, therefore downdrag is not expected to occur on the pier caissons.

Downdrag for caissons installed at the abutments may be calculated as outlined in Section 11.1.2 using an unfactored downdrag load of 775, 975 and 1175 kN for a 1.2, 1.5 and 1.8 m diameter caisson, respectively. The application of downdrag and the appropriate load factors should follow the recommendations provided in Section 11.1.2.

### 11.2.3 Lateral Geotechnical Resistance

The lateral resistance provided by the soils above the bedrock may be calculated using p-y curves. The p-y curves for static conditions are shown in Appendix H to allow for calculation

of the ultimate lateral capacity of an individual caisson. Reduction factors should be applied to these ultimate values in accordance with Table 6.2 of the CHBDC.

The ultimate lateral resistance force that can be mobilized by the embedded portion of a caisson socketed within sound bedrock is constant with depth and can be taken as 2.7 MN/m, 3.5 MN/m and 4.2 MN/m length of caisson into sound bedrock for 1.2, 1.5 and 1.8 m diameter caissons, respectively. A suitable reduction factor should be applied to this ultimate value in accordance with Table 6.2 of the CHBDC.

Where lateral spacing between an adjacent caisson or another structural element is less than four equivalent caisson diameters, the lateral resistance will also need to be further reduced based on the center-to-center spacing. The reduction factors to be used can be obtained from Figures C6.22, C6.23 and C6.24 of the CHBDC.

#### 11.2.4 Caisson Installation

Caisson installation must be in accordance with OPSS.PROV 903.

The caisson equipment supplied by the Contractor must be capable of advancing through the existing soil and penetrate or push aside potential obstructions. Coring equipment must be able to penetrate the bedrock without fracturing the sidewalls. Depth of socket should be measured from the lower bedrock elevation for a sloping bedrock scenario.

Construction of caissons will require use of slurry methods or a water filled steel liner seated into the bedrock surface to support the sidewalls, minimize groundwater inflow and enable machine-cleaning of the socket base.

Integrity testing should be considered where space allows for testing of the caissons such as Crosshole Sonic Logging or Thermal Integrity Profiling (TIP).

The Contractor shall use appropriate means such as a clean-out bucket, air lift, hydraulic pump or other devices approved by the CA to clean the bottom of all sockets. A clean-out alone is not sufficient for final clean-out. The cleaning methods, inspection method and any additional measures required to satisfy the acceptance criteria must be selected by the Contractor to ensure direct contact between the concrete and undisturbed bedrock at the socket base. It is the Contractor's responsibility to apply means necessary to clean the socket and sidewalls. A shaft inspection field report shall be submitted to the CA for acceptance prior to proceeding with concreting the caissons. Caisson concrete should be placed within 6 hours after the socket inspection or the socket must be reinspected. The caisson concrete should be allowed to cure prior to initiating drilling of the adjacent caisson.

### 11.3 Spread Footings

Although footings are not recommended at the abutments from a foundation constructability perspective, design recommendations have been provided for spread footings to allow for structural evaluations. *It should be noted that full embankment preloading is required at both abutments prior to the construction of the bridge foundations.* The requirement for a preload will result in the need for extensive excavations after completion of the preload period in order to construct the abutment footings. A temporary protection system (see Section 12.2) may need to be employed to allow for footing construction. Excavation extents

for the pier may encounter space restrictions to maintain the work zone within the existing median.

The existing fill is not considered suitable for the support of a spread footing. The existing fill extended down to elevations 93.8, 93.7 and 94.3 m at the north abutment, pier and south abutment, respectively. The native founding layer, directly below the existing fill, consisted of clay with sand to silty, clayey sand and is approximately 4.6, 5.8 and 4.6 m below the existing grade at the north abutment, pier and south abutment, respectively as shown on the GA drawing. Substantial temporary excavations will be required through the approach fill to construct the abutment footings. The groundwater level within the piezometers nearest to the bridge foundations was recorded as high as elev. 95.1 m during the time of the field investigation.

Footings should be founded at a depth, when measured perpendicular to the ground surface, that is greater than the depth of frost (see Section 11.6).

The footings should be constructed on a minimum 1 m thick engineered granular pad consisting of Granular 'A' material that is placed on the founding soil layer. A geotextile (Class II non-woven FOS 50 to 150 µm) should be placed as a separator between the Granular 'A' and the underlying material. The top of the Granular 'A' pad must extend to 1.0 m beyond the edge of all sides of the footing and be sloped away from the footing at 1H:1V, or flatter.

Where space restricts the construction of an engineered granular pad, a mud slab can be poured with concrete of the same class as the footing to protect the exposed subgrade from disturbance. This will require a taller abutment stem to reach the founding elevation. The mud slab should be placed as soon as possible after reaching the subgrade level to protect the subgrade from traffic and weather.

The following table provides the factored geotechnical resistance values that are recommended for cast-in-place footings:

**Table 11-3. Geotechnical Resistances for Cast-in-Place Footing**

Cast-in-Place Footing Width (m)	Factored Geotechnical Resistance		
	ULS at Abutments & Pier (kPa)	SLS at Abutments (kPa)	SLS at Pier (kPa)
3	225	150	200
4	250	135	175
5	275	120	150
6	300	100	125

The geotechnical resistances presented are for vertical concentric loading only on cast-in-place footings and will need to be adjusted for the effects of inclined or eccentric loadings, where applicable, in accordance with CHBDC Clause 6.10.5. The geotechnical SLS resistance values given above are based on an estimated total settlement not

exceeding 25 mm and are in addition to the settlements presented in Table 11-10. *It is noted that the settlement limit of 25 mm at SLS assumes that the preload program described in Section 11.8 has been completed in advance of abutment construction.* The footing settlement is expected to be substantially completed by the end of construction. Differential settlement is not expected to exceed 15 mm across the width of the structure for subgrades prepared with good workmanship and following the recommendations provided in Section 11.8.

The horizontal resistance against sliding between a cast-in-place concrete footings founded on engineered fill can be computed using a unfactored coefficient of friction factor 0.5. Appropriate resistance factors should be applied for the design.

#### 11.4 Wingwalls

Based on August 2021 GA drawing, it is understood that the wingwalls will be cantilevered from the abutment stem and therefore foundation recommendations are not required.

#### 11.5 Backfill and Lateral Earth Pressures

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 to the extents shown on OPSD 3101.150. The backfill should be compacted and compaction equipment to be used adjacent to the structure must be restricted in accordance with OPSS.PROV 501.

The design of the abutments and wingwalls must incorporate a subdrain as shown in OPSD 3101.150. 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. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in abutment and wingwall design.

##### 11.5.1 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 11-4.

**Table 11-4. Static Earth Pressure Coefficients**

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active, $K_A$ (Yielding Wall)	0.27	0.40
At Rest, $K_O$ (Non-Yielding Wall)	0.43	-
Passive, $K_p$ (movement toward soil)	3.7	-

A geotechnical resistance factor of 0.5 ( $\phi_{gu}$ ) should be applied in static design to the passive earth pressures in accordance with Table 6.2 of the CHBDC (static analysis - *typical* understanding).

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. Where ground surfaces are sloped behind the walls, the corresponding coefficients provided in the Table 11-4 should be used.

If lateral movement is not permissible and/or the wall is restrained, the at-rest earth pressure coefficient should be used. If the wall design allows lateral movement, the active earth pressures should be used. Passive earth resistance in front of the structure should be ignored.

#### 11.5.2 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:

- $k_h = \frac{1}{2} * F(\text{PGA}) * \text{PGA}$ , for structures that allow 25 to 50 mm of movement, and
- $k_h = F(\text{PGA}) * \text{PGA}$ , for non-yielding walls

The coefficients of horizontal earth pressure for seismic loading presented in Table 11-5 may be used for vertical walls. The provided earth pressure coefficients are based on a Seismic Site Class C, *reference* PGA with a 2% probability of exceedance in 50 years of

0.095g (Geological Survey of Canada – Fifth Generation) and a F(PGA) of 1.0 as per Table 4.8 of the CHBDC.

**Table 11-5. Combined Static and Seismic Earth Pressure Coefficients**

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Slope Surface Behind Wall (2H:1V)
Active, $K_{AE}$ Yielding Wall	0.30	0.45
Active, $K_{AE}$ Non-Yielding Wall	0.33	0.53

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)

## 11.6 Frost Depth

The frost penetration depth at this site is 1.5 m as per OPSD 3090.101. Therefore, a minimum of 1.5 m of earth cover, or thermal equivalent, must be provided above the base of the footings and pile caps to serve as protection against frost. The earth cover should be measured perpendicular to the ground surface. Thermally equivalent frost protection could be in the form of insulation, provided it is placed above the high water level.

Frost taper treatments, if required, should be as directed by the Pavement Engineer.

## 11.7 Cement Type and Corrosion Potential

Analytical tests were completed to determine the potential for degradation of concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel used in

buried infrastructure. The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. The class of concrete selected should consider the effects of road de-icing salts.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The tests results provided in Section 6.1.10 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The corrosive effects of road de-icing salts should also be considered.

## **11.8 Embankment Design and Construction**

### **11.8.1 Embankment Construction**

Based on the proposed profile of the realigned Palace Road, high fill embankments will extend approximately 350 m north and 95 m south of the new abutments. Fill heights will reach a peak of approximately 16.0 m above the existing grade at 90 m north (near Sta. 9+870) of the north abutment. The embankments are considered to be very high and consideration should be given to lowering the profile if possible.

The subsurface conditions of the proposed high fill embankments were investigated to assess stability, potential for settlement as well as construction concerns. For the purposes of preparing geotechnical design recommendations, a number of assumptions have been made, including:

- Organic deposits and other deleterious materials will be removed prior to constructing embankments (OPSS.PROV 206). Where new fill is to cross an existing road, all asphalt will be removed within the embankment footprint.
- Embankments will be constructed with Select Subgrade Material (SSM), Granular B Type I or Type II.
  - It is understood that rockfill is not expected to be available in large quantities. Therefore, embankment construction and slope inclinations should follow the recommendations for granular embankments unless sufficient rock fill quantities are available to construct the embankment up to the pavement structure. Consideration could be given to using available rock fill to backfill the existing Palace Road once the existing Highway 401 Overpasses are removed. The rock fill will more closely match the behaviour of the adjacent bedrock than would granular fill.
  - Earth fill is not recommended as the preferred material to be used due to the significant height of the embankments. However, earth fill could be used provided it is non-plastic or low plastic material, no organic content, unfrozen, with a moisture content near optimum and is handled and stored appropriately to control moisture. Additional placement restrictions are provided in Section 11.8.2.
- The fill will be placed in lifts and compacted in accordance with OPSS.PROV 501.
- Embankment construction will be carried out in accordance with OPSS.PROV 206.

- Where new fill is placed against an existing embankment slope or on a sloping ground surface steeper than 3H:1V, the existing slope will be benched (OPSD 208.010).
- Embankment should be constructed with side slopes no steeper than 2.5H:1V (see Section 11.8.2) if constructed with SSM or Earth Fill.
  - Where embankments are constructed with Granular B Type I or Type II, consideration could be given to constructing with side slopes no steeper than 2H:1V.
- Embankment slopes will be provided with one 2 m wide bench for every 8 m of vertical height. This will require 2 berms for embankment where heights are 16 m or greater. The elevation profile of the berms should match the roadway profile.
- Permanent drainage will be provided along the highway and erosion protection will be provided for embankment slopes. Consideration should be given to including an asphalt curb (OPSD 601.010) along the highway and directing flow to a subdrain or a defined rock lined channel.
- The Owners of existing utilities within and near the footprint of the proposed embankments will be consulted to determine the associated impacts to their utilities.

#### 11.8.2 Embankment Stability

Stability analyses were carried out for the north approach embankment (near 9+953) and highest fill (Sta. 9+870) under both static and seismic loading conditions. The stability analyses were carried out utilizing the commercially available slope stability program SLOPE/W of the GeoStudio software package developed by Geo-Slope International. The Morgenstern-Price method of slices for limit equilibrium analyses was used.

The input parameters and soil model used in the stability analyses, including soil stratigraphy, engineering properties, groundwater conditions and the embankment geometry for selected analyses are shown in Appendix H. The material properties used in the analyses are summarized in Table 11-6 and were determined by in-situ testing and soil index correlations developed during current and past projects. The results of the stability analyses are summarized in Table 11-7 and provided in Figures H1 through H60 within Appendix H.

**Table 11-6. Summary of Material Properties in Slope Stability Analyses**

Material	Unit Weight (kN/m <sup>3</sup> )	Drained / Long Term		Undrained / Short Term
		Friction Angle (deg.)	Cohesion Intercept (kPa)	Cohesion (kPa)
<i>New Fill: Gran B II</i>	22	35	-	-
<i>New Fill: Gran B I</i>	20	32	-	-
<i>New Fill: SSM</i>	21	30	-	-
<i>New Fill: Earth</i>	20	28	-	-
Fill: Silty Clayey Sand	21	30	-	-
Clay with Sand	19	29	-	75
Silty Clayey Sand	19	29	-	-
Sandy Silt	19	29	-	-
Silty Sand	20	30	-	-

**Table 11-7. Summary of Slope Stability Factors of Safety**

Location	Embank. Fill	Slope Inclination	Factor of Safety (Outputs provided in Appendix H)			
			Long Term (Effective Stress Parameters)	Short Term (Effective Stress Parameters with Bbar)		Seismic ( $k_h = 0.05g$ )
			<i>minimum target Factors of Safety</i>			
			1.5	1.3	1.3	1.1
High Fill Embank. (Sta. 9+870) H ~ 16.0 m <sup>(**)</sup>	Gran. B Type II	2.0H:1V	1.6	1.4	1.7	1.5
	Gran. B Type I		1.5	1.3	1.5	1.3
	SSM		1.4	1.2	1.4	1.2
		2.5H:1V	1.6	1.4	1.6	1.4
	Earth <sup>(*)</sup>	1.5	1.3	1.5	1.3	
North Approach Embank. (Sta. 9+953) H ~ 10.5 m <sup>(**)</sup>	Gran. B Type II	2.0H:1V	1.6	1.6	1.6	1.4
	Gran. B Type I		1.5	1.5	1.5	1.3
	SSM		1.3	1.3	1.3	1.2
		2.5H:1V	1.6	1.6	1.6	1.4
	Earth <sup>(*)</sup>	1.5	1.5	1.5	1.3	
North Approach Embank. Forward Slope H ~ 10.5 m	Gran. B Type II	2H:1V	1.5	1.5	1.5	1.3
	Gran. B Type I		1.3	1.3	1.3	1.2
	SSM		1.2	1.2	1.2	1.1
		2.5H:1V	1.5	1.5	1.5	1.3
	Earth <sup>(*)</sup>	1.4	1.4	1.4	1.2	

Note: (\*) Please see Section 11.8.1 for description of Earth Fill, (\*\*) Includes a 2 m wide berm for every 8 m of vertical embankment height

Adequate factors of safety are achieved for embankments constructed with Granular B Type I or Type II Fill with side slope inclination of 2H:1V, or flatter, with 2 m wide mid-height benches at 8 m vertical intervals.

The stability analyses indicate that the required factors of safety are not met for embankments constructed with SSM with 2H:1V side slopes. Adequate factors of safety are achieved for embankments constructed with SSM or Earth Fill with side slope inclination of 2.5H:1V. *However, agreement should be obtained from the Ministry to use earth fill for construction of embankments with such significant heights.*

Additional placement restrictions would not need to be considered for an embankment constructed with SSM, Granular BI or BII. However, if earth fill is to be used, the rate of fill placement should be limited to no more than a total of 4 m height placed per week. A suggested operational constraint is provided in Appendix I. Compaction efforts for each 0.3 m lift (OPSS 206.07.07.02) should be carefully monitored. Earth fill must not be placed in winter months or freezing conditions. Regrading and compaction may be required after precipitation events. Earth fill must not be placed within or above the structural backfill envelope (OPSD 3101.150)

Provided the subgrade preparation and construction of the embankment is carried out in accordance with recommendations provided within this report and OPSS 206, embankment side slopes at 2.5H:1V or flatter should remain stable under both static and seismic conditions. Surficial erosion protection will be required. Ditch geometry should be determined such that the final design does not have an impact on embankment stability.

*It is noted that analyses incorporating spread footing foundations for the bridge abutment have not been included herein. Design build contractors will need to verify embankment stability for this scenario.*

### 11.8.3 Embankment Settlement

An analysis was carried out to estimate the settlement of the soils under the weight of the proposed embankment fill materials of up to 16.0 m in height.

In accordance with MTO's document "Embankment Settlement Criteria for Design" (March 2, 2010), the criteria adopted for embankment design at this site is as follows:

**Table 11-8. Summary of MTO Settlement Criteria**

Distance from Abutment	0-20 m	20-50 m	50-75 m	>75 m	Post Construction Settlement Period
Settlement Limits Non-Freeway	25 mm	50 mm	100 mm	200 mm	15 years

The material properties used in the settlement analyses are summarized in Table 11-9. The estimated foundation settlements are presented in Table 11-10.

**Table 11-9. Summary of Material Properties in Settlement Analysis**

Material	Unit Weight (kN/m <sup>3</sup> )	Elastic Modulus (kPa)
Fill: Silty Clayey Sand	21	5,000 to 15,000
Clay with Sand	19	15,000 to 30,000
Silty Clayey Sand	19	7,000 to 9,000
Sandy Silt	19	7,000
Silty Sand	20	6,000 to 19,000

**Table 11-10. Summary of Estimated Settlements**

Location	Drainage Culvert  Sta. 10+075	South Abutment  Sta. 10+047	North Abutment  Sta. 9+953	Highest Centerline Fill  Sta. 9+870	Drainage Culvert  Sta. 9+830
Fill Height	11.0 m	8.5 to 12.5 m	10.5 m	16.0 m	12.5 m
Borehole Reference	20-01	20-03 20-04	20-07 20-08 21-16 21-17	20-10 20-11	20-11
Settlement Criteria (see Table 11-8)	50 mm	25 mm	25 mm	200 mm	200 mm
Estimated Total Foundation Settlement	160 mm	120 mm	200 mm	180 mm	175 mm
Embankment Fill Compression (SSM, Gran BI or BII)	55 mm	45 mm	55 mm	85 mm	65 mm
Embankment Fill Compression (Earth Fill)	85 mm	70 mm	80 mm	120 mm	95 mm
Estimated Post-Const. Foundation Settlement	~ 25 mm	~ 25 mm	35 mm	60 mm	70 mm

The magnitude of the self-compression for the new embankment constructed with granular materials (SSM, Granular BI or BII) is in the order of 0.5% (~45 to 85 mm) of the newly placed embankment height and is expected to predominantly occur during fill placement. For properly compacted earth fill, the self-compression will be in the order of 0.75% of the

newly placed embankment height (70 to 120 mm) and it should be expected that half of the self compression would occur during construction and the remainder to occur up to 1 year after completion of construction.

The embankment and platform width must be overbuilt to allow for the anticipated settlement of the underlying soils as well as the embankment self-compression. Embankment fill top-up may be required to reinstate the design grades.

The combined foundation settlement and embankment compression is greater than MTO criteria. Therefore, it is recommended that a 3 month preload period be included in the construction schedule to allow for the majority of the settlement to occur prior to construction of the culverts, bridge and foundation elements. The preload period for approach embankments within 50 m of abutments constructed with earth fill should be increased to 5 months. Paving should also be delayed until end of the preload period. Provided the recommended preload period is achieved, the MTO settlement criteria summarized in Table 11-8 should be met.

*It should be noted that the new abutments and approach fills will encroach onto the existing N/S-W ramp and W-N/S ramp. Preloading will not be achieved in these areas without a full closure or relocation of these ramps. If the ramps can not be closed for sufficient duration, additional analyses will be required.*

The design of the non-structural drainage culverts should consider the magnitude of foundation settlement. An oversized culvert and/or cambering may be required. Alternatively, consideration could also be given to installing the culvert with trenchless methods after the preload period has occurred.

It is suggested that the requirement for a settlement monitoring program be incorporated into the Contract. The settlement monitoring program will be utilized to confirm the duration of the preload period. The required specifications and drawings should be prepared by the Design-Build Contractor.

The abutment piles or caissons will be subjected to downdrag loads as a result of the foundation settlements. See Section 11.1.2 and 11.2.2 for discussion on downdrag loading. If the abutment area is fully preloaded for the recommended duration, downdrag on the abutment piles will be reduced.

### **11.9 Cut Slope Recommendations for E-N/S Ramp**

A road profile for the E-N/S ramp was provided by MPCE in May 2021. The proposed top of road grade for the ramp is summarized in the following table as well as the refusal depth for the nearest borehole. It is noted that the base of ditch is approximately 1.2 m below the top of top of road grade.

**Table 11-11 Ramp Elevation Data**

E-N/S Ramp Station	Nearest Borehole	Existing Grade Elev. at BH (m)	Approximate Top of Ramp Elev. (m)	Depth of Cut to Top of Ramp** (m)	Top of Bedrock/ Refusal Elev. (m)	Water Elevation (Table 6-5)
60+035	21-18	102.8	101.4	1.4	93.1*	93.1
60+060	21-19	105.8	103.1	2.7	92.9*	94.0
60+075	21-20	106.8	103.8	3.0	96.5*	N/A
60+110	21-21	111.9	105.6	6.3	105.3	N/A
61+145	21-22	111.2	106.8	4.4	103.4	N/A
	21-23	111.5		4.7	105.0*	
61+180	21-24	111.9	109.1	2.8	108.0	N/A
61+230	21-25	114.5	111.6	2.9	113.3*	N/A

Note: (\*) elevation inferred by auger refusal. (\*\*) maximum cut height in rock is approximately 1.2 m deeper to account for crossfall, pavement structure thickness and ditch depth.

The final cut slopes will be constructed in sections containing predominately native earth slopes with limited areas containing rock faces.

All excavation to form the cut slopes must be carried out in accordance with Occupation Health and Safety Act (OSHA). For the purposes of the OSHA, the overburden cut material at this site is classified as Type 3 soils above the water level.

Construction should be carried out in accordance with OPSS.PROV 206. To maintain stability of the cut slopes, it is required that drainage measures be incorporated into the design. An interceptor ditch should be provided at the top of earth cuts as per OPSD 200.010 and 201.010. Roadside ditches are expected to provide an adequate level of surface drainage. The drainage/unwatering system design must take account of all MOE/MNR requirements regarding, among other things, taking water, discharge water and the turbidity of the discharge.

#### 11.9.1 Earth Cuts

Excavation of cut slopes should be carried out in accordance with OPSS.PROV 206. In earth cuts with a height of less than 8m, final slopes constructed no steeper than 2 horizontal to 1 vertical (2H:1V) are expected remain stable. Should the earth cut slopes be in excess of 6 m in total height, a 2 m wide mid-height bench must be provided along the length of the earth cut. An interceptor ditch should be provided at the top of the earth cut. Slopes should be protected from erosion in a timely manner and prior to spring run-off.

#### 11.9.2 Rock Cuts

Excavation into bedrock is expected. The selection of the method of excavating and removing the bedrock is the responsibility of the contractor. Overburden should be removed prior to commencing drilling and blasting operations to accurately establish the bedrock surface. Rock excavation should be completed in accordance with OPSS.PROV 206. The

rock cut should be designed in accordance with OPSD 201.010. The design of temporary slopes is the responsibility of the contractor. For rock cuts under 10 m, the rock face can remain vertical provided the required clear zone is maintained.

Clearzone width for the ramp should meet the requirements of the Roadside Design Manual (RDM). The maximum rock cut height is anticipated to be less than 4 m from bottom of ditch to top of rock, thus the risk of rockfall debris interacting with traffic is low provided OPSD 201.010 is utilized. Carefully controlled excavation techniques will minimize face instabilities and long-term maintenance problems resulting from damage to the rock mass. Where final cuts are to have earth slopes on top of the rock cut, the toe of the earth slope must be set back a minimum of 3 m from the top of the rock face and constructed no steeper than 2 horizontal to 1 vertical (2H:1V) as per OPSD 201.010.

Consideration should be given to widening the rock excavations should there be a need for rock fill elsewhere on the project.

Rock excavation utilizing blasting should be carried out in accordance with OPSS 120, including blast design by a qualified Engineer/firm, explosive use by a competent blasting contractor, monitoring by a blast monitoring consultant, preparation of a pre-blast survey, and notification of any nearby utility authorities. Preconstruction survey of structures, utilities and water wells within 500 m of blasting should be carried out. Likewise, vibration monitoring should also be considered for nearby facilities.

### 11.9.3 Transitional Areas

Transitional treatments are required between rock/earth and cut/fill subgrades, please refer to the pavement design report for recommendations.

## 12 CONSTRUCTION CONSIDERATIONS

### 12.1 Temporary Excavations

All excavation must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The fill materials and native soils above the water table may be classified as Type 3 soil. The soils below the groundwater level are classified as Type 4 soils. If an excavation penetrates more than one soil type, the entire excavation must be completed in accordance with the more stringent requirement. Excavation should occur in a dewatered environment. Excavations must be planned and carried out in a manner that does not impact on the stability of existing roadways.

The excavated soils are not considered to be reusable as embankment fill or backfill on this site. However, consideration could be given to reuse in landscaped areas.

Excavation for the structure must be carried out in accordance with OPSS 902 as amended by SP 109S12 and NSSP FOUN0003 and will be carried out through the existing fill and into the underlying native deposits. Please refer to Section 12.3 for designer fill-in recommendations. Selection of the equipment and methodology to excavate and prepare the founding surface 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) are also the Contractor's responsibility.

At locations where there are space restrictions or where a slope has to be retained, the excavations will need to be carried out within a protection system. Further discussion on temporary protection systems (TPS) is presented in Section 12.2.

## 12.2 Temporary Protection Systems

Temporary Protection Systems may be required during various stages of construction and must be implemented in accordance with OPSS.PROV 539 as amended by SP 105S09. Performance Level 2 (maximum 25 mm horizontal deflection) is considered appropriate where the protection supports the existing highway. More stringent performance levels may be required if the protection system is intended to support existing structures or utilities. The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system.

The design of roadway protection is the responsibility of the Contractor. All protection systems should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The design of the roadway protection system must incorporate traffic loading and surcharge loading due to construction equipment and operations. A suitable anchoring and/or bracing system may need to be incorporated into the temporary protection design to resist lateral earth pressure loadings.

Lateral earth pressure coefficients, under fully mobilized conditions, that can be used in design of the protection system installed through Granular A material are provided in Table 11-4. The lateral earth pressure coefficients for the existing soils are given below:

Existing fills:

$$\begin{aligned}\gamma &= 21 \text{ (kN/m}^3 \text{ bulk unit weight of soil, to be adjusted below water)} \\ K_A &= 0.33 \\ K_P &= 3.0\end{aligned}$$

Native cohesionless:

$$\begin{aligned}\gamma &= 20 \text{ (kN/m}^3 \text{ bulk unit weight of soil, to be adjusted below water)} \\ K_A &= 0.33 \\ K_P &= 3.0\end{aligned}$$

Native cohesive soils:

$$\begin{aligned}\gamma &= 19 \text{ (kN/m}^3 \text{ bulk unit weight of soil, to be adjusted below water)} \\ K_A &= 0.35 \\ K_P &= 2.88 \\ S_u &= 50 \text{ kPa}\end{aligned}$$

### **12.3 Surface and Groundwater Control**

The depth of excavation is not expected to extend below the groundwater level observed at the time of investigation. Water from surface flow and/or groundwater must be diverted away from excavation(s) at all times. Groundwater perched within the fill and surface water will tend to seep into and accumulate in excavations. The Contractor must be prepared to control the groundwater and surface water at the site. The water level must be lowered below the base of the excavation to allow construction in the dry.

The design of dewatering 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 SP FOUN0003 which amends OPSS 902. A preconstruction survey is not required, thus Designer Fill-In \*\* in SP FOUN0003 should be "N/A".

The water level will fluctuate and the minimum groundwater elevation for the site at the time of the excavation should be taken as the expected high water level defined in SP517F01 and SP FOUN0003.

Where required, a sheet piled enclosure can be designed following the recommendations provided in Sections 12.1 and 12.2.

Excavation that extend below the groundwater level without prior dewatering is not recommended since the inflow of groundwater will make it difficult to maintain a dry, sound base on which to work. Disturbance of the subgrade soils is considered to be a risk without proper consideration of groundwater lowering. The groundwater level should be lowered to 0.5 m below the planned base of excavation for each stage of excavation.

Further assessment of the dewatering requirements and the need for a Permit to take Water (PTTW) should be carried out by specialists experienced in this field.

### **12.4 Erosion Control**

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

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. A vegetation cover should be established on all exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804. Additional measures may be required due to the significant height of embankments proposed for this site. Likewise, erosion protection measure will need to be implemented for embankments constructed with earth fill to maintain integrity.

Earth cut slopes must be provided with erosion protection in accordance with OPSS 804. The finished earth cut slopes should be inspected for ongoing seepage emerging from the cut slopes. Gravel sheeting or rock protection may be required to provide drainage of the seepage to prevent erosion of the slope face

### 13 CONSTRUCTION CONCERNS

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

- Obstructions may be encountered during construction and interfere with excavations and installation of deep foundation and temporary protection systems. 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.
- Excavation will be required adjacent to Highway 401. The stability of the excavation slopes and the base of the excavations must be considered in the design and selection of excavation protection and dewatering systems.
- Consideration will have to be given to the proximity of the nearby utilities and hydro transmission towers and special attention will need to be taken into account during construction to avoid any damage to the utilities. The overhead hydro lines should be relocated in advance of bridge construction as they represent possible equipment headroom restrictions.
- 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.
- The existing overpass structures are to be demolished upon completion of the new interchange. Structural elements deeper than 1.5 m below finished grade can be cut off and left in place. Embankment fill to support Highway 401 should consist of OPSS Select Subgrade Material placed and compacted in accordance with OPSS.PROV 206 and 501. The embankment should incorporate 2H:1V side slopes. Consideration could be given to using rock fill with 1.5H:1V side slopes.

The successful performance of the project will depend largely upon good workmanship and quality control during construction. Subgrade examination and field density testing should be carried out by qualified personnel during construction to confirm that foundation recommendations are correctly implemented and material specifications are met.

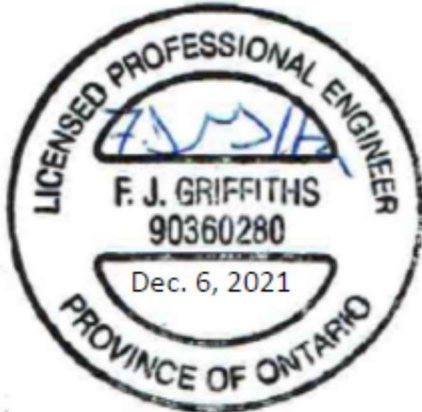
## 14 CLOSURE

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

Thurber Engineering Ltd.  
Report Prepared By:



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Geotechnical Engineer



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Senior Associate  
Senior Geotechnical Engineer



Dr. P.K. Chatterji, P.Eng.  
Review Principal  
Senior Geotechnical Engineer

## References

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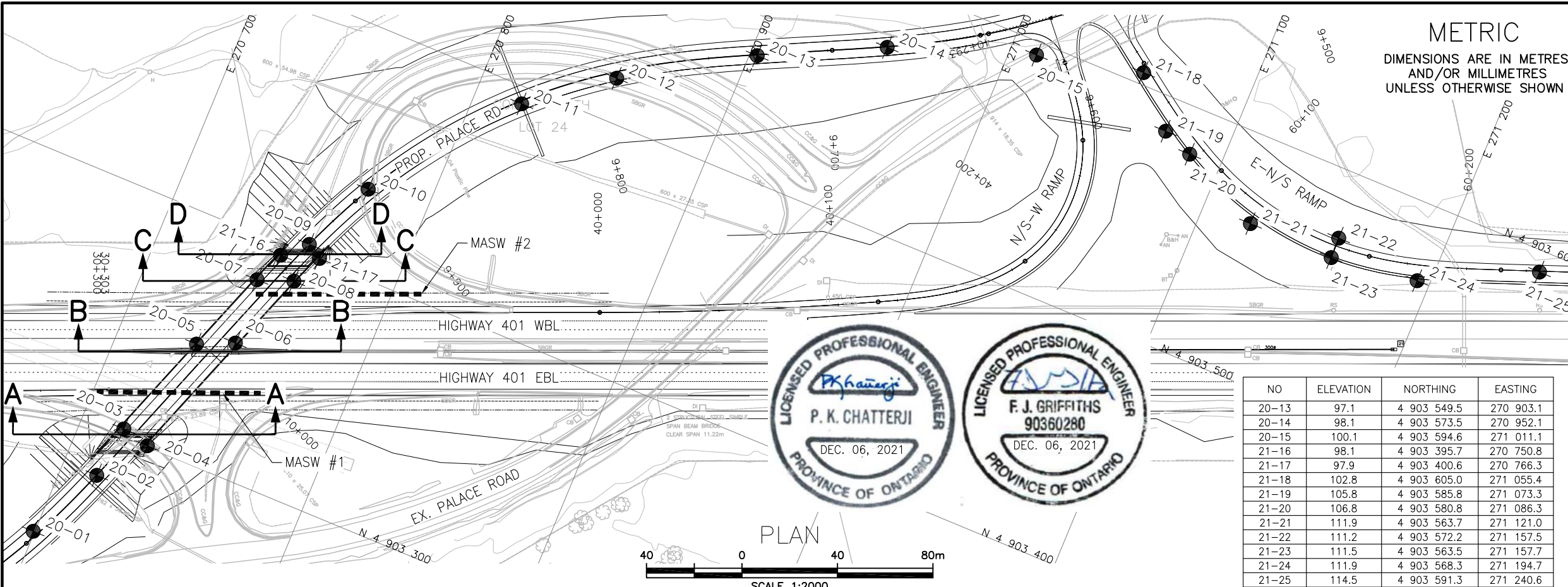
<sup>1</sup> Bray, J. D. et al. (2004b). Liquefaction susceptibility of fine-grained soils. Proc., 11th Int. Conf. on Soil Dynamics and Earthquake Engineering and 3rd Int. Conf. on Earthquake Geotechnical Engineering, D. Doolin et al., eds., Stallion Press, Singapore, 655–662

<sup>2</sup> 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.

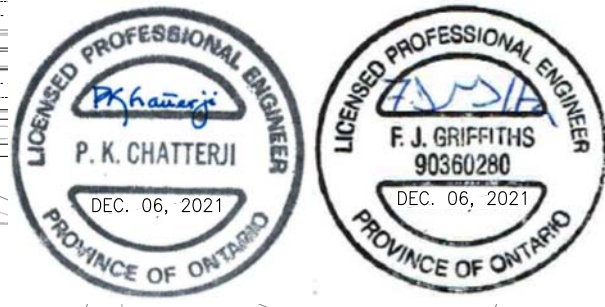
## **Appendix A.**

### **Drawings**

MINISTRY OF TRANSPORTATION, ONTARIO



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

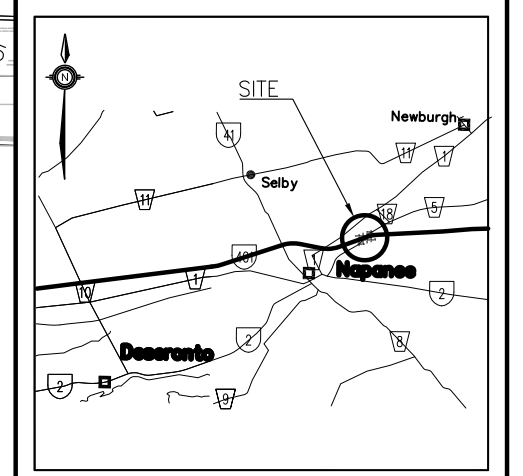


NO	ELEVATION	NORTHING	EASTING
20-13	97.1	4 903 549.5	270 903.1
20-14	98.1	4 903 573.5	270 952.1
20-15	100.1	4 903 594.6	271 011.1
21-16	98.1	4 903 395.7	270 750.8
21-17	97.9	4 903 400.6	270 766.3
21-18	102.8	4 903 605.0	271 055.4
21-19	105.8	4 903 585.8	271 073.3
21-20	106.8	4 903 580.8	271 086.3
21-21	111.9	4 903 563.7	271 121.0
21-22	111.2	4 903 572.2	271 157.5
21-23	111.5	4 903 563.5	271 157.7
21-24	111.9	4 903 568.3	271 194.7
21-25	114.5	4 903 591.3	271 240.6

CONT No  
WP No 4197-13-00

HIGHWAY 401  
PALACE ROAD INTERCHANGE  
PROPOSED PALACE ROAD  
BOREHOLE LOCATIONS AND SOIL STRATA

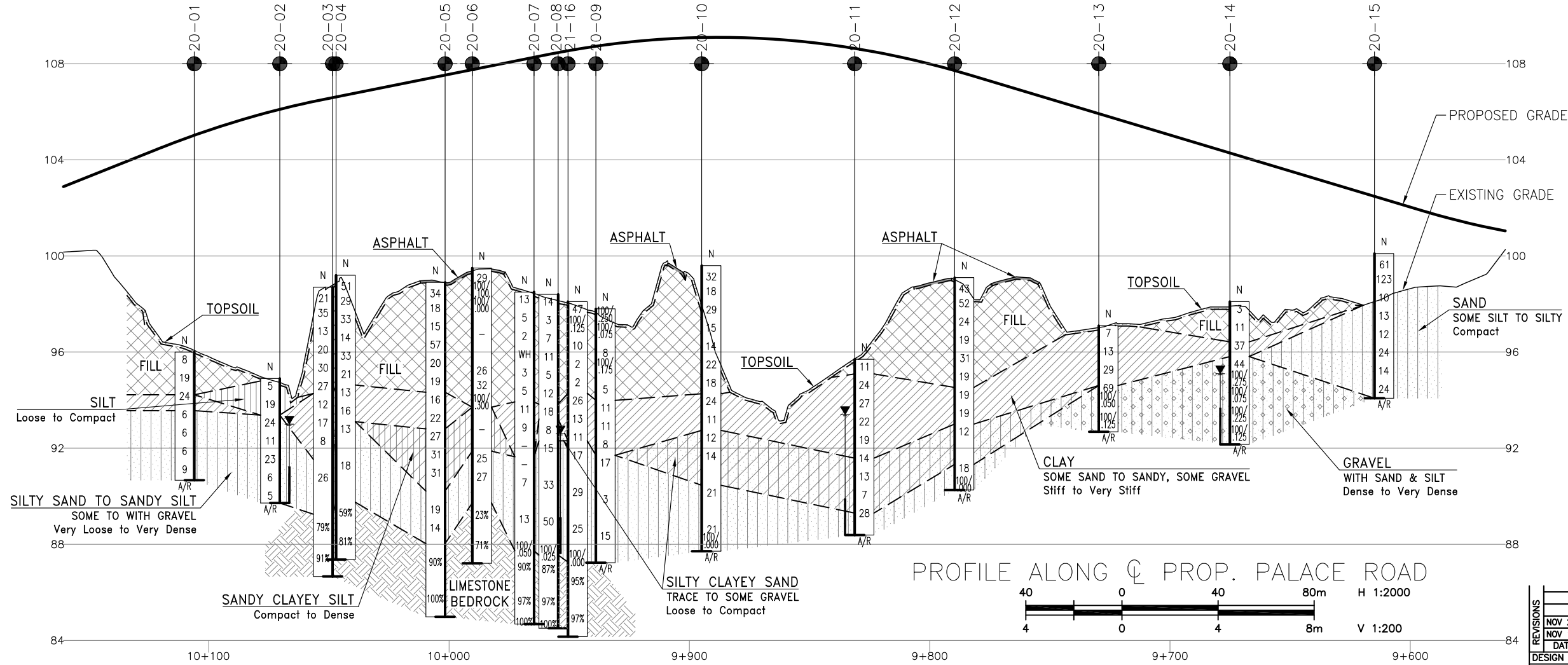
SHEET



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
20-01	96.0	4 903 249.1	270 699.3
20-02	94.9	4 903 280.9	270 715.0
20-03	98.7	4 903 303.2	270 718.0
20-04	99.2	4 903 300.5	270 729.8
20-05	98.9	4 903 347.8	270 732.5
20-06	99.5	4 903 354.4	270 747.3
20-07	98.5	4 903 382.4	270 745.6
20-08	98.4	4 903 387.7	270 760.1
20-09	97.8	4 903 404.5	270 760.1
20-10	99.6	4 903 435.3	270 774.0
20-11	95.7	4 903 493.0	270 819.7
20-12	99.1	4 903 518.1	270 852.4

- NOTES-**
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
  - This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
  - Coordinate system is MTM NAD 83 Zone 9.

**GEOCREs No. 31C-305**

REVISIONS

NO	DATE	BY	DESCRIPTION
1	NOV 26	SP	ADDED SECTION D-D
2	NOV 16	SP	ADDED BH21-16 TO PALACE ROAD PROFILE

DESIGN CM CHK SP CODE LOAD DATE DEC 2021  
DRAWN MFA CHK CM SITE STRUCT 17X-003/20 DWG 1

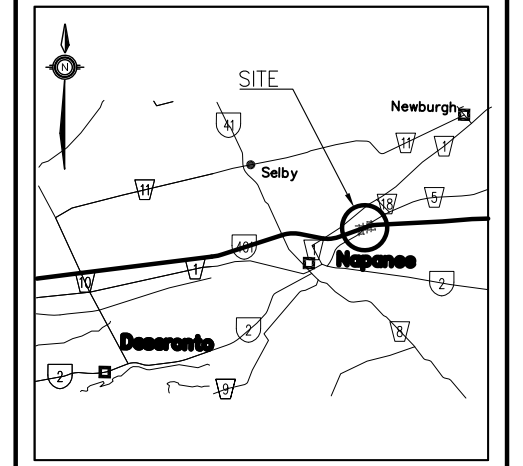
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METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WP No 4197-13-00

HIGHWAY 401  
PALACE ROAD INTERCHANGE  
PROPOSED PALACE ROAD  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



KEYPLAN  
LEGEND

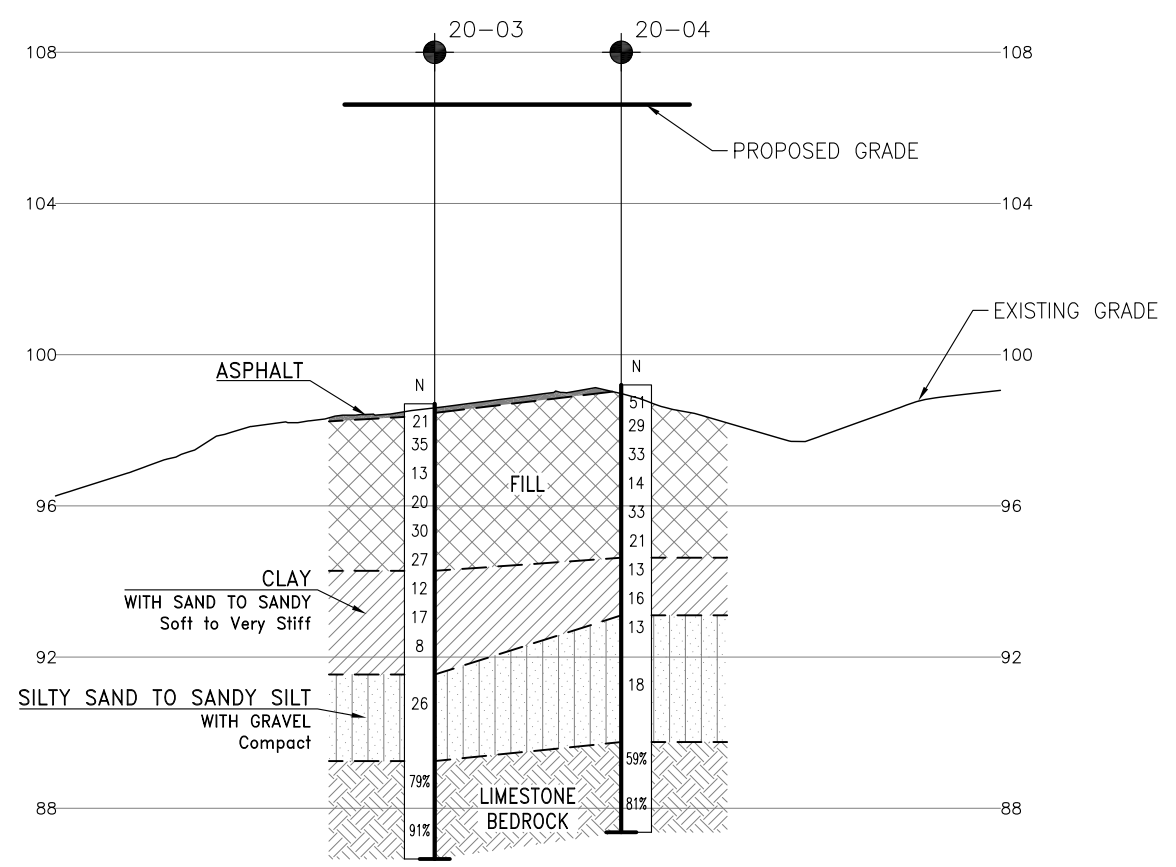
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	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
20-03	98.7	4 903 303.2	270 718.0
20-04	99.2	4 903 300.5	270 729.8
20-05	98.9	4 903 347.8	270 732.5
20-06	99.5	4 903 354.4	270 747.3
20-07	98.5	4 903 382.4	270 745.6
20-08	98.4	4 903 387.7	270 760.1

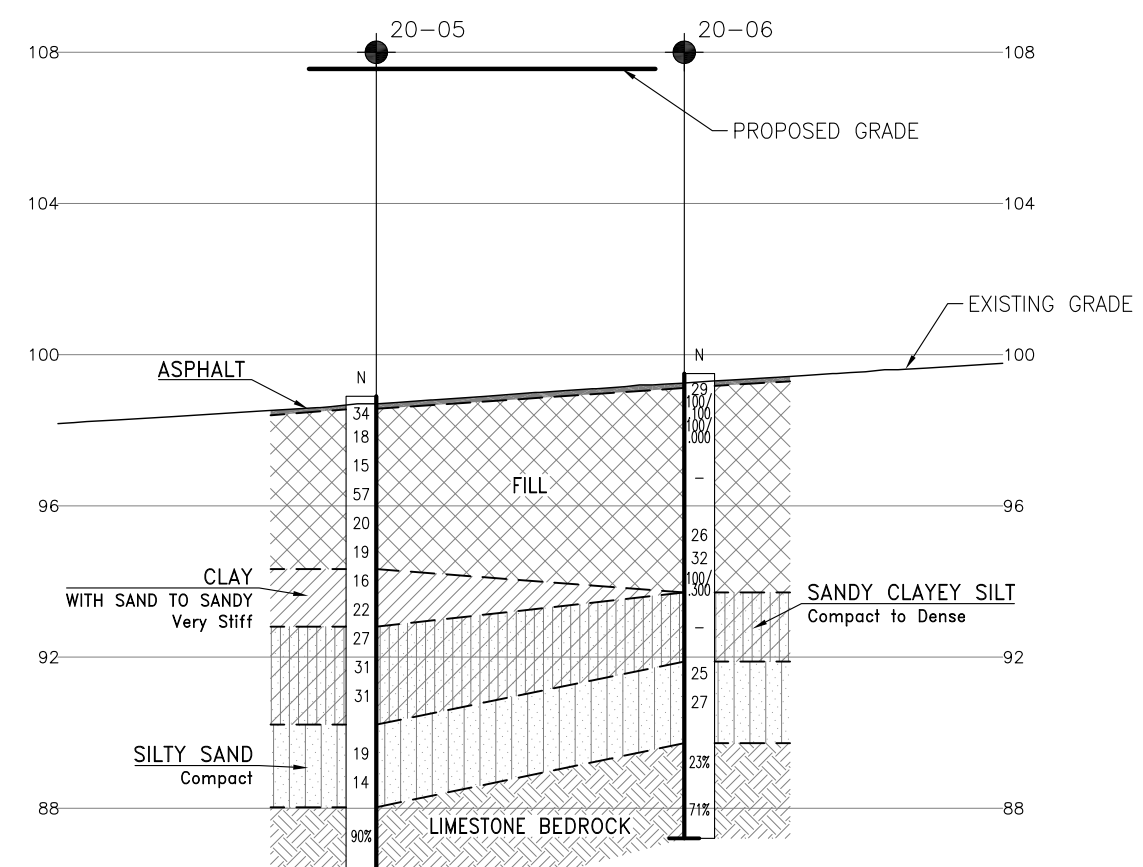
-NOTES-

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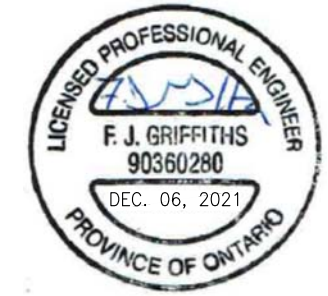
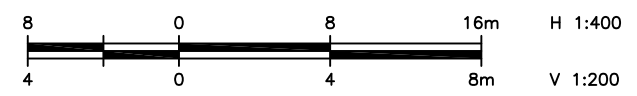
GEORES No. 31C-305



SECTION A-A (SOUTH ABUTMENT)



SECTION B-B (PIER)



REVISIONS	DATE	BY	DESCRIPTION
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NOV 16	SP		ADDED BH21-16 TO PALACE ROAD PROFILE

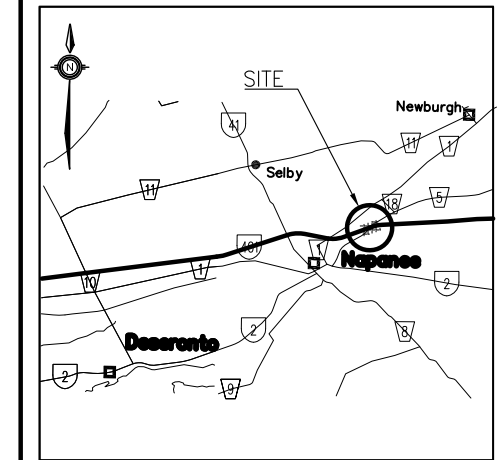
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DRAWN MFA CHK CM SITE STRUCT 17X-003/20 DWG 2

METRIC  
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AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WP No 4197-13-00

HIGHWAY 401  
PALACE ROAD INTERCHANGE  
PROPOSED PALACE ROAD  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



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

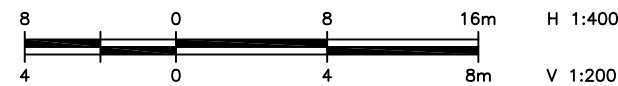
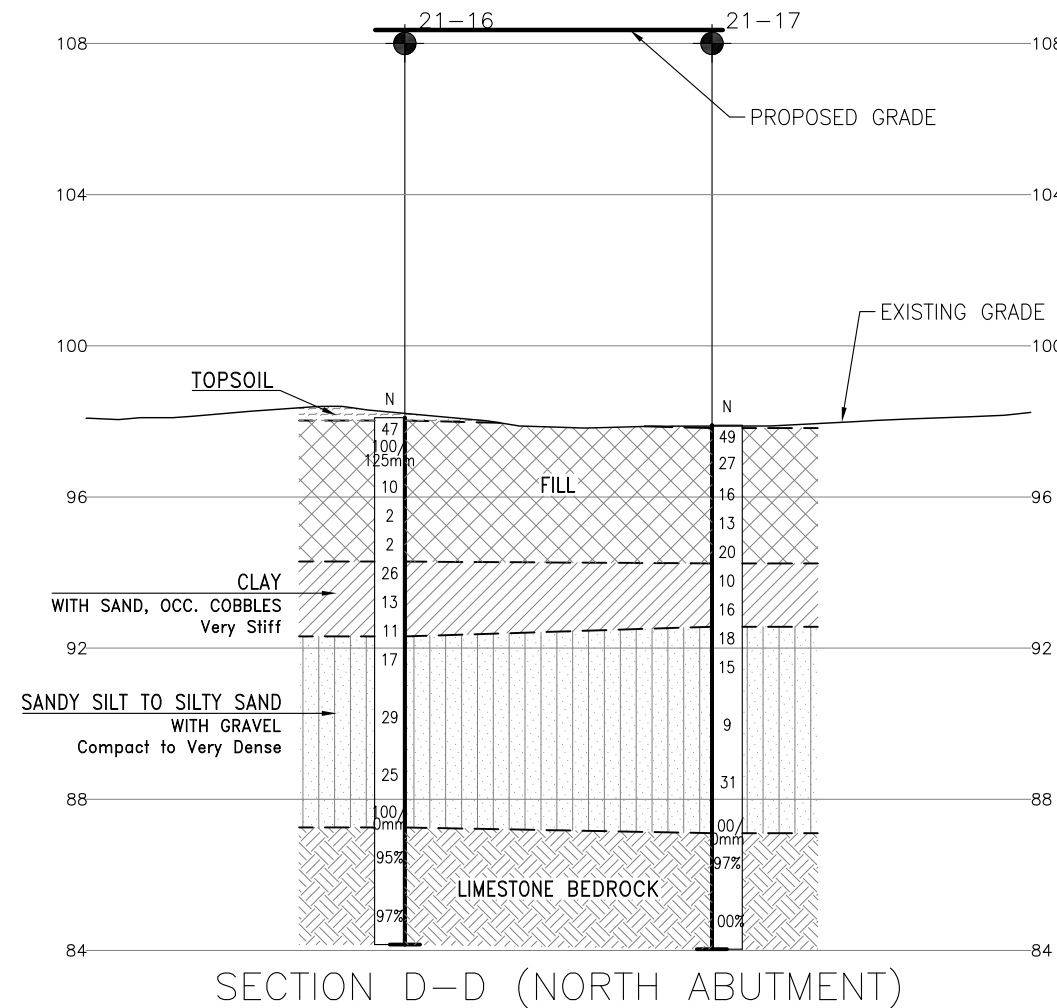
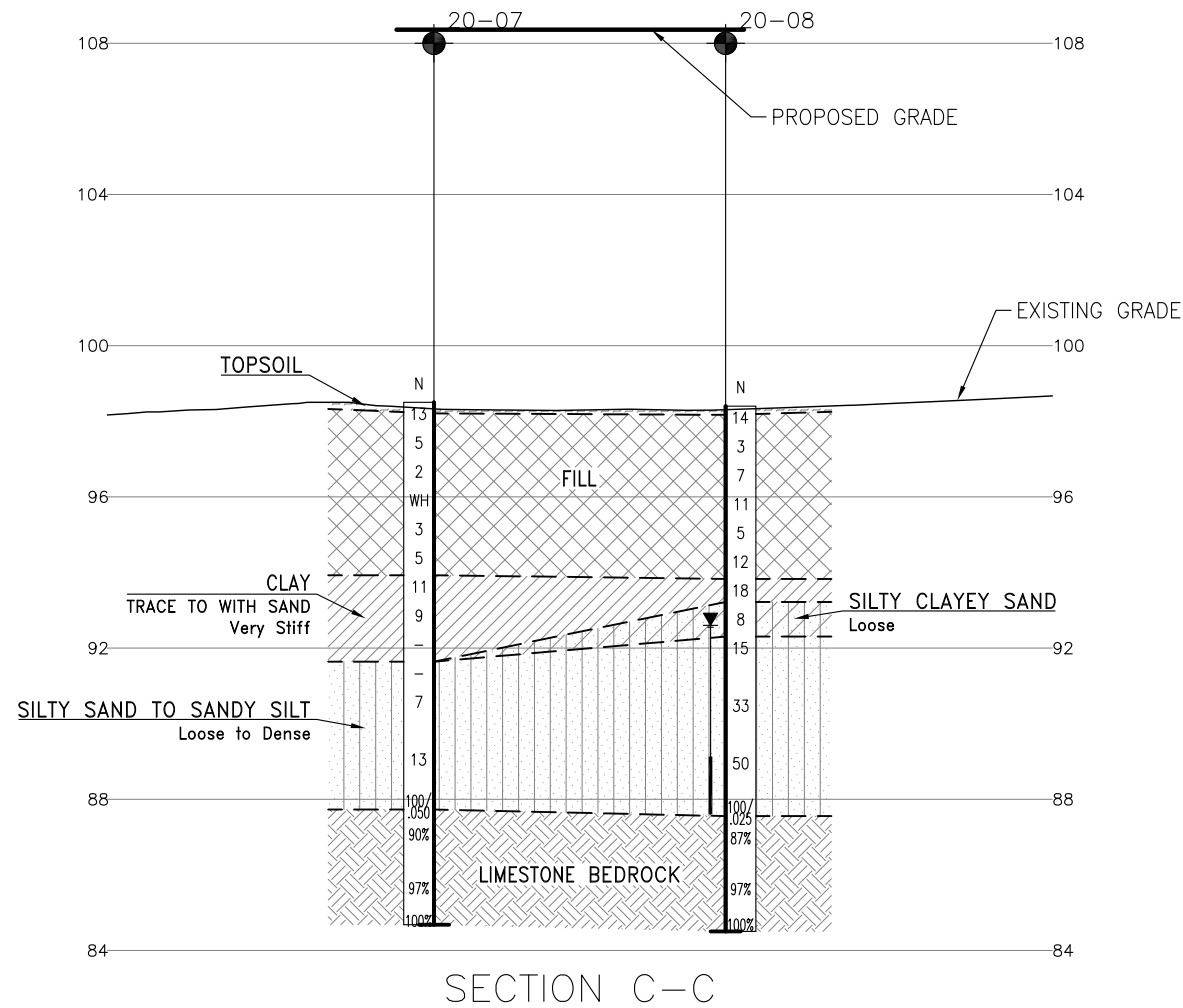
NO	ELEVATION	NORTHING	EASTING
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20-04	99.2	4 903 300.5	270 729.8
20-05	98.9	4 903 347.8	270 732.5
20-06	99.5	4 903 354.4	270 747.3
20-07	98.5	4 903 382.4	270 745.6
20-08	98.4	4 903 387.7	270 760.1

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GEORES No. 31C-305

REVISIONS	DATE	BY	DESCRIPTION
NOV 26	SP		ADDED SECTION D-D
NOV 16	SP		ADDED BH21-16 TO PALACE ROAD PROFILE
DATE	BY		DESCRIPTION
DESIGN	CM	CHK SP	CODE
DRAWN	MFA	CHK CM	SITE
			LOAD
			DATE DEC 2021
			STRUCT 17X-003/20 DWG 3



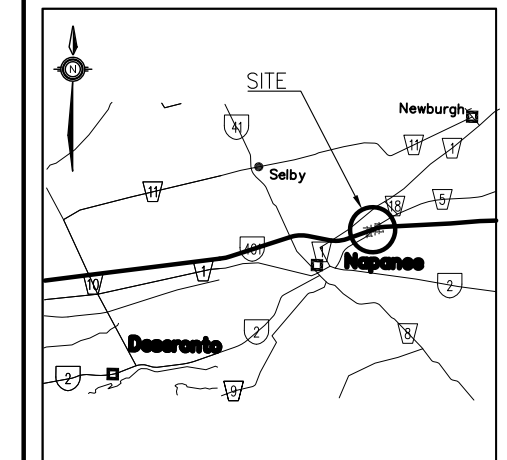
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AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



CONT No  
WP No 4197-13-00

HIGHWAY 401  
PALACE ROAD INTERCHANGE  
PROPOSED E-N/S RAMP  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



KEYPLAN

LEGEND

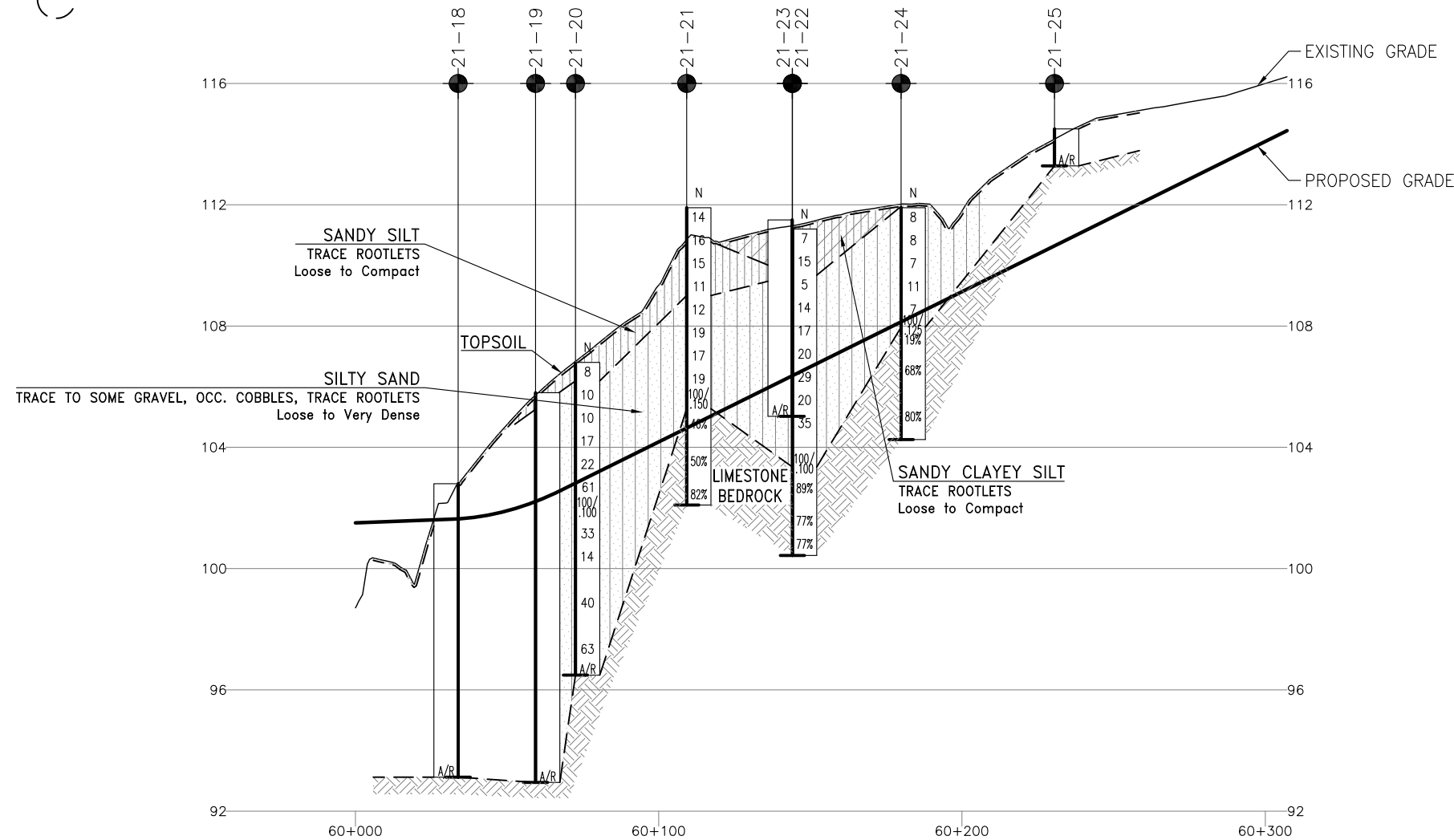
- Borehole
- ⊙ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- ∇ Water Level
- ⊕ Head Artesian Water
- ⊥ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
21-18	102.8	4 903 605.0	271 055.4
21-19	105.8	4 903 585.8	271 073.3
21-20	106.8	4 903 580.8	271 086.3
21-21	111.9	4 903 563.7	271 121.0
21-22	111.2	4 903 572.2	271 157.5
21-23	111.5	4 903 563.5	271 157.7
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21-25	114.5	4 903 591.3	271 240.6

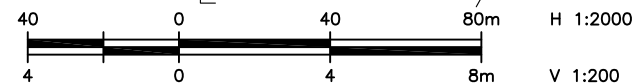
-NOTES-

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- 3) Coordinate system is MTM NAD 83 Zone 9.

GEOCREs No. 31C-305



PROFILE ALONG C PROP. E-N/S RAMP



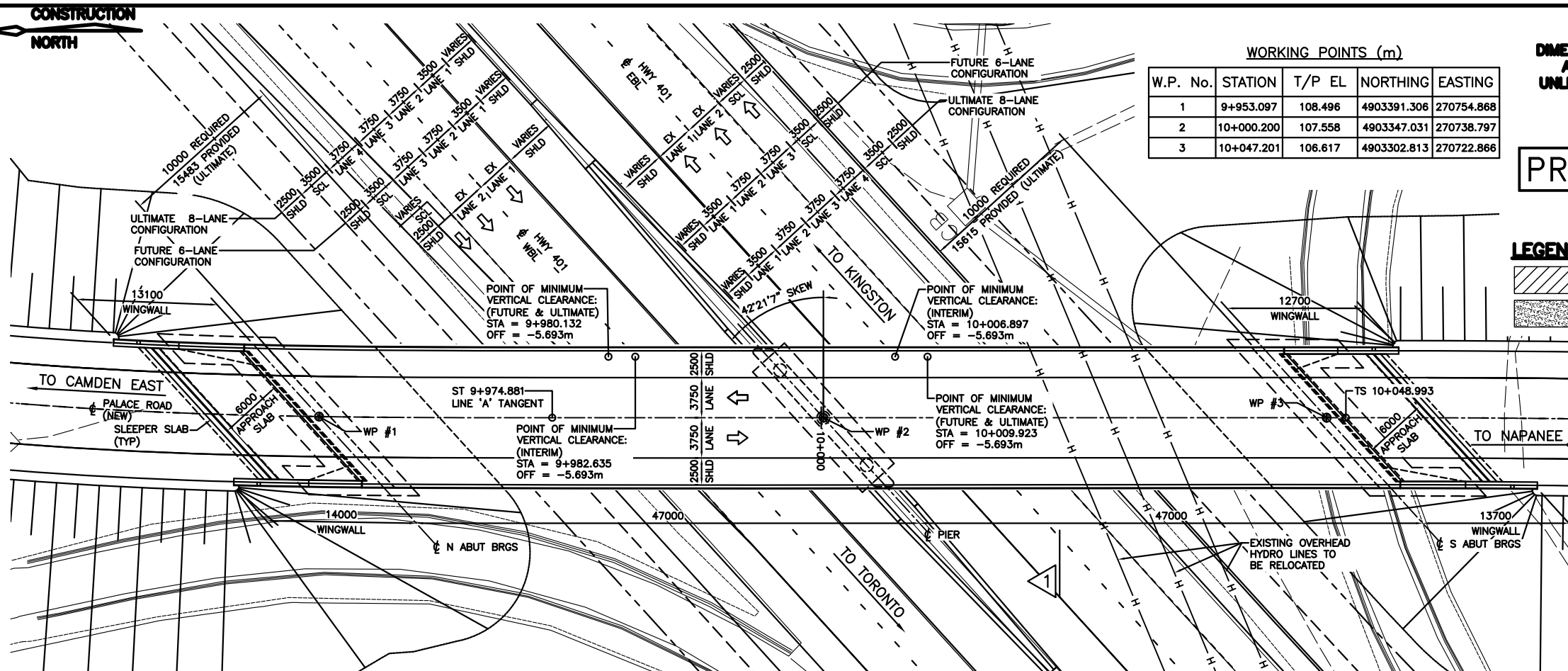
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NOV 16	SP		ADDED BH21-16 TO PALACE ROAD PROFILE

DESIGN	CM	CHK	SP	CODE	LOAD	DATE	DEC 2021
DRAWN	MFA	CHK	CM	SITE	STRUCT 17X-003/20	DWG	4

CONSTRUCTION

NORTH



WORKING POINTS (m)

W.P. No.	STATION	T/P EL	NORTHING	EASTING
1	9+953.097	108.496	4903391.306	270754.868
2	10+000.200	107.558	4903347.031	270738.797
3	10+047.201	106.617	4903302.813	270722.868

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

**HIGHWAY 401**  
CONT. No. XXXX-XXXX  
GWP No. 4197-13-00



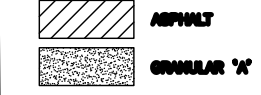
**PALACE ROAD UNDERPASS**  
REPLACEMENT  
**PRELIMINARY**  
GENERAL ARRANGEMENT

**SHEET**  
137

**PRELIMINARY**

**McINTOSH PERRY**

LEGEND:



GENERAL NOTES:

- CLASS OF CONCRETE 30 MPa
- CLEAR COVER TO REINFORCING STEEL
  - FOOTING 100 ± 25
  - DECK TOP 70 ± 20
  - DECK BOTTOM 40 ± 10
  - PIER CAPS 70 ± 10
  - REMAINDER 70 ± 20
  - UNLESS OTHERWISE NOTED
- REINFORCING STEEL
  - REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
  - UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES SHALL BE CLASS B.
  - STAINLESS REINFORCING STEEL SHALL BE TYPE 316LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPa, UNLESS OTHERWISE SPECIFIED.
  - BAR MARKS WITH PREFIX 'S' DENOTES STAINLESS STEEL BARS.
  - BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1 UNLESS INDICATED OTHERWISE.

CONSTRUCTION NOTES:

- THE CONTRACTOR SHALL VERIFY ALL RELEVANT DIMENSIONS, ELEVATIONS AND DETAILS ON SITE AND REPORT ANY DISCREPANCIES TO THE CONTRACT ADMINISTRATOR PRIOR TO PROCEEDING.
- THE CONTRACTOR IS FULLY RESPONSIBLE FOR ADEQUATE PROTECTION OF ALL UTILITIES, SERVICES, ROADWAYS, ETC., DURING CONSTRUCTION OPERATIONS.
- THE CONTRACTOR SHALL ESTABLISH THE BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESS FROM THE TOP OF BEARING ELEVATION, IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN IN THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.
- BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH ABUTMENT DIAPHRAGMS KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm, IN ACCORDANCE WITH OPSS 902.
- BACKFILL SHALL NOT BE PLACED BEHIND THE ABUTMENT DIAPHRAGMS UNTIL CONCRETE IN DECK AND DIAPHRAGMS HAS REACHED 25 MPa STRENGTH.

LIST OF ABBREVIATIONS:

ABUT	ABUTMENT	OG	ORIGINAL GROUND
APPROX	APPROXIMATE	SHLD	SHOULDER
BRGS	BEARINGS	STA	STATION
EBL	EASTBOUND LANES	TYP	TYPICAL
EXIST	EXISTING	WBL	WESTBOUND LANES
EXP	EXPANSION	WP	WORKING POINT
FIN	FINISH		
FIX	FIXED		
OFF	OFFSET		

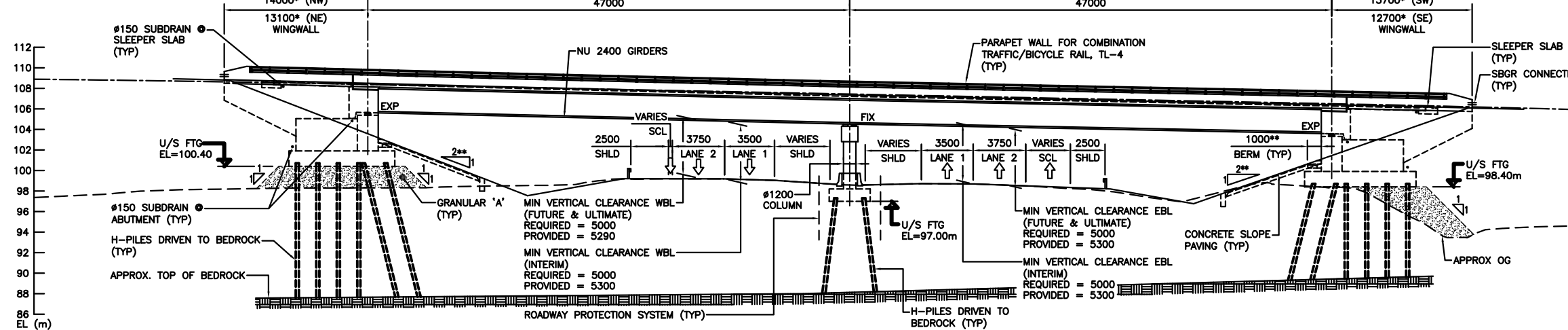
LIST OF DRAWINGS:

P1	GENERAL ARRANGEMENT
----	---------------------

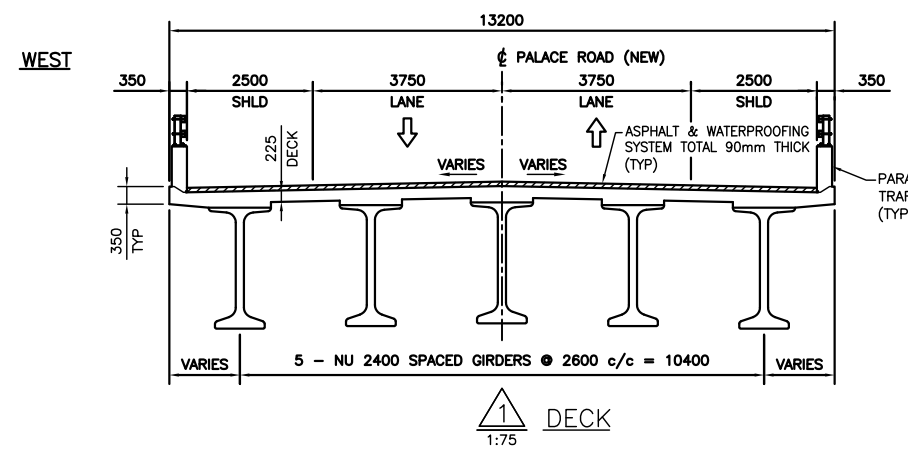
APPLICABLE STANDARD DRAWINGS:

- OPSD 3370.100 DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE WITH PROTECTION BOARD
- OPSD 3370.101 DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE AT ACTIVE CRACKS GREATER THAN 2mm WIDE AND CONSTRUCTION JOINTS
- OPSD 3101.150 WALLS, ABUTMENTS, BACKFILL, MINIMUM GRANULAR REQUIREMENTS
- OPSD 3390.100 DECK DRIP CHANNEL
- OPSD 3419.100 BARRIERS AND RAILINGS, STEEL BEAM, GUIDE RAIL AND CHANNEL ANCHORAGE
- MTD 3941.210 FIGURES IN CONCRETE SITE NUMBER AND DATE LAYOUT
- OPSD 3950.100 JOINTS CONCRETE EXPANSION AND CONSTRUCTION ON STRUCTURE

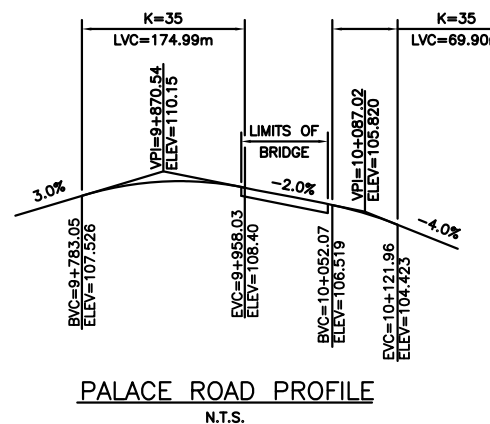
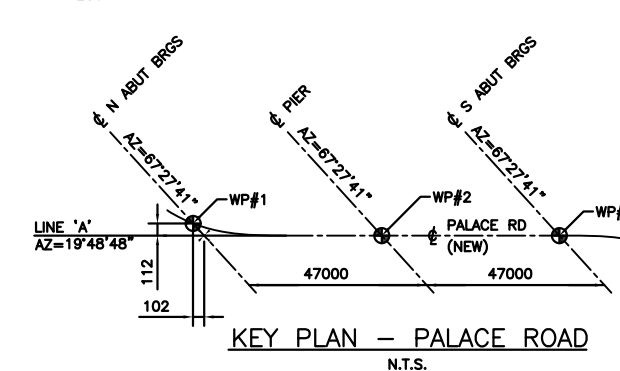
NORTH 14000\* (NW) 47000 47000 13700\* (SW) SOUTH



ELEVATION 1:250  
\* MEASURED ALONG OUTSIDE FACE OF PARAPET WALL  
\*\* MEASURED PERPENDICULAR TO HWY 401



1 DECK  
1:75



DATE	BY	REV	DESCRIPTION

ALL DIMENSIONS AND WORKING POINTS TO BE SHOWN - MAY 401 PALACE ROAD UNDERPASS - ADVISORY ONLY - NOT TO BE USED FOR CONSTRUCTION  
 DATE PLOTTED: 07/24/2023 09:58:58 AM  
 USER: JLM

**Appendix B.**  
**Record of Borehole Sheets**



## 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).

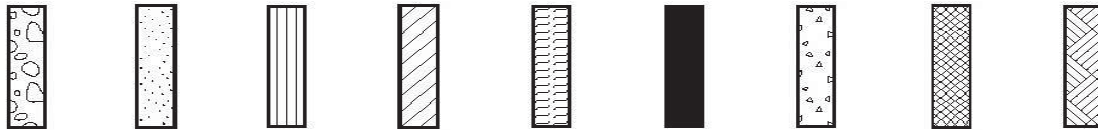
### DYNAMIC CONE PENETRATION TEST (DCPT):

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.



**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



**MODIFIED UNIFIED SOIL CLASSIFICATION**

Major Divisions		Group Symbol	Typical Description
<b>COARSE GRAINED SOIL</b>	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.
<b>FINE GRAINED SOILS</b>	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 or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
<b>HIGHLY ORGANIC SOILS</b>		Pt	Peat and other organic soils.

Note -  $W_L$  = Liquid Limit



## 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 20-01

1 OF 1

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.268446°, Long: -76.927135° Palace Road Interchange, MTM z9: N 4 903 249.1 E 270 699.3 ORIGINATED BY SH  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.22 - 2020.10.22 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
						WATER CONTENT (%)								
						PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	W <sub>p</sub>	W	W <sub>L</sub>			
96.0	Ground Surface													
0.0	TOPSOIL (100mm)													
0.1	SAND with Silt Loose to Compact Brown FILL		1	SS	8									
			2	SS	19								2 86 12 (SI+CL)	
94.2														
1.8	CLAY (C) with Sand Stiff to Very Stiff Brown		3	SS	24								1 20 28 51	
93.6														
2.4	SILTY SAND trace gravel Loose Brown		4	SS	6									
			5	SS	6									
			6	SS	6									
			7	SS	9								6 67 27 (SI+CL)	
90.7														
5.3	End of Borehole - Auger Refusal Borehole Dry on Completion													

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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



### RECORD OF BOREHOLE No 20-03

1 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.268934°, Long: -76.926906° Palace Road Interchange, MTM z9: N 4 903 303.2 E 270 718.0 ORIGINATED BY RH  
 HWY 401 BOREHOLE TYPE CME75 Truckmount, HSA / NW Casing / NQ Coring COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.22 - 2020.10.22 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa 20 40 60 80 100							
98.7	Pavement Surface														
0.0	ASPHALT (150 mm)														
0.2	GRAVEL with Silt and Sand Compact to Dense Grey FILL	[Pattern]	1	SS	21									45 45 10 (SI+CL)	
97.4			2	SS	35										
1.3	Clayey SAND some Gravel to Silty, Clayey Sand some Gravel Compact Grey FILL	[Pattern]	3	SS	13										
			4	SS	20										14 43 29 14
			5	SS	30										
			6	SS	27										
94.3	CLAY (C) with Sand Stiff to Very Stiff Grey	[Pattern]	7	SS	12										
4.4			8	SS	17										2 25 38 35
			9	SS	8										
91.5	SILTY SAND with Gravel Compact Brown	[Pattern]													
7.2			10	SS	26										16 60 24 (SI+CL)
89.3	LIMESTONE BEDROCK Very Strong Slightly Weathered to Fresh	[Pattern]													
9.4															FI 1 RUN #1 TCR=100% SCR=95% RQD=79% 2

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

Continued Next Page

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

### RECORD OF BOREHOLE No 20-03

2 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.268934°, Long: -76.926906° Palace Road Interchange, MTM z9: N 4 903 303.2 E 270 718.0 ORIGINATED BY RH  
 HWY 401 BOREHOLE TYPE CME75 Truckmount, HSA / NW Casing / NQ Coring COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.22 - 2020.10.22 CHECKED BY CM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	Continued From Previous Page					20 40 60 80 100										
							○ UNCONFINED	+	FIELD VANE							
							● QUICK TRIAXIAL	×	LAB VANE							
							WATER CONTENT (%)									
							20	40	60	80	100					
86.7	LIMESTONE BEDROCK Very Strong Slightly Weathered to Fresh Thinly Bedded Fine Grained Grey		1	RUN											1	RUN #2 TCR=95% SCR=95% RQD=91%
							88									
			2	RUN											0	
						87									1	
12.0	End of Borehole														2	

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

### RECORD OF BOREHOLE No 20-04

1 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.26891°, Long: -76.926757° Palace Road Interchange, MTM z9: N 4 903 300.5 E 270 729.8 ORIGINATED BY RH  
 HWY 401 BOREHOLE TYPE CME75 Truckmount, HSA / NW Casing / NQ Coring COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.21 - 2020.10.21 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
							20	40	60	80	100				
99.2	Pavement Surface														
0.0	ASPHALT (150 mm)														
0.2	SAND and GRAVEL Dense to Compact Grey FILL		1	SS	51										
97.9			2	SS	29										
1.3	GRAVEL with Silt and Sand Compact to Dense Grey FILL		3	SS	33										57 36 7 (SI+CL)
96.2			4	SS	14										
3.0	Silty, Clayey SAND trace Gravel Dense to Compact Grey FILL		5	SS	33										9 44 35 12
94.6			6	SS	21										
4.6	Sandy CLAY (Cl) Stiff to Very Stiff Grey		7	SS	13										
93.1			8	SS	16										5 27 29 39
6.1	SANDY SILT trace Gravel to SILTY SAND Compact Brown-Grey		9	SS	13										6 43 51 (SI+CL)
92			10	SS	18										
89.8															
9.4	LIMESTONE BEDROCK Very Strong Slightly Weathered to Fresh		1	RUN									FI		RUN #1 TCR=100% SCR=100% RQD=59% UCS=111MPa

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

Continued Next Page

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

### RECORD OF BOREHOLE No 20-04

2 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.26891°, Long: -76.926757° Palace Road Interchange, MTM z9: N 4 903 300.5 E 270 729.8 ORIGINATED BY RH  
 HWY 401 BOREHOLE TYPE CME75 Truckmount, HSA / NW Casing / NQ Coring COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.21 - 2020.10.21 CHECKED BY CM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	Continued From Previous Page					20 40 60 80 100										
						○ UNCONFINED + FIELD VANE										
						● QUICK TRIAXIAL × LAB VANE										
						20 40 60 80 100										
87.4	LIMESTONE BEDROCK Very Strong Slightly Weathered to Fresh Thinly Bedded Fine Grained Grey		2	RUN		89									0	RUN #2 TCR=100% SCR=96% RQD=81% UCS=196MPa
						88									1	
															0	
															3	
															3	
11.8	End of Borehole														2	

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

### RECORD OF BOREHOLE No 20-05

1 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.269336°, Long: -76.926727° Palace Road Interchange, MTM z9: N 4 903 347.8 E 270 732.5 ORIGINATED BY RH  
 HWY 401 BOREHOLE TYPE CME75 Truckmount, HSA / NW Casing / NQ Coring COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.22 - 2020.10.22 CHECKED BY CM

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								WATER CONTENT (%)	
						20	40	60	80	100	20	40	60	GR	SA	SI	CL
98.9	Pavement Surface																
0.0	ASPHALT (150 mm)																
0.2	SAND with Silt and Gravel Compact to Dense Grey FILL		1	SS	34						o						
			2	SS	18						o						39 52 9 (SI+CL)
97.4	Silty, Clayey SAND with Gravel Compact to Very Dense Grey-Brown FILL		3	SS	15						o						
			4	SS	57						o						
			5	SS	20						o	H					15 49 25 11
			6	SS	19						o						
94.3	CLAY (Cl) with Sand Very Stiff Grey		7	SS	16						o						
			8	SS	22							o					2 26 37 35
92.8	Sandy, Clayey SILT (CL) Compact to Dense Grey		9	SS	27						o						
			10	SS	31							o					5 32 36 27
			11	SS	31						o						
90.2	SILTY SAND Compact Brown		12	SS	19						o						
89																	

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

Continued Next Page

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

### RECORD OF BOREHOLE No 20-05

2 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.269336°, Long: -76.926727° Palace Road Interchange, MTM z9: N 4 903 347.8 E 270 732.5 ORIGINATED BY RH  
 HWY 401 BOREHOLE TYPE CME75 Truckmount, HSA / NW Casing / NQ Coring COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.22 - 2020.10.22 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						20	40	60	80	100	20	40	60				
88.0	SILTY SAND Compact Brown		13	SS	14											2 75 23 (SI+CL)	
10.9	LIMESTONE BEDROCK Very Strong Slightly Weathered to Fresh Thinly Bedded Fine Grained Grey		1	RUN												RUN #1 TCR=100% SCR=98% RQD=90% UCS=140MPa	
85.0			2	RUN												RUN #2 TCR=100% SCR=100% RQD=100% UCS=228MPa	
13.9	End of Borehole																

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

### RECORD OF BOREHOLE No 20-06

1 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.269396°, Long: -76.926541° Palace Road Interchange, MTM z9: N 4 903 354.4 E 270 747.3 ORIGINATED BY RH  
 HWY 401 BOREHOLE TYPE CME75 Truckmount, HSA / NW Casing / NQ Coring COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.18 - 2020.10.18 CHECKED BY CM

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								WATER CONTENT (%)	
						20	40	60	80	100	20	40	60	GR	SA	SI	CL
99.5	Pavement Surface																
0.0	ASPHALT (100 mm)																
0.1	SAND with Silt and Gravel Compact Grey FILL		1	SS	29						○						
98.5			2	SS	100/						○			45	46	9	(SI+CL)
1.0	GRAVEL with Sand Frequent Cobbles and Boulders Very Dense Grey FILL - 300mm Boulder at 1.5 m		3	SS	100/	100mm											
95.5			4	SS	26						⊕			20	44	27	9
4.0	Silty, Clayey SAND trace to with gravel Compact Grey FILL		5	SS	32						⊕			6	49	33	12
93.7			6	SS	100/	300mm					○						
5.8	Inferred Sandy, Clayey SILT		2	NQ	-												
91.9			7	SS	25						○			4	75	21	(SI+CL)
7.6	SILTY SAND Compact Grey-brown		8	SS	27						○						
89.7																	
9.8	LIMESTONE BEDROCK													FI			

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

Continued Next Page

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

### RECORD OF BOREHOLE No 20-06

2 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.269396°, Long: -76.926541° Palace Road Interchange, MTM z9: N 4 903 354.4 E 270 747.3 ORIGINATED BY RH  
 HWY 401 BOREHOLE TYPE CME75 Truckmount, HSA / NW Casing / NQ Coring COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.18 - 2020.10.18 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
Continued From Previous Page																	
	LIMESTONE BEDROCK Very Strong Slightly Weathered to Fresh Thinly Bedded Fine Grained Grey		1	RUN											6	RUN #1 TCR=95% SCR=77% RQD=23%	
																	5
				2	RUN											2	RUN #2 TCR=100% SCR=100% RQD=71%
																1	
87.2																1	
12.3	End of Borehole																

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

### RECORD OF BOREHOLE No 20-07

1 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.269648°, Long: -76.926565° Palace Road Interchange, MTM z9: N 4 903 382.4 E 270 745.6 ORIGINATED BY SH  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA / NW Casing / NQ Coring COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.27 - 2020.10.27 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80			100	PLASTIC LIMIT w <sub>p</sub>
98.5	Ground Surface														
0.0	TOPSOIL (180 mm)														
0.2	Silty, Clayey SAND some Gravel Compact to Very Loose Brown FILL		1	SS	13										
			2	SS	5										10 39 30 21
			3	SS	2										
			4	SS	WH										
			5	SS	3										
			6	SS	5										10 46 29 15
93.9	CLAY (Cl) with Sand Very Stiff Brown  - Unable to turn N-Vane, Shear Strength > 106 kPa		7	SS	11										
			8	SS	9										0 17 46 37
			9	SS	-										
91.6	SANDY SILT Loose Brown		10	ST	-										
			11	SS	7										3 41 48 8
89.4	SILTY SAND Compact Brown		12	SS	13										
9.1															2 86 12 (SI+CL)

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

Continued Next Page

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

### RECORD OF BOREHOLE No 20-07

2 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.269648°, Long: -76.926565° Palace Road Interchange, MTM z9: N 4 903 382.4 E 270 745.6 ORIGINATED BY SH  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA / NW Casing / NQ Coring COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.27 - 2020.10.27 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page						20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
87.7	<b>SILTY SAND</b> Compact Brown		13	SS	100/												
10.8	<b>LIMESTONE BEDROCK</b> Very Strong Slightly Weathered to Fresh Thinly Bedded Fine Grained Grey		1	RUN	50mm												RUN #1 TCR=100% SCR=90% RQD=90%
			2	RUN													RUN #2 TCR=98% SCR=97% RQD=97%
84.7			3	RUN													RUN #3 TCR=100% SCR=100% RQD=100%
13.8	End of Borehole																

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

### RECORD OF BOREHOLE No 20-08

1 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.269697°, Long: -76.926384° Palace Road Interchange, MTM z9: N 4 903 387.7 E 270 760.1 ORIGINATED BY SH  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA / NW Casing / NQ Coring COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.27 - 2020.10.28 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80			100	PLASTIC LIMIT w <sub>p</sub>
98.4	Ground Surface														
0.0	TOPSOIL (150 mm)														
0.2	GRAVEL with Silt and Sand Very Loose to Compact Brown to grey-brown FILL	[Pattern]	1	SS	14										
			2	SS	3										
			3	SS	7										
95.9	SILTY SAND some Gravel Loose to Compact Brown FILL	[Pattern]	4	SS	11										
2.5			5	SS	5										
			6	SS	12										
			7	SS	18										
93.8	CLAY (CH) Very Stiff Brown	[Pattern]	8	SS	8										
93.2	Silty, Clayey SAND trace gravel Loose Brown	[Pattern]	9	SS	15										
92.3	SILTY SAND Compact to dense Brown	[Pattern]	10	SS	33										
6.1			11	SS	50										

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

Continued Next Page

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

### RECORD OF BOREHOLE No 20-08

2 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.269697°, Long: -76.926384° Palace Road Interchange, MTM z9: N 4 903 387.7 E 270 760.1 ORIGINATED BY SH  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA / NW Casing / NQ Coring COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.27 - 2020.10.28 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa 20 40 60 80 100																			
87.6	<b>SILTY SAND</b> Compact to dense Brown		12	SS	100/		88																				
10.8	<b>LIMESTONE BEDROCK</b> Very Strong Slightly Weathered to Fresh Thinly Bedded Fine Grained Grey		1	RUN	25mm		87									0											
			2	RUN			86									0											
84.5			3	RUN			85									0											
13.9	End of Borehole 19 mm Standpipe Piezometer Installed on Completion WATER LEVEL READINGS: <table border="1"> <thead> <tr> <th>Date</th> <th>Depth (m)</th> <th>Elev. (m)</th> </tr> </thead> <tbody> <tr> <td>28/10/20</td> <td>5.8</td> <td>92.6</td> </tr> <tr> <td>08/12/20</td> <td>9.4</td> <td>89.0</td> </tr> <tr> <td>25/08/21</td> <td>5.7</td> <td>92.7</td> </tr> </tbody> </table>	Date	Depth (m)	Elev. (m)	28/10/20	5.8	92.6	08/12/20	9.4	89.0	25/08/21	5.7	92.7														
Date	Depth (m)	Elev. (m)																									
28/10/20	5.8	92.6																									
08/12/20	9.4	89.0																									
25/08/21	5.7	92.7																									

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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



### RECORD OF BOREHOLE No 20-09

2 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.269848°, Long: -76.926384°  
Palace Road Interchange, MTM z9: N 4 903 404.5 E 270 760.1 ORIGINATED BY SH  
HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA COMPILED BY MW  
DATUM Geodetic DATE 2020.10.28 - 2020.10.28 CHECKED BY CM

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
	Continued From Previous Page							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>					
87.2	SILTY SAND to SAND with Silt Very Loose to Compact Brown																			
10.6	End of Borehole - Auger Refusal																			

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

### RECORD OF BOREHOLE No 20-10

1 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.270125°, Long: -76.926212° Palace Road Interchange, MTM z9: N 4 903 435.3 E 270 774.0 ORIGINATED BY RH  
 HWY 401 BOREHOLE TYPE CME75 Truckmount, HSA COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.22 - 2020.10.22 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
							20	40	60	80	100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)			
							20	40	60	80	100	20	40	60	
99.6	Pavement Surface														
0.0	ASPHALT (150 mm)														
0.2	SILTY SAND with Gravel Compact to Dense Brown FILL		1	SS	32							○			29 55 16 (SI+CL)
			2	SS	18							○			
98.2	Silty, Clayey SAND trace Gravel Compact Brown FILL		3	SS	29							○			
			4	SS	15							○			
			5	SS	14							○			5 51 31 13
			6	SS	22							○			
			7	SS	18							○			
94.3	Sandy CLAY (Cl) some Gravel Very Stiff Grey-brown		8	SS	24							○			
			9	SS	11							○			14 32 31 23
92.7	Silty, Clayey SAND some Gravel Compact Brown		10	SS	12							○			
			11	SS	14							○			13 40 27 20
90.5	SILTY SAND some Gravel Compact to Very Dense Brown		12	SS	21							○			

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

Continued Next Page

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



# RECORD OF BOREHOLE No 20-11

1 OF 1

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.270647°, Long: -76.925644° Palace Road Interchange, MTM z9: N 4 903 493.0 E 270 819.7 ORIGINATED BY SH  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.23 - 2020.10.23 CHECKED BY CM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40	60	80	100			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W
95.7	Ground Surface														
0.0	TOPSOIL (150 mm)														
0.2	SILTY SAND Compact Brown	1	SS	11										3	82 15 (SH+CL)
95.1	FILL														
0.6	CLAY (CH) trace Sand Very Stiff Brown	2	SS	24											
		3	SS	27											
		4	SS	22											
		5	SS	19										1	10 31 58
91.6		6	SS	14											
4.1	Silty, Clayey SAND trace Gravel Loose to Compact Brown	7	SS	13											
		8	SS	7										10	41 35 14
89.3		9	SS	28										2	63 35 (SH+CL)
6.4	SILTY SAND Compact Brown														
88.4	End of Borehole - Auger Refusal 19 mm Standpipe Piezometer Installed on Completion WATER LEVEL READINGS: Date Depth (m) Elev. (m) 23/10/20 3.1 92.6 28/10/20 2.6 93.1 08/12/20 2.3 93.4 25/08/21 2.6 93.1														

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

### RECORD OF BOREHOLE No 20-12

1 OF 1

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.270875°, Long: -76.925236° Palace Road Interchange, MTM z9: N 4 903 518.1 E 270 852.4 ORIGINATED BY RH  
 HWY 401 BOREHOLE TYPE CME75 Truckmount, HSA COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.23 - 2020.10.23 CHECKED BY CM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						
						20	40	60	80	100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	
99.1	Pavement Surface													
0.0	ASPHALT (150 mm)													
0.2	SILTY SAND with Gravel Dense Grey		1	SS	43						o			21 63 16 (SI+CL)
98.3	FILL													
0.8	Silty, Clayey SAND trace gravel Compact to Dense Grey		2	SS	52						o			
	FILL													
			3	SS	24						o			
			4	SS	19						o			7 48 30 15
			5	SS	31						o			
			6	SS	19						o			
94.5	CLAY (CH) trace Sand Very Stiff Brown		7	SS	19						o			1 5 34 60
			8	SS	19						o			
93.0	Silty, Clayey SAND some Gravel Compact Grey		9	SS	12						o			11 49 29 11
91.3	SILTY SAND Compact Brown		10	SS	18						o			
90.3	End of Borehole - Auger Refusal		11	SS	100/0mm									

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

### RECORD OF BOREHOLE No 20-13

1 OF 1

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.271159°, Long: -76.924603° Palace Road Interchange, MTM z9: N 4 903 549.5 E 270 903.1 ORIGINATED BY SH  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.23 - 2020.10.23 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
						20	40	60	80	100	20	40	60			
97.1	Ground Surface															
0.0	TOPSOIL (200 mm)															
0.2	CLAY (CH) trace Sand Very Stiff Brown		1	SS	7											
			2	SS	13										0 6 34 60	
			3	SS	29											
94.6	GRAVEL with Sand and Silt Very dense Grey		4	SS	69										57 34 9 (SI+CL)	
2.5			5	SS	100/ 50mm											
			6	SS	100/ 125mm											
92.7	End of Borehole - Auger Refusal Borehole Dry on Completion															
4.4																

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

# RECORD OF BOREHOLE No 20-14

1 OF 1

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.271378°, Long: -76.923991° Palace Road Interchange, MTM z9: N 4 903 573.5 E 270 952.1 ORIGINATED BY SH  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.22 - 2020.10.22 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80			100
98.1	Ground Surface													
0.0	TOPSOIL (150 mm)													
0.2	SILTY SAND trace Gravel Very Loose to Compact Brown FILL		1	SS	3									
			2	SS	11									5 67 28 (SI+CL)
96.4														
1.7	CLAY (CH) Very Stiff Brown		3	SS	37									
95.8														
2.3	GRAVEL with Sand and Silt Dense to Very Dense Grey		4	SS	44									49 40 11 (SI+CL)
			5	SS	100/ 275mm									
			6	SS	100/ 75mm									
			7	SS	100/ 225mm									
			8	SS	100/ 125mm									48 42 10 (SI+CL)
92.2														
5.9	End of Borehole - Auger Refusal 19 mm Standpipe Piezometer Installed on Completion WATER LEVEL READINGS: Date Depth (m) Elev. (m) 23/10/20 4.4 93.7 28/10/20 4.4 93.7 08/12/20 3.0 95.1 25/08/21 4.2 93.9													

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

# RECORD OF BOREHOLE No 20-15

1 OF 1

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.27157°, Long: -76.923253° Palace Road Interchange, MTM z9: N 4 903 594.6 E 271 011.1 ORIGINATED BY RH  
 HWY 401 BOREHOLE TYPE CME75 Truckmount, HSA COMPILED BY MW  
 DATUM Geodetic DATE 2020.10.27 - 2020.10.27 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
						WATER CONTENT (%)									
						PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	W P	W	W L				
100.1	Pavement Surface														
0.0	ASPHALT (150 mm)														
99.8	SAND and GRAVEL Very Dense Grey FILL	[Pattern]	1	SS	61										
0.3															
	SILTY SAND some gravel Very Dense Grey FILL	[Pattern]	2	SS	123								13 75 12 (SI+CL)		
98.6															
	SAND with Silt to SILTY SAND Compact Brown	[Pattern]	3	SS	10										
1.5															
					4	SS	13								4 86 10 (SI+CL)
					5	SS	12								
					6	SS	24								
					7	SS	14								0 80 20 (SI+CL)
			8	SS	24										
94.1	End of Borehole - Auger Refusal														
6.0															

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

### RECORD OF BOREHOLE No 21-16

1 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.269768°, Long: -76.926501° Palace Road Interchange, MTM z9: N 4 903 395.7 E 270 750.8 ORIGINATED BY AO  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA / NW Casing / NQ Coring COMPILED BY AO  
 DATUM Geodetic DATE 2021.08.23 - 2021.08.23 CHECKED BY CM

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			20	40	60					
98.1	Ground surface														
0.0	<b>TOPSOIL (100 mm)</b>														
0.1	Sandy GRAVEL Occasional Cobbles and Boulders Dense to Compact Grey-Brown <b>FILL</b>		1	SS	47										
			2	SS	100/ 125mm										
			3	SS	10										64 32 4 (SI+CL)
95.8															
2.3	Clayey SAND trace Gravel Very Loose Brown <b>FILL</b>		4	SS	2										
			5	SS	2										7 48 29 16
94.3															
3.8	<b>CLAY (CH)</b> Occasional Cobbles Very Stiff Grey-Brown		6	SS	26										
			7	SS	13										0 4 36 60
92.3															
5.8	Sandy SILT with Gravel Compact Light Brown		8	SS	11										
91.9															
6.2	Silty SAND (SM) Compact Light brown		9	SS	17										
			10	SS	29										3 78 19 (SI+CL)
			11	SS	25										

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

Continued Next Page

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

### RECORD OF BOREHOLE No 21-16

2 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.269768°, Long: -76.926501° Palace Road Interchange, MTM z9: N 4 903 395.7 E 270 750.8 ORIGINATED BY AO  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA / NW Casing / NQ Coring COMPILED BY AO  
 DATUM Geodetic DATE 2021.08.23 - 2021.08.23 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
87.3	Continued From Previous Page <b>Silty SAND (SM)</b> Compact Light brown																
10.8	<b>LIMESTONE BEDROCK</b> Very Strong Fresh Medium Bedded Fine Grained Grey		12	SS	100/ 0mm											FI 4 1 3 1 1 1 1 0 0 1	RUN #1 TCR=100% SCR=94% RQD=95%  RUN #2 TCR=100% SCR=98% RQD=97%
84.2	End of Borehole		1	RUN													
13.9	End of Borehole		2	RUN													

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  $\frac{20}{15} \pm 5$  (%) STRAIN AT FAILURE









### RECORD OF BOREHOLE No 21-19

2 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.271494°, Long: -76.922473° Palace Road Interchange, MTM z9: N 4 903 585.8 E 271 073.3 ORIGINATED BY AO  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA Probe Hole COMPILED BY AO  
 DATUM Geodetic DATE 2021.08.24 - 2021.08.24 CHECKED BY CM

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	20			40	60	80	100	W <sub>p</sub>					
92.9	Continued From Previous Page Overburden Probe Hole advanced by hollow stem auger See BH 21-20 for stratigraphy																	
94																		
93																		
12.9	End of Borehole - Auger Refusal Water at 11.8 m on completion																	

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

### RECORD OF BOREHOLE No 21-20

1 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.271449°, Long: -76.92231° Palace Road Interchange, MTM z9: N 4 903 580.8 E 271 086.3 ORIGINATED BY AO  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA COMPILED BY AO  
 DATUM Geodetic DATE 2021.08.24 - 2021.08.24 CHECKED BY CM

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							
106.8	Ground surface														
0.0	<b>TOPSOIL (60 mm)</b>														
106.2	Sandy SILT trace Rootlets Loose Dark Brown		1	SS	8										
0.6	Silty SAND (SM) some Gravel Compact Brown		2	SS	10										
			3	SS	10									11 64 25 (SI+CL)	
104.5	Silty SAND (SM) trace Gravel Occasional Cobbles Compact to Very Dense Light Brown		4	SS	17										
2.3			5	SS	22									9 41 35 15	
			6	SS	61										
			7	SS	100/ 100mm										
			8	SS	33										
			9	SS	14									7 46 34 13	
99.0	SAND (SP-SM) with Silt and Gravel Occasional Cobbles Dense to Very dense Light brown		10	SS	40										
7.8			11	SS	63									24 67 9 (SI+CL)	

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

Continued Next Page

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

### RECORD OF BOREHOLE No 21-20

2 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.271449°, Long: -76.92231°  
Palace Road Interchange, MTM z9: N 4 903 580.8 E 271 086.3 ORIGINATED BY AO  
HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA COMPILED BY AO  
DATUM Geodetic DATE 2021.08.24 - 2021.08.24 CHECKED BY CM

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kn/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) 20 40 60							
96.5	Continued From Previous Page <b>SAND (SP-SM)</b> with Silt and Gravel Occasional Cobbles																	
10.3	Very dense Light brown End of Borehole - Auger Refusal																	

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

# RECORD OF BOREHOLE No 21-21

1 OF 1

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.271297°, Long: -76.921874° Palace Road Interchange, MTM z9: N 4 903 563.7 E 271 121.0 ORIGINATED BY AO  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA / NW Casing / NQ Coring COMPILED BY AO  
 DATUM Geodetic DATE 2021.08.24 - 2021.08.25 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
111.9	Ground surface														
0.0 0.1	TOPSOIL (100 mm) Sandy SILT (ML) trace Rootlets Compact Dark brown		1	SS	14									GR SA SI CL	
			2	SS	16		111							3 45 31 21	
			3	SS	15		110								
			4	SS	11		109								
109.0	Silty SAND (SM) some Gravel Occasional Cobbles and Boulders Compact to Very Dense Light brown		5	SS	12		108							13 47 29 11	
2.9			6	SS	19		107								
			7	SS	17		106							11 47 31 11	
			8	SS	19		105								
			9	SS	100/ 150mm		104								
105.3	LIMESTONE BEDROCK Strong to Very Strong Slightly Weathered to Fresh Medium Bedded Fine Grained Grey		1	RUN			103							RUN #1 TCR=100% SCR=51% RQD=46% UCS=127MPa	
6.6			2	RUN										RUN #2 TCR=100% SCR=52% RQD=50% UCS=75MPa	
			3	RUN										RUN #3 TCR=100% SCR=79% RQD=82%	
102.1	End of Borehole														
9.8															

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  $\frac{20}{15 \pm 5}$  (%) STRAIN AT FAILURE

### RECORD OF BOREHOLE No 21-22

1 OF 2

METRIC

GWP# 4197-13-00 LOCATION Lat: 44.271376°, Long: -76.921418° Palace Road Interchange, MTM z9: N 4 903 572.2 E 271 157.5 ORIGINATED BY AO  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA / NW Casing / NQ Coring COMPILED BY AO  
 DATUM Geodetic DATE 2021.08.24 - 2021.08.24 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80			100
111.2	Ground surface													
0.0 0.1	TOPSOIL (100 mm)													
	Sandy Clayey SILT (CL) trace Rootlets Loose to Compact Dark brown		1	SS	7									
			2	SS	15									5 45 30 20
109.7														
1.5	Silty SAND (SM) trace Gravel Loose to Compact Light brown		3	SS	5									
			4	SS	14									
			5	SS	17									6 53 30 11
			6	SS	20									
			7	SS	29									
			8	SS	20									
105.1														
6.1	Silty SAND (SM) with Gravel Dense to Very Dense Light brown		9	SS	35									18 38 31 13
			10	SS	100/									
103.4														
7.8	LIMESTONE BEDROCK Strong to Very Strong Fresh Medium Bedded Fine Grained Grey		1	RUN	100mm									RUN #1 TCR=100% SCR=96% RQD=89%
			2	RUN										RUN #2 TCR=97% SCR=87% RQD=77%

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

Continued Next Page

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

### RECORD OF BOREHOLE No 21-22

2 OF 2

**METRIC**

GWP# 4197-13-00 LOCATION Lat: 44.271376°, Long: -76.921418° Palace Road Interchange, MTM z9: N 4 903 572.2 E 271 157.5 ORIGINATED BY AO  
 HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA / NW Casing / NQ Coring COMPILED BY AO  
 DATUM Geodetic DATE 2021.08.24 - 2021.08.24 CHECKED BY CM

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page						20 40 60 80 100										
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W P      W      W L  ----- ----- -----					
							20 40 60 80 100										
100.4	<b>LIMESTONE BEDROCK</b> Strong to Very Strong Fresh Medium Bedded Fine Grained Grey		2	RUN		101									2	RUN #2 TCR=97% SCR=87% RQD=77%	
10.8																	1
			End of Borehole														

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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



### RECORD OF BOREHOLE No 21-24

1 OF 1

METRIC

Lat: 44.271342°, Long: -76.920952°

Palace Road Interchange, MTM z9: N 4 903 568.3 E 271 194.7

GWP# 4197-13-00 LOCATION ORIGINATED BY AO

HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA / NW Casing / NQ Coring COMPILED BY AO

DATUM Geodetic DATE 2021.08.25 - 2021.08.25 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
							20	40	60	80	100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)			
							20	40	60	80	100	20	40	60	
111.9	Ground surface														
0.0	TOPSOIL (50 mm)														
111.3	Silty SAND (SM) trace Rootlets Loose Dark Brown		1	SS	8										
0.6	Silty SAND (SM) with to Silty SAND (SM) some Gravel Loose to Very Dense Light brown		2	SS	8		111					○			
			3	SS	7		110					○			17 46 28 9
			4	SS	11		109					○			
			5	SS	7							○			7 49 33 11
108.0			6	SS	100/		108					○			
3.9	LIMESTONE BEDROCK Strong to Very Strong Slightly Weathered to Fresh Medium Bedded Fine Grained Grey		1	RUN	125mm		107								RUN #1 TCR=100% SCR=35% RQD=19%
			2	RUN			106								RUN #2 TCR=100% SCR=87% RQD=68% UCS=63MPa
			3	RUN			105								RUN #3 TCR=100% SCR=83% RQD=80%
104.3	End of Borehole														

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

### RECORD OF BOREHOLE No 21-25

1 OF 1

**METRIC**

GWP# 4197-13-00 LOCATION Lat: 44.271551°, Long: -76.920378°  
Palace Road Interchange, MTM z9: N 4 903 591.3 E 271 240.6 ORIGINATED BY AO  
HWY 401 BOREHOLE TYPE CME55 Trackmount, HSA Probe Hole COMPILED BY AO  
DATUM Geodetic DATE 2021.08.24 - 2021.08.25 CHECKED BY CM

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa												
								20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
114.5	Ground surface																	
0.0	Overburden Probe Hole advanced by hollow stem auger						114											
113.3																		
1.2	End of Borehole - Auger Refusal																	

DOUBLE LINE 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ\_2012TEMPLATE(MTO).GDT\_21-10-7

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

**Appendix C.**  
**Laboratory Testing**

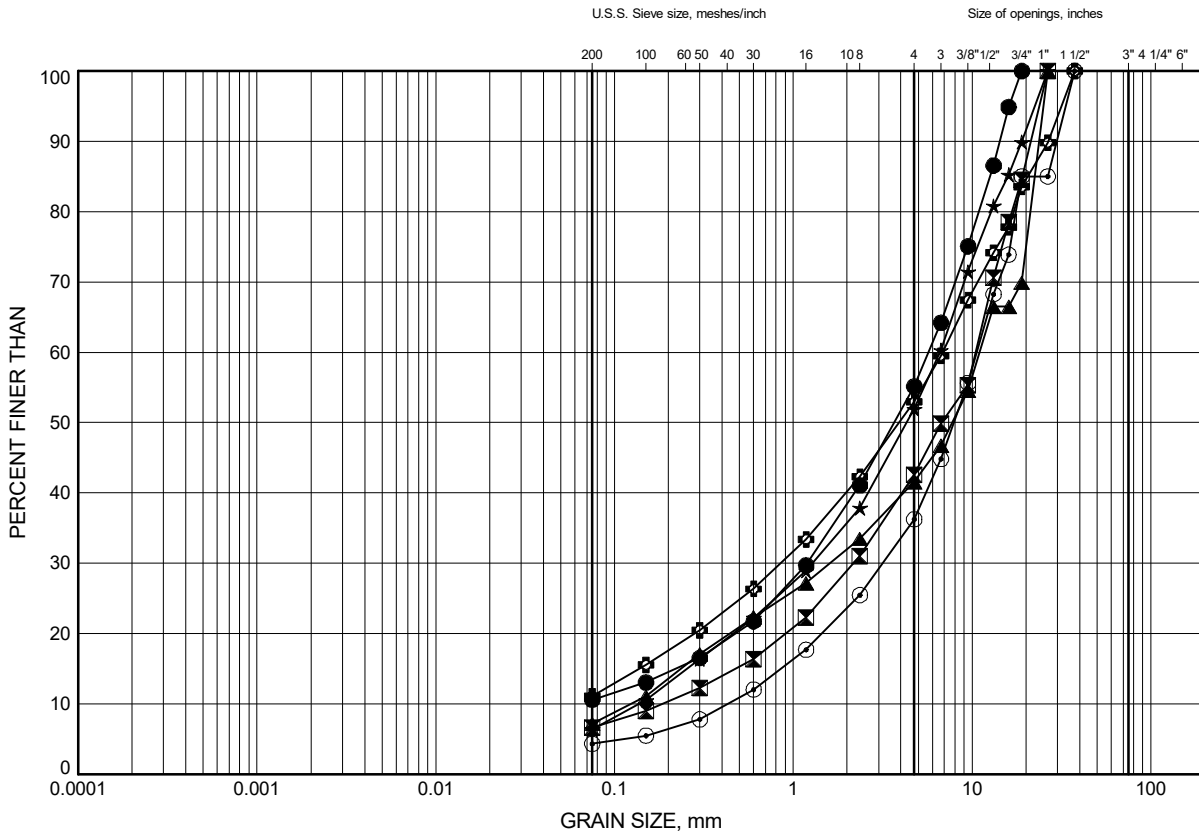
## Appendix C.1

### Particle Size Analysis and Atterberg Limits Test Figures

# Highway 401 Palace Road Interchange GRAIN SIZE DISTRIBUTION

FIGURE C1

## FILL: Gravel to Sand and Gravel



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-03	0.5	98.2
⊠	20-04	1.8	97.4
▲	20-08	1.8	96.6
★	20-09	1.8	96.0
⊙	21-16	1.8	96.3
⊕	21-17	1.0	96.9

Date ..October 2021.....  
GWP# ..4197-13-00.....

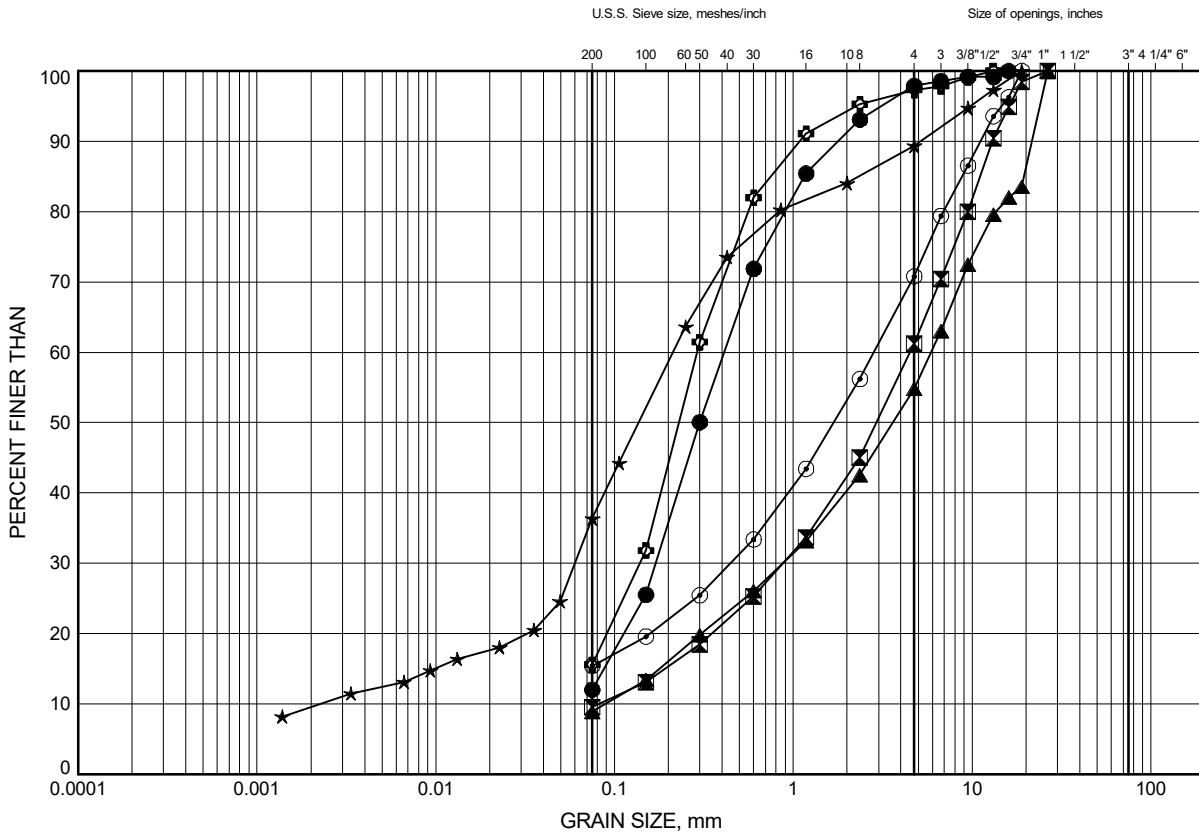


Prep'd .....CM.....  
Chkd. ....SBP.....

# Highway 401 Palace Road Interchange GRAIN SIZE DISTRIBUTION

FIGURE C2

## FILL: Sand to Silty Sand



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-01	1.1	94.9
⊠	20-05	1.1	97.8
▲	20-06	0.9	98.6
★	20-08	3.4	95.0
⊙	20-10	0.5	99.1
⊕	20-11	0.4	95.3

Date ..October 2021.....  
GWP# ..4197-13-00.....



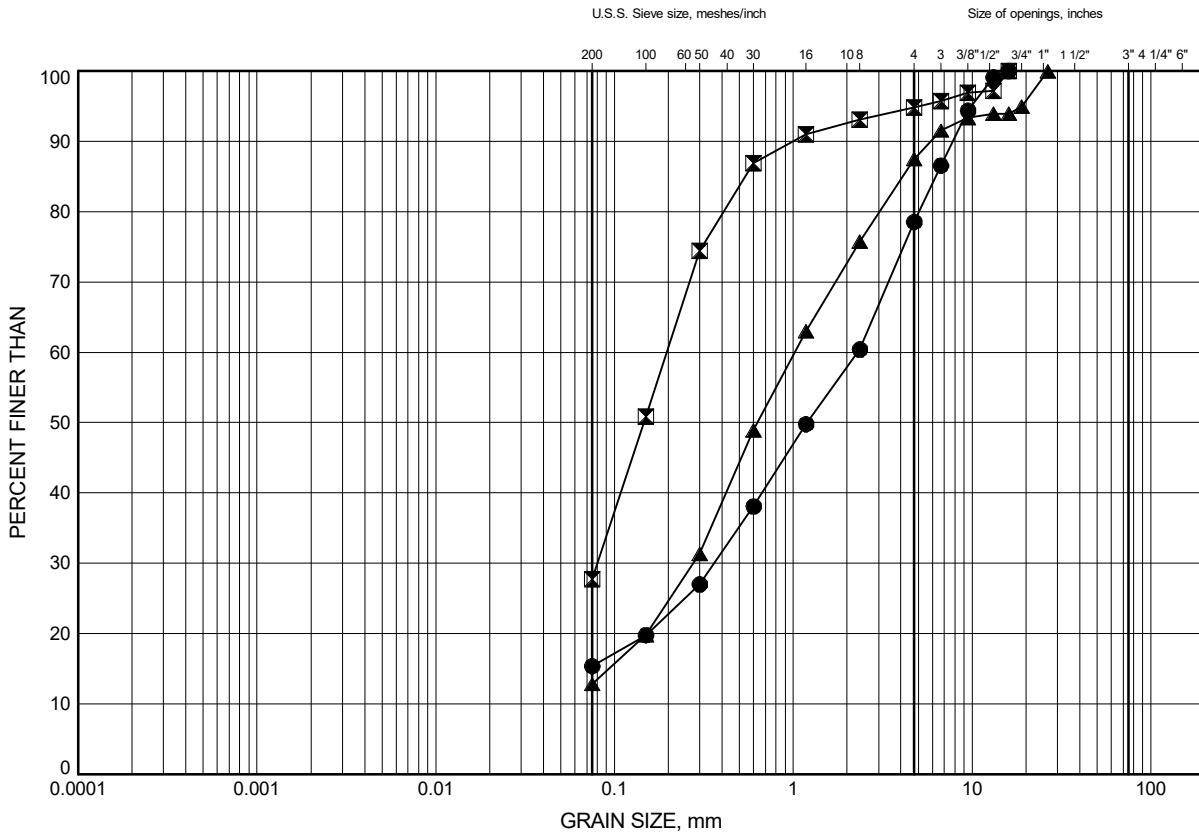
Prep'd .....CM.....  
Chkd. ....SBP.....

GRAIN SIZE DISTRIBUTION - THURBER - 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Highway 401 Palace Road Interchange  
**GRAIN SIZE DISTRIBUTION**

FIGURE C3

FILL: Sand to Silty Sand



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-12	0.5	98.6
⊠	20-14	1.1	97.0
▲	20-15	1.1	99.0

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

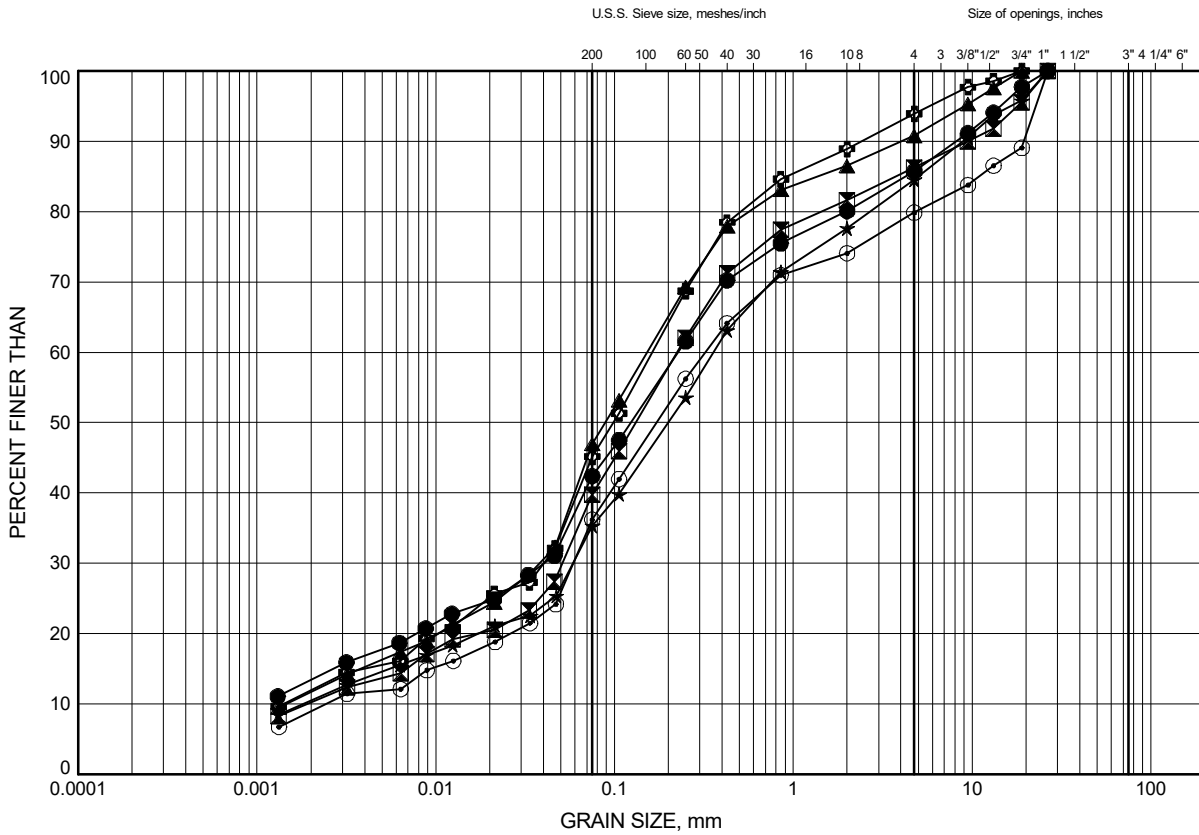


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**GRAIN SIZE DISTRIBUTION**

FIGURE C4

FILL: Clayey Sand to Silty Clayey Sand



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-03	2.6	96.1
⊠	20-03	4.1	94.6
▲	20-04	3.4	95.8
★	20-05	3.4	95.5
⊙	20-06	4.3	95.2
⊕	20-06	4.9	94.6

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

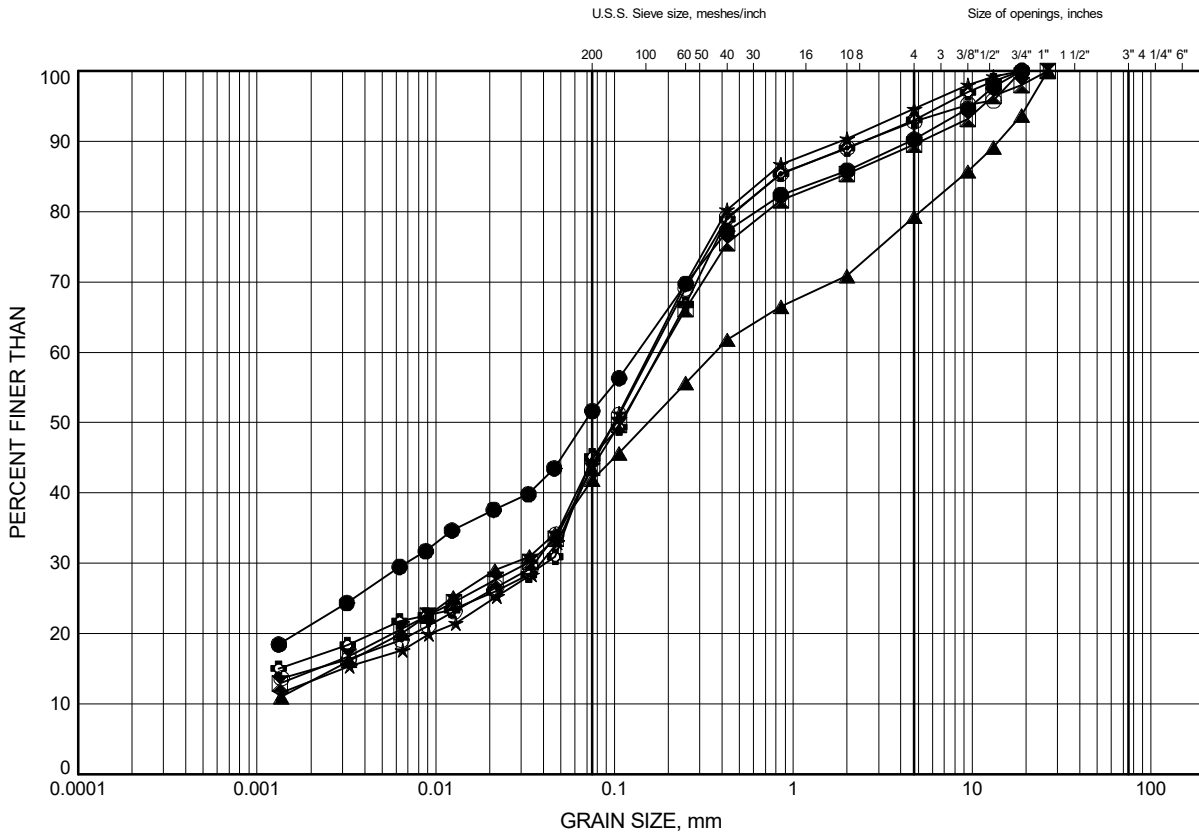


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**GRAIN SIZE DISTRIBUTION**

FIGURE C5

FILL: Clayey Sand to Silty Clayey Sand



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-07	1.1	97.4
⊠	20-07	4.1	94.4
▲	20-09	3.4	94.4
★	20-10	3.4	96.2
⊙	20-12	2.6	96.5
⊕	21-16	3.4	94.7

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

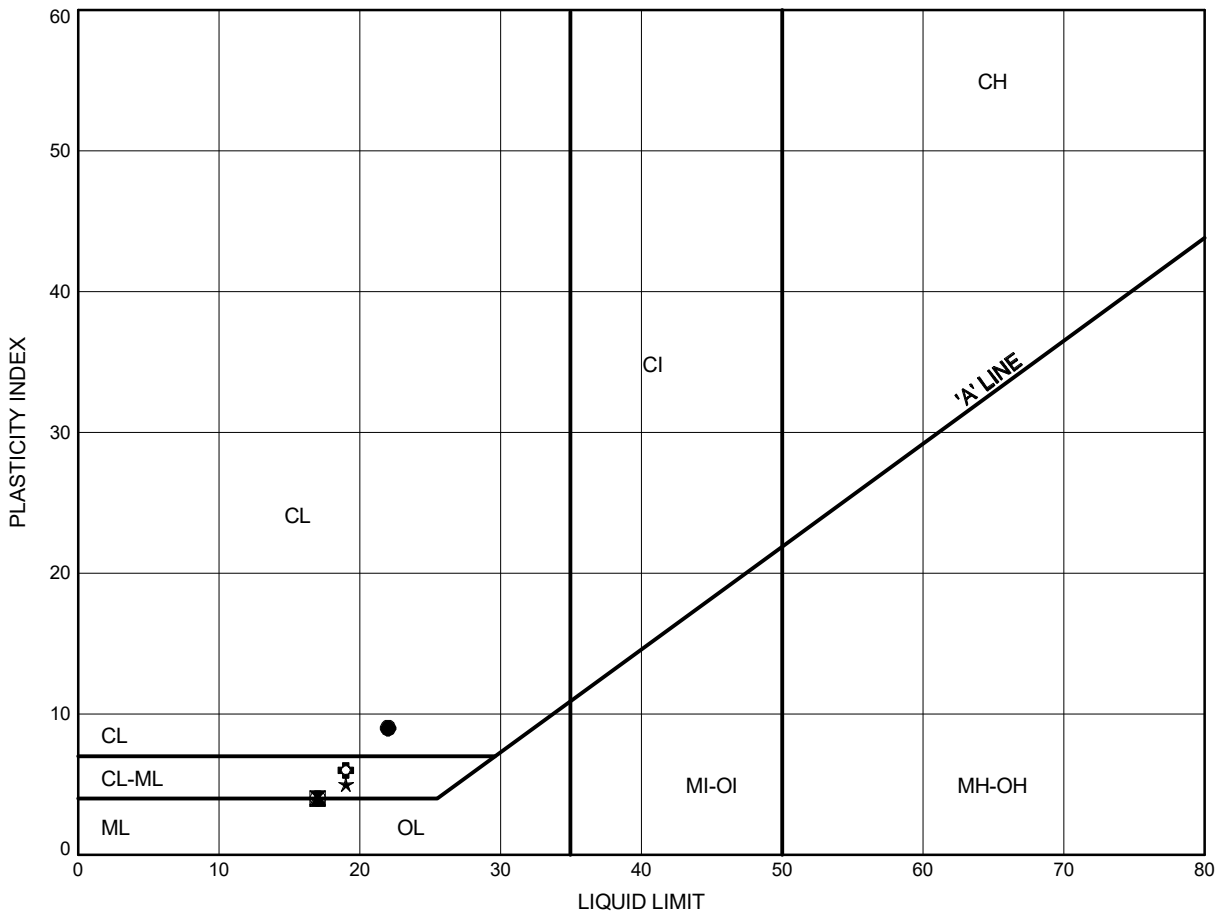


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C6

FILL: Clayey Sand to Silty Clayey Sand



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-03	2.6	96.1
⊠	20-03	4.1	94.6
▲	20-04	3.4	95.8
★	20-05	3.4	95.5
⊙	20-06	4.3	95.2
⊕	20-06	4.9	94.6

Date ..October 2021.....  
 GWP# ..4197-13-00.....

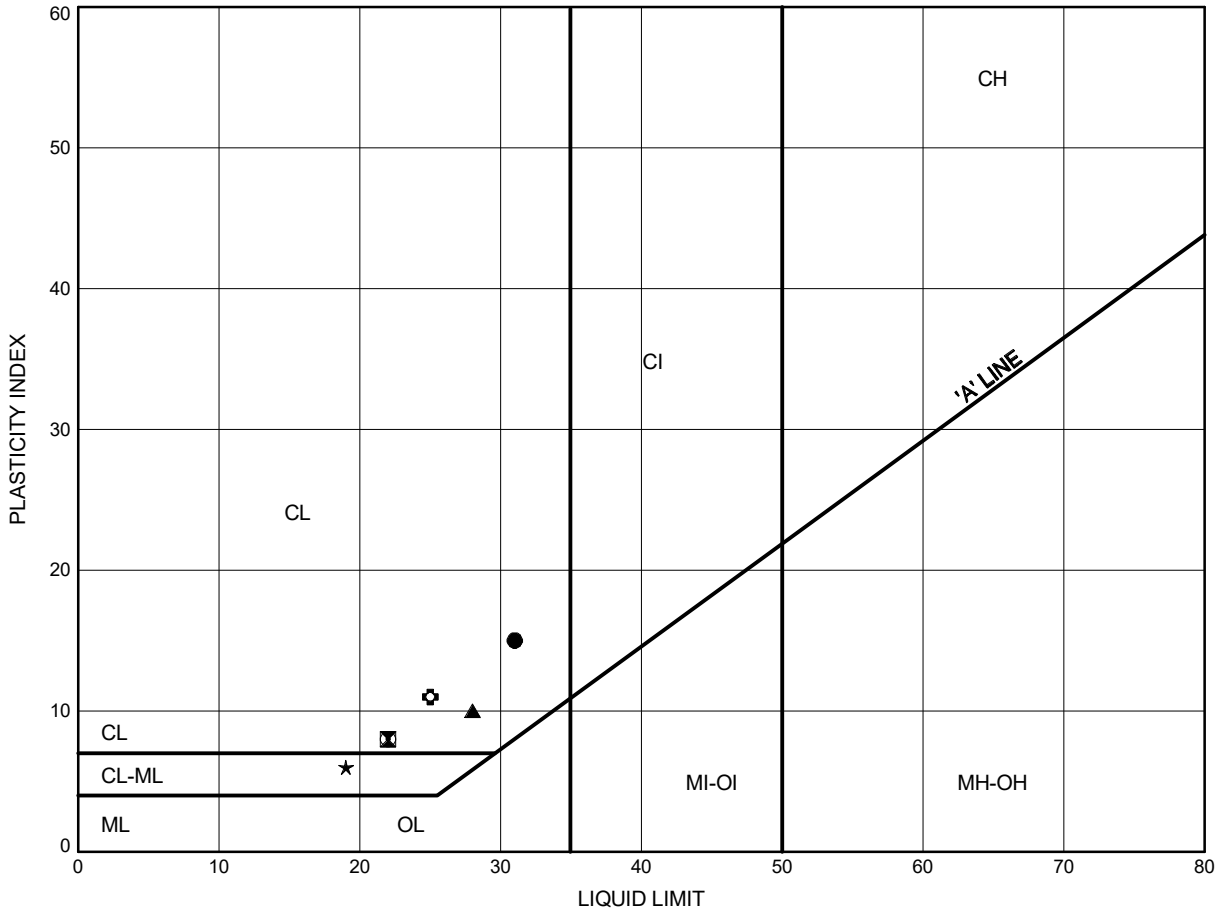


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C7

FILL: Clayey Sand to Silty Clayey Sand



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-07	1.1	97.4
⊠	20-07	4.1	94.4
▲	20-09	3.4	94.4
★	20-10	3.4	96.2
⊙	20-12	2.6	96.5
⊕	21-16	3.4	94.7

THURBALT 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

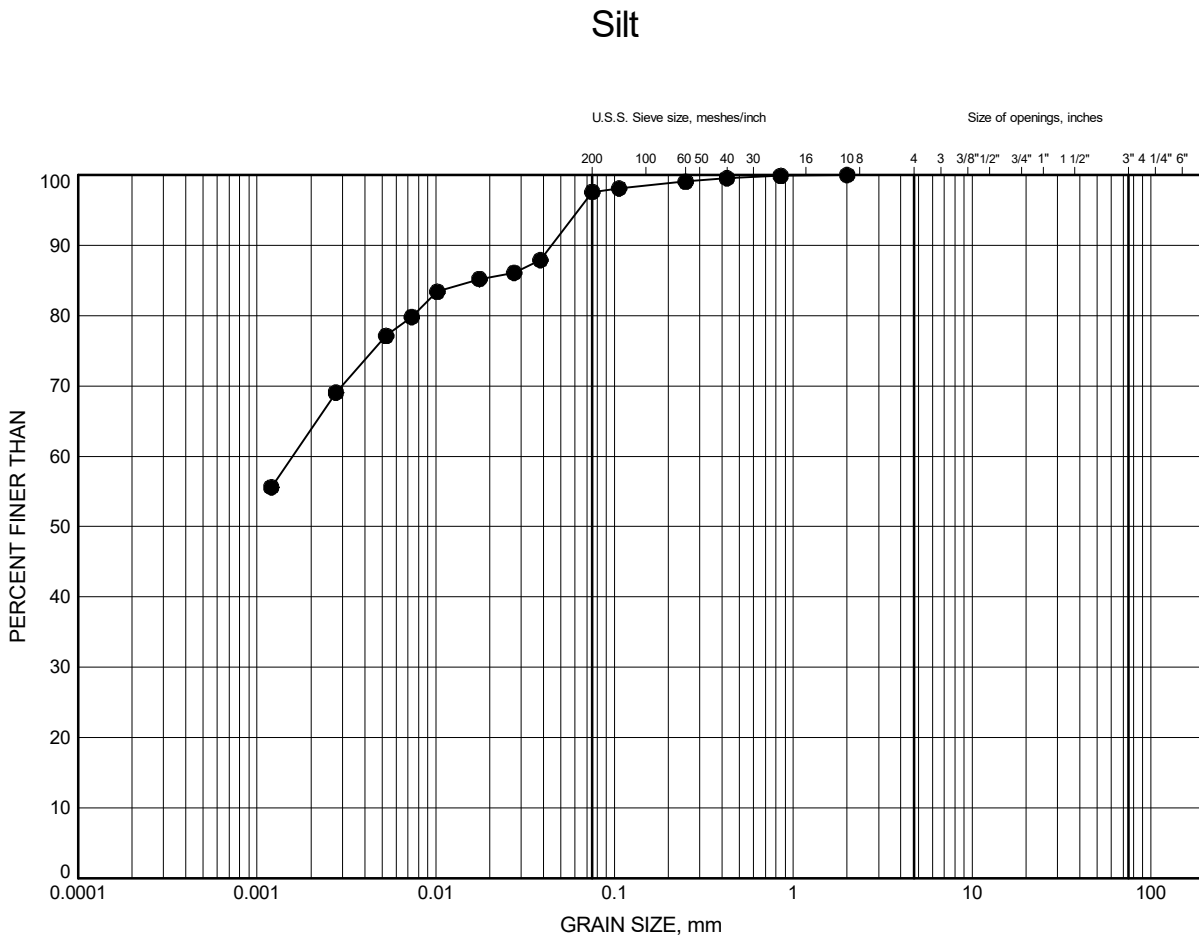
Date ..October 2021.....  
 GWP# ..4197-13-00.....



Prep'd .....CM.....  
 Chkd. ....SBP.....

# Highway 401 Palace Road Interchange GRAIN SIZE DISTRIBUTION

FIGURE C8



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-02	1.1	93.8

Date .. October 2021 ..  
GWP# .. 4197-13-00 ..

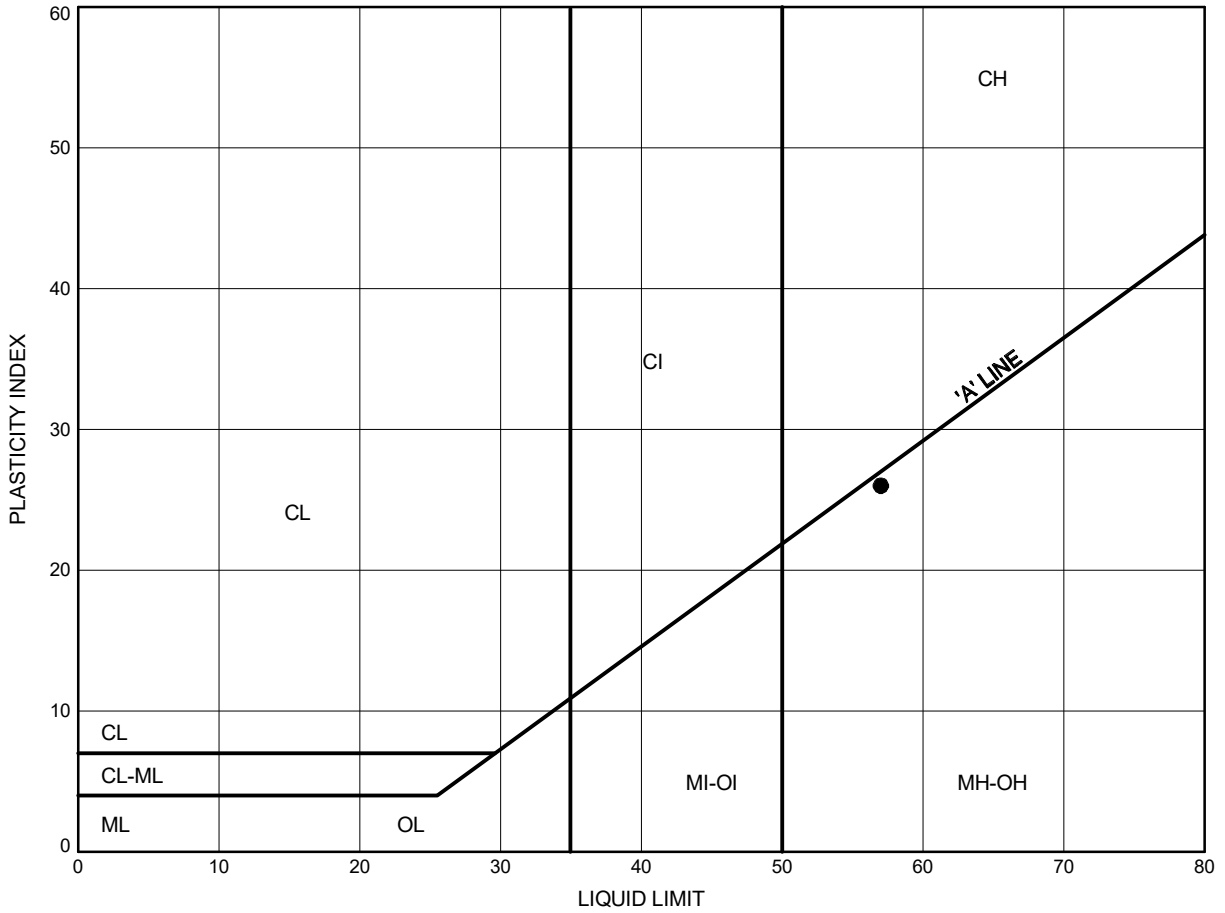


Prep'd ..... CM .....  
Chkd. .... SBP .....

Highway 401 Palace Road Interchange  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C9

Silt



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-02	1.1	93.8

Date ..October 2021.....  
 GWP# ..4197-13-00.....

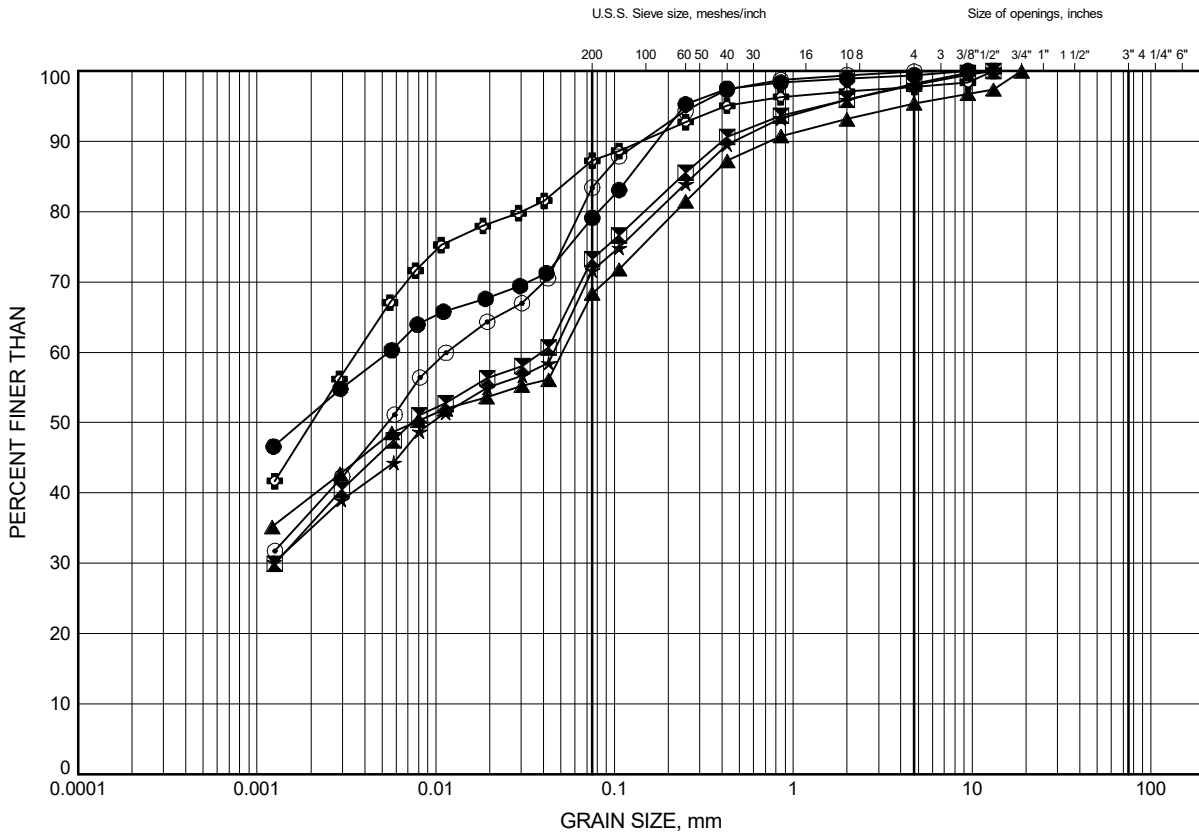


Prep'd .....CM.....  
 Chkd. ....SBP.....

# Highway 401 Palace Road Interchange GRAIN SIZE DISTRIBUTION

FIGURE C10

## Sandy Clay



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-01	2.0	94.0
⊠	20-03	5.6	93.1
▲	20-04	5.6	93.6
★	20-05	5.6	93.3
⊙	20-07	5.6	92.9
⊕	20-08	4.9	93.5

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
GWP# ..4197-13-00.....

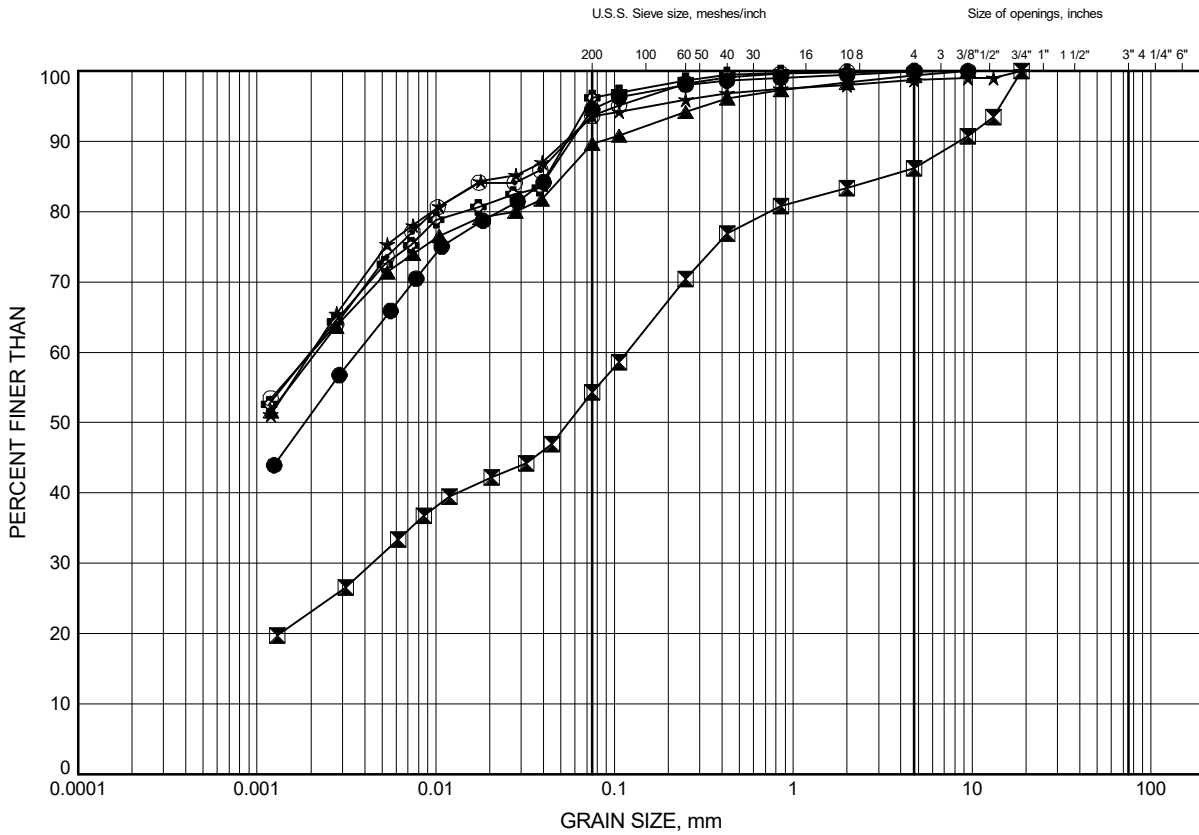


Prep'd .....CM.....  
Chkd. ....SBP.....

# Highway 401 Palace Road Interchange GRAIN SIZE DISTRIBUTION

FIGURE C11

## Sandy Clay



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-09	4.9	92.9
⊠	20-10	6.4	93.2
▲	20-11	3.4	92.3
★	20-12	4.9	94.2
⊙	20-13	1.1	96.0
⊞	21-16	4.9	93.2

Date ..October 2021.....  
GWP# ..4197-13-00.....



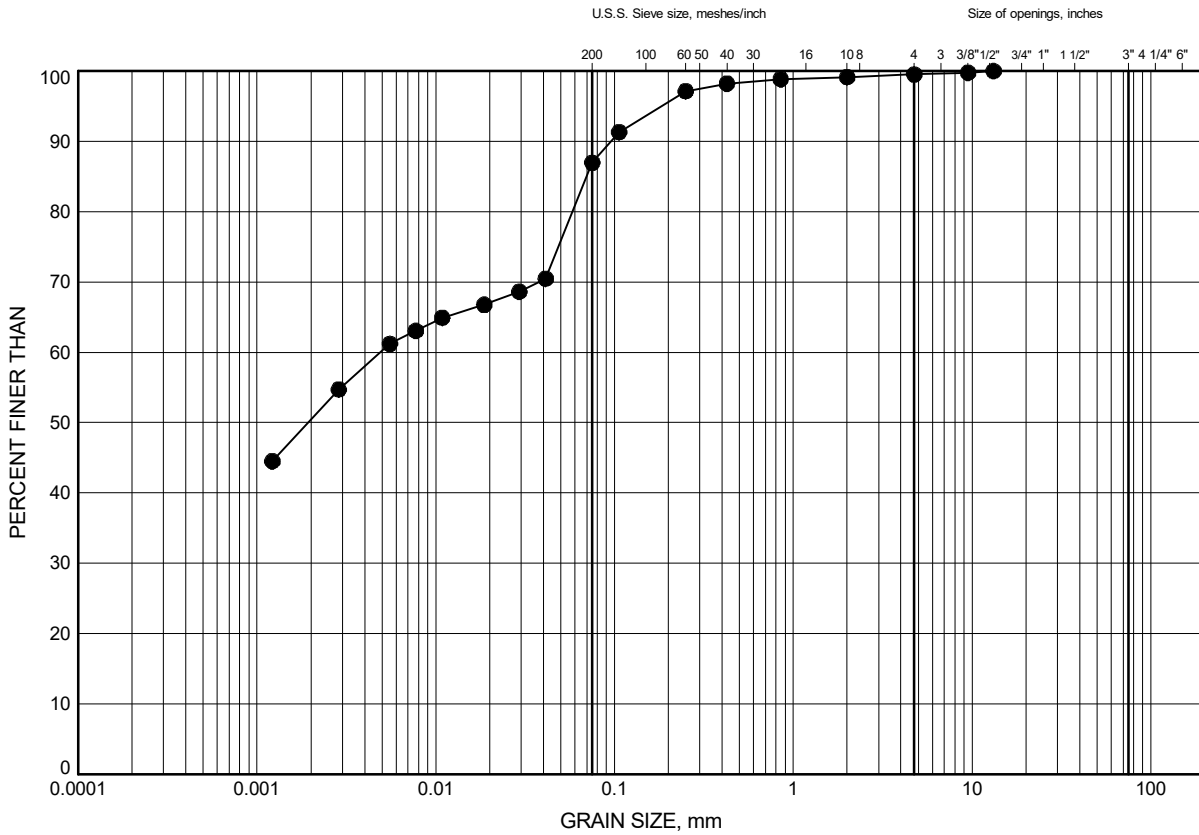
Prep'd .....CM.....  
Chkd. ....SBP.....

GRAIN SIZE DISTRIBUTION - THURBER - 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Highway 401 Palace Road Interchange  
**GRAIN SIZE DISTRIBUTION**

FIGURE C12

**Sandy Clay**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21-17	4.9	93.0

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date .. October 2021 ..  
 GWP# .. 4197-13-00 ..

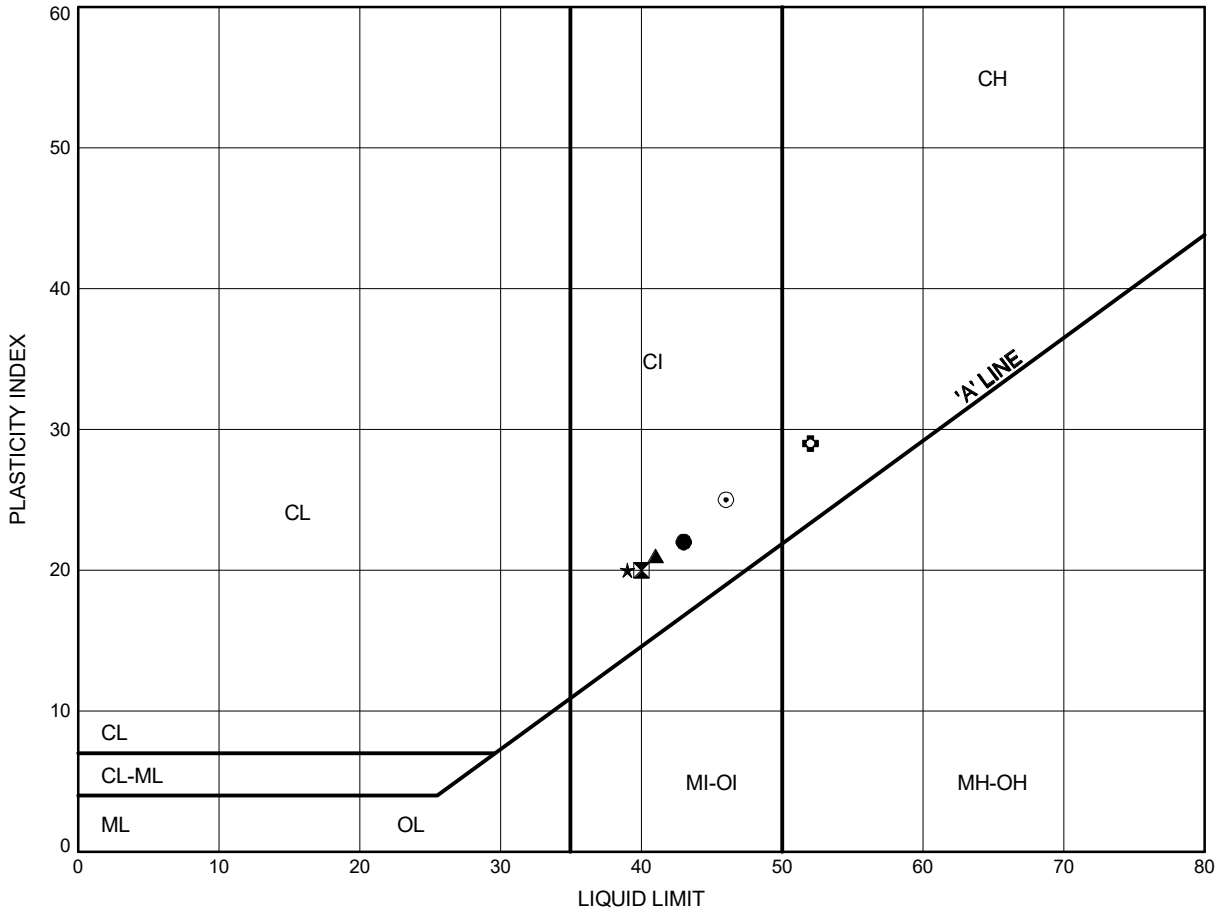


Prep'd ..... CM .....  
 Chkd. .... SBP .....

Highway 401 Palace Road Interchange  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C13

**Sandy Clay**



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-01	2.0	94.0
⊠	20-03	5.6	93.1
▲	20-04	5.6	93.6
★	20-05	5.6	93.3
⊙	20-07	5.6	92.9
⊕	20-08	4.9	93.5

Date ..October 2021.....  
 GWP# ..4197-13-00.....

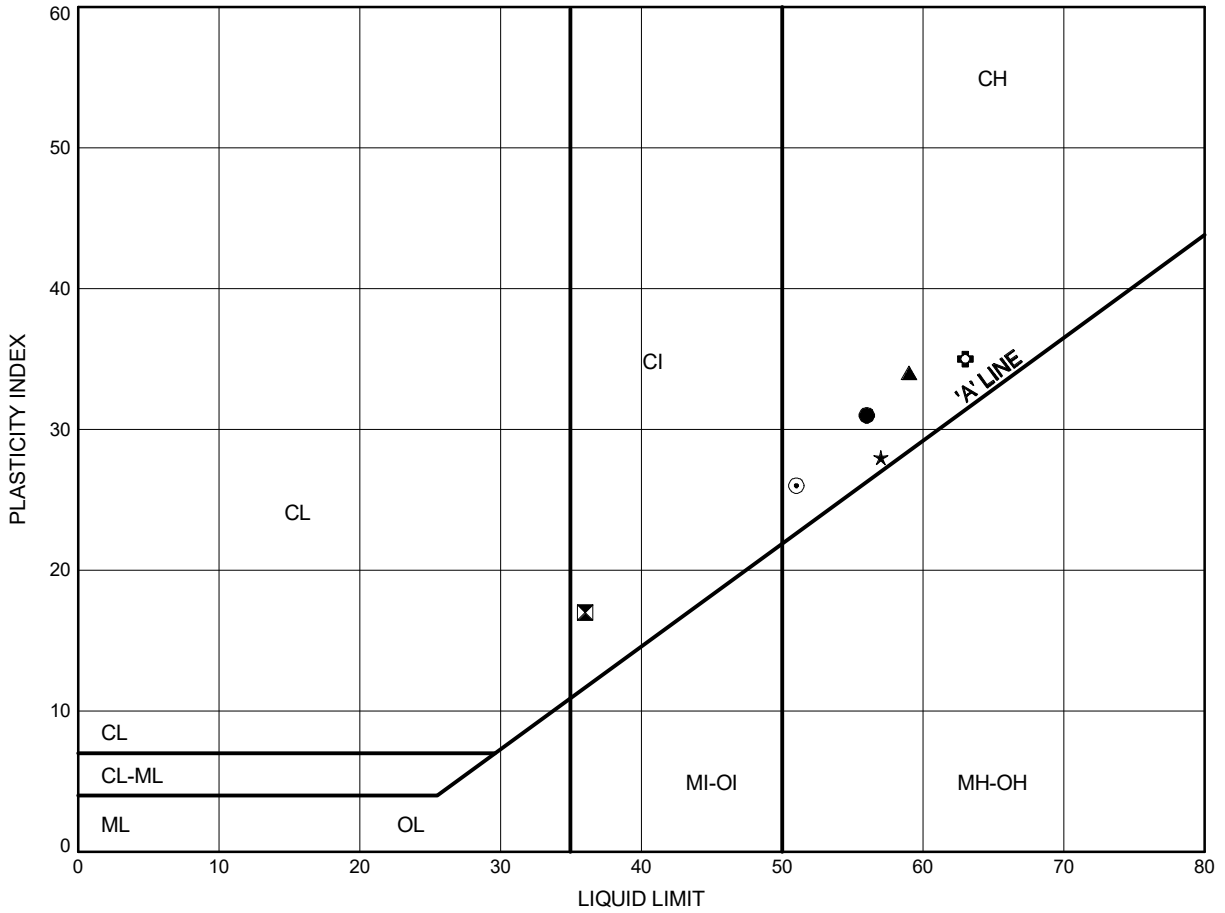


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C14

**Sandy Clay**



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-09	4.9	92.9
⊠	20-10	6.4	93.2
▲	20-11	3.4	92.3
★	20-12	4.9	94.2
⊙	20-13	1.1	96.0
⊕	21-16	4.9	93.2

Date ..October 2021.....  
 GWP# ..4197-13-00.....

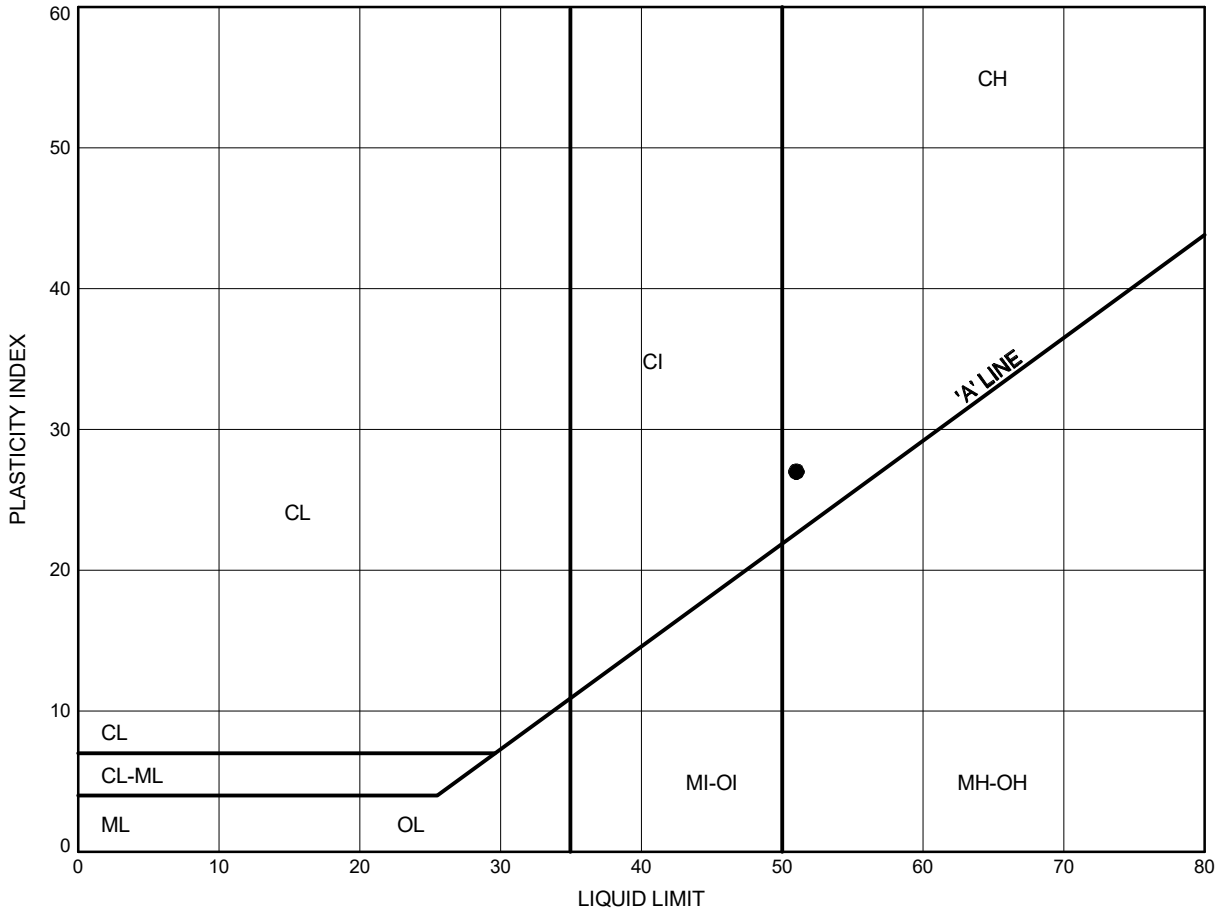


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C15

Sandy Clay



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21-17	4.9	93.0

THURBALT 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

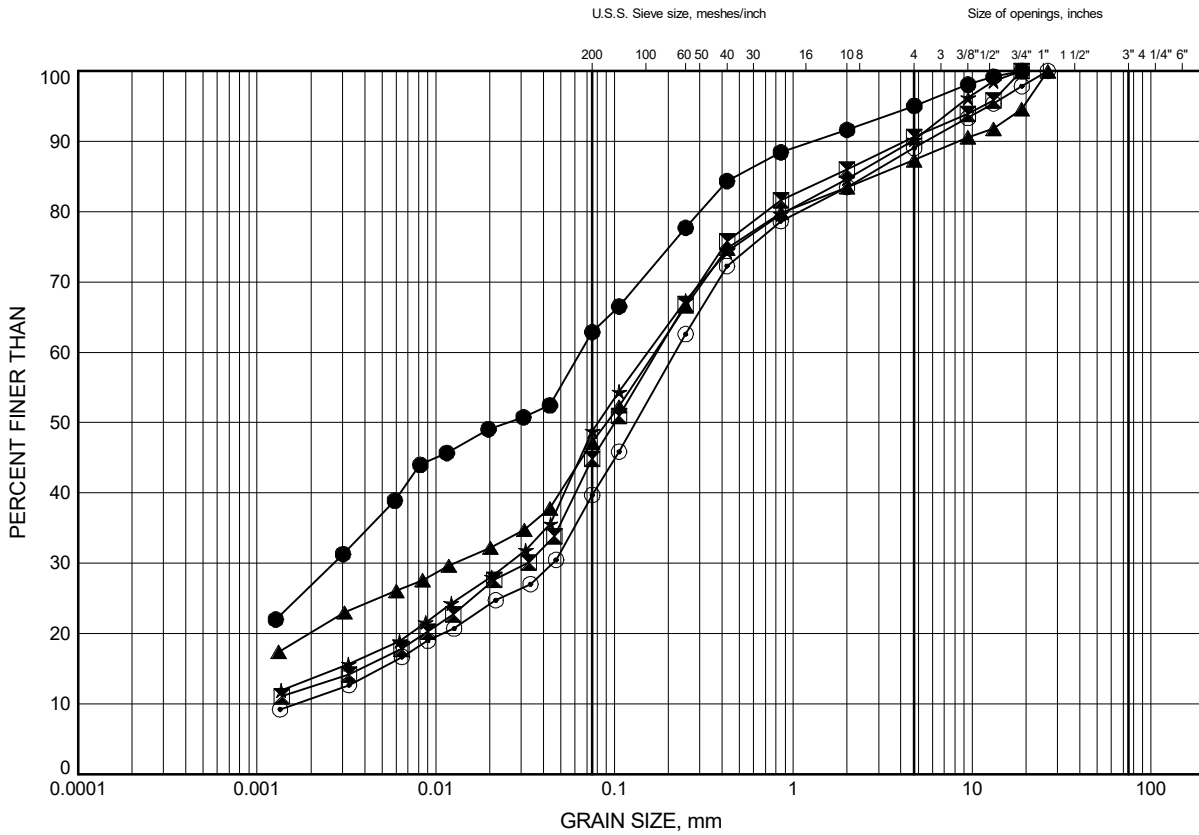


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**GRAIN SIZE DISTRIBUTION**

FIGURE C16

**Sandy Clayey Silt to Silty Clayey Sand**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-05	7.2	91.7
⊠	20-08	5.6	92.8
▲	20-10	7.9	91.7
★	20-11	5.6	90.1
⊙	20-12	6.4	92.7

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

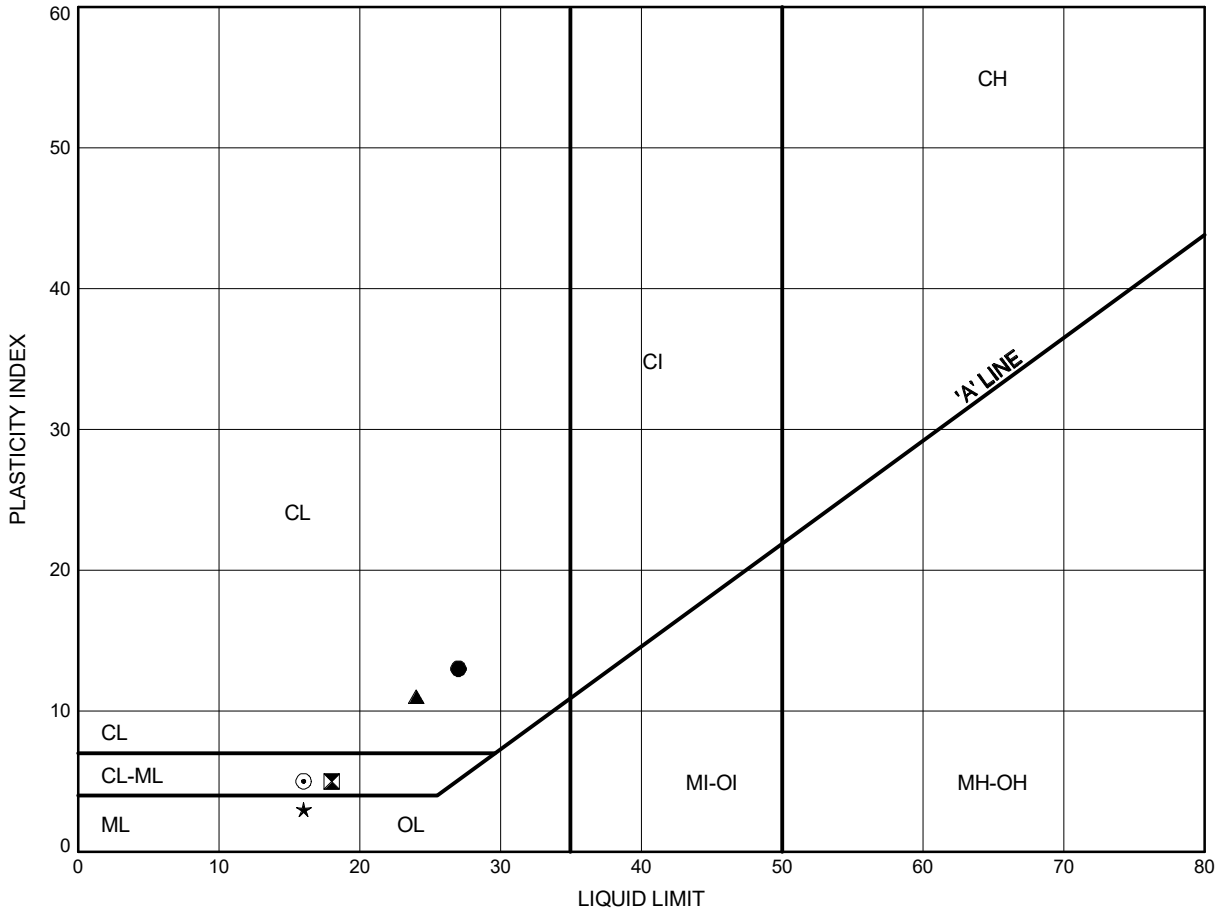


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C17

Sandy Clayey Silt to Silty Clayey Sand



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-05	7.2	91.7
⊠	20-08	5.6	92.8
▲	20-10	7.9	91.7
★	20-11	5.6	90.1
⊙	20-12	6.4	92.7

Date ..October 2021.....  
 GWP# ..4197-13-00.....

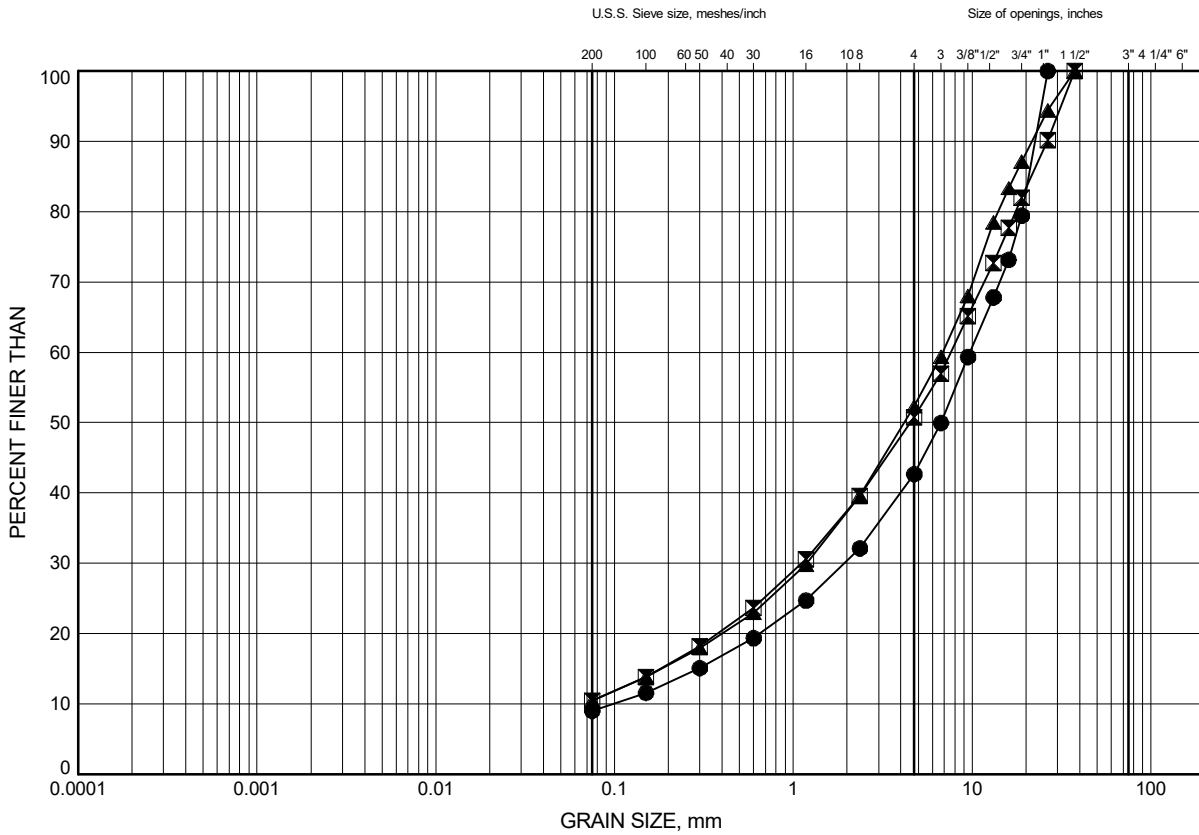


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**GRAIN SIZE DISTRIBUTION**

FIGURE C18

**Gravel with Sand and Silt**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-13	2.7	94.4
⊠	20-14	2.6	95.5
▲	20-14	5.6	92.5

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

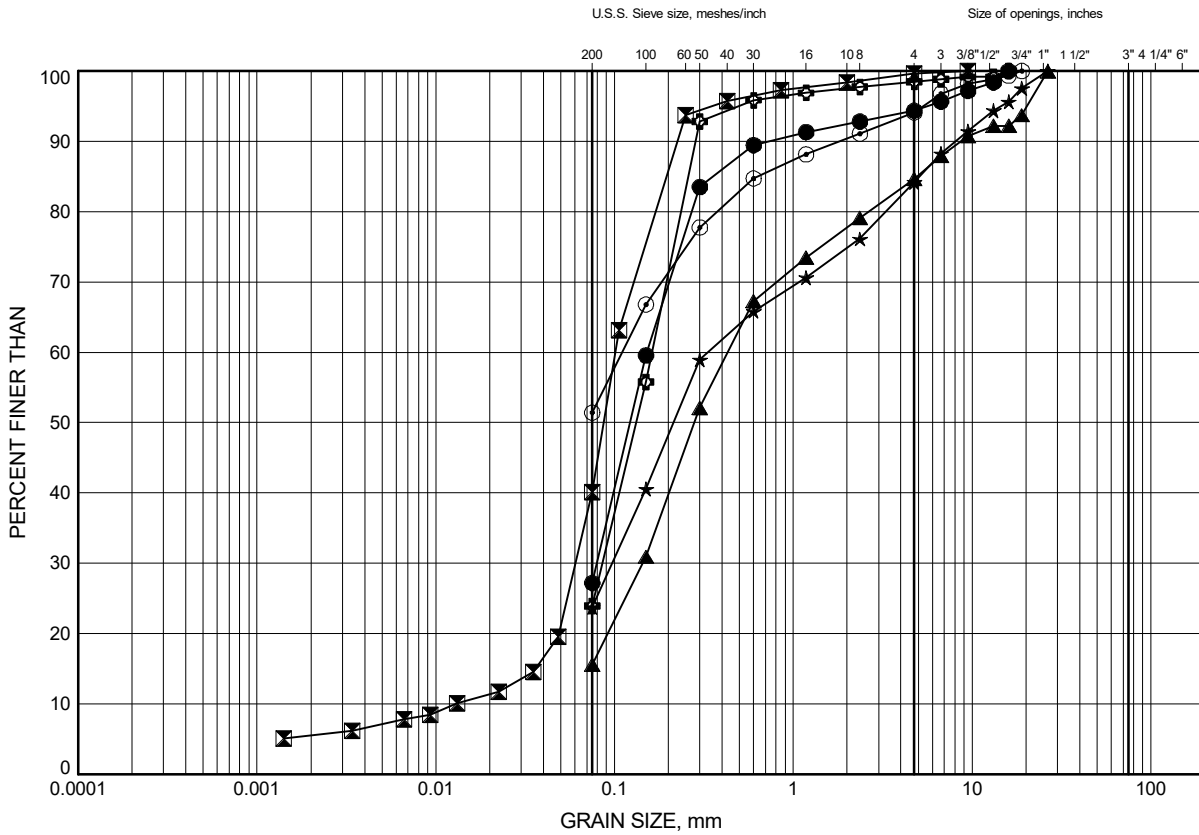


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**GRAIN SIZE DISTRIBUTION**

FIGURE C19

**Silty Sand to Sand with Silt to Sandy Silt**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-01	4.9	91.1
⊠	20-02	2.6	92.3
▲	20-02	3.4	91.5
★	20-03	7.9	90.8
⊙	20-04	6.4	92.8
⊕	20-05	10.2	88.7

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

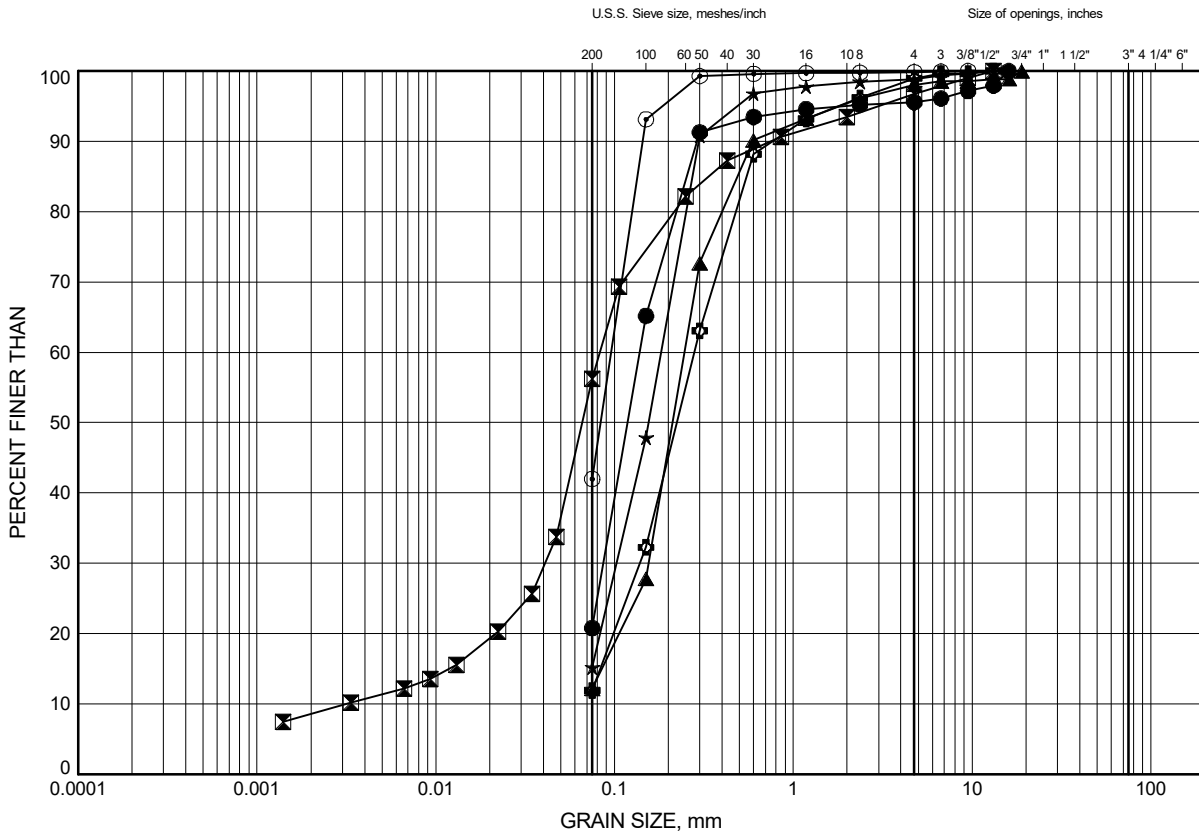


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**GRAIN SIZE DISTRIBUTION**

FIGURE C20

**Silty Sand to Sand with Silt to Sandy Silt**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-06	7.9	91.6
⊠	20-07	7.9	90.6
▲	20-07	9.4	89.1
★	20-08	7.9	90.5
⊙	20-09	6.4	91.4
⊕	20-09	7.9	89.9

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

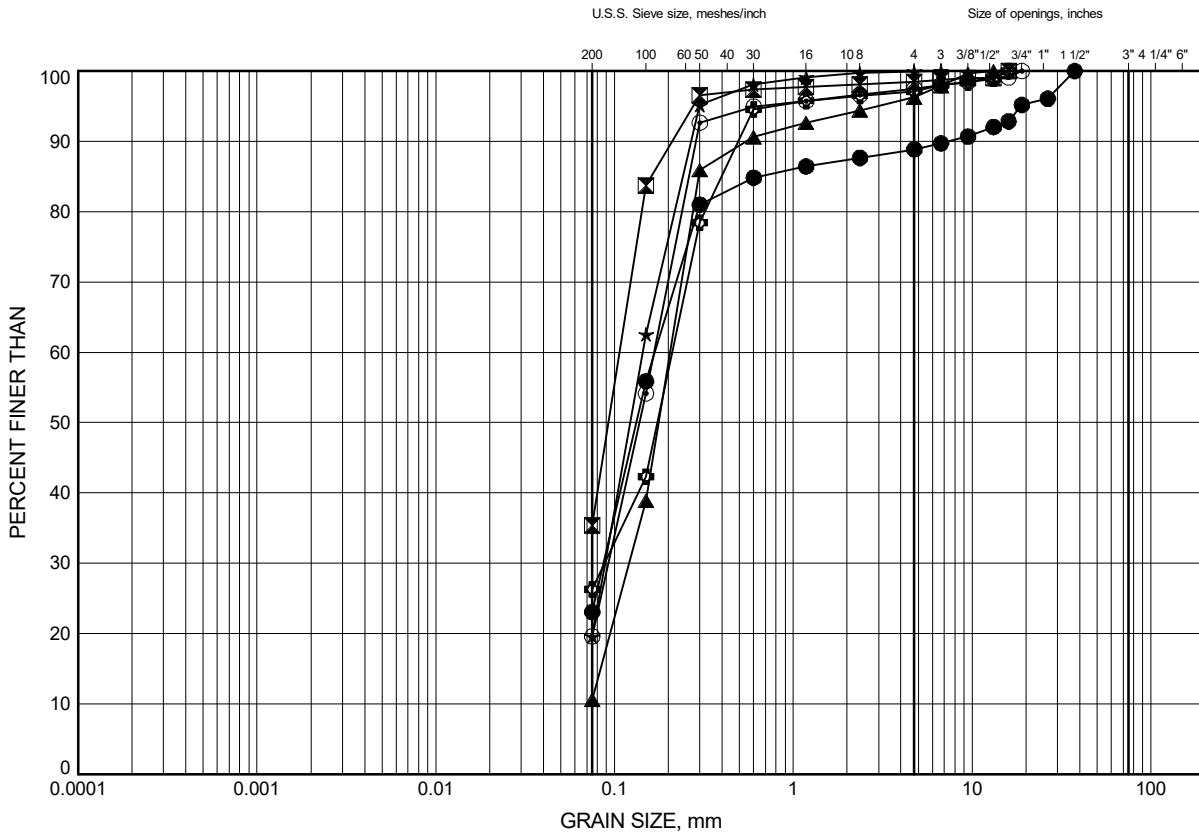


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**GRAIN SIZE DISTRIBUTION**

FIGURE C21

**Silty Sand to Sand with Silt to Sandy Silt**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	20-10	11.0	88.6
⊠	20-11	6.5	89.2
▲	20-15	2.6	97.5
★	20-15	4.9	95.2
⊙	21-16	7.9	90.2
⊕	21-17	6.4	91.5

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

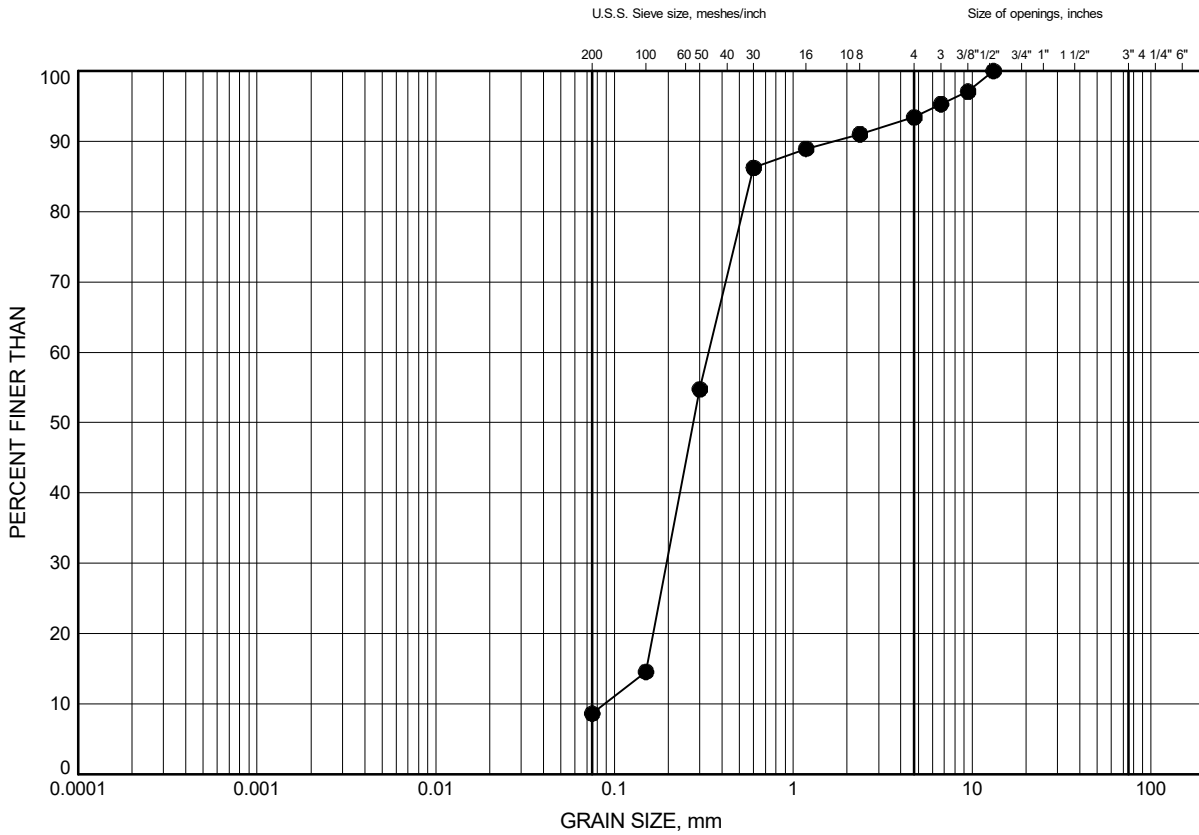


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**GRAIN SIZE DISTRIBUTION**

FIGURE C22

**Silty Sand to Sand with Silt to Sandy Silt**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21-17	9.4	88.5

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

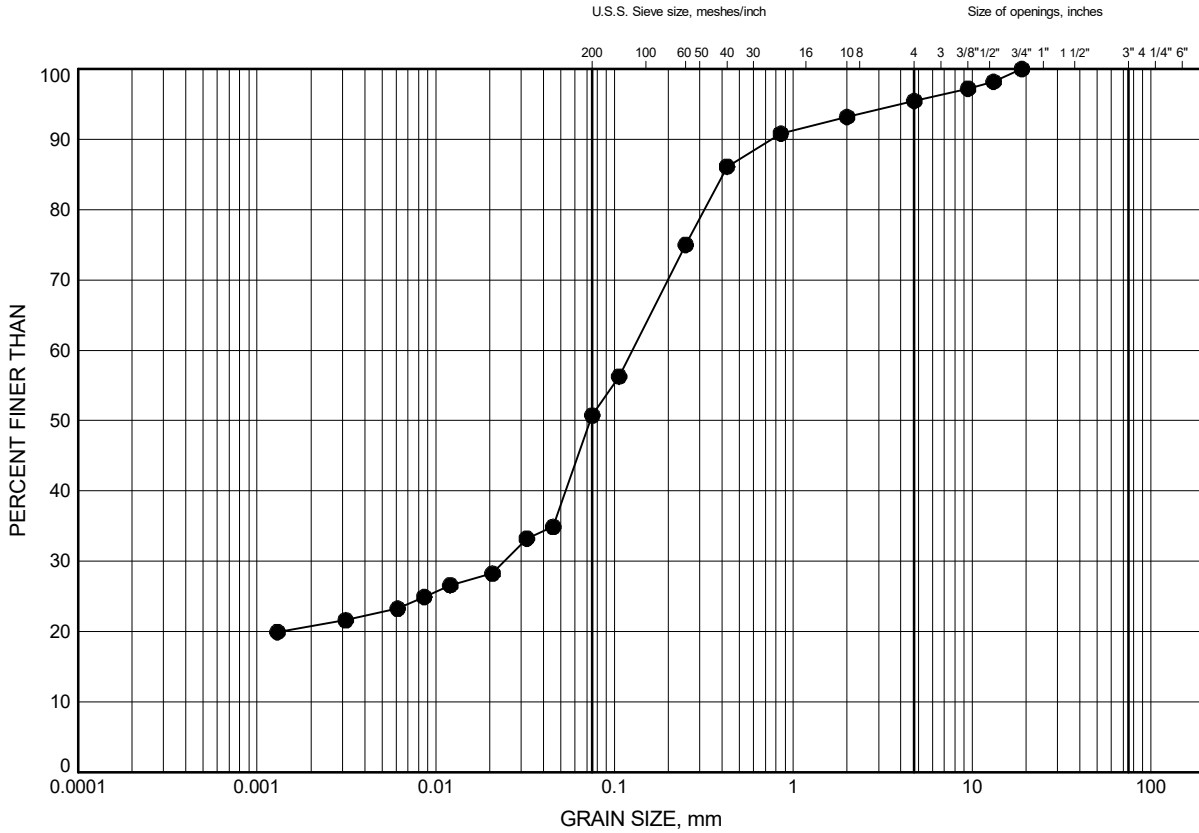


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**GRAIN SIZE DISTRIBUTION**

FIGURE C23

**Sandy Clayey Silt**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21-22	1.1	110.1

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

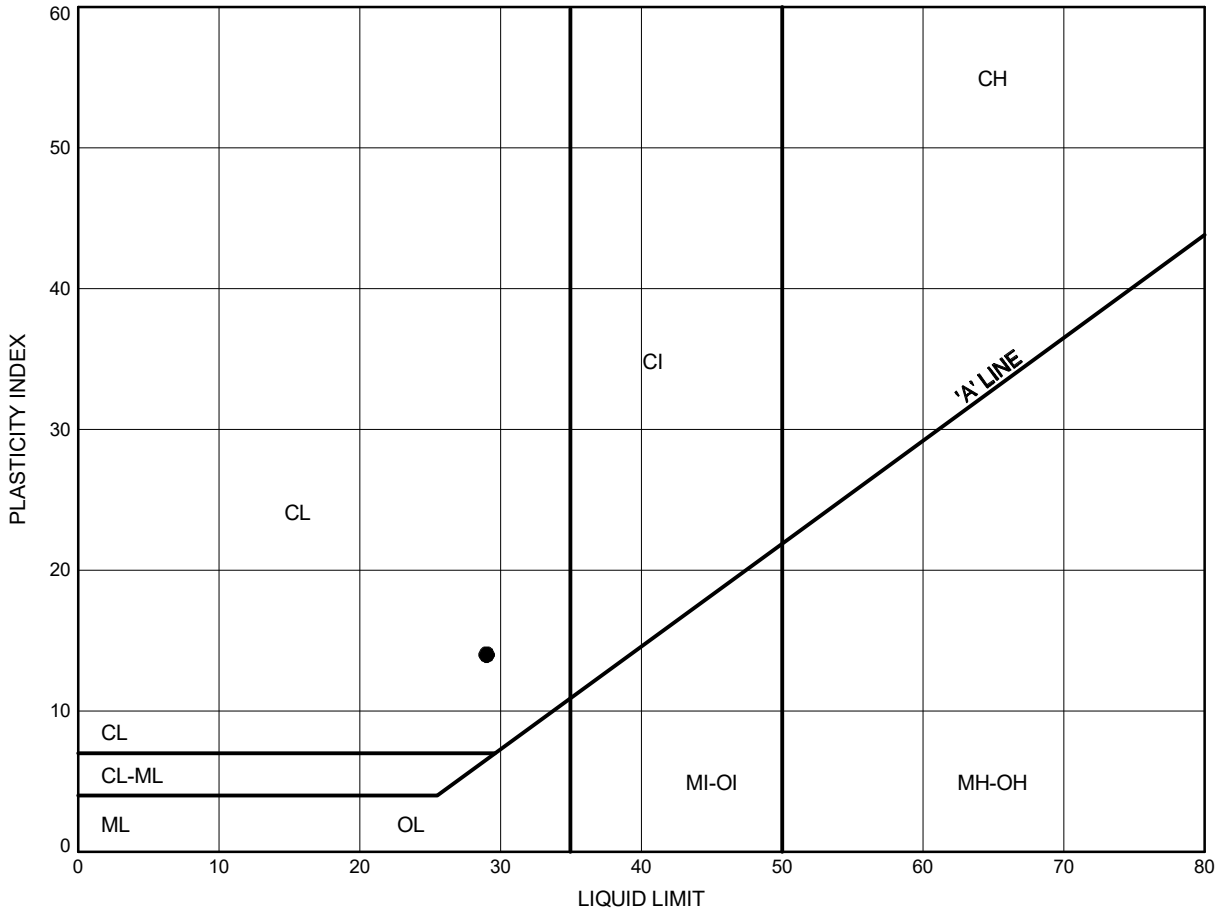


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C24

Sandy Clayey Silt



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21-22	1.1	110.1

THURBALT 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

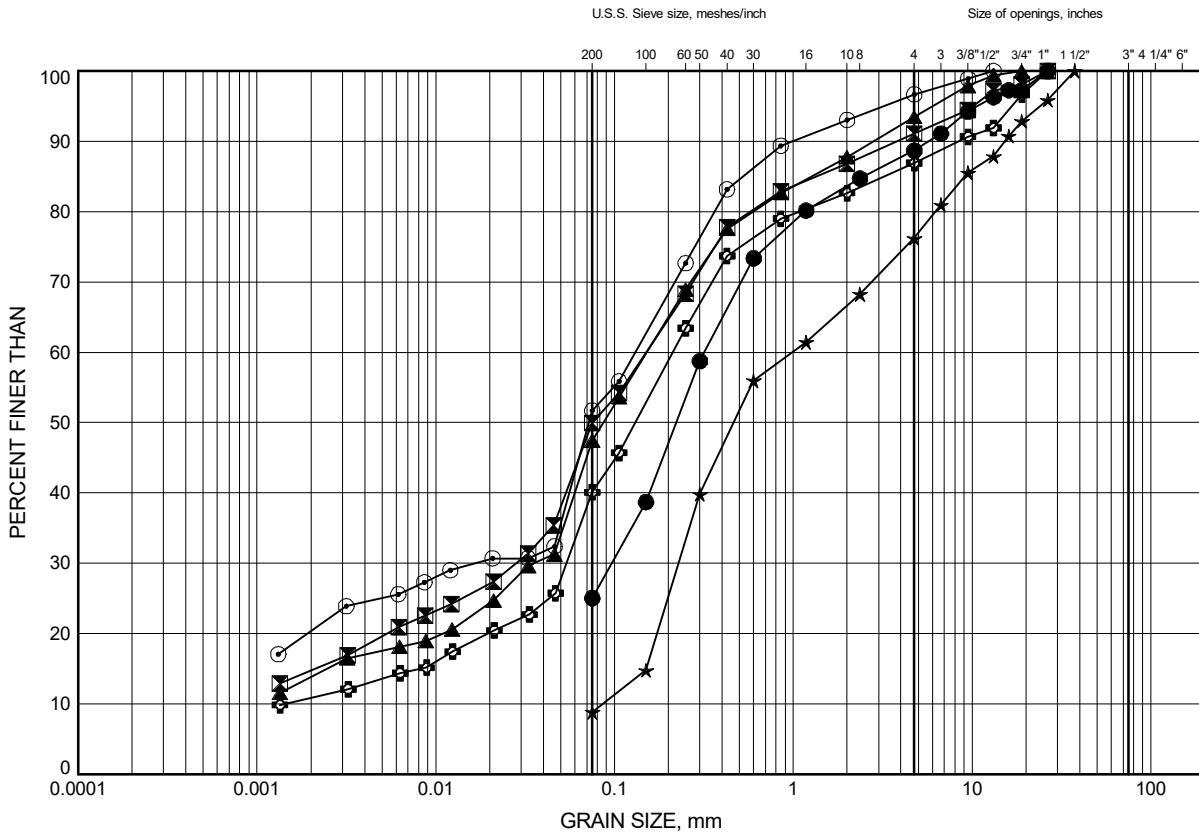


Prep'd .....CM.....  
 Chkd. ....SBP.....

# Highway 401 Palace Road Interchange GRAIN SIZE DISTRIBUTION

FIGURE C25

## Silty Sand to Sand with Silt to Sandy Silt



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21-20	1.8	105.0
⊠	21-20	3.4	103.4
▲	21-20	6.4	100.4
★	21-20	8.0	98.8
⊙	21-21	1.1	110.8
⊕	21-21	4.1	107.8

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
GWP# ..4197-13-00.....

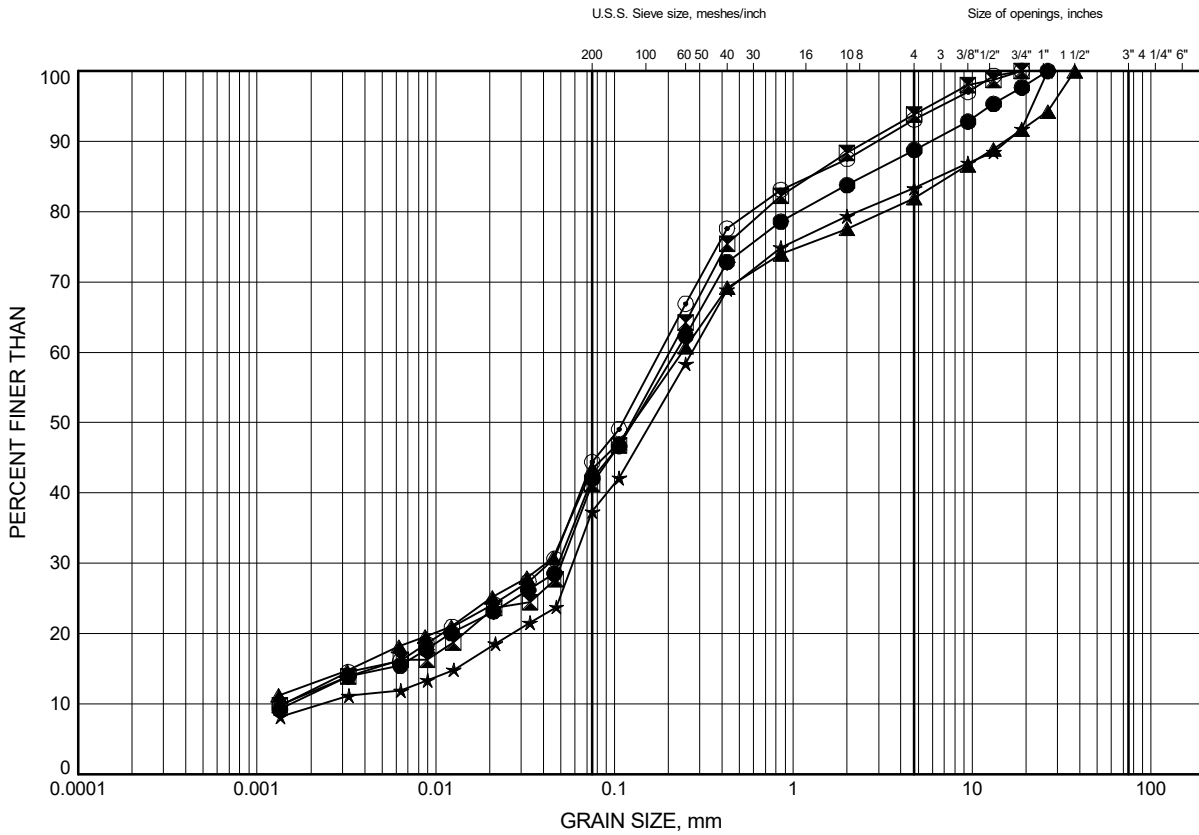


Prep'd .....CM.....  
Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**GRAIN SIZE DISTRIBUTION**

FIGURE C26

**Silty Sand to Sand with Silt to Sandy Silt**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21-21	5.6	106.3
⊠	21-22	3.4	107.8
▲	21-22	6.4	104.8
★	21-24	1.8	110.1
⊙	21-24	3.4	108.5

GRAIN SIZE DISTRIBUTION - THURBER 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....

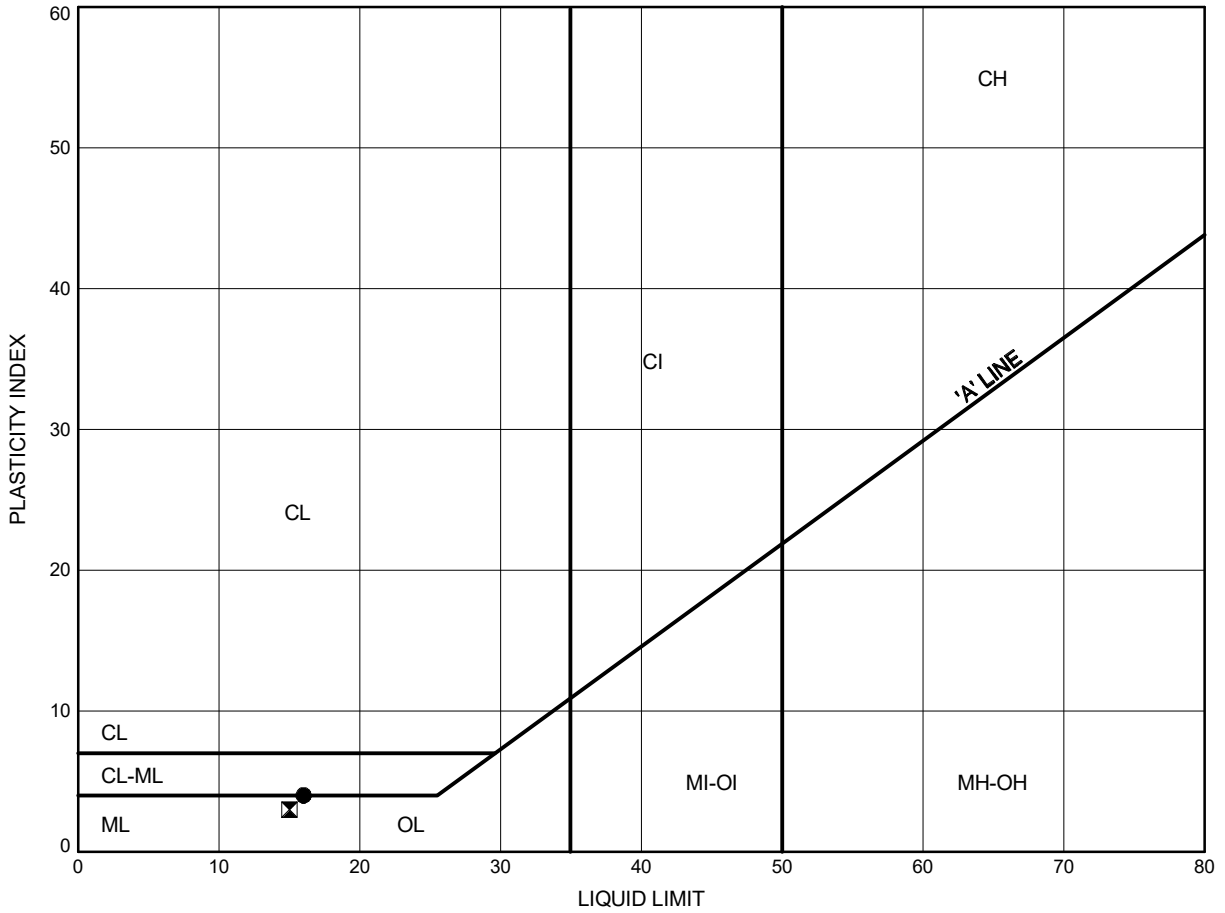


Prep'd .....CM.....  
 Chkd. ....SBP.....

Highway 401 Palace Road Interchange  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C27

Silty Sand to Sand with Silt to Sandy Silt



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	21-20	3.4	103.4
⊠	21-22	6.4	104.8

THURBALT 28707 HWY 401 PALACE ROAD INTERCHANGE.GPJ 21-10-26

Date ..October 2021.....  
 GWP# ..4197-13-00.....



Prep'd .....CM.....  
 Chkd. ....SBP.....

**Appendix C.2**  
**Analytical Testing Results**

Certificate of Analysis

Report Date: 02-Nov-2020

Client: Thurber Engineering Ltd.

Order Date: 27-Oct-2020

Client PO: 28707

Project Description: 28707

<b>Client ID:</b>	20-04, SS7 (15'-17')	20-05, SS4 (7'6"-9'6")	-	-
<b>Sample Date:</b>	21-Oct-20 15:00	22-Oct-20 13:15	-	-
<b>Sample ID:</b>	2044225-01	2044225-02	-	-
<b>MDL/Units</b>	Soil	Soil	-	-

**Physical Characteristics**

% Solids	0.1 % by Wt.	83.1	91.7	-	-
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**General Inorganics**

Conductivity	5 uS/cm	472	309	-	-
pH	0.05 pH Units	7.58	7.78	-	-
Resistivity	0.10 Ohm.m	21.2	32.4	-	-

**Anions**

Chloride	5 ug/g dry	187	131	-	-
Sulphate	5 ug/g dry	17	29	-	-



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

10-November-2020

**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. :** 28 October 2020  
**LR Report:** CA15485-OCT20  
**Reference:** Project#: 2044225

**Copy:** #1

# CERTIFICATE OF ANALYSIS

## Final Report

Sample ID	Sample Date & Time	Sulphide (Na2CO3) %
1: Analysis Start Date		06-Nov-20
2: Analysis Start Time		13:57
3: Analysis Completed Date		06-Nov-20
4: Analysis Completed Time		15:22
5: QC - Blank		< 0.04
6: QC - STD % Recovery		109%
7: QC - DUP % RPD		4%
8: RL		0.02
9: 20-04, SS7 (15'-17')	21-Oct-20 15:00	< 0.04
10: 20-05, SS4 (7'6"-9'6")	22-Oct-20 13:15	< 0.04

RL - SGS Reporting Limit

Kimberley Didsbury  
Project Specialist,  
Environment, Health & Safety

Certificate of Analysis

Report Date: 09-Nov-2020

Client: Thurber Engineering Ltd.

Order Date: 2-Nov-2020

Client PO: 28708

Project Description: 28708

<b>Client ID:</b>	20-07 SS5 (10'-12')	-	-	-
<b>Sample Date:</b>	27-Oct-20 15:00	-	-	-
<b>Sample ID:</b>	2045064-01	-	-	-
<b>MDL/Units</b>	Soil	-	-	-

**Physical Characteristics**

% Solids	0.1 % by Wt.	81.6	-	-	-
----------	--------------	------	---	---	---

**General Inorganics**

Conductivity	5 uS/cm	830	-	-	-
pH	0.05 pH Units	7.32	-	-	-
Resistivity	0.10 Ohm.m	12.0	-	-	-

**Anions**

Chloride	5 ug/g dry	422	-	-	-
Sulphate	5 ug/g dry	29	-	-	-



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - KOL 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

10-November-2020

**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. :** 03 November 2020  
**LR Report:** CA13089-NOV20  
**Reference:** Project#:2045064

**Copy:** #1

# CERTIFICATE OF ANALYSIS

## Final Report

Sample ID	Sample Date & Time	Sulphide (Na2CO3) %
1: Analysis Start Date		06-Nov-20
2: Analysis Start Time		13:57
3: Analysis Completed Date		06-Nov-20
4: Analysis Completed Time		15:07
5: QC - Blank		< 0.04
6: QC - STD % Recovery		109%
7: QC - DUP % RPD		4%
8: RL		0.02
9: 20-07 SS5 (10'-12')	27-Oct-20 15:00	< 0.04

RL - SGS Reporting Limit

\_\_\_\_\_  
Kimberley Didsbury  
Project Specialist,  
Environment, Health & Safety

**Appendix C.3**  
**Rock Core UCS and Photographs**



**Stantec Consulting Ltd**  
 2781 Lancaster Rd, Suite 100 A&B  
 Ottawa, ON K1B 1A7  
 Tel: (613) 738-6075  
 Fax: (613) 722-2799

**Stantec**

Date: November 4, 2020  
 File: 122410864

**Attention: Thurber Engineering, File #28708**

**Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core**

The following table summarizes six intact rock core unconfined compressive strength results.

Project	Location	Sample Depth	Compressive Strength (MPa)	Description of Break
Hwy 401 Palace Rd	20-04 Run-1	29'4"-30'2"	111.1	Well-formed cones at both ends
Hwy 401 Palace Rd	20-04 Run-2	38'1"-38'10"	195.7	Vertical cracking throughout, no cones formed
Hwy 401 Palace Rd	20-05 Run-1	36'1"-36'10"	140.1	Cone formed at one end, cracking throughout the rest
Hwy 401 Palace Rd	20-05 Run-2	44'9"-45'4"	228.1	Vertical cracking throughout, no cones formed
Hwy 401 Palace Rd	20-08 Run-1	36'3"	113.1	No cones formed, vertical cracking throughout
Hwy 401 Palace Rd	20-08 Run-3	44'11"	185.3	Well-formed cones at both ends

Sincerely,

**Stantec Consulting Ltd**

*Brian Prevost*

Brian Prevost  
 Laboratory Supervisor  
 Tel: 613-738-6075  
[brian.prevost@stantec.com](mailto:brian.prevost@stantec.com)



**Stantec Consulting Ltd**  
2781 Lancaster Rd, Suite 100 A&B  
Ottawa, ON K1B 1A7  
Tel: (613) 738-6075  
Fax: (613) 722-2799

**Stantec**

September 14, 2021  
File: 122410864

**Attention: Stephen Peters, Thurber Engineering, File #28708**

**Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core**

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

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
BH21-17 Run-2	40'7"-41'2"	140.7	Vertical cracking throughout, no well-formed cones
BH21-21 Run-1	22'4"-23'3"	127.0	Vertical cracking throughout, no well-formed cones
BH21-21 Run-2	29'10"-30'4"	74.6	Well-formed cone at both ends
BH21-24 Run-2	16'4"-17'5"	63.0	Well-formed cone at both ends

Sincerely,

**Stantec Consulting Ltd**

Brian Prevost  
Laboratory Supervisor  
Tel: 613-738-6075  
[brian.prevost@stantec.com](mailto:brian.prevost@stantec.com)

**Borehole 20-03**  
**Run 1 to 2 (of 2)**  
**Elevation 89.3 m to 86.7 m**



**THURBER** ENGINEERING LTD.

**Geotechnical Investigation**  
**HWY 401 Palace Road**  
**Napanee, Ontario**

**BH 20-03**  
**Project No.: 28708**

**Borehole 20-04**  
**Run 1 to 2 (of 2)**  
**Elevation 89.8 m to 87.4 m**



**THURBER** ENGINEERING LTD.

**Geotechnical Investigation**  
**HWY 401 Palace Road**  
**Napanee, Ontario**

**BH 20-04**  
**Project No.: 28708**

**Borehole 20-05**  
**Run 1 to 2 (of 2)**  
**Elevation 88.0 m to 85.0 m**



**THURBER** ENGINEERING LTD.

**Geotechnical Investigation**  
**HWY 401 Palace Road**  
**Napanee, Ontario**

**BH 20-05**  
**Project No.: 28708**

**Borehole 20-06**  
**Run 1 to 2 (of 2)**  
**Elevation 89.7 m to 87.2 m**

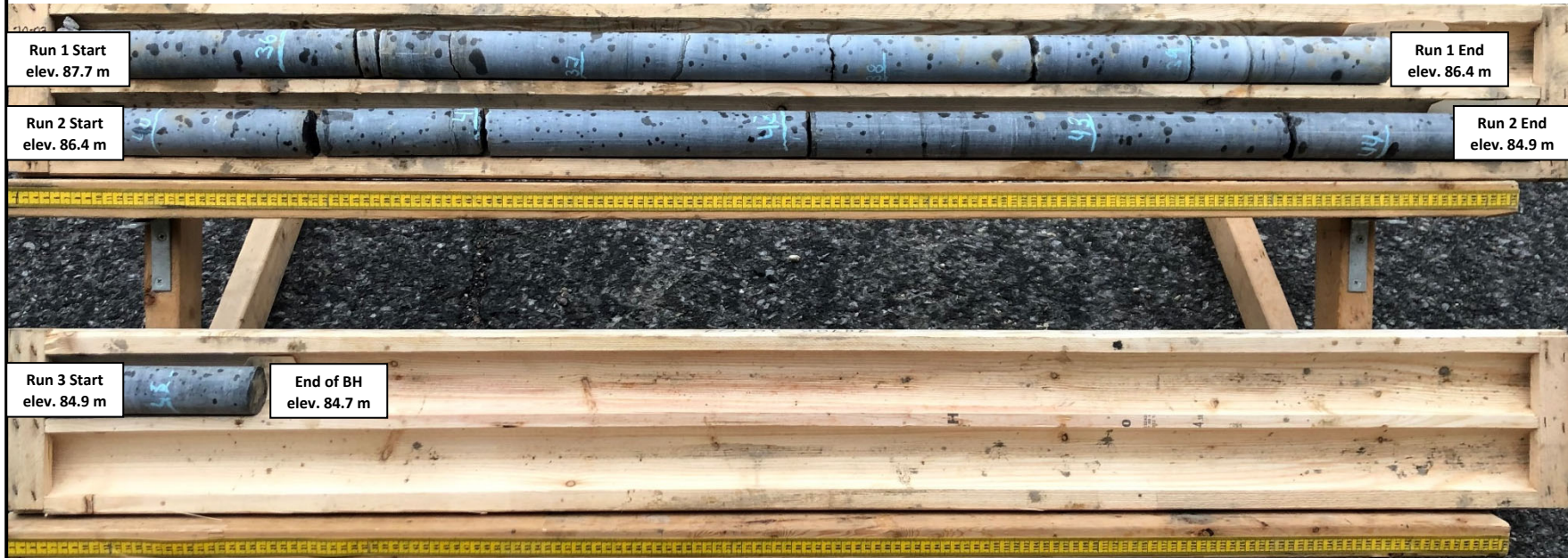


**THURBER** ENGINEERING LTD.

**Geotechnical Investigation**  
**HWY 401 Palace Road**  
**Napanee, Ontario**

**BH 20-06**  
**Project No.: 28708**

**Borehole 20-07**  
**Run 1 to 3 (of 3)**  
**Elevation 87.7 m to 84.7 m**



**THURBER** ENGINEERING LTD.

**Geotechnical Investigation**  
**HWY 401 Palace Road**  
**Napanee, Ontario**

**BH 20-07**  
**Project No.: 28708**

**Borehole 20-08**  
**Run 1 to 3 (of 3)**  
**Elevation 87.6 m to 84.5 m**



**THURBER** ENGINEERING LTD.

**Geotechnical Investigation**  
**HWY 401 Palace Road**  
**Napanee, Ontario**

**BH 20-08**  
**Project No.: 28708**

**Borehole 21-16**  
**Run 1 to 2 (of 2)**  
**Elevation 87.3 m to 84.2 m**



**Geotechnical Investigation**  
**HWY 401 Palace Road**  
**Napanee, Ontario**

**BH 21-16**  
**Project No.: 28708**

**Borehole 21-17**  
**Run 1 to 2 (of 2)**  
**Elevation 87.1 m to 84.0 m**



**Geotechnical Investigation**  
**HWY 401 Palace Road**  
**Napanee, Ontario**

**BH 21-17**  
**Project No.: 28708**

**Borehole 21-21**  
**Run 1 to 3 (of 3)**  
**Elevation 105.3 m to 102.1 m**



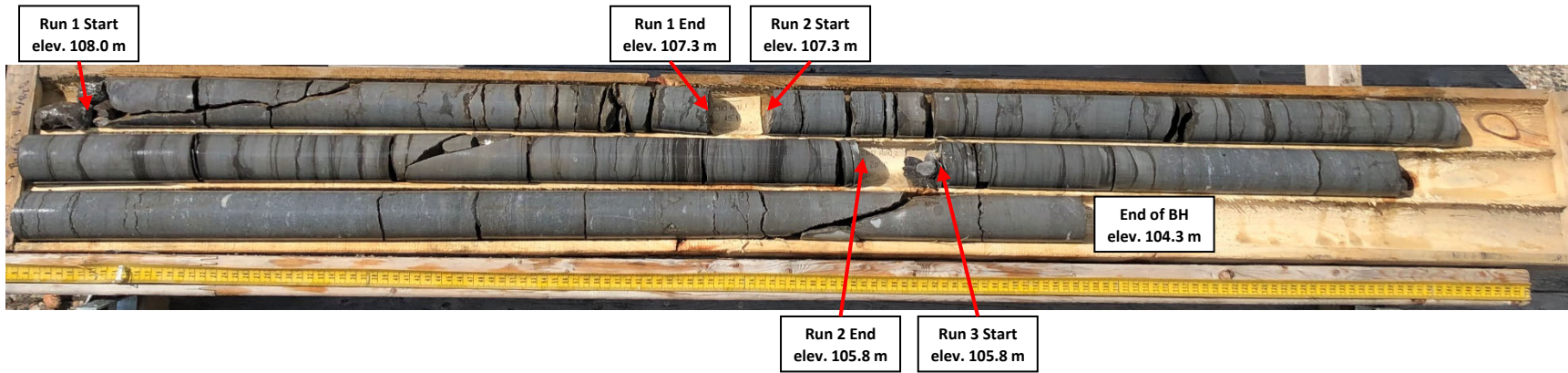
**Borehole 21-22**  
**Run 1 to 2 (of 2)**  
**Elevation 103.4 m to 100.4 m**



**Geotechnical Investigation**  
**HWY 401 Palace Road**  
**Napanee, Ontario**

**BH 21-22**  
**Project No.: 28708**

**Borehole 21-24**  
**Run 1 to 3 (of 3)**  
**Elevation 108.0 m to 104.3 m**



**Geotechnical Investigation**  
**HWY 401 Palace Road**  
**Napanee, Ontario**

**BH 21-24**  
**Project No.: 28708**

**Appendix D.**  
**Site Photographs**



Photo 1. Looking northwest toward Highway 401 from Borehole 20-01 [Oct. 2020]



Photo 2. Looking northeast toward W-N/S ramp from Borehole 20-02 [Oct. 2020].



Photo 3. Looking northeast toward Boreholes 20-07, 20-08 and 20-09 [Sept. 2020]/



Photo 4. Looking northeast toward Borehole 20-11 from E-N/S ramp [Oct. 2020].



Photo 5. Looking west toward N/S-W ramp from Borehole 20-13 [Oct. 2020].



Photo 6. Looking south toward Borehole 20-13 from Borehole 20-14 [Oct. 2020].



Photo 7. Looking east along proposed E-N/S ramp alignment, westbound Hwy 401 to right in photo [Aug. 2021].

**Appendix E.**  
**MASW Testing Results**



**GEOPHYSICS GPR INTERNATIONAL INC.**

6741 Columbus Road  
Unit 14  
Mississauga, Ontario  
Canada L5T 2G9

Tel.: (905) 696-0656  
Fax: (905) 696-0570  
gprtor@gprtor.com  
www.geophysicsgpr.com

November 13, 2020  
Rev. January 6, 2020

GPR file: T202510

Christopher Murray M.A.Sc., P.Eng.  
Geotechnical Engineer  
**Thurber Engineering Ltd.**  
2460 Lancaster Road, Suite 104  
Ottawa, Ontario  
K1B 4S5

**RE: Shear-wave velocity sounding at Place Road Interchange, Napanee, Ontario**

Dear Mr. Murray:

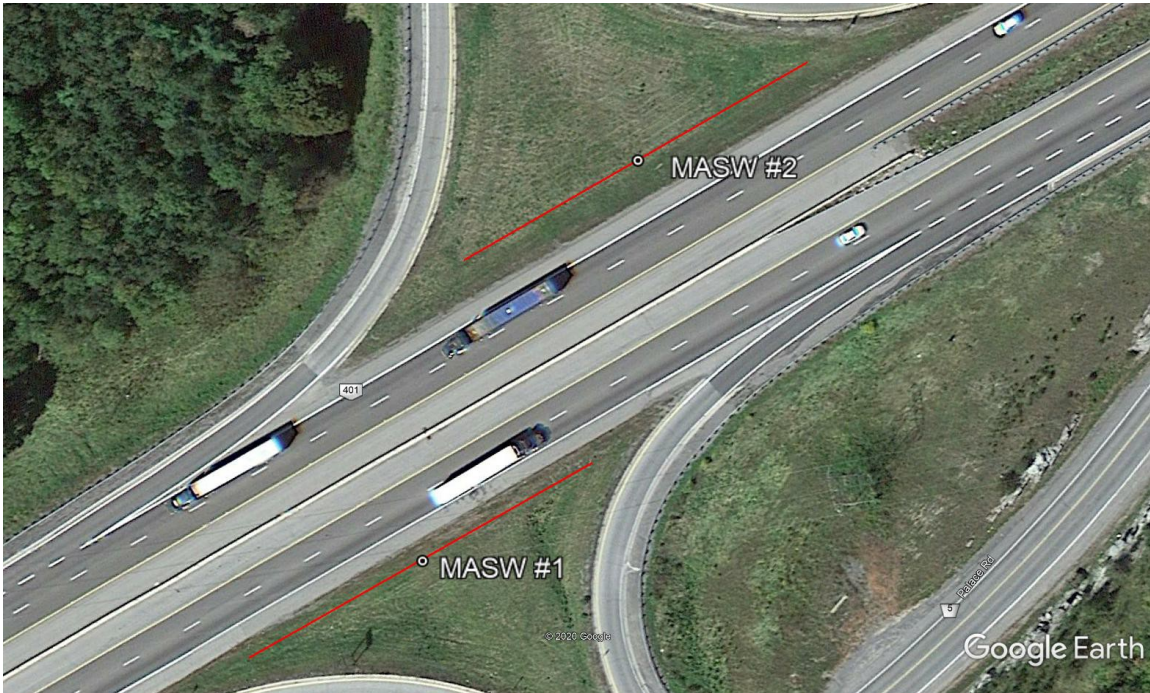
Geophysics GPR International Inc. has been requested by Thurber Engineering Ltd. to carry out a shear-wave velocity sounding at the above site in Napanee. Figure 1 shows the location of the test profile.

The survey was performed on October 26<sup>th</sup>, 2020.

The investigation included the multi-channel analysis of surface waves (MASW), the micro-tremor array measurements (MAM) and the refraction methods to generate a shear-wave velocity model (Figures 4&5).

The following paragraphs describe the survey design, the principles of the test method, the methodology for interpreting the data, and provide a culmination of the results in table format.





**Figure 1:** Approximate location of the shear-wave velocity soundings

## MASW and MAM Surveys

### *Basic Theory*

The Multi-channel Analysis of Surface Waves (MASW) and the Micro-tremor Array Measurements (MAM) are seismic methods used to evaluate the shear-wave velocities of subsurface materials through the analysis of the dispersion properties of Rayleigh surface waves (“ground roll”). The dispersion properties are measured as a change in phase velocity with frequency. Surface wave energy will decay exponentially with depth. Lower frequency surface waves will travel deeper and thus be more influenced by deeper velocity layering than the shallow higher frequency waves. Inversion of the Rayleigh wave dispersion curve yields a shear-wave ( $V_s$ ) velocity depth profile (sounding). Figure 2 outlines the basic operating procedure for the MASW method. Figure 3 is an example image of a typical MASW record and resulting 1D  $V_s$  model. A more detailed description of the method can be found in the paper *Multi-channel Analysis of Surface Waves*, Park, C.B., Miller, R.D. and Xia, J. *Geophysics*, Vol. 64, No. 3 (May-June 1999); P. 800–808.

### *Survey Design*

The geometry of an MASW survey is similar to that of a seismic refraction investigation (i.e. 24 geophones in a linear array). The fundamental principle involves intentionally generating an acoustic wave at the surface and digitally recording the surface waves from the moment of source impact with a linear series of geophones on the surface. This is referred to as an “active source” method. An elastic-wave hammer was used as the primary energy source with traces being recorded at 6 locations: approximately 6 m off both ends, 25 to 30 m off both



ends, and in the middle of the spread. Data were collected with geophones spacing of 3m and 1m for a total of 10 shot records per sounding.

Unlike the refraction method, which produces a data point beneath each geophone, the shear-wave depth profile is the average of the bulk area within the middle third of the geophone spread.

The theoretical maximum depth of penetration (34.5m) is half of the maximum seismic array length (69 m), in practice the maximum depth of penetration is often influenced by the geology.

The MAM/passive survey used the same geophone array set up as for the MASW survey. Unlike the MASW survey, the MAM method is considered a “passive source” method in that there is no time break and the motions recorded are from ambient energy generated by cultural noise such as traffic, wind, wave motion, etc. Data collection for the passive method involves recording approximately 10 minutes of background “noise.” The records generated by the MAM method contain lower frequency data, thus increasing the data resolution at greater depths of investigation. Typically the MAM results aid in clarifying the MASW results for depths greater than 20 m; however, the direction of noise propagation relative to the spread orientation can influence the results.

### ***Interpretation Method and Accuracy of Results***

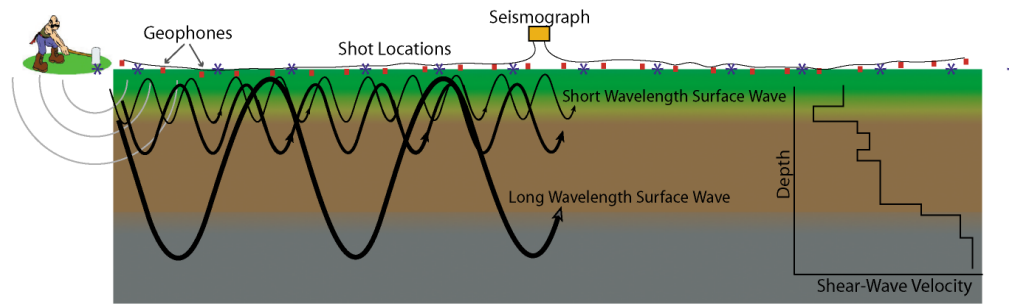
The main processing sequence involved plotting, picking, and 1-D inversion of the MASW/MAM shot records using the SeisimagerSW™ software package. In theory, all MASW shot records should produce a similar shear-wave velocity profile. In practice, however, differences can arise due to energy dissipation and localized surface variations. The results of the inversion process are inherently non-unique and the final model must be judged to be geologically realistic. The inversion modelling also assumes that all layering is flat/horizontal and laterally uniform.

The results of the MASW/MAM tests are presented in chart format as Figures 4 & 5. The chart presents the 1-D shear wave velocity values from the inversion models of the passive and active seismic records.

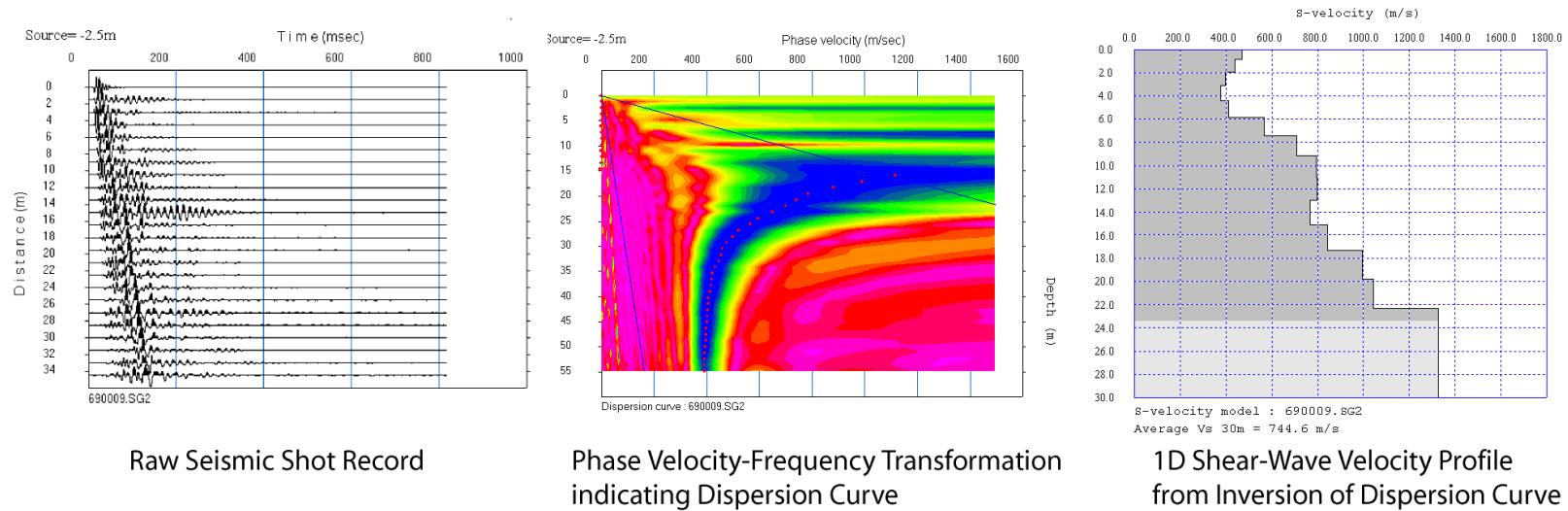
The  $V_{s30}$  values for the sounding are presented in Table 1. The  $V_{s30}$  values are based on the harmonic mean of the shear wave velocities over the upper 30 m. The  $V_{s30}$  value is calculated by dividing the total depth of interest (e.g. 30 m) by the sum of the time spent in each velocity layer up to that depth. This harmonic mean value reflects the equivalent single layer response.

The estimated error in the average  $V_{s30}$  value determined through MASW tests is typically +/-10 to 15% for overburden sites. The shear-wave velocities modelled through the MASW method within bedrock have a higher estimated error.



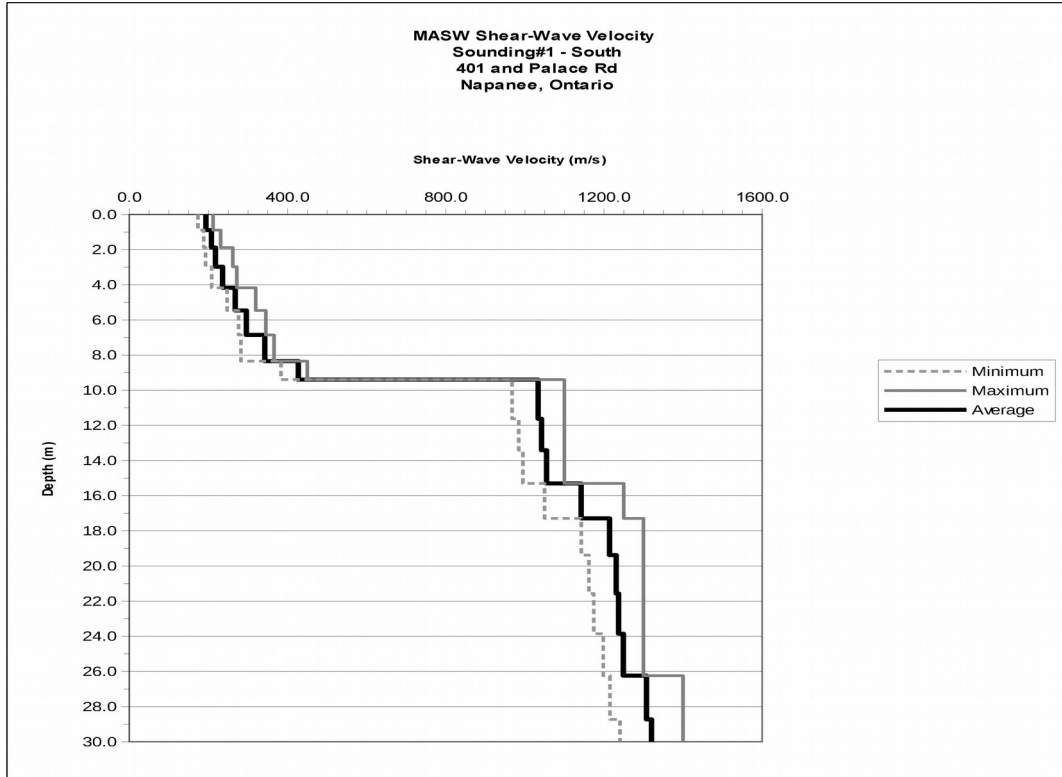


**Figure 2: MASW Operating Principle**

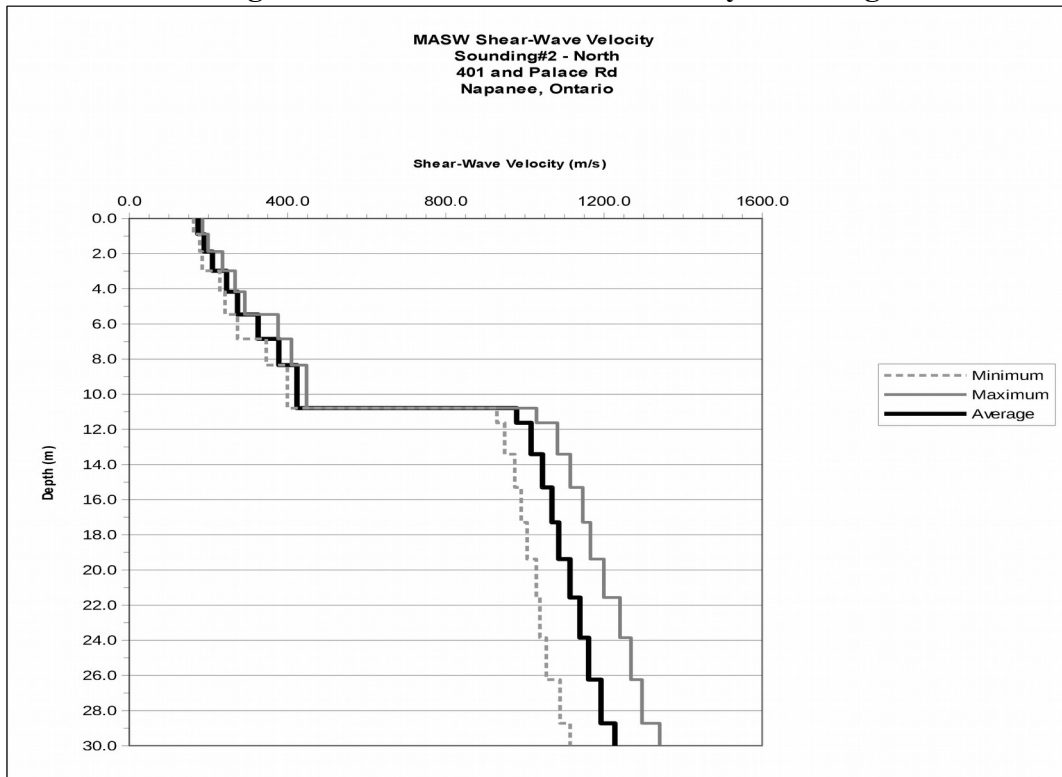


**Figure 3: Example of a typical MASW shot record, phase velocity/frequency curve and resulting 1D shear-wave velocity model.**





**Figure 4: MASW Shear-wave Velocity Sounding**



**Figure 5: MASW Shear-wave Velocity Sounding**



## CONCLUSIONS

The approximate location of the shear-wave soundings is indicated in Figure 1.

The MASW shear-wave model is presented in Figures 4. The results are summarized in Table 1. The background seismic noise levels at this site were moderate. The quality of the seismic records and the resulting dispersion curves was good.

Simple critical distance calculations from refracted P-waves show that the bedrock could be approximately at 9 to 10m deep. MASW models were constrained with refraction data.

The boreholes provided by the client confirmed the general soils type and the bedrock depth. The boreholes were used to adjust the bedrock depth for the MASW models.

**Table 1: Calculated  $V_{s30}$  values (m/s) from the MASW data (0 to 30m)**

Sounding	Minimum	Average	Maximum	Site Class
1	511	<b>563</b>	624	<b>C</b>
2	485	<b>531</b>	574	<b>C</b>

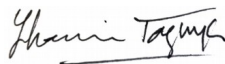
The calculated average  $V_{s30}$  values from the 1D MASW soundings collected was 563 and 531m/s +/-15% to 20% respectively for soundings 1 and 2.

The  $V_{s30}$  values calculated for the minimum and the maximum envelopes ranged from 485 to 624m/s.

Based on the average  $V_{s30}$  values (as determined through the MASW method) and table 4.1.8.4.A of the National Building Code of Canada, 2015 Edition, the investigated area is site class "C" ( $360 < V_{s30} \leq 760$  m/s).

It must be noted that the site classification provided in this report is based solely on the  $V_{s30}$  value as derived from the MASW method and that it can be superseded by other geotechnical information. This geotechnical information includes, but is not limited to, the presence of sensitive and/or liquefiable soils, more than 3m of soft clays, high moisture content, etc. The reader is referred to section 4.1.8.4 of the National Building Code of Canada, 2015 Edition for more information on the requirements for site classification.

This report has been written by Lhoucin Taghya, P.Geo.



Lhoucin Taghya, P.Geo.  
Geophysicist



## **Appendix F.**

### **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: 44.269N 76.927W

User File Reference: Palace Road Interchange

2020-12-16 20:32 UT

Requested by: C.Murray, Thurber Engineering

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)	0.124	0.075	0.049	0.018
Sa (0.1)	0.165	0.104	0.070	0.027
Sa (0.2)	0.156	0.102	0.071	0.028
Sa (0.3)	0.131	0.088	0.061	0.025
Sa (0.5)	0.106	0.071	0.050	0.020
Sa (1.0)	0.063	0.042	0.029	0.011
Sa (2.0)	0.033	0.021	0.014	0.004
Sa (5.0)	0.009	0.005	0.003	0.001
Sa (10.0)	0.004	0.002	0.001	0.001
PGA (g)	0.095	0.060	0.040	0.015
PGV (m/s)	0.091	0.057	0.037	0.013

**Notes:** Spectral ( $S_a(T)$ , where  $T$  is the period in seconds) and peak ground acceleration (PGA) values are given in units of  $g$  ( $9.81 \text{ m/s}^2$ ). Peak ground velocity is given in  $\text{m/s}$ . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity  $450 \text{ m/s}$ ). 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](http://www.EarthquakesCanada.ca) and [www.nationalcodes.ca](http://www.nationalcodes.ca) for more information

**Appendix G.**  
**Foundation Comparison**

### Comparison of Alternative Foundation Types

Shallow Foundation	Caisson (Drilled Shafts)	Driven Steel Piles
<b>Advantages</b>		
Generally less costly construction than deep foundations Requires less specialized construction equipment	Higher geotechnical resistance than spread footings and steel piles Construction could continue in winter weather conditions	Higher geotechnical capacity than spread footings Construction could continue in winter weather conditions Requires less concrete than spread footings and caissons Likely requires less dewatering effort
<b>Disadvantages</b>		
Requires large excavations adjacent to Highway Lower geotechnical resistance than deep foundations Less efficient for resistance to uplift or overturning Does not allow for integral abutments	Specialized installation measures such as equipment, liners and drilling mud may be required Difficulty in cleaning and inspecting base Excavated fill to be disposed of. Does not allow for integral abutments	Lower geotechnical resistance than caissons Has potential to encounter obstructions in fill
<b>Risk/Consequences</b>		
Large Excavation adjacent to Highway	Difficulty in advancing through dense soils and unbalanced hydrostatic pressures	Difficult advancing through obstructions in fill
<b>Relative Cost</b>		
Moderate	High	Moderate to High
<b>Recommendation</b>		
<b>Not Recommended</b>	<b>Feasible but Not Preferred</b>	<b>Recommended</b>

## Appendix H.

### P-y Curves and Slope Stability Analyses

SOIL P-Y CURVES - Palace Road Interchange

H-Pile

HP310x110: North Abutment, Underside Elev. 100.4m, Borehole 21-16

Elev. (m)	99.9		98.9		97.9		96.9		95.9		94.9		93.9		92.9		91.9		90.9		89.9		88.9		87.9	
P-y Curves	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0
	0.0016	9.2	0.0005	8.6	0.0048	104.6	0.0096	360.9	0.0009	52.9	0.0009	64.7	0.0000	14.0	0.0000	14.0	0.0012	92.8	0.0011	98.4	0.0011	104.0	0.0010	109.6	0.0010	115.2
	0.0019	9.7	0.0009	12.3	0.0049	105.0	0.0097	366.9	0.0018	105.9	0.0018	129.4	0.0000	27.9	0.0000	27.9	0.0023	185.5	0.0022	196.7	0.0021	207.9	0.0020	219.1	0.0020	230.3
	0.0023	10.2	0.0014	15.4	0.0049	105.4	0.0099	372.9	0.0027	158.8	0.0027	194.1	0.0001	41.9	0.0001	41.9	0.0035	278.3	0.0033	295.1	0.0032	311.9	0.0030	328.7	0.0029	345.5
	0.0026	10.6	0.0018	18.2	0.0049	105.8	0.0100	378.9	0.0036	211.7	0.0036	258.8	0.0004	55.8	0.0004	55.8	0.0047	371.0	0.0044	393.4	0.0042	415.8	0.0041	438.2	0.0039	460.6
	0.0029	11.0	0.0022	20.7	0.0050	106.1	0.0102	384.9	0.0045	264.7	0.0045	323.5	0.0011	69.8	0.0011	69.8	0.0058	463.8	0.0055	491.8	0.0053	519.8	0.0051	547.8	0.0049	575.8
	0.0032	11.4	0.0026	23.0	0.0050	106.5	0.0104	390.9	0.0055	317.6	0.0055	388.2	0.0022	83.7	0.0022	83.7	0.0070	556.5	0.0066	590.1	0.0063	623.7	0.0061	657.4	0.0059	691.0
	0.0036	11.7	0.0030	25.1	0.0050	106.9	0.0105	396.9	0.0064	370.5	0.0064	452.9	0.0041	97.7	0.0041	97.7	0.0081	649.3	0.0077	688.5	0.0074	727.7	0.0071	766.9	0.0069	806.1
	0.0039	12.0	0.0035	27.2	0.0051	107.3	0.0107	402.9	0.0073	423.5	0.0073	517.6	0.0070	111.6	0.0070	111.6	0.0093	742.0	0.0088	786.9	0.0084	831.7	0.0081	876.5	0.0079	921.3
	0.0042	12.3	0.0039	29.1	0.0051	107.6	0.0108	408.9	0.0082	476.4	0.0082	582.2	0.0112	125.6	0.0112	125.6	0.0105	834.8	0.0099	885.2	0.0095	935.6	0.0091	986.0	0.0088	1036.4
	0.0045	12.6	0.0043	31.0	0.0051	108.0	0.0110	414.9	0.0091	529.3	0.0091	646.9	0.0171	139.5	0.0171	139.5	0.0116	927.6	0.0110	983.6	0.0106	1039.6	0.0102	1095.6	0.0098	1151.6
	0.0048	12.9	0.0047	32.7	0.0051	108.4	0.0111	420.9	0.0100	582.2	0.0100	711.6	0.0251	153.5	0.0251	153.5	0.0128	1020.3	0.0121	1081.9	0.0116	1143.5	0.0112	1205.2	0.0108	1266.8
	0.0052	13.2	0.0052	34.5	0.0052	108.7	0.0113	427.0	0.0109	635.2	0.0109	776.3	0.0356	167.4	0.0356	167.4	0.0140	1113.1	0.0132	1180.3	0.0127	1247.5	0.0122	1314.7	0.0118	1381.9
	0.0084	15.7	0.0084	47.4	0.0084	150.1	0.0115	432.3	0.0118	688.1	0.0118	841.0	0.0490	181.4	0.0490	181.4	0.0151	1205.8	0.0144	1278.6	0.0137	1351.5	0.0132	1424.3	0.0128	1497.1
	0.0116	18.3	0.0116	60.3	0.0116	191.4	0.0116	437.0	0.0127	741.0	0.0127	905.7	0.0659	195.3	0.0659	195.3	0.0163	1298.6	0.0155	1377.0	0.0148	1455.4	0.0142	1533.8	0.0138	1612.2
	0.0140	18.3	0.0140	60.3	0.0140	191.4	0.0140	437.0	0.0153	741.0	0.0153	905.7	0.0868	209.3	0.0868	209.3	0.0196	1298.6	0.0185	1377.0	0.0177	1455.4	0.0171	1533.8	0.0165	1612.2
	0.0163	18.3	0.0163	60.3	0.0163	191.4	0.0163	437.0	0.0178	741.0	0.0178	905.7	0.1085	209.3	0.1085	209.3	0.0228	1298.6	0.0216	1377.0	0.0207	1455.4	0.0199	1533.8	0.0193	1612.2

HP310x110: Pier, Underside Elev. 97.0m, Borehole 20-05

Elev. (m)	96.5		95.5		94.5		93.5		92.5		91.5		90.5		89.5		88.5	
P-y Curves	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0
	0.0030	9.6	0.0014	13.2	0.0037	80.5	0.0000	11.6	0.0009	38.3	0.0011	54.4	0.0010	60.6	0.0009	66.2	0.0009	71.8
	0.0032	9.8	0.0017	15.1	0.0039	82.2	0.0000	23.3	0.0018	76.7	0.0021	108.8	0.0020	121.2	0.0019	132.4	0.0018	143.6
	0.0034	10.0	0.0020	16.9	0.0040	83.8	0.0001	34.9	0.0027	115.0	0.0032	163.2	0.0030	181.8	0.0028	198.6	0.0027	215.4
	0.0036	10.2	0.0024	18.5	0.0041	85.5	0.0004	46.5	0.0036	153.3	0.0042	217.6	0.0040	242.4	0.0038	264.8	0.0036	287.2
	0.0038	10.3	0.0027	20.1	0.0043	87.1	0.0011	58.1	0.0045	191.7	0.0053	272.0	0.0050	303.0	0.0047	331.0	0.0045	359.0
	0.0040	10.5	0.0031	21.6	0.0044	88.8	0.0022	69.8	0.0055	230.0	0.0063	326.4	0.0060	363.6	0.0056	397.2	0.0054	430.8
	0.0042	10.7	0.0034	23.0	0.0045	90.4	0.0041	81.4	0.0064	268.3	0.0074	380.8	0.0070	424.2	0.0066	463.4	0.0063	502.7
	0.0044	10.8	0.0038	24.4	0.0046	91.9	0.0070	93.0	0.0073	306.6	0.0084	435.2	0.0080	484.8	0.0075	529.6	0.0072	574.5
	0.0046	11.0	0.0041	25.7	0.0048	93.5	0.0112	104.6	0.0082	345.0	0.0095	489.6	0.0089	545.4	0.0085	595.9	0.0081	646.3
	0.0048	11.1	0.0045	26.9	0.0049	95.1	0.0171	116.3	0.0091	383.3	0.0105	544.0	0.0099	606.0	0.0094	662.1	0.0090	718.1
	0.0050	11.3	0.0048	28.2	0.0050	96.6	0.0251	127.9	0.0100	421.6	0.0116	598.4	0.0109	666.7	0.0104	728.3	0.0099	789.9
	0.0052	11.4	0.0052	29.4	0.0052	98.1	0.0356	139.5	0.0109	460.0	0.0127	652.8	0.0119	727.3	0.0113	794.5	0.0108	861.7
	0.0084	13.6	0.0084	40.4	0.0084	135.4	0.0490	151.1	0.0118	498.3	0.0137	707.2	0.0129	787.9	0.0122	860.7	0.0117	933.5
	0.0116	15.9	0.0116	51.4	0.0116	172.7	0.0659	162.8	0.0127	536.6	0.0148	761.6	0.0139	848.5	0.0132	926.9	0.0126	1005.3
	0.0140	15.9	0.0140	51.4	0.0140	172.7	0.0868	174.4	0.0153	536.6	0.0177	761.6	0.0167	848.5	0.0158	926.9	0.0151	1005.3
	0.0163	15.9	0.0163	51.4	0.0163	172.7	0.1085	174.4	0.0178	536.6	0.0207	761.6	0.0195	848.5	0.0185	926.9	0.0177	1005.3

HP310x110: South Abutment, Underside Elev. 98.4m, Borehole 20-03

Elev. (m)	97.9		96.9		95.9		94.9		93.9		92.9		91.9		90.9		89.9	
P-y Curves	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0
	0.0030	9.6	0.0014	13.2	0.0037	80.5	0.0079	297.6	0.0000	14.0	0.0000	14.0	0.0000	14.0	0.0011	74.2	0.0010	80.4
	0.0032	9.8	0.0017	15.1	0.0039	82.2	0.0082	308.5	0.0000	27.9	0.0000	27.9	0.0000	27.9	0.0021	148.4	0.0020	160.9
	0.0034	10.0	0.0020	16.9	0.0040	83.8	0.0085	319.4	0.0001	41.9	0.0001	41.9	0.0001	41.9	0.0032	222.5	0.0030	241.3
	0.0036	10.2	0.0024	18.5	0.0041	85.5	0.0087	327.2	0.0004	55.8	0.0004	55.8	0.0004	55.8	0.0042	296.7	0.0040	321.7
	0.0038	10.3	0.0027	20.1	0.0043	87.1	0.0090	335.0	0.0011	69.8	0.0011	69.8	0.0011	69.8	0.0053	370.9	0.0050	402.2
	0.0040	10.5	0.0031	21.6	0.0044	88.8	0.0093	342.8	0.0022	83.7	0.0022	83.7	0.0022	83.7	0.0063	445.1	0.0061	482.6
	0.0042	10.7	0.0034	23.0	0.0045	90.4	0.0096	350.6	0.0041	97.7	0.0041	97.7	0.0041	97.7	0.0074	519.2	0.0071	563.0
	0.0044	10.8	0.0038	24.4	0.0046	91.9	0.0099	358.4	0.0070	111.6	0.0070	111.6	0.0070	111.6	0.0084	593.4	0.0081	643.5
	0.0046	11.0	0.0041	25.7	0.0048	93.5	0.0102	366.2	0.0112	125.6	0.0112	125.6	0.0112	125.6	0.0095	667.6	0.0091	723.9
	0.0048	11.1	0.0045	26.9	0.0049	95.1	0.0105	374.0	0.0171	139.5	0.0171	139.5	0.0171	139.5	0.0105	741.8	0.0101	804.3
	0.0050	11.3	0.0048	28.2	0.0050	96.6	0.0108	381.8	0.0251	153.5	0.0251	153.5	0.0251	153.5	0.0116	815.9	0.0111	884.8
	0.0052	11.4	0.0052	29.4	0.0052	98.1	0.0110	389.6	0.0356	167.4	0.0356	167.4	0.0356	167.4	0.0127	890.1	0.0121	965.2
	0.0084	13.6	0.0084	40.4	0.0084	135.4	0.0113	397.4	0.0490	181.4	0.0490	181.4	0.0490	1				

SOIL P-Y CURVES - Palace Road Interchange

Caisson

1.2m Caisson: North Abutment, Underside Elev. 100.4m, Borehole 21-16

Elev. (m)	99.9		98.9		97.9		96.9		95.9		94.9		93.9		92.9		91.9		90.9		89.9		88.9		87.9	
P-y Curves	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0
	0.0058	32.7	0.0065	109.6	0.0115	248.3	0.0087	327.8	0.0058	336.3	0.0056	397.5	0.0000	54.0	0.0000	54.0	0.0124	990.5	0.0145	1294.6	0.0168	1656.6	0.0193	2082.7	0.0220	2579.0
	0.0071	34.6	0.0077	115.5	0.0123	253.8	0.0097	342.8	0.0071	374.6	0.0069	450.5	0.0001	108.0	0.0001	108.0	0.0131	1023.5	0.0150	1321.4	0.0171	1673.8	0.0194	2086.8	0.0238	2712.7
	0.0084	36.2	0.0089	120.7	0.0131	259.0	0.0107	357.0	0.0084	409.8	0.0082	499.5	0.0005	162.0	0.0005	162.0	0.0138	1055.9	0.0155	1347.8	0.0174	1691.0	0.0194	2090.8	0.0255	2843.5
	0.0097	37.7	0.0102	125.5	0.0138	264.0	0.0118	370.3	0.0097	442.5	0.0095	545.5	0.0017	216.0	0.0017	216.0	0.0145	1087.6	0.0160	1373.8	0.0177	1707.9	0.0195	2094.9	0.0273	2974.4
	0.0110	39.1	0.0114	129.9	0.0146	268.8	0.0128	382.9	0.0109	473.3	0.0108	588.9	0.0041	270.0	0.0041	270.0	0.0152	1118.7	0.0165	1399.6	0.0180	1724.8	0.0196	2099.0	0.0291	3105.3
	0.0123	40.3	0.0126	134.0	0.0154	273.5	0.0138	395.0	0.0122	502.4	0.0121	630.2	0.0086	324.0	0.0086	324.0	0.0159	1149.3	0.0170	1425.0	0.0183	1741.6	0.0196	2103.1	0.0308	3236.2
	0.0135	41.4	0.0139	137.8	0.0161	278.0	0.0149	406.5	0.0135	530.0	0.0134	669.7	0.0159	378.0	0.0159	378.0	0.0166	1179.3	0.0175	1450.2	0.0186	1758.3	0.0197	2107.1	0.0326	3367.1
	0.0148	42.5	0.0151	141.4	0.0169	282.4	0.0159	417.6	0.0148	556.5	0.0148	707.7	0.0272	432.0	0.0272	432.0	0.0172	1208.9	0.0180	1475.1	0.0188	1774.9	0.0198	2111.2	0.0344	3497.9
	0.0161	43.5	0.0163	144.8	0.0177	286.6	0.0169	428.2	0.0161	581.9	0.0161	744.4	0.0435	486.0	0.0435	486.0	0.0179	1238.0	0.0185	1499.7	0.0191	1791.3	0.0198	2115.3	0.0362	3628.8
	0.0174	44.5	0.0175	148.0	0.0185	290.8	0.0179	438.5	0.0174	606.4	0.0174	779.9	0.0664	540.0	0.0664	540.0	0.0186	1266.7	0.0190	1524.0	0.0194	1807.7	0.0199	2119.3	0.0379	3759.7
	0.0187	45.4	0.0188	151.1	0.0192	294.8	0.0190	448.4	0.0187	630.1	0.0187	814.2	0.0972	594.0	0.0972	594.0	0.0193	1295.0	0.0195	1548.2	0.0197	1824.0	0.0199	2123.4	0.0397	3890.6
	0.0200	46.2	0.0200	154.0	0.0200	298.7	0.0200	458.0	0.0200	653.0	0.0200	847.7	0.1376	648.0	0.1376	648.0	0.0200	1322.8	0.0200	1572.0	0.0200	1840.2	0.0200	2127.4	0.0415	4021.4
	0.0325	54.3	0.0325	183.0	0.0325	361.0	0.0325	572.7	0.0325	870.9	0.0325	1162.1	0.1896	702.0	0.1896	702.0	0.0325	1825.5	0.0325	2169.4	0.0325	2539.5	0.0325	2935.8	0.0432	4152.3
	0.0450	62.3	0.0450	212.1	0.0450	423.4	0.0450	687.4	0.0450	1088.9	0.0450	1476.5	0.2550	756.0	0.2550	756.0	0.0450	2328.2	0.0450	2766.8	0.0450	3238.7	0.0450	3744.2	0.0450	4283.2
	0.0540	62.3	0.0540	212.1	0.0540	423.4	0.0540	687.4	0.0540	1088.9	0.0540	1476.5	0.3360	810.0	0.3360	810.0	0.0540	2328.2	0.0540	2766.8	0.0540	3238.7	0.0540	3744.2	0.0540	4283.2
	0.0630	62.3	0.0630	212.1	0.0630	423.4	0.0630	687.4	0.0630	1088.9	0.0630	1476.5	0.4200	810.0	0.4200	810.0	0.0630	2328.2	0.0630	2766.8	0.0630	3238.7	0.0630	3744.2	0.0630	4283.2

1.2m Caisson: Pier, Underside Elev. 97.0m, Borehole 20-05

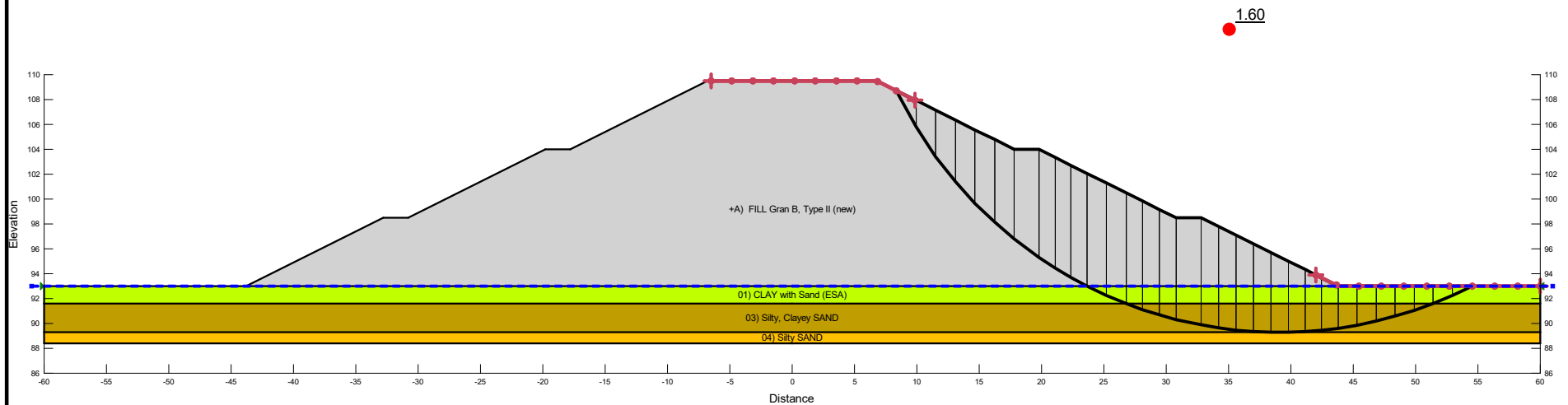
Elev. (m)	96.5		95.5		94.5		93.5		92.5		91.5		90.5		89.5		88.5	
P-y Curves	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0
	0.0106	34.4	0.0118	114.5	0.0107	231.6	0.0000	26.4	0.0095	400.0	0.0058	300.7	0.0056	343.4	0.0086	604.9	0.0101	803.6
	0.0115	35.2	0.0125	116.6	0.0116	237.4	0.0001	52.7	0.0104	417.4	0.0071	336.8	0.0069	389.8	0.0096	648.2	0.0110	846.6
	0.0123	35.9	0.0133	118.7	0.0124	243.0	0.0005	79.1	0.0114	434.0	0.0084	370.2	0.0082	432.9	0.0107	689.7	0.0119	888.2
	0.0132	36.5	0.0140	120.6	0.0133	248.3	0.0017	105.5	0.0123	449.8	0.0097	401.4	0.0096	473.3	0.0117	729.7	0.0128	928.6
	0.0140	37.2	0.0148	122.5	0.0141	253.4	0.0041	131.8	0.0133	465.0	0.0110	430.9	0.0109	511.7	0.0127	768.3	0.0137	967.8
	0.0149	37.8	0.0155	124.4	0.0149	258.3	0.0086	158.2	0.0143	479.5	0.0123	458.9	0.0122	548.3	0.0138	805.7	0.0146	1006.1
	0.0157	38.4	0.0163	126.2	0.0158	263.0	0.0159	184.6	0.0152	493.6	0.0136	485.7	0.0135	583.4	0.0148	842.0	0.0155	1043.5
	0.0166	39.0	0.0170	127.9	0.0166	267.6	0.0272	211.0	0.0162	507.1	0.0148	511.3	0.0148	617.1	0.0159	877.4	0.0164	1080.0
	0.0174	39.5	0.0178	129.5	0.0175	272.0	0.0435	237.3	0.0171	520.2	0.0161	536.1	0.0161	649.7	0.0169	911.8	0.0173	1115.7
	0.0183	40.0	0.0185	131.2	0.0183	276.3	0.0664	263.7	0.0181	532.9	0.0174	560.0	0.0174	681.3	0.0179	945.4	0.0182	1150.7
	0.0191	40.6	0.0193	132.7	0.0192	280.4	0.0972	290.1	0.0190	545.3	0.0187	583.2	0.0187	712.0	0.0190	978.3	0.0191	1185.1
	0.0200	41.1	0.0200	134.3	0.0200	284.4	0.1376	316.4	0.0200	557.3	0.0200	605.6	0.0200	741.8	0.0200	1010.4	0.0200	1218.8
	0.0325	48.2	0.0325	159.6	0.0325	343.0	0.1896	342.8	0.0325	712.0	0.0325	820.6	0.0325	1023.7	0.0325	1394.4	0.0325	1681.9
	0.0450	55.4	0.0450	184.9	0.0450	401.7	0.2550	369.2	0.0450	866.7	0.0450	1035.7	0.0450	1305.6	0.0450	1778.3	0.0450	2145.0
	0.0540	55.4	0.0540	184.9	0.0540	401.7	0.3360	395.5	0.0540	866.7	0.0540	1035.7	0.0540	1305.6	0.0540	1778.3	0.0540	2145.0
	0.0630	55.4	0.0630	184.9	0.0630	401.7	0.4200	395.5	0.0630	866.7	0.0630	1035.7	0.0630	1305.6	0.0630	1778.3	0.0630	2145.0

1.2m Caisson: South Abutment, Underside Elev. 98.4m, Borehole 20-03

Elev. (m)	97.9		96.9		95.9		94.9		93.9		92.9		91.9		90.9		89.9	
P-y Curves	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0
	0.0106	34.4	0.0118	114.5	0.0107	231.6	0.0085	320.1	0.0000	39.1	0.0000	43.1	0.0000	46.5	0.0069	488.4	0.0085	673.9
	0.0115	35.2	0.0125	116.6	0.0116	237.4	0.0095	334.7	0.0001	78.2	0.0001	86.2	0.0001	92.9	0.0081	537.6	0.0095	723.6
	0.0123	35.9	0.0133	118.7	0.0124	243.0	0.0106	348.5	0.0005	117.3	0.0005	129.3	0.0005	139.4	0.0093	584.0	0.0106	771.2
	0.0132	36.5	0.0140	120.6	0.0133	248.3	0.0116	361.4	0.0017	156.3	0.0017	172.4	0.0017	185.8	0.0105	628.2	0.0116	816.9
	0.0140	37.2	0.0148	122.5	0.0141	253.4	0.0127	373.5	0.0041	195.4	0.0041	215.4	0.0041	232.3	0.0117	670.4	0.0127	861.1
	0.0149	37.8	0.0155	124.4	0.0149	258.3	0.0137	385.1	0.0086	234.5	0.0086	258.5	0.0086	278.7	0.0129	711.0	0.0137	903.8
	0.0157	38.4	0.0163	126.2	0.0158	263.0	0.0148	396.2	0.0159	273.6	0.0159	301.6	0.0159	325.2	0.0141	750.1	0.0148	945.3
	0.0166	39.0	0.0170	127.9	0.0166	267.6	0.0158	406.8	0.0272	312.7	0.0272	344.7	0.0272	371.6	0.0153	788.0	0.0158	985.7
	0.0174	39.5	0.0178	129.5	0.0175	272.0	0.0169	416.9	0.0435	351.8	0.0435	387.8	0.0435	418.1	0.0164	824.8	0.0169	1025.0
	0.0183	40.0	0.0185	131.2	0.0183	276.3	0.0179	426.7	0.0664	390.8	0.0664	430.9	0.0664	464.5	0.0176	860.5	0.0179	1063.3
	0.0191	40.6	0.0193	132.7	0.0192	280.4	0.0190	436.2	0.0972	429.9	0.0972	474.0	0.0972	511.0	0.0188	895.2	0.0190	1100.8
	0.0200	41.1	0.0200	134.3	0.0200	284.4	0.0200	445.3	0.1376	469.0	0.1376	517.1	0.1376	557.4				

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Grey	+A) FILL Gran B, Type II (new)	22	0	35	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Dark Green	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

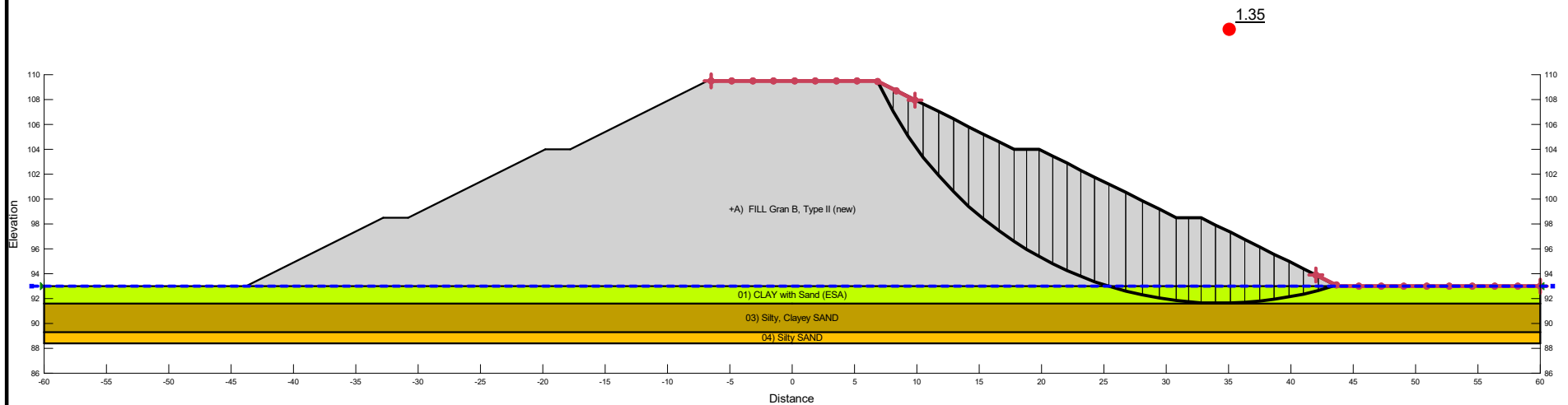


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB II, BH 20-11 (ESA)</b>		Name: Station 9+870, High Fill (A) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (8.3702431, 108.71488) m, Exit: (54.536262, 93) m Center: (39.09445, 123.30519) m, Radius: 34.012558 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:00 PM	Scale 1:500	

**Figure H1**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Grey	+A) FILL Gran B, Type II (new)	22	0	35	1	0	Yes
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Dark Green	03) Silty, Clayey SAND	19	0	29	1	0	No
Yellow	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g



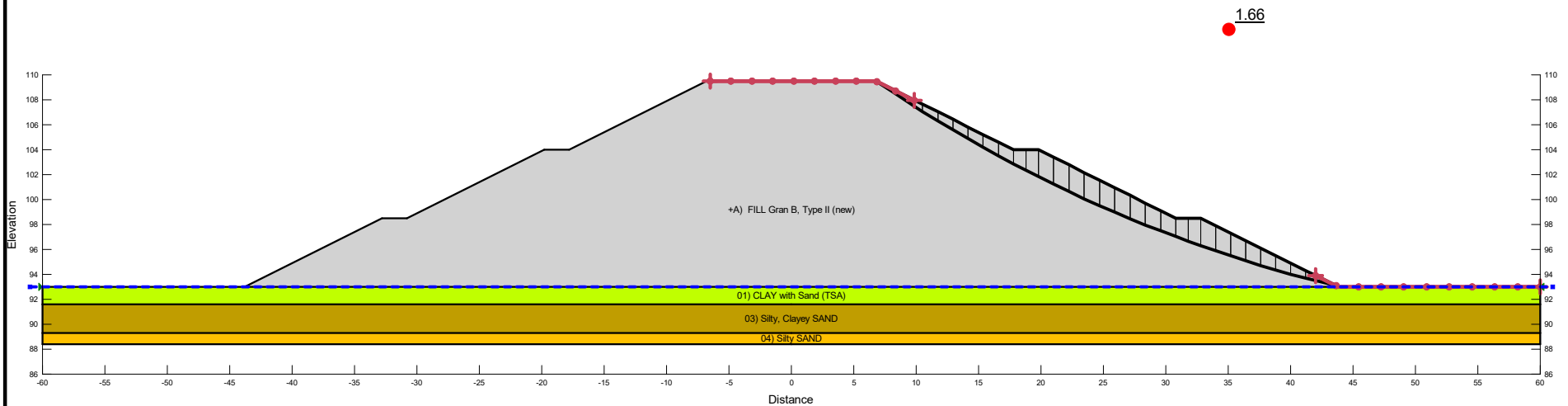
Project		Palace Road Interchange	
Analysis		2.0H:1V, GB II, BH 20-11 (ESA, Bbar)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:50:01 PM	1:500	

Additional Details  
 Name: Station 9+870, High Fill (A)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.874007, 109.463) m, Exit: (43.628972, 93.085514) m  
 Center: (34.372789, 121.74462) m, Radius: 30.116795 m

**Figure H2**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Grey	+A) FILL Gran B, Type II (new)	22	0	35	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Brown	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g



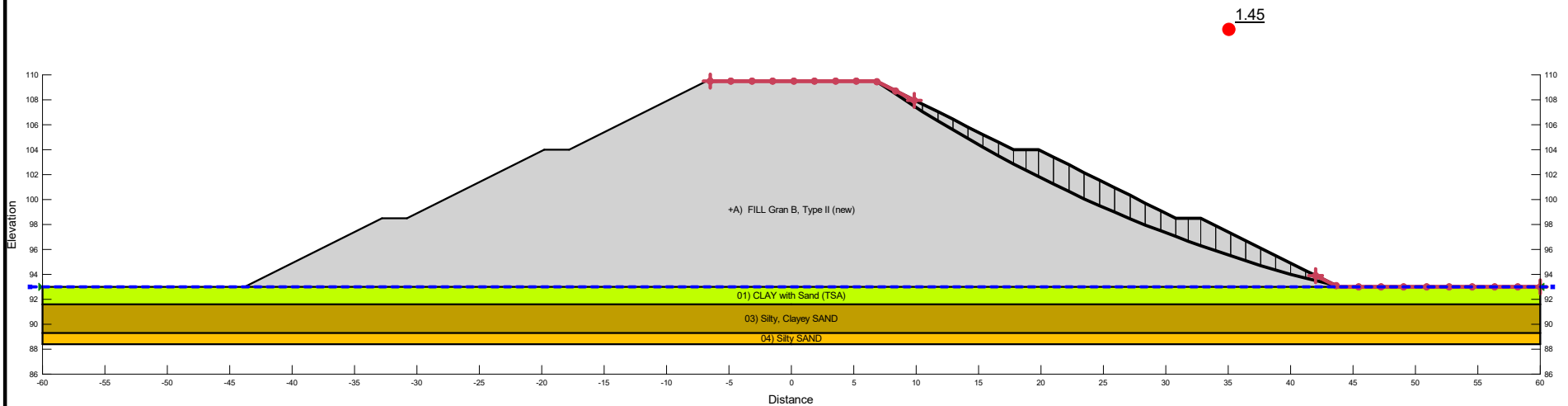
Project <b>Palace Road Interchange</b>	
Analysis <b>2.0H:1V, GB II, BH 20-11 (TSA)</b>	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:01 PM
Scale 1:500	

Additional Details  
 Name: Station 9+870, High Fill (A)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.874007, 109.463) m, Exit: (43.628972, 93.085514) m  
 Center: (69.928175, 201.53936) m, Radius: 111.59698 m

**Figure H3**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Grey	+A) FILL Gran B, Type II (new)	22	0	35	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Brown	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g



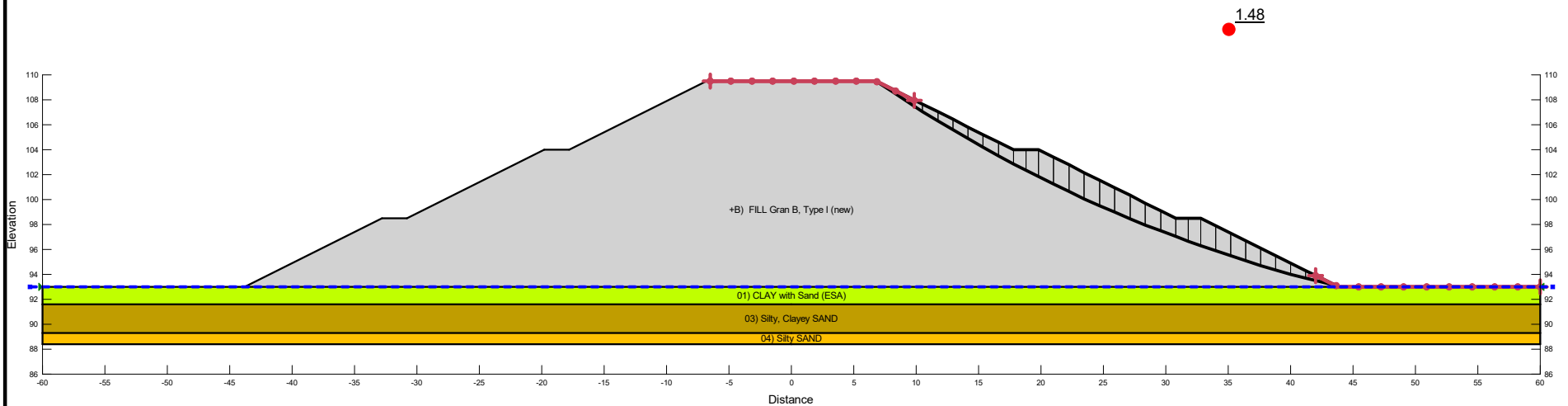
Project		Palace Road Interchange	
Analysis		2.0H:1V, GB II, BH 20-11 (TSA, seismic)	
Seismic Coefficient	Last Run	Scale	
H: 0.05g, V: 0g	11/15/2021, 03:50:02 PM	1:500	

Additional Details  
 Name: Station 9+870, High Fill (A)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.874007, 109.463) m, Exit: (43.628972, 93.085514) m  
 Center: (69.928175, 201.53936) m, Radius: 111.59698 m

**Figure H4**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Grey	+B) FILL Gran B, Type I (new)	21	0	32	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Dark Green	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g



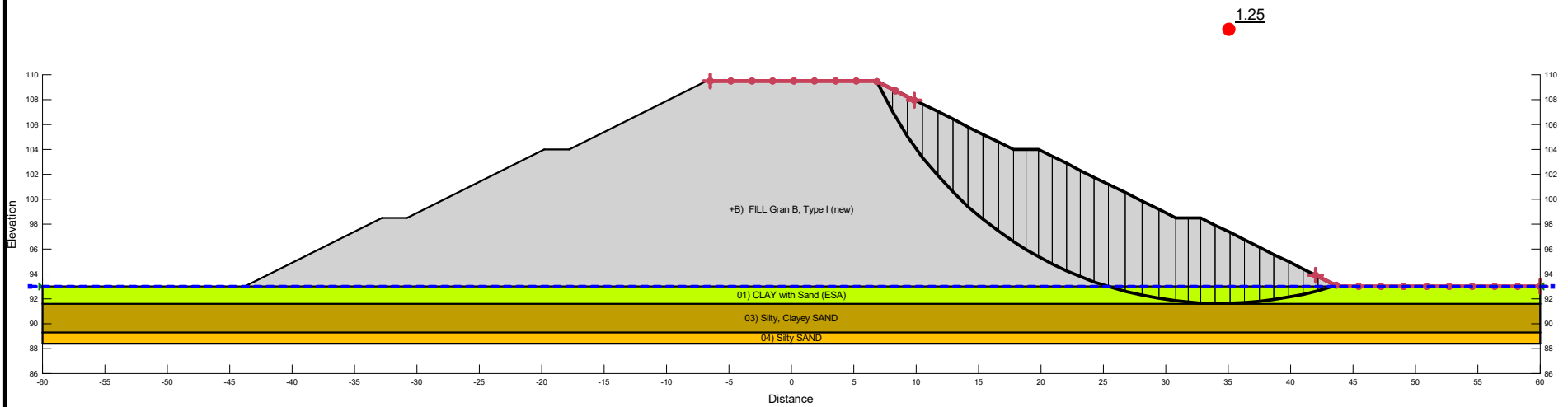
Project <b>Palace Road Interchange</b>	
Analysis <b>2.0H:1V, GB I, BH 20-11 (ESA)</b>	
Seismic Coefficient <b>H: 0g, V: 0g</b>	Last Run <b>11/15/2021, 03:49:58 PM</b>
Scale <b>1:500</b>	

Additional Details  
 Name: Station 9+870, High Fill (B)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.874007, 109.463) m, Exit: (43.628972, 93.085514) m  
 Center: (69.928175, 201.53936) m, Radius: 111.59698 m

**Figure H5**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Grey	+B) FILL Gran B, Type I (new)	21	0	32	1	0	Yes
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Brown	03) Silty, Clayey SAND	19	0	29	1	0	No
Yellow	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g



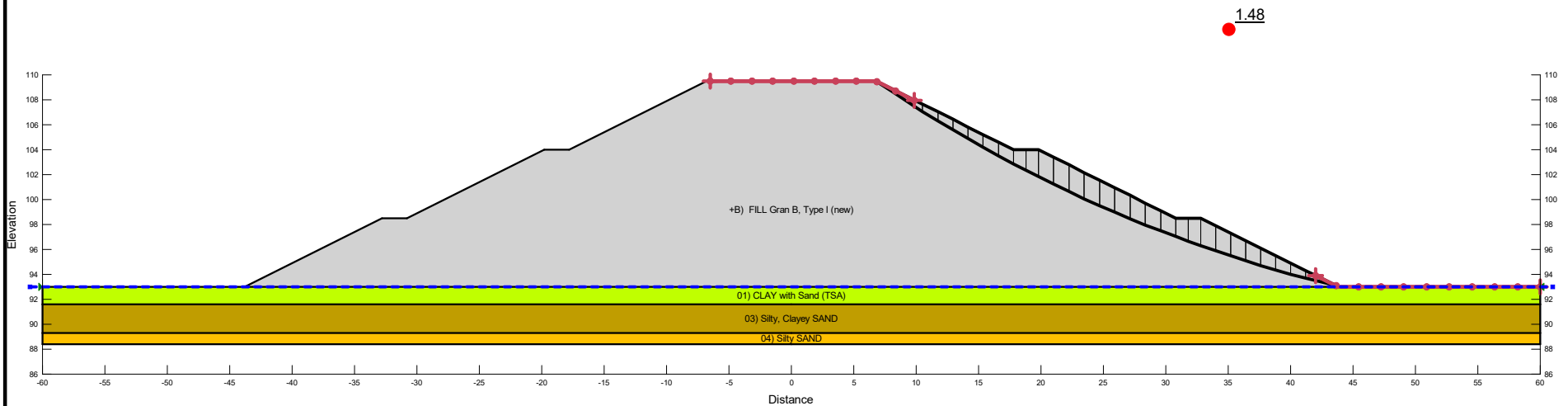
Project		Palace Road Interchange	
Analysis		2.0H:1V, GB I, BH 20-11 (ESA, Bbar)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:49:58 PM	1:500	

Additional Details  
 Name: Station 9+870, High Fill (B)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.874007, 109.463) m, Exit: (43.628972, 93.085514) m  
 Center: (34.372789, 121.74462) m, Radius: 30.116795 m

**Figure H6**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Grey	+B) FILL Gran B, Type I (new)	21	0	32	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Dark Green	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g



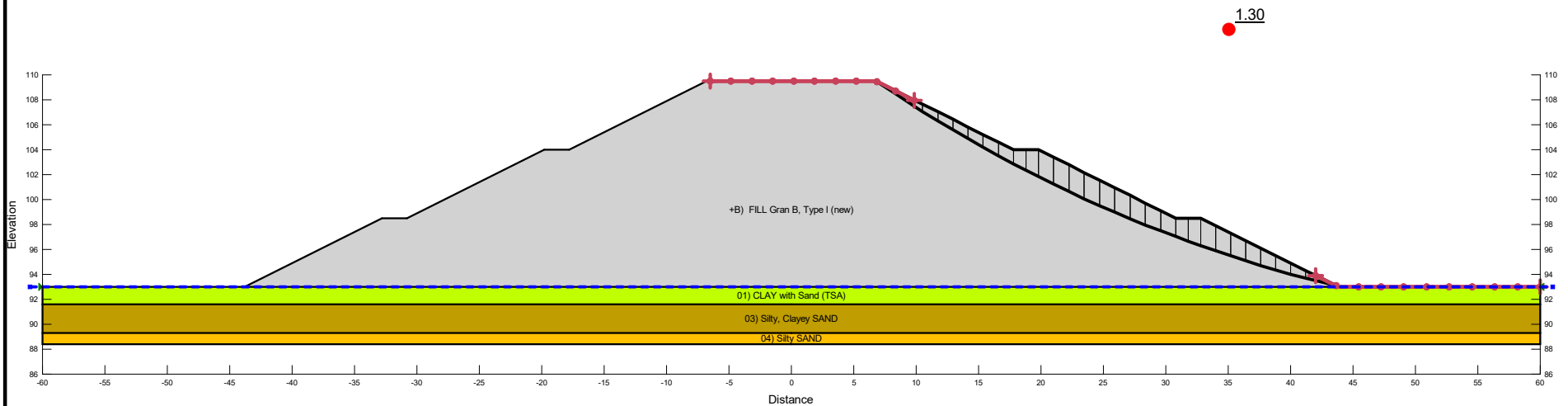
Project <b>Palace Road Interchange</b>	
Analysis <b>2.0H:1V, GB I, BH 20-11 (TSA)</b>	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:49:59 PM
Scale 1:500	

Additional Details  
 Name: Station 9+870, High Fill (B)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.874007, 109.463) m, Exit: (43.628972, 93.085514) m  
 Center: (69.928175, 201.53936) m, Radius: 111.59698 m

**Figure H7**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Grey	+B) FILL Gran B, Type I (new)	21	0	32	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Brown	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g



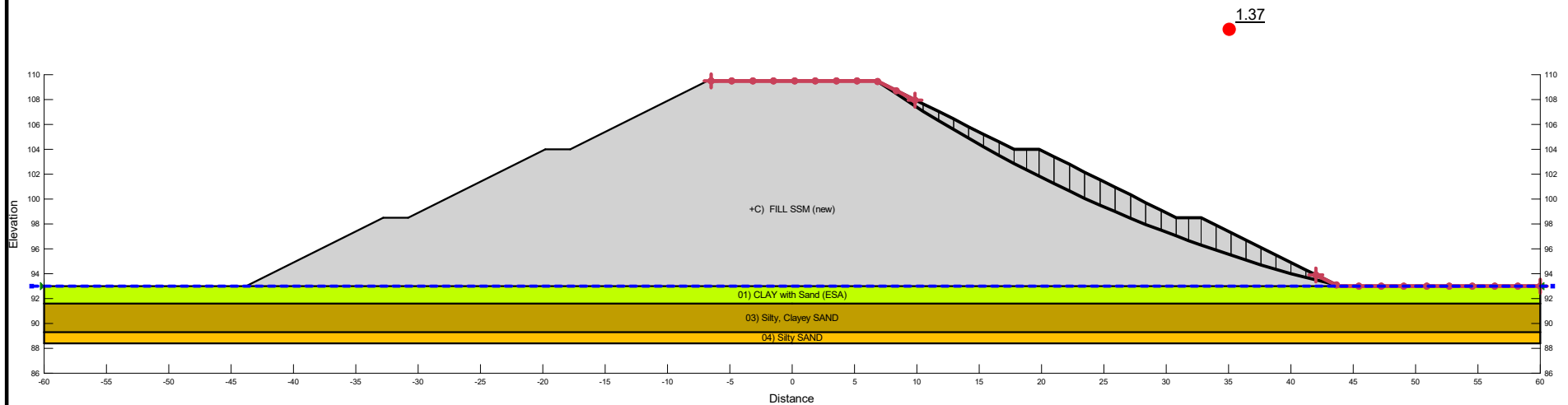
Project		Palace Road Interchange	
Analysis		2.0H:1V, GB I, BH 20-11 (TSA, seismic)	
Seismic Coefficient	Last Run	Scale	
H: 0.05g, V: 0g	11/15/2021, 03:49:59 PM	1:500	

Additional Details  
 Name: Station 9+870, High Fill (B)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.874007, 109.463) m, Exit: (43.628972, 93.085514) m  
 Center: (69.928175, 201.53936) m, Radius: 111.59698 m

**Figure H8**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+C) FILL SSM (new)	21	0	30	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Light Brown	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g



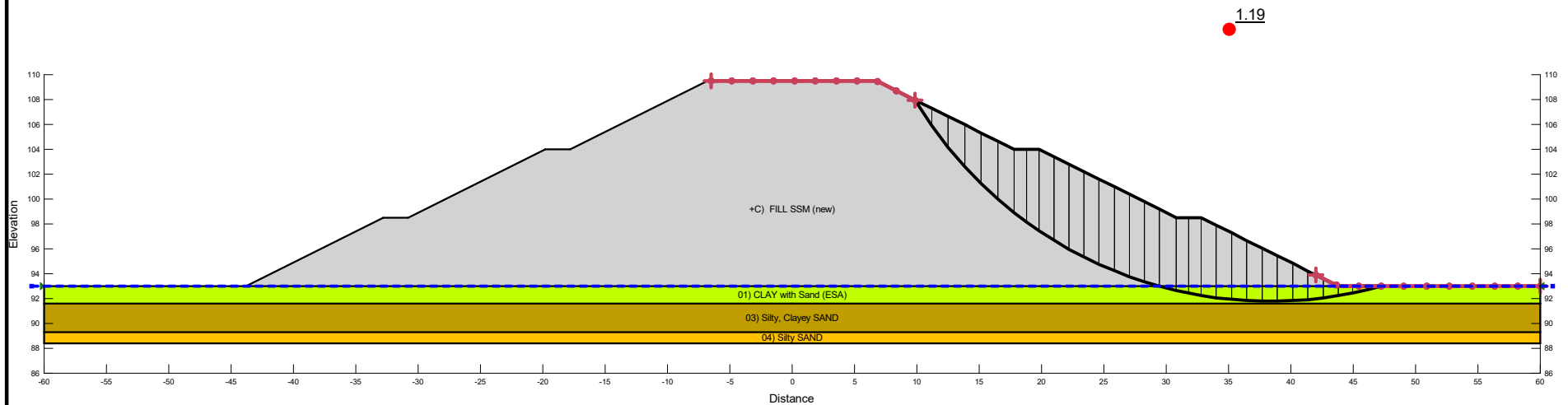
Project <b>Palace Road Interchange</b>	
Analysis <b>2.0H:1V, SSM, BH 20-11 (ESA)</b>	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:49:56 PM
Scale 1:500	

Additional Details  
 Name: Station 9+870, High Fill (C)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.874007, 109.463) m, Exit: (43.628972, 93.085514) m  
 Center: (69.928175, 201.53936) m, Radius: 111.59698 m

**Figure H9**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Grey	+C) FILL SSM (new)	21	0	30	1	0	Yes
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Brown	03) Silty, Clayey SAND	19	0	29	1	0	No
Yellow	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g

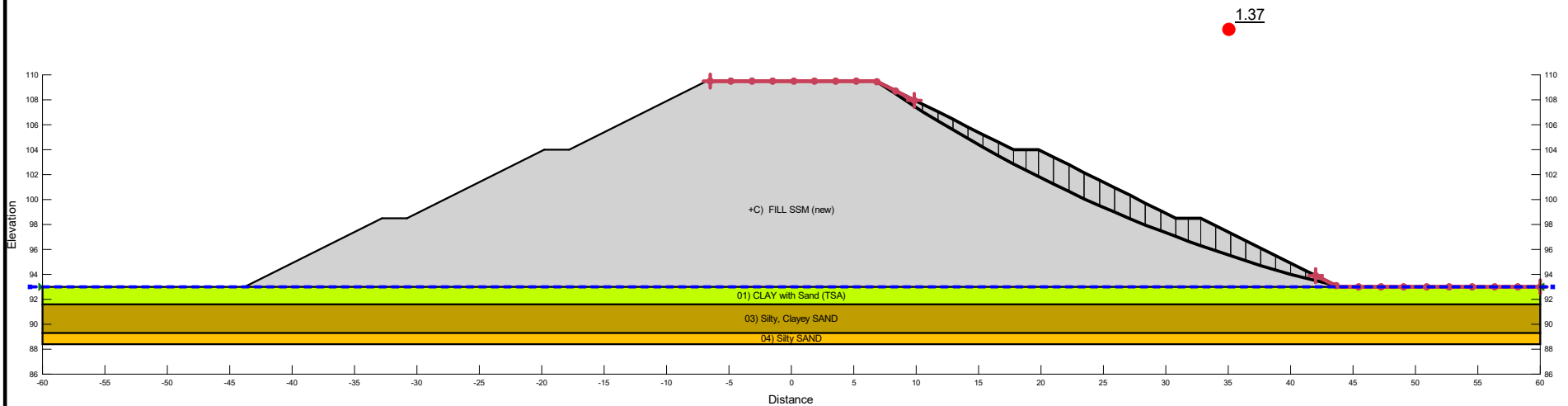


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, SSM, BH 20-11 (ESA, Bbar)</b>		Name: Station 9+870, High Fill (C) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (9.8664792, 107.96676) m, Exit: (47.251277, 93) m Center: (38.349383, 124.93864) m, Radius: 33.156003 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:49:56 PM	Scale 1:500	

**Figure H10**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+C) FILL SSM (new)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Light Brown	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g



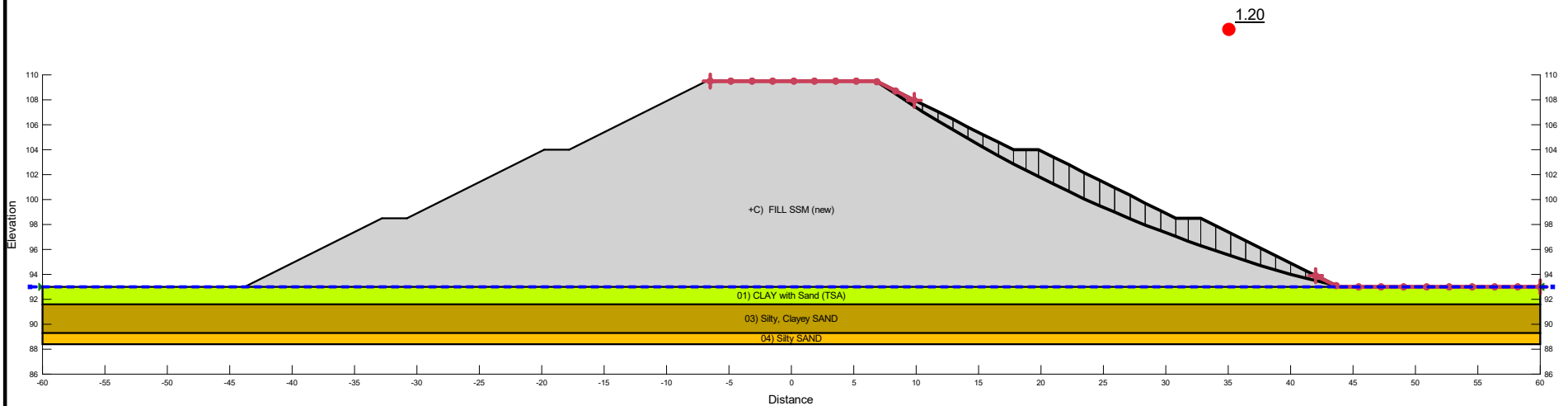
Project <b>Palace Road Interchange</b>	
Analysis <b>2.0H:1V, SSM, BH 20-11 (TSA)</b>	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:49:57 PM
Scale 1:500	

Additional Details  
 Name: Station 9+870, High Fill (C)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.874007, 109.463) m, Exit: (43.628972, 93.085514) m  
 Center: (69.928175, 201.53936) m, Radius: 111.59698 m

**Figure H11**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+C) FILL SSM (new)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Light Brown	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g



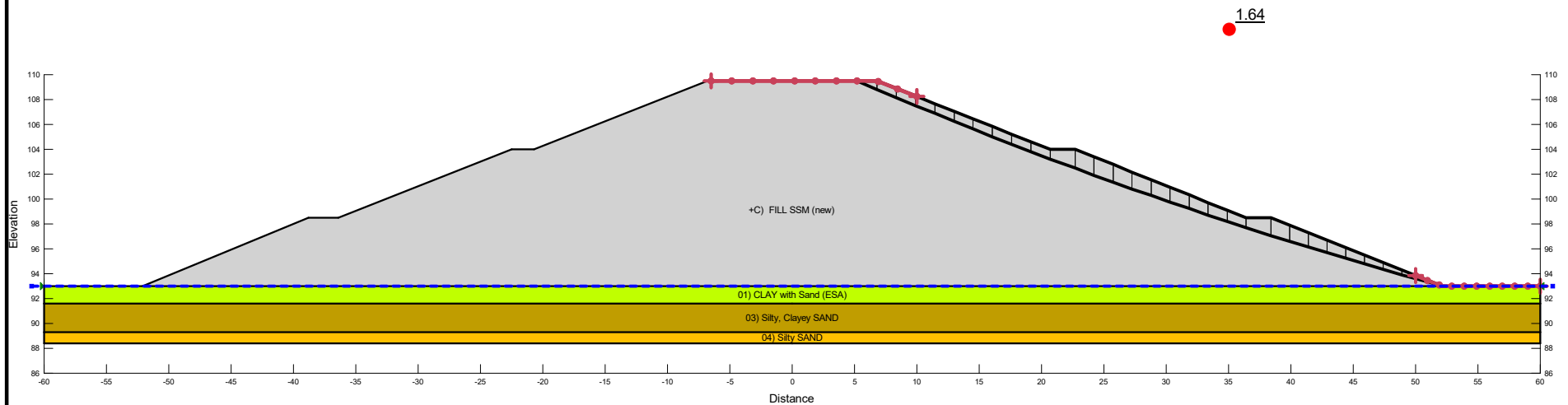
Project <b>Palace Road Interchange</b>	
Analysis <b>2.0H:1V, SSM, BH 20-11 (TSA, seismic)</b>	
Seismic Coefficient <b>H: 0.05g, V: 0g</b>	Last Run <b>11/15/2021, 03:49:57 PM</b>
Scale <b>1:500</b>	

Additional Details  
 Name: Station 9+870, High Fill (C)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.874007, 109.463) m, Exit: (43.628972, 93.085514) m  
 Center: (69.928175, 201.53936) m, Radius: 111.59698 m

**Figure H12**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Grey	+C) FILL SSM (new)	21	0	30	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Brown	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

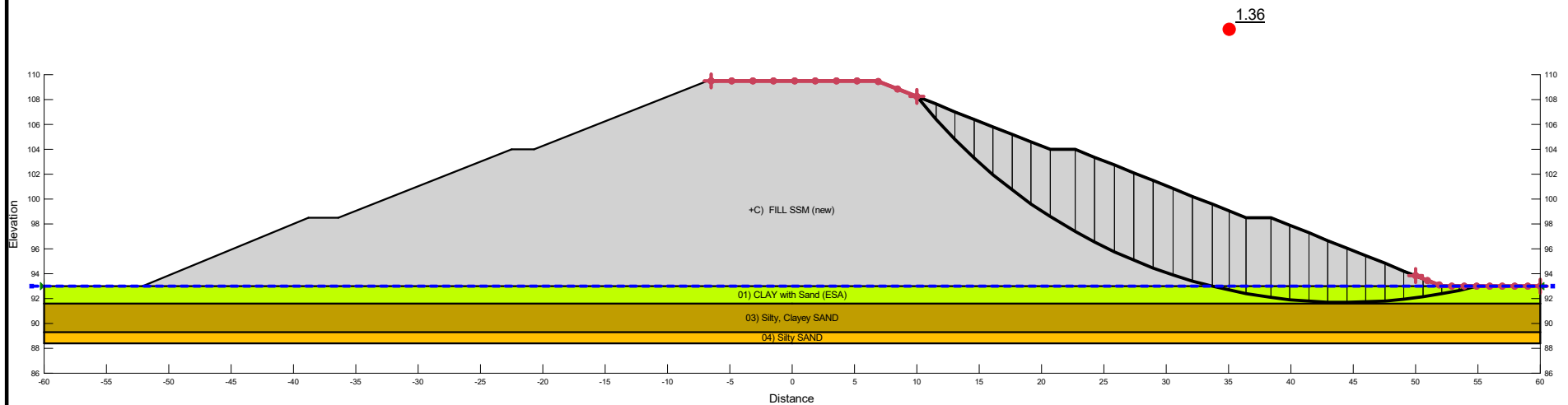


Project <b>Palace Road Interchange</b>	
Analysis <b>2.5H:1V, SSM, BH 20-11 (ESA)</b>	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:49:49 PM
Scale 1:500	

Additional Details Name: Station 9+870, High Fill (D) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (5.2189829, 109.5) m, Exit: (51.886247, 93.085813) m Center: (144.27348, 430.29954) m, Radius: 349.64053 m	<b>Figure H13</b>
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Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Grey	+C) FILL SSM (new)	21	0	30	1	0	Yes
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Brown	03) Silty, Clayey SAND	19	0	29	1	0	No
Yellow	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g



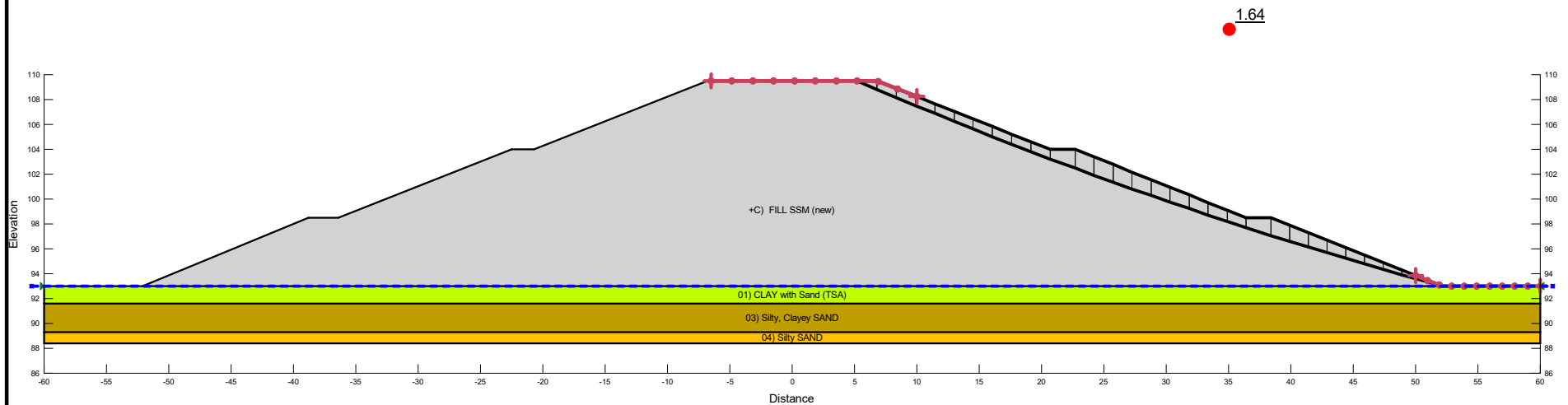
Project		Palace Road Interchange	
Analysis		2.5H:1V, SSM, BH 20-11 (ESA, Bbar)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:49:50 PM	1:500	

Additional Details	
Name: Station 9+870, High Fill (D)	
Comments: Stability Assessment	
Method: Morgenstern-Price, Half-Sine	
Minimum Slip Surface Depth: 1.5 m	
Entry: (10.000004, 108.23381) m, Exit: (54.918541, 93) m	
Center: (44.298851, 135.52718) m, Radius: 43.83308 m	

**Figure H14**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Grey	+C) FILL SSM (new)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Brown	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g



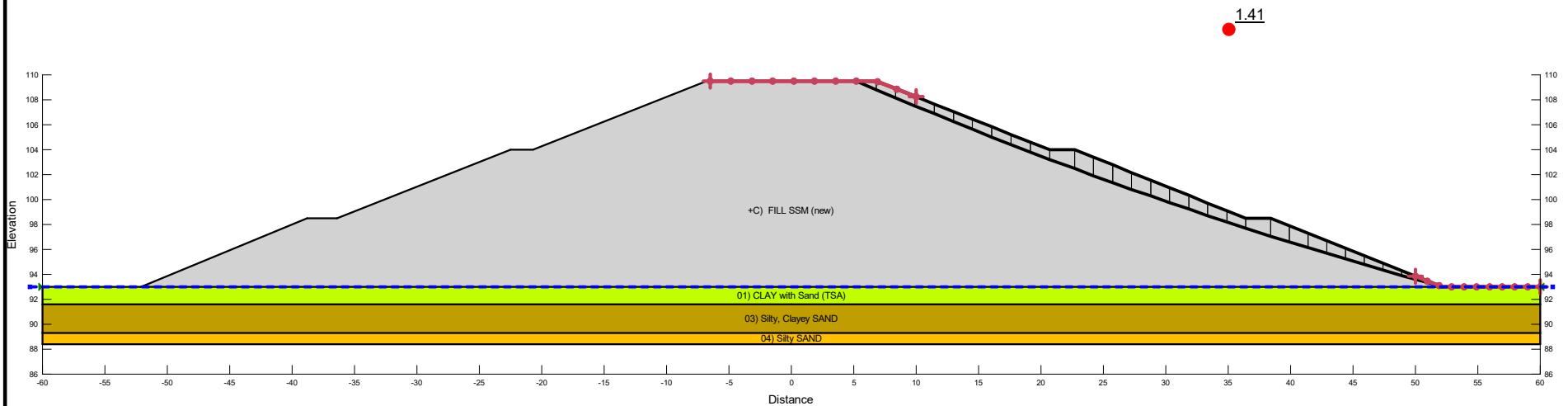
Project <b>Palace Road Interchange</b>	
Analysis <b>2.5H:1V, SSM, BH 20-11 (TSA)</b>	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:49:50 PM
Scale 1:500	

Additional Details  
 Name: Station 9+870, High Fill (D)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (5.2189829, 109.5) m, Exit: (51.886247, 93.085813) m  
 Center: (144.27348, 430.29954) m, Radius: 349.64053 m

**Figure H15**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Grey	+C) FILL SSM (new)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Brown	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g



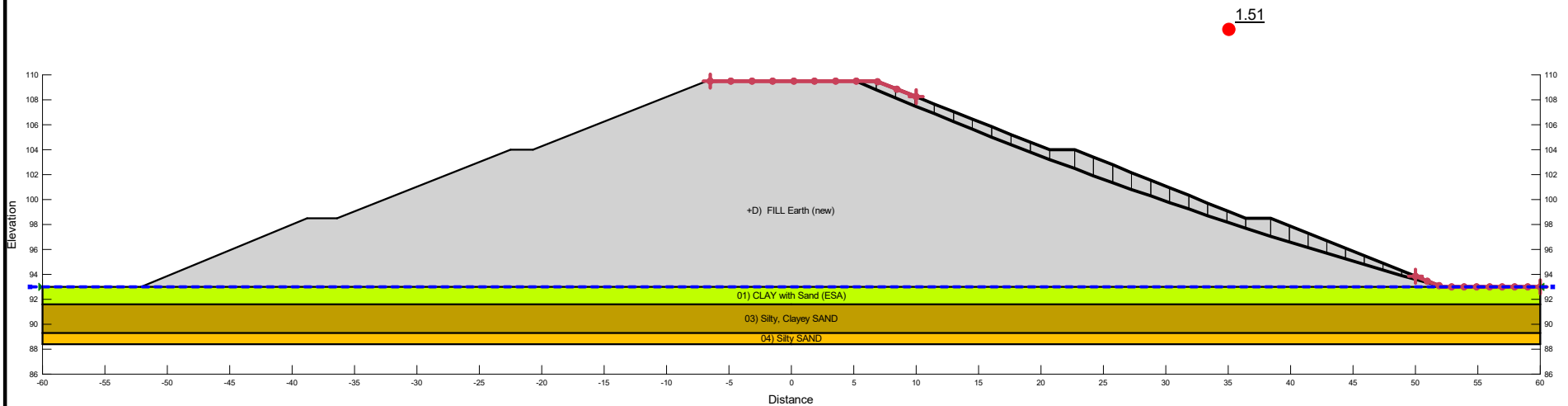
Project		Palace Road Interchange	
Analysis		2.5H:1V, SSM, BH 20-11 (TSA, seismic)	
Seismic Coefficient	Last Run	Scale	
H: 0.05g, V: 0g	11/15/2021, 03:49:51 PM	1:500	

Additional Details  
 Name: Station 9+870, High Fill (D)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (5.2189829, 109.5) m, Exit: (51.886247, 93.085813) m  
 Center: (144.27348, 430.29954) m, Radius: 349.64053 m

**Figure H16**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Grey	+D) FILL Earth(new)	20	0	28	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Brown	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g



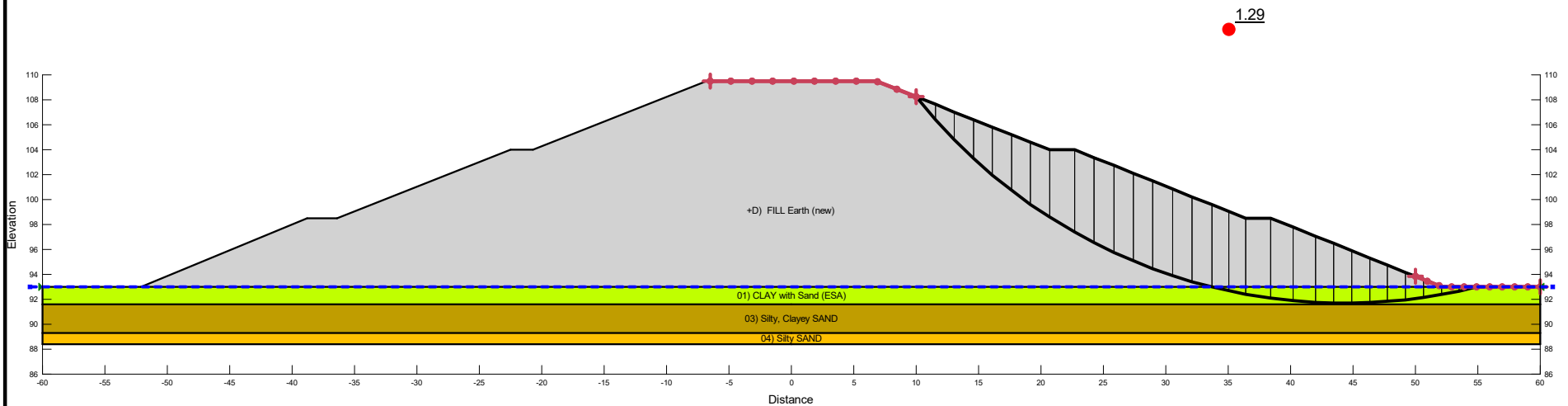
Project		Palace Road Interchange	
Analysis		2.5H:1V, Earth Fill, BH 20-11 (ESA)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:49:51 PM	1:500	

Additional Details  
 Name: Station 9+870, High Fill (E)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (5.2189829, 109.5) m, Exit: (51.886247, 93.085813) m  
 Center: (144.27348, 430.29954) m, Radius: 349.64053 m

**Figure H17**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Grey	+D) FILL Earth(new)	20	0	28	1	0	Yes
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Brown	03) Silty, Clayey SAND	19	0	29	1	0	No
Yellow	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g



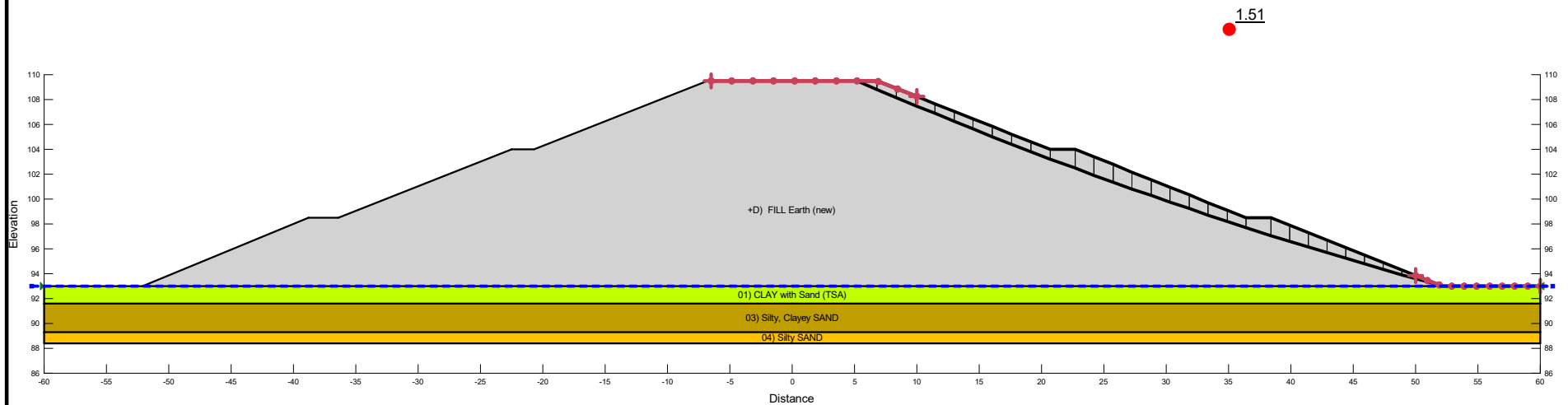
Project		Palace Road Interchange	
Analysis		2.5H:1V, Earth Fill, BH 20-11 (ESA, Bbar)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:49:52 PM	1:500	

Additional Details  
 Name: Station 9+870, High Fill (E)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (10.000004, 108.23381) m, Exit: (54.918541, 93) m  
 Center: (44.298851, 135.52718) m, Radius: 43.83308 m

**Figure H18**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Grey	+D) FILL Earth(new)	20	0	28	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Brown	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g



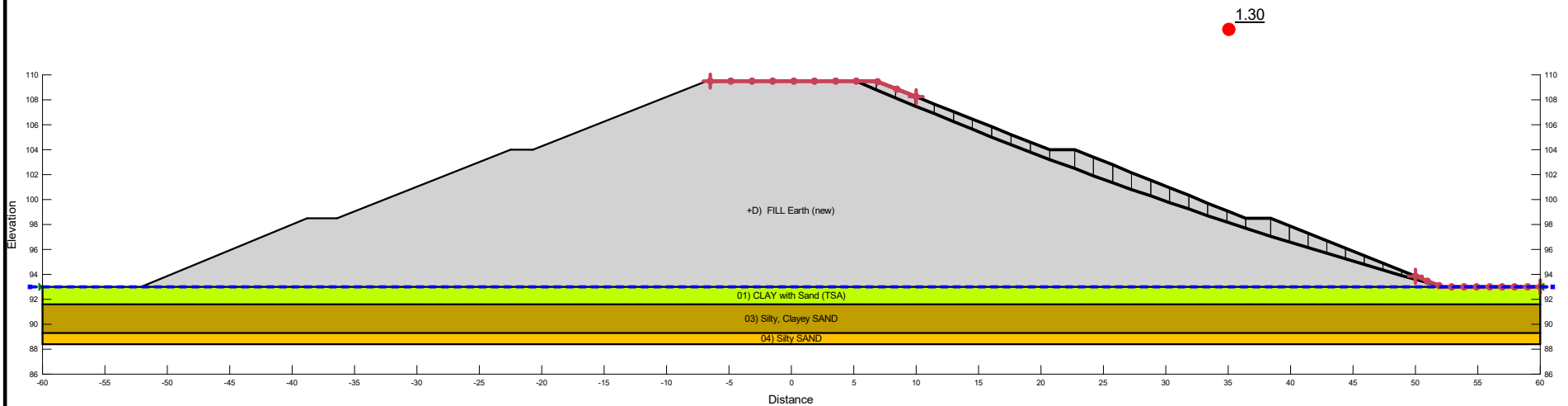
Project		Palace Road Interchange	
Analysis		2.5H:1V, Earth Fill, BH 20-11 (TSA)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:49:52 PM	1:500	

Additional Details  
 Name: Station 9+870, High Fill (E)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (5.2189829, 109.5) m, Exit: (51.886247, 93.085813) m  
 Center: (144.27348, 430.29954) m, Radius: 349.64053 m

**Figure H19**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Grey	+D) FILL Earth(new)	20	0	28	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Brown	03) Silty, Clayey SAND	19	0	29	1
Yellow	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g



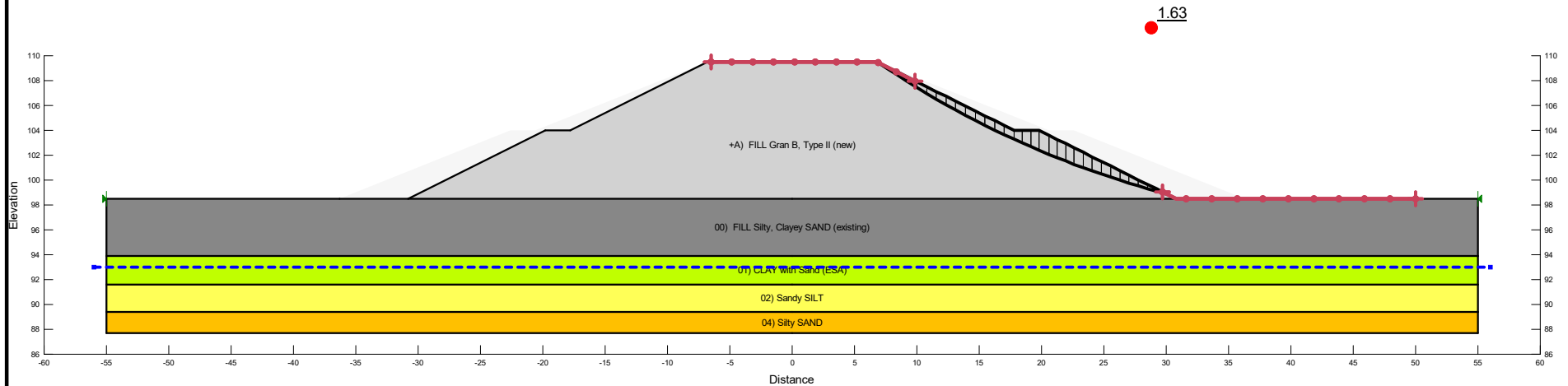
Project		Palace Road Interchange	
Analysis		2.5H:1V, Earth Fill, BH 20-11 (TSAs)	
Seismic Coefficient	Last Run	Scale	
H: 0.05g, V: 0g	11/15/2021, 03:49:53 PM	1:500	

Additional Details  
 Name: Station 9+870, High Fill (E)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (5.2189829, 109.5) m, Exit: (51.886247, 93.085813) m  
 Center: (144.27348, 430.29954) m, Radius: 349.64053 m

**Figure H20**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+A) FILL Gran B, Type II (new)	22	0	35	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

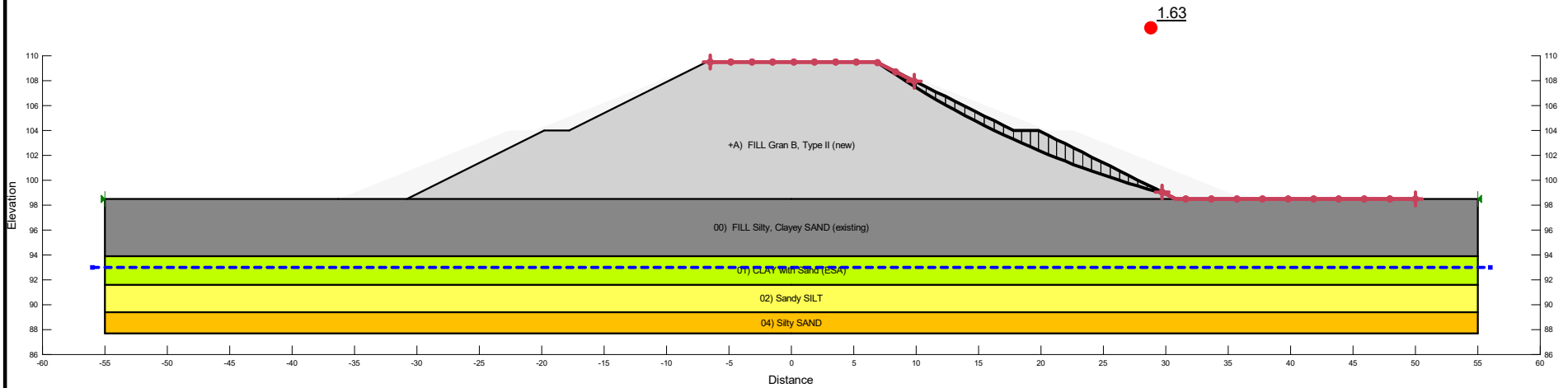


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB II, BH 20-07 (ESA)</b>		Name: Station 9+953, North Abutment (A) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (6.876937, 109.46153) m, Exit: (29.974613, 98.912693) m Center: (49.079425, 171.30617) m, Radius: 74.871953 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:16 PM	Scale 1:500	

**Figure H21**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Light Gray	+A) FILL Gran B, Type II (new)	22	0	35	1	0	Yes
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1	0	No
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Yellow	02) Sandy SILT	19	0	29	1	0	No
Orange	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g



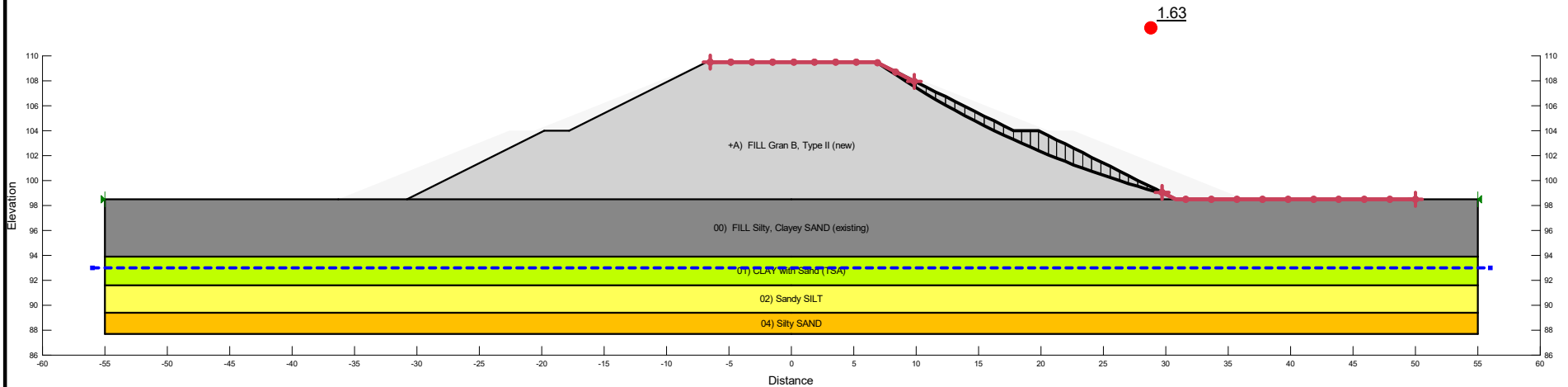
Project		Palace Road Interchange	
Analysis		2.0H:1V, GB II, BH 20-07 (ESA, BBar)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:50:16 PM	1:500	

Additional Details	
Name: Station 9+953, North Abutment (A)	
Comments: Stability Assessment	
Method: Morgenstern-Price, Half-Sine	
Minimum Slip Surface Depth: 1.5 m	
Entry: (6.876937, 109.46153) m, Exit: (29.974613, 98.912693) m	
Center: (49.079425, 171.30617) m, Radius: 74.871953 m	

**Figure H22**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+A) FILL Gran B, Type II (new)	22	0	35	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

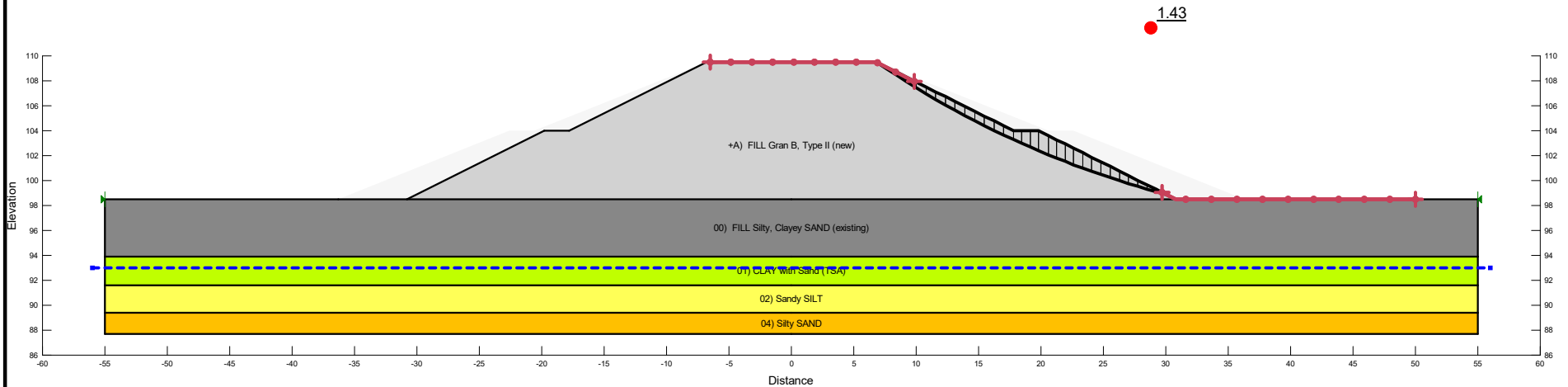


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB II, BH 20-07 (TSA)</b>		Name: Station 9+953, North Abutment (A) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (6.876937, 109.46153) m, Exit: (29.974613, 98.912693) m Center: (49.079425, 171.30617) m, Radius: 74.871953 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:17 PM	Scale 1:500	

**Figure H23**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+A) FILL Gran B, Type II (new)	22	0	35	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g

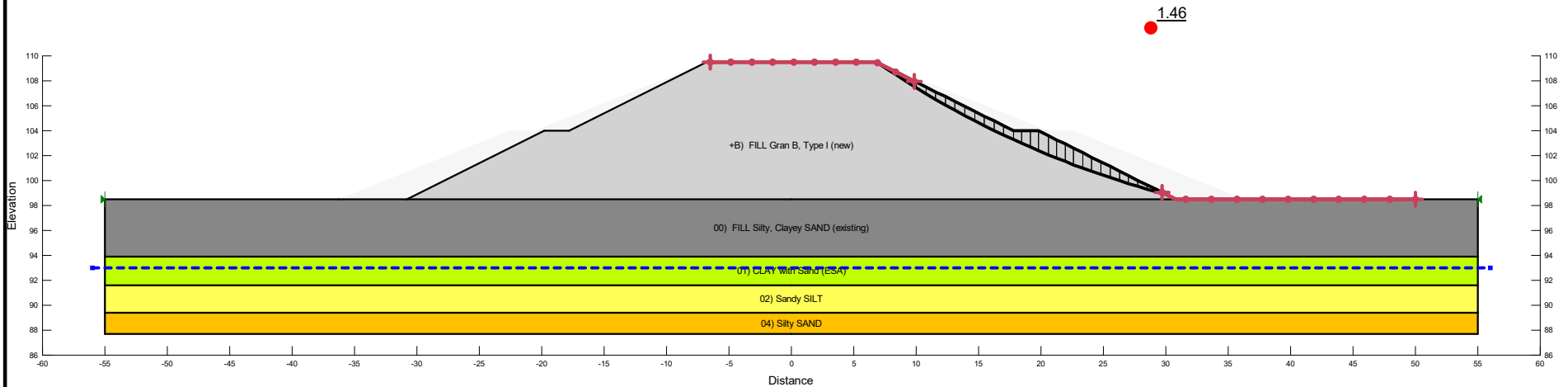


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB II, BH 20-07 (TSA, seismic)</b>		Name: Station 9+953, North Abutment (A) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (6.876937, 109.46153) m, Exit: (29.974613, 98.912693) m Center: (49.079425, 171.30617) m, Radius: 74.871953 m	
Seismic Coefficient H: 0.05g, V: 0g	Last Run 11/15/2021, 03:50:17 PM	Scale 1:500	

**Figure H24**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+B) FILL Gran B, Type I (new)	21	0	32	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

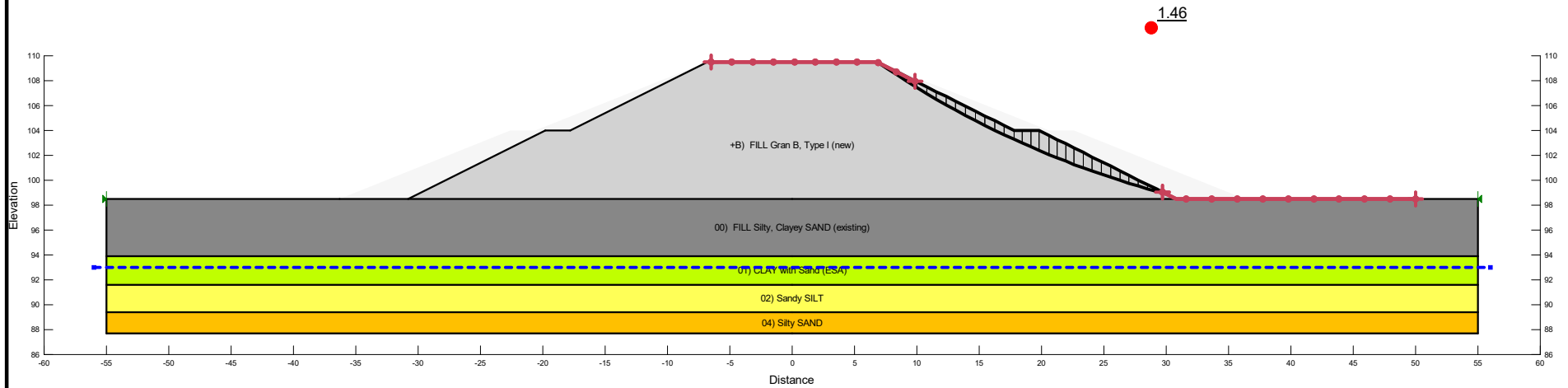


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB I, BH 20-07 (ESA)</b>		Name: Station 9+953, North Abutment (B) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (6.876937, 109.46153) m, Exit: (29.974613, 98.912693) m Center: (49.079425, 171.30617) m, Radius: 74.871953 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:02 PM	Scale 1:500	

**Figure H25**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Light Gray	+B) FILL Gran B, Type I (new)	21	0	32	1	0	Yes
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1	0	No
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Yellow	02) Sandy SILT	19	0	29	1	0	No
Orange	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g

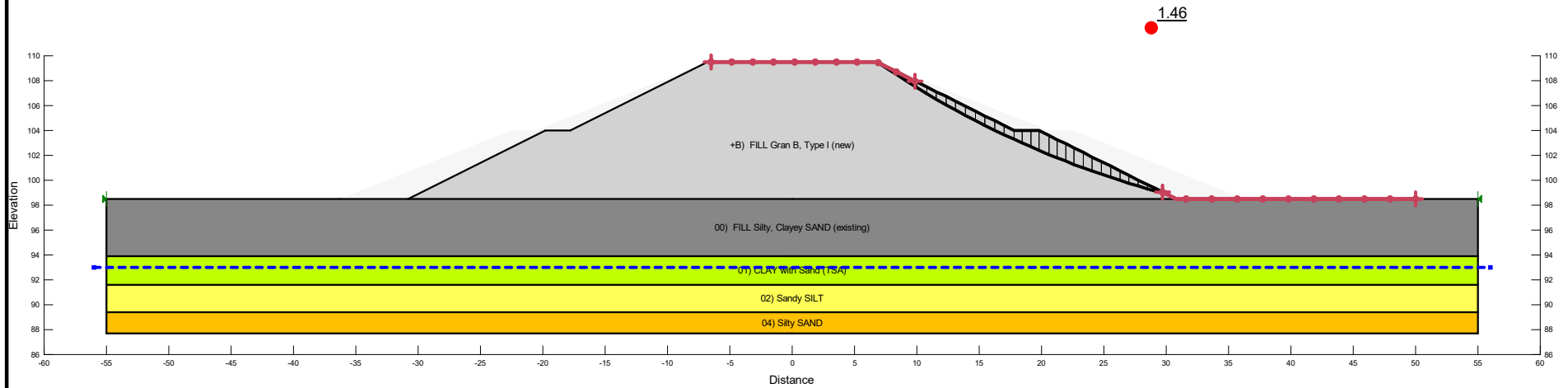


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB I, BH 20-07 (ESA, BBar)</b>		Name: Station 9+953, North Abutment (B) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (6.876937, 109.46153) m, Exit: (29.974613, 98.912693) m Center: (49.079425, 171.30617) m, Radius: 74.871953 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:03 PM	Scale 1:500	

**Figure H26**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+B) FILL Gran B, Type I (new)	21	0	32	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

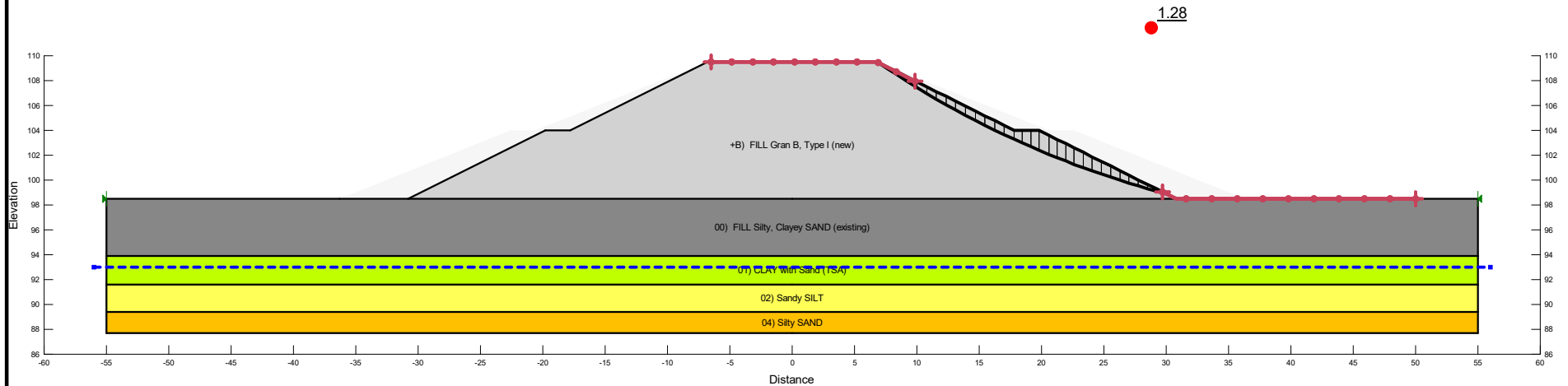


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB I, BH 20-07 (TSA)</b>		Name: Station 9+953, North Abutment (B) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (6.876937, 109.46153) m, Exit: (29.974613, 98.912693) m Center: (49.079425, 171.30617) m, Radius: 74.871953 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:03 PM	Scale 1:500	

**Figure H27**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+B) FILL Gran B, Type I (new)	21	0	32	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g

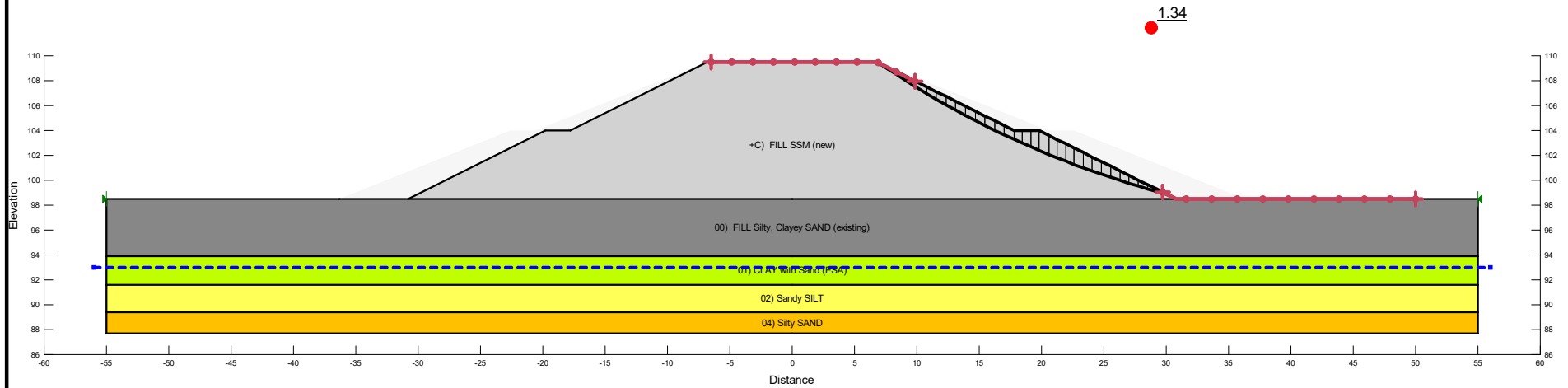


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB I, BH 20-07 (TSA, seismic)</b>		Name: Station 9+953, North Abutment (B) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (6.876937, 109.46153) m, Exit: (29.974613, 98.912693) m Center: (49.079425, 171.30617) m, Radius: 74.871953 m	
Seismic Coefficient H: 0.05g, V: 0g	Last Run 11/15/2021, 03:50:04 PM	Scale 1:500	

**Figure H28**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+C) FILL SSM (new)	21	0	30	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

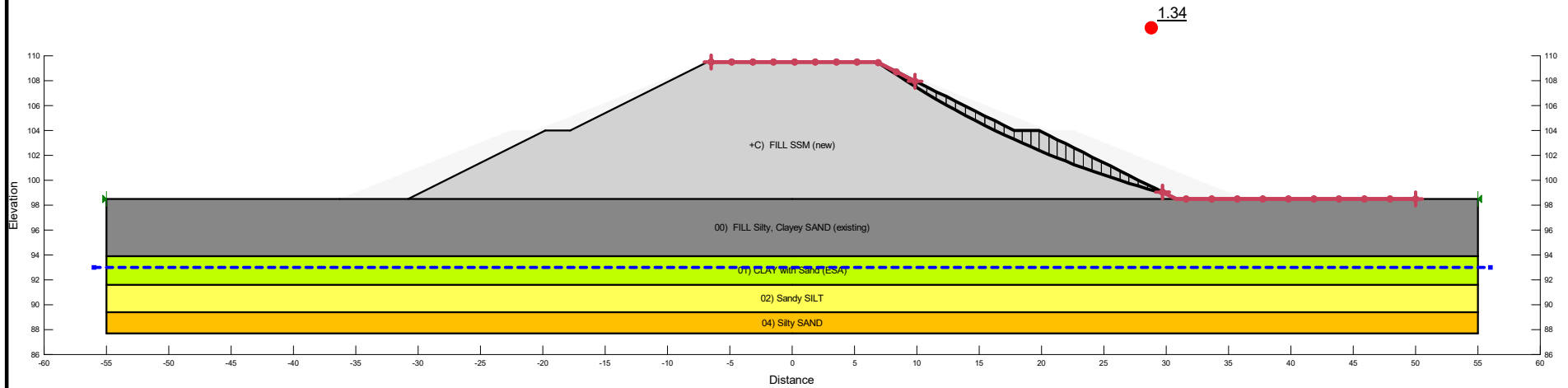


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, SSM, BH 20-07 (ESA)</b>		Name: Station 9+953, North Abutment (C) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (6.876937, 109.46153) m, Exit: (29.974613, 98.912693) m Center: (49.079425, 171.30617) m, Radius: 74.871953 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:04 PM	Scale 1:500	

**Figure H29**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Light Gray	+C) FILL SSM (new)	21	0	30	1	0	Yes
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1	0	No
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Yellow	02) Sandy SILT	19	0	29	1	0	No
Orange	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g

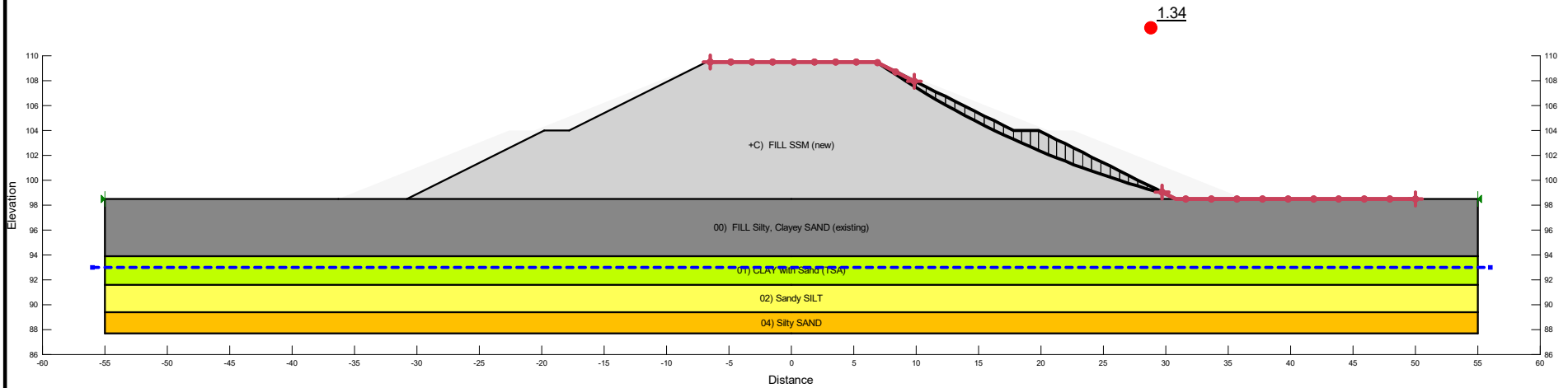


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, SSM, BH 20-07 (ESA, BBar)</b>		Name: Station 9+953, North Abutment (C) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (6.876937, 109.46153) m, Exit: (29.974613, 98.912693) m Center: (49.079425, 171.30617) m, Radius: 74.871953 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:05 PM	Scale 1:500	

**Figure H30**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
■	+C) FILL SSM (new)	21	0	30	1
■	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
■	01) CLAY with Sand (TSA)	19	75	0	1
■	02) Sandy SILT	19	0	29	1
■	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

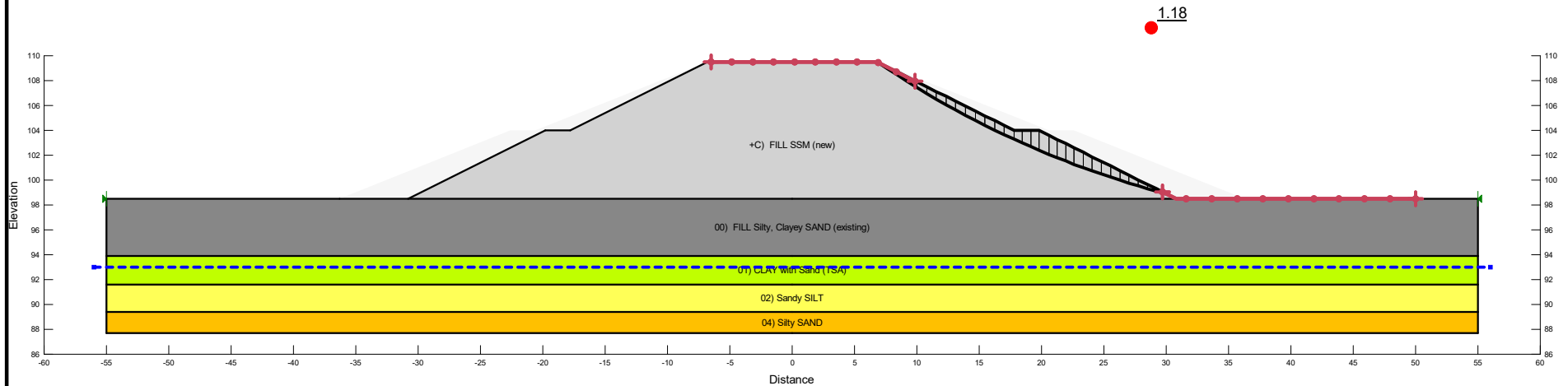


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, SSM, BH 20-07 (TSA)</b>		Name: Station 9+953, North Abutment (C) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (6.876937, 109.46153) m, Exit: (29.974613, 98.912693) m Center: (49.079425, 171.30617) m, Radius: 74.871953 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:05 PM	Scale 1:500	

**Figure H31**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+C) FILL SSM (new)	21	0	30	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g



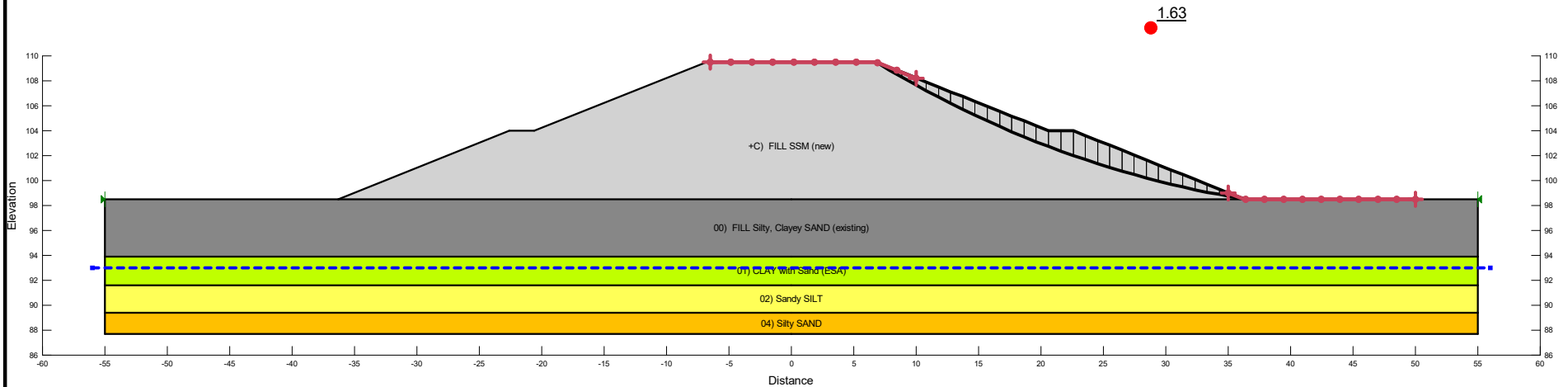
Project		Palace Road Interchange	
Analysis		2.0H:1V, SSM, BH 20-07 (TSA, seismic)	
Seismic Coefficient	Last Run	Scale	
H: 0.05g, V: 0g	11/15/2021, 03:50:06 PM	1:500	

Additional Details  
 Name: Station 9+953, North Abutment (C)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.876937, 109.46153) m, Exit: (29.974613, 98.912693) m  
 Center: (49.079425, 171.30617) m, Radius: 74.871953 m

**Figure H32**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
□	+C) FILL SSM (new)	21	0	30	1
■	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
■	01) CLAY with Sand (ESA)	19	0	29	1
■	02) Sandy SILT	19	0	29	1
■	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g



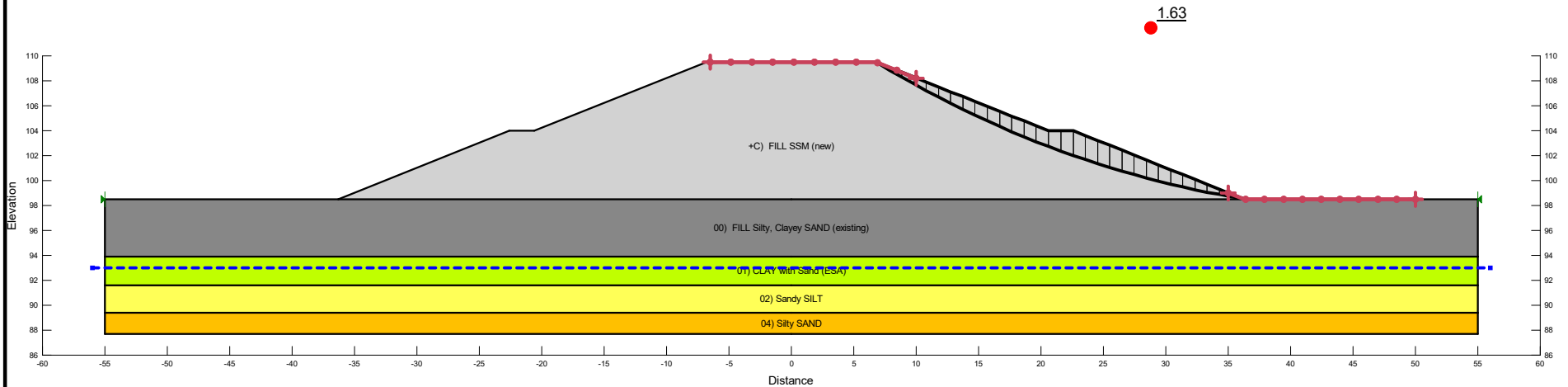
Project		Palace Road Interchange	
Analysis		2.5H:1V, SSM, BH 20-07 (ESA)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:49:47 PM	1:500	

Additional Details  
 Name: Station 9+953, North Abutment (D)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.8890163, 109.46452) m, Exit: (36.224442, 98.530334) m  
 Center: (49.541029, 179.07674) m, Radius: 81.639785 m

**Figure H33**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Light Gray	+C) FILL SSM (new)	21	0	30	1	0	Yes
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1	0	No
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Yellow	02) Sandy SILT	19	0	29	1	0	No
Orange	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g



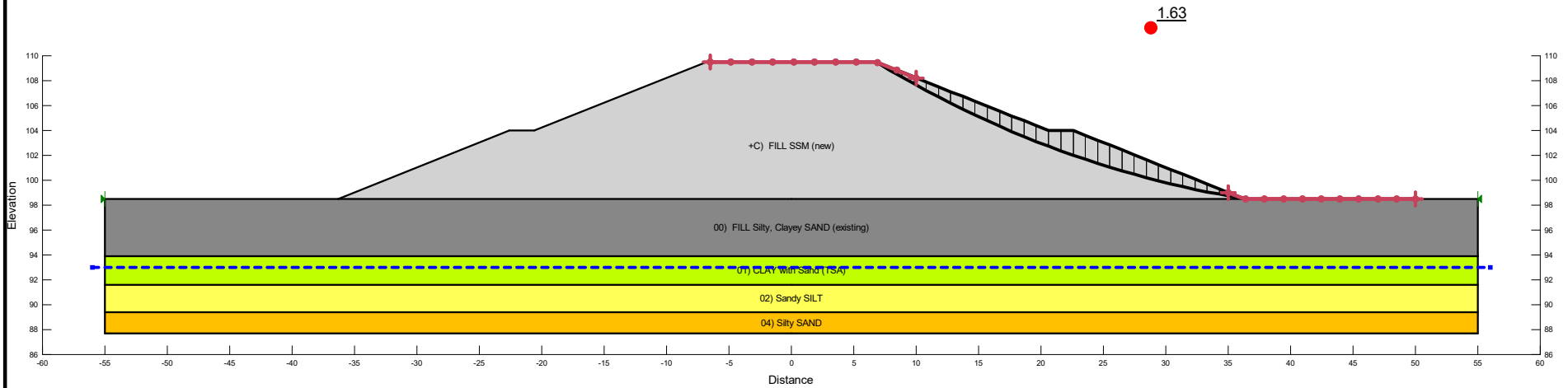
Project		Palace Road Interchange	
Analysis		2.5H:1V, SSM, BH 20-07 (ESA, BBar)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:49:49 PM	1:500	

Additional Details  
 Name: Station 9+953, North Abutment (D)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.8890163, 109.46452) m, Exit: (36.224442, 98.530334) m  
 Center: (49.541029, 179.07674) m, Radius: 81.639785 m

**Figure H34**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+C) FILL SSM (new)	21	0	30	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g



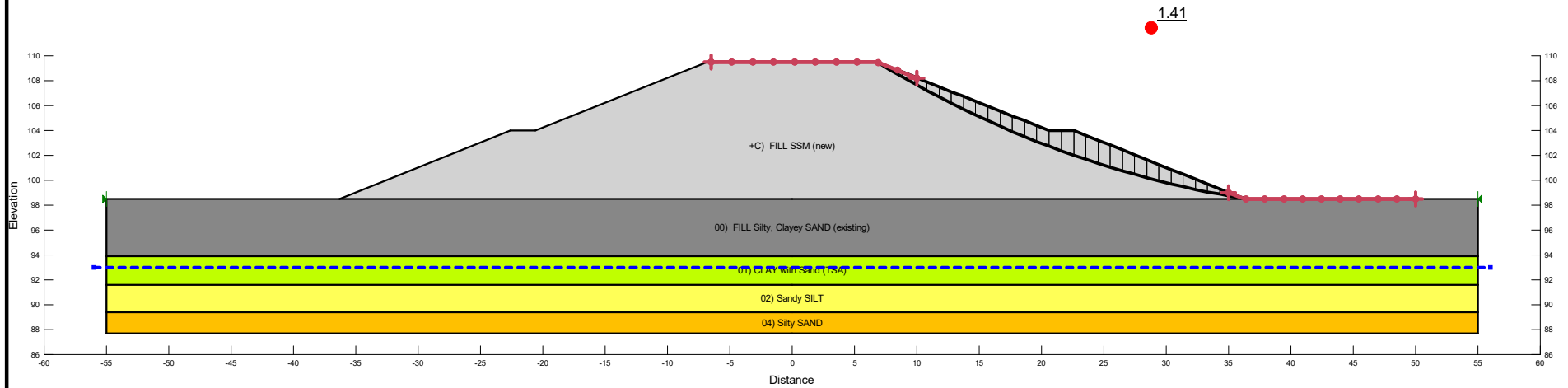
Project		Palace Road Interchange	
Analysis		2.5H:1V, SSM, BH 20-07 (TSA)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:49:47 PM	1:500	

Additional Details  
 Name: Station 9+953, North Abutment (D)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.8890163, 109.46452) m, Exit: (36.224442, 98.530334) m  
 Center: (49.541029, 179.07674) m, Radius: 81.639785 m

**Figure H35**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+C) FILL SSM (new)	21	0	30	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g



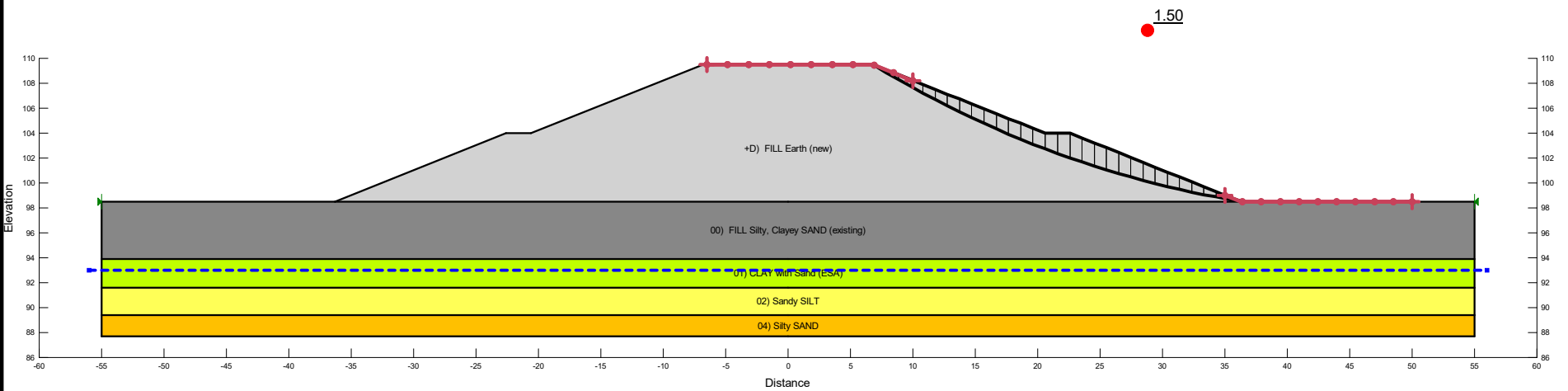
Project		Palace Road Interchange	
Analysis		2.5H:1V, SSM, BH 20-07 (TSA, seismic)	
Seismic Coefficient	Last Run	Scale	
H: 0.05g, V: 0g	11/15/2021, 03:49:48 PM	1:500	


Additional Details  
 Name: Station 9+953, North Abutment (D)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.8890163, 109.46452) m, Exit: (36.224442, 98.530334) m  
 Center: (49.541029, 179.07674) m, Radius: 81.639785 m

**Figure H36**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+D) FILL Earth(new)	20	0	28	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

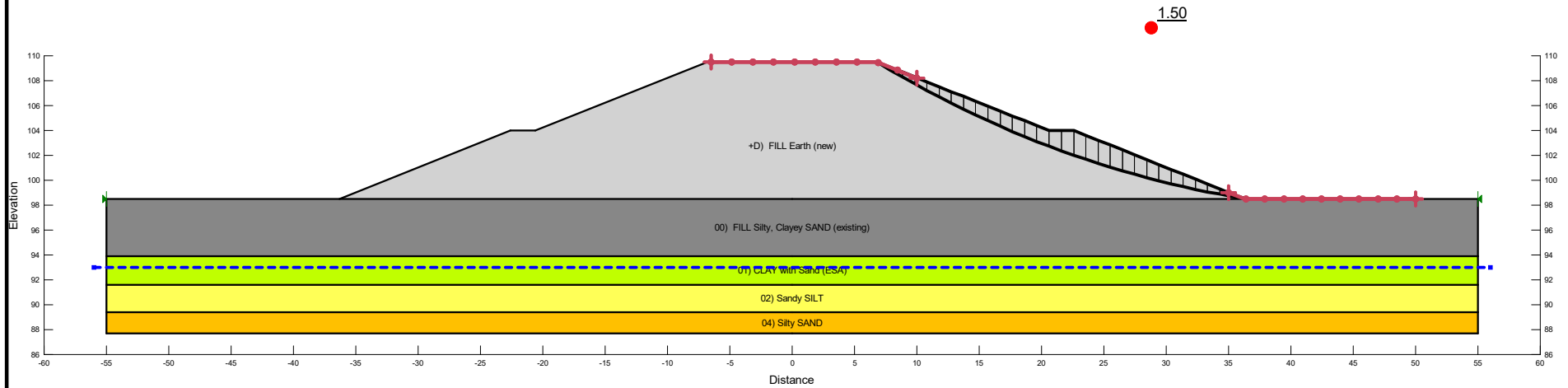


	<b>Project</b> Palace Road Interchange		<b>Additional Details</b> Name: Station 9+953, North Abutment (E) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (6.8890163, 109.46452) m, Exit: (36.224442, 98.530334) m Center: (49.541029, 179.07674) m, Radius: 81.639785 m	
	<b>Analysis</b> 2.5H:1V, Earth Fill, BH 20-07 (ESA)			
	<b>Seismic Coefficient</b> H: 0g, V: 0g	<b>Last Run</b> 11/15/2021, 03:49:54 PM	<b>Scale</b> 1:500	

**Figure H37**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Light Gray	+D) FILL Earth(new)	20	0	28	1	0	Yes
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1	0	No
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Yellow	02) Sandy SILT	19	0	29	1	0	No
Orange	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g



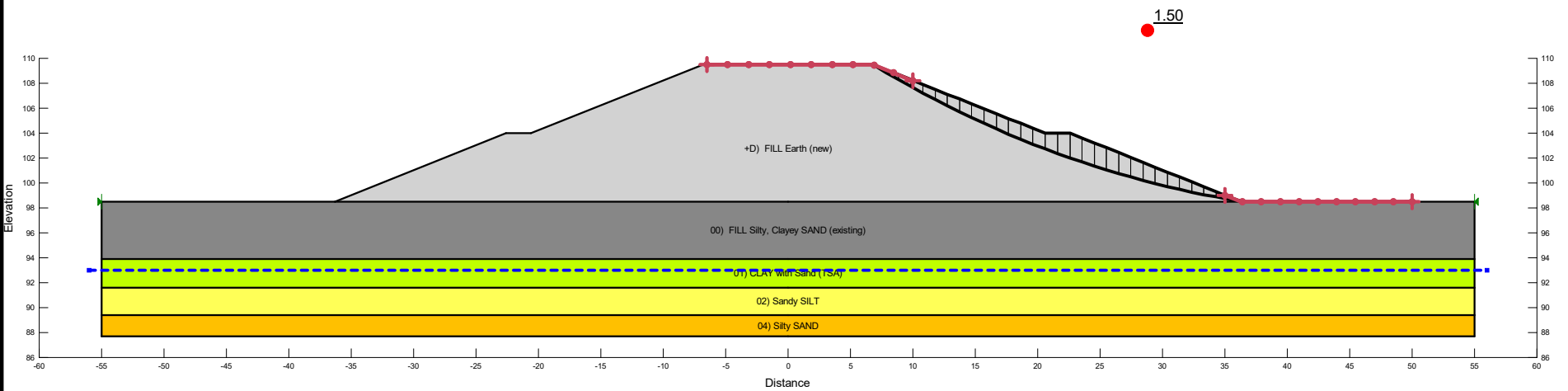
Project		Palace Road Interchange	
Analysis		2.5H:1V, Earth Fill, BH 20-07 (ESA, BBar)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:49:54 PM	1:500	


Additional Details  
 Name: Station 9+953, North Abutment (E)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.8890163, 109.46452) m, Exit: (36.224442, 98.530334) m  
 Center: (49.541029, 179.07674) m, Radius: 81.639785 m

**Figure H38**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
□	+D) FILL Earth(new)	20	0	28	1
■	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
■	01) CLAY with Sand (TSA)	19	75	0	1
■	02) Sandy SILT	19	0	29	1
■	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

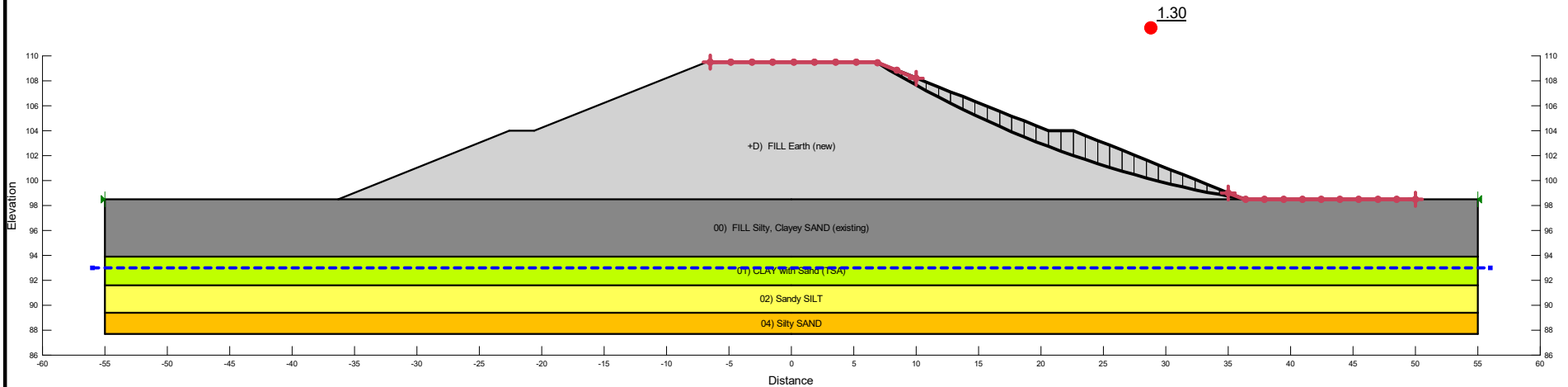


	Project <b>Palace Road Interchange</b>		Additional Details Name: Station 9+953, North Abutment (E) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (6.8890163, 109.46452) m, Exit: (36.224442, 98.530334) m Center: (49.541029, 179.07674) m, Radius: 81.639785 m	
	Analysis <b>2.5H:1V, Earth Fill, BH 20-07 (TSA)</b>			
	Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:49:55 PM	Scale 1:500	

**Figure H39**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
□	+D) FILL Earth(new)	20	0	28	1
■	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
■	01) CLAY with Sand (TSA)	19	75	0	1
■	02) Sandy SILT	19	0	29	1
■	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g



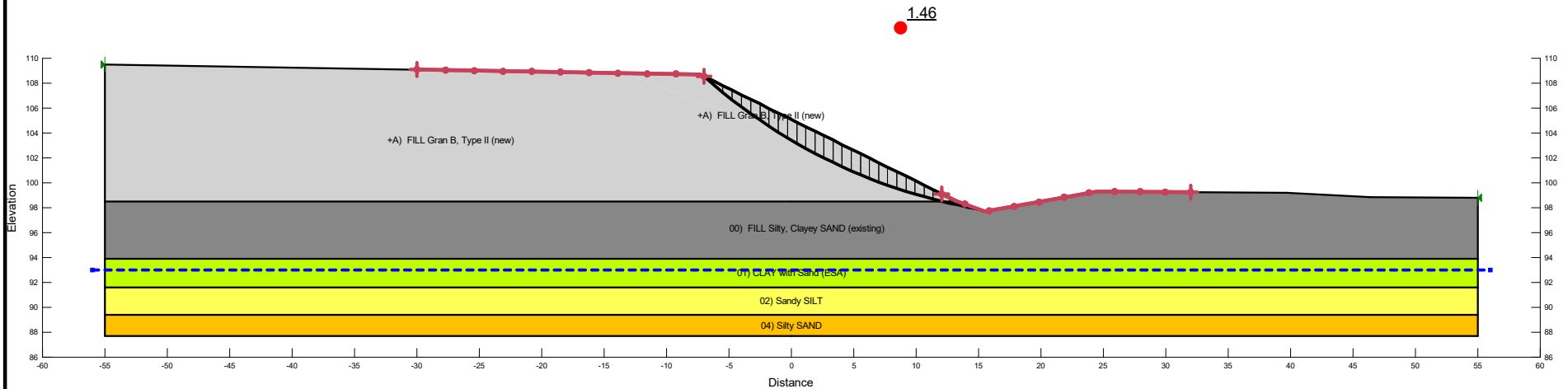
Project		Palace Road Interchange	
Analysis		2.5H:1V, Earth Fill, BH 20-07 (TSA, seismic)	
Seismic Coefficient	Last Run	Scale	
H: 0.05g, V: 0g	11/15/2021, 03:49:55 PM	1:500	

Additional Details  
 Name: Station 9+953, North Abutment (E)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (6.8890163, 109.46452) m, Exit: (36.224442, 98.530334) m  
 Center: (49.541029, 179.07674) m, Radius: 81.639785 m

**Figure H40**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+A) FILL Gran B, Type II (new)	22	0	35	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

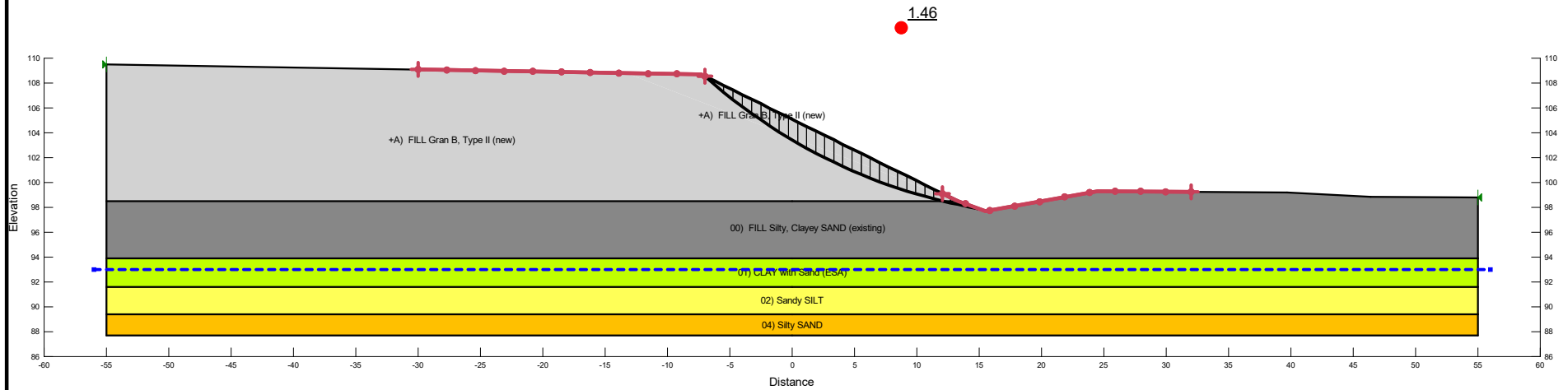


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB II, BH 20-07 (ESA) (2)</b>		Name: Station 9+953, North Abutment Foward Slope (A) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (-7.0000031, 108.55146) m, Exit: (14.918851, 97.911327) m Center: (22.541304, 141.51039) m, Radius: 44.260365 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:14 PM	Scale 1:500	

**Figure 41**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Light Gray	+A) FILL Gran B, Type II (new)	22	0	35	1	0	Yes
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1	0	No
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Yellow	02) Sandy SILT	19	0	29	1	0	No
Orange	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g



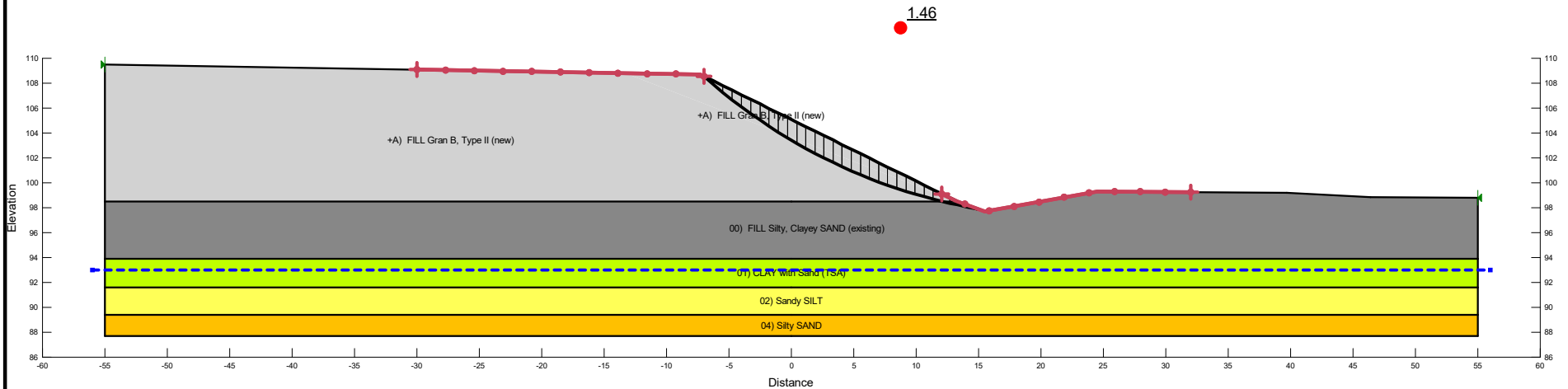
Project		Palace Road Interchange	
Analysis		2.0H:1V, GB II, BH 20-07 (ESA, BBar) (2)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:50:14 PM	1:500	

Additional Details  
 Name: Station 9+953, North Abutment Foward Slope (A)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (-7.0000031, 108.55146) m, Exit: (14.918851, 97.911327) m  
 Center: (22.541304, 141.51039) m, Radius: 44.260365 m

**Figure 42**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+A) FILL Gran B, Type II (new)	22	0	35	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

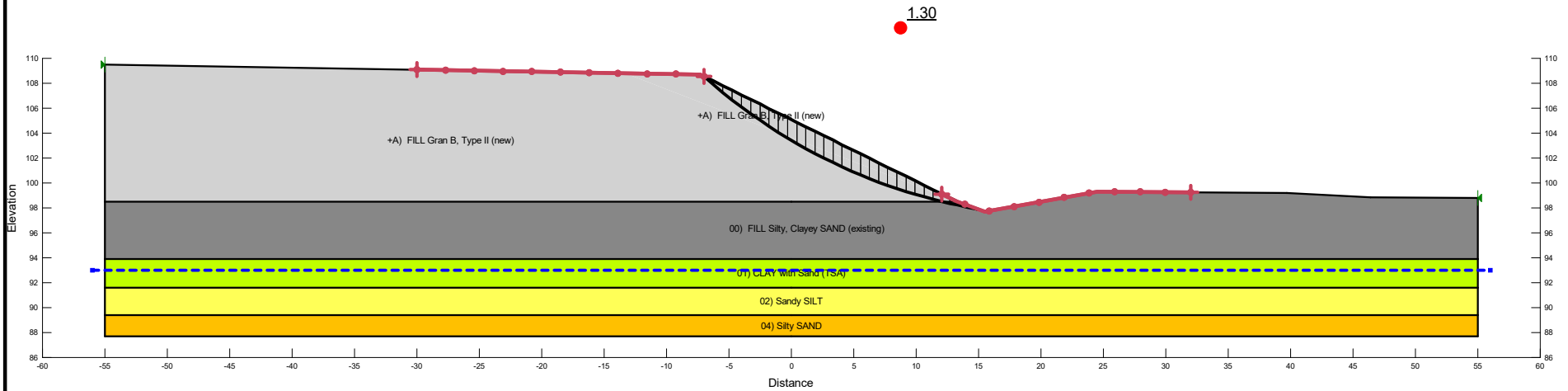


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB II, BH 20-07 (TSA) (2)</b>		Name: Station 9+953, North Abutment Foward Slope (A) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (-7.0000031, 108.55146) m, Exit: (14.918851, 97.911327) m Center: (22.541304, 141.51039) m, Radius: 44.260365 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:15 PM	Scale 1:500	

**Figure 43**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+A) FILL Gran B, Type II (new)	22	0	35	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g



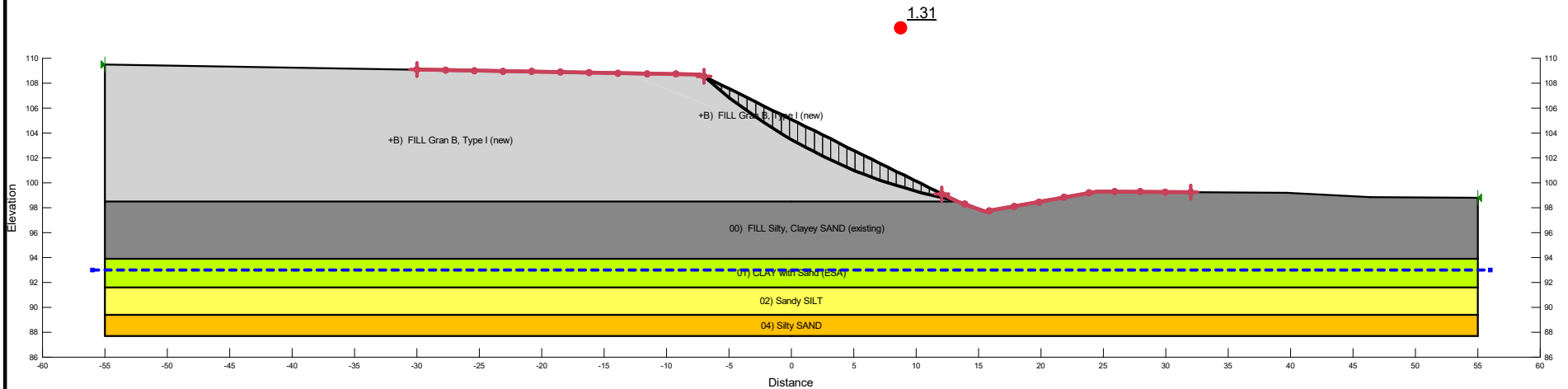
Project		Palace Road Interchange	
Analysis		2.0H:1V, GB II, BH 20-07 (TSA, seismic) (2)	
Seismic Coefficient	Last Run	Scale	
H: 0.05g, V: 0g	11/15/2021, 03:50:15 PM	1:500	

Additional Details  
 Name: Station 9+953, North Abutment Foward Slope (A)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (-7.0000031, 108.55146) m, Exit: (14.918851, 97.911327) m  
 Center: (22.541304, 141.51039) m, Radius: 44.260365 m

**Figure 44**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+B) FILL Gran B, Type I (new)	21	0	32	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

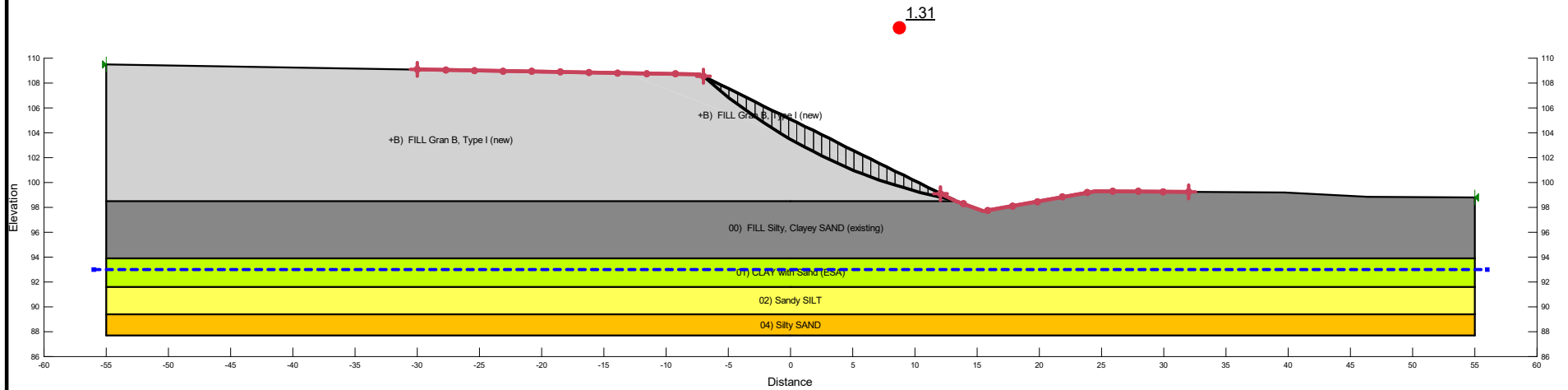



Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB I, BH 20-07 (ESA) (2)</b>		Name: Station 9+953, North Abutment Foward Slope (B) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (-7.0000031, 108.55146) m, Exit: (13.126405, 98.585955) m Center: (21.115406, 140.02708) m, Radius: 42.20416 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:11 PM	Scale 1:500	

**Figure 45**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Light Gray	+B) FILL Gran B, Type I (new)	21	0	32	1	0	Yes
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1	0	No
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Yellow	02) Sandy SILT	19	0	29	1	0	No
Orange	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g

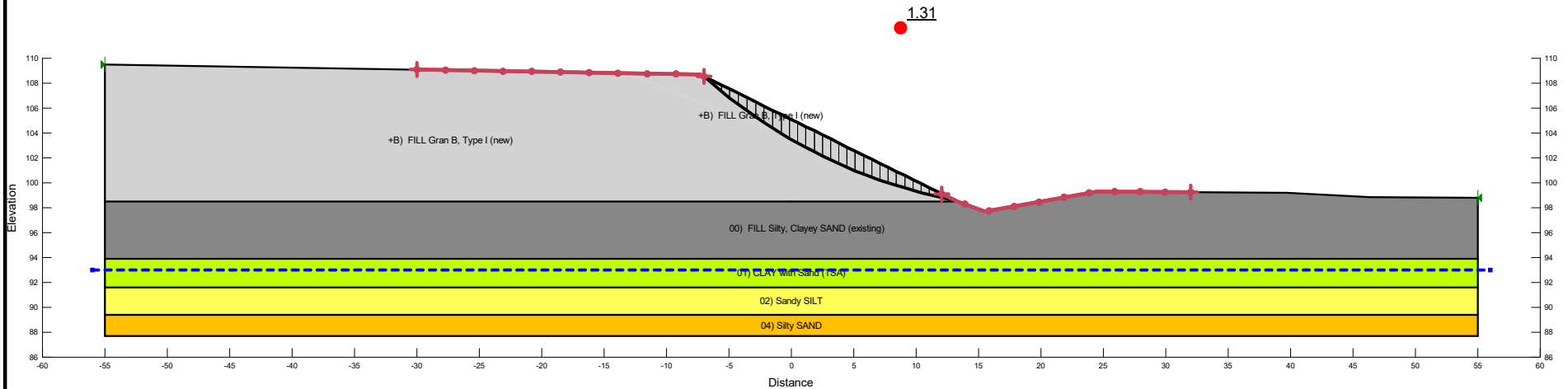


	Project		Additional Details		
	Palace Road Interchange		Name: Station 9+953, North Abutment Foward Slope (B)		
	Analysis		Comments: Stability Assessment		
2.0H:1V, GB I, BH 20-07 (ESA, BBar) (2)		Method: Morgenstern-Price, Half-Sine			
Seismic Coefficient		Last Run		Minimum Slip Surface Depth: 1.5 m	
H: 0g, V: 0g		11/15/2021, 03:50:12 PM		Entry: (-7.0000031, 108.55146) m, Exit: (13.126405, 98.585955) m	
		Scale		Center: (21.115406, 140.02708) m, Radius: 42.20416 m	
		1:500			

**Figure 46**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+B) FILL Gran B, Type I (new)	21	0	32	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

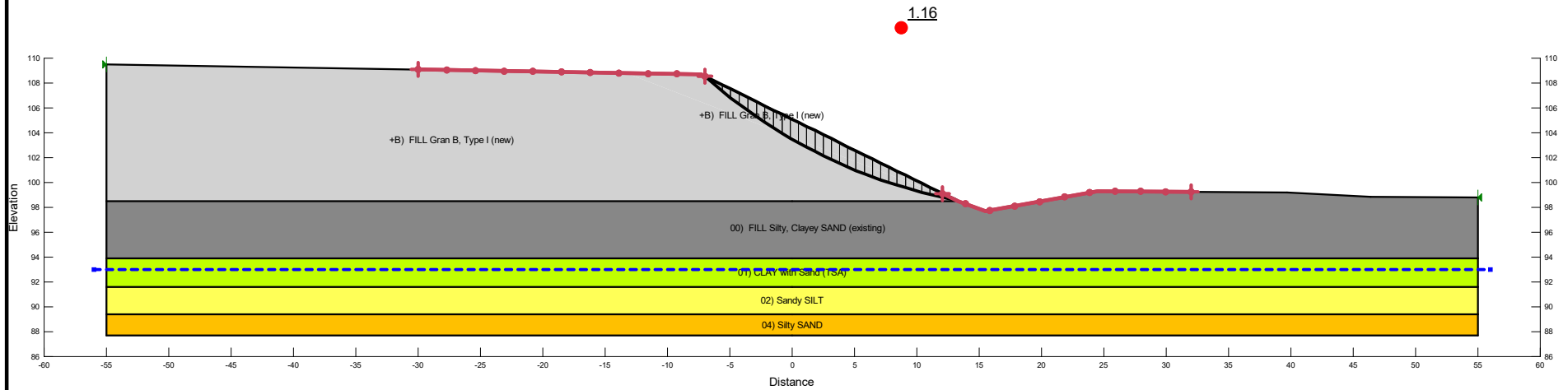


Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB I, BH 20-07 (TSA) (2)</b>		Name: Station 9+953, North Abutment Foward Slope (B) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (-7.0000031, 108.55146) m, Exit: (13.126405, 98.585955) m Center: (21.115406, 140.02708) m, Radius: 42.20416 m	
Seismic Coefficient H: 0g, V: 0g	Last Run 11/15/2021, 03:50:12 PM	Scale 1:500	

**Figure 47**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+B) FILL Gran B, Type I (new)	21	0	32	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g

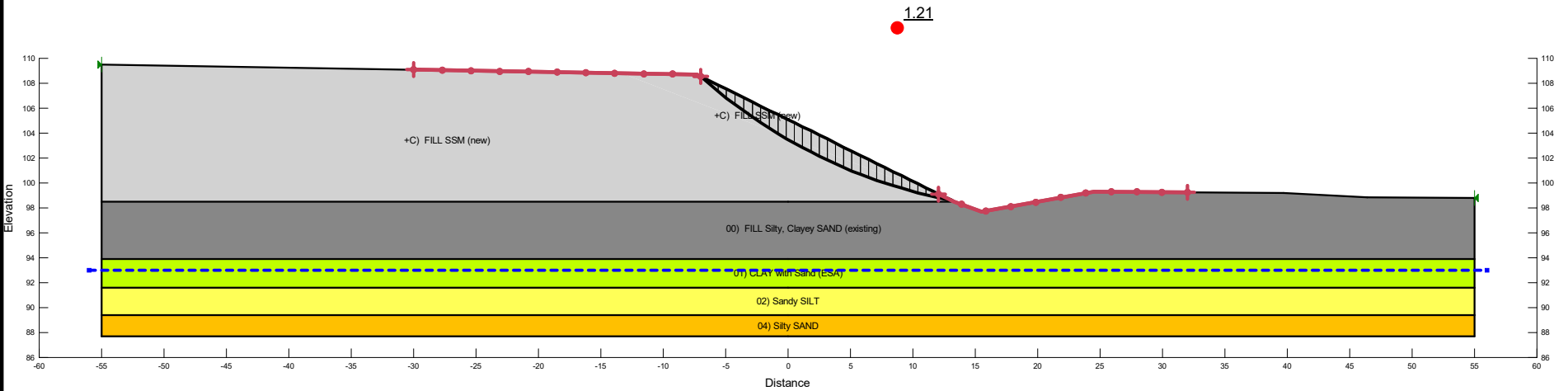



Project <b>Palace Road Interchange</b>		Additional Details	
Analysis <b>2.0H:1V, GB I, BH 20-07 (TSA, seismic) (2)</b>		Name: Station 9+953, North Abutment Foward Slope (B) Comments: Stability Assessment Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.5 m Entry: (-7.0000031, 108.55146) m, Exit: (13.126405, 98.585955) m Center: (21.115406, 140.02708) m, Radius: 42.20416 m	
Seismic Coefficient H: 0.05g, V: 0g	Last Run 11/15/2021, 03:50:13 PM	Scale 1:500	

**Figure 48**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+C) FILL SSM (new)	21	0	30	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

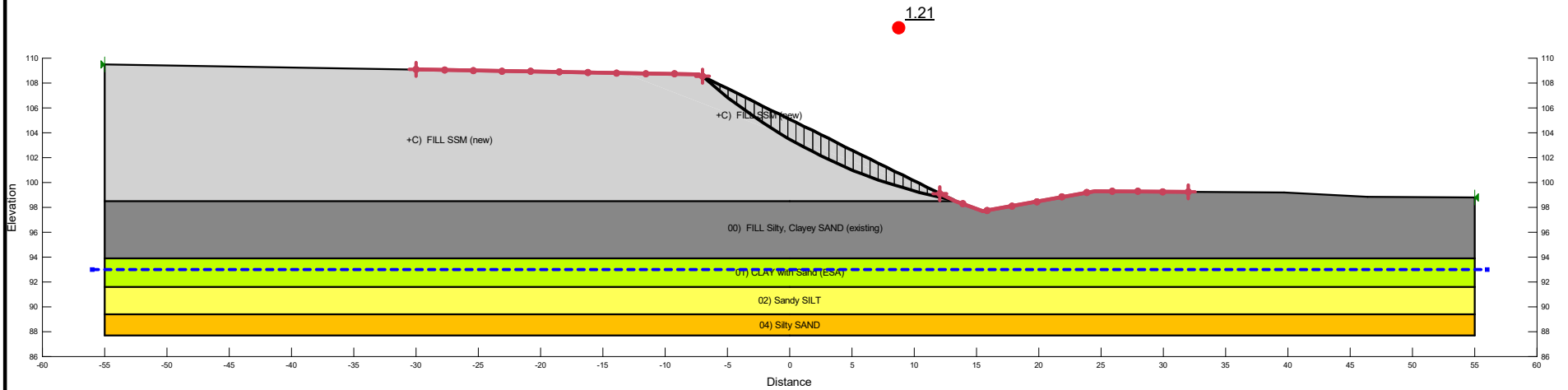



	Project		Additional Details		
	Palace Road Interchange		Name: Station 9+953, North Abutment Foward Slope (C)		
	Analysis		Comments: Stability Assessment		
	2.0H:1V, SSM, BH 20-07 (ESA) (2)		Method: Morgenstern-Price, Half-Sine		
Seismic Coefficient		Last Run		Minimum Slip Surface Depth: 1.5 m	
H: 0g, V: 0g		11/15/2021, 03:50:18 PM		Entry: (-7.0000031, 108.55146) m, Exit: (13.126405, 98.585955) m	
		Scale		Center: (21.115406, 140.02708) m, Radius: 42.20416 m	
		1:500			

**Figure 49**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Light Gray	+C) FILL SSM (new)	21	0	30	1	0	Yes
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1	0	No
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Yellow	02) Sandy SILT	19	0	29	1	0	No
Orange	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g

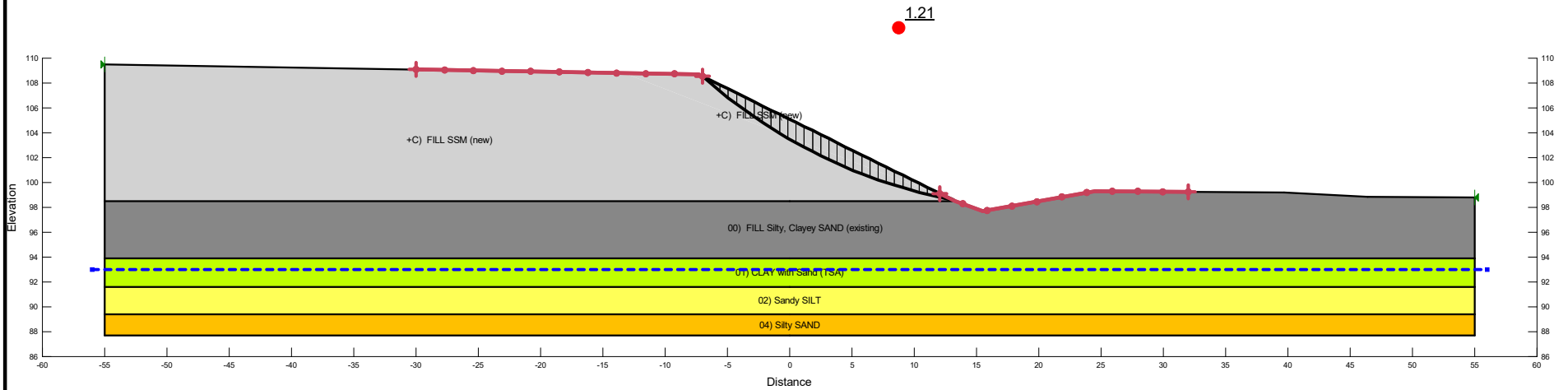



	Project		Additional Details	
	Palace Road Interchange		Name: Station 9+953, North Abutment Foward Slope (C)	
	Analysis		Comments: Stability Assessment	
2.0H:1V, SSM, BH 20-07 (ESA, BBar) (2)		Method: Morgenstern-Price, Half-Sine		
Seismic Coefficient		Minimum Slip Surface Depth: 1.5 m		
H: 0g, V: 0g		Entry: (-7.0000031, 108.55146) m, Exit: (13.126405, 98.585955) m		
Last Run		Center: (21.115406, 140.02708) m, Radius: 42.20416 m		
11/15/2021, 03:50:19 PM				
Scale				
1:500				

**Figure 50**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
■	+C) FILL SSM (new)	21	0	30	1
■	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
■	01) CLAY with Sand (TSA)	19	75	0	1
■	02) Sandy SILT	19	0	29	1
■	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

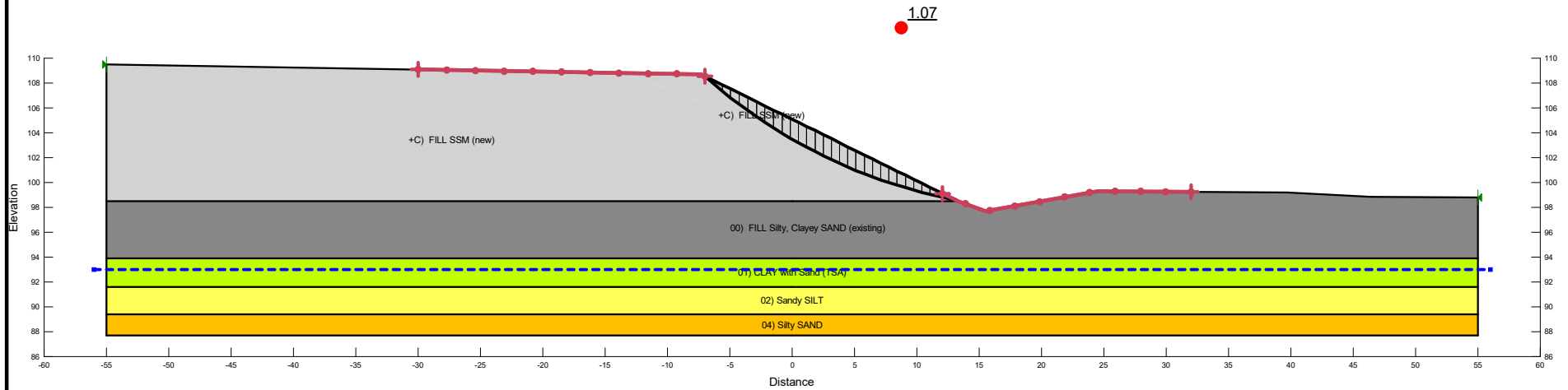


	Project		Additional Details		
	Palace Road Interchange		Name: Station 9+953, North Abutment Foward Slope (C)		
	Analysis		Comments: Stability Assessment		
2.0H:1V, SSM, BH 20-07 (TSA) (2)		Method: Morgenstern-Price, Half-Sine			
Seismic Coefficient		Last Run		Minimum Slip Surface Depth: 1.5 m	
H: 0g, V: 0g		11/15/2021, 03:50:19 PM		Entry: (-7.0000031, 108.55146) m, Exit: (13.126405, 98.585955) m	
		Scale		Center: (21.115406, 140.02708) m, Radius: 42.20416 m	
		1:500			

**Figure 51**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+C) FILL SSM (new)	21	0	30	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g



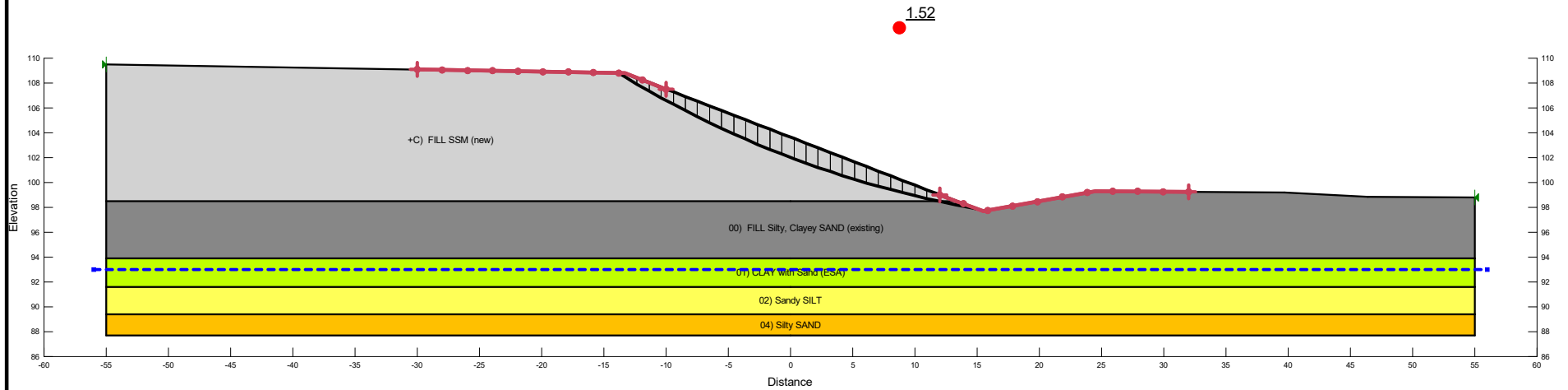
Project		Palace Road Interchange	
Analysis		2.0H:1V, SSM, BH 20-07 (TSA, seismic) (2)	
Seismic Coefficient	Last Run	Scale	
H: 0.05g, V: 0g	11/15/2021, 03:50:20 PM	1:500	


Additional Details  
 Name: Station 9+953, North Abutment Foward Slope (C)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (-7.0000031, 108.55146) m, Exit: (13.126405, 98.585955) m  
 Center: (21.115406, 140.02708) m, Radius: 42.20416 m

**Figure 52**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
■	+C) FILL SSM (new)	21	0	30	1
■	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
■	01) CLAY with Sand (ESA)	19	0	29	1
■	02) Sandy SILT	19	0	29	1
■	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

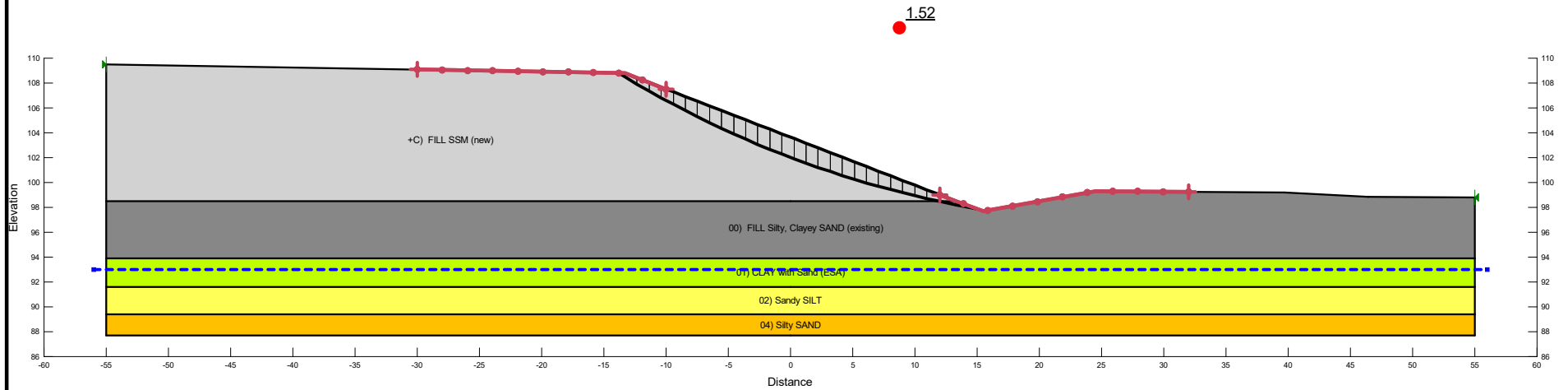



	Project		Additional Details		
	Palace Road Interchange		Name: Station 9+953, North Abutment Foward Slope (D)		
	Analysis		Comments: Stability Assessment		
2.5H:1V, SSM, BH 20-07 (ESA) (2)		Method: Morgenstern-Price, Half-Sine			
Seismic Coefficient		Last Run		Minimum Slip Surface Depth: 1.5 m	
H: 0g, V: 0g		11/15/2021, 03:50:07 PM		Entry: (-13.809391, 108.80855) m, Exit: (14.896674, 97.919391) m	
		Scale		Center: (29.154341, 178.78766) m, Radius: 82.115516 m	
		1:500			

**Figure 53**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Light Gray	+C) FILL SSM (new)	21	0	30	1	0	Yes
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1	0	No
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Yellow	02) Sandy SILT	19	0	29	1	0	No
Orange	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g

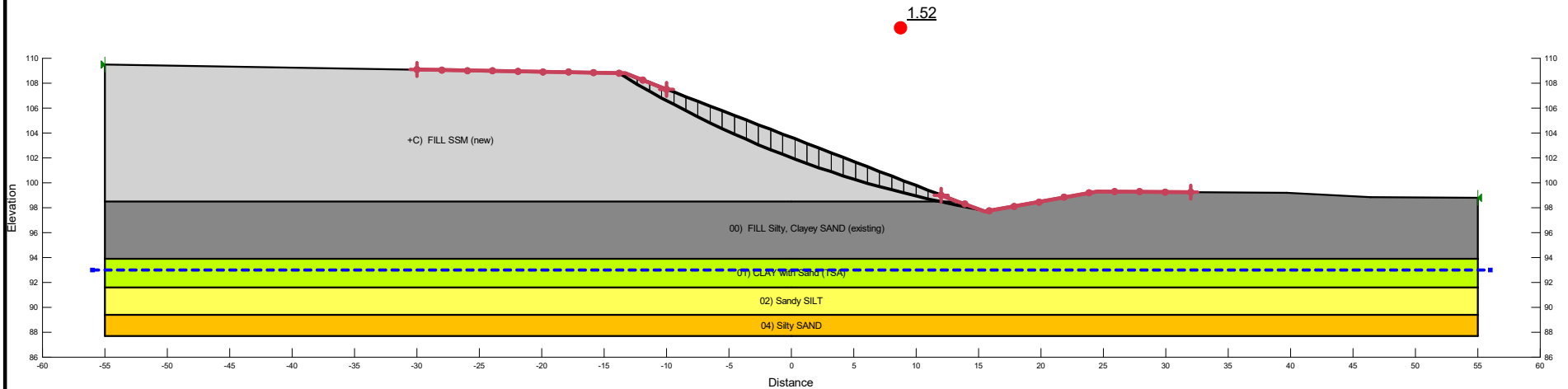


	Project		Additional Details		
	Palace Road Interchange		Name: Station 9+953, North Abutment Foward Slope (D)		
	Analysis		Comments: Stability Assessment		
2.5H:1V, SSM, BH 20-07 (ESA, BBar) (2)		Method: Morgenstern-Price, Half-Sine			
Seismic Coefficient		Last Run		Minimum Slip Surface Depth: 1.5 m	
H: 0g, V: 0g		11/15/2021, 03:50:07 PM		Entry: (-13.809391, 108.80855) m, Exit: (14.896674, 97.919391) m	
		Scale		Center: (29.154341, 178.78766) m, Radius: 82.115516 m	
		1:500			

**Figure 54**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+C) FILL SSM (new)	21	0	30	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g



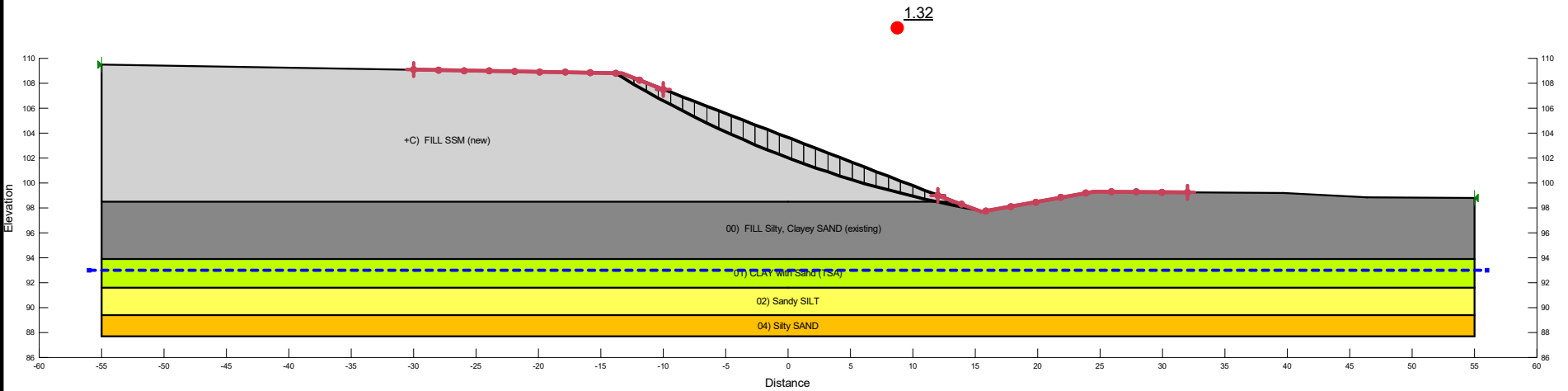
Project		Palace Road Interchange	
Analysis		2.5H:1V, SSM, BH 20-07 (TSA) (2)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:50:08 PM	1:500	


Additional Details  
 Name: Station 9+953, North Abutment Foward Slope (D)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (-13.809391, 108.80855) m, Exit: (14.896674, 97.919391) m  
 Center: (29.154341, 178.78766) m, Radius: 82.115516 m

**Figure 55**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+C) FILL SSM (new)	21	0	30	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g

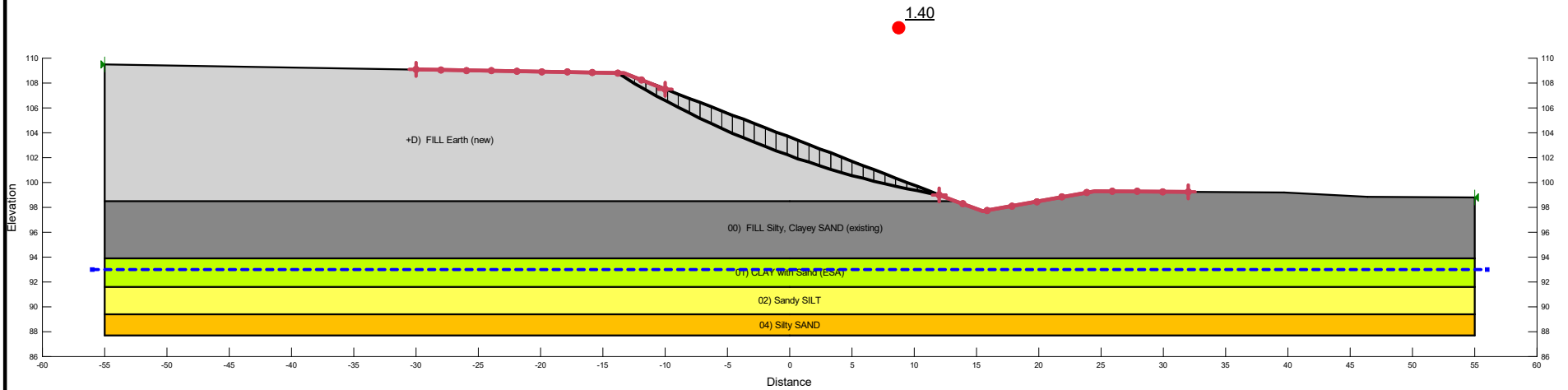



	Project		Additional Details	
	Palace Road Interchange		Name: Station 9+953, North Abutment Foward Slope (D)	
	Analysis		Comments: Stability Assessment	
2.5H:1V, SSM, BH 20-07 (TSA, seismic) (2)		Method: Morgenstern-Price, Half-Sine		
Seismic Coefficient		Minimum Slip Surface Depth: 1.5 m		
Last Run		Entry: (-13.809391, 108.80855) m, Exit: (14.896674, 97.919391) m		
H: 0.05g, V: 0g		Center: (29.154341, 178.78766) m, Radius: 82.115516 m		
11/15/2021, 03:50:08 PM		Scale		
1:500				

**Figure 56**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+D) FILL Earth(new)	20	0	28	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (ESA)	19	0	29	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g

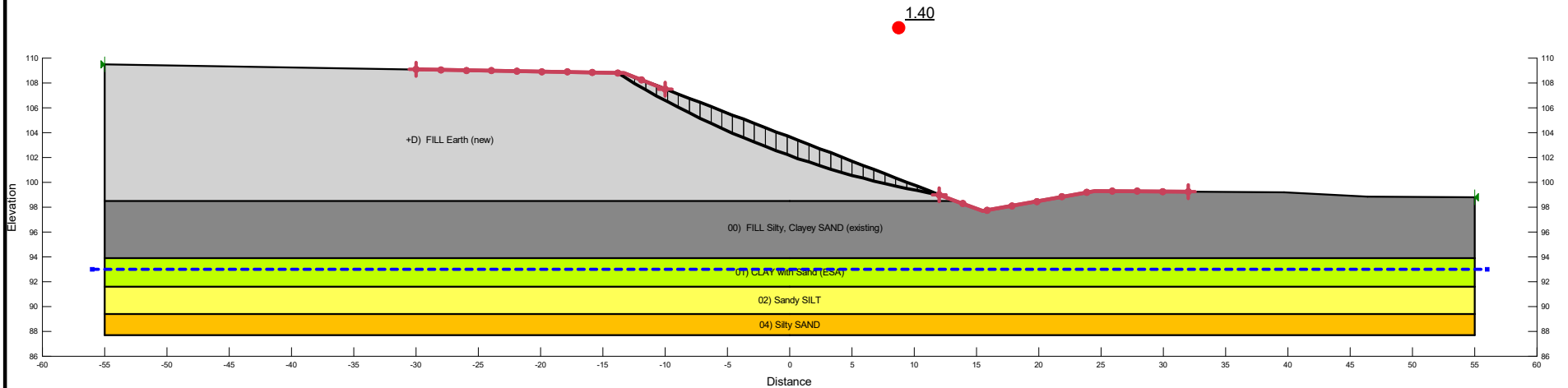


	Project		Additional Details		
	Palace Road Interchange		Name: Station 9+953, North Abutment Foward Slope (E)		
	Analysis		Comments: Stability Assessment		
2.5H:1V, Earth Fill, BH 20-07 (ESA) (2)		Method: Morgenstern-Price, Half-Sine			
Seismic Coefficient		Last Run		Minimum Slip Surface Depth: 1.5 m	
H: 0g, V: 0g		11/15/2021, 03:50:09 PM		Entry: (-13.809391, 108.80855) m, Exit: (12.000006, 99.003381) m	
		Scale		Center: (24.24066, 170.09415) m, Radius: 72.13689 m	
		1:500			

**Figure 57**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line	B-bar	Add Weight
Light Gray	+D) FILL Earth(new)	20	0	28	1	0	Yes
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1	0	No
Light Green	01) CLAY with Sand (ESA)	19	0	29	1	0.6	No
Yellow	02) Sandy SILT	19	0	29	1	0	No
Orange	04) Silty SAND	20	0	30	1	0	No

Horz Seismic Coef.: 0g



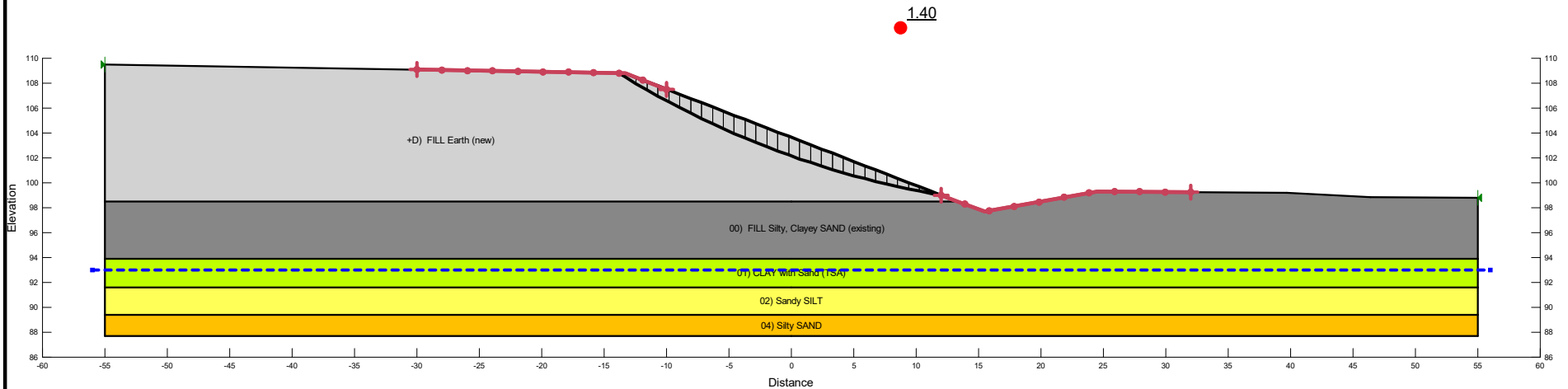
Project		Palace Road Interchange	
Analysis		2.5H:1V, Earth Fill, BH 20-07 (ESA, BBar) (2)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:50:09 PM	1:500	

Additional Details  
 Name: Station 9+953, North Abutment Foward Slope (E)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (-13.809391, 108.80855) m, Exit: (12.000006, 99.003381) m  
 Center: (24.24066, 170.09415) m, Radius: 72.13689 m

**Figure 58**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+D) FILL Earth(new)	20	0	28	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0g



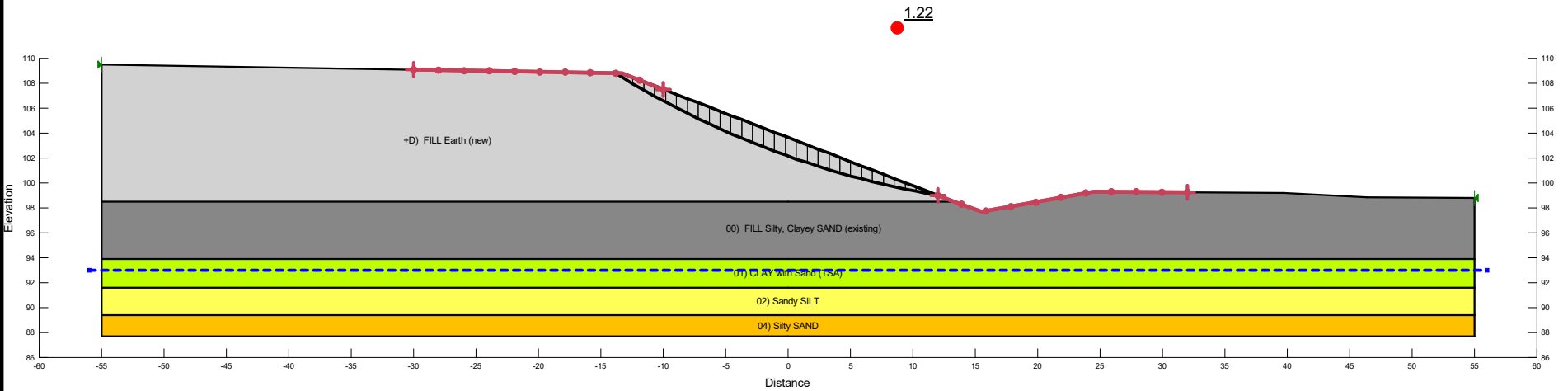
Project		Palace Road Interchange	
Analysis		2.5H:1V, Earth Fill, BH 20-07 (TSA) (2)	
Seismic Coefficient	Last Run	Scale	
H: 0g, V: 0g	11/15/2021, 03:50:10 PM	1:500	


Additional Details  
 Name: Station 9+953, North Abutment Foward Slope (E)  
 Comments: Stability Assessment  
 Method: Morgenstern-Price, Half-Sine  
 Minimum Slip Surface Depth: 1.5 m  
 Entry: (-13.809391, 108.80855) m, Exit: (12.000006, 99.003381) m  
 Center: (24.24066, 170.09415) m, Radius: 72.13689 m

**Figure 59**

Color	Name	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
Light Gray	+D) FILL Earth(new)	20	0	28	1
Dark Gray	00) FILL Silty, Clayey SAND (existing)	21	0	30	1
Light Green	01) CLAY with Sand (TSA)	19	75	0	1
Yellow	02) Sandy SILT	19	0	29	1
Orange	04) Silty SAND	20	0	30	1

Horz Seismic Coef.: 0.05g



	Project		Additional Details		
	Palace Road Interchange		Name: Station 9+953, North Abutment Foward Slope (E)		
	Analysis		Comments: Stability Assessment		
	2.5H:1V, Earth Fill, BH 20-07 (TSA, seismic) (2)		Method: Morgenstern-Price, Half-Sine		
Seismic Coefficient		Last Run		Minimum Slip Surface Depth: 1.5 m	
H: 0.05g, V: 0g		11/15/2021, 03:50:10 PM		Entry: (-13.809391, 108.80855) m, Exit: (12.000006, 99.003381) m	
		Scale		Center: (24.24066, 170.09415) m, Radius: 72.13689 m	
		1:500			

**Figure 60**

## **Appendix I.**

### **List of Referenced Specifications**

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

- OPSS.PROV 206
- OPSS.PROV 501
- OPSS.PROV 517
- OPSS.PROV 539
- OPSS.PROV 804
- OPSS 805
- OPSS 902
- OPSS.PROV 903
- OPSS.PROV 1010
- OPSD 802.010
- OPSD 3090.101
- OPSD 3101.150
- SP110S06
- SP517F01
- FOUN0003

2. Operation Constraint – Earth Fill

Embankments constructed with earth fill shall not be built at a rate faster than 4 m total height per week. Earth fill must not be placed in winter months or freezing conditions. Regrading and compaction may be required after precipitation events. Earth fill must be non-plastic or low plastic material with a moisture content less than the liquid limit. The material shall be handled and stored effectively to control moisture.

3. Operation Constraint - Preload

The Contractor is advised that the contract includes a required preloading of the ground. The Contractor shall complete the preloading prior to winter conditions. For the purpose of scheduling contractor operations, the preloading period is to be a minimum of three months.

4. Notice to Contractor – Obstructions

The Contractor is advised that obstructions could be encountered within the existing fill and may be encountered during excavation and pile driving operations. Appropriate equipment and procedures will be required by the Contractor.