APPENDIX H
Stability and Liquefaction Analysis Graphical Results

APPENDIX H.1
Stability Analysis Results - Snowshed Temporary Soil Nail Wall and Wall 1

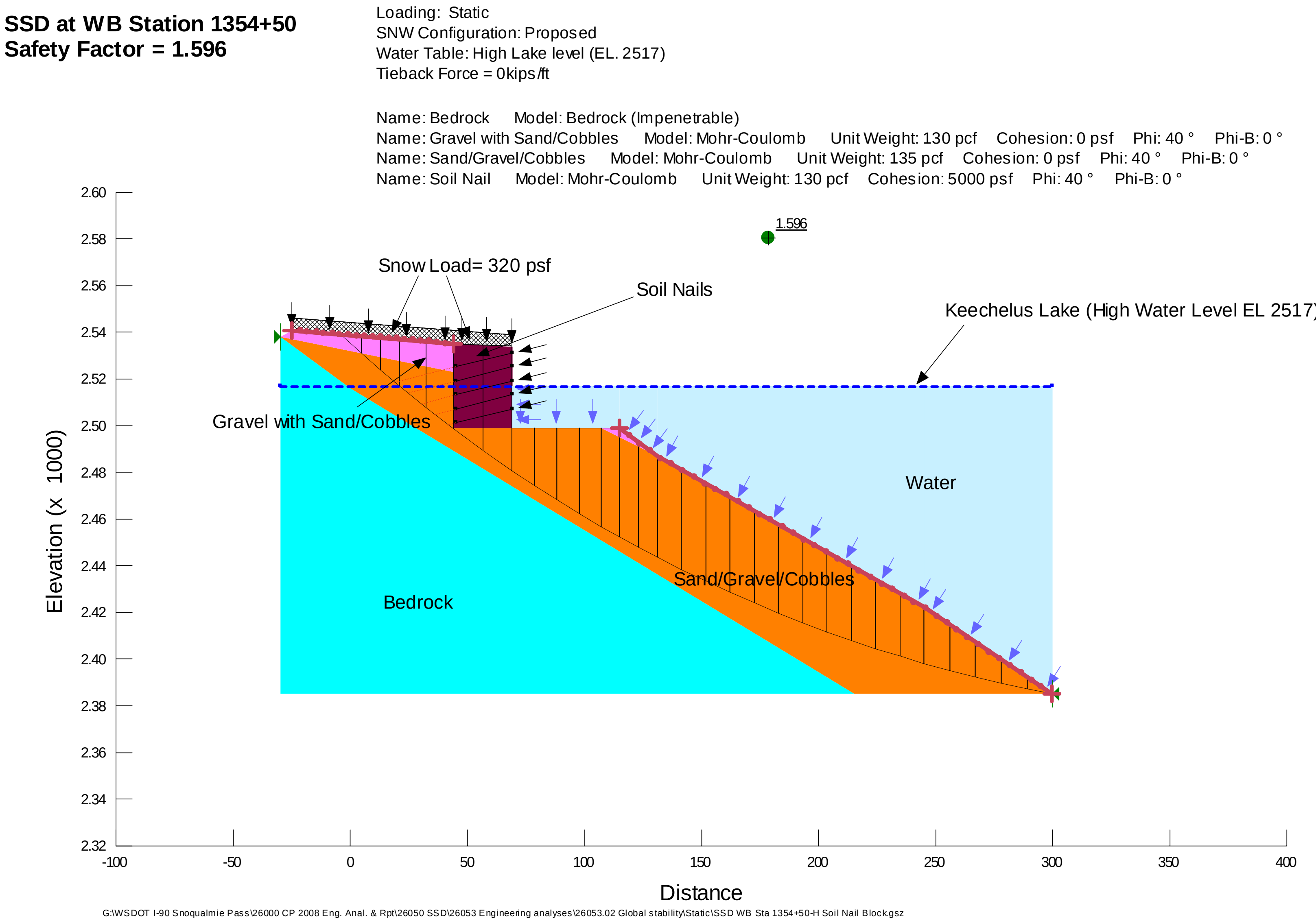


Figure H.1.1

Global Stability – Static, High Water, WB Sta. 1354+50

Job No. 33758662

URS

I-90 Snoqualmie Pass East
Hyak to Keechelus Dam, Washington

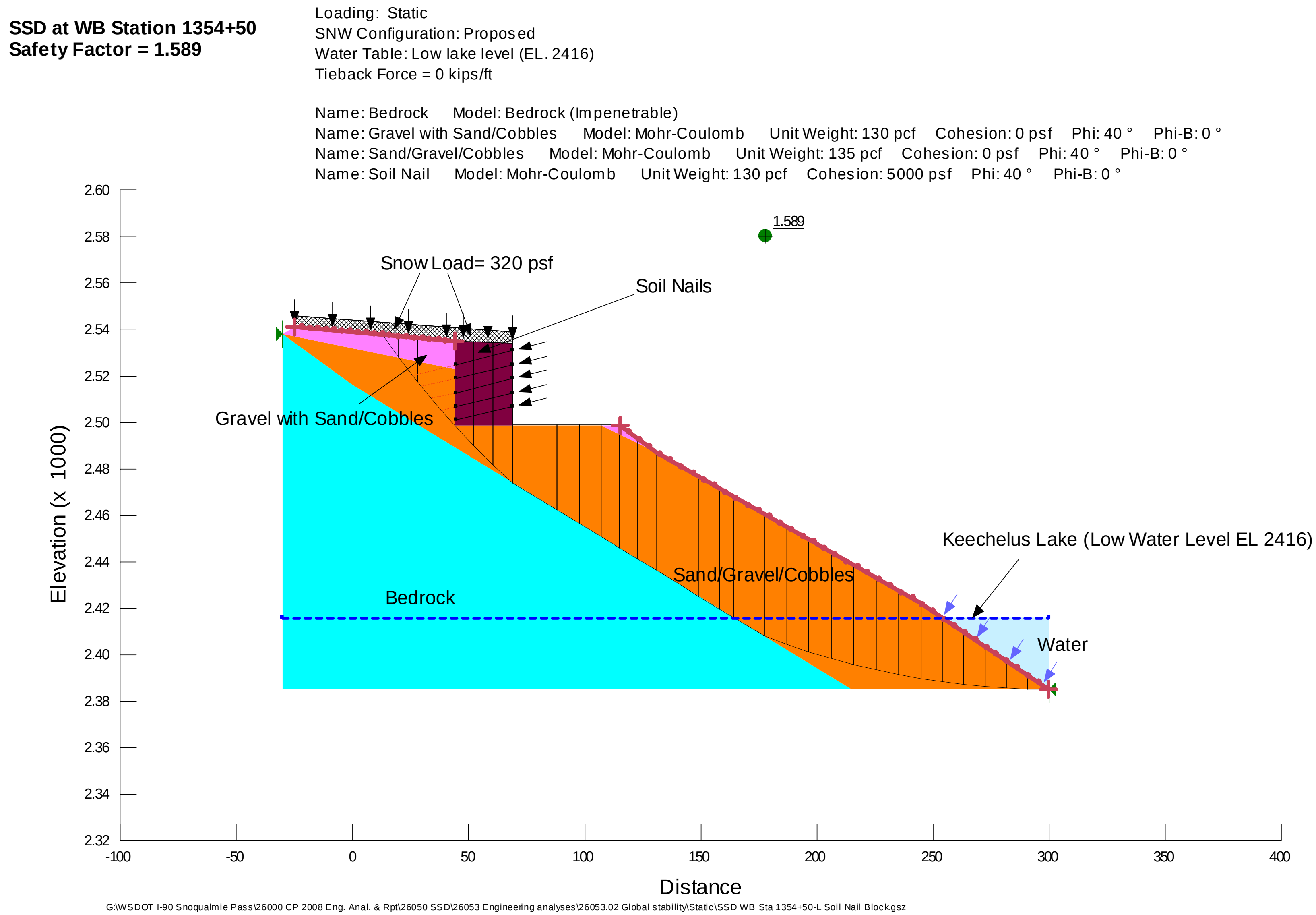


Figure H.1.2

Job No. 33758662

Global Stability – Existing, Static, Low Water, WB Sta. 1354+50

URS

I-90 Snoqualmie Pass East
Hyak to Keechelus Dam, Washington

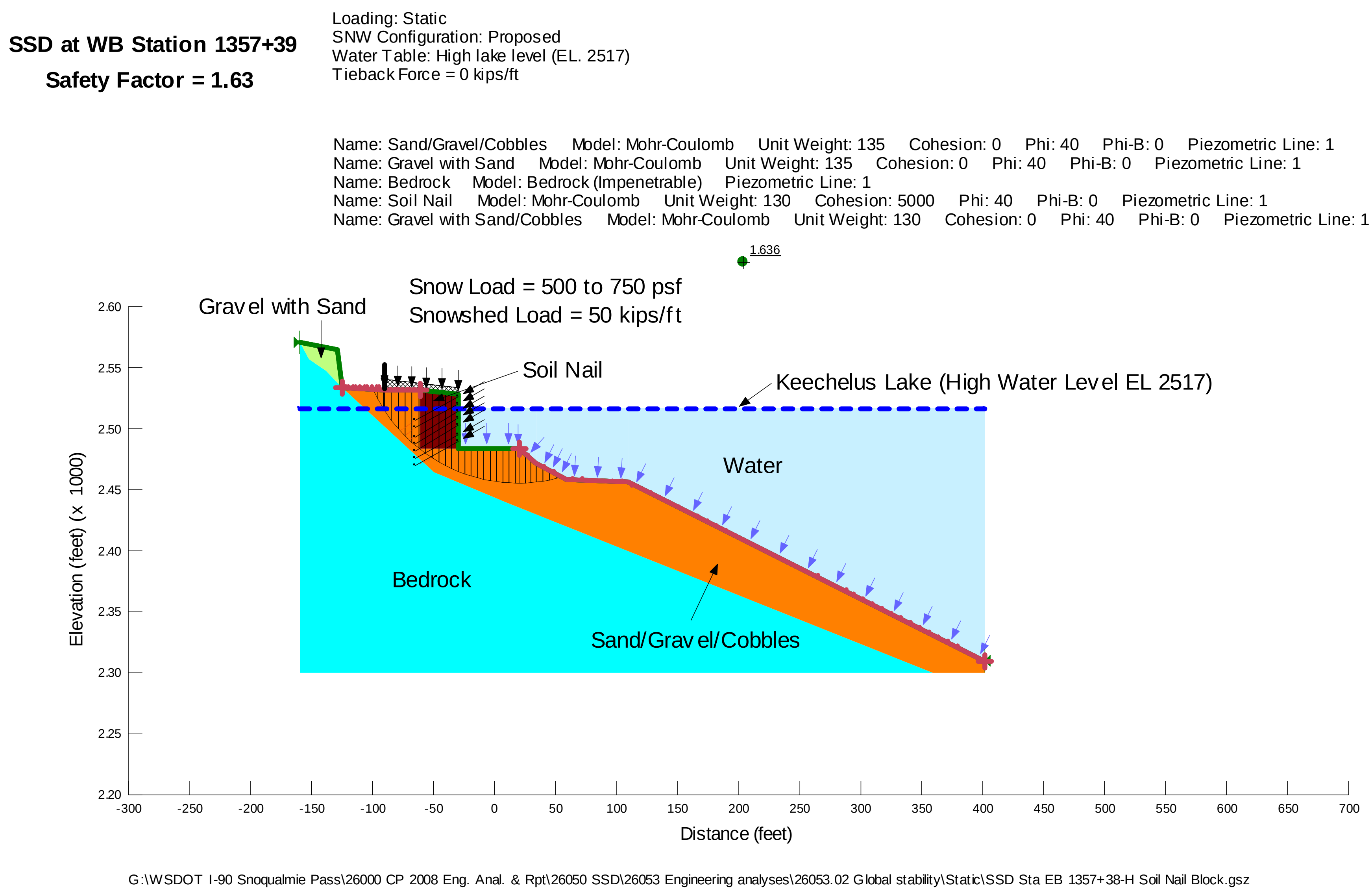


Figure H.1.3

Global Stability – Static, High Water, WB Sta. 1357+39

Job No. 33758662

URS

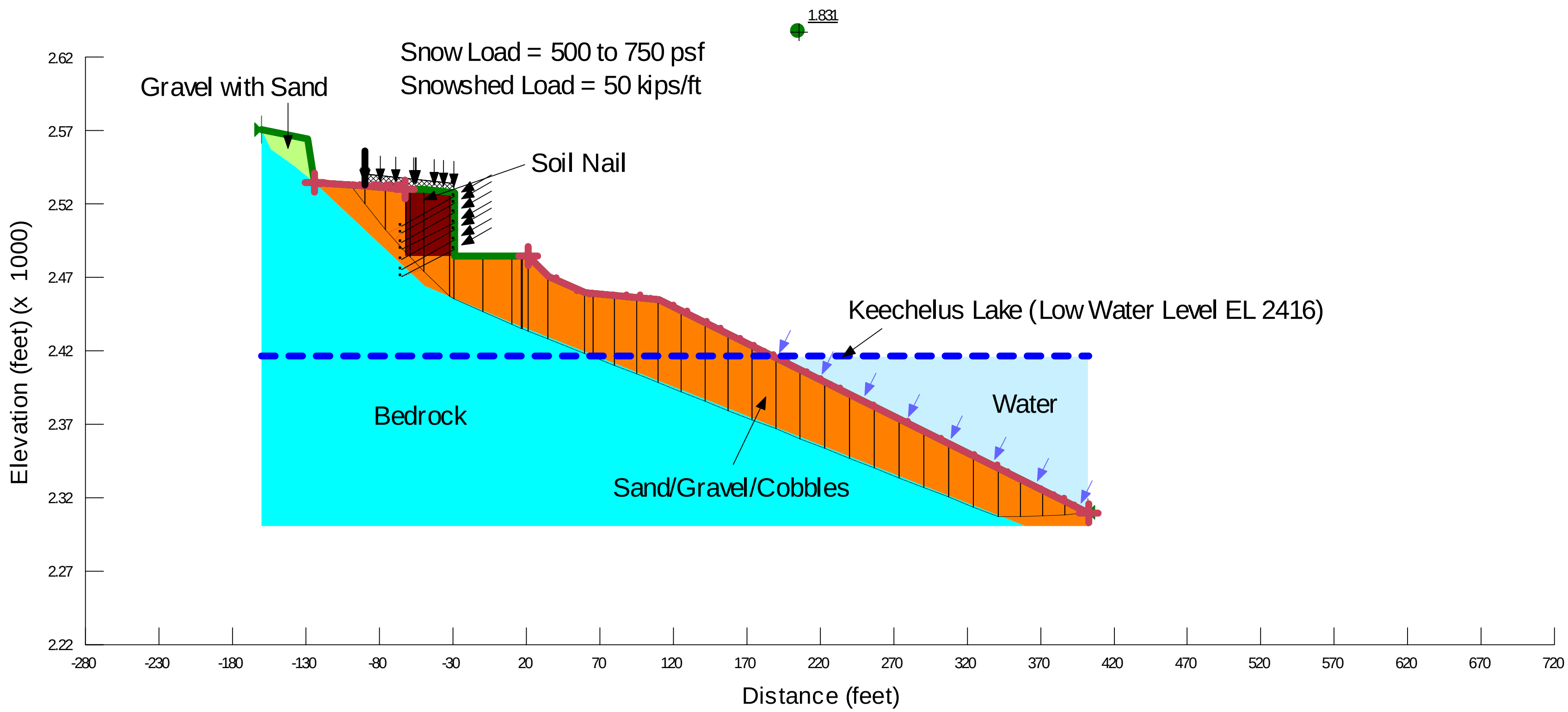
I-90 Snoqualmie Pass East
Hyak to Keechelus Dam, Washington

SSD at W B Station 1357+39

Safety Factor = 1.83

Loading: Static
SNW Configuration: Proposed
Water Table: Low lake level (EL. 2416)
Tieback Force = 0 kips/ft

Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Soil Nail Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1



G:\WSDOT I-90 Snoqualmie Pass\26000 CP 2008 Eng. Anal. & Rpt\26050 SSD\26053 Engineering analyses\26053.02 Global stability\Static\SSD Sta EB 1357+38-L Soil Nail Block.gsz

Figure H.1.4

Job No. 33758662

Global Stability – Static, Low Water, WB Sta. 1357+39

URS

I-90 Snoqualmie Pass East
Hyak to Keechelus Dam, Washington

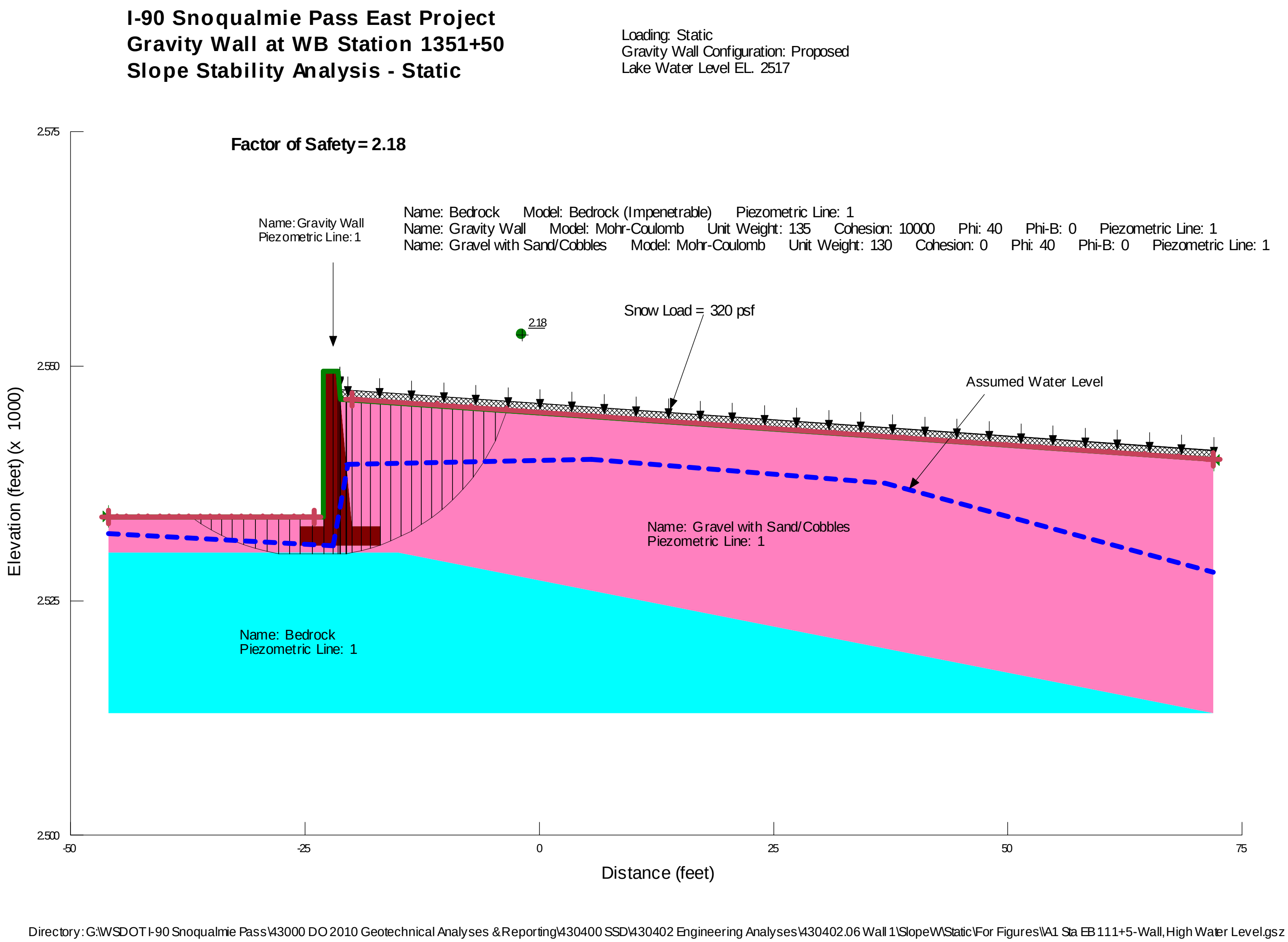


Figure H.1.5

Global Stability – Wall 1, Static Loading

Job No. 33758662

URS

I-90 Snoqualmie Pass East
Hyak to Keechelus Dam, Washington

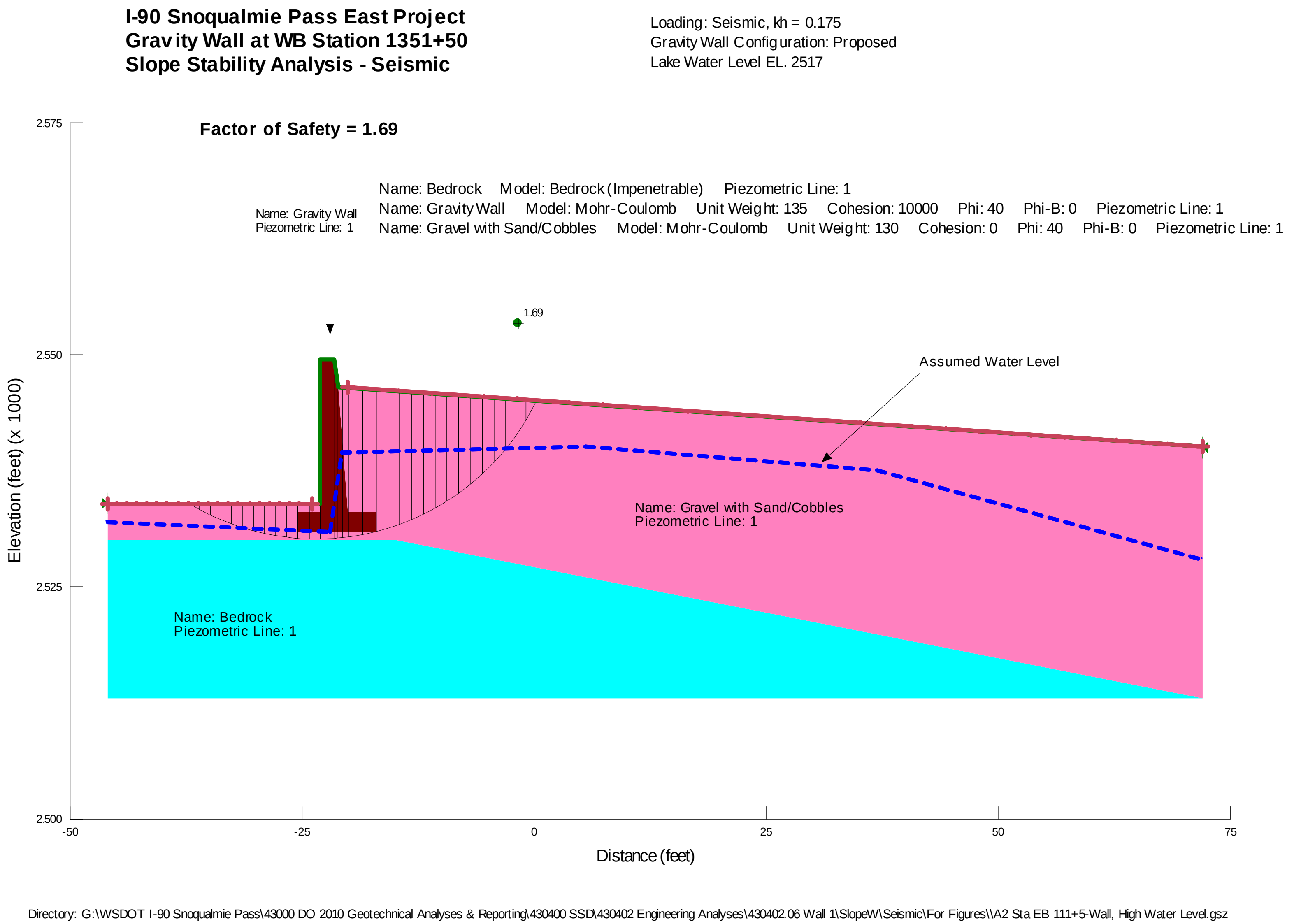


Figure H.1.6

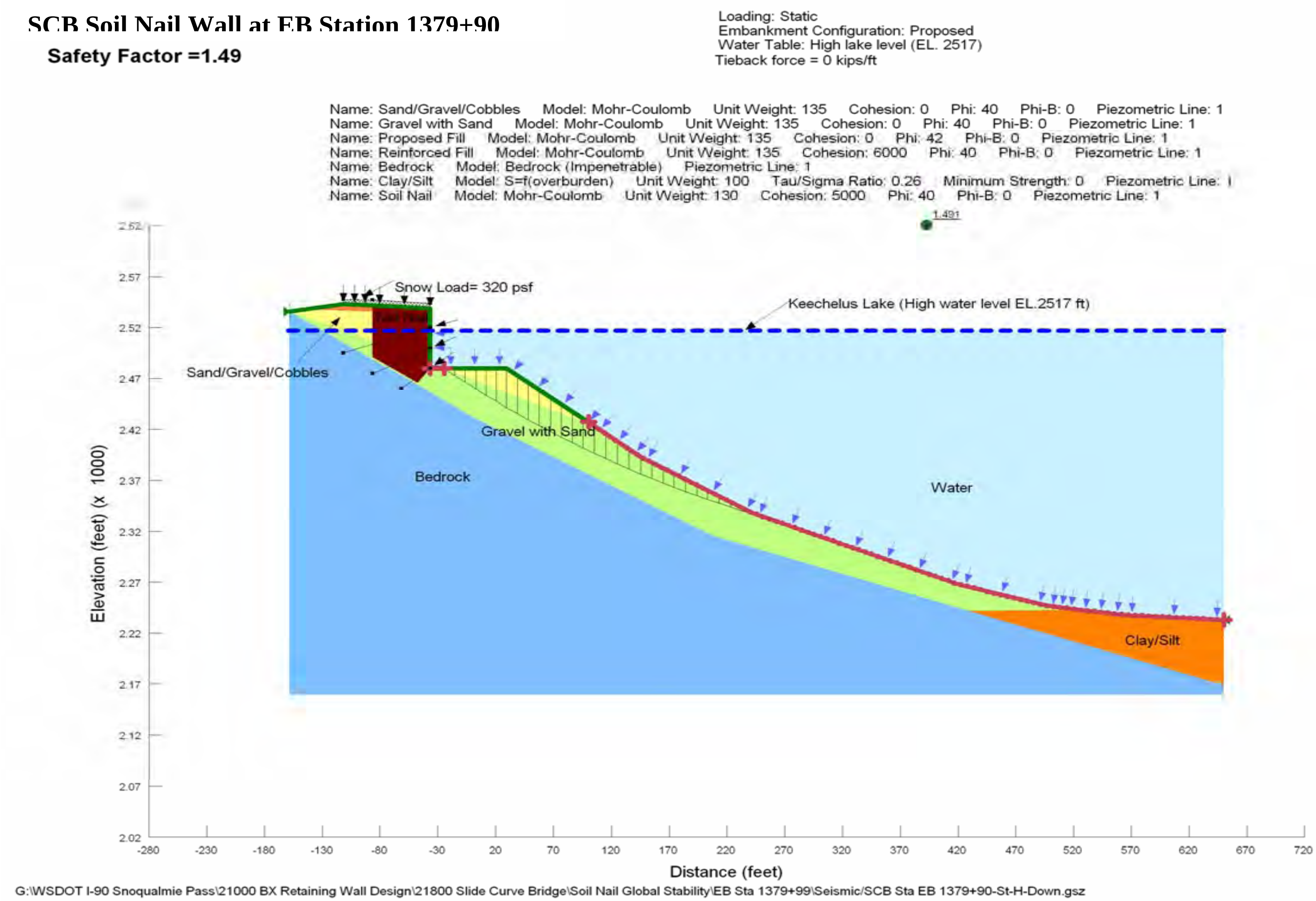
Global Stability – Wall 1, Seismic Loading

Job No. 33758662

URS

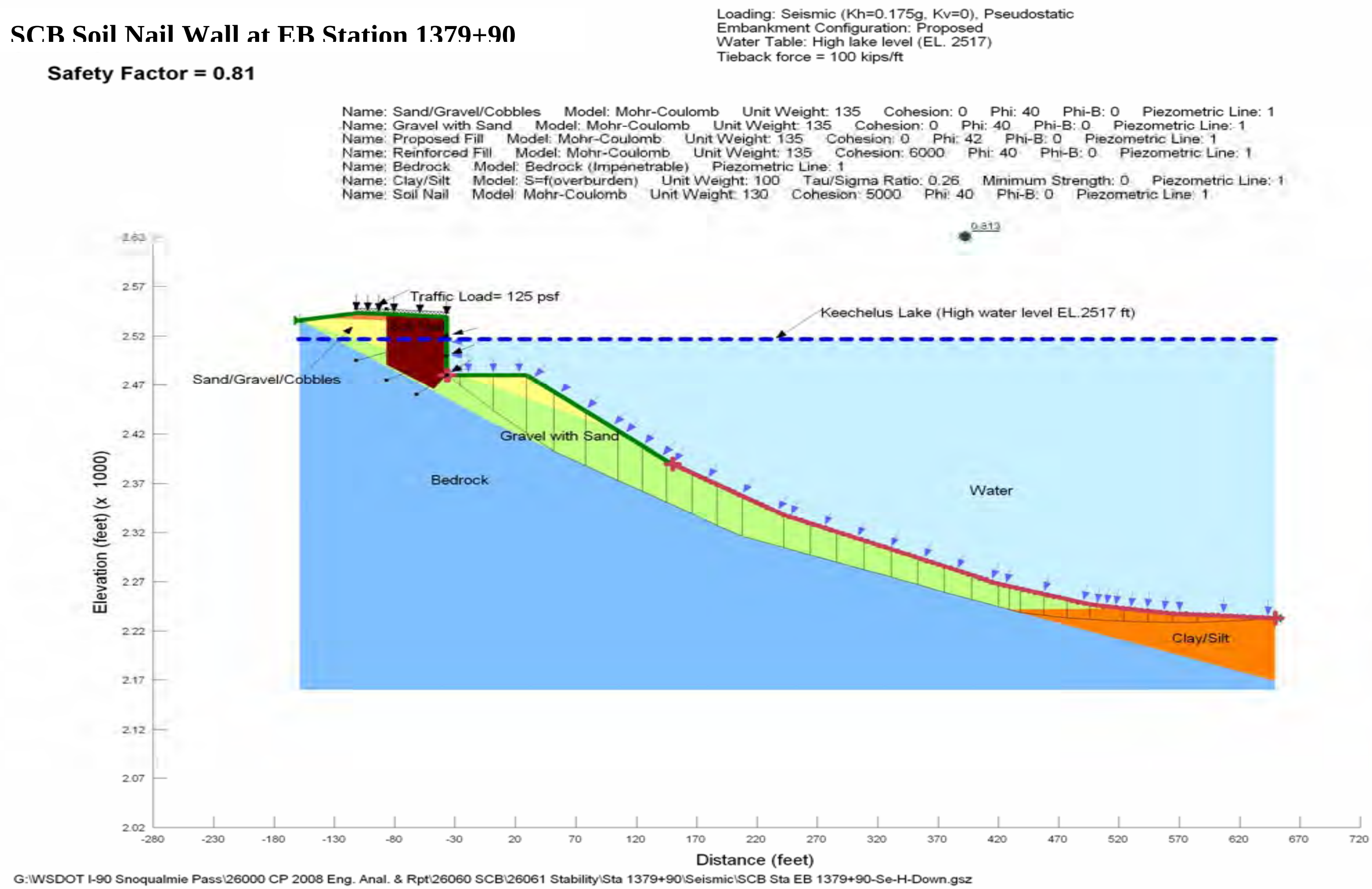
I-90 Snoqualmie Pass East
Hyak to Keechelus Dam, Washington

APPENDIX H.2
Stability Analysis Results - Slide Curve Bridge and Walls



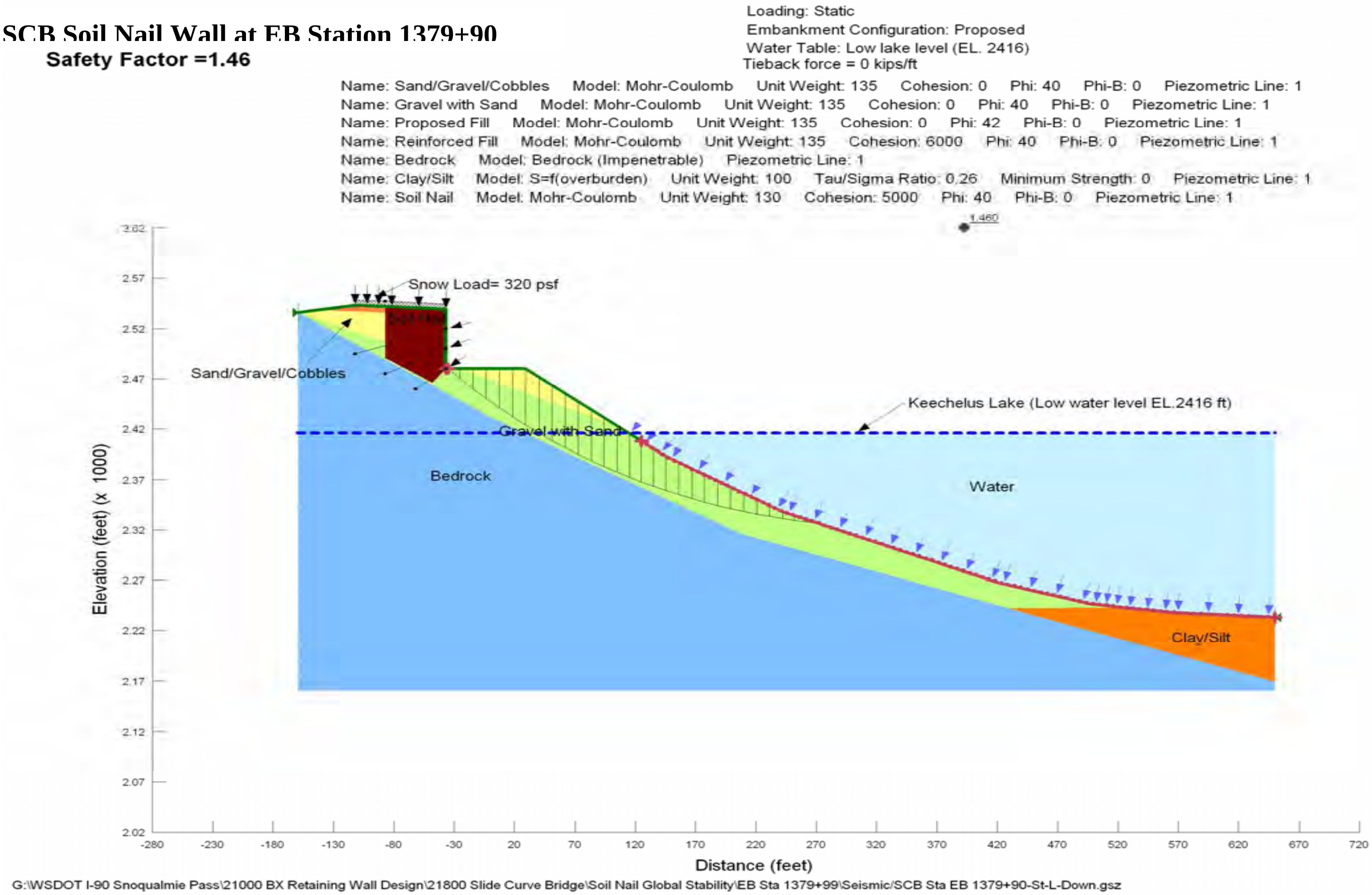
Job No. 33758662

Figure H.2.1



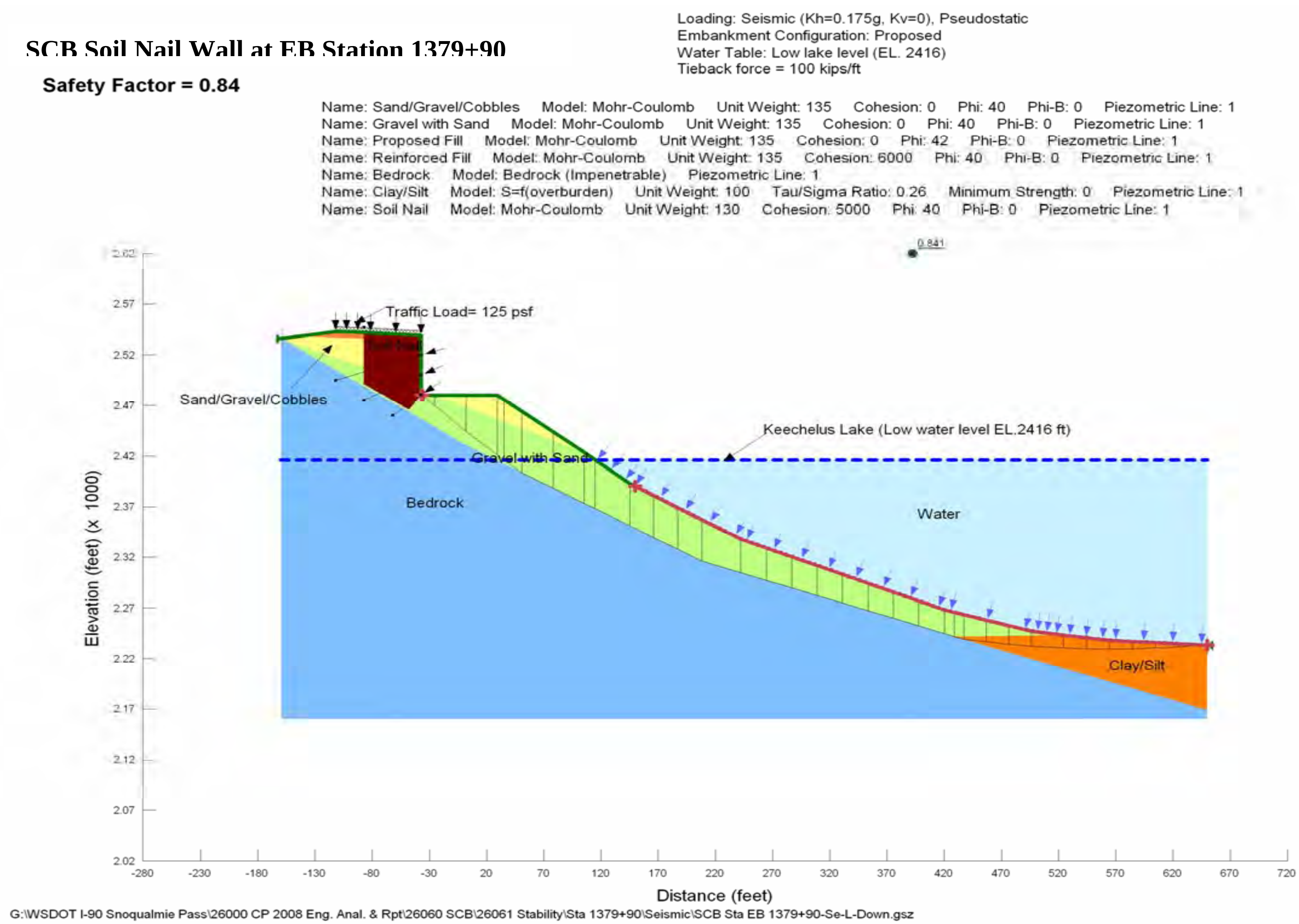
Job No. 33758662

Figure H.2.2



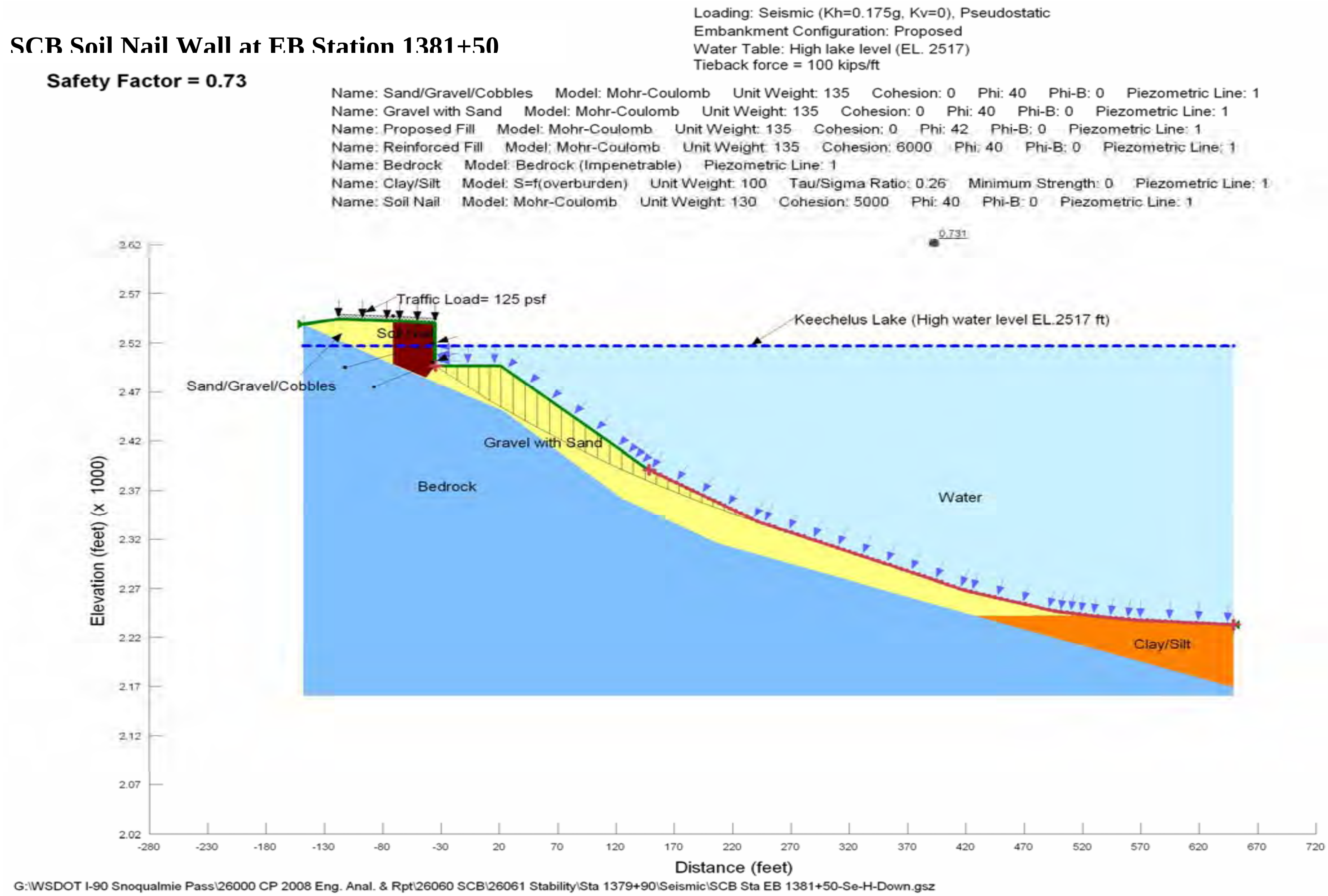
Job No. 33758662

Figure H.2.3



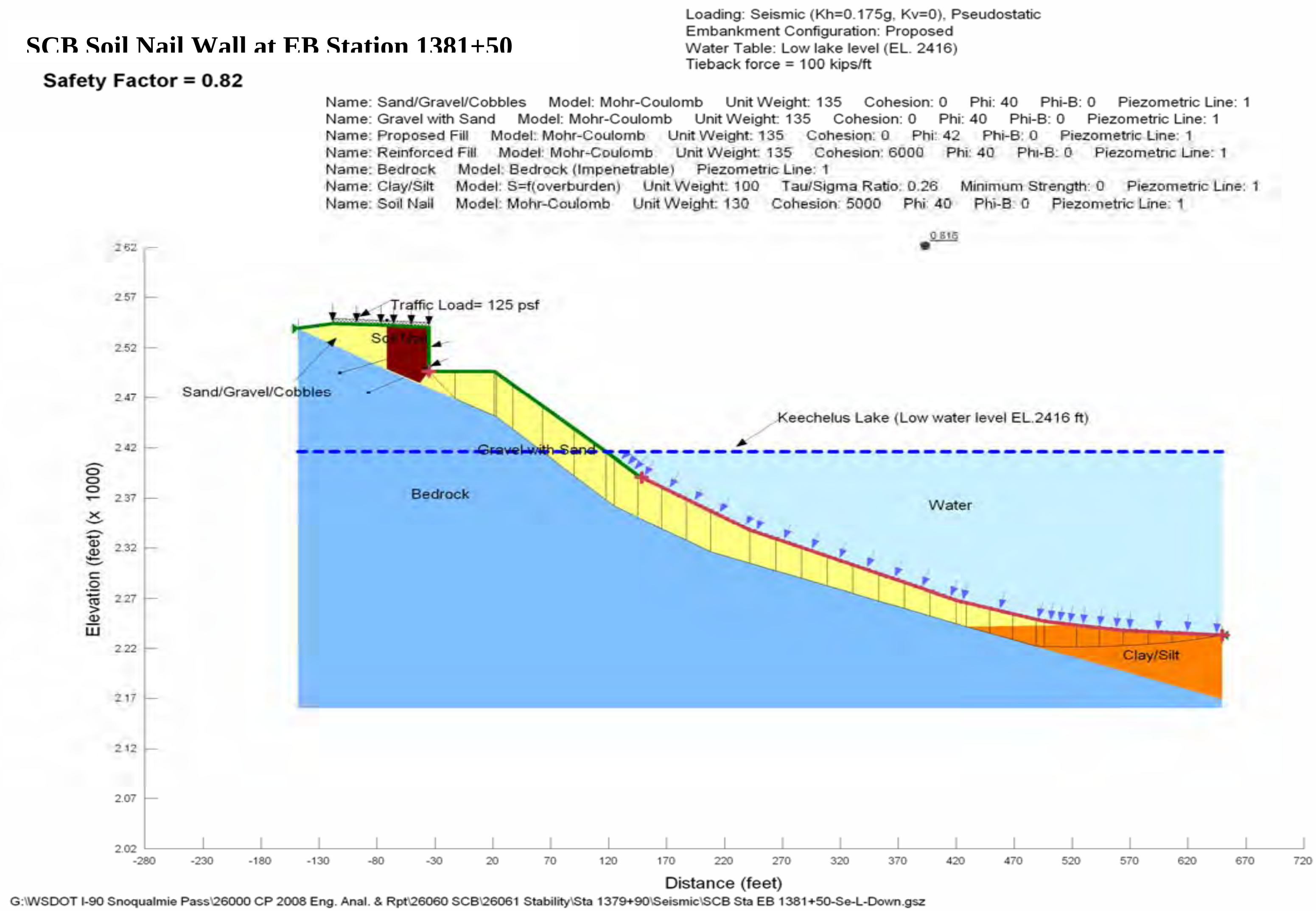
Job No. 33758662

Figure H.2.4



Job No. 33758662

Figure H.2.5



Job No. 33758662

Figure H.2.6

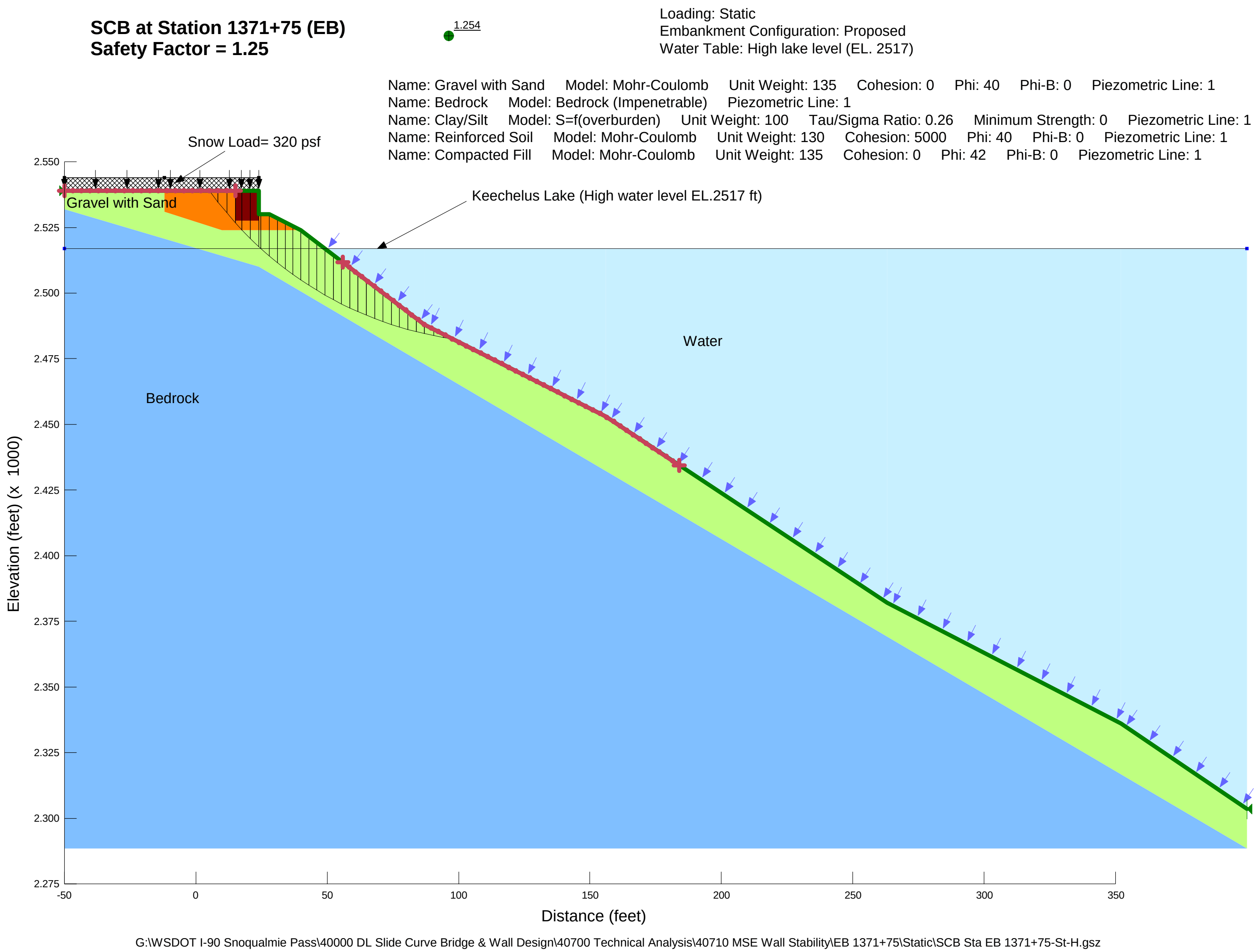
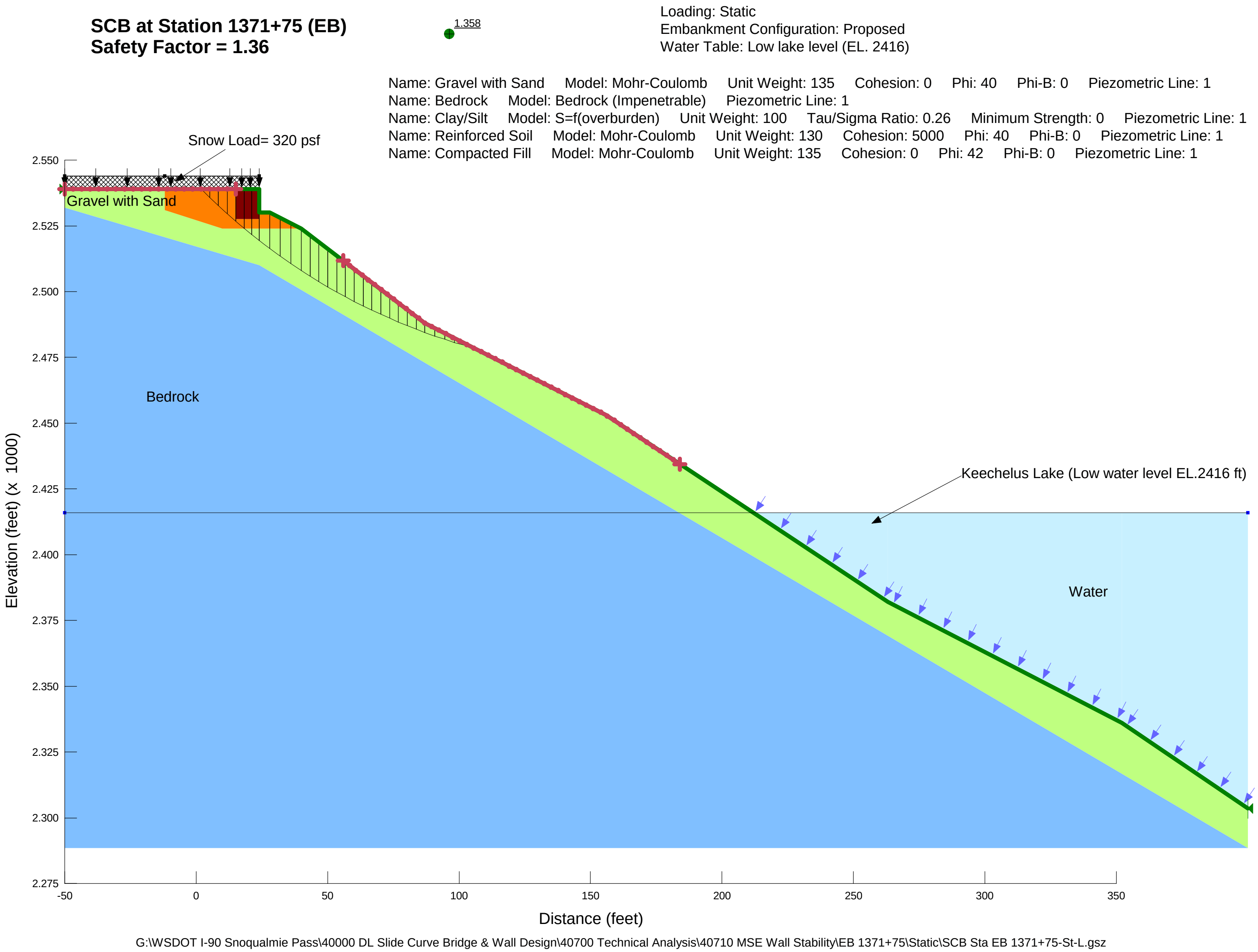

SCB at Station 1371+75 (EB)
Safety Factor = 1.25
1.254
Loading: Static
Embankment Configuration: Proposed
Water Table: High lake level (EL. 2517)
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Snow Load= 320 psf
Gravel with Sand
Keechelus Lake (High water level EL.2517 ft)
Water
Bedrock
Elevation (feet) (x 1000)
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
2.325
2.300
2.275
-50
0
50
100
150
200
250
300
350
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\40000 DL Slide Curve Bridge & Wall Design\40700 Technical Analysis\40710 MSE Wall Stability\EB 1371+75\Static\SCB Sta EB 1371+75-St-H.gsz

Figure H.2.7



SCB at Station 1371+75 (EB)
Safety Factor = 1.36
1.358
Loading: Static
Embankment Configuration: Proposed
Water Table: Low lake level (EL. 2416)
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Snow Load= 320 psf
Gravel with Sand
Bedrock
Keechelus Lake (Low water level EL.2416 ft)
Water
Elevation (feet) (x 1000)
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
2.325
2.300
2.275
-50
0
50
100
150
200
250
300
350
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\40000 DL Slide Curve Bridge & Wall Design\40700 Technical Analysis\40710 MSE Wall Stability\EB 1371+75\Static\SCB Sta EB 1371+75-St-L.gsz

Figure H.2.8

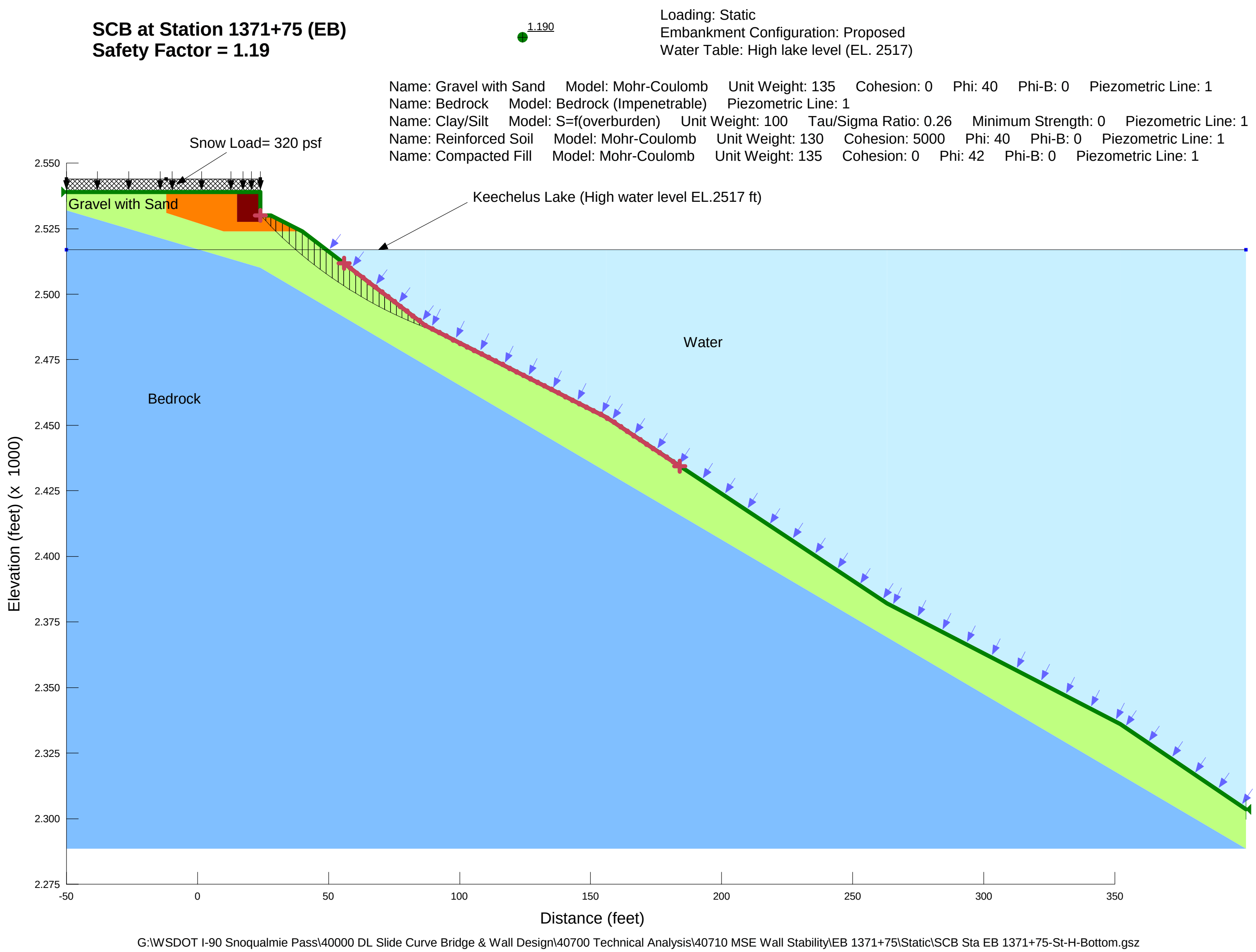
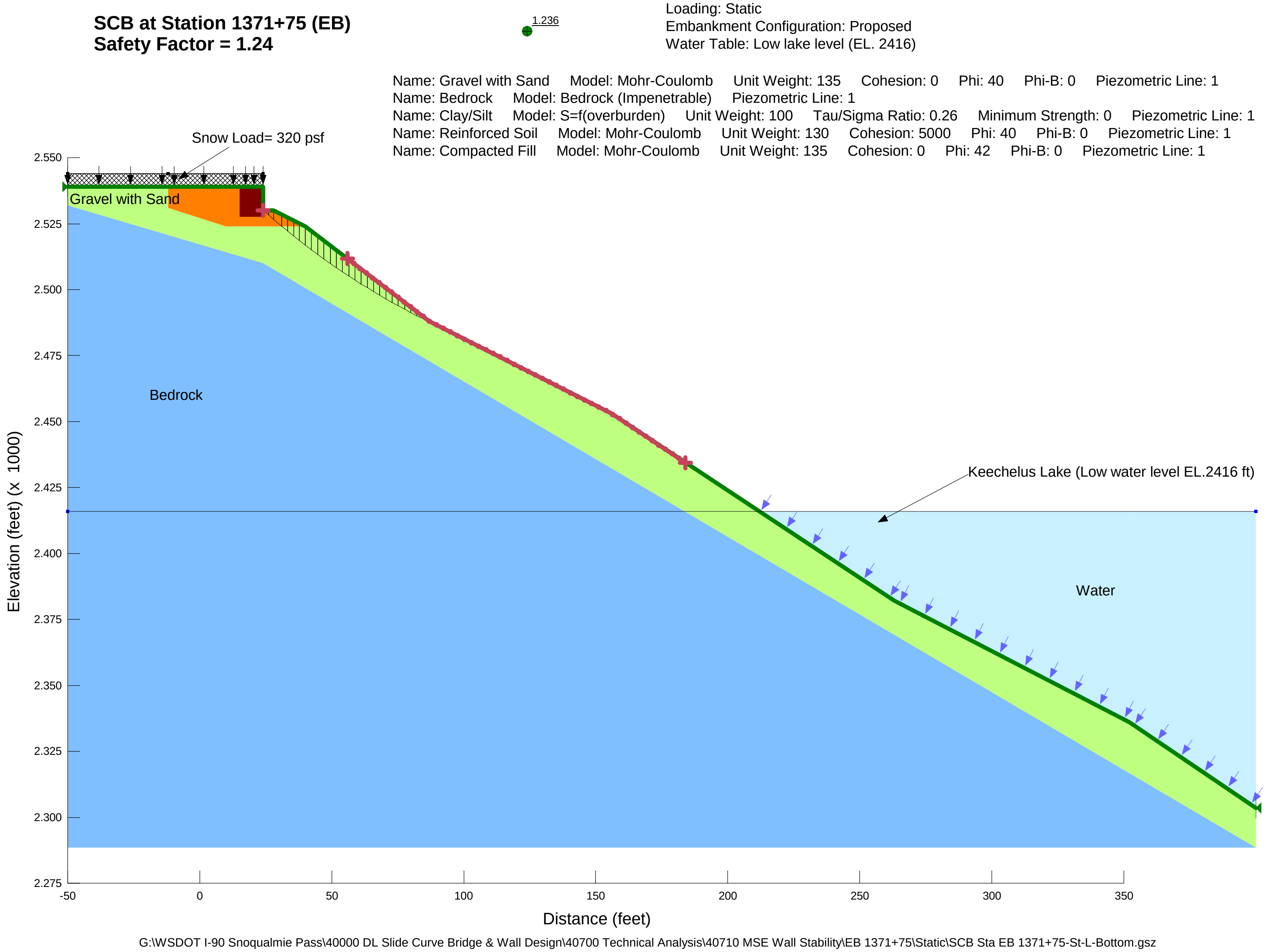

SCB at Station 1371+75 (EB)
Safety Factor = 1.19
1.190
Loading: Static
Embankment Configuration: Proposed
Water Table: High lake level (EL. 2517)
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Snow Load= 320 psf
Keechelus Lake (High water level EL.2517 ft)
Gravel with Sand
Water
Bedrock
Elevation (feet) (x 1000)
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
2.325
2.300
2.275
-50
0
50
100
150
200
250
300
350
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\40000 DL Slide Curve Bridge & Wall Design\40700 Technical Analysis\40710 MSE Wall Stability\EB 1371+75\Static\SCB Sta EB 1371+75-St-H-Bottom.gsz

Figure H.2.9



SCB at Station 1371+75 (EB)
Safety Factor = 1.24
1.236
Loading: Static
Embankment Configuration: Proposed
Water Table: Low lake level (EL. 2416)
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Snow Load= 320 psf
Gravel with Sand
Bedrock
Keechelus Lake (Low water level EL.2416 ft)
Water
Elevation (feet) (x 1000)
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
2.325
2.300
2.275
-50
0
50
100
150
200
250
300
350
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\40000 DL Slide Curve Bridge & Wall Design\40700 Technical Analysis\40710 MSE Wall Stability\EB 1371+75\Static\SCB Sta EB 1371+75-St-L-Bottom.gsz

Figure H.2.10

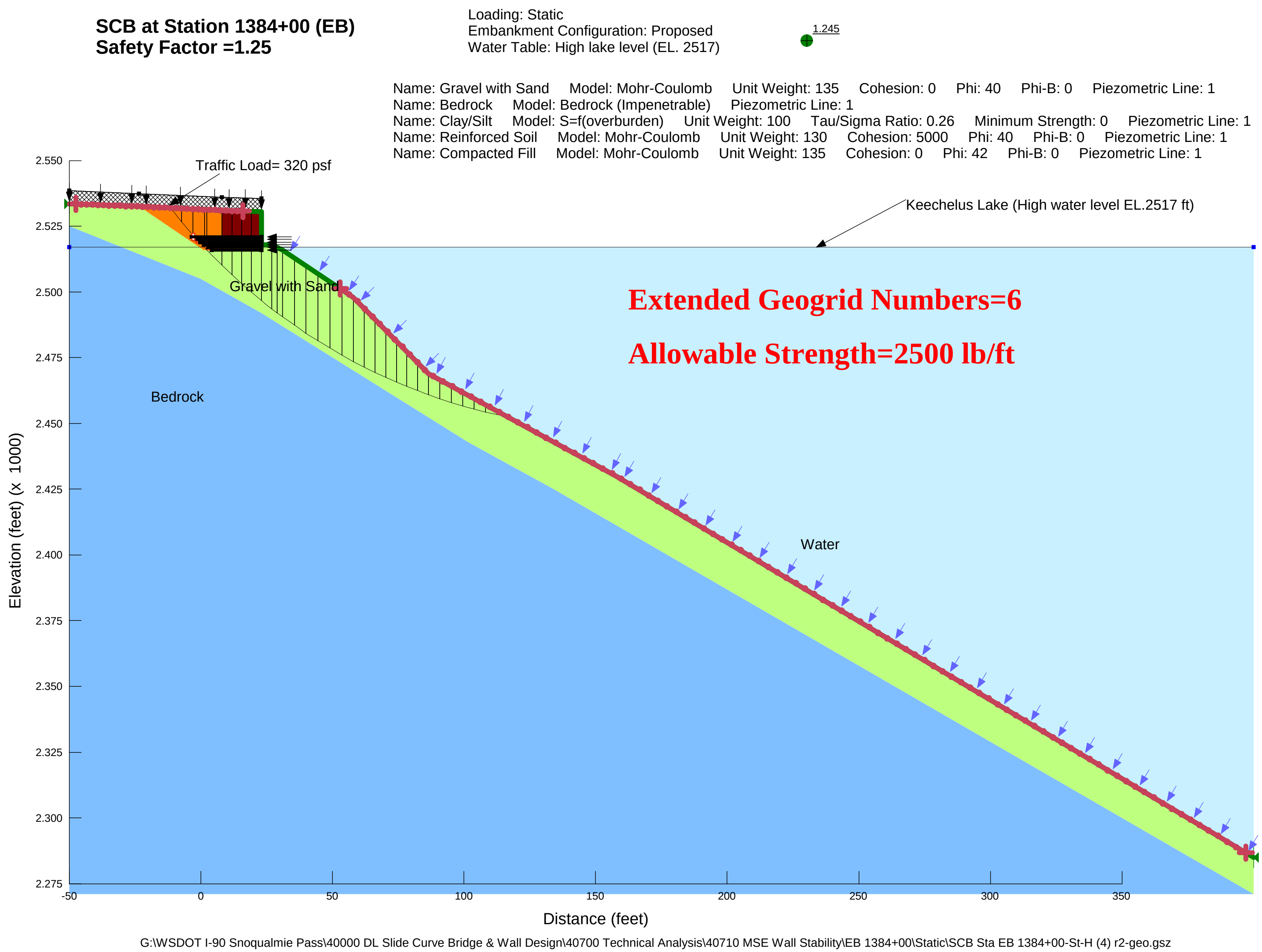
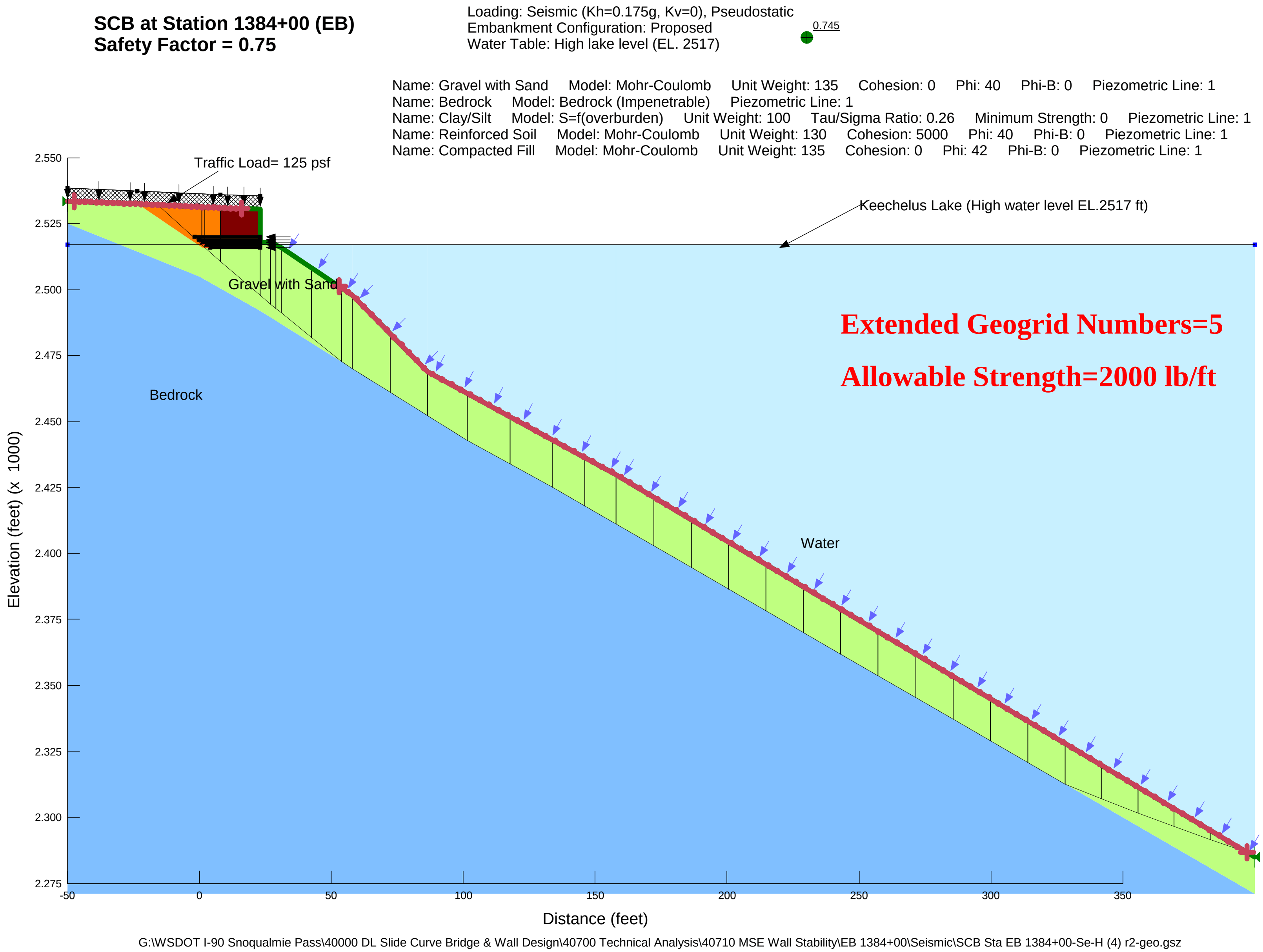
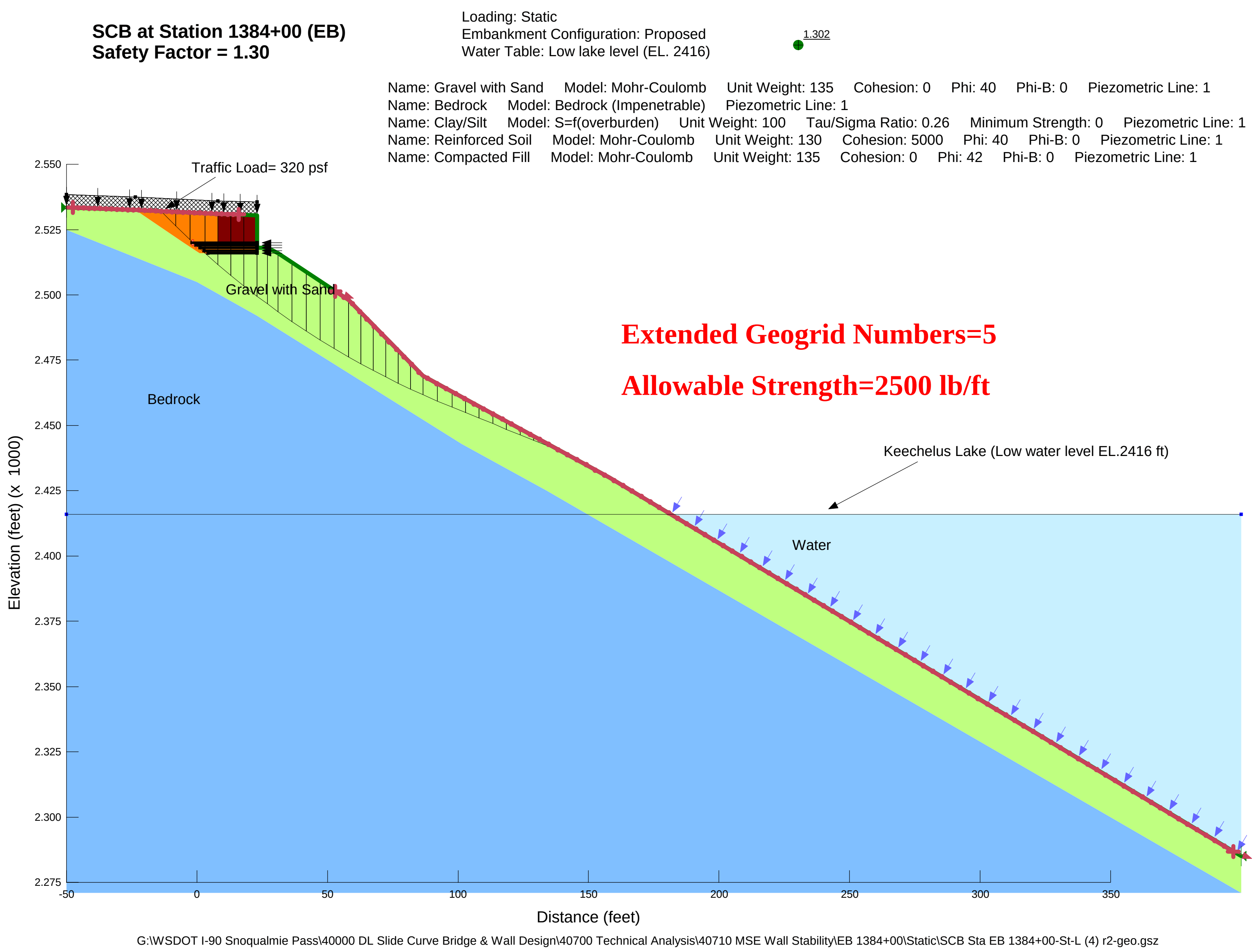

SCB at Station 1384+00 (EB)
Safety Factor =1.25
Loading: Static
Embankment Configuration: Proposed
Water Table: High lake level (EL. 2517)
1.245
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Traffic Load= 320 psf
Keechelus Lake (High water level EL.2517 ft)
Extended Geogrid Numbers=6
Allowable Strength=2500 lb/ft
Gravel with Sand
Bedrock
Water
Elevation (feet) (x 1000)
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
2.325
2.300
2.275
-50
0
50
100
150
200
250
300
350
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\40000 DL Slide Curve Bridge & Wall Design\40700 Technical Analysis\40710 MSE Wall Stability\EB 1384+00\Static\SCB Sta EB 1384+00-St-H (4) r2-geo.gsz

Figure H.2.11



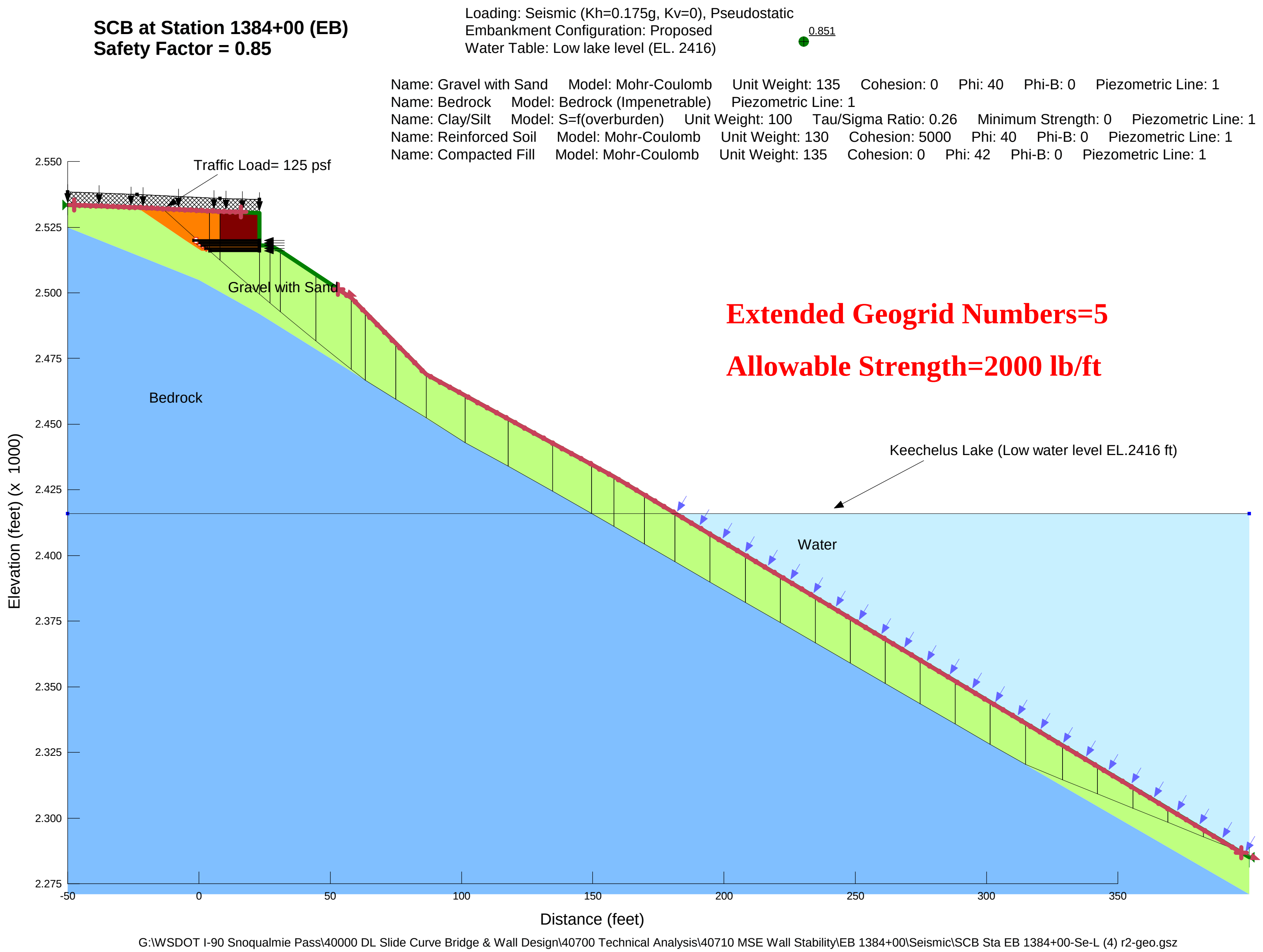
SCB

Figure H.2.12



SCB

Figure H.2.13



SCB

Figure H.2.14

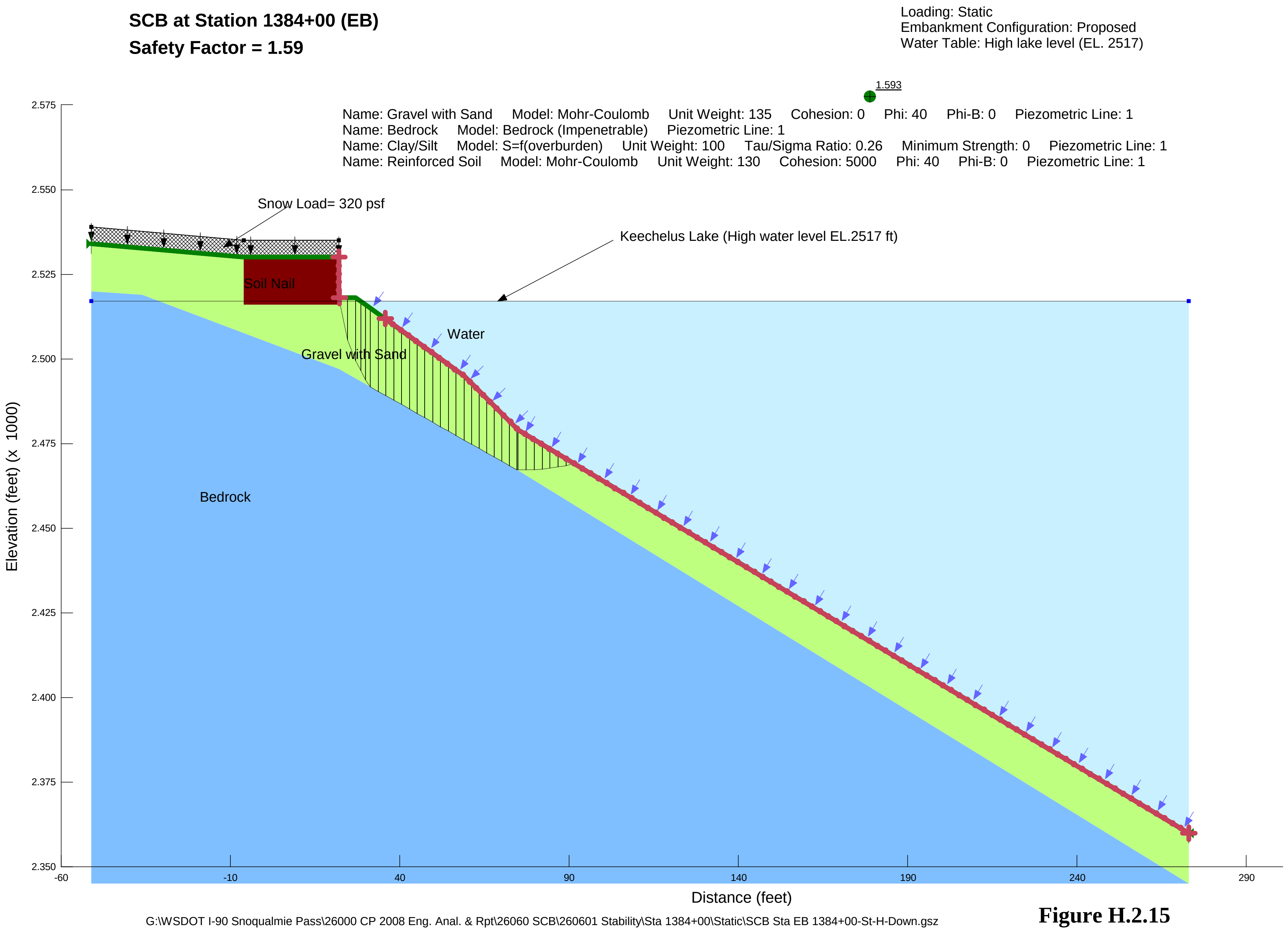
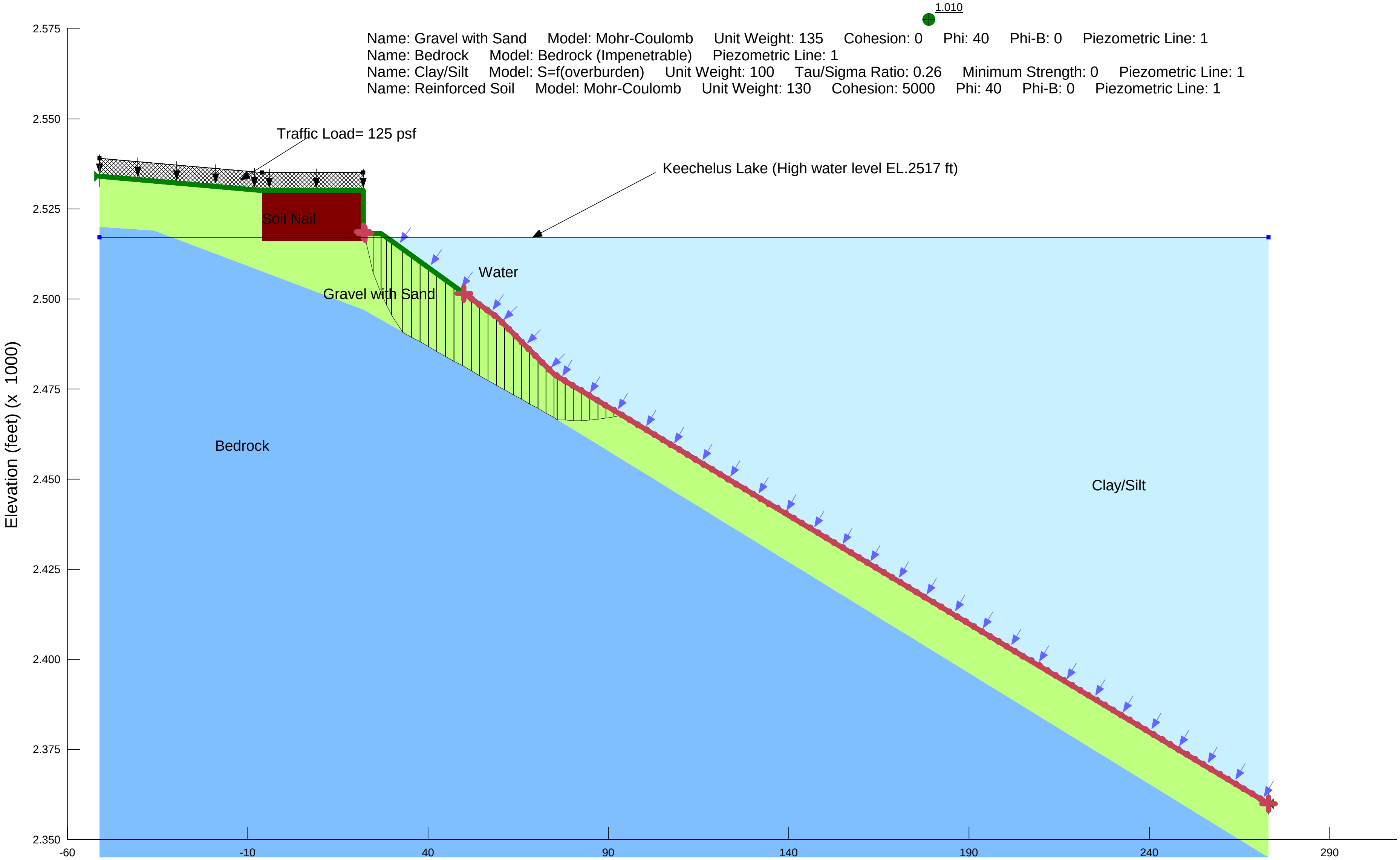

SCB at Station 1384+00 (EB)
Safety Factor = 1.59
Loading: Static
Embankment Configuration: Proposed
Water Table: High lake level (EL. 2517)
1.593
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Snow Load= 320 psf
Keechelus Lake (High water level EL.2517 ft)
Soil Nail
Water
Gravel with Sand
Bedrock
Elevation (feet) (x 1000)
2.575
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
-60
-10
40
90
140
190
240
290
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\26000 CP 2008 Eng. Anal. & Rpt\26060 SCB\260601 Stability\Sta 1384+00\Static\SCB Sta EB 1384+00-St-H-Down.gsz

Figure H.2.15

SCB at Station 1384+00 (EB)

Safety Factor = 1.0

Loading: Seismic (Kh=0.175g, Kv=0), Pseudostatic
Embankment Configuration: Proposed
Water Table: High lake level (EL. 2517)



G:\WSDOT I-90 Snoqualmie Pass\26000 CP 2008 Eng. Anal. & Rpt\26060 SCB\260601 Stability\Sta 1384+00\Seismic\SCB Sta EB 1384+00-Se-H-Down.gsz

Figure H.2.16

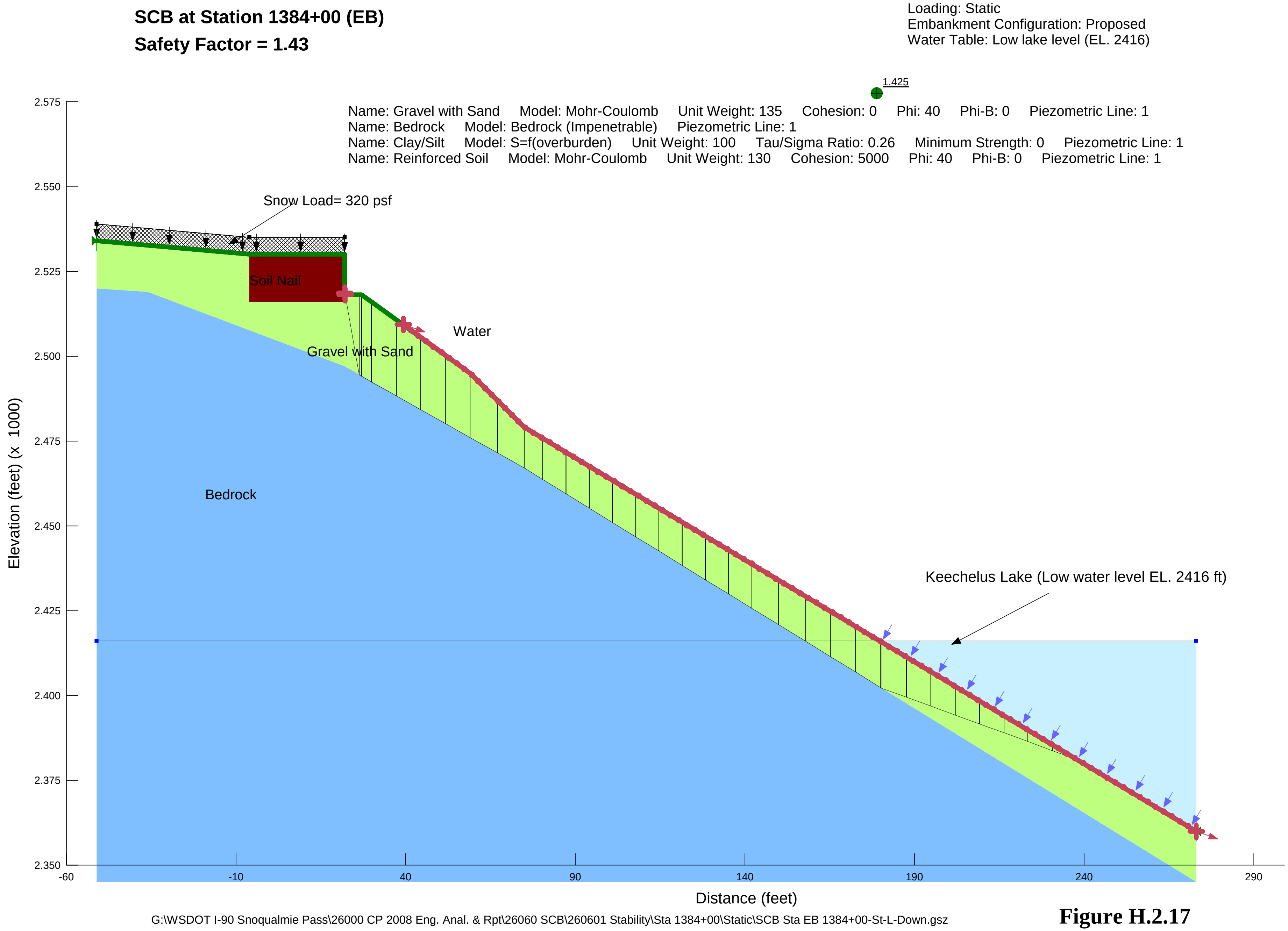
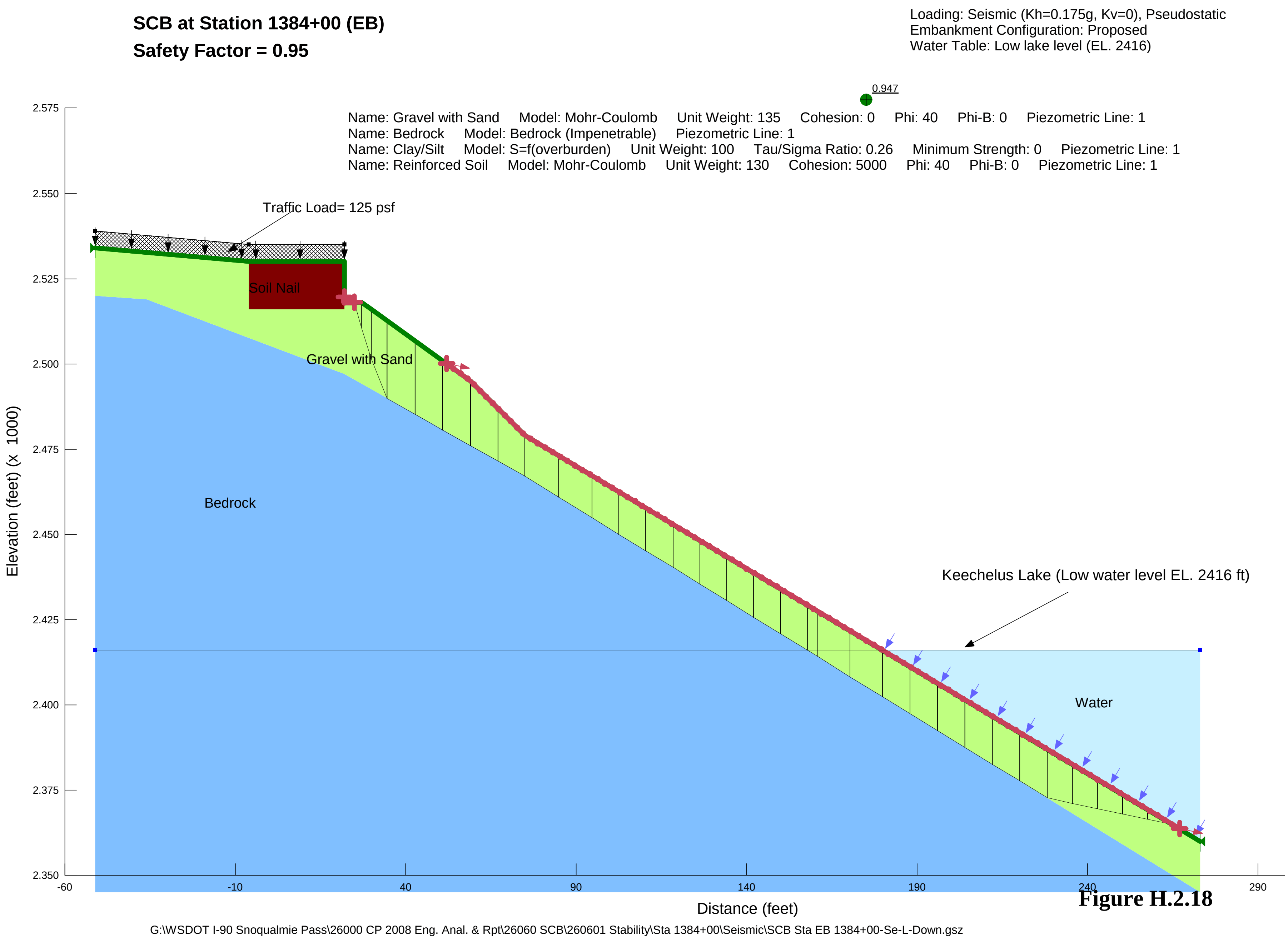
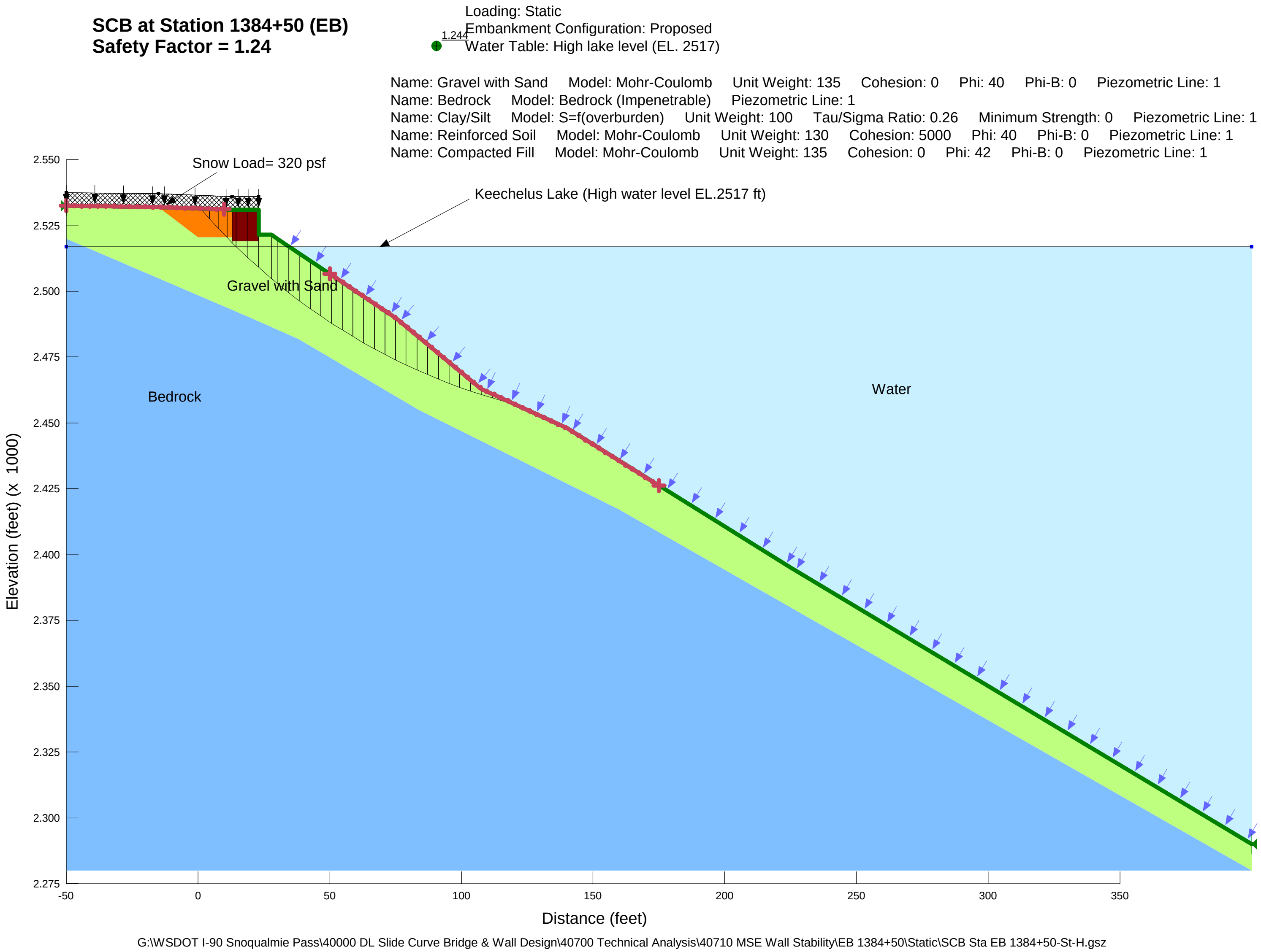

SCB at Station 1384+00 (EB)
Safety Factor = 1.43
Loading: Static
Embankment Configuration: Proposed
Water Table: Low lake level (EL. 2416)
1.425
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Snow Load= 320 psf
Soil Nail
Water
Gravel with Sand
Bedrock
Keechelus Lake (Low water level EL. 2416 ft)
Elevation (feet) (x 1000)
2.575
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
-60
-10
40
90
140
190
240
290
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\26000 CP 2008 Eng. Anal. & Rpt\26060 SCB\260601 Stability\Sta 1384+00\Static\SCB Sta EB 1384+00-St-L-Down.gsz

Figure H.2.17



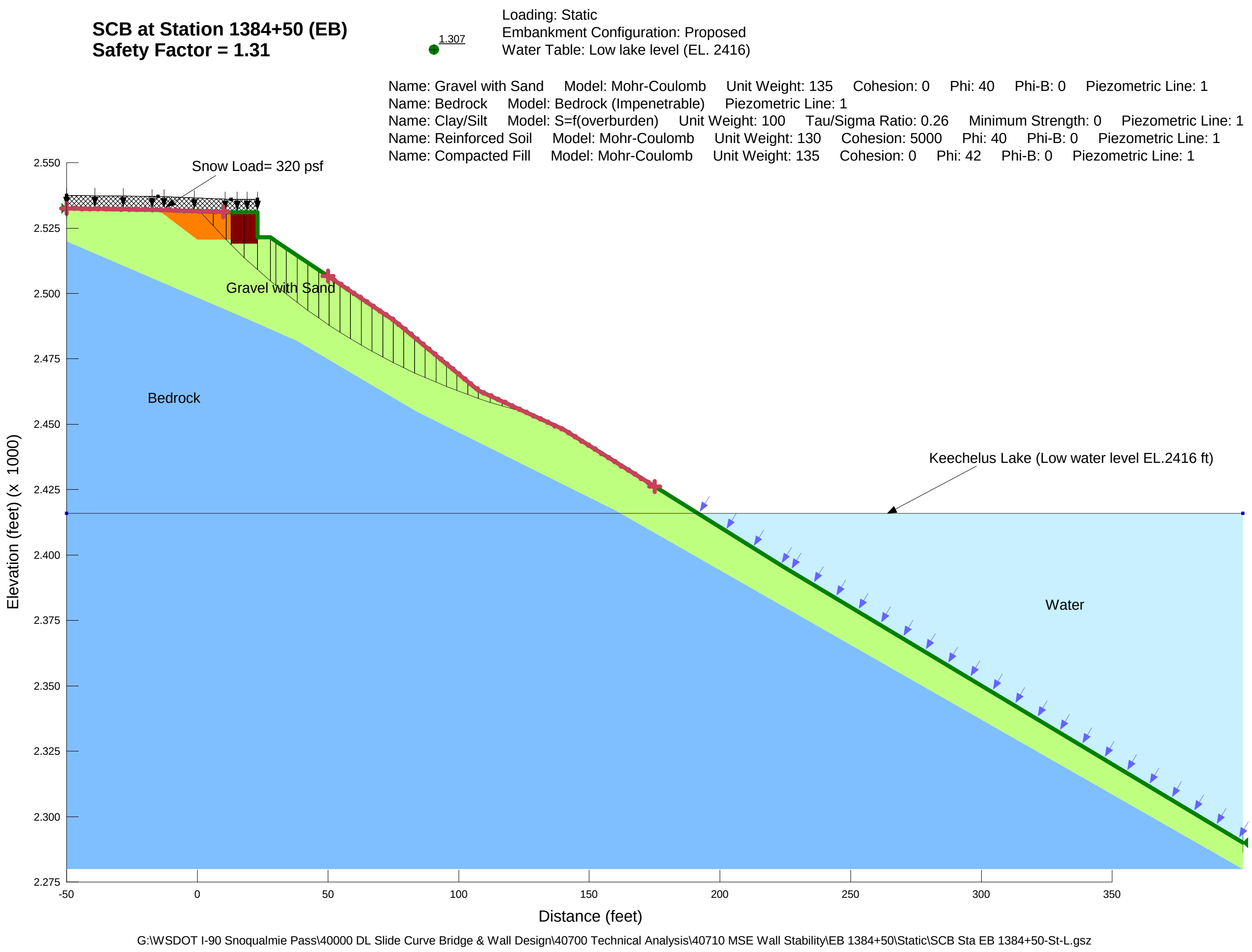
SCB at Station 1384+00 (EB)
Safety Factor = 0.95
Loading: Seismic (Kh=0.175g, Kv=0), Pseudostatic
Embankment Configuration: Proposed
Water Table: Low lake level (EL. 2416)
0.947
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Traffic Load= 125 psf
Soil Nail
Gravel with Sand
Bedrock
Keechelus Lake (Low water level EL. 2416 ft)
Water
Elevation (feet) (x 1000)
2.575
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
-60
-10
40
90
140
190
240
290
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\26000 CP 2008 Eng. Anal. & Rpt\26060 SCB\260601 Stability\Sta 1384+00\Seismic\SCB Sta EB 1384+00-Se-L-Down.gsz

Figure H.2.18



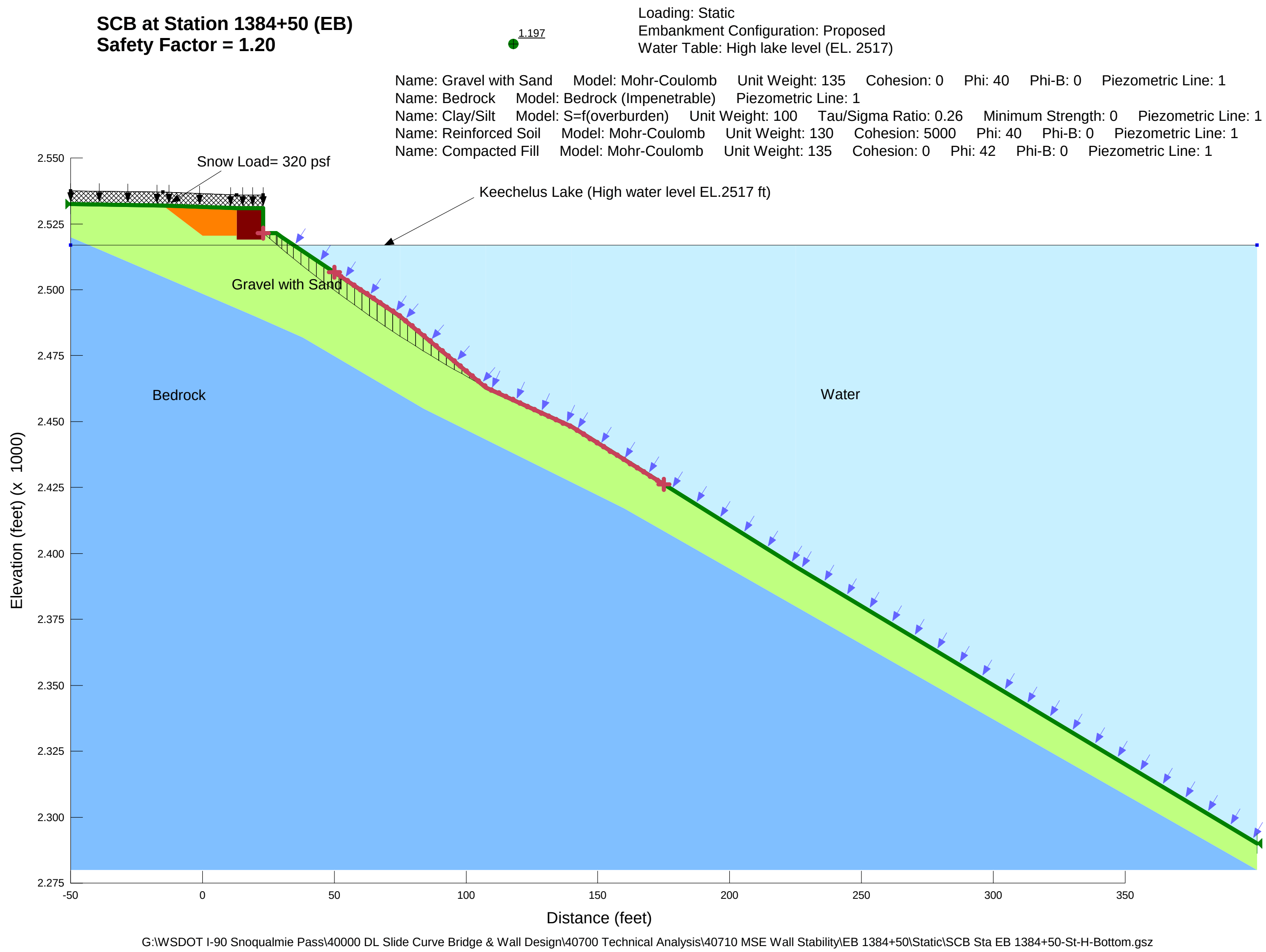
SCB at Station 1384+50 (EB)
Safety Factor = 1.24
Loading: Static
Embankment Configuration: Proposed
Water Table: High lake level (EL. 2517)
1.244
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Snow Load= 320 psf
Keechelus Lake (High water level EL.2517 ft)
Gravel with Sand
Bedrock
Water
Elevation (feet) (x 1000)
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
2.325
2.300
2.275
-50
0
50
100
150
200
250
300
350
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\40000 DL Slide Curve Bridge & Wall Design\40700 Technical Analysis\40710 MSE Wall Stability\EB 1384+50\Static\SCB Sta EB 1384+50-St-H.gsz

Figure H.2.19



SCB at Station 1384+50 (EB)
Safety Factor = 1.31
1.307
Loading: Static
Embankment Configuration: Proposed
Water Table: Low lake level (EL. 2416)
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Snow Load= 320 psf
Gravel with Sand
Bedrock
Keechelus Lake (Low water level EL.2416 ft)
Water
Elevation (feet) (x 1000)
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
2.325
2.300
2.275
-50
0
50
100
150
200
250
300
350
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\40000 DL Slide Curve Bridge & Wall Design\40700 Technical Analysis\40710 MSE Wall Stability\EB 1384+50\Static\SCB Sta EB 1384+50-St-L.gsz

Figure H.2.20



SCB at Station 1384+50 (EB)
Safety Factor = 1.20
1.197
Loading: Static
Embankment Configuration: Proposed
Water Table: High lake level (EL. 2517)
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Snow Load= 320 psf
Keechelus Lake (High water level EL.2517 ft)
Gravel with Sand
Bedrock
Water
Elevation (feet) (x 1000)
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
2.325
2.300
2.275
-50
0
50
100
150
200
250
300
350
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\40000 DL Slide Curve Bridge & Wall Design\40700 Technical Analysis\40710 MSE Wall Stability\EB 1384+50\Static\SCB Sta EB 1384+50-St-H-Bottom.gsz

Figure H.2.21

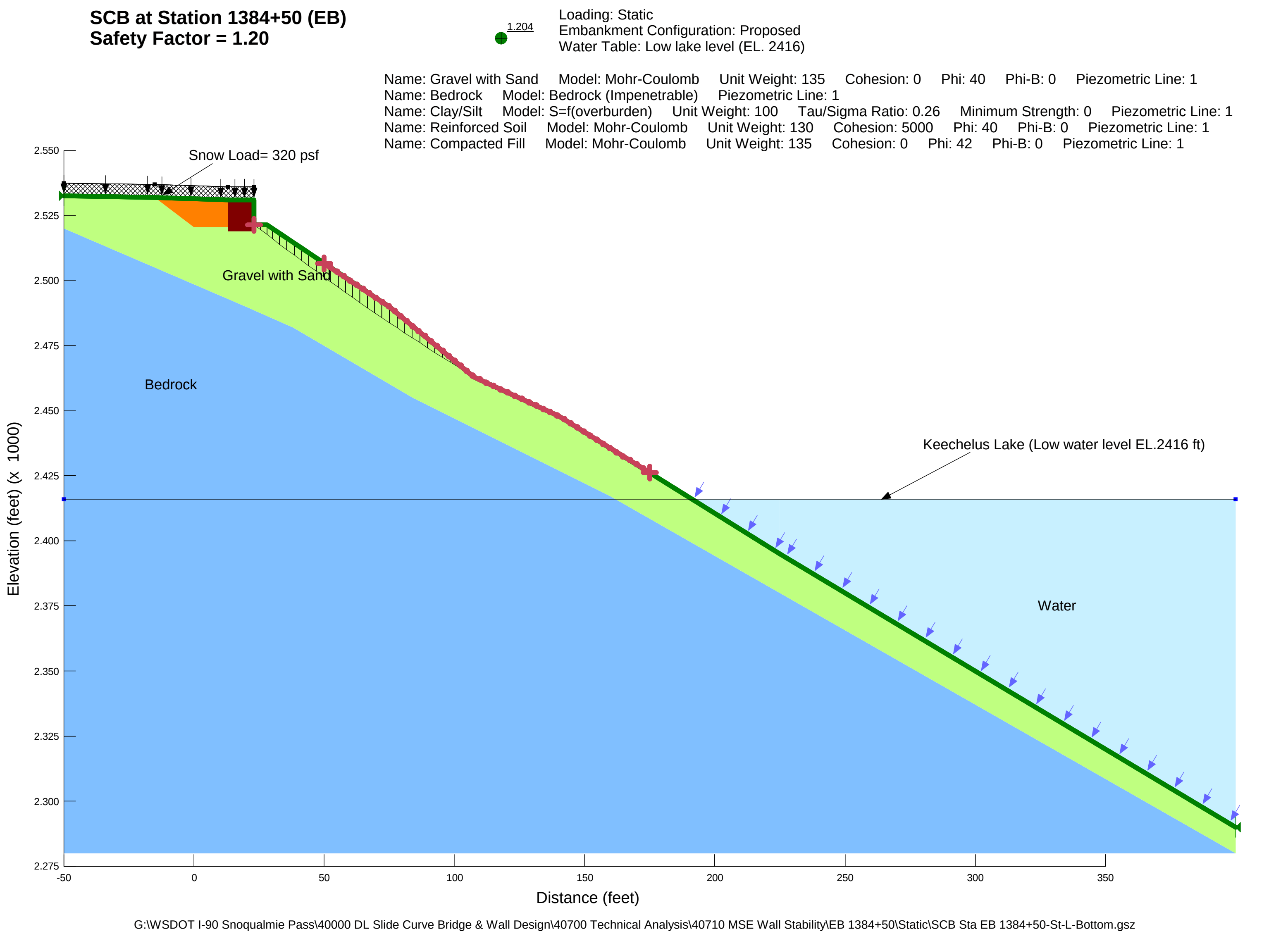
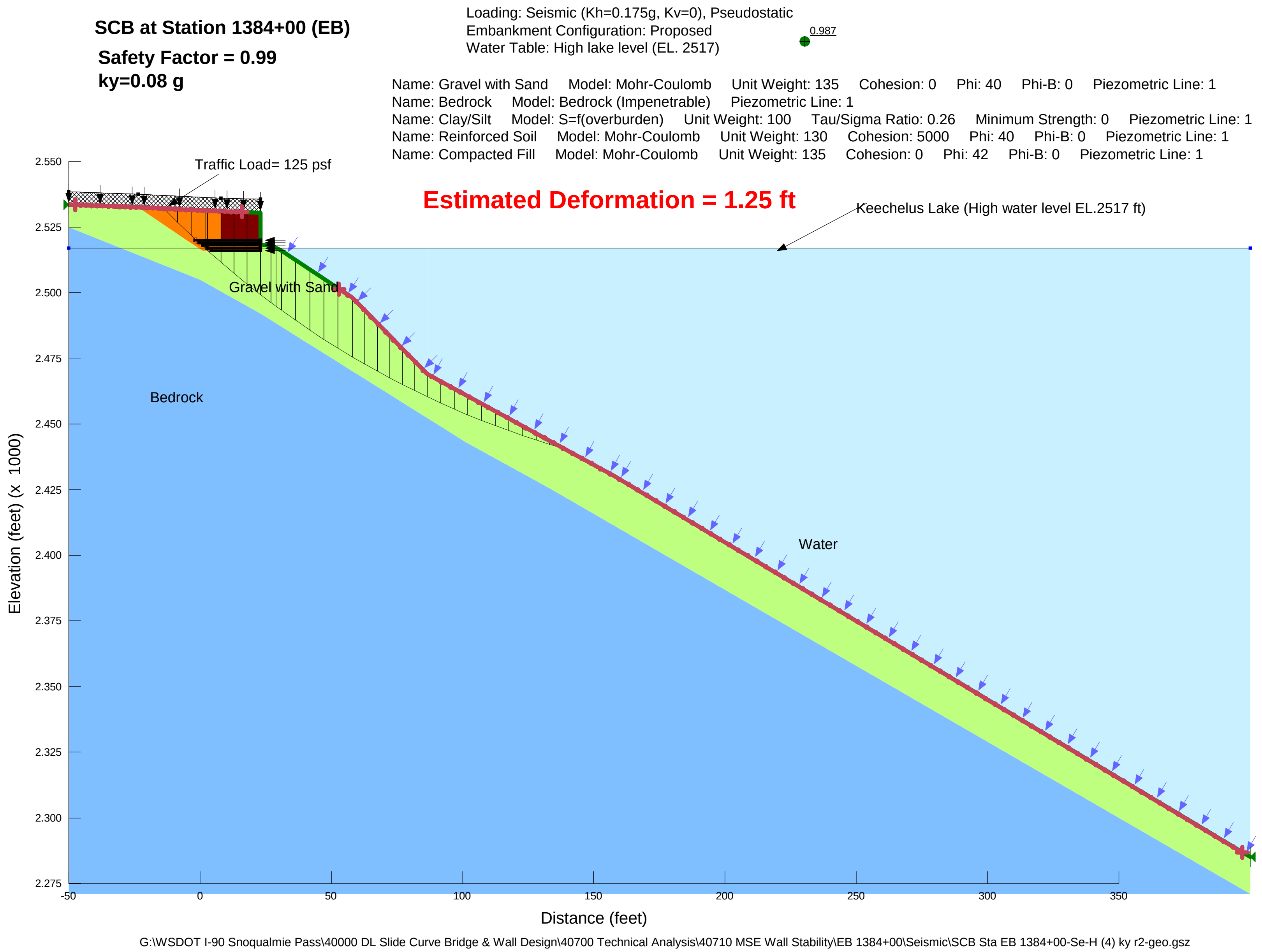
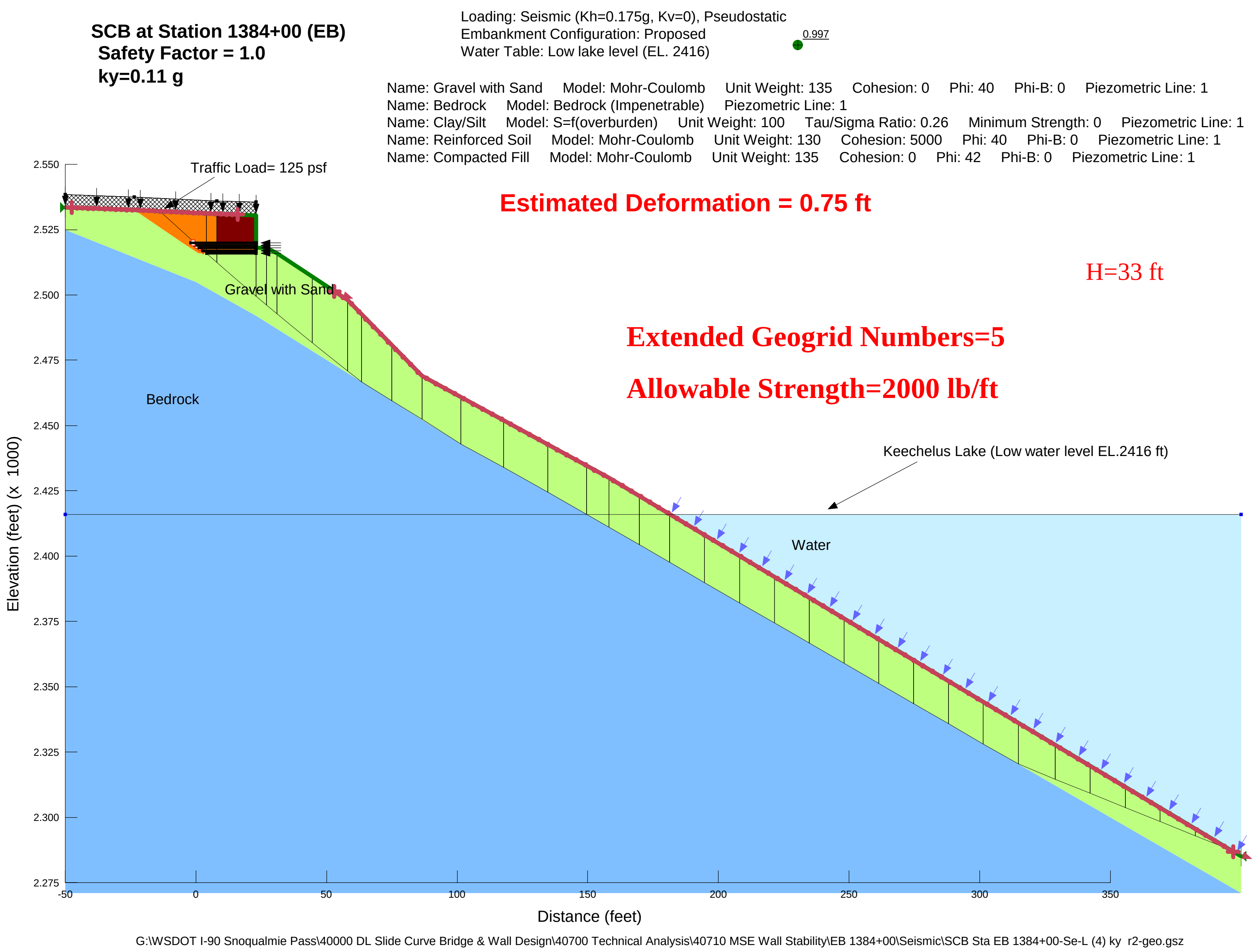

SCB at Station 1384+50 (EB)
Safety Factor = 1.20
1.204
Loading: Static
Embankment Configuration: Proposed
Water Table: Low lake level (EL. 2416)
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Snow Load= 320 psf
Gravel with Sand
Bedrock
Keechelus Lake (Low water level EL.2416 ft)
Water
Elevation (feet) (x 1000)
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
2.325
2.300
2.275
-50
0
50
100
150
200
250
300
350
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\40000 DL Slide Curve Bridge & Wall Design\40700 Technical Analysis\40710 MSE Wall Stability\EB 1384+50\Static\SCB Sta EB 1384+50-St-L-Bottom.gsz

Figure H.2.22



SCB

Figure H.2.23



SCB

Figure H.2.24

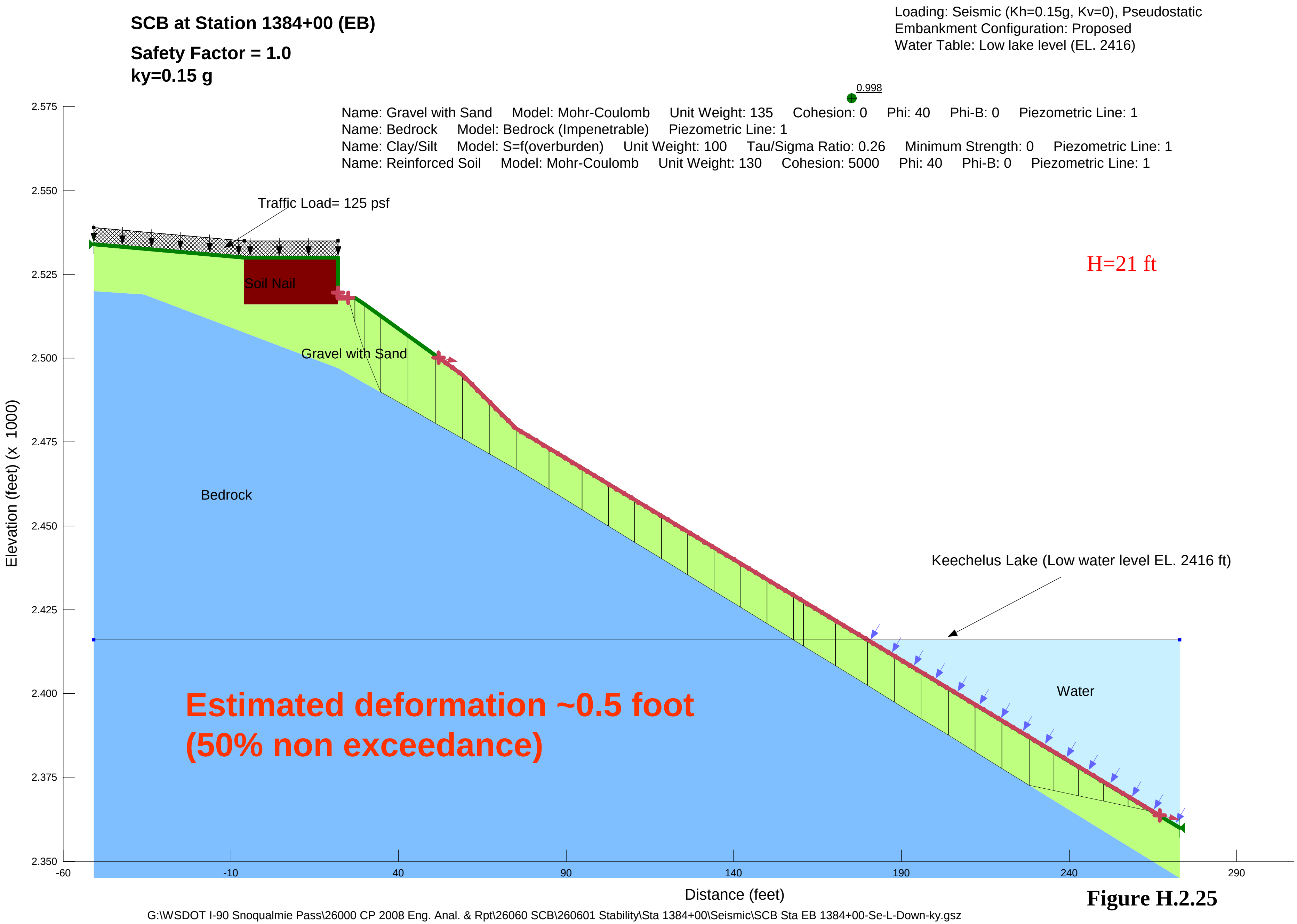

SCB at Station 1384+00 (EB)
Safety Factor = 1.0
ky=0.15 g
Loading: Seismic (Kh=0.15g, Kv=0), Pseudostatic
Embankment Configuration: Proposed
Water Table: Low lake level (EL. 2416)
0.998
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Clay/Silt Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 5000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Traffic Load= 125 psf
H=21 ft
Soil Nail
Gravel with Sand
Bedrock
Keechelus Lake (Low water level EL. 2416 ft)
Water
Estimated deformation ~0.5 foot
(50% non exceedance)
Elevation (feet) (x 1000)
2.575
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
2.350
-60
-10
40
90
140
190
240
290
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\26000 CP 2008 Eng. Anal. & Rpt\26060 SCB\260601 Stability\Sta 1384+00\Seismic\SCB Sta EB 1384+00-Se-L-Down-ky.gsz

Figure H.2.25

APPENDIX H.3
W&N Technical Memorandum Dated August 9, 2010 - Slide Curve Bridge Stability Analysis

Memorandum

To: John Zeman, P.E. (URS Corporation)

From: Norman I. Norrish, P.E. (Wyllie & Norrish Rock Engineers Inc.)

Date: August 9, 2010

Re: Bedrock Global Stability Evaluation
Slide Curve Bridge

Background

As specified in Work Order number 33758637.21000, Wyllie & Norrish Rock Engineers Inc. (W&N) is pleased to present this technical memorandum with the results of our stability evaluation for Piers 1, 7 and 9 of the proposed Slide Curve Bridge (SCB) located within Phase 1C of the I-90 Snoqualmie Pass East Project. The specific terms of reference for W&N included an assessment of bedrock slope stability controlled by the structural geology at each pier location.

The main reference documents for this study are:

- A technical memorandum submitted by W&N to URS Corporation (URS) dated July 29, 2009 titled "Piers 1 and 6 Global Stability, Slide Curve Bridge". The memorandum was followed by an email to Mr. John Zeman of URS dated August 3, 2009 which summarized the results of revised analyses for Slide Curve Bridge. The July 29th memorandum and the follow-up August 3rd email will be collectively referred to as **W&N, 2009a**.

- The final design report for the new I-90 alignment dated April, and titled "Phase 1C – Rock Slope Engineering Report, 2008 Geotechnical Program". The report will be referred to as **W&N, 2009b**.

These documents enumerated the specific information either supplied by URS or developed by W&N that was used in the present stability evaluation. Such information will be included by reference and will not be repeated herein.

The W&N (2009a) study evaluated the global stability of Piers 1 and 6 (LE Stations 1374+40 and LE 1382+40, respectively). Note that the design concept at that time consisted of a full width bridge with the abutments founded on spread footings. The study concluded that the orientation and persistence of clay/silt infilled discontinuities could be critical to the global stability of the piers under consideration and that additional exploration and geologic interpretation should be undertaken to investigate the clay/silt layers. The W&N (2009a) memorandum concluded with the statement "A favorable interpretation could possibly enable a less conservative engineering assessment for the stability of Piers 1 and 6."

During October 2009 additional drilling was performed by URS at Slide Curve Bridge. Specifically, two boreholes were advanced at the west end of the bridge and three boreholes at the east end of the bridge. The holes were logged with televiewer equipment to obtain in situ structural geologic measurements. An extensive geologic and engineering analysis of the new data and the previous data was undertaken by Messrs. M. Molinari and M. McCabe and culminated in URS Technical Memorandum titled "I-90 Snoqualmie Pass East Project, Slide Curve Bridge and Walls, Geologic and Geotechnical Interpretation of Significant Discontinuities" dated February 5, 2010. This is the primary reference for the current W&N stability evaluation and will be referred to herein as **URS (2010)**.

Methodology

Structural Analysis:

Rock slope stability evaluations are a two-part process. The initial step is to analyze the structural geology to determine if geologic discontinuities (joints, faults, flow boundaries etc) are adversely oriented such that structure-bound blocks can displace with respect to the orientation of a slope under consideration. This is often referred to as a kinematic analysis. The structures of most concern are those with the greatest persistence (i.e. continuity) and the lowest shear strength (i.e. clay-filled faults or flow boundaries).

Previous drilling at Slide Curve Bridge had identified clay/silt filled layers at both the Pier 1 and 6 locations (see Figure 3, W&N, 2009a). In the absence of information to the contrary and for the purposes of a conservative global stability evaluation, these layers were assumed to be persistent and ubiquitous throughout the rock mass. This led to the determination of marginal stability for the Pier 6 spread footing. Therefore, a primary focus of the 2009 URS drilling campaign was to confirm or refute the significance of these features and considerable effort was expended by URS to examine correlations of significant clay-filled layers between adjacent boreholes. To quote from the Conclusions and Recommendations section of URS (2010): "Based on the available data, it is unlikely that any of the significant discontinuities at the east end of the Slide Curve Bridge are persistent from one side of the bridge foundation to the other." Furthermore, the memorandum stated "…due to the limited discontinuities at the west end of the bridge, additional evaluation was not warranted."

Although continuous clay/silt filled discontinuities were concluded to not be present at either end of the SCB, stereographic analysis did indicate the presence of two discontinuity sets that were kinematically viable for planar movement and could therefore affect rock mass strength and foundation stability. These consisted of a low angle set with 10°to 11° dip and dip direction of 288° to 298° and a steeper joint set with 44° dip, dip direction 271° to 288°. URS (2010) recommended shear strength parameters of 40° friction angle and 3.5 psi (500 psf) for these discontinuities consistent with the interpretation that any features with clay/silt infillings were of limited persistence.

Pier 9 Stability Analysis:

Pier 9, the easternmost abutment for the current Slide Curve Bridge concept, is located at LE Sta. 1383+58. As described above, URS (2010) concluded that clay/silt filled discontinuities were not persistent across the full width of this abutment. Consequently, it was recommended that foundation design be based on rock mass shear strength modified by pier specific rock fabric (i.e. joints). In addition, parameter ranges representing the uncertainty associated with various geomechanical properties were recommended by URS as follows:

Rock Mass:

Geological Strength Index (GSI): 50 to 65

43 to 48 (for boreholes SCB 28-09 and SCB 30-09)

Unconfined Compressive Strength (UCS): 9 ksi ± 25% (i.e. 9 ksi ± 2.25 ksi)

Disturbance factor, D: 0 (corresponds to minimal rock disturbance during construction)

Other parameters based on default values for tuff rock type (ref: Rocscience software "RocLab").

Significant Discontinuities (clay/silt infilled):

Friction angle, Φ: 40° ± 2°

Cohesion, c: 3.5 psi (500 psf)

Orientation: (dip/dip direction)

Set 1: 11°/293° Set 2: 44°/271°

URS (2010) further recommended that the discontinuities be incorporated in the design procedure either by discounting the GSI values for the rock mass or by prorating the shear strength for those portions of the potential failure surface parallel to the inclination of Sets 1 and 2. The latter approach was followed in the current analysis, for which URS (2010) recommended a discontinuity / rock mass proportion of 75%/25% with a range of 67%/33% to 100%/0%. These ratios were applied only to those portions of the failure path parallel to Sets 1 or 2; with rock mass shear strength applied to the remainder of the failure path.

Using the URS (2010) recommendations as guidance, the general approach to the assignment of geomechanical properties was to define three rock quality categories spanning the range of values recommended by URS, namely "worst case", "probable case" and "best case". For the rock mass properties this was implemented as follows:

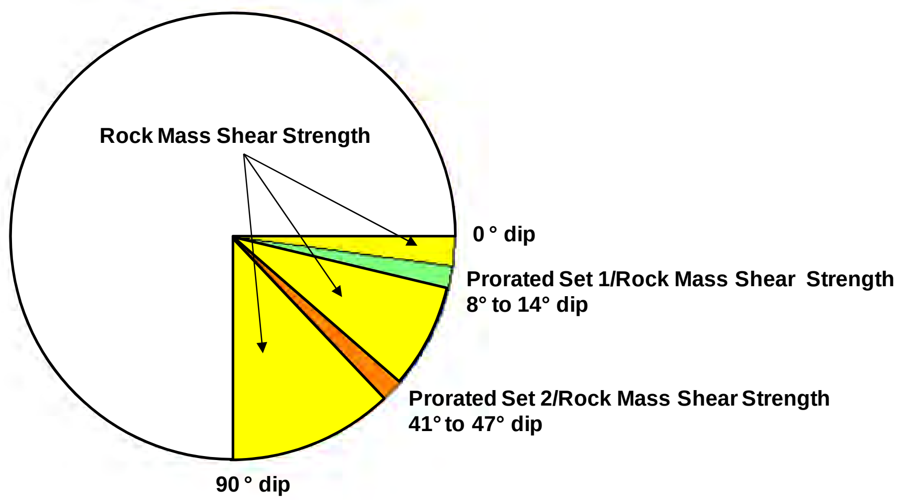
Parameter	Worst	Probable	Best
GSI	43	50	60
UCS	6.75 ksi	9.0 ksi	11.0 ksi
"D" factor	0.5	0.25	0

These values were analyzed using Rocscience software "RocLab", Version 1.031 to define the non-linear rock mass shear strength envelopes for each of the three rock categories (Figure 1). Conservative linear Mohr- Coulomb shear strength envelopes were fitted to the appropriate normal stress range to derive conventional friction angle and cohesion values for each rock quality category:

Parameter	Worst	Probable	Best
Φ (degrees)	52	56	60
C (ksf)	1.5	6	19

As a point of comparison, the values for the east pier area (then referred to as Pier 6) developed in W&N (2009a) were ϕ = 55°, c = 2.6 ksf.

To incorporate the anisotropic shear strength due to the discontinuities, a dip envelope of ±3° was assigned to each of the sets; thus Set 1 had a dip range of 11° ± 3° and Set 2 a dip range of 44° ±3°. Within these dip ranges the shear strength was prorated depending on the proportion of discontinuity and rock mass path length. This is shown graphically in the sketch below.



The prorating was in accordance with the URS (2010) recommendations. As an example:

	Φ	C
Rock Mass (25% of path length)	52°	1.5 ksf
Discontinuity(75% of path length)	40°	0.5 ksf
Prorated Strength	43.5°	0.75 ksf

Based on an email received on 2/17/10 from Mr. Moein El-Aarag of KPFF Structural Engineers, Pier 9 loads are as follows:

Unfactored Superstructure Dead Load = 1000 kips
Unfactored Substructure Dead Load = 1800 kips (This load does not include the self weight of the shafts)
Unfactored Live Load = 480 kips

The issue with respect to external loading is the methodology to incorporate the complex loading into a two-dimensional analysis. The analysis section for Pier 9 is at the junction of the shaft-supported structure and the approach span supported on a reinforced embankment. The structure loading was implemented as follows:

The Pier 9 loads were applied to an area defined by the width of the shaft cap beam (nominal 40 feet) and half the distance to the adjacent Pier 8 (nominal 60 feet). Therefore the loading is 1000+1800+480 = 3280 kips / (40 ft x 60 ft) = 1.37 ksf.

The loading due to the nominal 25-foot high reinforced embankment = 20ft x 135 pcf = 3.38 ksf plus live loading.

Given the difference in magnitude of these distributed loads for Pier 9, a conservative design value of 3 ksf was assumed for the outboard 40 feet corresponding to the cap beam width for the two-dimensional analysis.

Keechelus reservoir was assumed to be at 2518 ft MSL with an assumed moderate rise into the slope.

Using cross sections provided by URS, 2D models were developed using Rocscience Software "Slide" version 5.044. Both circular and step-wise linear failure paths were analyzed. Factors of Safety for Spencer, Morgenstern Price (GLE) and Janbu Corrected methods were calculated and compared for consistency. Static loading and pseudo static loading (seismic coefficient = 0.175g) were considered.

The general approach to the stability analyses was to analyze first for the lower combinations of rock mass shear strength and discontinuity strength. If these combinations provided adequate margin for global stability, it was rationalized that it was unnecessary to analyze for more optimistic assumptions.

Figure 2 and the Table below summarize the Pier 9 stability analyses for the following conditions:

Case	**Rock Mass**		**Discontinuity**		**Relative Proportion**		**Factor of Safety**	
	Φ (deg)	C (ksf)	Φ (deg)	C (ksf)	% Rock Mass	% Disc	FS Static	FS 0.175g
1	52	1.5	38	0.5	0	100	2.02	1.23
2	56	6.0	40	0.5	0	100	2.65	1.52
3	56	6.0	45	1.875	25	75	4.24	2.82
4	56	6.0	46.4	2.315	33	67	4.93	2.93

Both non-circular (step-wise linear) and circular failure surfaces were analyzed. It was noted that non-circular failure surfaces have lower Factor of Safety (FS) values than do circular surfaces. The reason for this is that the former surfaces are more able to exploit the lower shear strength discontinuities (Set1 and 2) built into the bedrock model. For the worst case situation (Case 1 above) the minimum FS values were calculated at 2.02 and 1.23 for the static and pseudo static cases, respectively. For the more probable situations (Cases 2 through 4), calculated FS values are well in excess of 2 for the static case. It should be noted that the search algorithm to locate the critical surface was constrained to force failure through the bedrock. Lower factors of safety may be present through the sand and gravel deposits.

Pier 1 Stability Analysis:

Based on the available boreholes, rock quality at Pier 1, the westernmost abutment, is better than that observed at Pier 9 (see W&N, 2009a and URS, 2010). Given that stability analyses for Pier 9 assuming the lower to moderate rock mass and discontinuity strength estimates yielded favorable margins for global rock mass stability, Pier 1 can reasonably be assumed to be more stable than Pier 9 and detailed stability analyses are not required.

Pier 7 Stability Analysis:

The interior Pier 7 at Station 1380+80 LE was designated for a specific stability analysis because of the localized poor quality rock identified in the vicinity (see Page 7, URS, 2010). This poor quality was manifested as low RQD values for the core and as low compressive strengths for the intact rock. Following the same general procedure as for Pier 9, geomechanical properties were selected using the recommendations of URS (2010) as guidance:

Rock Mass:

Geological Strength Index (GSI): 40
Unconfined Compressive Strength (UCS): 2 ksi
"D" Factor: Assumed to range from zero (no disturbance) to 0.5 to account for possible tectonic disturbance
(*Note: URS, 2010 recommended a "D" value of zero for Pier 9 but did not make a recommendation for Pier 7.)*

These values were analyzed using Rocscience software "RocLab", Version 1.031 to define the non-linear rock mass shear strength envelopes for the range of disturbance factors (Figure 3). A single linear Mohr- Coulomb shear strength envelope was fitted to the appropriate normal stress range to yield the design values:

Friction angle , $\Phi = 48°$, cohesion, c = 1.0 ksf

Note that this envelope compares to the worst case rock for Pier 9 for which $\Phi = 52°$, c = 1.5 ksf.

The shear strength for discontinuities at Pier 7 was the same as that for Pier 9, namely:

Friction angle, Φ: $40° \pm 2°$

Cohesion, c: 3.5 psi (500 psf)

Orientation: (dip/dip direction)

Set 1: 11°/293° Set 2: 44°/271°

Similarly, the presence of discontinuities was accounted for in the rock mass strength by defining a dip envelope of ±3° for each of the sets; thus Set 1 had a dip range of 11° ± 3° and Set 2 a dip range of 44° ±3°. Within these dip ranges the shear strength was prorated depending on the proportion of discontinuity and rock mass path length as described above.

The bridge loads for Pier 7 were supplied by URS email dated April 19, 2010 as follows:

Dead Load: 2125 kips/shaft

Live Load: 350 kips/shaft

Incorporation of such point loads into a two-dimensional stability analysis is somewhat problematic. The approach was to model the loads as line loads parallel to the alignment with centerline offsets corresponding to the shaft locations. The question then was over what alignment length the point load should be assumed to be acting to develop the equivalent line load. At one extreme the shaft loads could be spread over half the distance to the adjacent piers (nominal 160 feet) resulting in an equivalent line load of 2475kips/160 ft = 15.5 kips/ft. At the other extreme the shaft load could be assumed to only act over the diameter of the shaft yielding an equivalent line load of 2475 kips/9 ft = 275 kips/ft. The preferred approach is to spread the shaft loads over the width of the block of rock likely to be involved in a slope failure. For the case of a pseudo planar failure this would correspond to the spacing of major persistent discontinuities (i.e. faults or flow boundaries) that might laterally define the block on which the pier is located. As illustrated in Figures 27 and 47 of W&N (2010b) such spacing for the existing highway cuts proximal to the SCB is on the order of 50 to 100 feet. To be conservative, a spacing of 50 feet was selected resulting in an equivalent line load of 2475 kips/50 ft = 49.5 rounded to 50 kips/ft.

Figure 4 summarizes the Pier 7 stability analyses for the following conditions:

1. Rock mass strength, ϕ = 48°, c = 1.0 ksf.
2. Discontinuity strength, ϕ = 43°, c = 0.665 ksf. (This prorated strength assumes discontinuities comprise 67% of failure path within the dip ranges for Sets 1 and 2)
3. Static condition and pseudo static condition with seismic coefficient set at 0.175g.
4. Sand and gravel deposits, ϕ = 40°, c = 0.

Note that the failure surfaces were constrained to avoid shallow surfical failures in the existing soils and to force the surfaces to depths in the bedrock comparable to the proposed shaft sockets. The resultant FS values were determined to be 1.84 and 1.17 for static and pseudo static loading. Engineering practice would typically target a minimum FS value of 2.0 under static loading. It is noted from Figure 4 that the critical failure surface in bedrock is almost entirely discontinuity controlled with segment lengths from 45 to 100 feet. This is significantly greater than the typical joint persistence mapped for the highway alignment (W&N, 2010b).

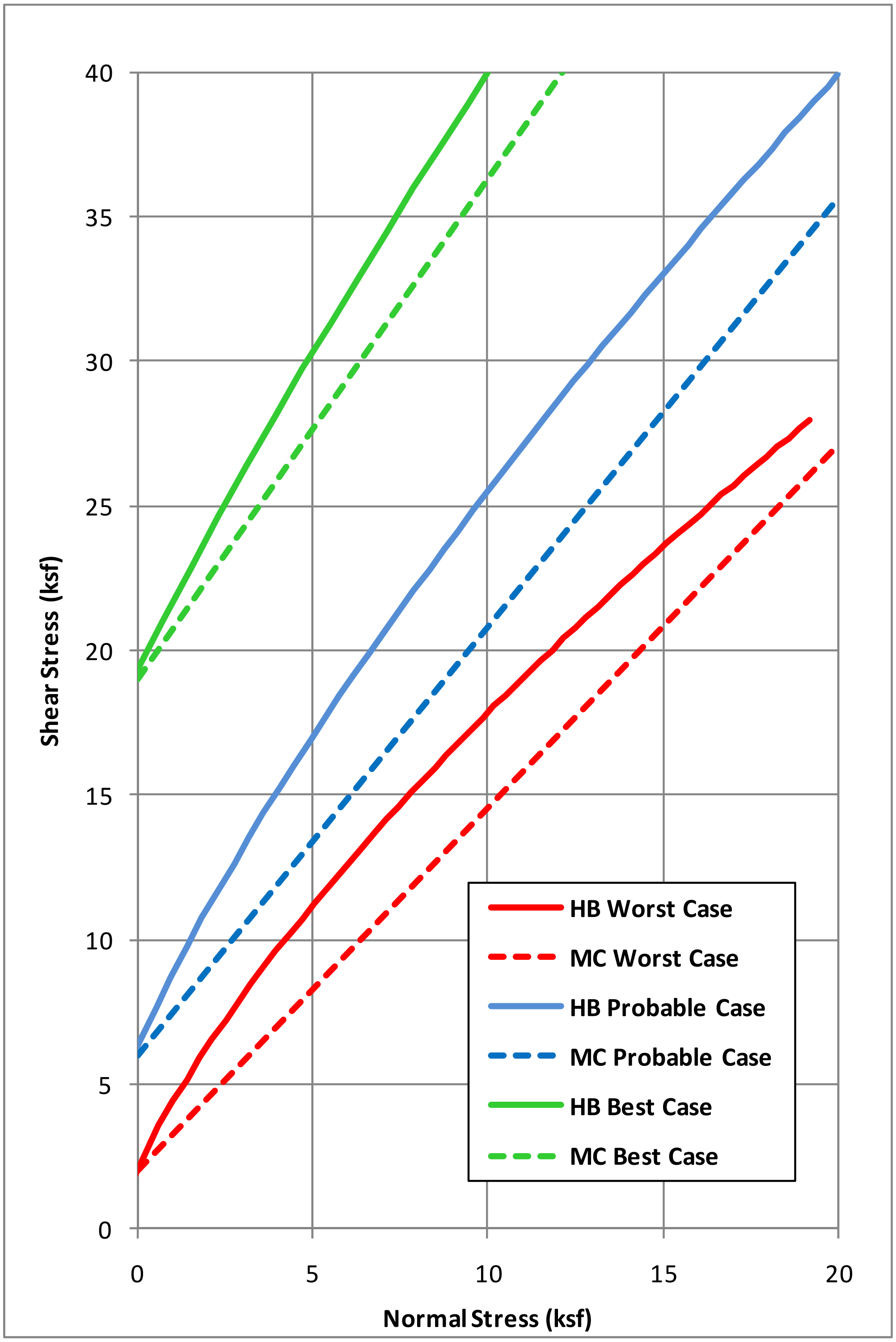
Summary

Based on a combination of "worst to probable conditions" derived from URS (2010), the analyses herein indicate an adequate margin for global stability for Pier 9. Conditions for Pier 1 at the western end are interpreted by URS to be more favorable than at Pier 9. It is concluded that the margin of safety for bedrock stability at both the abutment locations for the proposed Slide Curve Bridge is acceptable.

For the interior Pier 7 the calculated margin for stability is less than the customary minimum for a rock slope proximal to a structure. Given the conservative assumptions in the analysis, the uncertainty in the load application and the localized nature of the poor quality rock, the calculated stability could reasonably be characterized to be at the lower limit of acceptability. It is pointed out that the shaft loads in the model are assumed to be transmitted to the rock at the top of the shafts. The extent to which loads are transmitted at depth through end bearing, will promote deeper failure surfaces in the bedrock and thereby greater stability. If the calculated stability margin is deemed unacceptable by the owner, the alternatives are:

1. Reconsider the very low intact rock compressive strength of 2 ksi assigned at Pier 7 and model the probable range of compressive strength.
2. Revisit whether the rock mass strength penalty due to discontinuity Sets 1 and 2 is warranted at Pier 7.
3. Design the shafts for end bearing and/or deepen the shafts.
4. Improve the rock mass strength adjacent to the piers using vertical untensioned dowels installed on a grid pattern from the work bench.

One final point is that the models had to be deliberately forced to avoid failure through the existing soil and proposed fill. This stability issue was outside the scope of the W&N study and was assumed to be addressed by URS.



HB = Hoek Brown non linear shear strength envelope
MC = Mohr Coulomb equivalent shear strength envelope

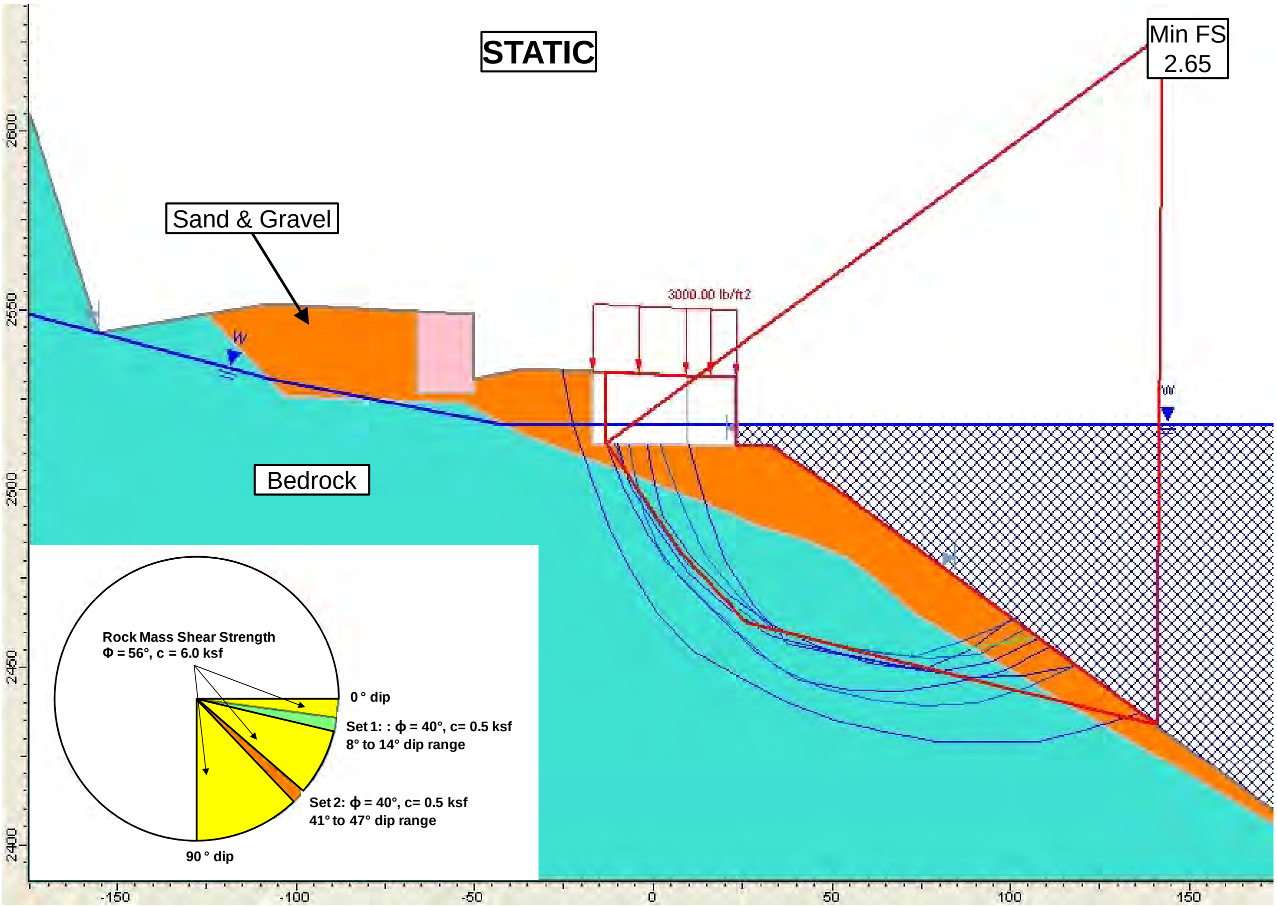
	Worst	Probable	Best
GSI	43	50	60
UCS	6.75 ksi	9.0 ksi	11.0 ksi
“D”	0.5	0.25	0
ϕ	52°	56°	60°
c	1.5ksf	6.0 ksf	19.0 ksf

Project No. 062-2002 Date: August 2010

Figure 1

Pier 9 Rock Mass Shear Strength

I-90 Snoqualmie Pass East
Slide Curve Bridge



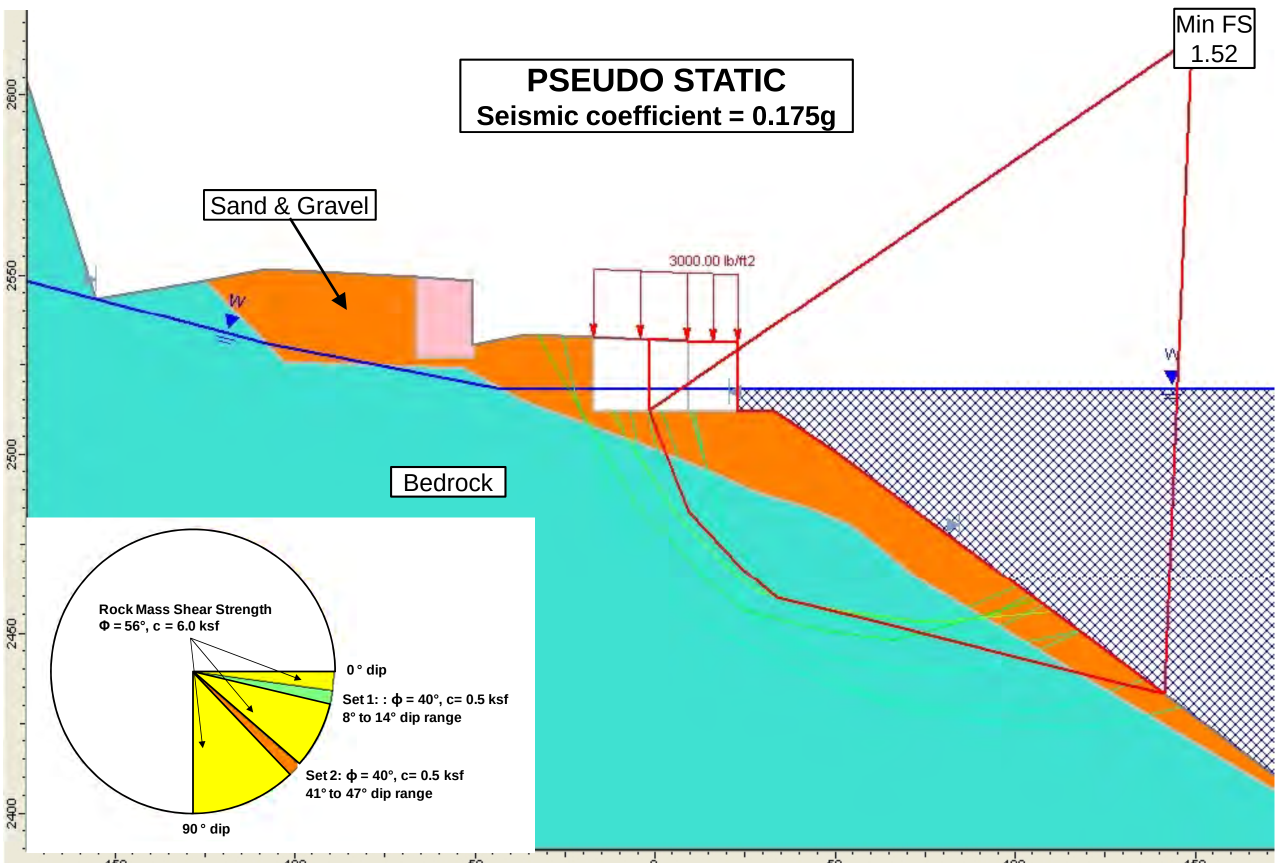
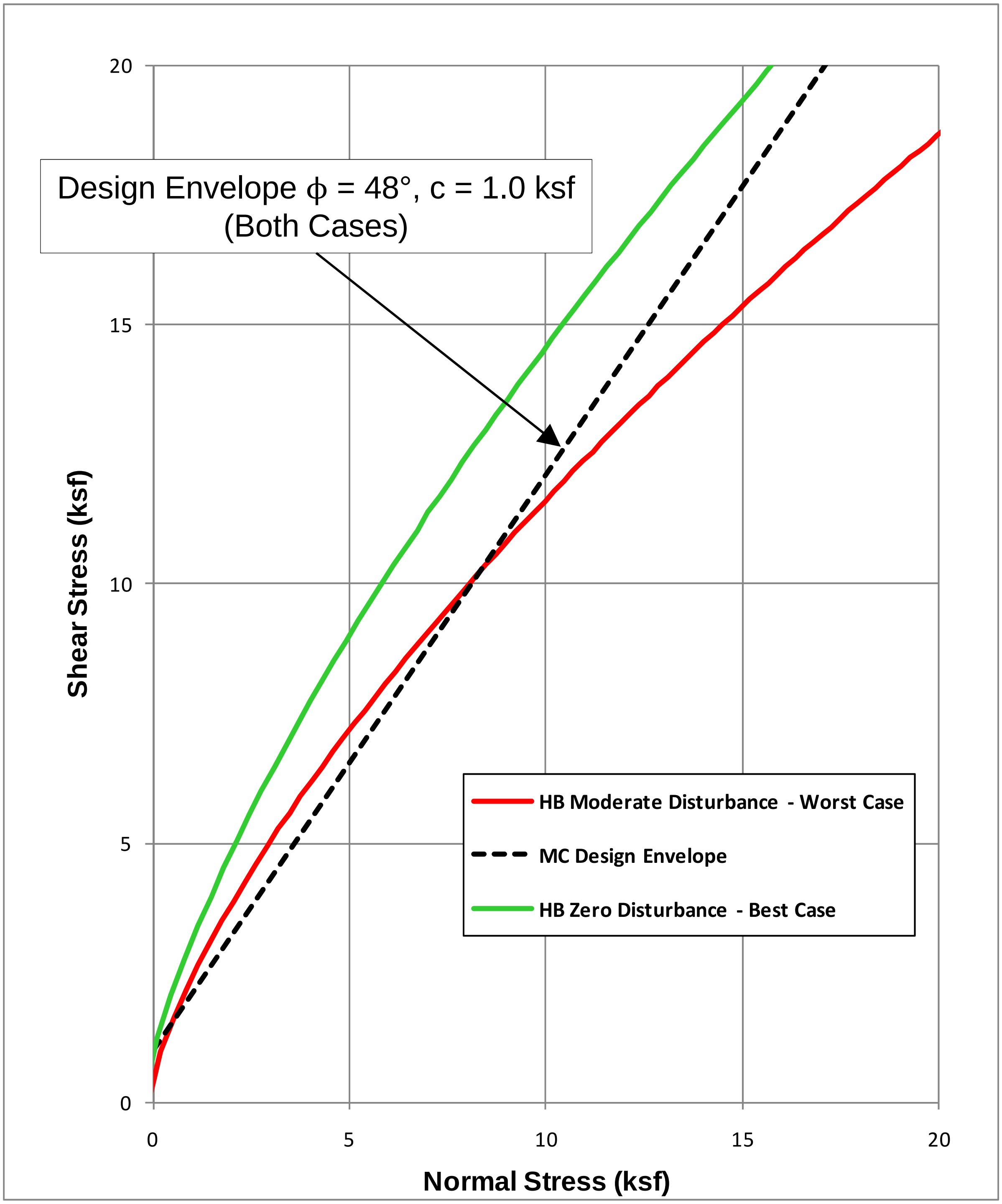


Figure 2

Bedrock Stability Analysis - Pier 9 Station 1383+58

I-90 Snoqualmie Pass East
Slide Curve Bridge

Project No. 062-2002 Date: August 2010

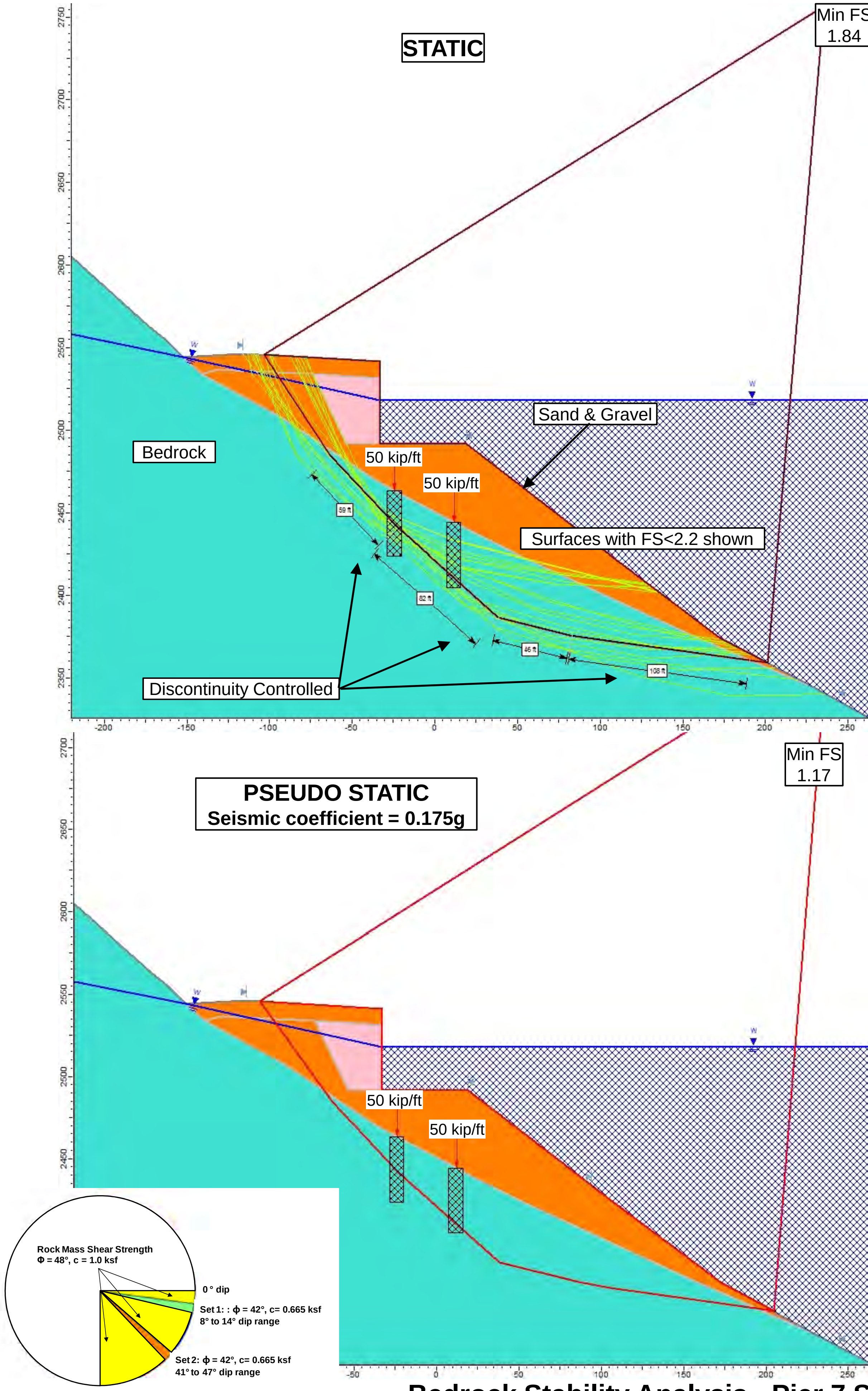


HB = Hoek Brown non linear shear strength envelope
MC = Mohr Coulomb equivalent shear strength envelope

	Worst	Best
GSI	40	40
UCS	2.0 ksi	2.0 ksi
“D”	0.5	0

Figure 3

Pier 7 Rock Mass Shear Strength



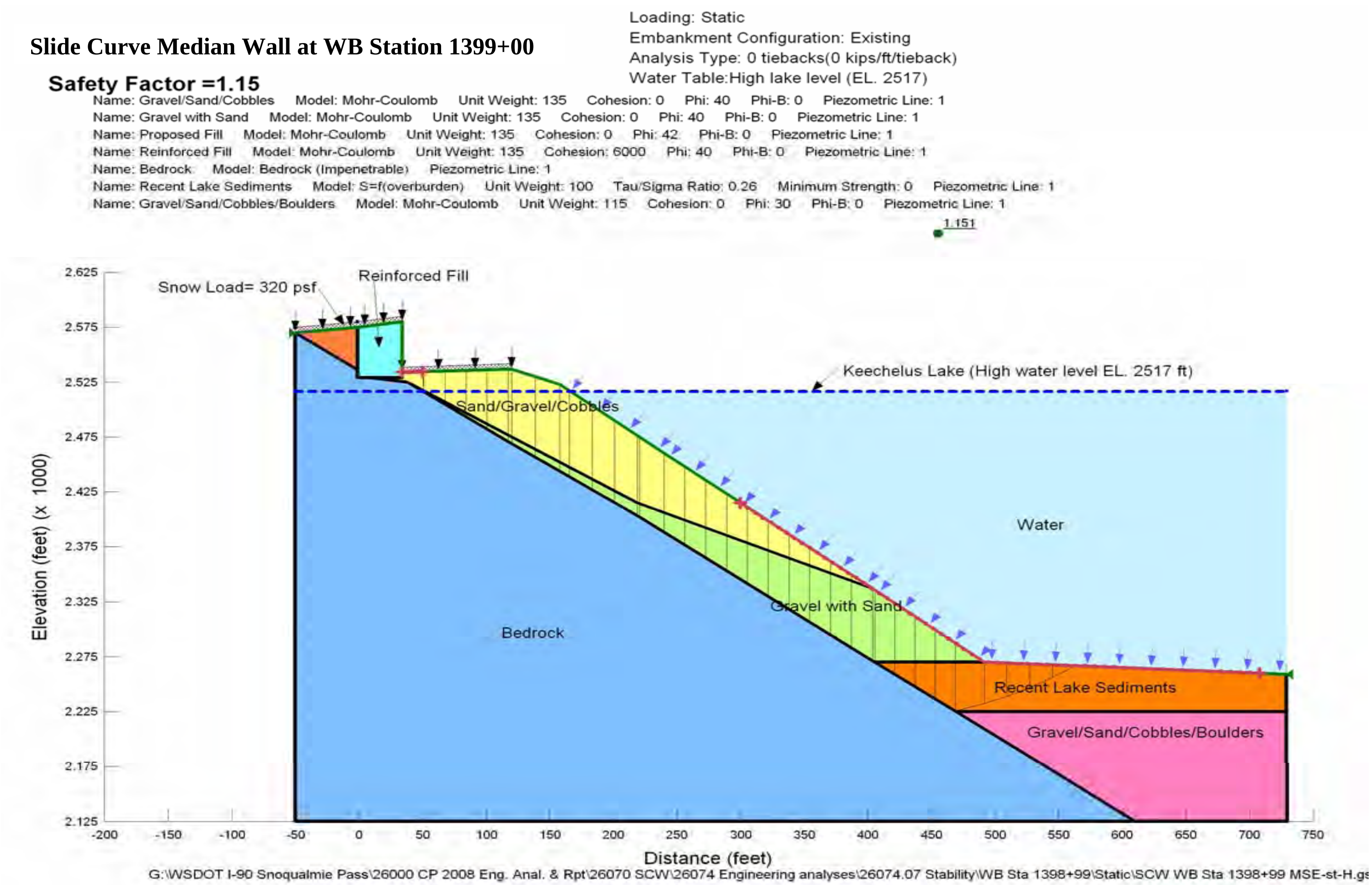
Project No. 062-2002 Date: August 2010

Figure 4

Bedrock Stability Analysis - Pier 7 Station 1380+80

I-90 Snoqualmie Pass East
Slide Curve Bridge

APPENDIX H.4
Stability Analysis Results - Slide Curve Median Wall

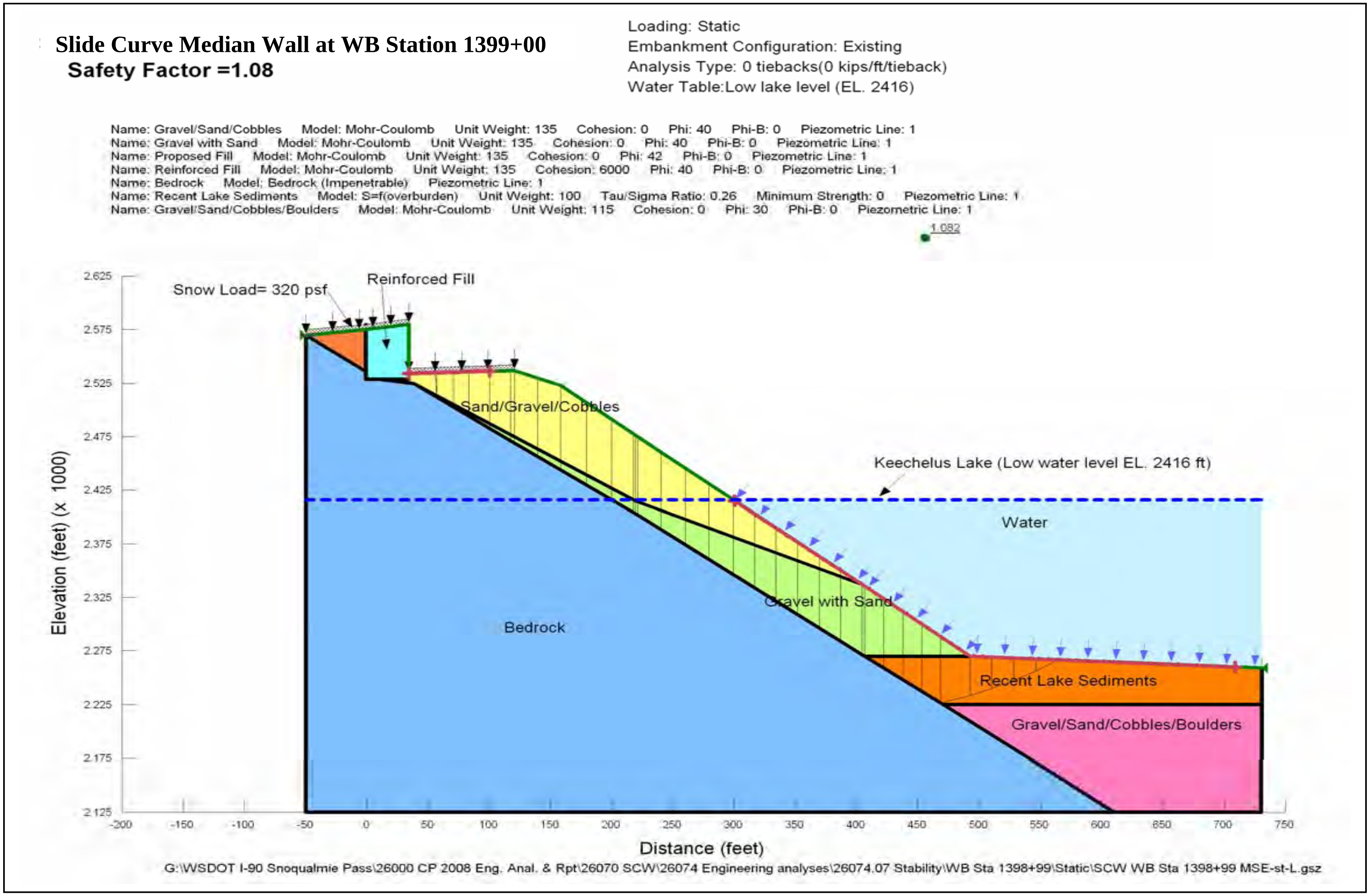


Job No. 33758662

Figure H.4.1

URS

WSDOT I-90 Snoqualmie Pass East
2010 Geotechnical Analysis and Reporting

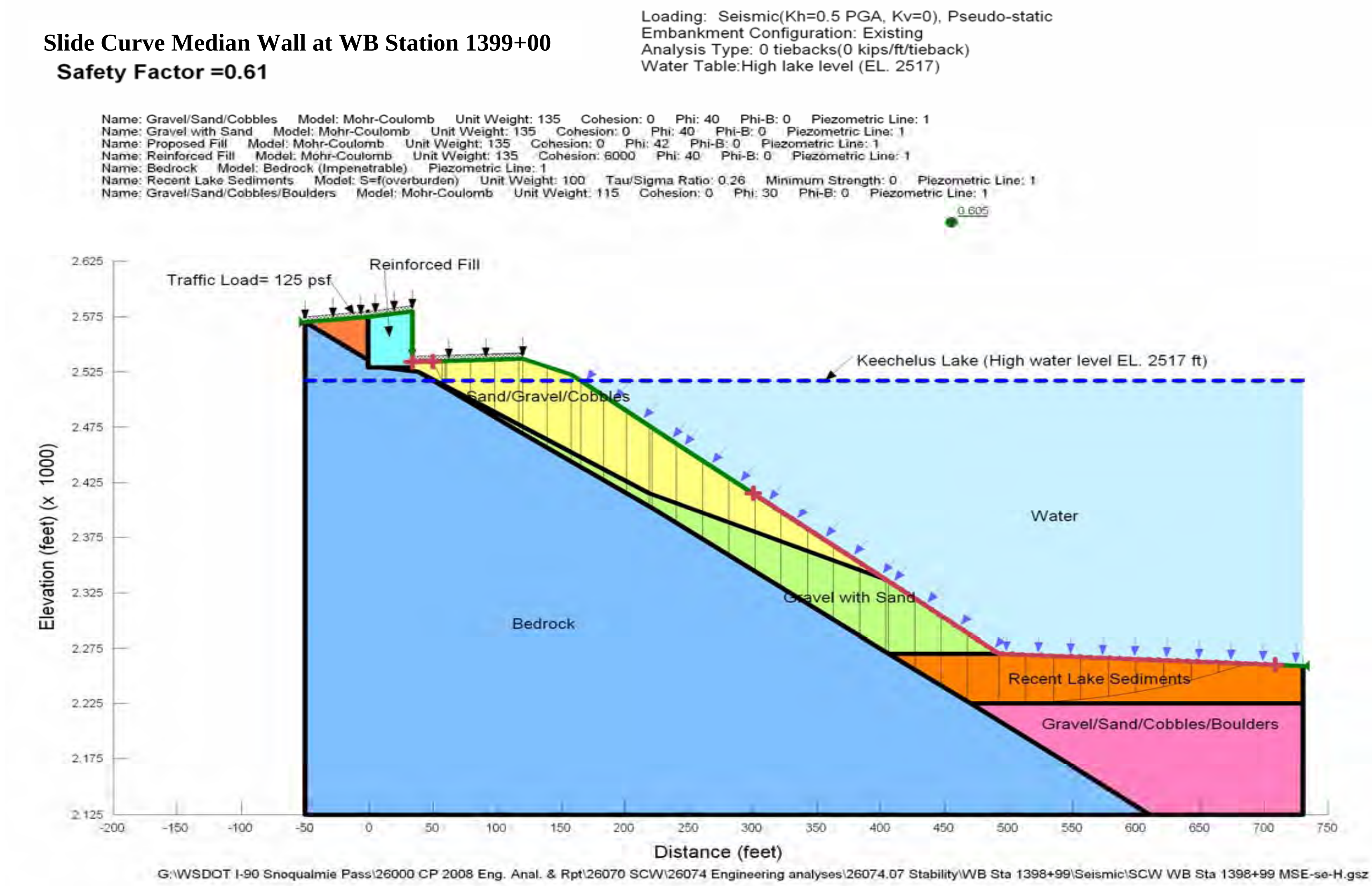


Job No. 33758662

Figure H.4.2

URS

WSDOT I-90 Snoqualmie Pass East
2010 Geotechnical Analysis and Reporting

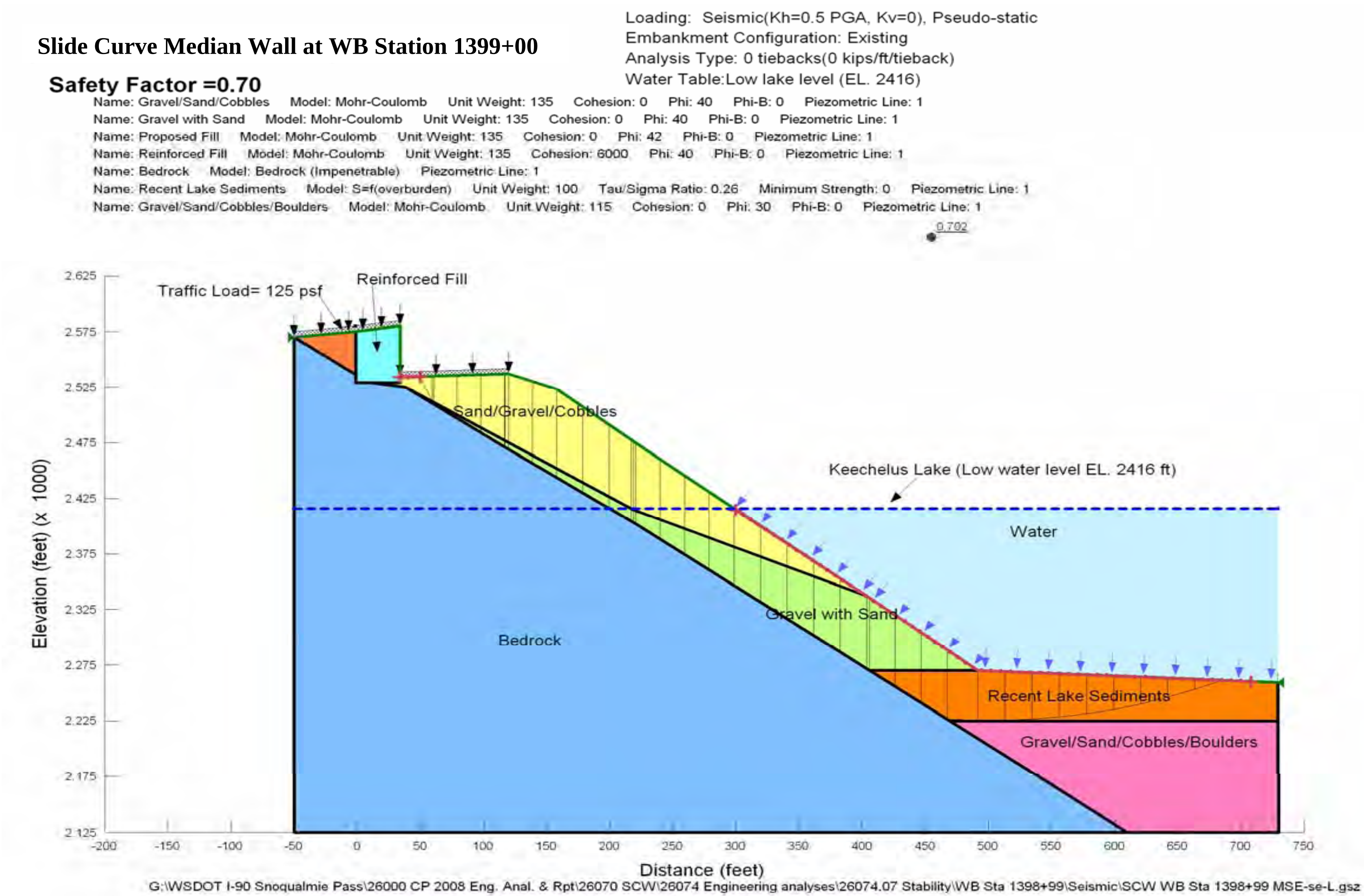


Job No. 33758662

Figure H.4.3

URS

WSDOT I-90 Snoqualmie Pass East
2010 Geotechnical Analysis and Reporting



Job No. 33758662

Figure H.4.4

Slide Curve Median Wall at WB Station 1404+17

Safety Factor =0.78

Loading: Seismic(Kh=0.5 PGA, Kv=0), Pseudo-static
Embankment Configuration: Existing
Analysis Type: 0 tiebacks(0 kips/ft/tieback)
Water Table:High lake level (EL. 2517)

Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Recent Lake Sediments Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Gravel/Sand/Cobbles/Boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1

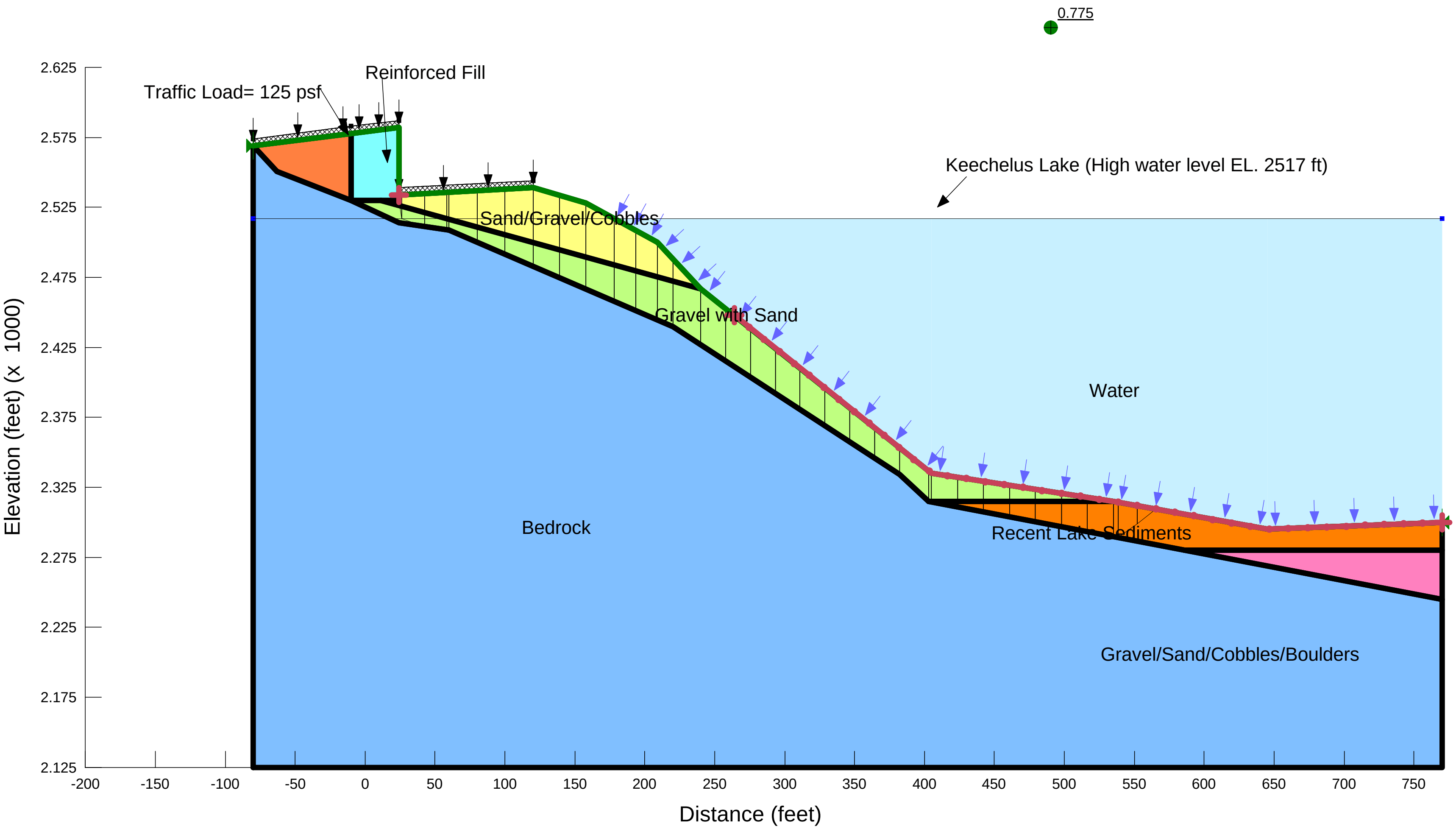


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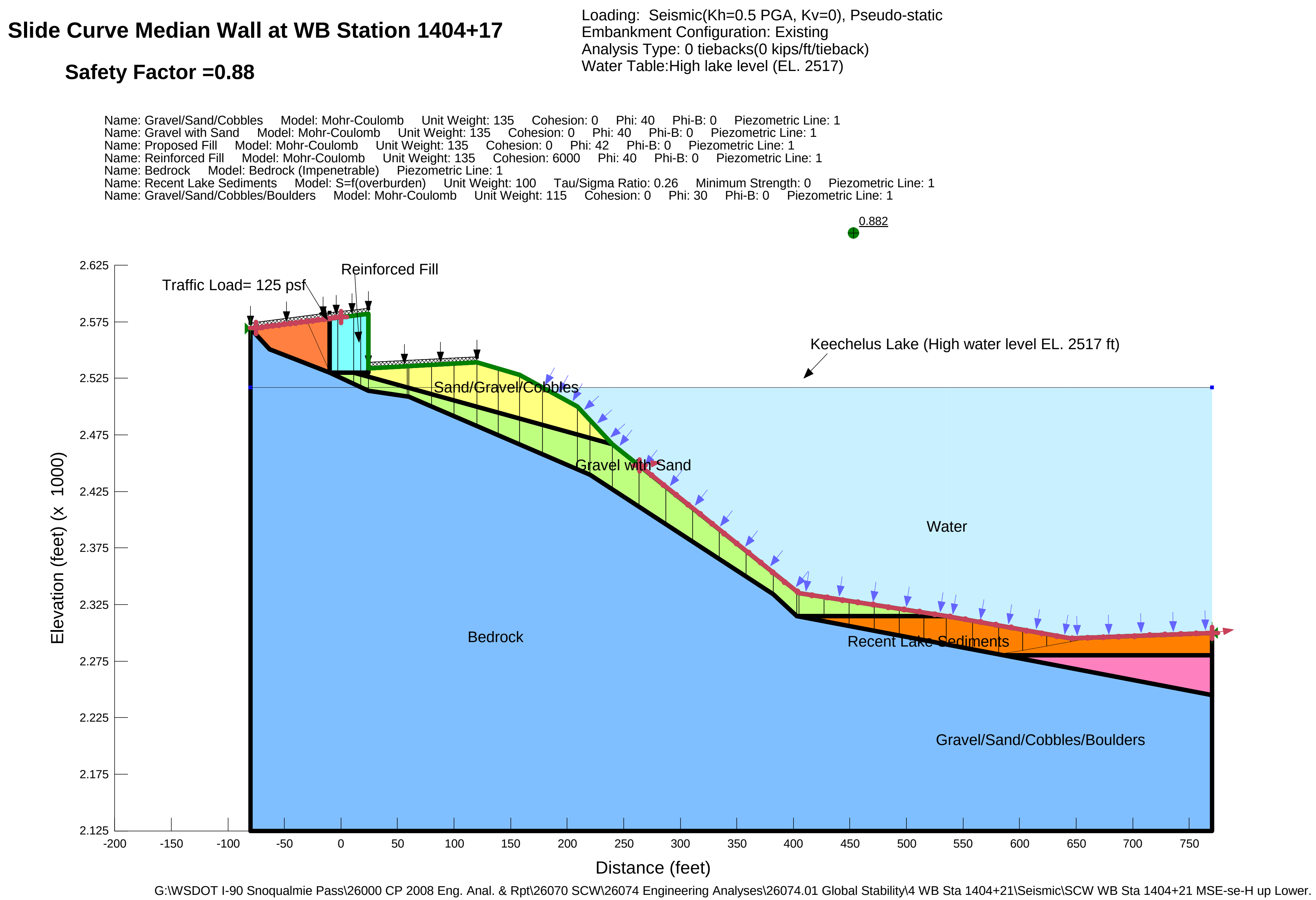
Figure H.4.5



Slide Curve Median Wall at WB Station 1404+17
Safety Factor =0.88
Loading: Seismic(Kh=0.5 PGA, Kv=0), Pseudo-static
Embankment Configuration: Existing
Analysis Type: 0 tiebacks(0 kips/ft/tieback)
Water Table:High lake level (EL. 2517)
Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Recent Lake Sediments Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Gravel/Sand/Cobbles/Boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
0.882
Reinforced Fill
Traffic Load= 125 psf
Keechelus Lake (High water level EL. 2517 ft)
Sand/Gravel/Cobbles
Gravel with Sand
Water
Bedrock
Recent Lake Sediments
Gravel/Sand/Cobbles/Boulders
Elevation (feet) (x 1000)
2.625
2.575
2.525
2.475
2.425
2.375
2.325
2.275
2.225
2.175
2.125
-200
-150
-100
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\26000 CP 2008 Eng. Anal. & Rpt\26070 SCW\26074 Engineering Analyses\26074.01 Global Stability\4 WB Sta 1404+21\Seismic\SCW WB Sta 1404+21 MSE-se-H up Lower.

Figure H.4.6

Slide Curve Median Wall at WB Station 1404+17

Safety Factor =0.99

Loading: Seismic(Kh=0.5 PGA, Kv=0), Pseudo-static
Embankment Configuration: Existing
Analysis Type: 0 tiebacks(0 kips/ft/tieback)
Water Table:Low lake level (EL. 2416)

Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Recent Lake Sediments Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Gravel/Sand/Cobbles/Boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1

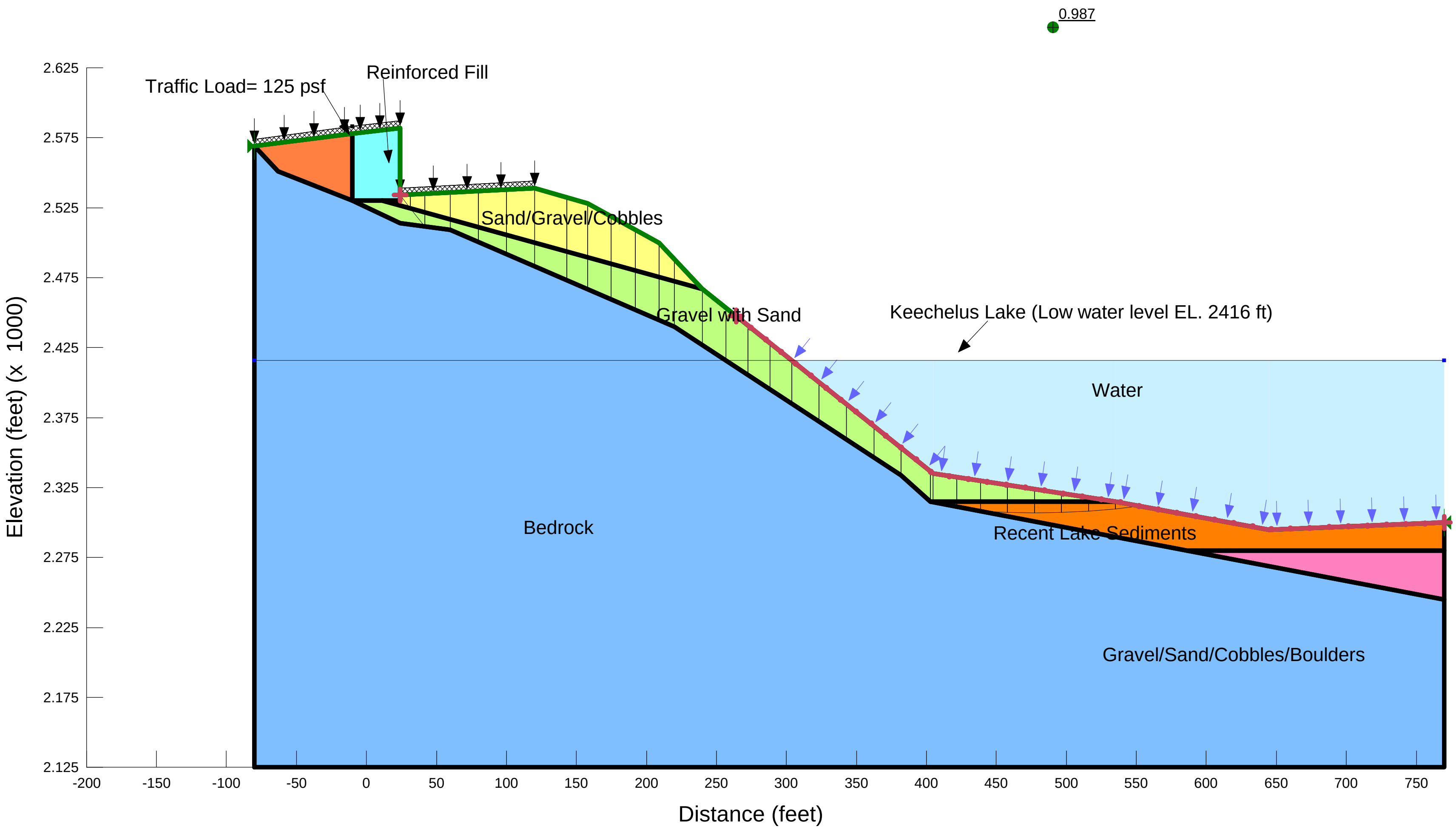


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Figure H.4.7

Slide Curve Median Wall at WB Station 1404+17

Safety Factor =1.00

Loading: Seismic(Kh=0.5 PGA, Kv=0), Pseudo-static
Embankment Configuration: Existing
Analysis Type: 0 tiebacks(0 kips/ft/tieback)
Water Table:Low lake level (EL. 2416)

Name: Gravel/Sand/Cobbles   Model: Mohr-Coulomb   Unit Weight: 135   Cohesion: 0   Phi: 40   Phi-B: 0   Piezometric Line: 1
Name: Gravel with Sand   Model: Mohr-Coulomb   Unit Weight: 135   Cohesion: 0   Phi: 40   Phi-B: 0   Piezometric Line: 1
Name: Proposed Fill   Model: Mohr-Coulomb   Unit Weight: 135   Cohesion: 0   Phi: 42   Phi-B: 0   Piezometric Line: 1
Name: Reinforced Fill   Model: Mohr-Coulomb   Unit Weight: 135   Cohesion: 6000   Phi: 40   Phi-B: 0   Piezometric Line: 1
Name: Bedrock   Model: Bedrock (Impenetrable)   Piezometric Line: 1
Name: Recent Lake Sediments   Model: S=f(overburden)   Unit Weight: 100   Tau/Sigma Ratio: 0.26   Minimum Strength: 0   Piezometric Line: 1
Name: Gravel/Sand/Cobbles/Boulders   Model: Mohr-Coulomb   Unit Weight: 115   Cohesion: 0   Phi: 30   Phi-B: 0   Piezometric Line: 1

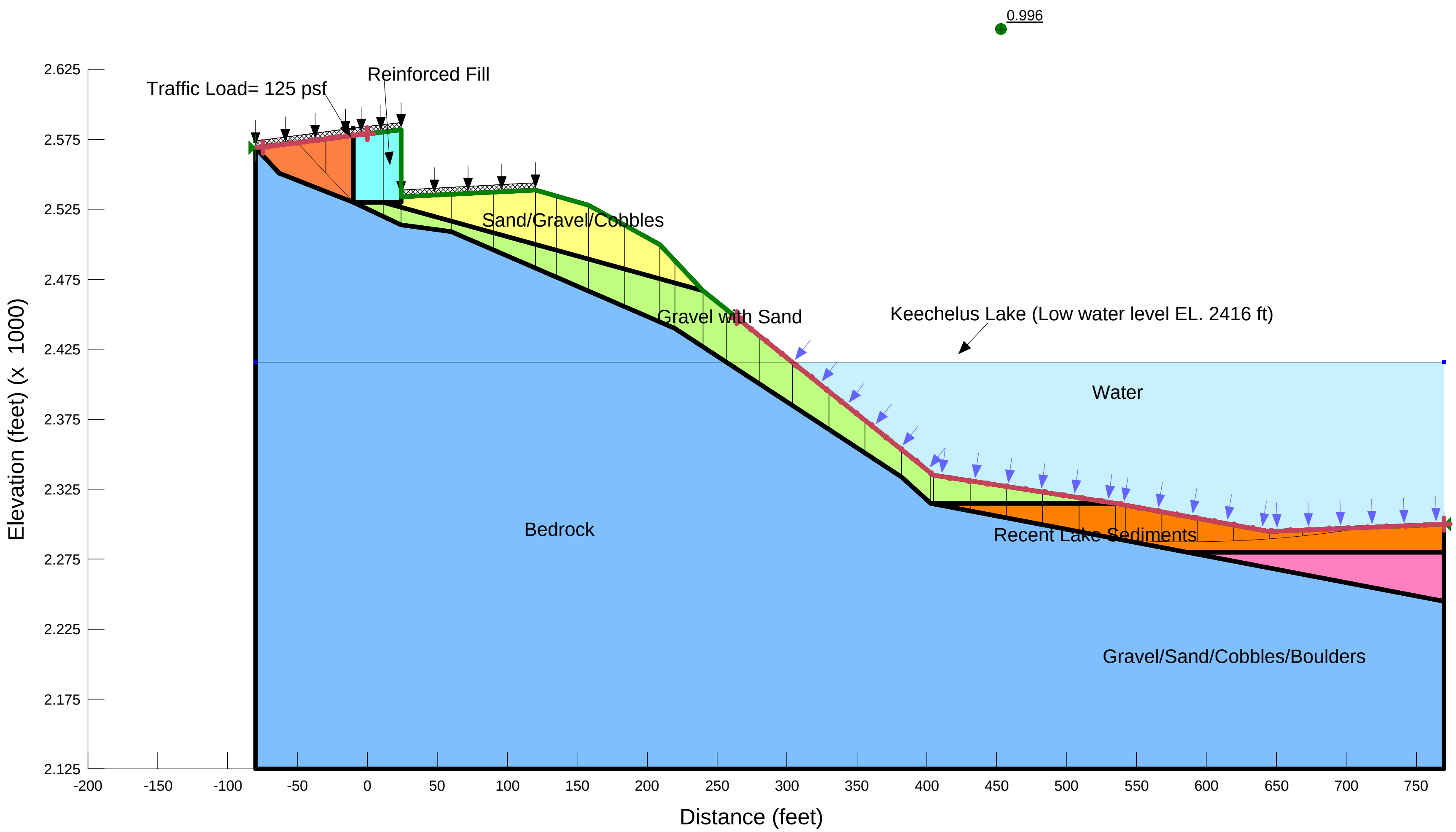

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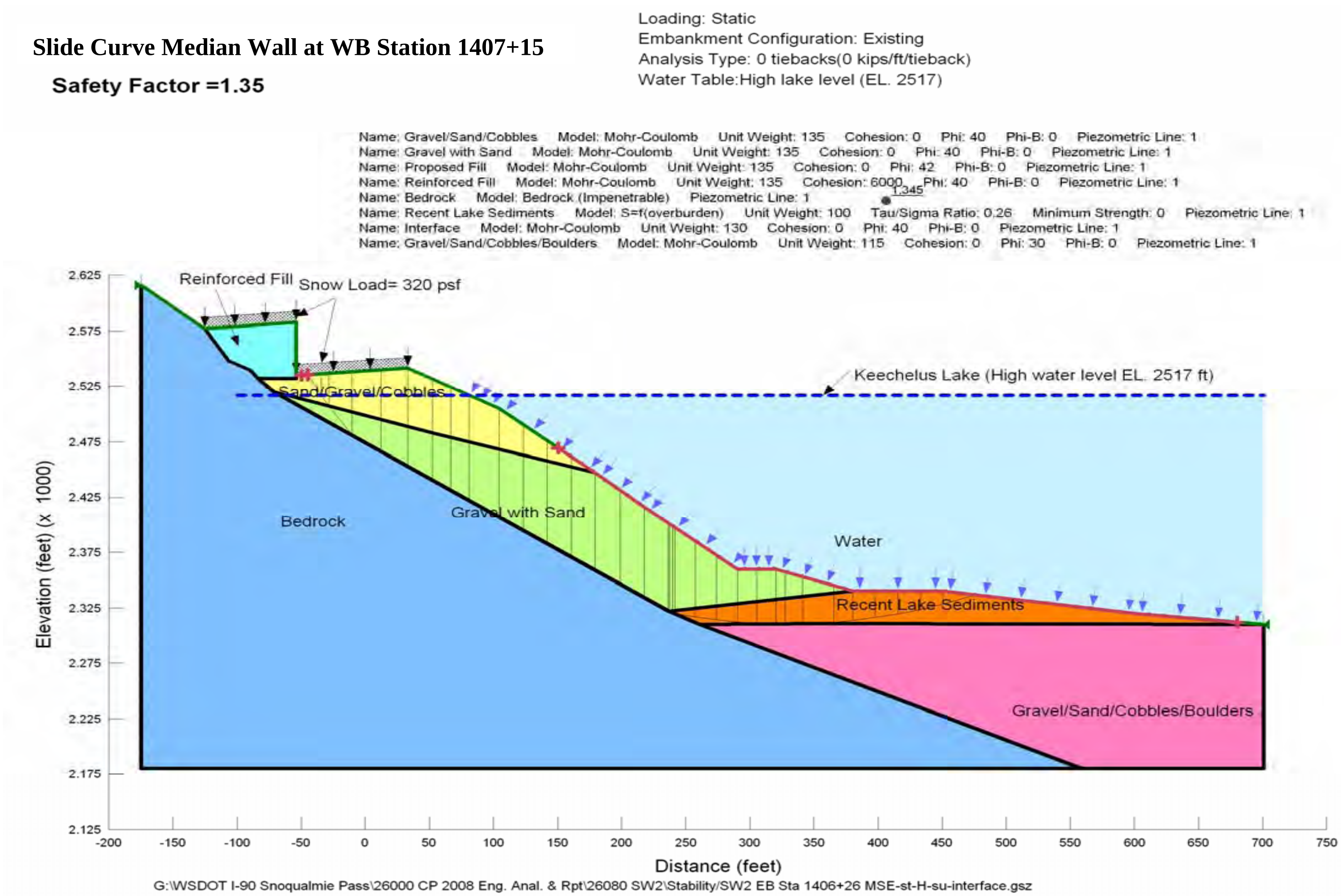
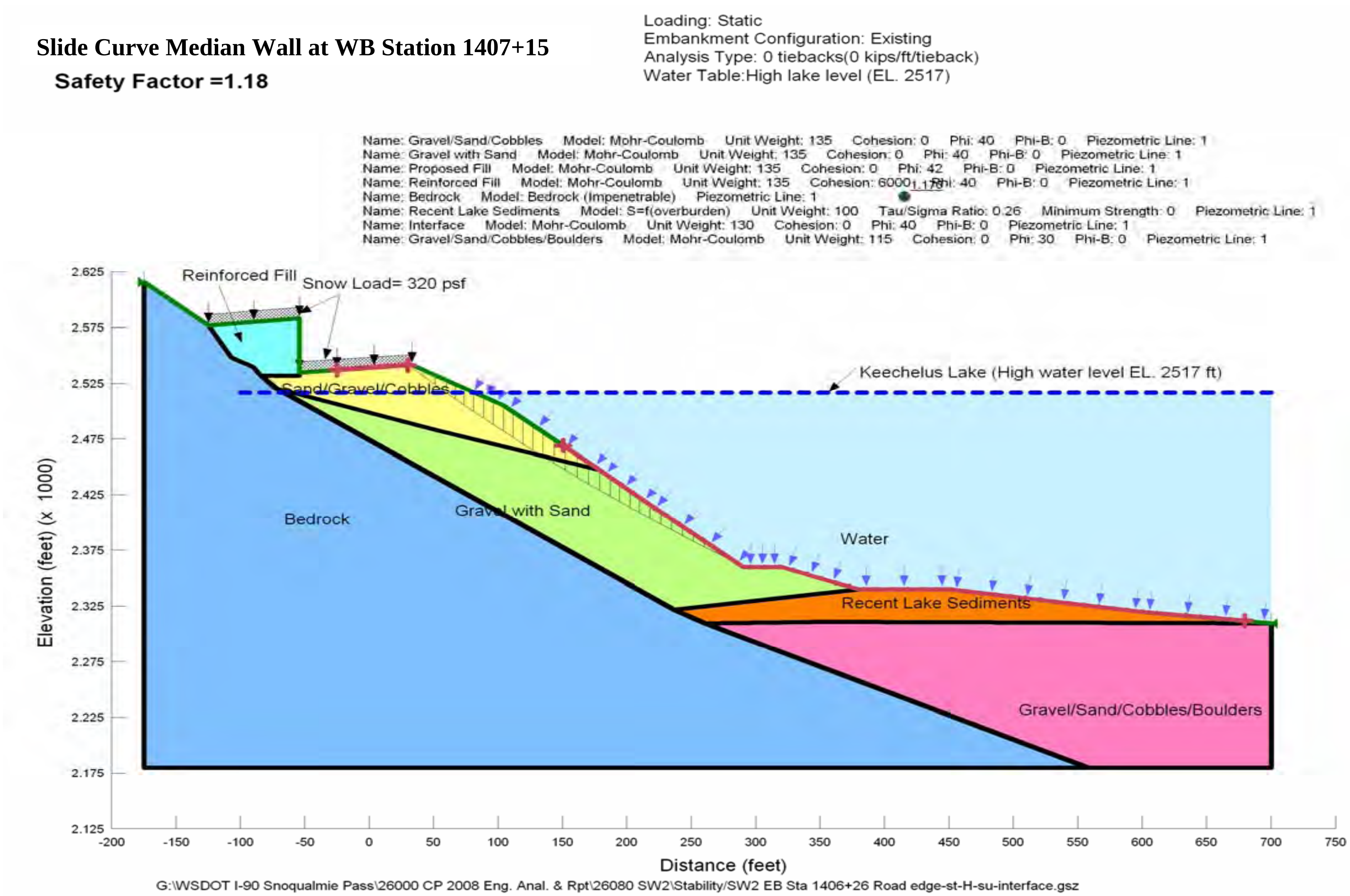
Figure H.4.8



Slide Curve Median Wall at WB Station 1407+15
Safety Factor =1.35
Loading: Static
Embankment Configuration: Existing
Analysis Type: 0 tiebacks(0 kips/ft/tieback)
Water Table:High lake level (EL. 2517)
Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1
1.345
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Recent Lake Sediments Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Interface Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel/Sand/Cobbles/Boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Reinforced Fill
Snow Load= 320 psf
Keechelus Lake (High water level EL. 2517 ft)
Sand/Gravel/Cobbles
Bedrock
Gravel with Sand
Water
Recent Lake Sediments
Gravel/Sand/Cobbles/Boulders
Elevation (feet) (x 1000)
2.625
2.575
2.525
2.475
2.425
2.375
2.325
2.275
2.225
2.175
2.125
-200 -150 -100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\26000 CP 2008 Eng. Anal. & Rpt\26080 SW2\Stability/SW2 EB Sta 1406+26 MSE-st-H-su-interface.gsz



Slide Curve Median Wall at WB Station 1407+15
Safety Factor =1.18
Loading: Static
Embankment Configuration: Existing
Analysis Type: 0 tiebacks(0 kips/ft/tieback)
Water Table:High lake level (EL. 2517)
Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Recent Lake Sediments Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Interface Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel/Sand/Cobbles/Boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
1.178
Reinforced Fill
Snow Load= 320 psf
Keechelus Lake (High water level EL. 2517 ft)
Sand/Gravel/Cobbles
Bedrock
Gravel with Sand
Water
Recent Lake Sediments
Gravel/Sand/Cobbles/Boulders
Elevation (feet) (x 1000)
2.625
2.575
2.525
2.475
2.425
2.375
2.325
2.275
2.225
2.175
2.125
-200 -150 -100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750
Distance (feet)
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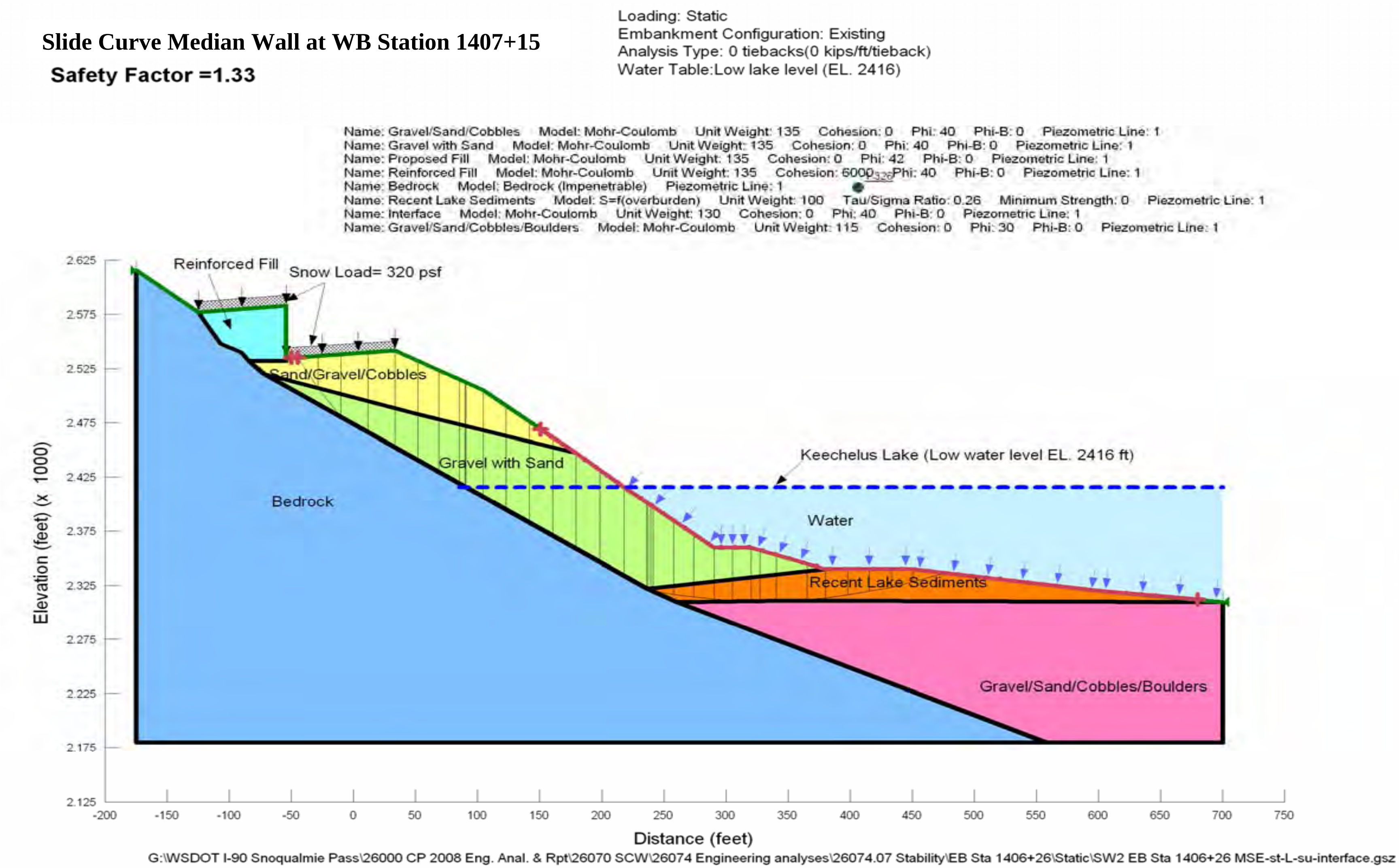


Job No. 33758662

Figure H.4.11

URS

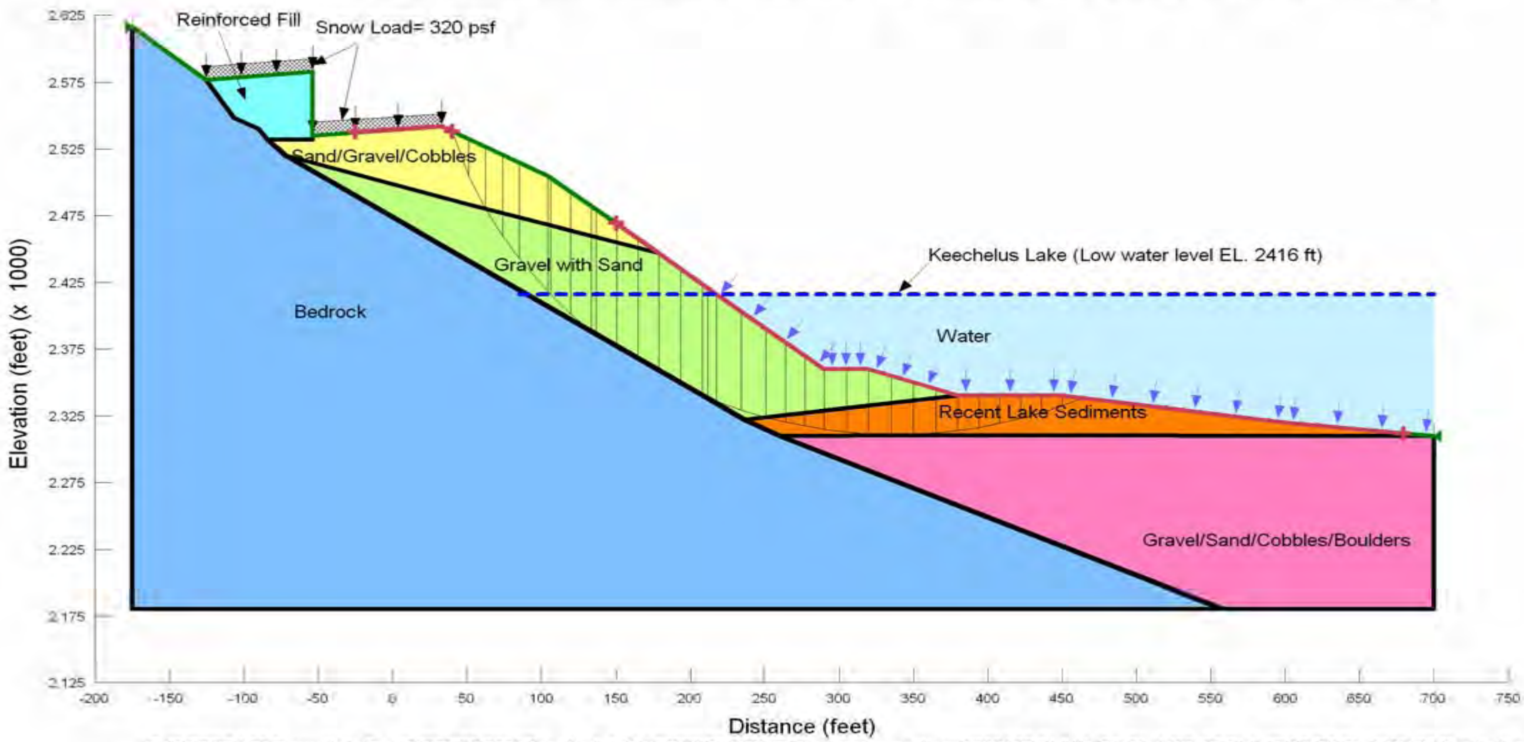
WSDOT I-90 Snoqualmie Pass East
2010 Geotechnical Analysis and Reporting

Slide Curve Median Wall at WB Station 1407+15

Safety Factor =1.11

Loading: Static
Embankment Configuration: Existing
Analysis Type: 0 tiebacks(0 kips/ft/tieback)
Water Table:Low lake level (EL. 2416)

Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Recent Lake Sediments Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Interface Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel/Sand/Cobbles/Boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1



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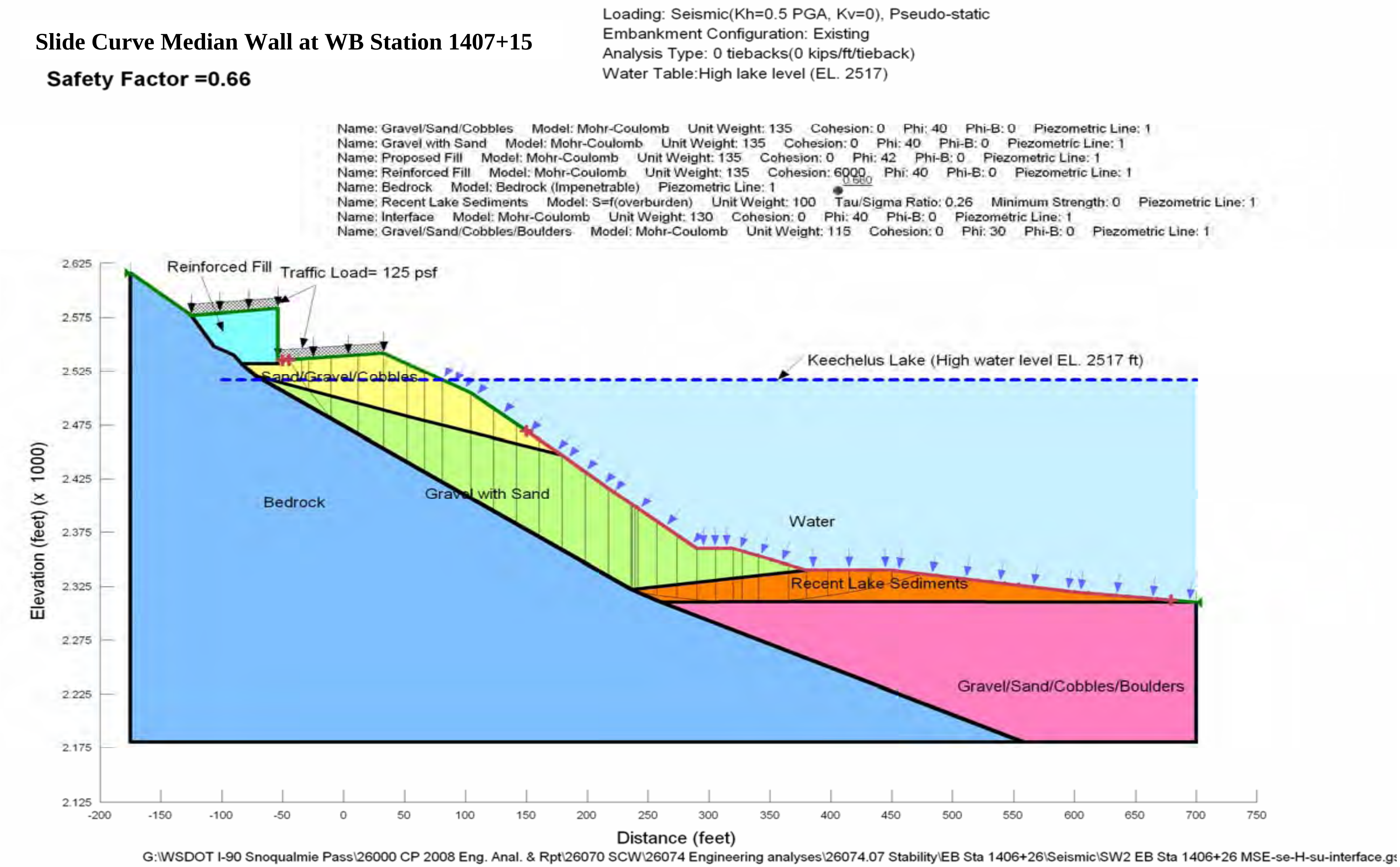
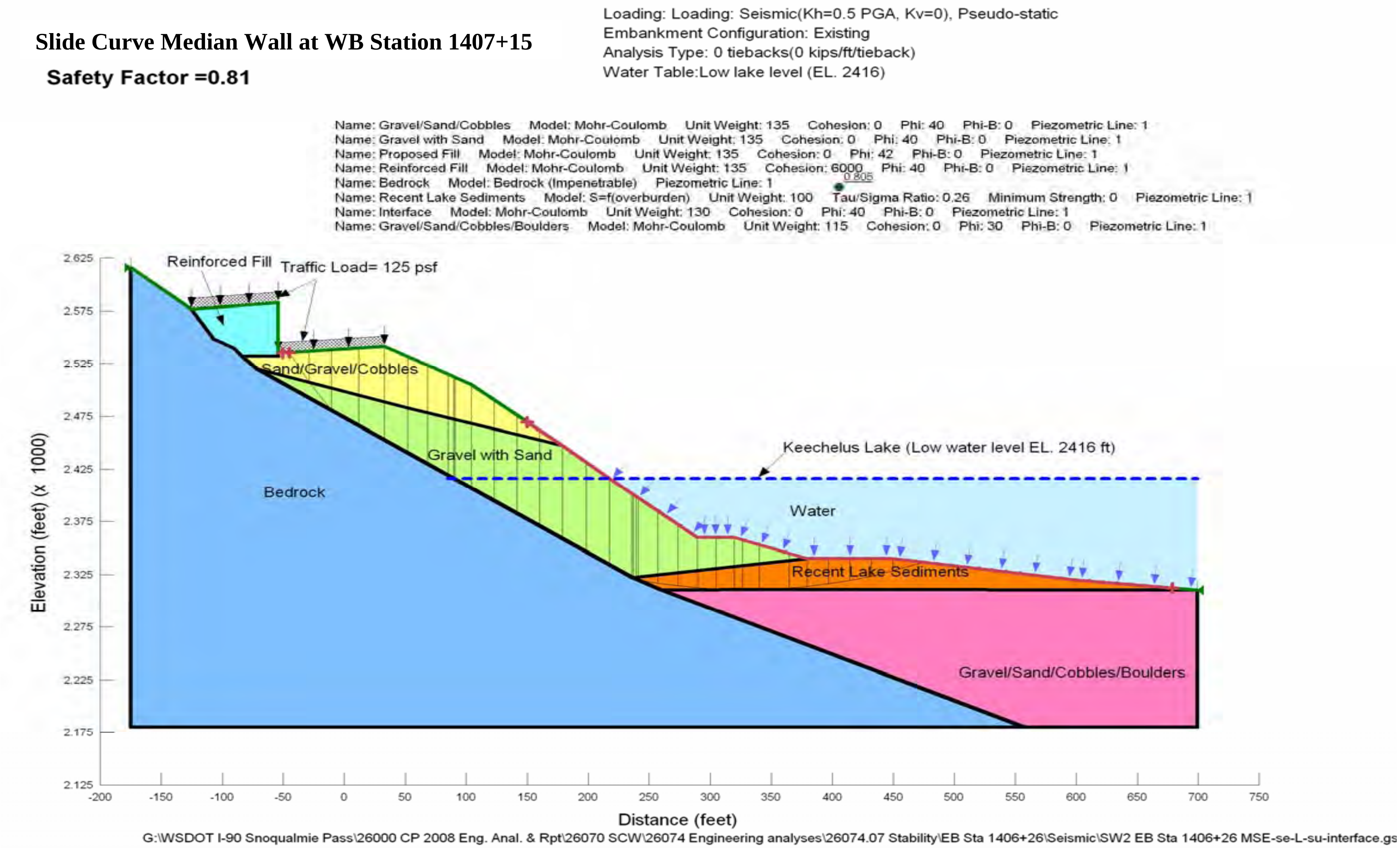


Job No. 33758662

Figure H.4.13

URS

WSDOT I-90 Snoqualmie Pass East
2010 Geotechnical Analysis and Reporting



Slide Curve Median Wall at WB Station 1407+15
Safety Factor =0.81
Loading: Loading: Seismic(Kh=0.5 PGA, Kv=0), Pseudo-static
Embankment Configuration: Existing
Analysis Type: 0 tiebacks(0 kips/ft/tieback)
Water Table:Low lake level (EL. 2416)
Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Recent Lake Sediments Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1
Name: Interface Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel/Sand/Cobbles/Boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Reinforced Fill
Traffic Load= 125 psf
Sand/Gravel/Cobbles
Gravel with Sand
Keechelus Lake (Low water level EL. 2416 ft)
Water
Bedrock
Recent Lake Sediments
Gravel/Sand/Cobbles/Boulders
Elevation (feet) (x 1000)
Distance (feet)
G:\WSDOT I-90 Snoqualmie Pass\26000 CP 2008 Eng. Anal. & Rpt\26070 SCW\26074 Engineering analyses\26074.07 Stability\EB Sta 1406+26\Seismic\SW2 EB Sta 1406+26 MSE-se-L-su-interface.gs

APPENDIX H.5
W&N Stability Analysis Results - Slide Curve Median Wall

"Norman Norrish" <nnorrish@msn.com>

11/07/2008 08:33 AM

To <Dave_Walker@URSCorp.com>

cc

bcc

Subject RE: Slide Curve median wall stability analysis

Files Attached: **0**	Total Email Size: **10 kb**
Click here to refresh values or press '**F9**' on your keyboard	

History: This message has been replied to and forwarded.
This message has been archived.

Dave:
Attached are the preliminary median wall analyses intended to guide your evaluation relative to further in-lake drilling.

I analyzed four scenarios:

Figure 1: Failure surface exploits residual failure surface from 1957, with embankment soil.
Figure 2: Failure surface exploits residual failure surface from 1957, embankment soil in front of wall has been evacuated.
Figure 3: Circular failure surface, with embankment soil
Figure 4: Circular failure surface, embankment soil in front of wall has been evacuated.

Shear strengths for soils down slope of wall per your instructions. Stratigraphy as presented in your Section 2-2' modified with the inclusion of boreholes SCW-006A-08 and SCW-006-08. The bedrock was categorized as Domain 1 (blue), Domain2(yellow) or Domain 3 (orange). Domains 1 and 2 are essentially too strong to fail without persistent, low shear strength, adversely-oriented structures. Although the down slope drilling below the wall was not deep enough to categorically refute the presence of such feature, the proximal geology gives no reason to suspect they exist. Domain 3 was modeled as a Hoek-Brown material with a non-linear shear strength envelope. The shear strength for Domain 3 is similar to the proposed embankment at the operative normal stresses. For the pre existing residual failure surface shear strengths in the range of 28 to 35 deg (zero cohesion) were used.

All materials except the gravels in front of the wall were assumed to be subjected to a high perched water table condition termed "transient" that is based on continuous monitoring records and site observation of ephemeral springs. The gravels were assumed to respond to a lower water table controlled by the lake level.

Removal of the embankment soils in front of the wall (shown in white) was simulated by assigning zero shear strength and zero unit weight. Thus the failure surfaces still pass through this material but there is no contribution to stability. The soils were assumed to evacuate down to the clayey silt layer. The results show the ten failure surfaces with the lowest FS values.

The results show adequate stability under static and pseudo static (0.175g) conditions for all cases (even with the unlikely superposition of a high transient water table and earthquake loading). The structurally controlled surface shows the lowest stability. The contribution of the dowels is probably reasonable for the structurally controlled failure but could be compromised by the location of the failure surface for the material failure case. It appears that the presence of Domain 2 rock immediately below the face of the wall is critical to preventing the failure surfaces from migrating deeper. In this regard, a high reliance is placed on borehole SCW-006A-08 (unfortunate it wasn't a bit deeper).

These results are preliminary and require review prior to being finalized in a future report. Call or email if you have any questions.

Regards
Norm Norrish
Wyllie & Norrish Rock Engineers Inc.

From: Dave_Walker@URSCorp.com [mailto:Dave_Walker@URSCorp.com]
Sent: Tuesday, October 28, 2008 10:37 AM
To: nnorrish@msn.com
Cc: Chuck_Vita@URSCorp.com; Suren_Balendra@URSCorp.com
Subject: Slide Curve median wall stability analysis

Norm-

This email is to confirm our discussion of 10/28. Please evaluate the factor of safety against a global stability failure through bedrock that would affect the median wall at WB Sta 1398+99 (seismic, kh = 0.175, and static loading). The median wall may be assumed to be founded on bedrock at this location.

Our cross section at this station is attached. Note that this section has not been updated to include borings SCW-006-08 and SCW-006A-08. Boring SCW-006A-08 encountered bedrock at a depth of 6.4 ft beneath the wall face at this section. SCW-006-08 was drilled 23 feet to the lakeside of the wall face alignment and encountered bedrock at a depth of 19 feet. I have also attached those boring logs.

For soil, please use these properties:

Stratum 1. Gravel with sand/cobbles/boulders.
Phi = 40 degrees
Total unit weight = 135 pcf

Stratum 2. Clayey silt.
Phi = 30
Total unit weight = 110

Stratum 3 (orange). Gravel with sand/cobbles/boulders.
Phi = 40
Total unit weight = 135

Please consider the effect of potential instability of the embankment soil in your analysis. One of the objectives of this analysis is to determine if borings in the lake are needed to evaluate stability of the embankment soil. One way of looking at this would be that if the wall is stable with both the embankment soil present or absent, then the stability of the embankment is not a concern.

We need to have a decision on whether to drill the lake borings by Friday, November 7. If your analysis could be completed before that date, it could be used to help make that decision.

Please provide a budget estimate for this work as we will need to submit an amendment to WSDOT. As we discussed, the results should be documented in the rock slopes report under Task Order CP.

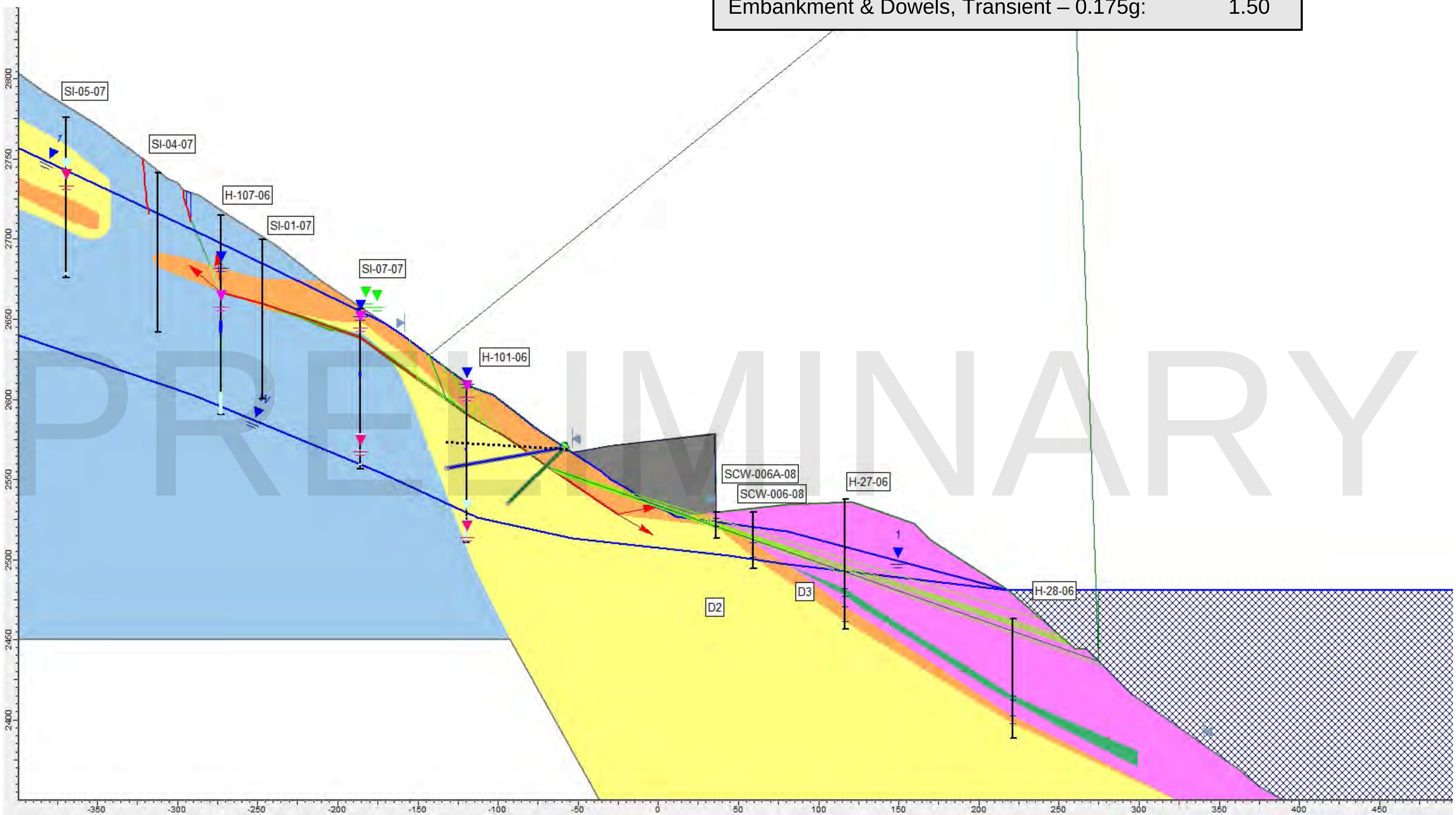
(See attached file: CROSSECTION 2-2'.pdf)(See attached file: Boring SCW-006-08.pdf)(See attached file: Boring SCW-006A-08.pdf)

Dave Walker, P.E.
URS Group, Inc.
1501 4th Avenue, Suite 1400
Seattle, WA 98101-1616
Direct: 206-438-2350
Fax: 1-866-495-5288

[attachment "W&N Median Wall Analyses.pdf" deleted by Dave Walker/Seattle/URSCorp]

Design Section at Station 1398+20WB

Case	FS
Embankment Only, Transient WT - static:	2.32
Embankment & Dowels, Transient – static:	2.35
Embankment Only, Transient – 0.175g:	1.47
Embankment & Dowels, Transient – 0.175g:	1.50



Project No. 062-2002 **Date:** September, 2008

Figure 1

Median Wall Stability Analysis: Structural Control with Embankment Soil

wyllie & norrish ROCK ENGINEERS

I-90 Snoqualmie Pass East
Hyak to Keechelus Dam

Design Section at Station 1398+20WB

Case	FS
Embankment Only, Transient WT - static:	2.04
Embankment & Dowels, Transient – static:	2.12
Embankment Only, Transient – 0.175g:	1.31
Embankment & Dowels, Transient – 0.175g:	1.40

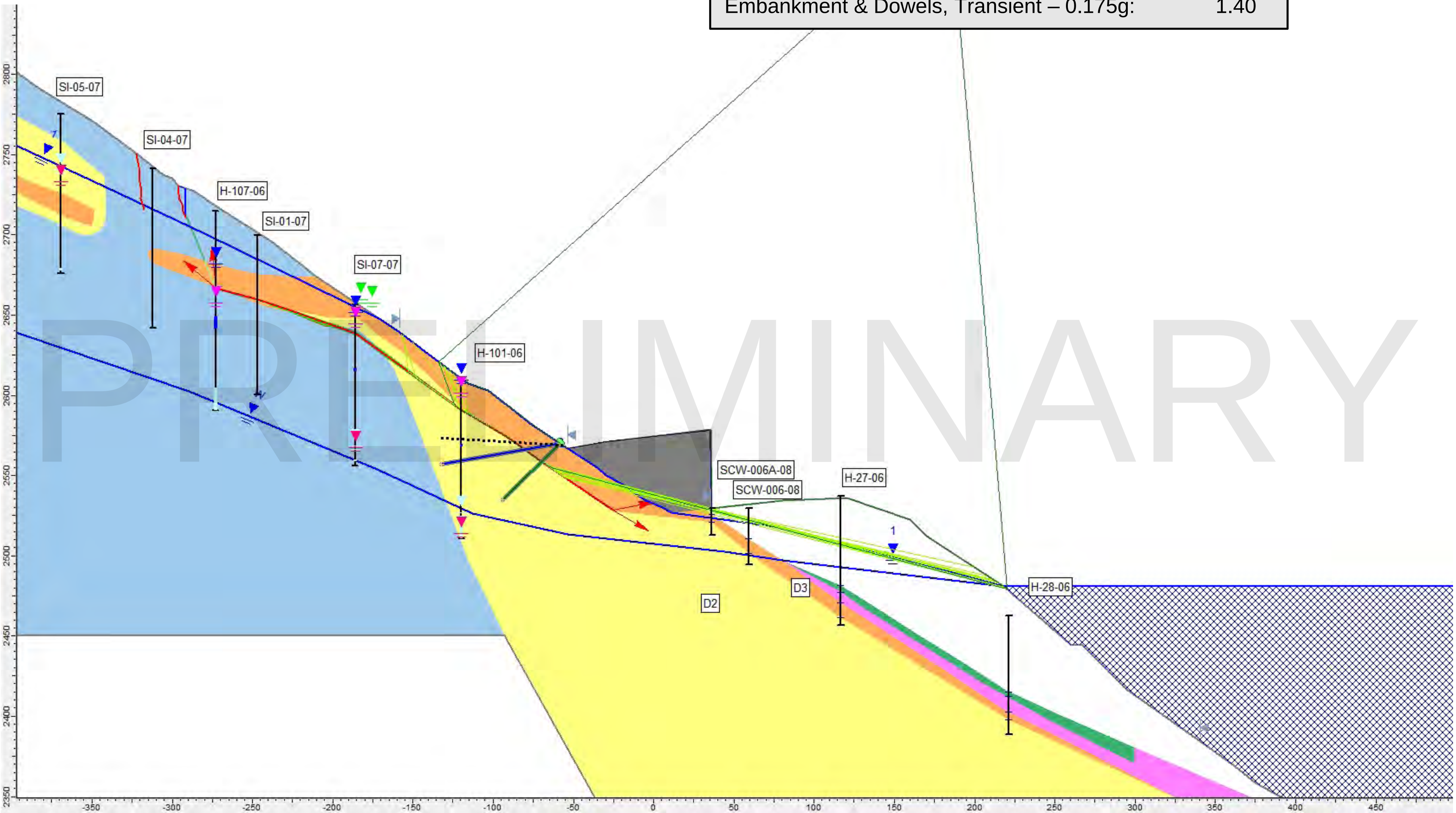


Figure 2

Median Wall Stability Analysis: Structural Control without Embankment Soil

Project No. 062-2002 **Date:** September, 2008

wyllie & norrish ROCK ENGINEERS

I-90 Snoqualmie Pass East
Hyak to Keechelus Dam

Design Section at Station 1398+20WB

Case	FS
Embankment Only, Transient WT - static:	2.67
Embankment & Dowels, Transient – static:	2.77
Embankment Only, Transient – 0.175g:	1.69
Embankment & Dowels, Transient – 0.175g:	1.78

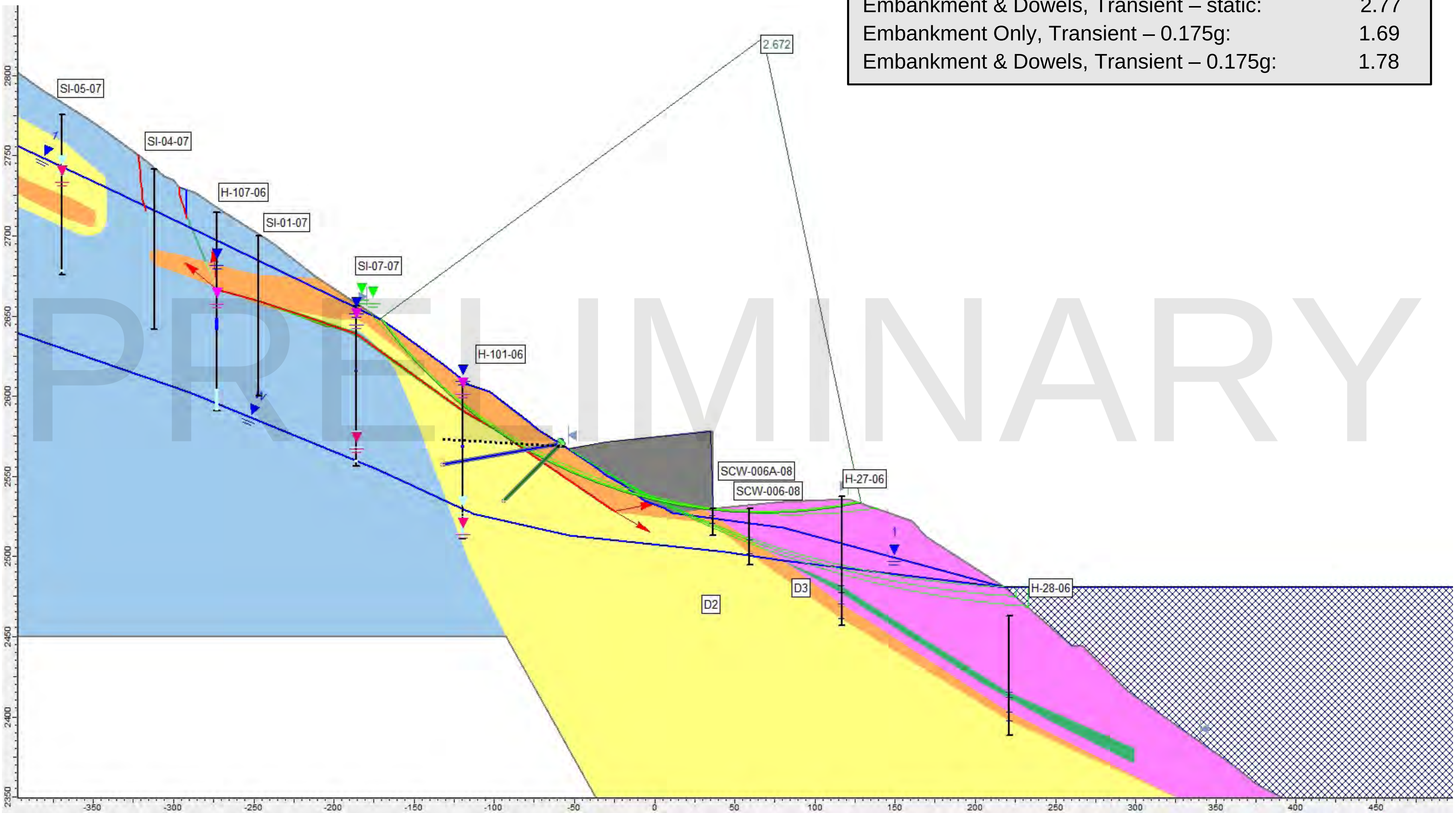


Figure 3

Median Wall Stability Analysis: Circular Failure with Embankment Soil

Project No. 062-2002 Date: September, 2008

wyllie & norrish ROCK ENGINEERS

I-90 Snoqualmie Pass East
Hyak to Keechelus Dam

Design Section at Station 1398+20WB

Case	FS
Embankment Only, Transient WT - static:	2.26
Embankment & Dowels, Transient – static:	2.40
Embankment Only, Transient – 0.175g:	1.44
Embankment & Dowels, Transient – 0.175g:	1.56

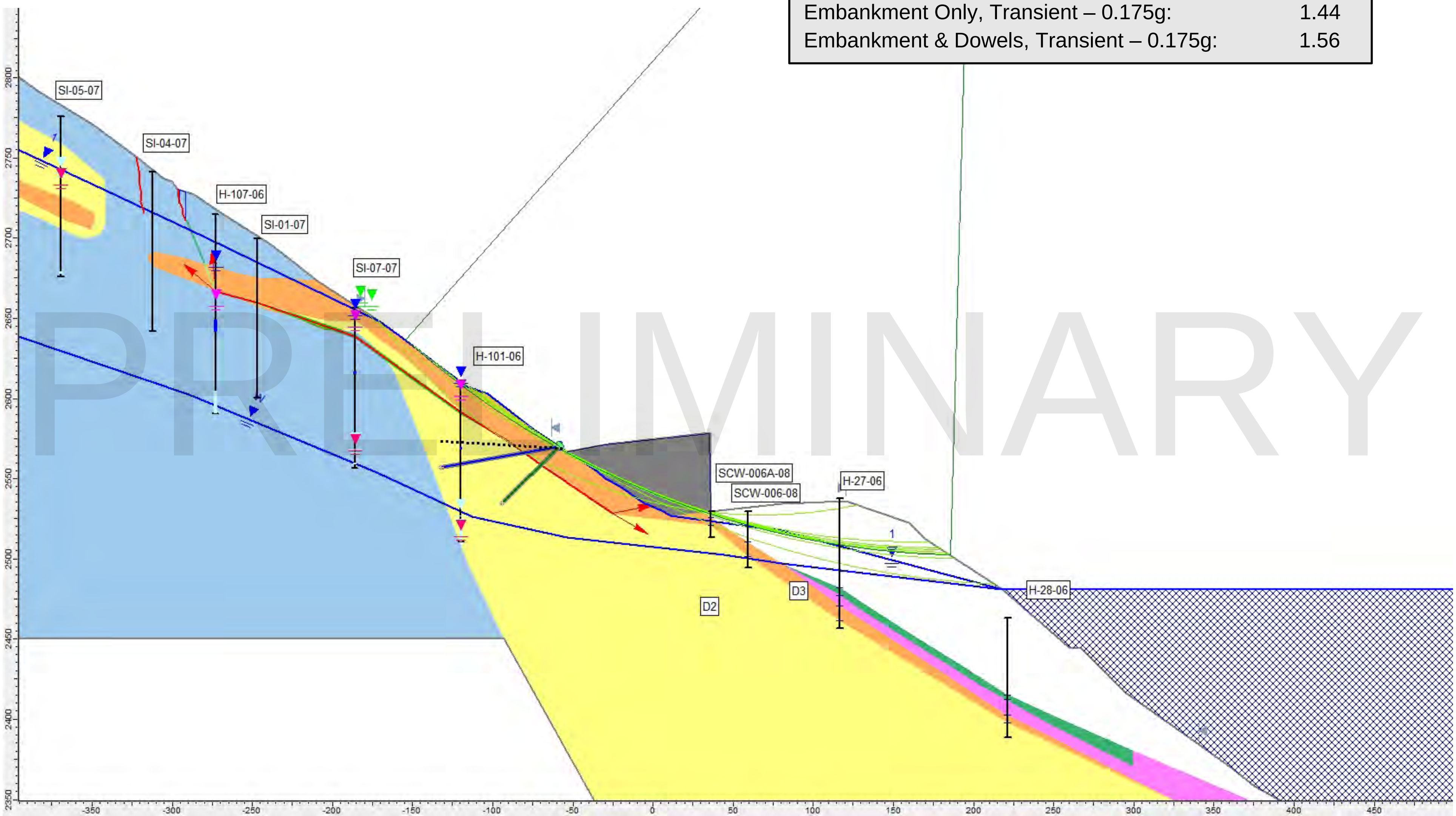


Figure 4

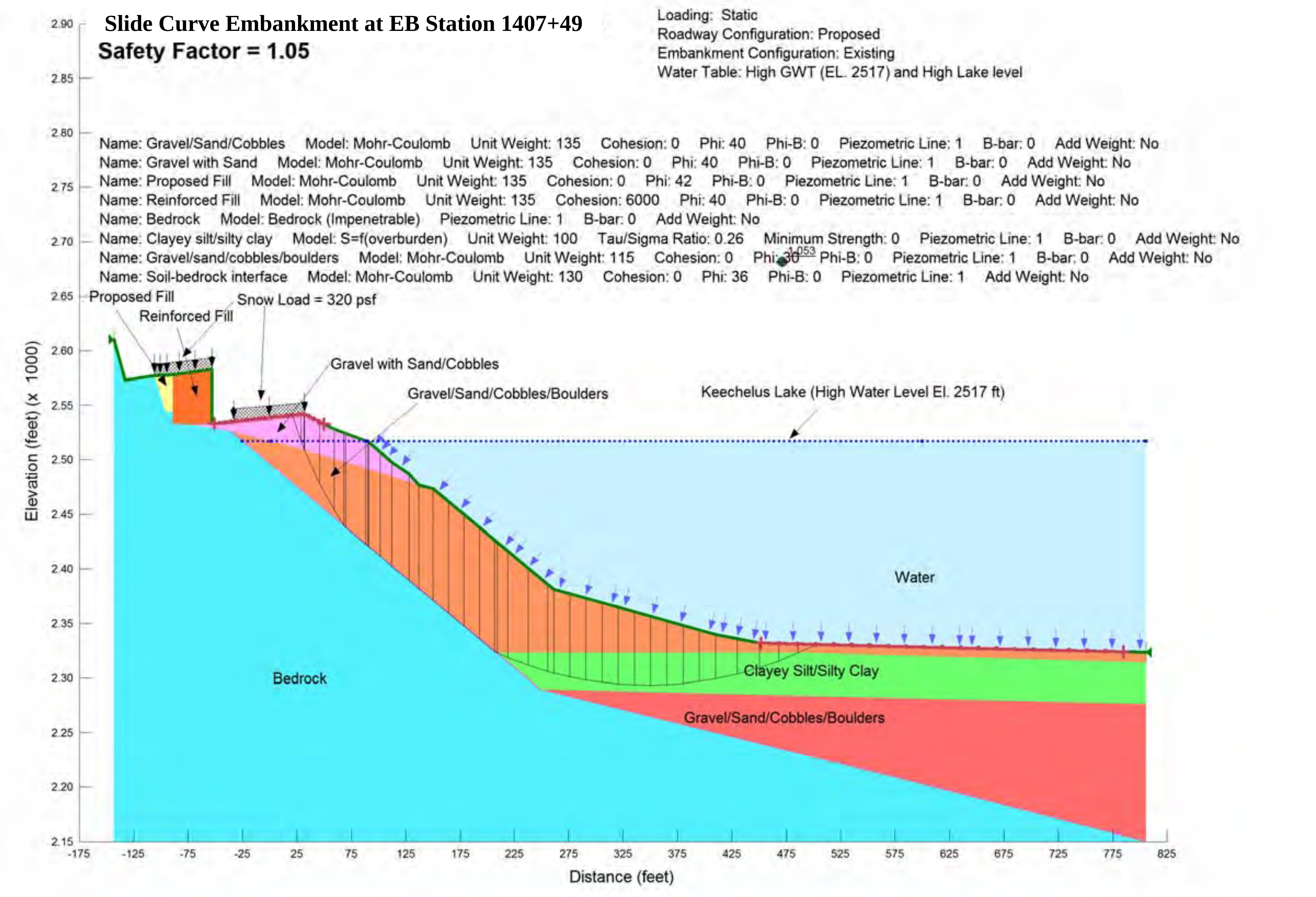
Median Wall Stability Analysis: Circular Failure without Embankment Soil

Project No. 062-2002 **Date:** September, 2008

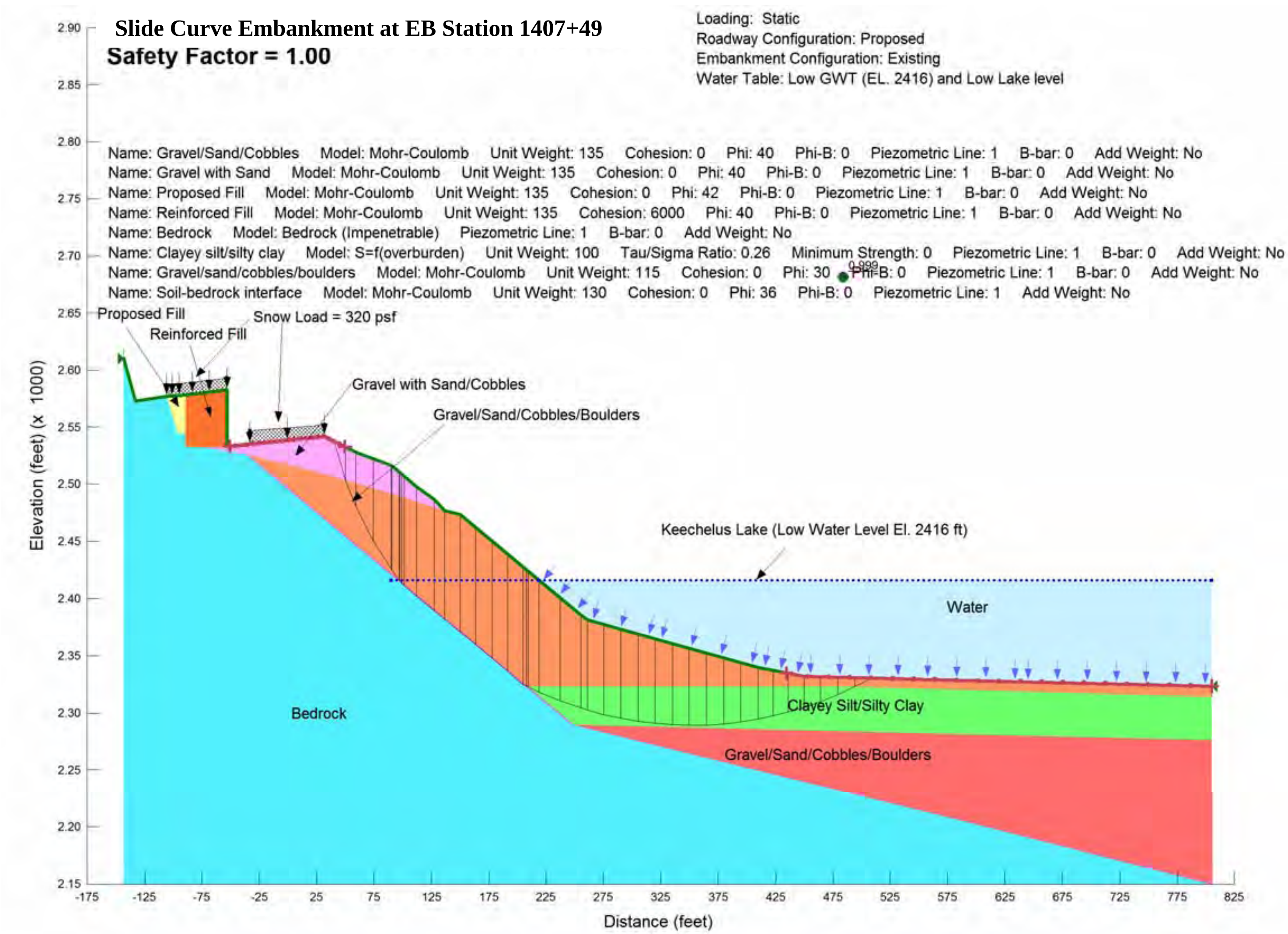
Wyllie & Norrish Rock Engineers

I-90 Snoqualmie Pass East
Hyak to Keechelus Dam

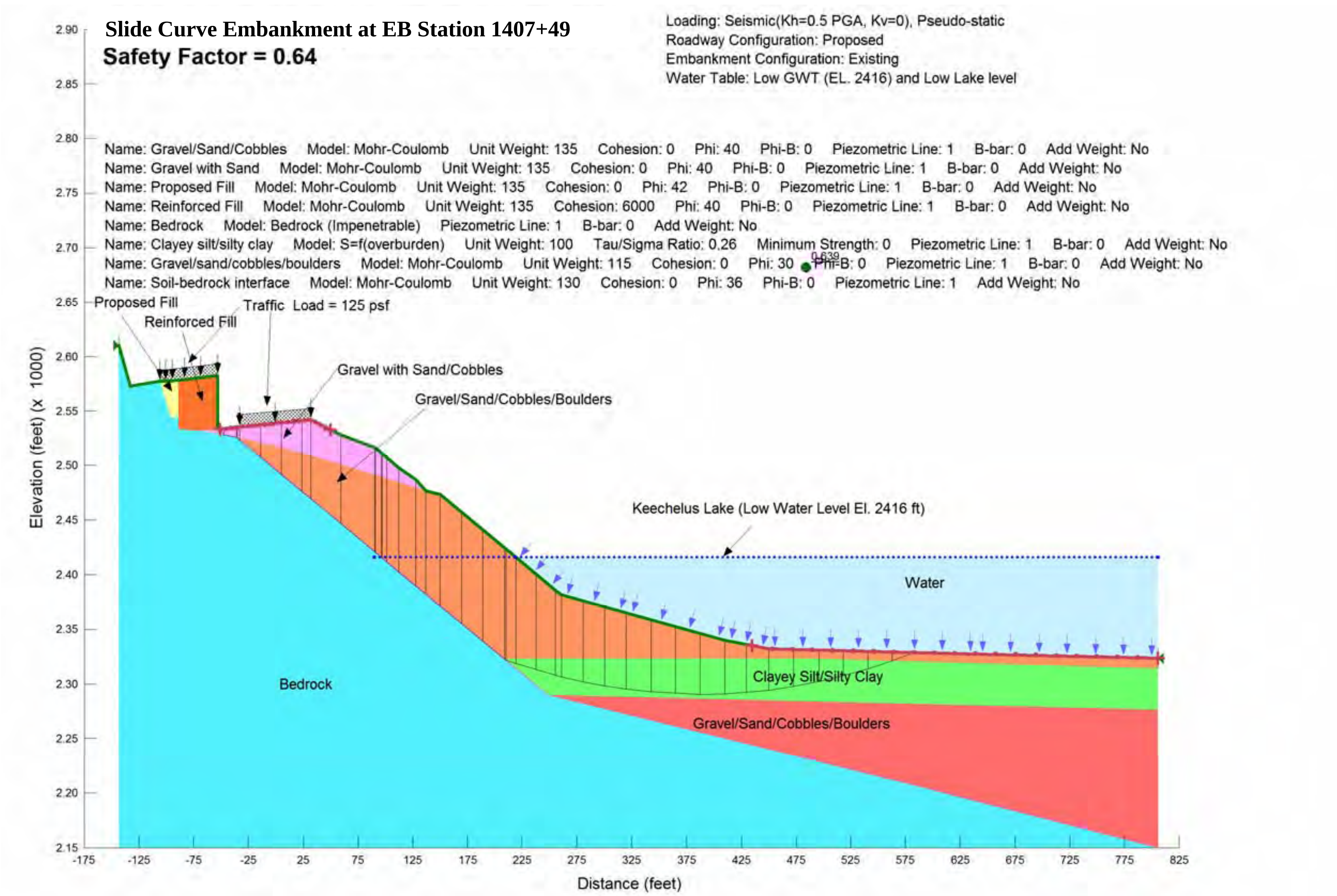
APPENDIX H.6
Stability Analysis Results - Slide Curve Embankment Stabilization



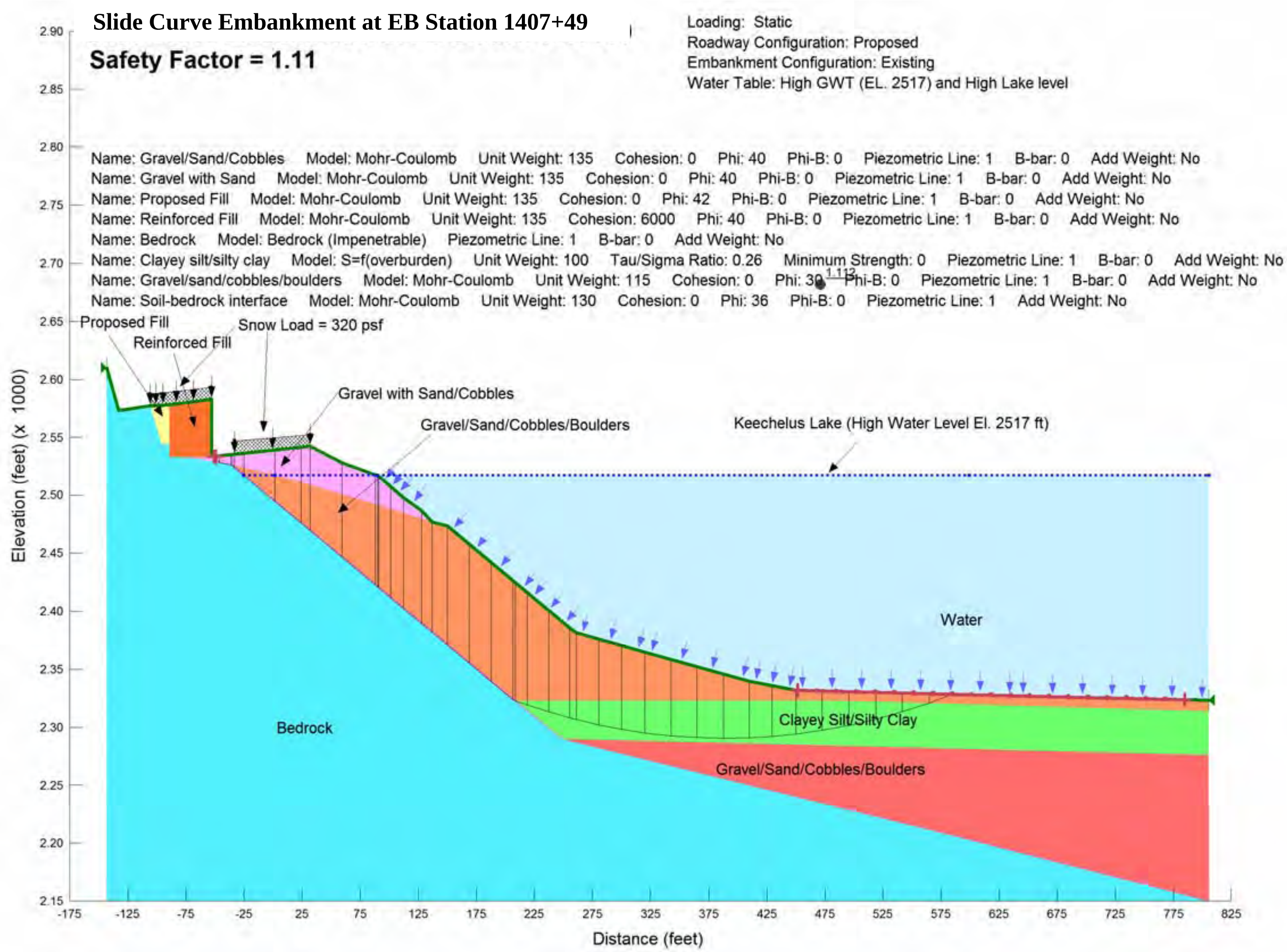
Slide Curve Embankment at EB Station 1407+49
Safety Factor = 1.05
Loading: Static
Roadway Configuration: Proposed
Embankment Configuration: Existing
Water Table: High GWT (EL. 2517) and High Lake level
Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Clayey silt/silty clay Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel/sand/cobbles/boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Soil-bedrock interface Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 36 Phi-B: 0 Piezometric Line: 1 Add Weight: No
1.053
Proposed Fill
Reinforced Fill
Snow Load = 320 psf
Gravel with Sand/Cobbles
Gravel/Sand/Cobbles/Boulders
Keechelus Lake (High Water Level El. 2517 ft)
Water
Bedrock
Clayey Silt/Silty Clay
Gravel/Sand/Cobbles/Boulders
Elevation (feet) (x 1000)
2.90
2.85
2.80
2.75
2.70
2.65
2.60
2.55
2.50
2.45
2.40
2.35
2.30
2.25
2.20
2.15
Distance (feet)
-175 -125 -75 -25 25 75 125 175 225 275 325 375 425 475 525 575 625 675 725 775 825



Slide Curve Embankment at EB Station 1407+49
Safety Factor = 1.00
Loading: Static
Roadway Configuration: Proposed
Embankment Configuration: Existing
Water Table: Low GWT (EL. 2416) and Low Lake level
Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Clayey silt/silty clay Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel/sand/cobbles/boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Soil-bedrock interface Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 36 Phi-B: 0 Piezometric Line: 1 Add Weight: No
0.999
Proposed Fill
Reinforced Fill
Snow Load = 320 psf
Gravel with Sand/Cobbles
Gravel/Sand/Cobbles/Boulders
Keechelus Lake (Low Water Level El. 2416 ft)
Water
Bedrock
Clayey Silt/Silty Clay
Gravel/Sand/Cobbles/Boulders
Elevation (feet) (x 1000)
2.90
2.85
2.80
2.75
2.70
2.65
2.60
2.55
2.50
2.45
2.40
2.35
2.30
2.25
2.20
2.15
-175
-125
-75
-25
25
75
125
175
225
275
325
375
425
475
525
575
625
675
725
775
825
Distance (feet)

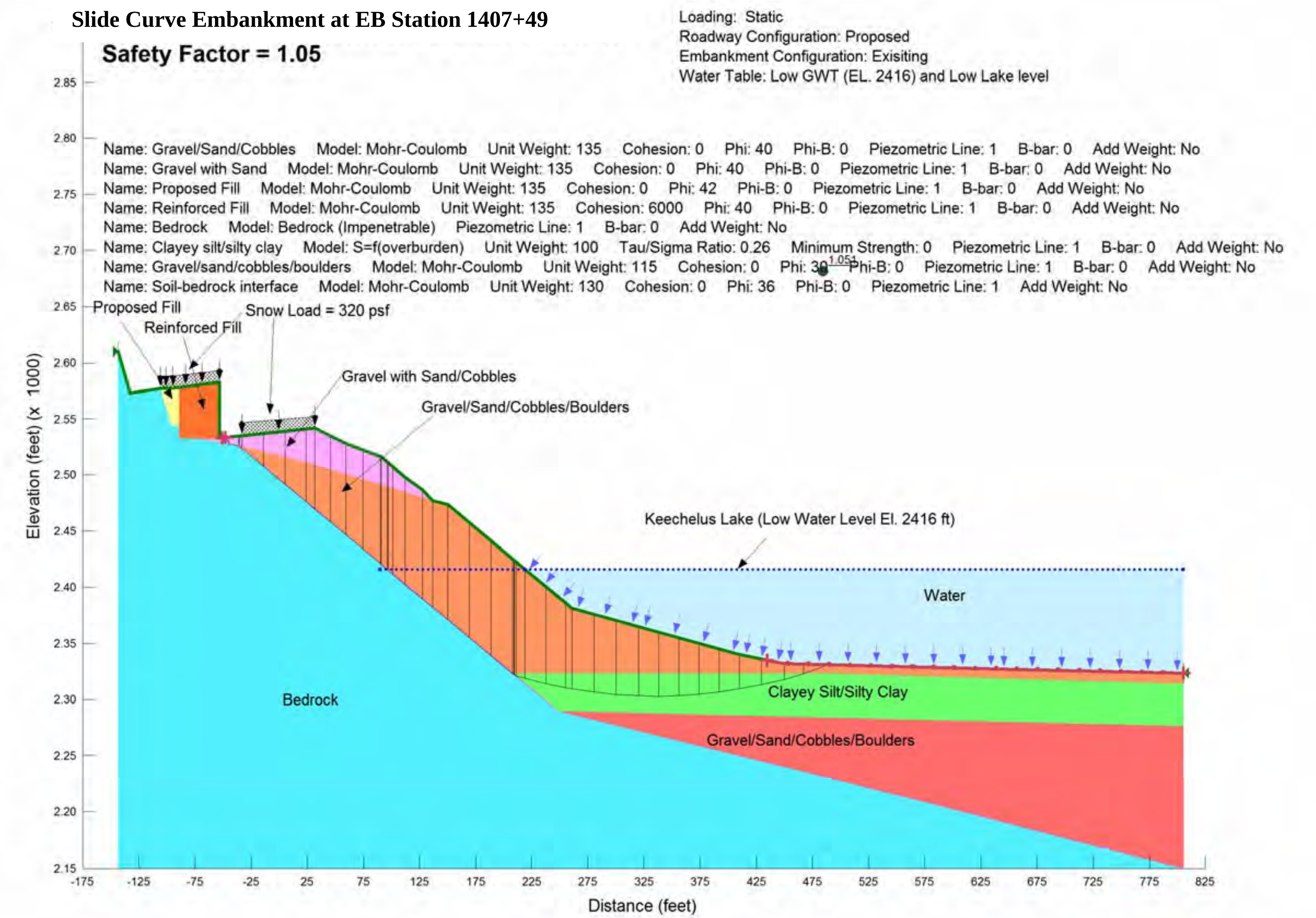


Slide Curve Embankment at EB Station 1407+49
Safety Factor = 0.64
Loading: Seismic(Kh=0.5 PGA, Kv=0), Pseudo-static
Roadway Configuration: Proposed
Embankment Configuration: Existing
Water Table: Low GWT (EL. 2416) and Low Lake level
Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Clayey silt/silty clay Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel/sand/cobbles/boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Soil-bedrock interface Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 36 Phi-B: 0 Piezometric Line: 1 Add Weight: No
0.639
Proposed Fill
Reinforced Fill
Traffic Load = 125 psf
Gravel with Sand/Cobbles
Gravel/Sand/Cobbles/Boulders
Keechelus Lake (Low Water Level El. 2416 ft)
Water
Bedrock
Clayey Silt/Silty Clay
Gravel/Sand/Cobbles/Boulders
Elevation (feet) (x 1000)
2.90
2.85
2.80
2.75
2.70
2.65
2.60
2.55
2.50
2.45
2.40
2.35
2.30
2.25
2.20
2.15
Distance (feet)
-175
-125
-75
-25
25
75
125
175
225
275
325
375
425
475
525
575
625
675
725
775
825

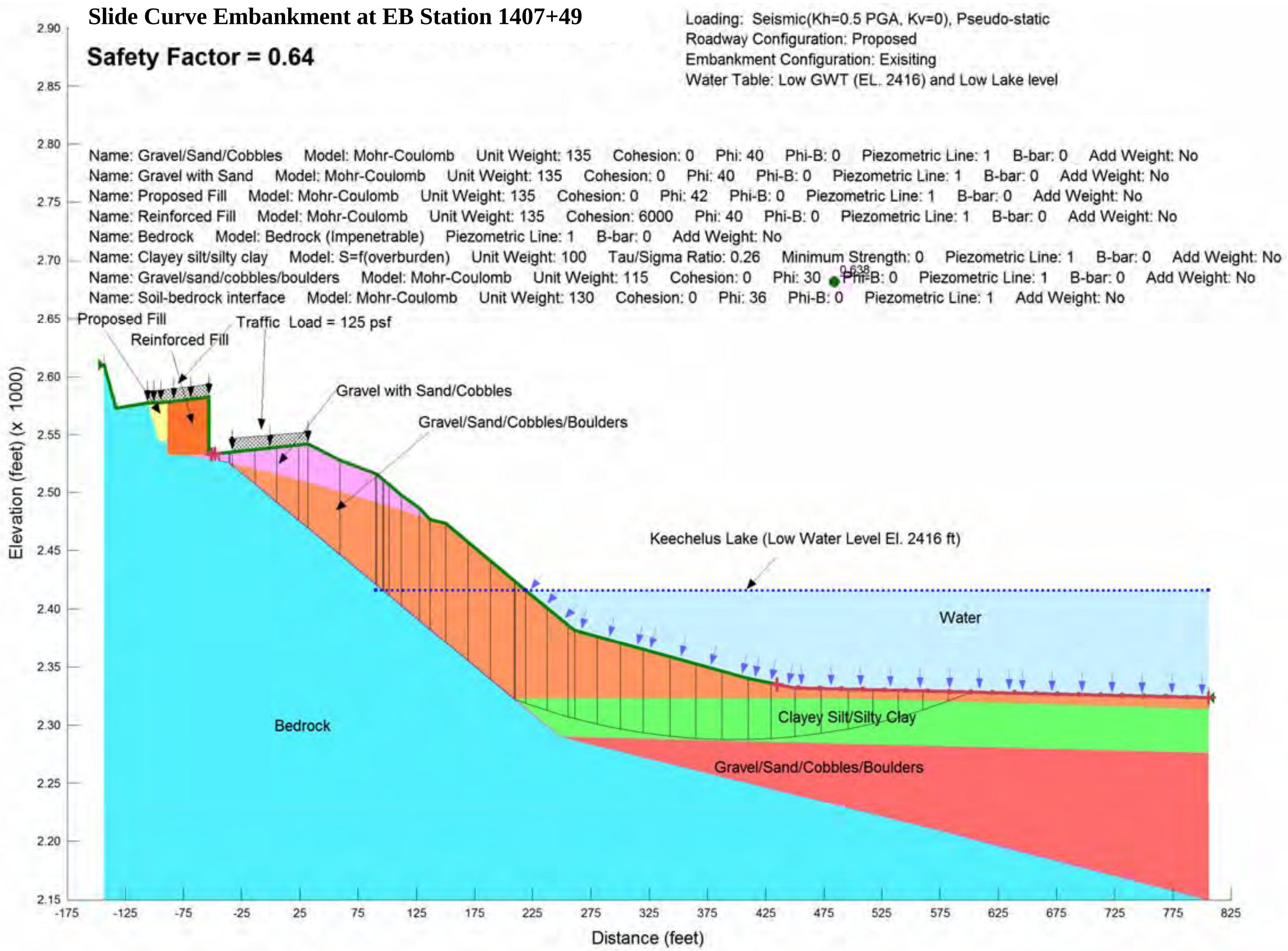


Job No. 33758662

Figure H.6.4



Slide Curve Embankment at EB Station 1407+49
Safety Factor = 1.05
Loading: Static
Roadway Configuration: Proposed
Embankment Configuration: Exisiting
Water Table: Low GWT (EL. 2416) and Low Lake level
Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Clayey silt/silty clay Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel/sand/cobbles/boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Soil-bedrock interface Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 36 Phi-B: 0 Piezometric Line: 1 Add Weight: No
1.051
Proposed Fill
Reinforced Fill
Snow Load = 320 psf
Gravel with Sand/Cobbles
Gravel/Sand/Cobbles/Boulders
Keechelus Lake (Low Water Level El. 2416 ft)
Water
Bedrock
Clayey Silt/Silty Clay
Gravel/Sand/Cobbles/Boulders
Elevation (feet) (x 1000)
2.85
2.80
2.75
2.70
2.65
2.60
2.55
2.50
2.45
2.40
2.35
2.30
2.25
2.20
2.15
-175 -125 -75 -25 25 75 125 175 225 275 325 375 425 475 525 575 625 675 725 775 825
Distance (feet)



Slide Curve Embankment at EB Station 1407+49
Safety Factor = 0.64
Loading: Seismic(Kh=0.5 PGA, Kv=0), Pseudo-static
Roadway Configuration: Proposed
Embankment Configuration: Exisiting
Water Table: Low GWT (EL. 2416) and Low Lake level
Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Clayey silt/silty clay Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel/sand/cobbles/boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Soil-bedrock interface Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 36 Phi-B: 0 Piezometric Line: 1 Add Weight: No
0.638
Proposed Fill
Reinforced Fill
Traffic Load = 125 psf
Gravel with Sand/Cobbles
Gravel/Sand/Cobbles/Boulders
Keechelus Lake (Low Water Level El. 2416 ft)
Water
Clayey Silt/Silty Clay
Bedrock
Gravel/Sand/Cobbles/Boulders
Elevation (feet) (x 1000)
2.90
2.85
2.80
2.75
2.70
2.65
2.60
2.55
2.50
2.45
2.40
2.35
2.30
2.25
2.20
2.15
-175
-125
-75
-25
25
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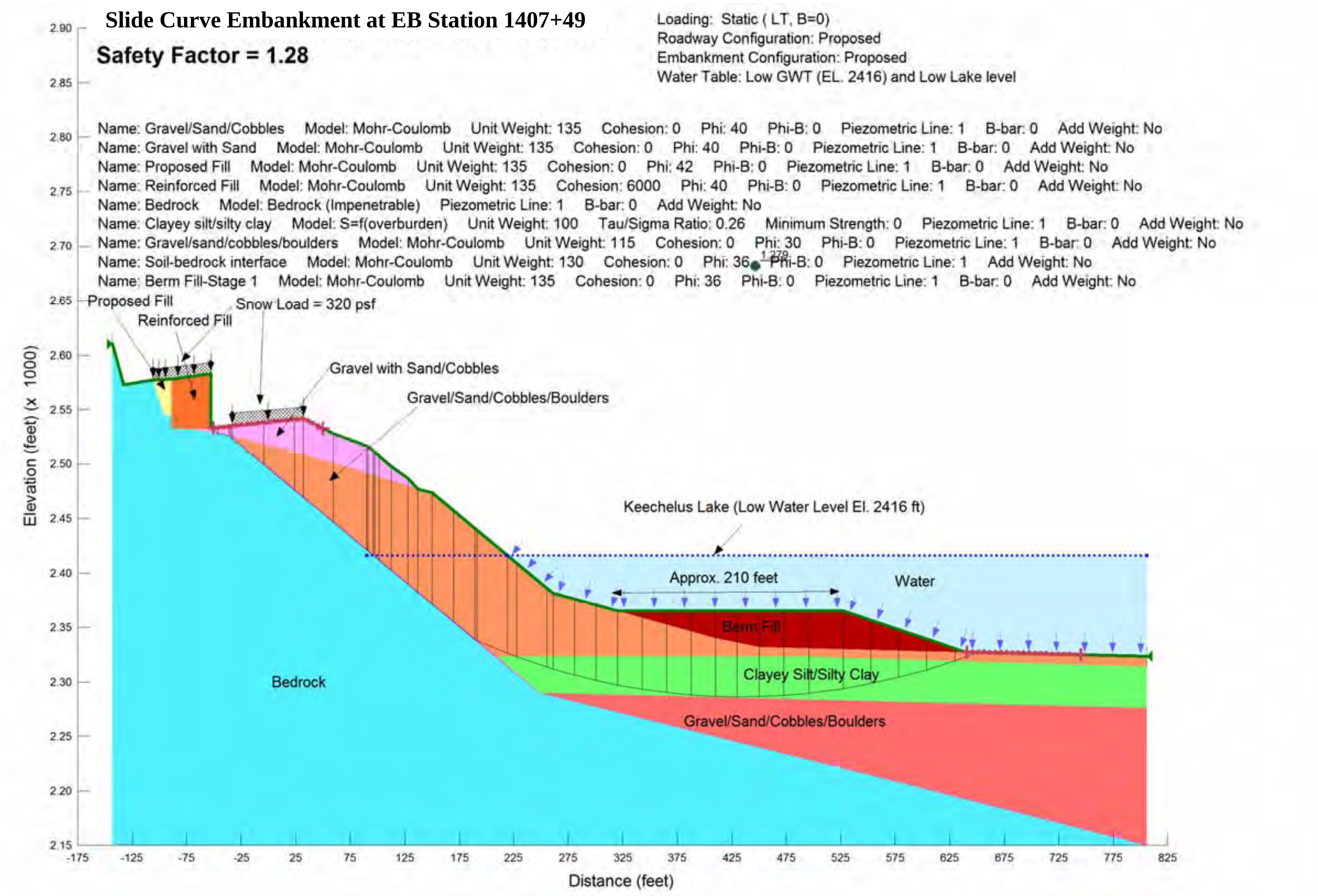
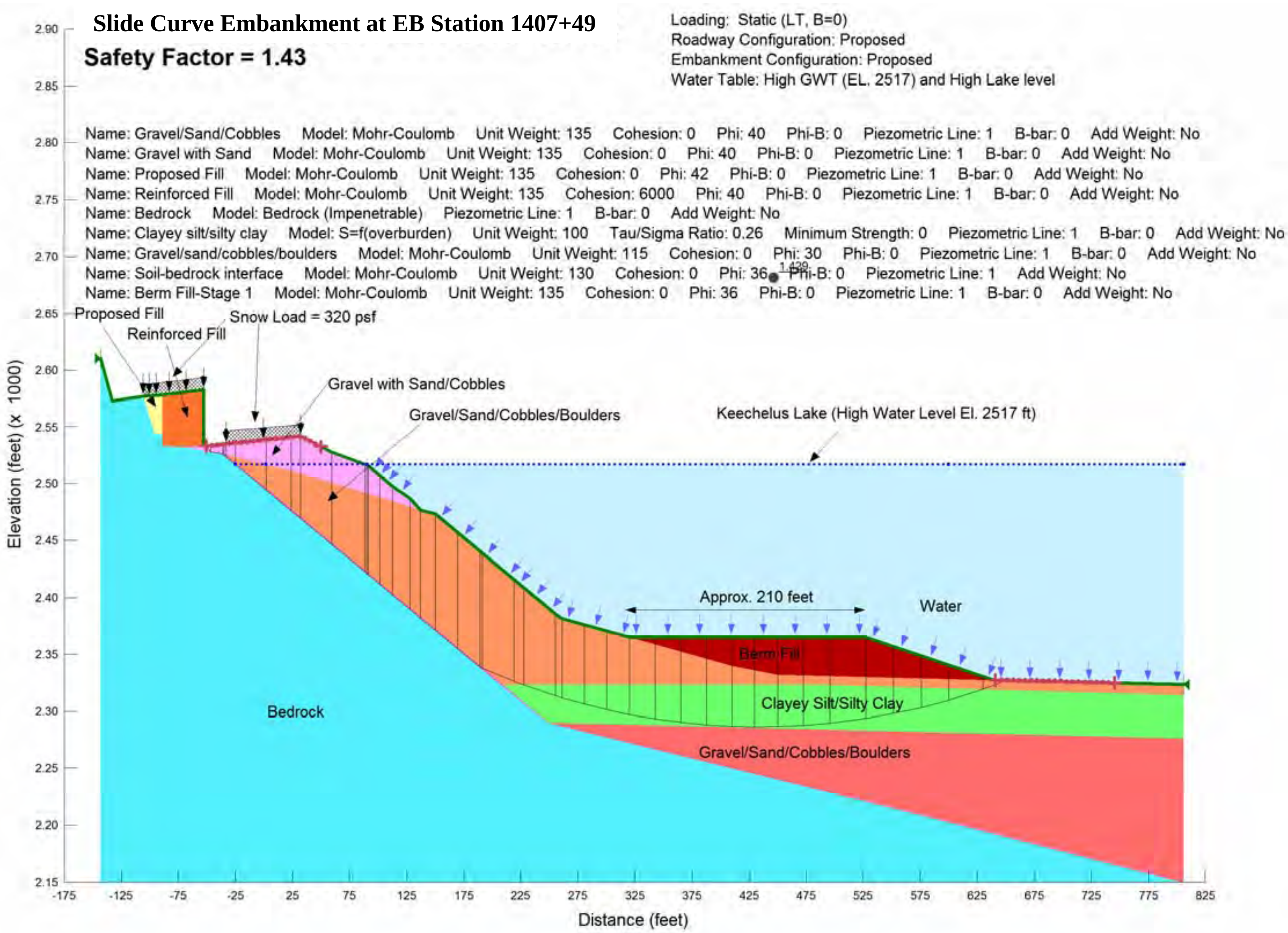
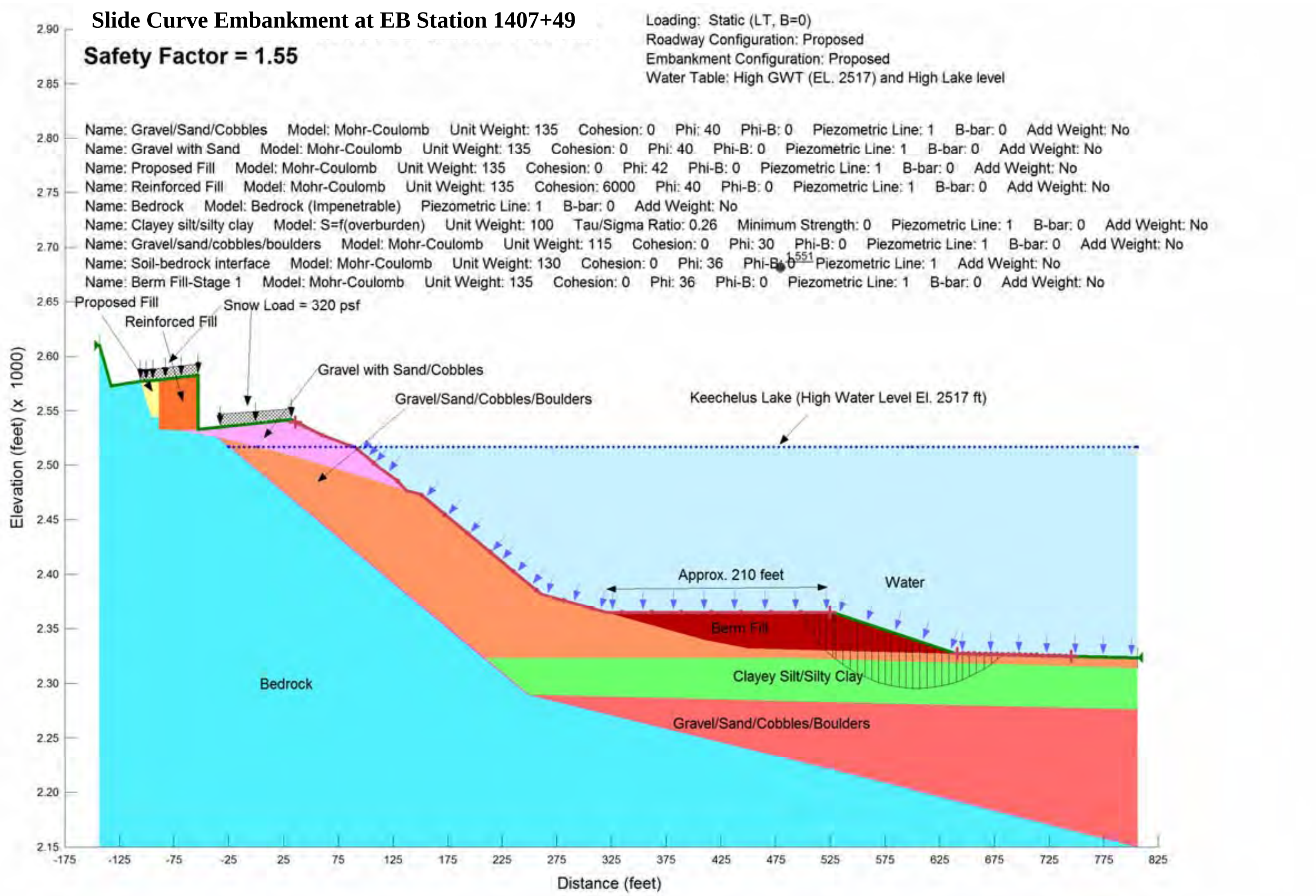
175
225
275
325
375
425
475
525
575
625
675
725
775
825
Distance (feet)


Slide Curve Embankment at EB Station 1407+49
Safety Factor = 1.28
Loading: Static (LT, B=0)
Roadway Configuration: Proposed
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2416) and Low Lake level
Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Clayey silt/silty clay Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel/sand/cobbles/boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Soil-bedrock interface Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 36 Phi-B: 0 Piezometric Line: 1 Add Weight: No
Name: Berm Fill-Stage 1 Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 36 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
1.279
Proposed Fill
Reinforced Fill
Snow Load = 320 psf
Gravel with Sand/Cobbles
Gravel/Sand/Cobbles/Boulders
Keechelus Lake (Low Water Level El. 2416 ft)
Approx. 210 feet
Water
Berm Fill
Clayey Silt/Silty Clay
Bedrock
Gravel/Sand/Cobbles/Boulders
Elevation (feet) (x 1000)
2.90
2.85
2.80
2.75
2.70
2.65
2.60
2.55
2.50
2.45
2.40
2.35
2.30
2.25
2.20
2.15
Distance (feet)
-175 -125 -75 -25 25 75 125 175 225 275 325 375 425 475 525 575 625 675 725 775 825



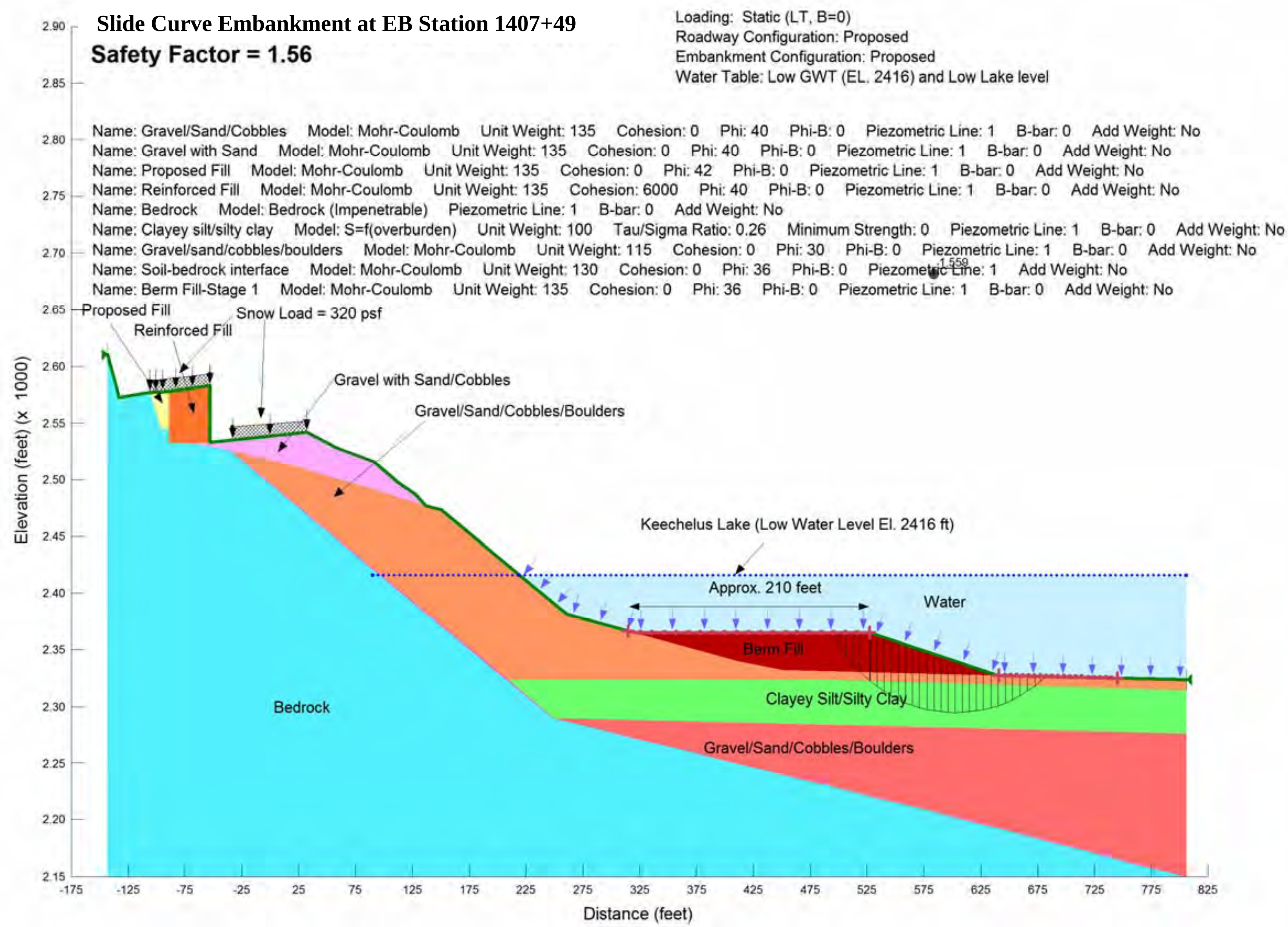
Job No. 33758662

Figure H.6.8



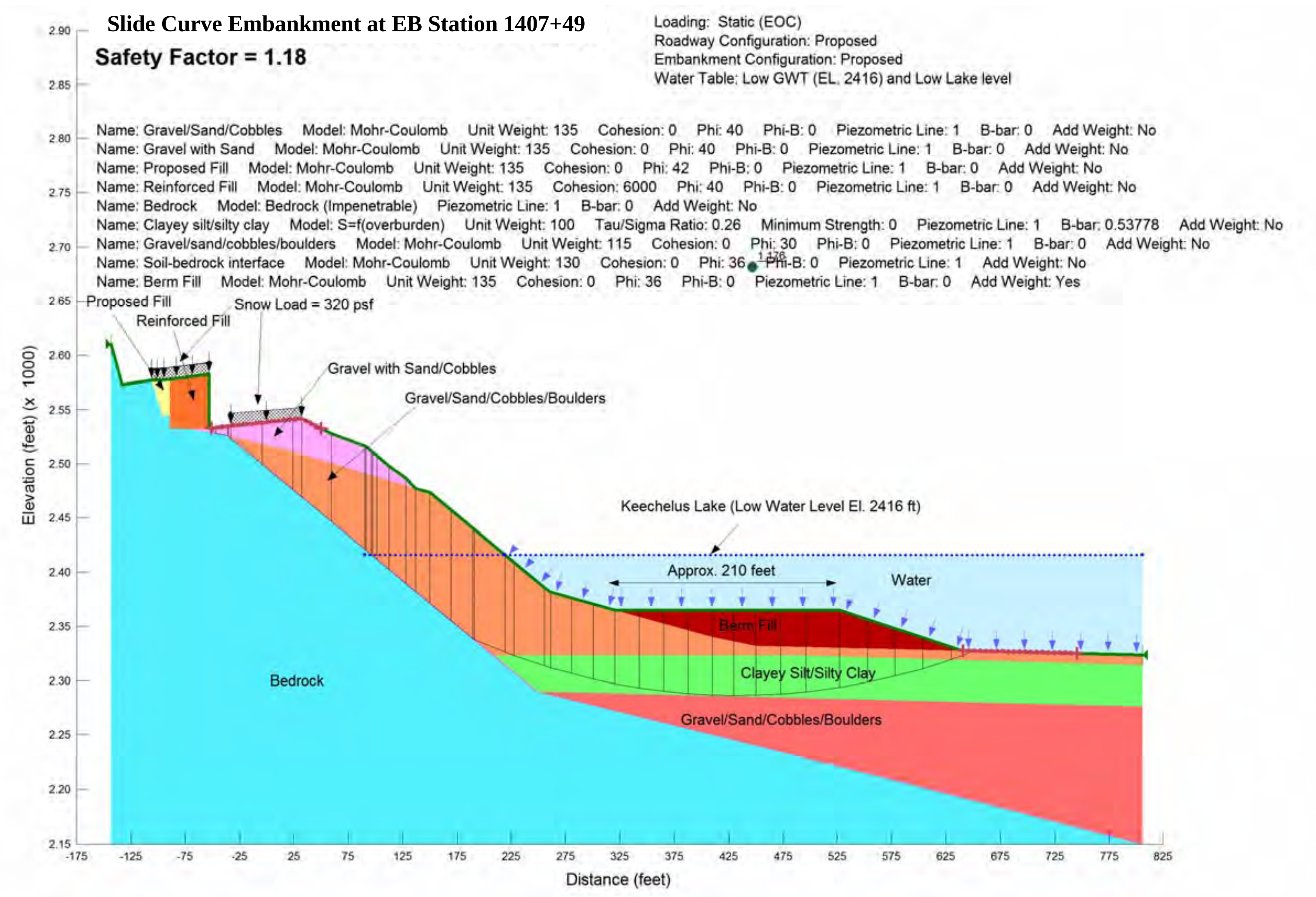
Job No. 33758662

Figure H.6.9



Job No. 33758662

Figure H.6.10



Job No. 33758662

Figure H.6.11

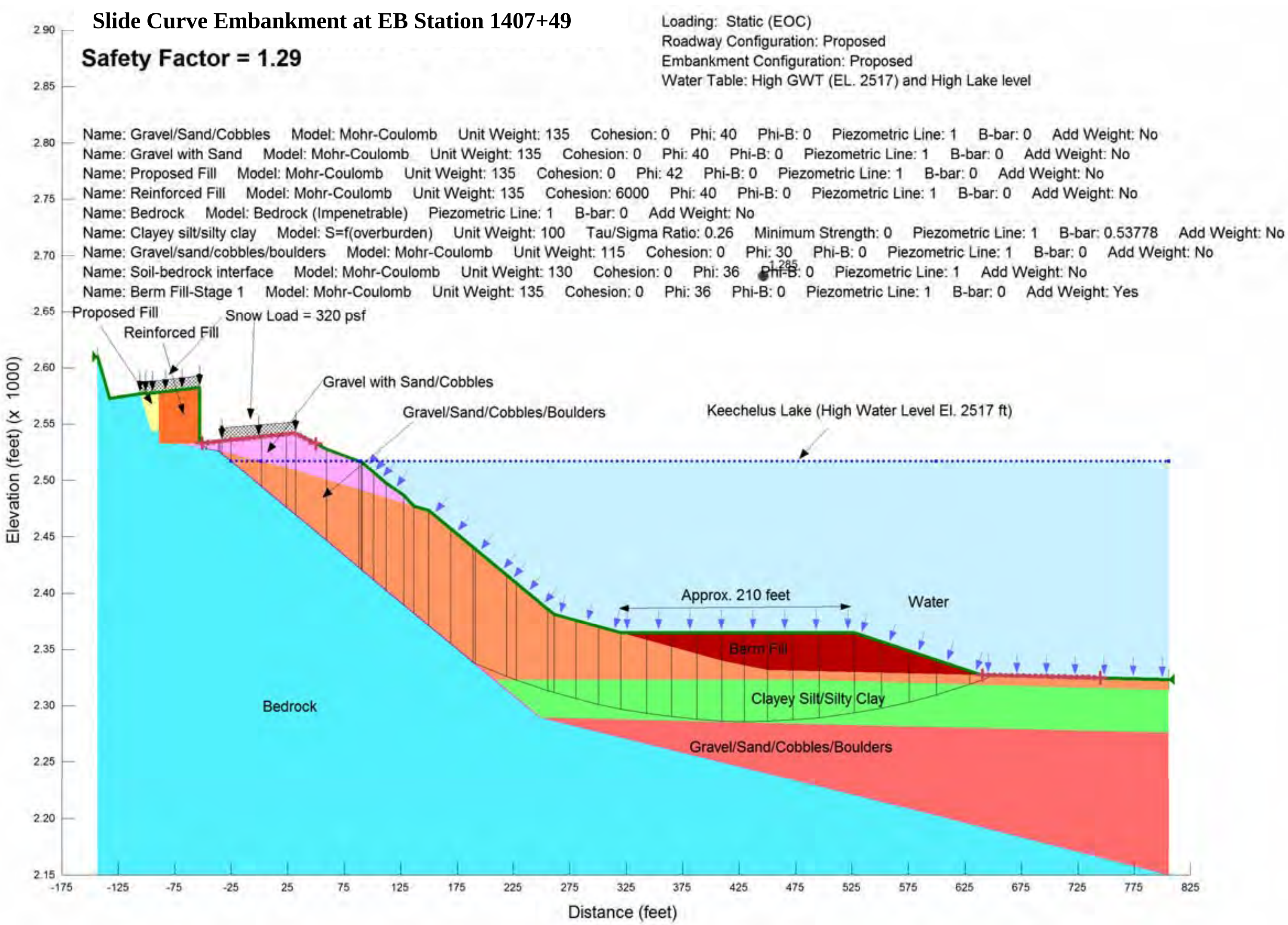

Slide Curve Embankment at EB Station 1407+49
Safety Factor = 1.29
Loading: Static (EOC)
Roadway Configuration: Proposed
Embankment Configuration: Proposed
Water Table: High GWT (EL. 2517) and High Lake level
Name: Gravel/Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Gravel with Sand Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 40 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Clayey silt/silty clay Model: S=f(overburden) Unit Weight: 100 Tau/Sigma Ratio: 0.26 Minimum Strength: 0 Piezometric Line: 1 B-bar: 0.53778 Add Weight: No
Name: Gravel/sand/cobbles/boulders Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: No
Name: Soil-bedrock interface Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 36 Phi-B: 0 Piezometric Line: 1 Add Weight: No
Name: Berm Fill-Stage 1 Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 36 Phi-B: 0 Piezometric Line: 1 B-bar: 0 Add Weight: Yes
Proposed Fill
Reinforced Fill
Snow Load = 320 psf
Gravel with Sand/Cobbles
Gravel/Sand/Cobbles/Boulders
Keechelus Lake (High Water Level El. 2517 ft)
Approx. 210 feet
Water
Berm Fill
Clayey Silt/Silty Clay
Gravel/Sand/Cobbles/Boulders
Bedrock
Elevation (feet) (x 1000)
Distance (feet)
2.90
2.85
2.80
2.75
2.70
2.65
2.60
2.55
2.50
2.45
2.40
2.35
2.30
2.25
2.20
2.15
-175
-125
-75
-25
25
75
125
175
225
275
325
375
425
475
525
575
625
675
725
775
825

Figure H.6.12

APPENDIX H.7
Stability and Liquefaction Analysis Results - Resort Creek Wall

WB Embankment at WB Station 1421+99

Loading: Static
Embankment Configuration: Proposed
Water Table: High GWT (EL. 2517) and High Lake level (EL. 2416)

Safety Factor = 1.43

Name: Primarily Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Sand/ Gravel Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Silt/ Fine Sand Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforcement Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 42 Phi-B: 0 Piezometric Line: 1

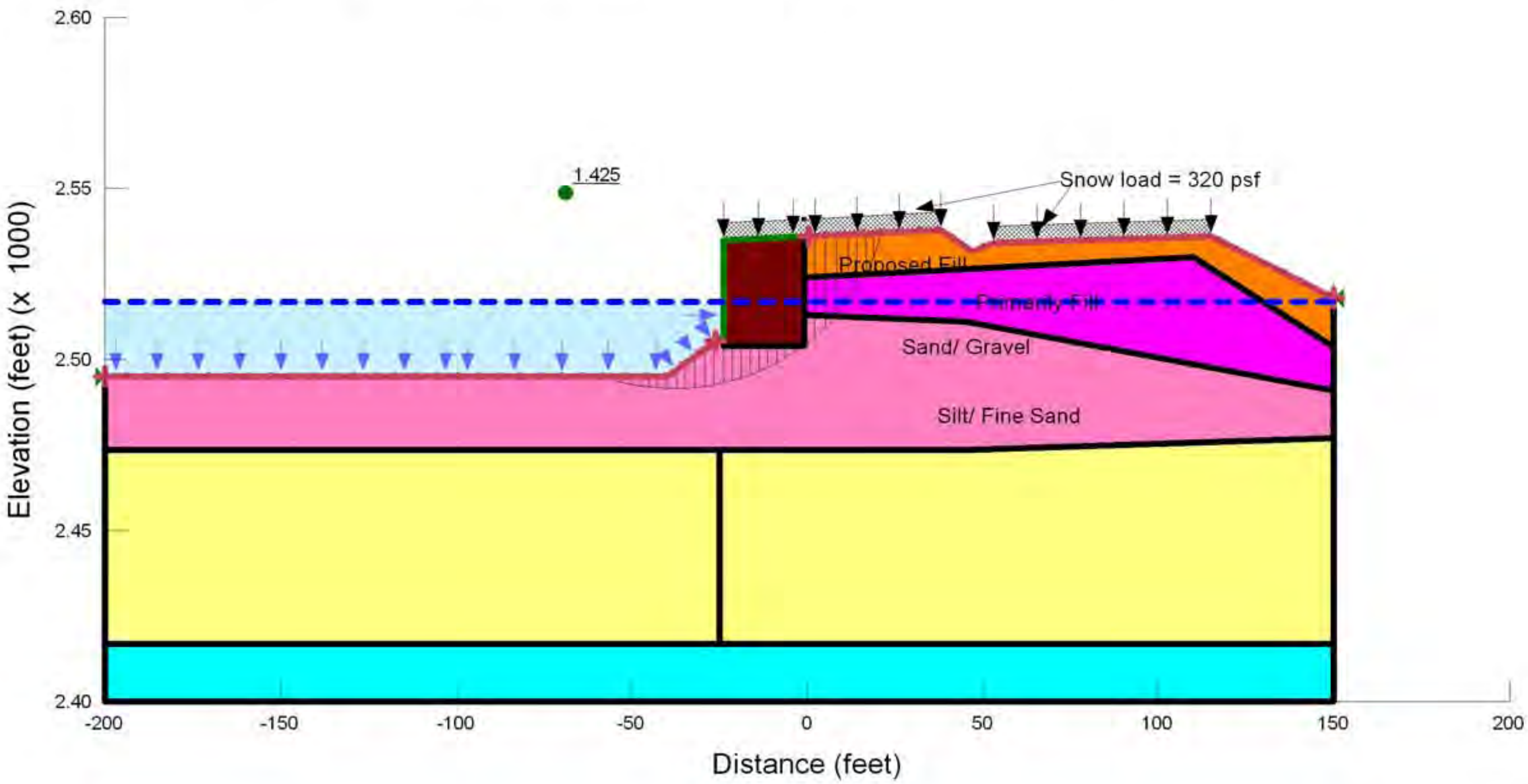


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Figure H.7.1

RCW

WB Embankment at WB Station 1421+99

Safety Factor = 1.45

Loading: Static
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2495) and Low Lake level (EL. 2416)

Name: Primarily Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Sand/ Gravel Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Silt/ Fine Sand Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforcement Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 42 Phi-B: 0 Piezometric Line: 1

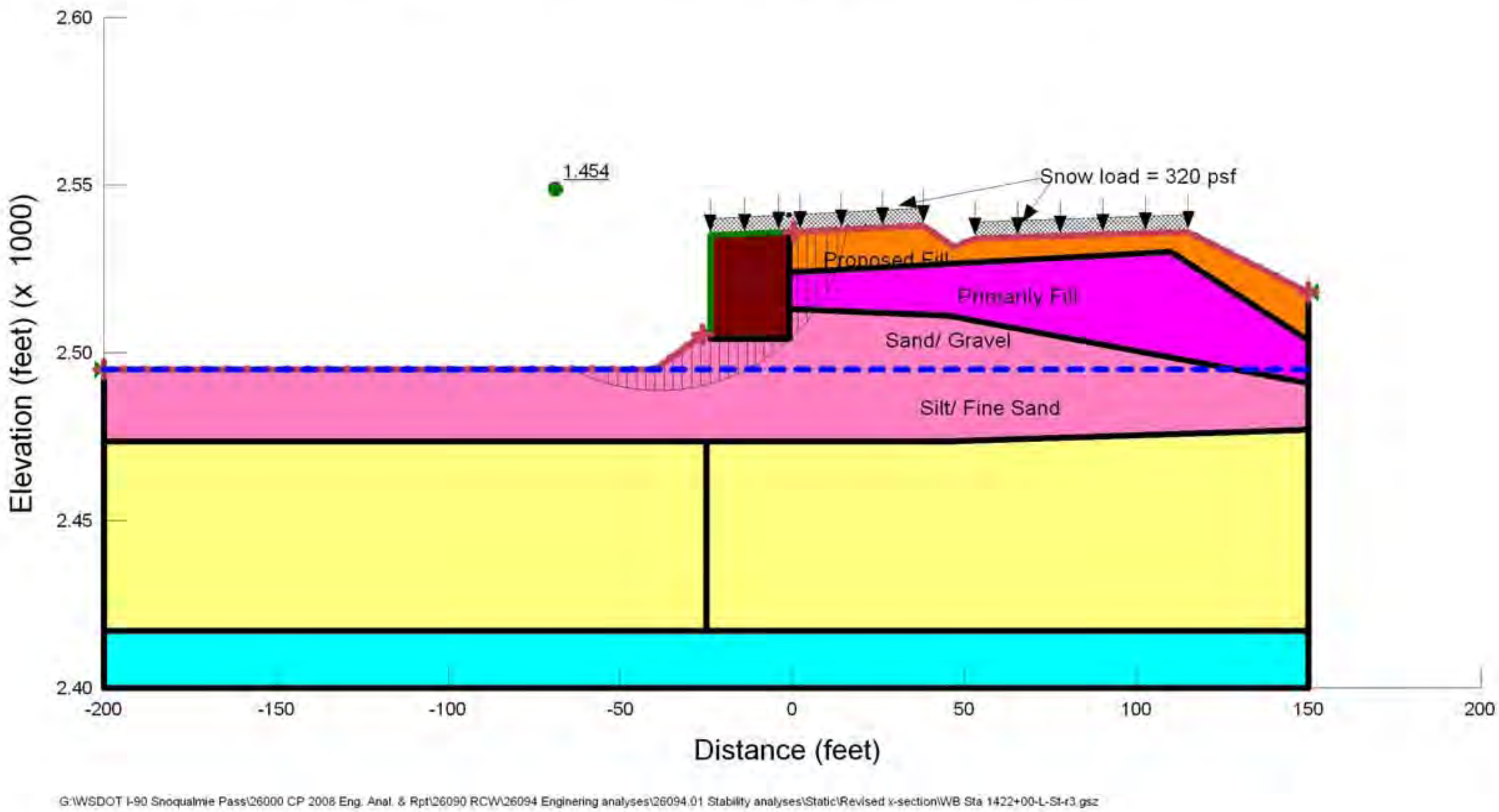

Figure H.7.2

WB Embankment at WB Station 1421+99

Loading: Seismic (Kh=0.5PGA, Kv=0), Pseudostatic
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2495) and Low Lake level (EL. 2416)

Safety Factor = 1.16

Name: Primarily Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Sand/ Gravel Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Silt/ Fine Sand Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforcement Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 42 Phi-B: 0 Piezometric Line: 1

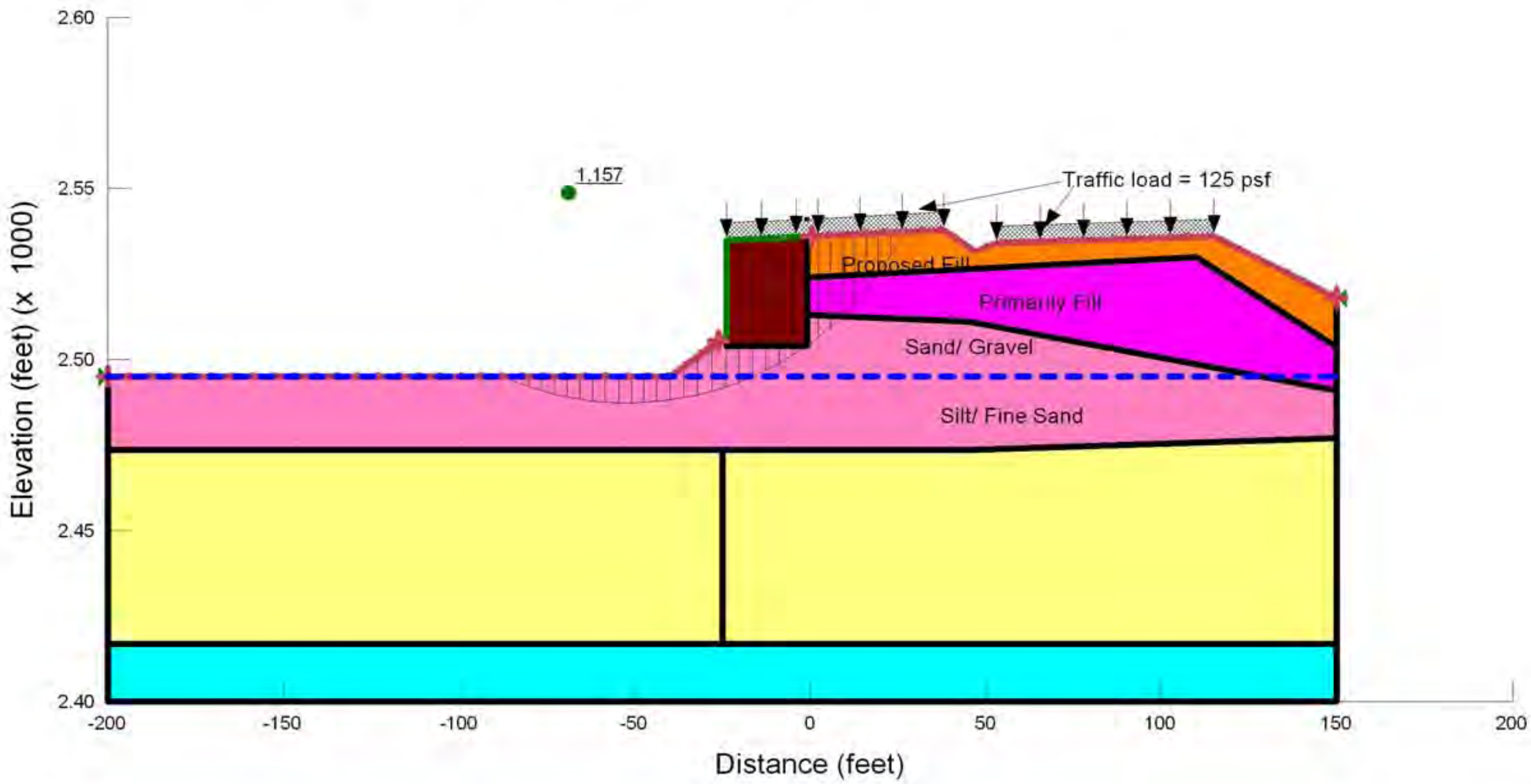

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Figure H.7.3

WB Embankment at WB Station 1421+99

Loading: Seismic (Kh=0, Kv=0), Residual Strength
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2495) and Low Lake level (EL. 2416

Safety Factor = 0.98

Name: Primarily Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Sand/ Gravel Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforcement Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Silt/ Fine Sand (right) Model: S=f(depth) Unit Weight: 120 C-Top of Layer: 650 C-Rate of Increase: 3.456 Limiting C: 2000 Piezometric Line: 1
Name: Silt/ Fine Sand (left) Model: S=f(depth) Unit Weight: 120 C-Top of Layer: 276 C-Rate of Increase: 4.608 Limiting C: 2000 Piezometric Line: 1

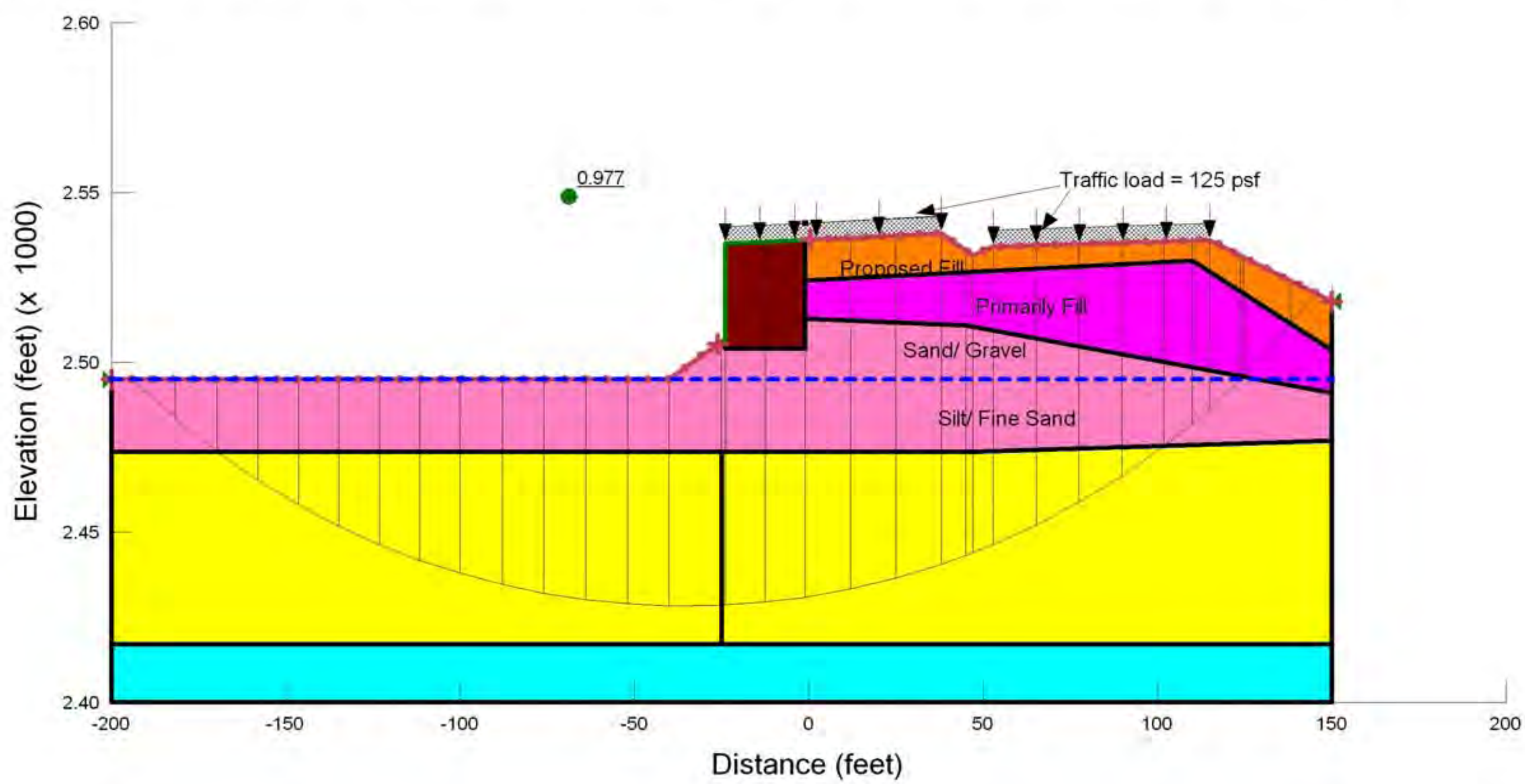

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Figure H.7.4

RCW

WB Embankment at WB Station 1421+99

Loading: Seismic (Kh=0, Kv=0), Residual Strength
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2495) and Low Lake level (EL. 2416)

Safety Factor =1.12

Name: Primarily Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Sand/ Gravel Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforcement Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Silt/ Fine Sand (right) Model: S=f(depth) Unit Weight: 120 C-Top of Layer: 650 C-Rate of Increase: 3.456 Limiting C: 2000 Piezometric Line: 1
Name: Silt/ Fine Sand (left) Model: S=f(depth) Unit Weight: 120 C-Top of Layer: 276 C-Rate of Increase: 4.608 Limiting C: 2000 Piezometric Line: 1
Name: Compaction Pile Model: Mohr-Coulomb Unit Weight: 114 Cohesion: 7200 Phi: 0 Phi-B: 0 Piezometric Line: 1

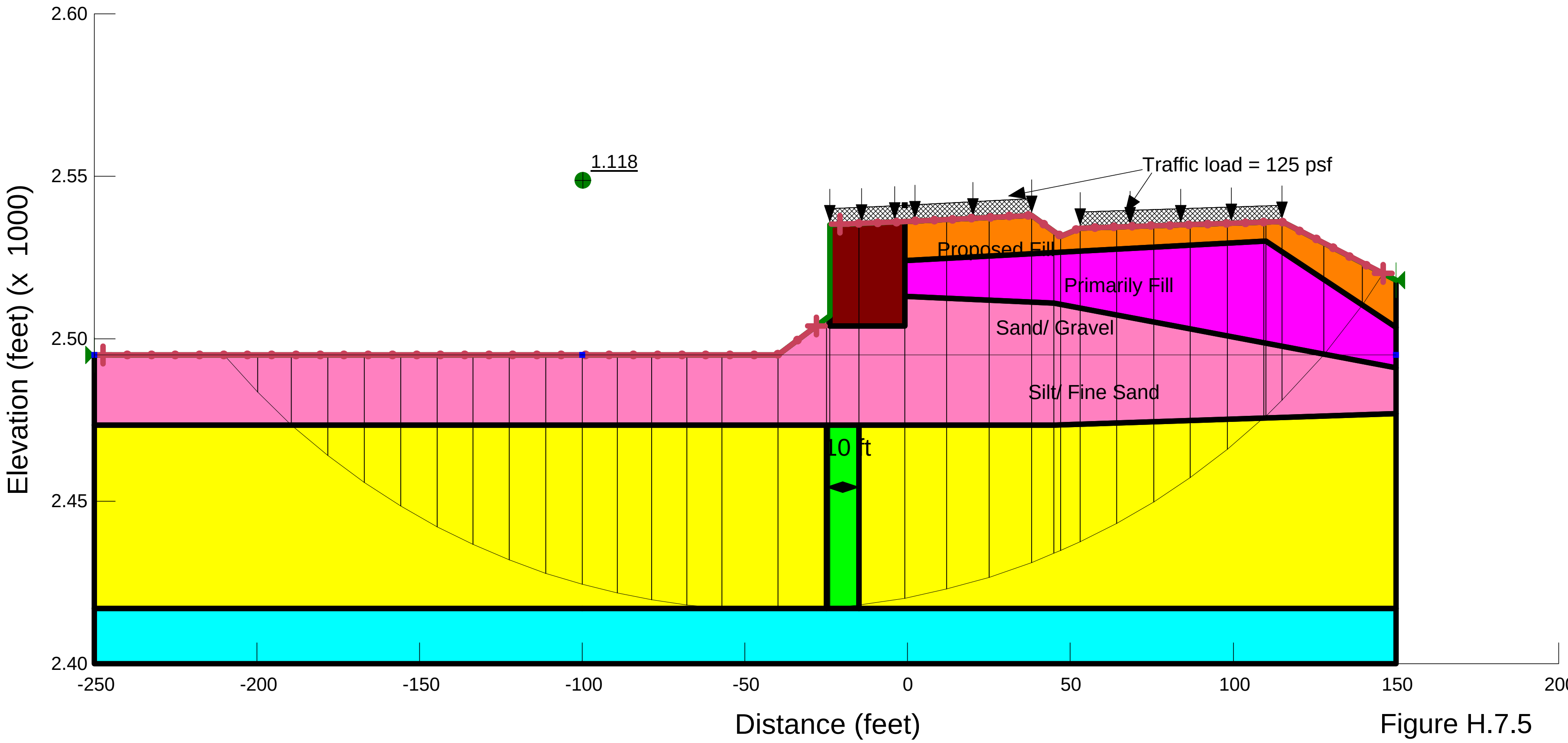

Figure H.7.5

RCW

G:\WSDOT I-90 Snoqualmie Pass\26000 CP 2008 Eng. Anal. & Rpt\26090 RCW\26094 Enginering Analyses\26094.01 Stability\Seismic\Revised Cross-Section\Compaction Pile\10 ft\WB Sta 1422+00-L-Se-Re-kramer-10%.gsz

WB Embankment at WB Station 1421+99

Loading: Seismic (Kh=0, Kv=0), Residual Strength
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2495) and Low Lake level (EL. 2416)

Safety Factor =1.00
Ky=0.026 g

Name: Primarily Fill   Model: Mohr-Coulomb   Unit Weight: 135   Cohesion: 0   Phi: 40   Phi-B: 0   Piezometric Line: 1
Name: Bedrock   Model: Bedrock (Impenetrable)   Piezometric Line: 1
Name: Sand/ Gravel   Model: Mohr-Coulomb   Unit Weight: 130   Cohesion: 0   Phi: 38   Phi-B: 0   Piezometric Line: 1
Name: Proposed Fill   Model: Mohr-Coulomb   Unit Weight: 135   Cohesion: 0   Phi: 42   Phi-B: 0   Piezometric Line: 1
Name: Reinforcement   Model: Mohr-Coulomb   Unit Weight: 135   Cohesion: 6000   Phi: 42   Phi-B: 0   Piezometric Line: 1
Name: Silt/ Fine Sand (right)   Model: S=f(depth)   Unit Weight: 120   C-Top of Layer: 650   C-Rate of Increase: 3.456   Limiting C: 2000   Piezometric Line: 1
Name: Silt/ Fine Sand (left)   Model: S=f(depth)   Unit Weight: 120   C-Top of Layer: 276   C-Rate of Increase: 4.608   Limiting C: 2000   Piezometric Line: 1
Name: Compaction Pile   Model: Mohr-Coulomb   Unit Weight: 114   Cohesion: 7200   Phi: 0   Phi-B: 0   Piezometric Line: 1

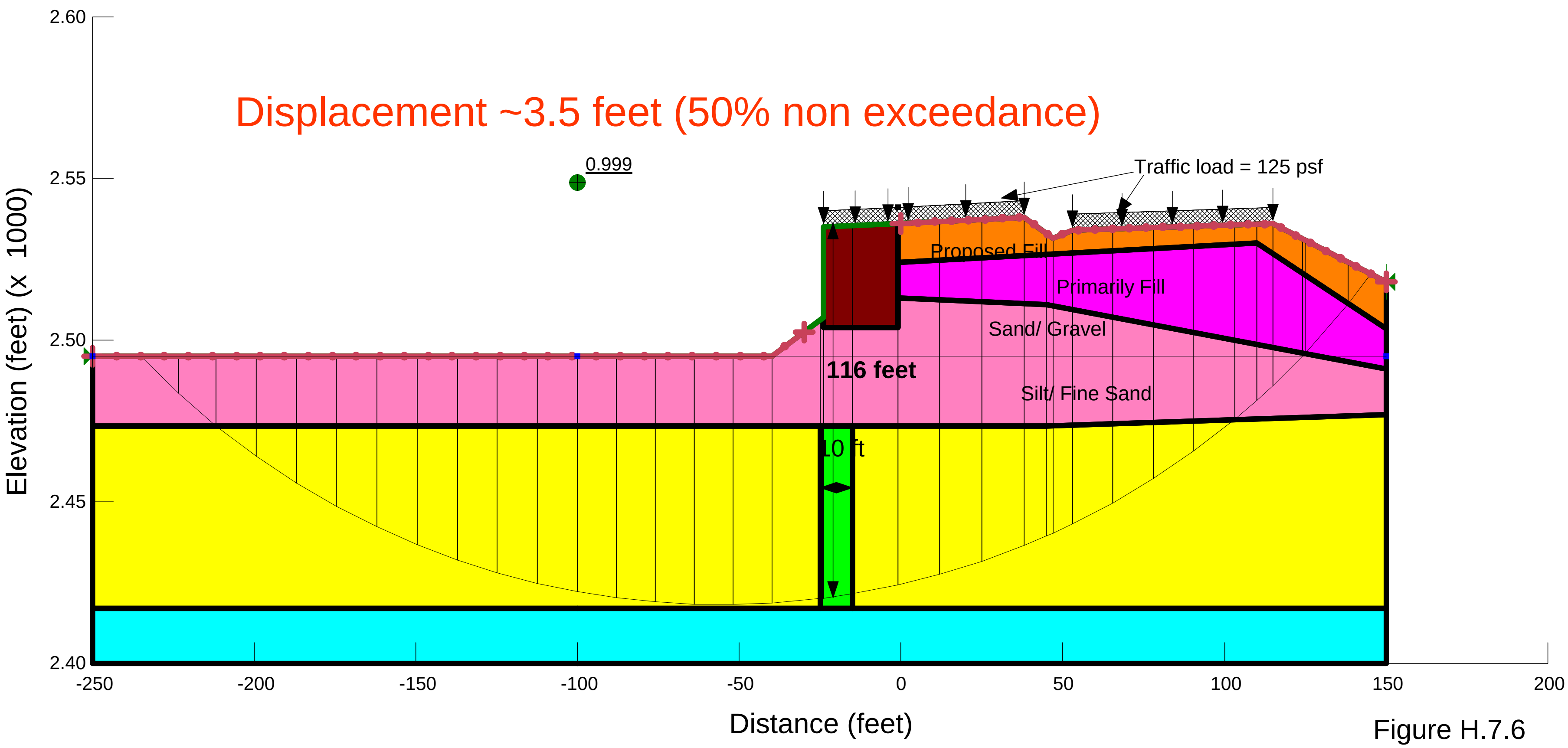

Figure H.7.6

RCW

G:\WSDOT I-90 Snoqualmie Pass\26000 CP 2008 Eng. Anal. & Rpt\26090 RCW\26094 Enginering Analyses\26094.01 Stability\Seismic\Revised Cross-Section\Compaction Pile\10 ft\WB Sta 1422+00-L-Se-Re-kramer-10%-ky.gsz

WB Embankment at WB Station 1421+99

Loading: Seismic (Kh=0, Kv=0), Residual Strength
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2495) and Low Lake level (EL. 2416)

Safety Factor =1.27

Name: Primarily Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Sand/ Gravel Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforcement Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Silt/ Fine Sand (right) Model: S=f(depth) Unit Weight: 120 C-Top of Layer: 650 C-Rate of Increase: 3.456 Limiting C: 2000 Piezometric Line: 1
Name: Silt/ Fine Sand (left) Model: S=f(depth) Unit Weight: 120 C-Top of Layer: 276 C-Rate of Increase: 4.608 Limiting C: 2000 Piezometric Line: 1
Name: Compaction Pile Model: Mohr-Coulomb Unit Weight: 114 Cohesion: 7200 Phi: 0 Phi-B: 0 Piezometric Line: 1

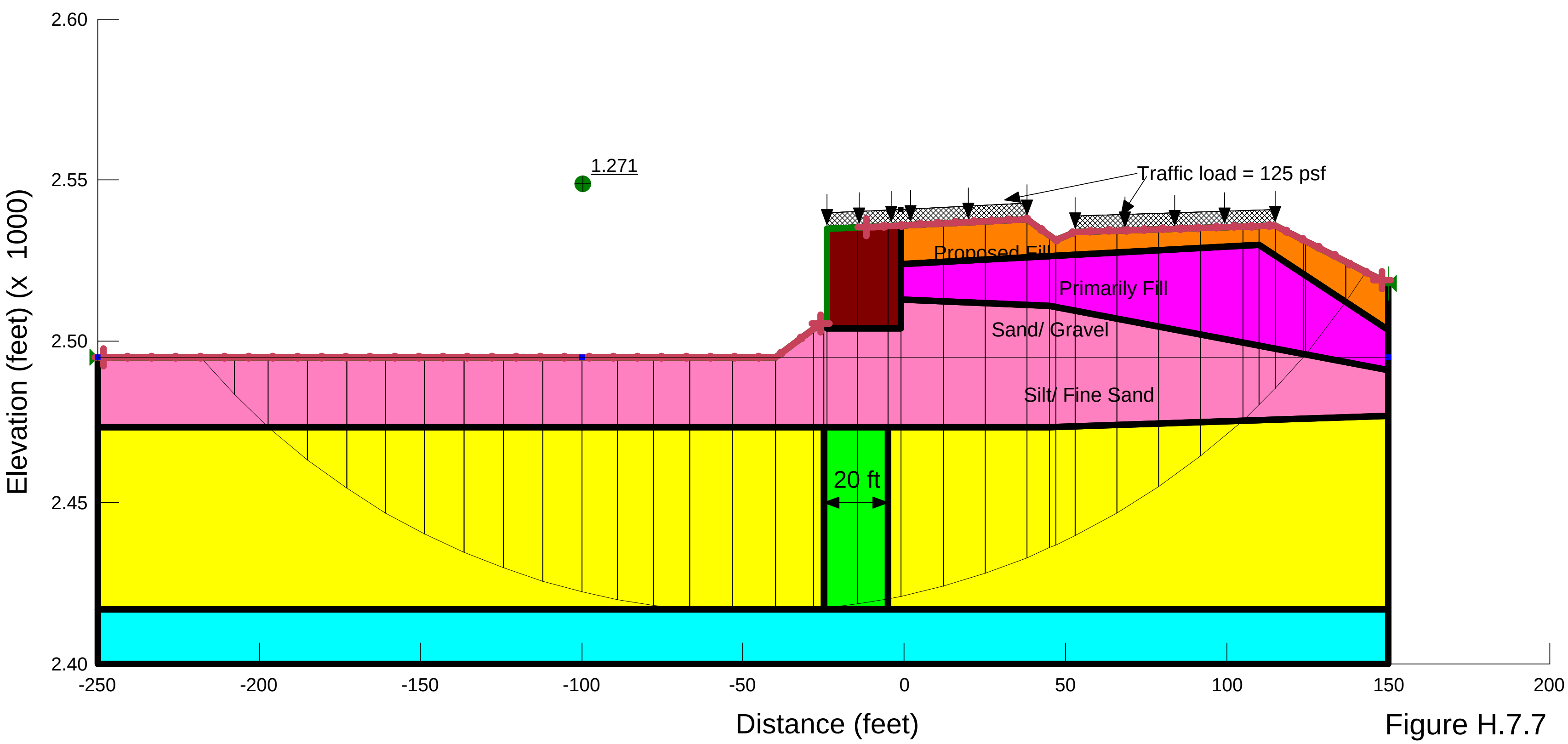

Figure H.7.7

RCW

G:\WSDOT I-90 Snoqualmie Pass\26000 CP 2008 Eng. Anal. & Rpt\26090 RCW\26094 Enginering Analyses\26094.01 Stability\Seismic\Revised Cross-Section\Compaction Pile\20 ft\WB Sta 1422+00-L-Se-Re-kramer-10%.gsz

WB Embankment at WB Station 1421+99

Loading: Seismic (Kh=0, Kv=0), Residual Strength
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2495) and Low Lake level (EL. 2416)

Safety Factor =1.00
Ky=0.057 g

Name: Primarily Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Sand/ Gravel Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforcement Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Silt/ Fine Sand (right) Model: S=f(depth) Unit Weight: 120 C-Top of Layer: 650 C-Rate of Increase: 3.456 Limiting C: 2000 Piezometric Line: 1
Name: Silt/ Fine Sand (left) Model: S=f(depth) Unit Weight: 120 C-Top of Layer: 276 C-Rate of Increase: 4.608 Limiting C: 2000 Piezometric Line: 1
Name: Compaction Pile Model: Mohr-Coulomb Unit Weight: 114 Cohesion: 7200 Phi: 0 Phi-B: 0 Piezometric Line: 1

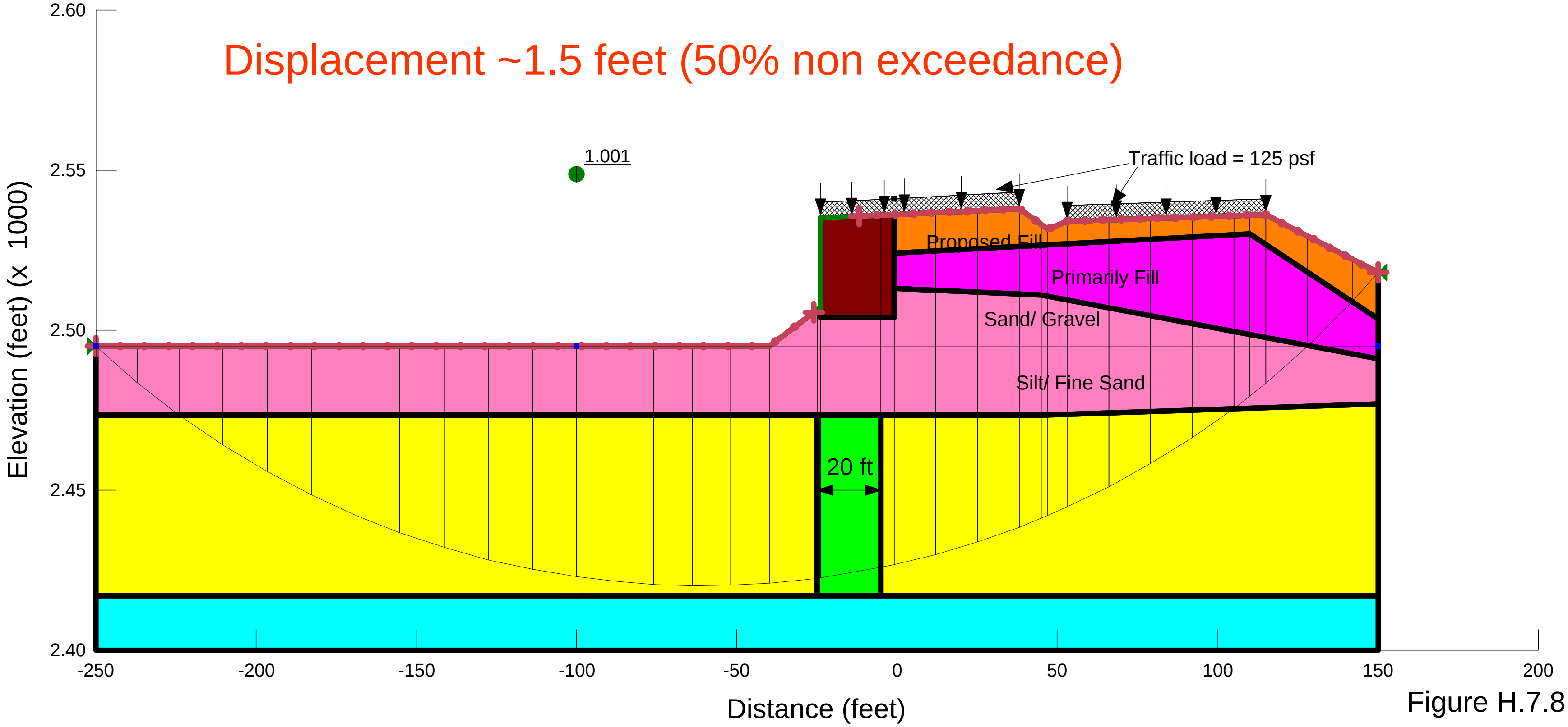

Figure H.7.8

RCW

WB Embankment at WB Station 1421+99

Safety Factor =1.44

Loading: Seismic (Kh=0, Kv=0), Residual Strength
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2495) and Low Lake level (EL. 2416)

Name: Primarily Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Sand/ Gravel Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforcement Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Silt/ Fine Sand (right) Model: S=f(depth) Unit Weight: 120 C-Top of Layer: 650 C-Rate of Increase: 3.456 Limiting C: 2000 Piezometric Line: 1
Name: Silt/ Fine Sand (left) Model: S=f(depth) Unit Weight: 120 C-Top of Layer: 276 C-Rate of Increase: 4.608 Limiting C: 2000 Piezometric Line: 1
Name: Compaction Pile Model: Mohr-Coulomb Unit Weight: 114 Cohesion: 7200 Phi: 0 Phi-B: 0 Piezometric Line: 1

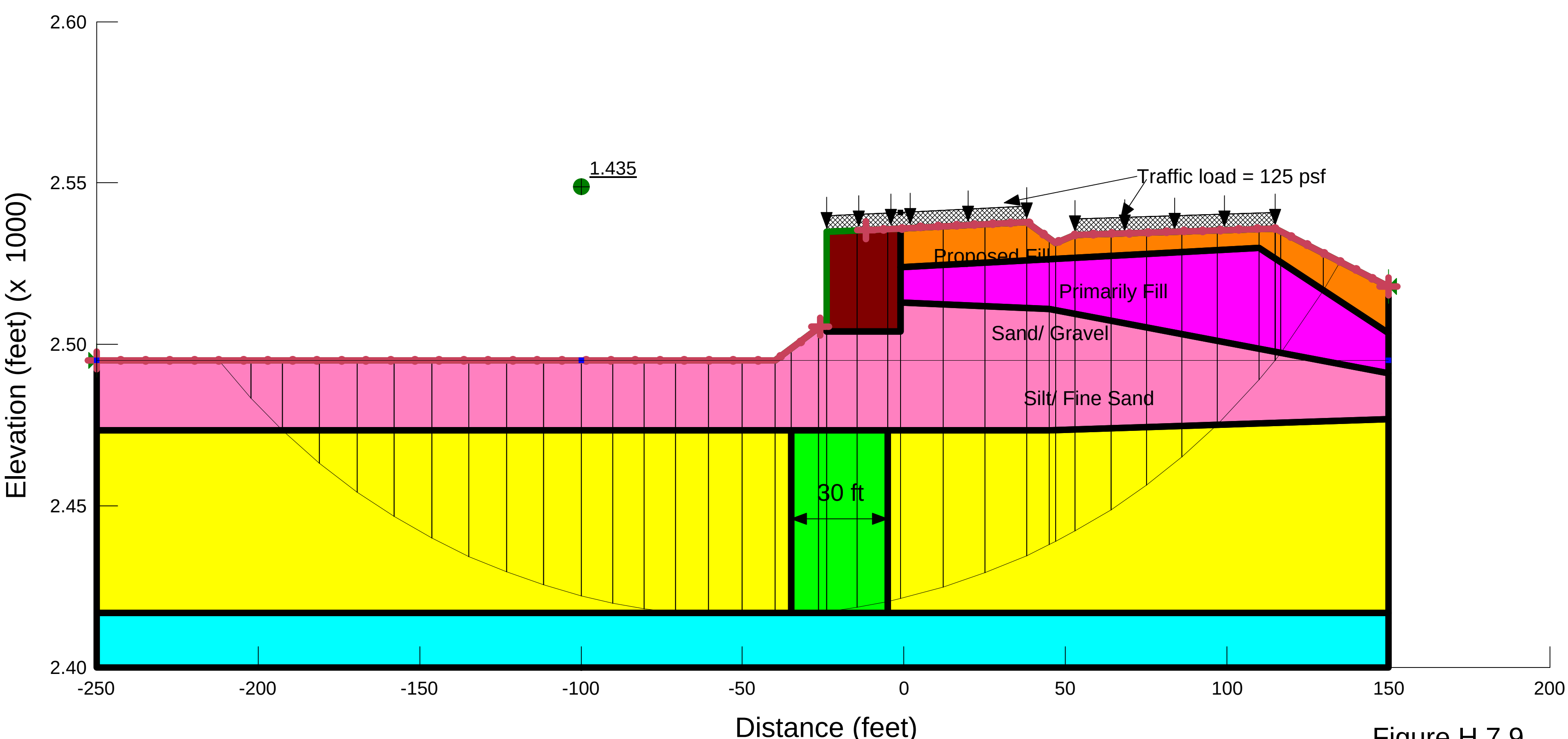

Figure H.7.9

RCW

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WB Embankment at WB Station 1421+99

Loading: Seismic (Kh=0, Kv=0), Residual Strength
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2495) and Low Lake level (EL. 2416)

Safety Factor =1.00
Ky=0.095 g

Name: Primarily Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Sand/ Gravel Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Reinforcement Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 6000 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Silt/ Fine Sand (right) Model: S=f(depth) Unit Weight: 120 C-Top of Layer: 650 C-Rate of Increase: 3.456 Limiting C: 2000 Piezometric Line: 1
Name: Silt/ Fine Sand (left) Model: S=f(depth) Unit Weight: 120 C-Top of Layer: 276 C-Rate of Increase: 4.608 Limiting C: 2000 Piezometric Line: 1
Name: Compaction Pile Model: Mohr-Coulomb Unit Weight: 114 Cohesion: 7200 Phi: 0 Phi-B: 0 Piezometric Line: 1

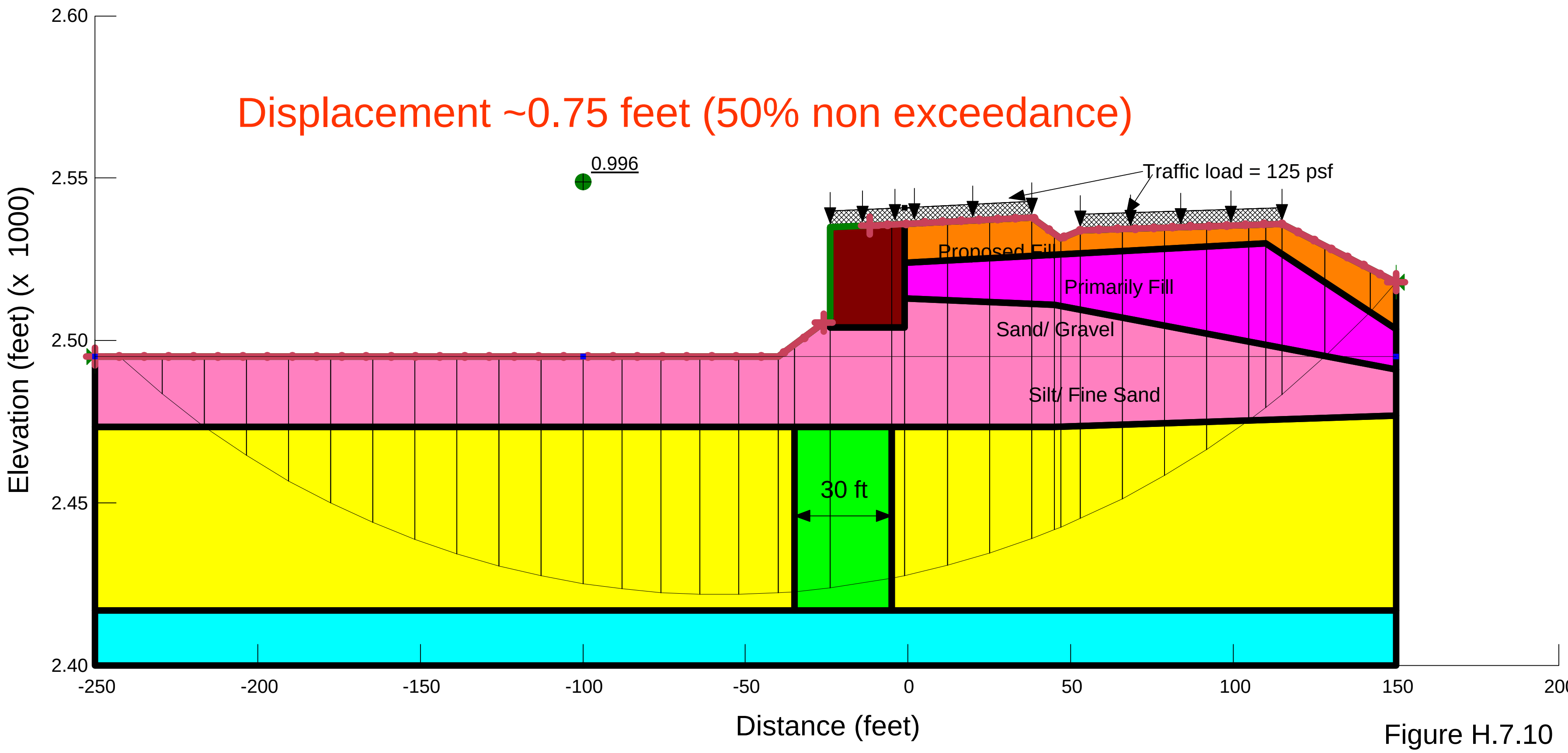

Figure H.7.10

RCW

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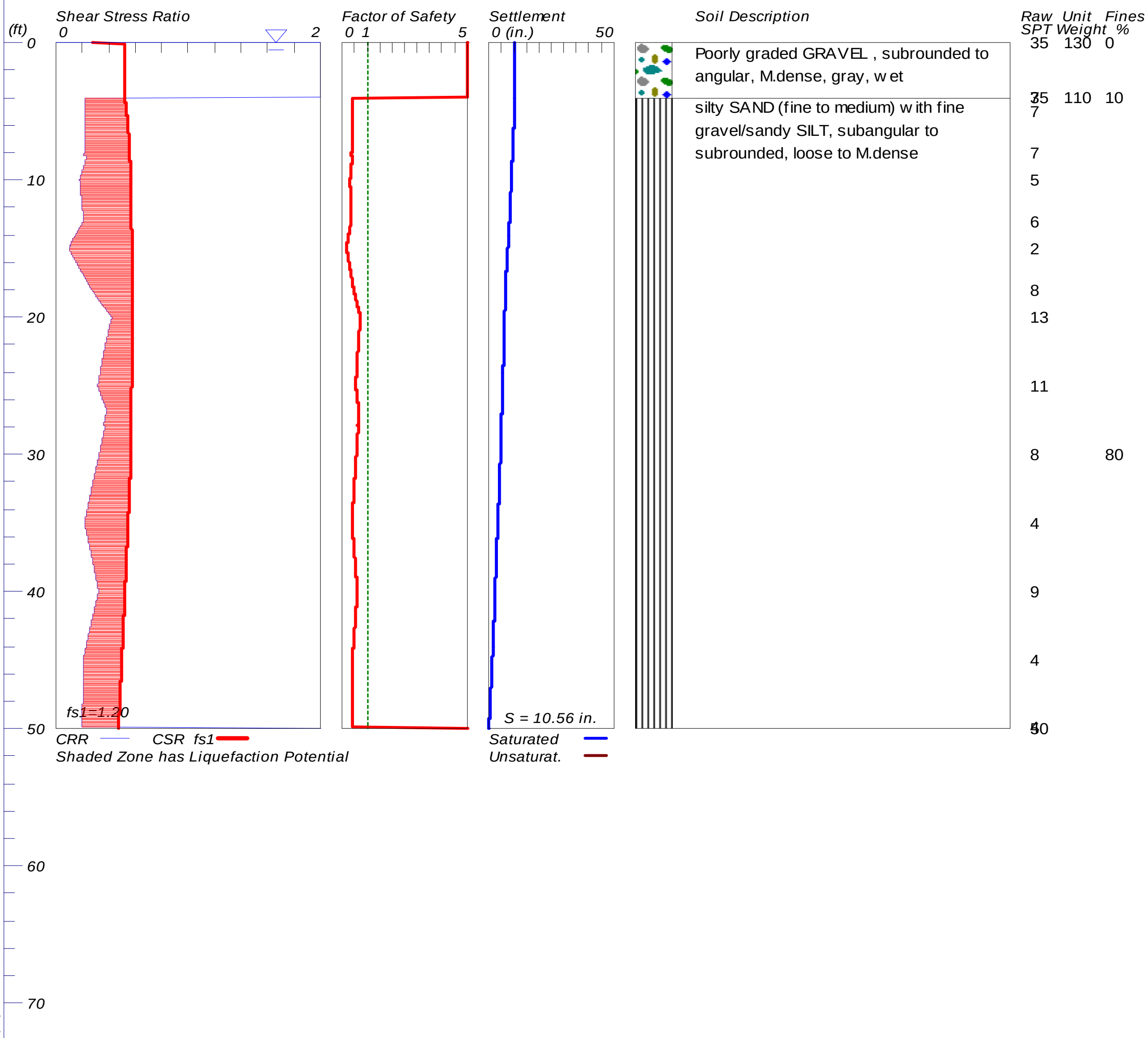
LIQUEFACTION ANALYSIS

WSDOT I-90 Snoqualmie Pass

Hole No.=CUL-008-07 Water Depth=0 ft Surface Elev.=2480.

Magnitude=6.35
Acceleration=.35g



Job No.:33758638

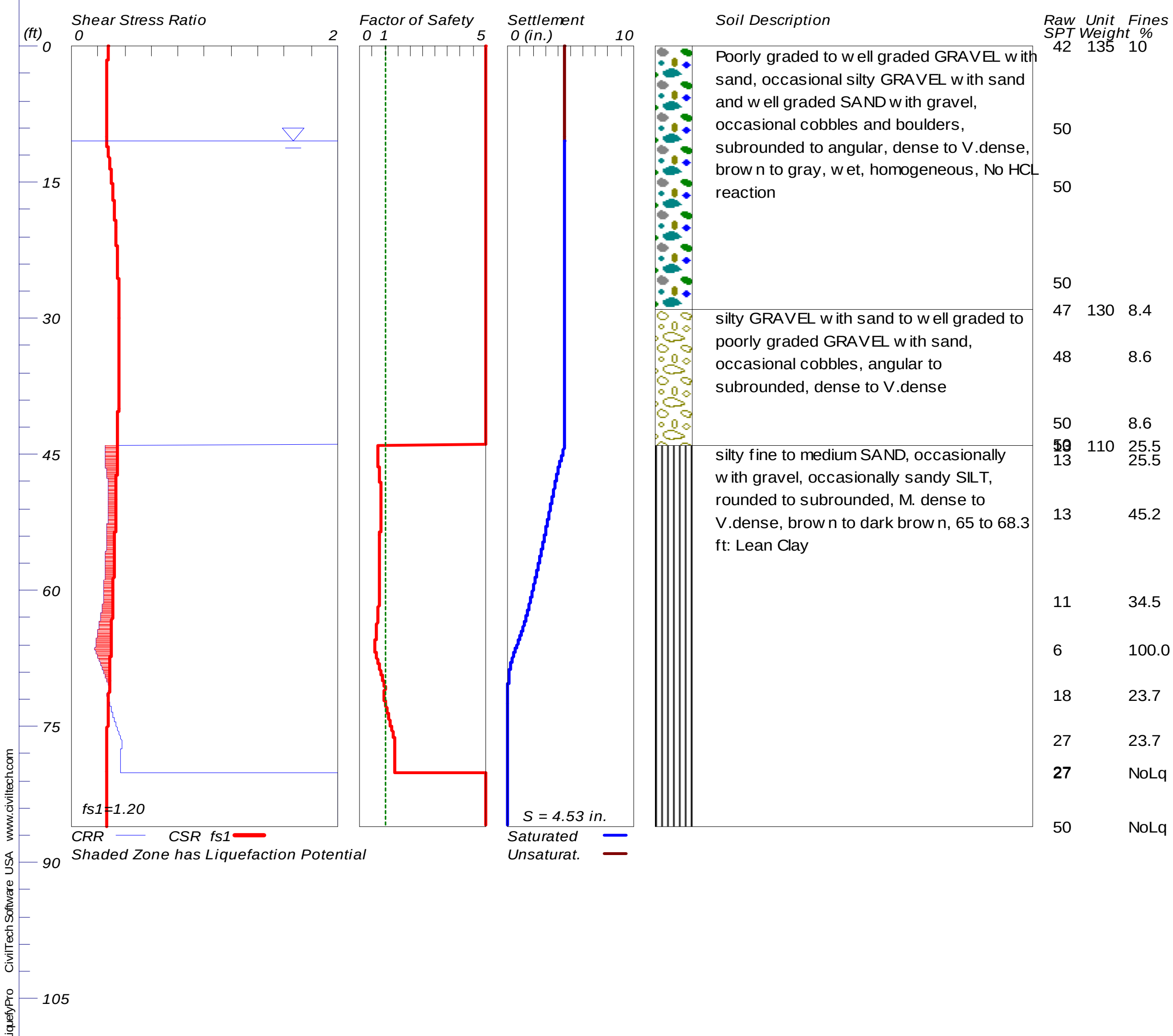
Liquefaction Analysis Results at Boring CUL-008-07

URS

LIQUEFACTION ANALYSIS

WSDOT I-90 Snoqualmie Pass

Hole No.=RCB-003-08 (OW)   Water Depth=10.49 ft   Surface Elev.=2527.   Magnitude=6.35
Acceleration=.35g



Job No.:33758638

Liquefaction Analysis Results at Boring RCB-003-08 (OW)

APPENDIX H.8
Stability and Liquefaction Analysis Results - Resort Creek Bridges

Resort Creek, Longitudinal
EB Profile between Station 1424+00 to 1430+00

Loading: Static
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)
Lateral force=0.0 kips/ft

Safety Factor = 1.237

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1

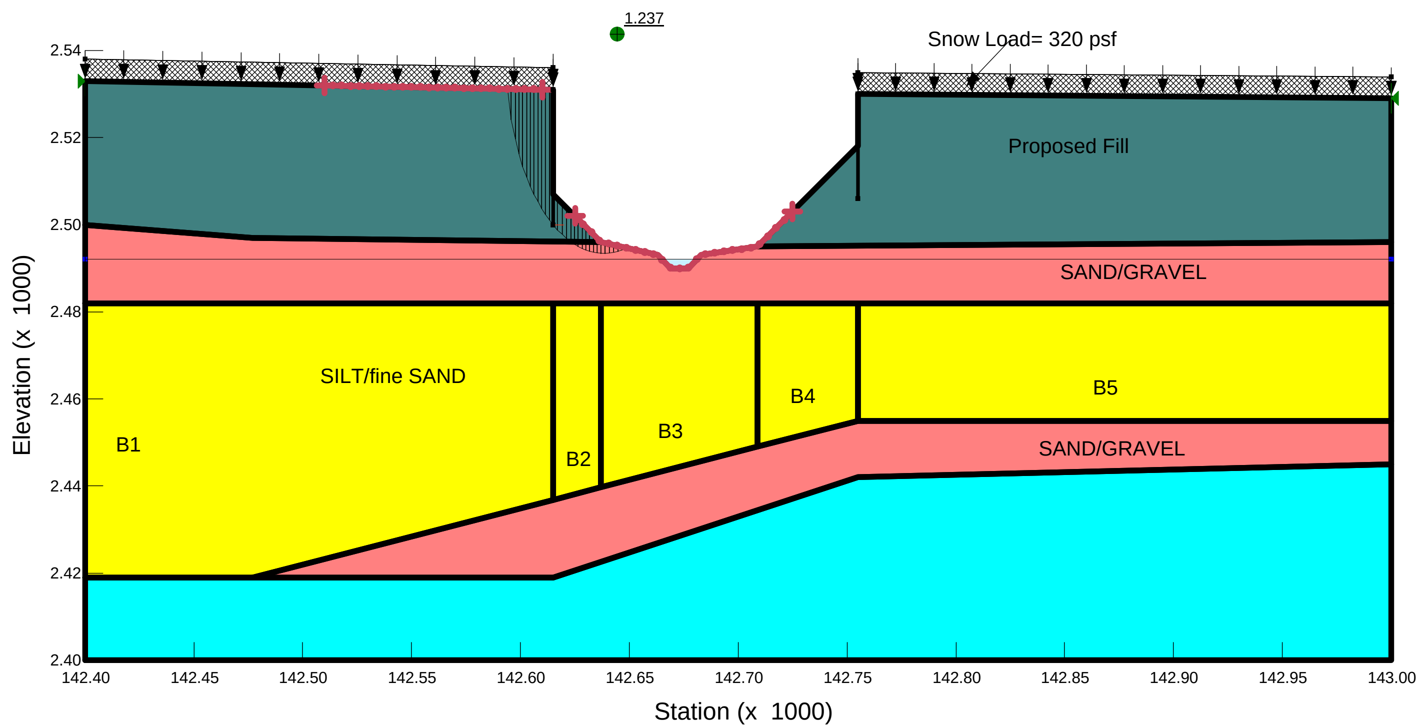


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Figure H.8.1

Resort Creek, Longitudinal
EB Profile between Station 1424+00 to 1430+00

Loading: Static
Embankment Configuration: Proposed
Water Table: High GWT (EL. 2517) and High Lake level (EL. 2517)
Lateral force=0.0 kips/ft

Safety Factor = 1.132

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1

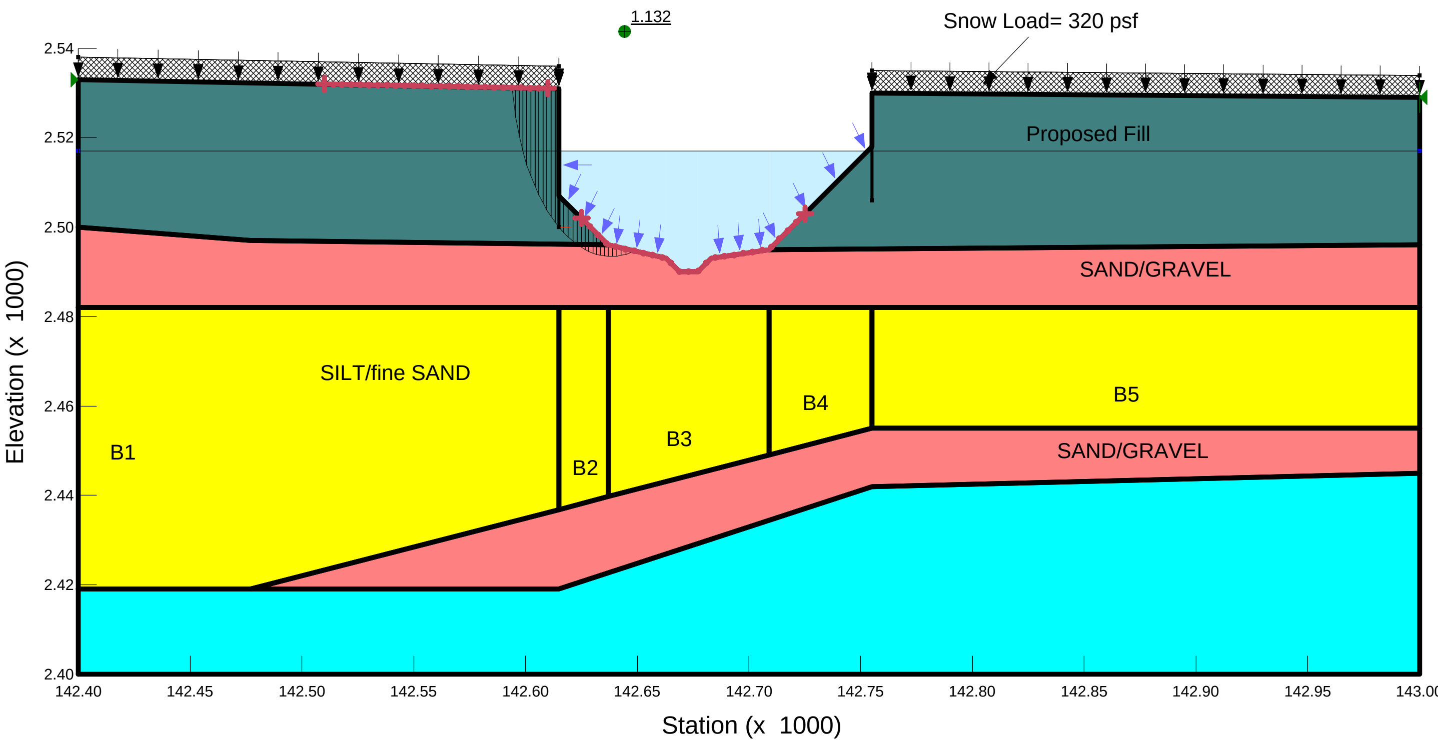

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Figure H.8.2

Resort Creek, Longitudinal
EB Profile between Station 1424+00 to 1430+00

Loading: Seismic (Kh=0.175, Kv=0), Pseudostatic
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416
Lateral force=0.0 kips/ft

Safety Factor = 1.030

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1

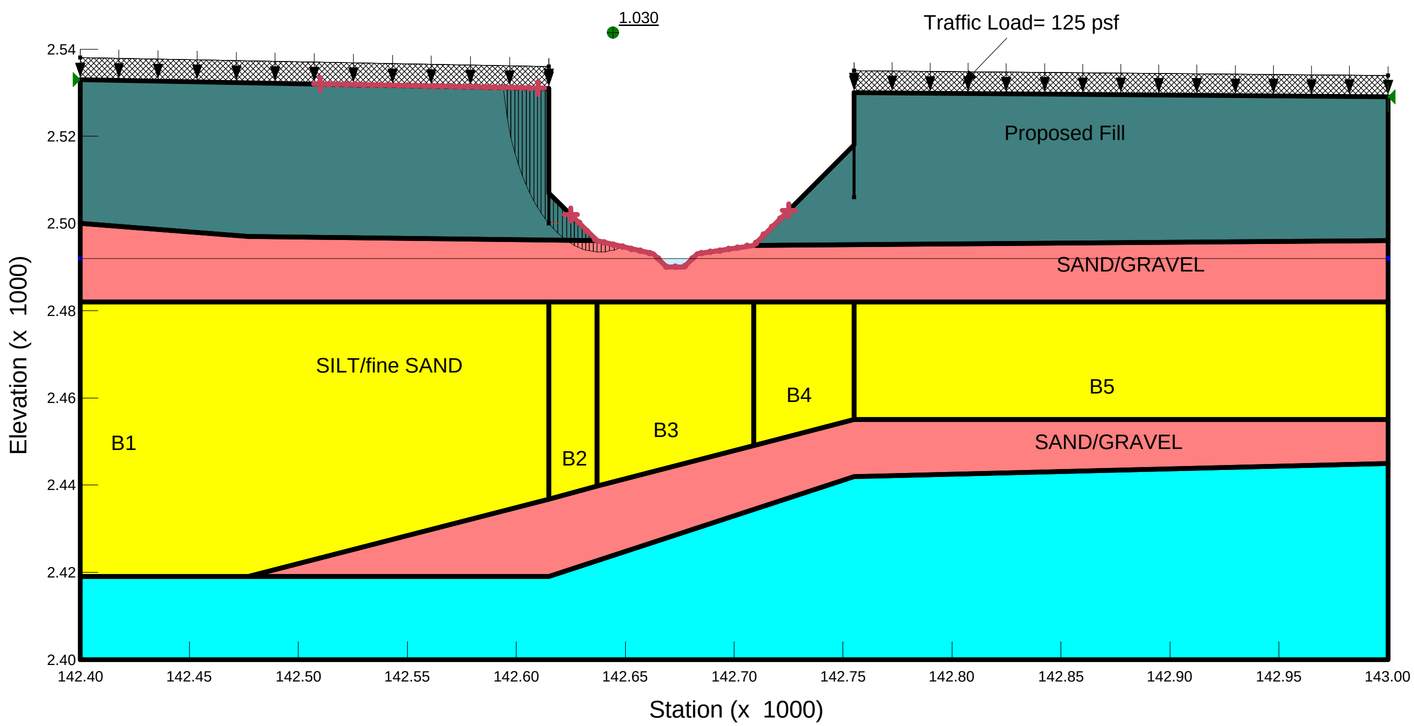

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Figure H.8.3

Resort Creek, Longitudinal
EB Profile between Station 1424+00 to 1430+00

Loading: Seismic (Kh=0, Kv=0), Residual
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)
Lateral force=0.0 kips/ft

Safety Factor = 0.851

Kramer

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND-B1 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 610 psf C-Rate of Change: 3.456 psf/ft Limiting C: 2000 psf Piezometric Line: 1
Name: SILT/fine SAND-B2 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 310 psf C-Rate of Change: 4.608 psf/ft Limiting C: 2000 psf Piezometric Line: 1
Name: SILT/fine SAND-B3 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 245 psf C-Rate of Change: 4.608 psf/ft Limiting C: 2000 psf Piezometric Line: 1
Name: SILT/fine SAND-B4 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 360 psf C-Rate of Change: 4.608 psf/ft Limiting C: 2000 psf Piezometric Line: 1
Name: SILT/fine SAND-B5 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 595 psf C-Rate of Change: 3.456 psf/ft Limiting C: 2000 psf Piezometric Line: 1

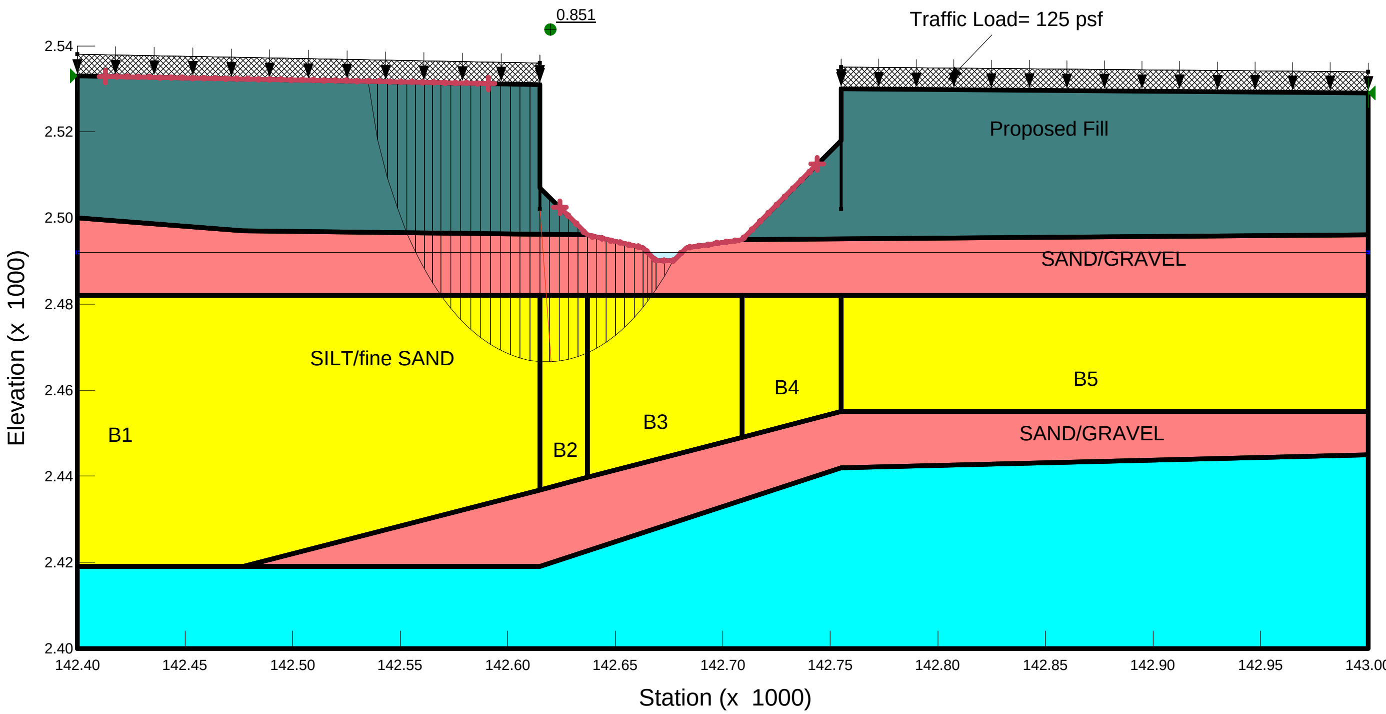

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Figure H.8.4

Resort Creek, Longitudinal
EB Profile between Station 1424+00 to 1430+00

Loading: Seismic (Kh=0, Kv=0), Residual
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)
Lateral force=0.0 kips/ft

Safety Factor = 0.860

O&S

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: S=f(overburden) Unit Weight: 120 pcf Tau/Sigma Ratio: 0.12 Minimum Strength: 0 Piezometric Line: 1

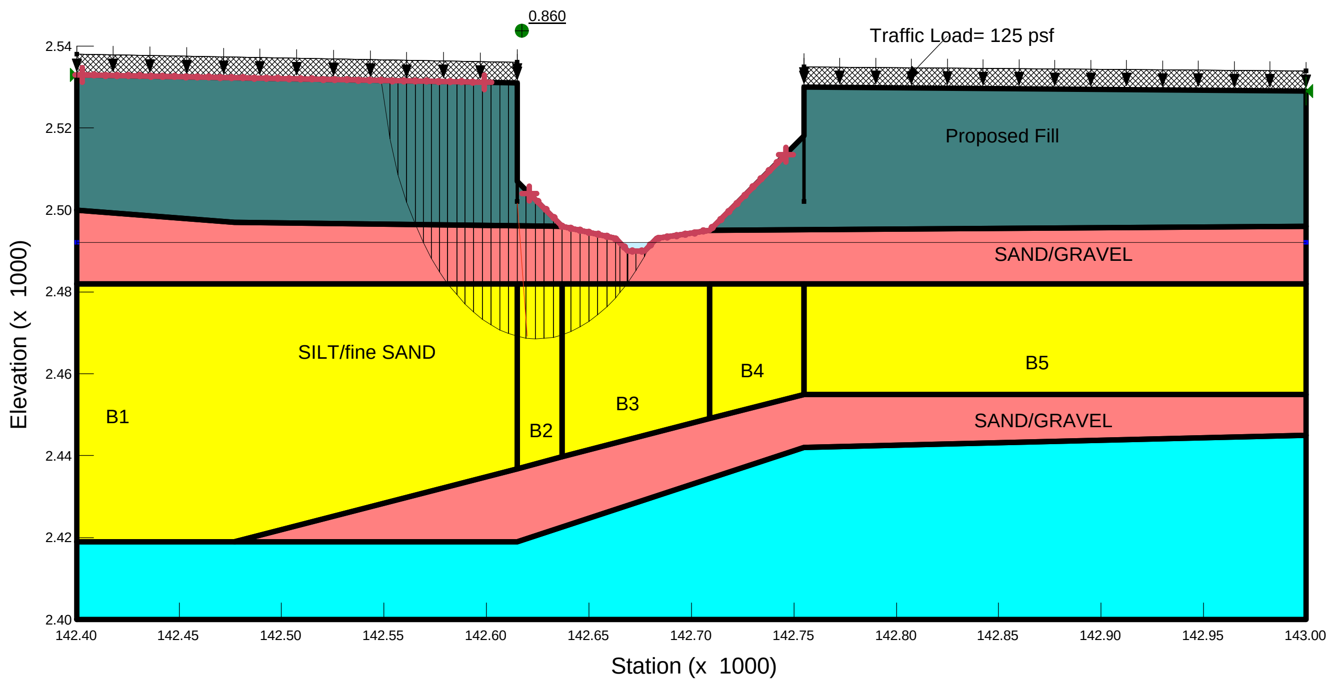

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Figure H.8.5

Resort Creek, Transverse

Wall 11

Loading: Static
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2492) and Low Lake level (EL. 2416)

Safety Factor = 1.650

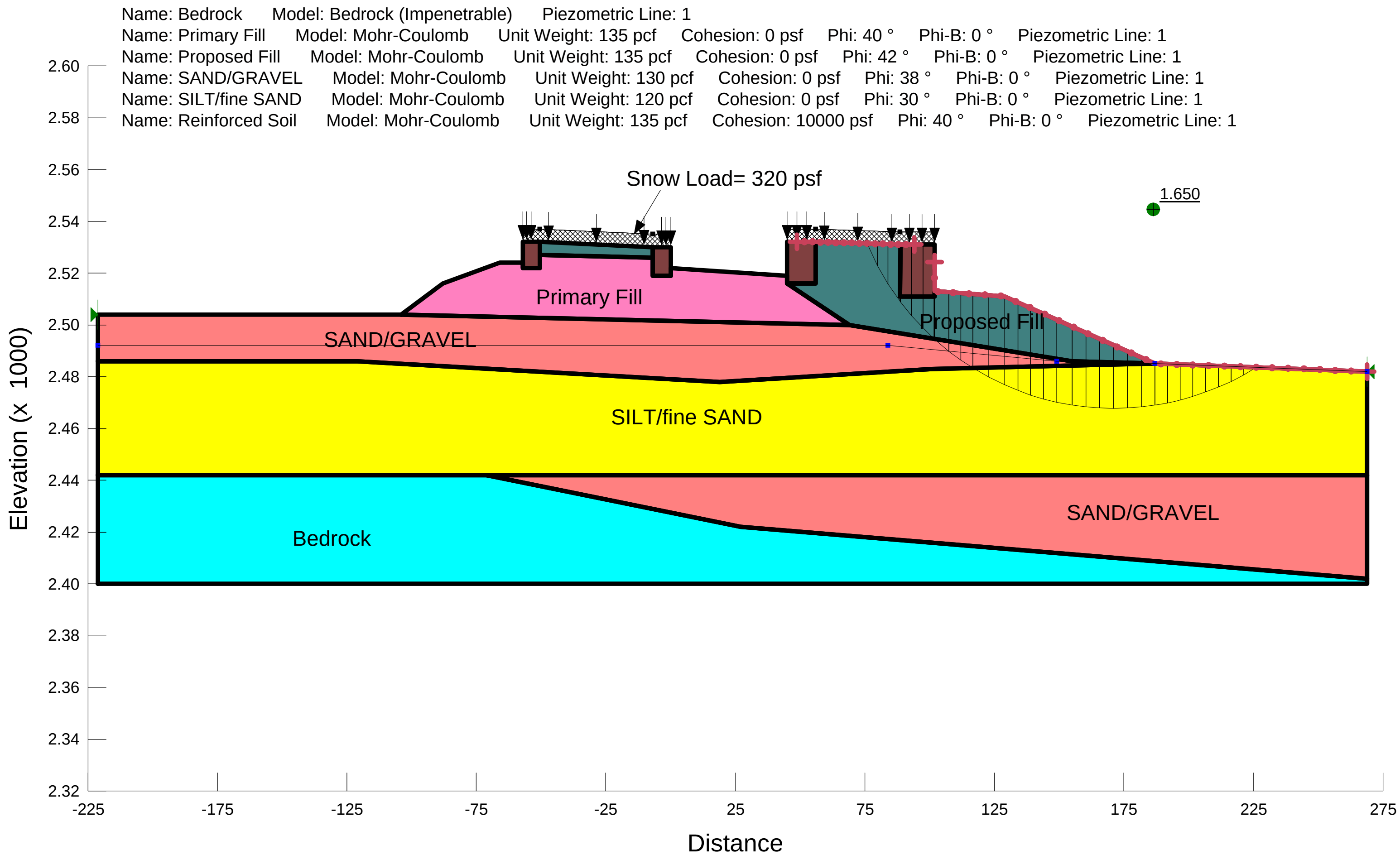

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Figure H.8.6

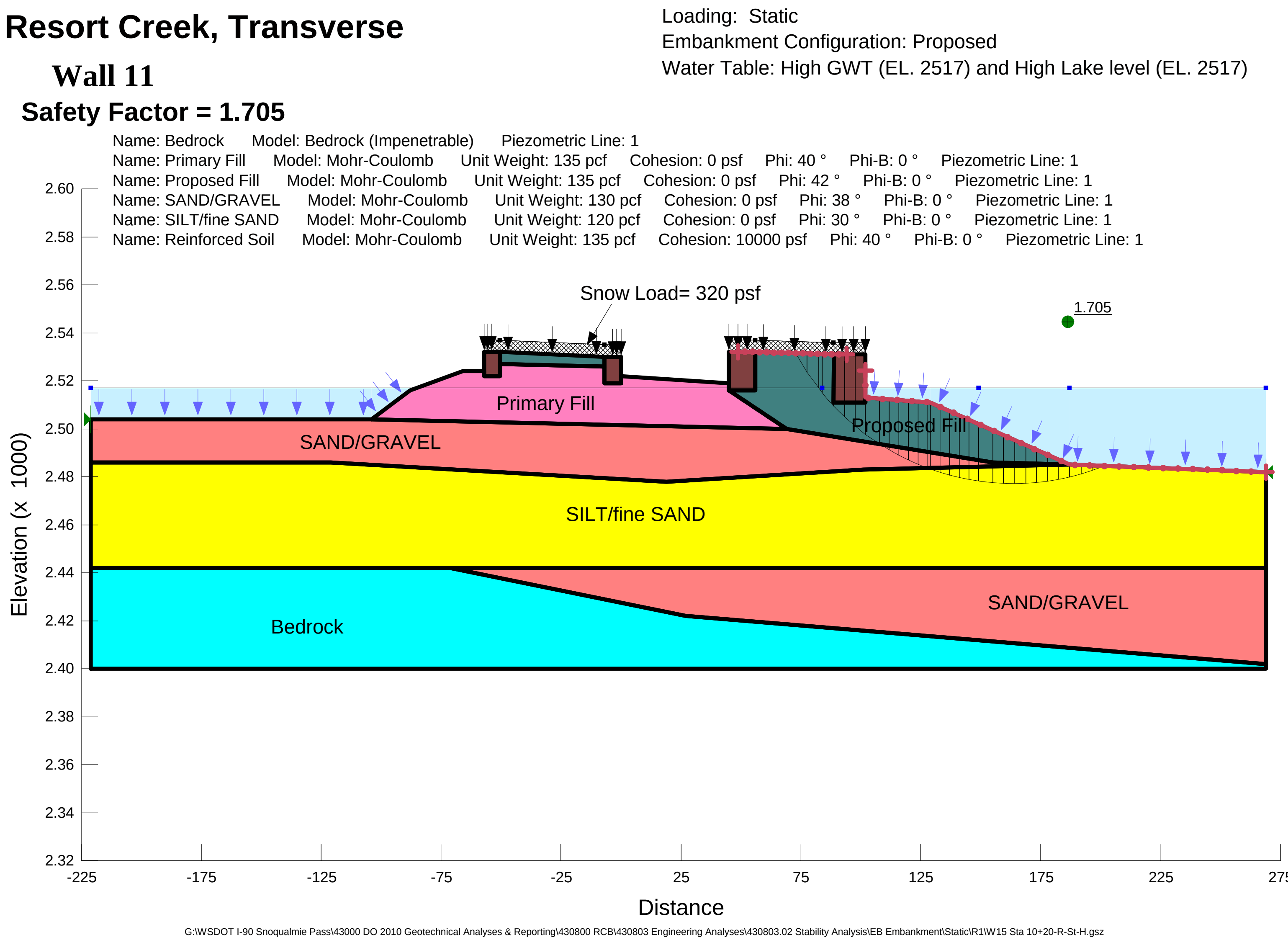
Resort Creek, Transverse
Wall 11
Safety Factor = 1.705
Loading: Static
Embankment Configuration: Proposed
Water Table: High GWT (EL. 2517) and High Lake level (EL. 2517)
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 10000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Snow Load= 320 psf
1.705
Primary Fill
Proposed Fill
SAND/GRAVEL
SILT/fine SAND
SAND/GRAVEL
Bedrock
Elevation (x 1000)
2.60
2.58
2.56
2.54
2.52
2.50
2.48
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
-225
-175
-125
-75
-25
25
75
125
175
225
275
Distance
G:\WSDOT I-90 Snoqualmie Pass\43000 DO 2010 Geotechnical Analyses & Reporting\430800 RCB\430803 Engineering Analyses\430803.02 Stability Analysis\EB Embankment\Static\R1\W15 Sta 10+20-R-St-H.gsz

Figure H.8.7

Resort Creek, Transverse

Wall 11

Loading: Seismic (Kh=0.175 g, Kv=0)
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2492) and Low Lake level (EL. 2416)

Safety Factor = 1.072

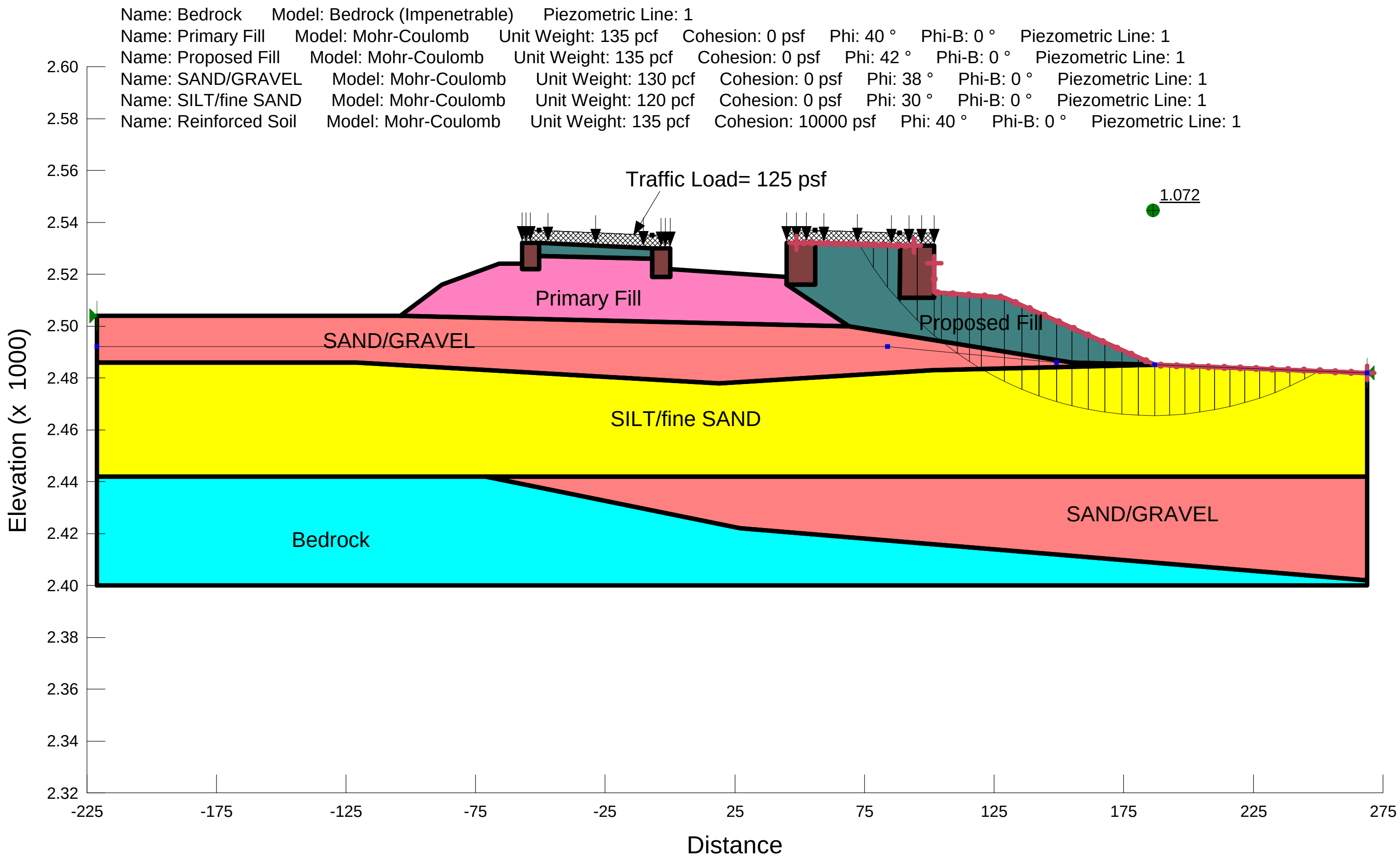

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Figure H.8.8

Kramer

Resort Creek, Transverse
EB Embankment at EB Station 1426+15

Safety Factor = 0.477

Loading: Seismic (Kh=0, Kv=0), Residual
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2492) and Low Lake level (EL. 2416)

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND-B1 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 325 psf C-Rate of Change: 4.608 psf/ft Limiting C: 2000 psf Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 10000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND-B2 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 450 psf C-Rate of Change: 4.608 psf/ft Limiting C: 2000 psf Piezometric Line: 1
Name: SILT/fine SAND-B3 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 600 psf C-Rate of Change: 3.456 psf/ft Limiting C: 2000 psf Piezometric Line: 1
Name: SILT/fine SAND-B4 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 505 psf C-Rate of Change: 3.456 psf/ft Limiting C: 2000 psf Piezometric Line: 1
Name: SILT/fine SAND-B5 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 610 psf C-Rate of Change: 3.456 psf/ft Limiting C: 2000 psf Piezometric Line: 1
Name: SILT/fine SAND-B6 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 300 psf C-Rate of Change: 4.608 psf/ft Limiting C: 2000 psf Piezometric Line: 1
Name: SILT/fine SAND-B7 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 160 psf C-Rate of Change: 4.608 psf/ft Limiting C: 2000 psf Piezometric Line: 1

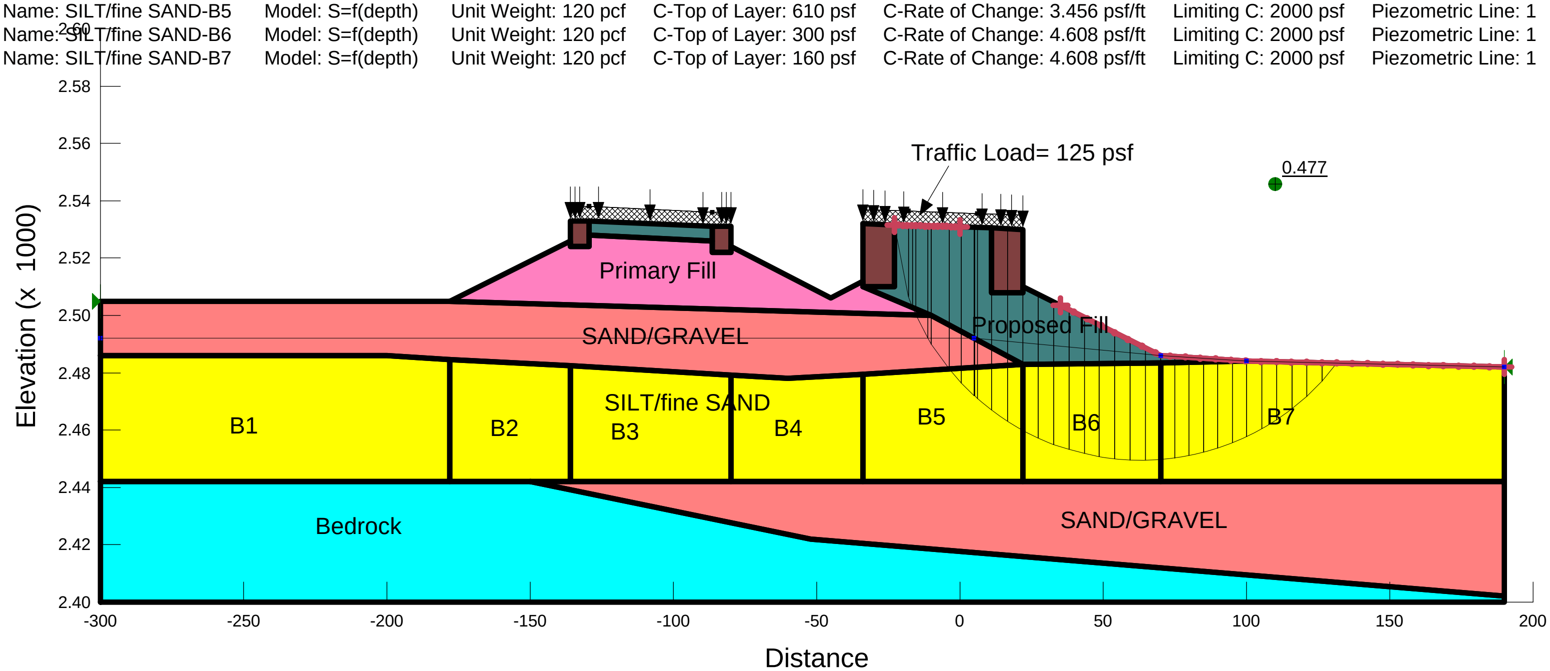

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Figure H.8.9

Resort Creek, Transverse
EB Embankment at EB Station 1426+15
Safety Factor = 0.452

Loading: Seismic (Kh=0, Kv=0), Residual
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2492) and Low Lake level (EL. 2416)

S & O

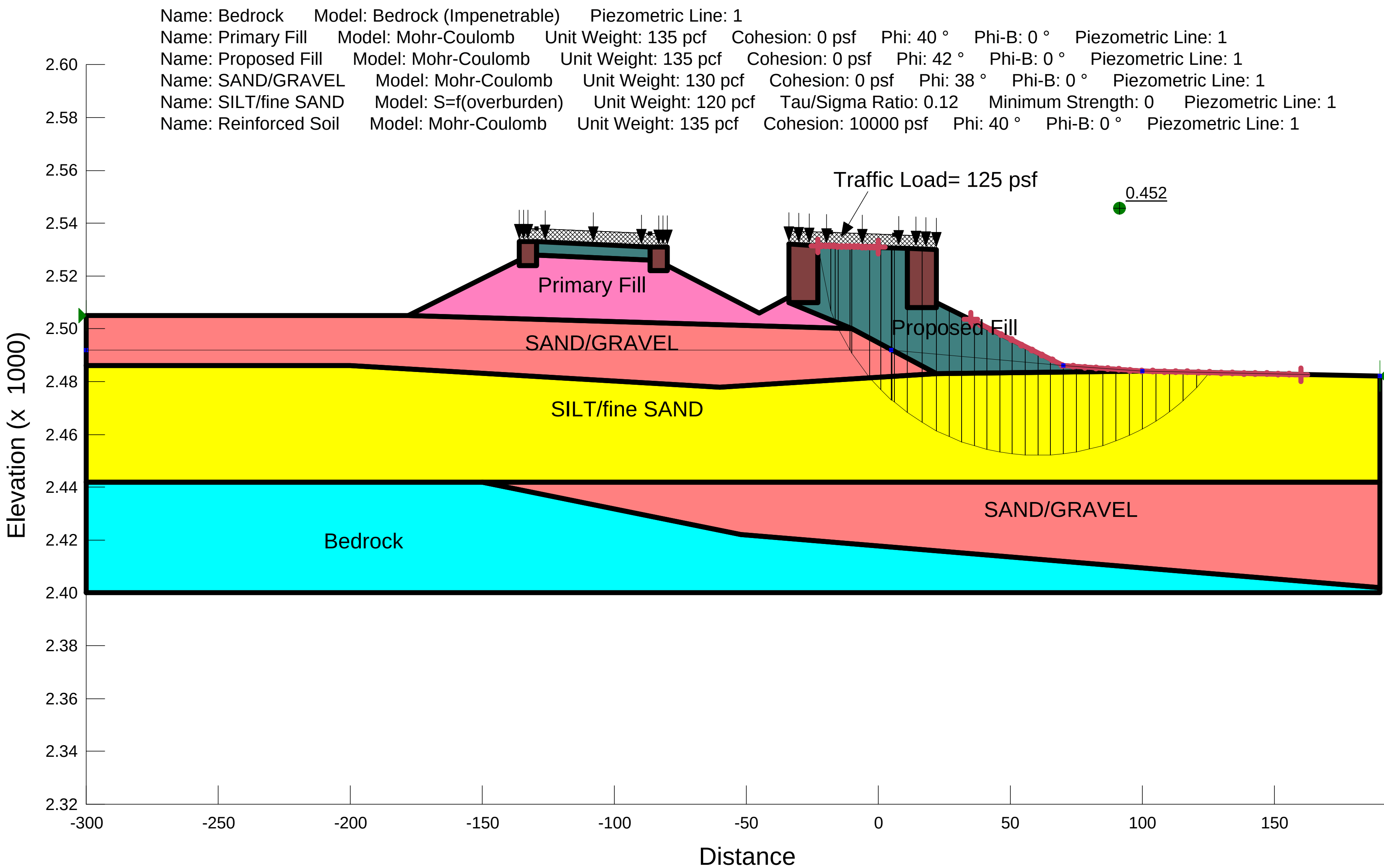

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Figure H.8.10

Resort Creek, Transverse
WB Embankment at EB Station 1426+15
Safety Factor = 1.619

Loading: Static
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2492) and Low Lake level (EL. 2416)

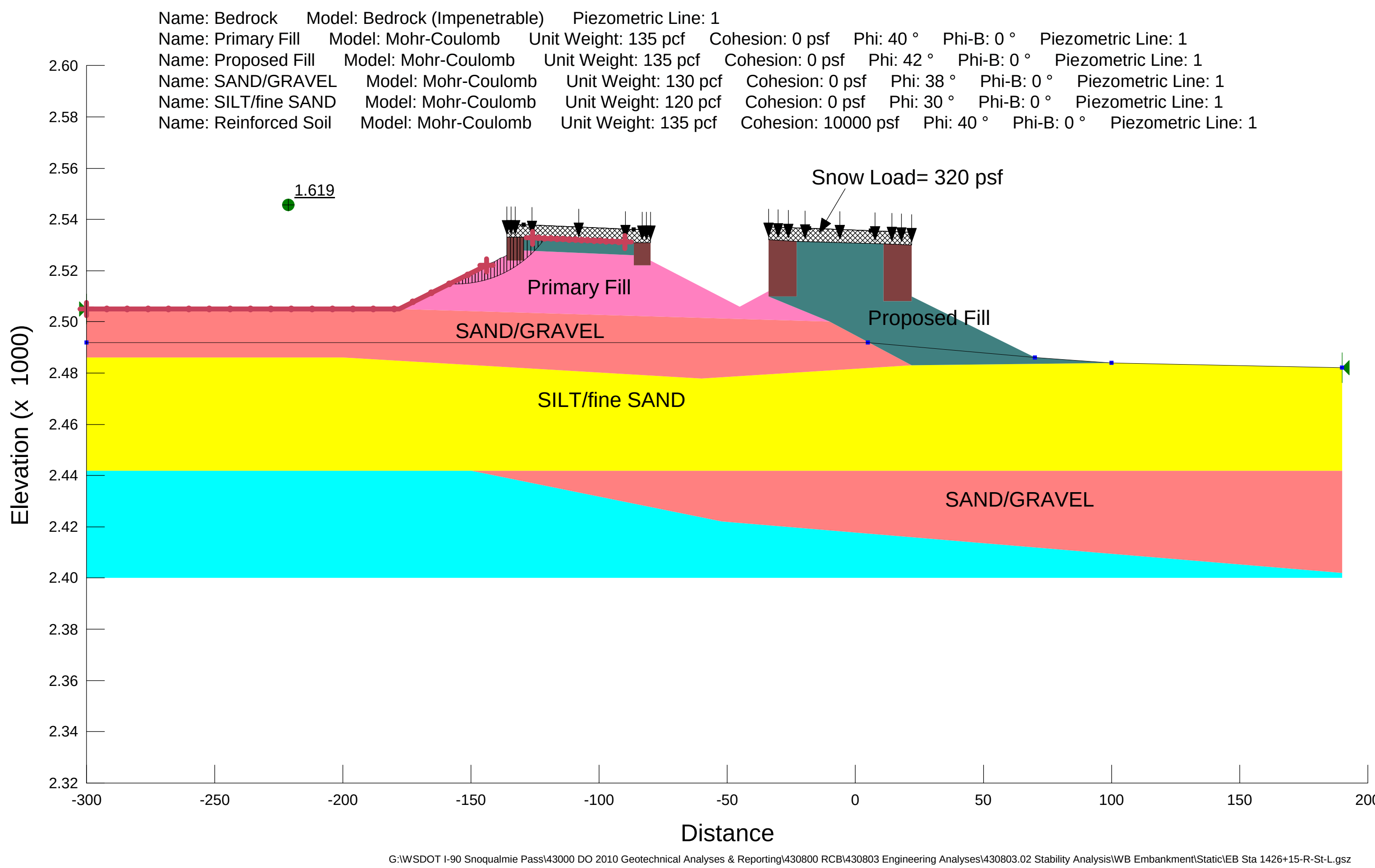

Figure H.8.11

Resort Creek, Transverse
WB Embankment at EB Station 1426+15
Safety Factor = 1.460

Loading: Static
Embankment Configuration: Proposed
Water Table: High GWT (EL. 2517) and High Lake level (EL. 2517)

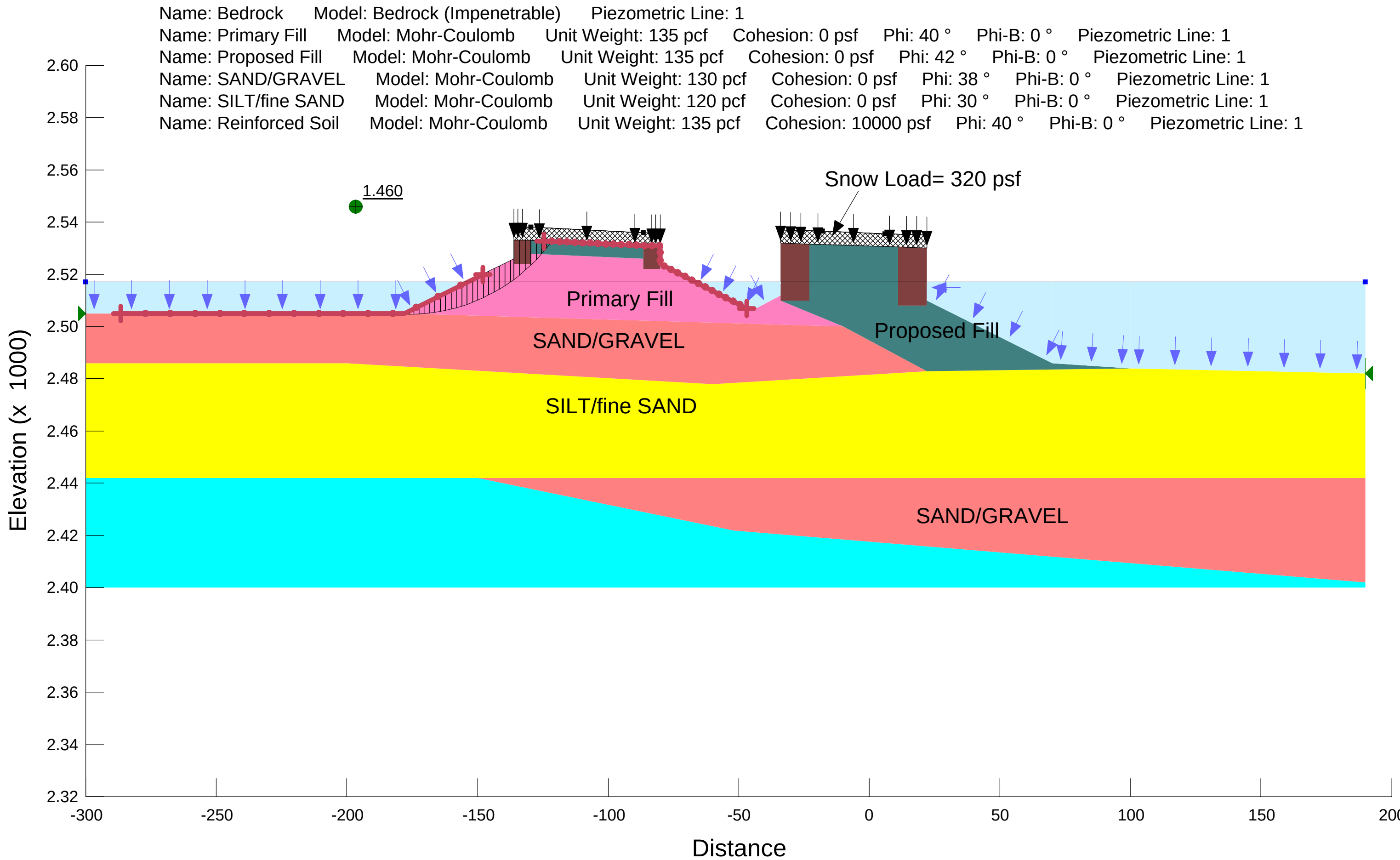

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Figure H.8.12

Resort Creek, Transverse
WB Embankment at EB Station 1426+15
Safety Factor = 1.189

Loading: Seismic (Kh=0.175, Kv=0)
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2492) and Low Lake level (EL. 2416)

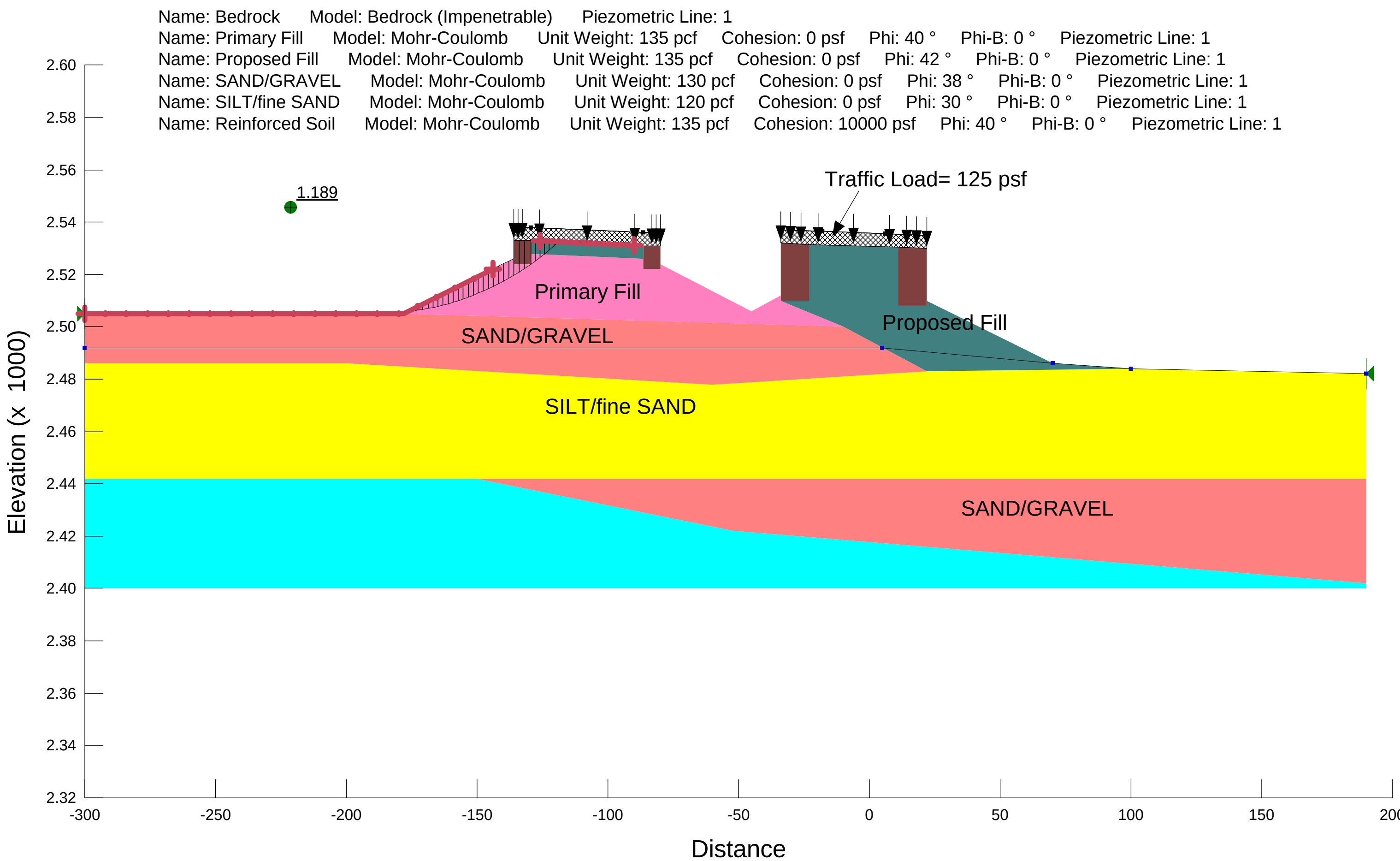

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Figure H.8.13

Resort Creek, Transverse
WB Embankment at EB Station 1426+12

Safety Factor = 1.30

Loading: Seismic (Kh=0, Kv=0), Residual
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level

Name: Bedrock   Model: Bedrock (Impenetrable)   Piezometric Line: 1
Name: Primary Fill   Model: Mohr-Coulomb   Unit Weight: 135 pcf   Cohesion: 0 psf   Phi: 40 °   Phi-B: 0 °   Piezometric Line: 1
Name: Proposed Fill   Model: Mohr-Coulomb   Unit Weight: 135 pcf   Cohesion: 0 psf   Phi: 42 °   Phi-B: 0 °   Piezometric Line: 1
Name: SAND/GRAVEL   Model: Mohr-Coulomb   Unit Weight: 130 pcf   Cohesion: 0 psf   Phi: 38 °   Phi-B: 0 °   Piezometric Line: 1
Name: SILT/fine SAND-B1   Model: S=f(depth)   Unit Weight: 120 pcf   C-Top of Layer: 315 psf   C-Rate of Change: 4.608 psf/ft   Limiting C: 2000 psf   Piezometric Line: 1
Name: SILT/fine SAND-B2   Model: S=f(depth)   Unit Weight: 120 pcf   C-Top of Layer: 445 psf   C-Rate of Change: 4.608 psf/ft   Limiting C: 2000 psf   Piezometric Line: 1
Name: SILT/fine SAND-B3   Model: S=f(depth)   Unit Weight: 120 pcf   C-Top of Layer: 600 psf   C-Rate of Change: 3.456 psf/ft   Limiting C: 2000 psf   Piezometric Line: 1
Name: SILT/fine SAND-B4   Model: S=f(depth)   Unit Weight: 120 pcf   C-Top of Layer: 450 psf   C-Rate of Change: 4.608 psf/ft   Limiting C: 2000 psf   Piezometric Line: 1
Name: SILT/fine SAND-B5   Model: S=f(depth)   Unit Weight: 120 pcf   C-Top of Layer: 160 psf   C-Rate of Change: 4.608 psf/ft   Limiting C: 2000 psf   Piezometric Line: 1
Name: SILT/fine SAND-NL   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 30 °   Phi-B: 0 °   Piezometric Line: 1
Name: Reinforcement   Model: Mohr-Coulomb   Unit Weight: 135 pcf   Cohesion: 25000 psf   Phi: 40 °   Phi-B: 0 °   Piezometric Line: 1
Name: Compaction Grouting   Model: Mohr-Coulomb   Unit Weight: 123 pcf   Cohesion: 7200 psf   Phi: 0 °   Phi-B: 0 °   Piezometric Line: 1

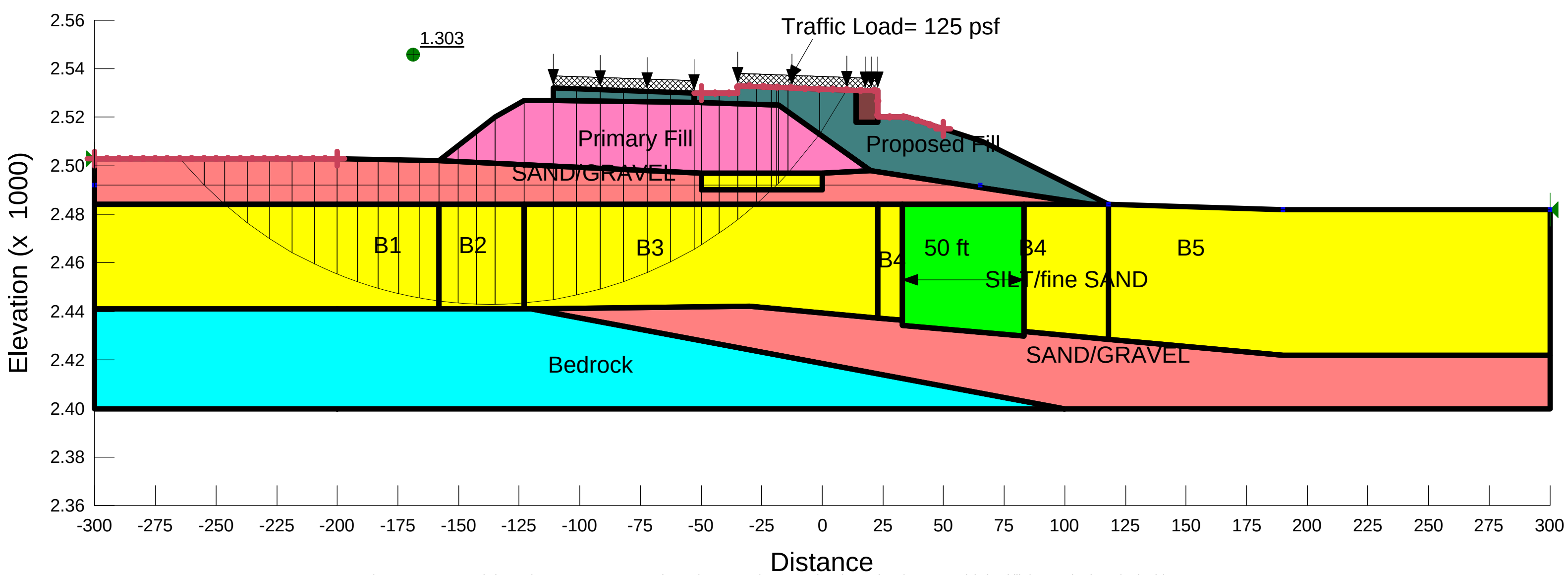

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Figure H.8.14

Resort Creek, Longitudinal
EB Profile between Station 1424+00 to 1430+00

Loading: Static
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)
Lateral force=0.0 kips/ft

Safety Factor = 1.711

Name: Bedrock   Model: Bedrock (Impenetrable)   Piezometric Line: 1
Name: Primary Fill   Model: Mohr-Coulomb   Unit Weight: 135 pcf   Cohesion: 0 psf   Phi: 40 °   Phi-B: 0 °   Piezometric Line: 1
Name: Proposed Fill   Model: Mohr-Coulomb   Unit Weight: 135 pcf   Cohesion: 0 psf   Phi: 42 °   Phi-B: 0 °   Piezometric Line: 1
Name: SAND/GRAVEL   Model: Mohr-Coulomb   Unit Weight: 130 pcf   Cohesion: 0 psf   Phi: 38 °   Phi-B: 0 °   Piezometric Line: 1
Name: SILT/fine SAND   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 30 °   Phi-B: 0 °   Piezometric Line: 1

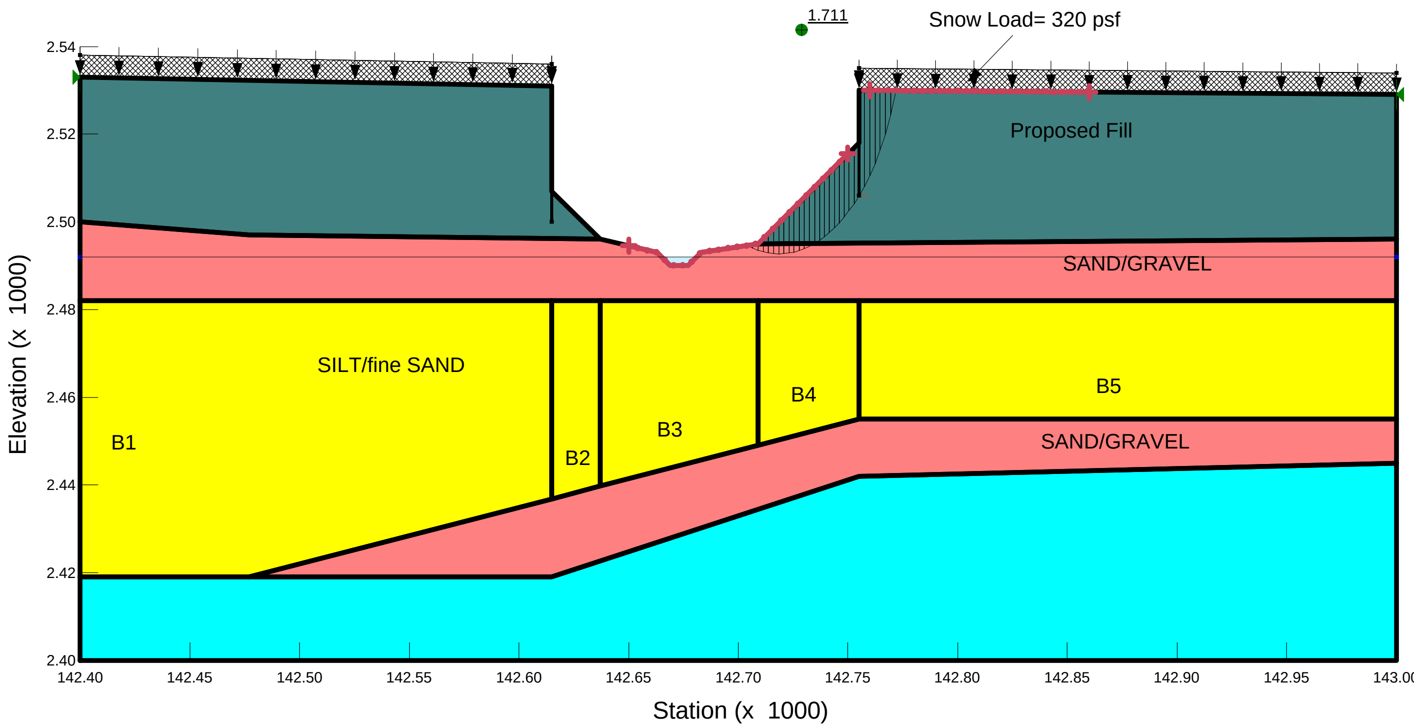

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Figure H.8.15

Resort Creek, Longitudinal
EB Profile between Station 1424+00 to 1430+00

Loading: Static
Embankment Configuration: Proposed
Water Table: High GWT (EL. 2517) and High Lake level (EL. 2517
Lateral force=0.0 kips/ft

Safety Factor = 1.495

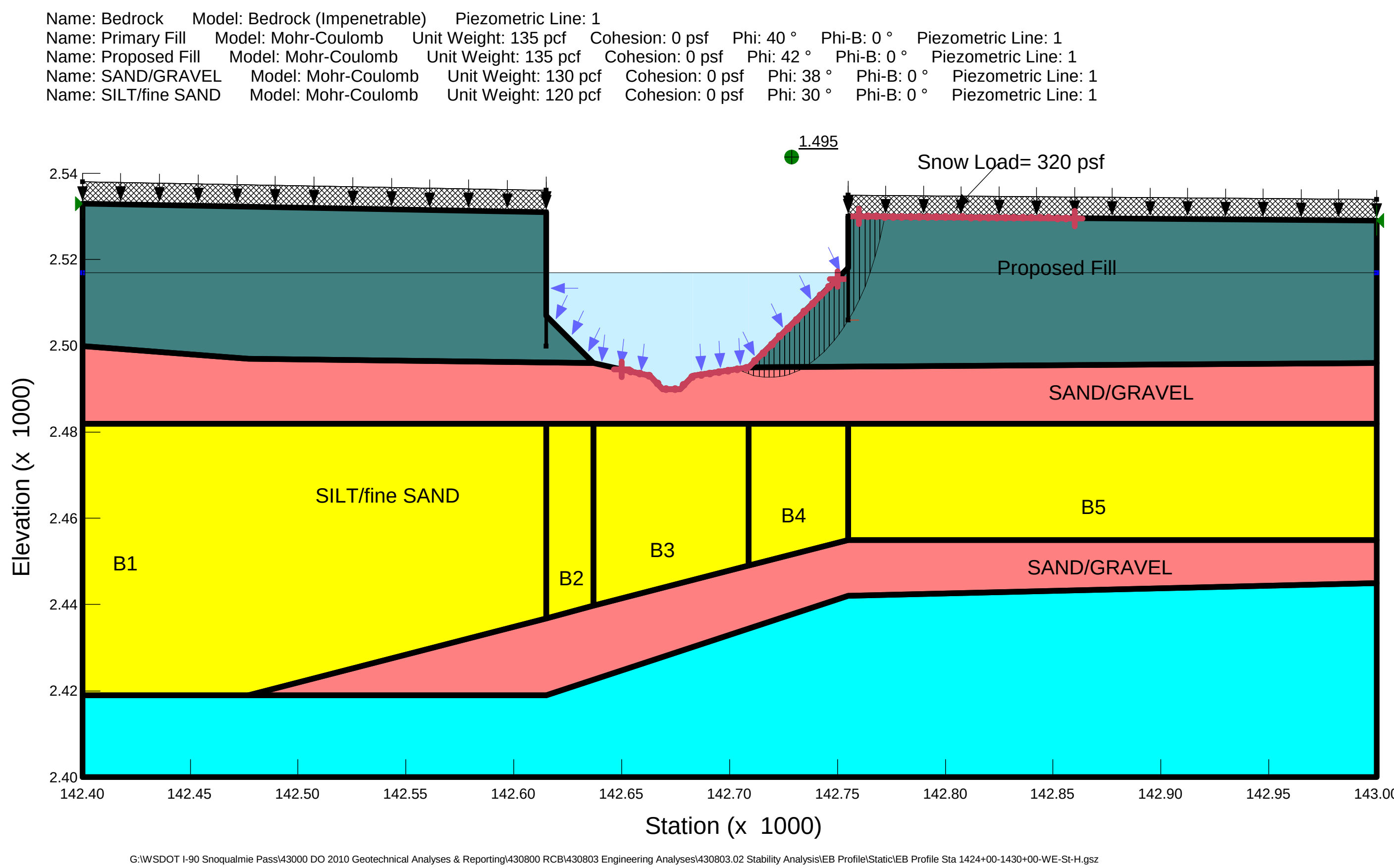

Figure H.8.16

Resort Creek, Longitudinal
EB Profile between Station 1424+00 to 1430+00

Loading: Seismic (Kh=0.175, Kv=0), Pseudostatic
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)
Lateral force=0.0 kips/ft

Safety Factor = 1.256

Name: Bedrock   Model: Bedrock (Impenetrable)   Piezometric Line: 1
Name: Primary Fill   Model: Mohr-Coulomb   Unit Weight: 135 pcf   Cohesion: 0 psf   Phi: 40 °   Phi-B: 0 °   Piezometric Line: 1
Name: Proposed Fill   Model: Mohr-Coulomb   Unit Weight: 135 pcf   Cohesion: 0 psf   Phi: 42 °   Phi-B: 0 °   Piezometric Line: 1
Name: SAND/GRAVEL   Model: Mohr-Coulomb   Unit Weight: 130 pcf   Cohesion: 0 psf   Phi: 38 °   Phi-B: 0 °   Piezometric Line: 1
Name: SILT/fine SAND   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion: 0 psf   Phi: 30 °   Phi-B: 0 °   Piezometric Line: 1

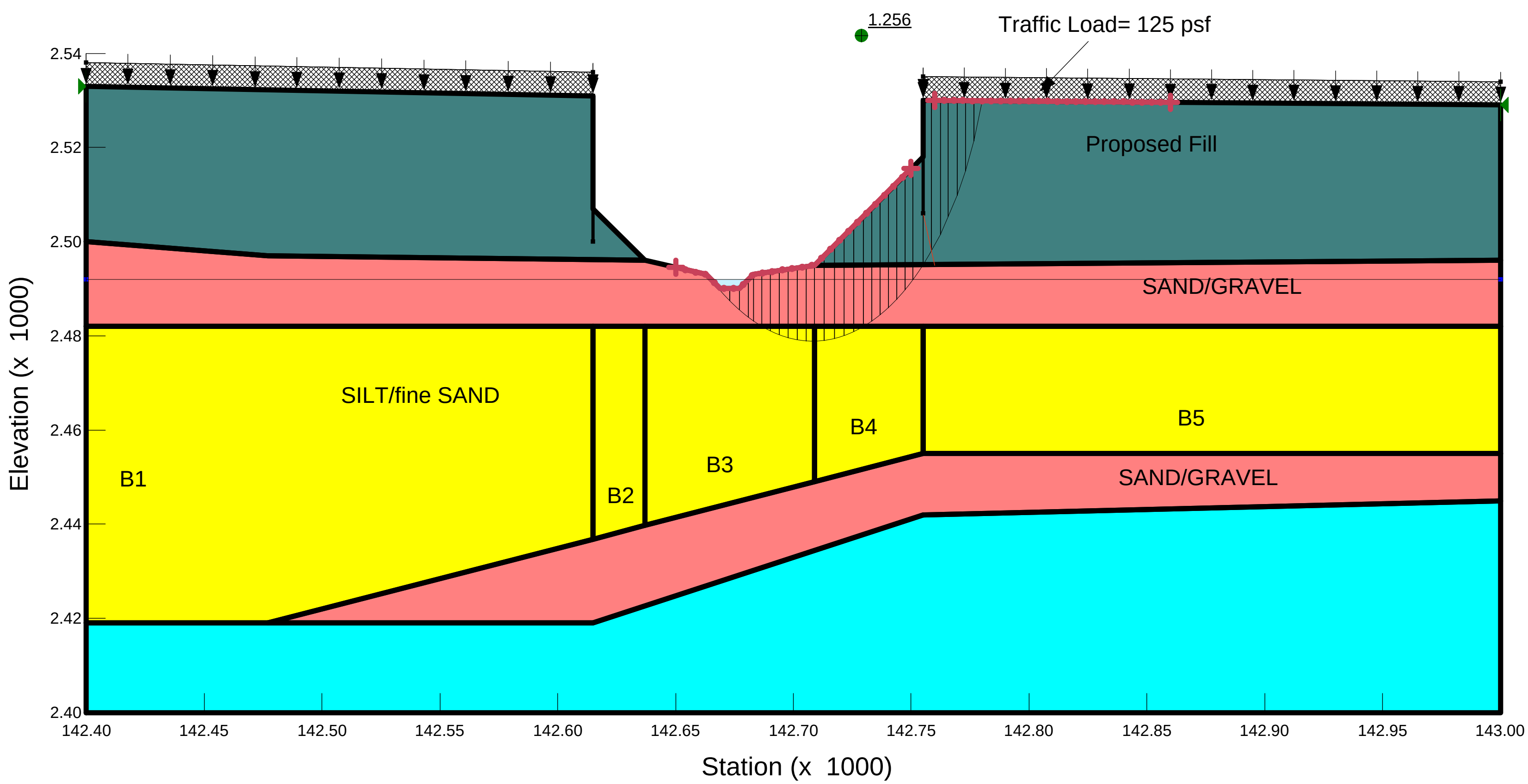

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Figure H.8.17

Resort Creek, Longitudinal
EB Profile between Station 1424+00 to 1430+00

Loading: Seismic (Kh=0, Kv=0), Residual
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)
Lateral force=0.0 kips/ft

Kramer

Safety Factor = 0.857

Name	Model	Unit Weight	Cohesion / C-Top of Layer	Phi / C-Rate of Change	Phi-B / Limiting C	Piezometric Line
Bedrock	Bedrock (Impenetrable)					1
Primary Fill	Mohr-Coulomb	135 pcf	Cohesion: 0 psf	Phi: 40 °	Phi-B: 0 °	1
Proposed Fill	Mohr-Coulomb	135 pcf	Cohesion: 0 psf	Phi: 42 °	Phi-B: 0 °	1
SAND/GRAVEL	Mohr-Coulomb	130 pcf	Cohesion: 0 psf	Phi: 38 °	Phi-B: 0 °	1
SILT/fine SAND-B1	S=f(depth)	120 pcf	C-Top of Layer: 610 psf	C-Rate of Change: 3.456 psf/ft	Limiting C: 2000 psf	1
SILT/fine SAND-B2	S=f(depth)	120 pcf	C-Top of Layer: 310 psf	C-Rate of Change: 4.608 psf/ft	Limiting C: 2000 psf	1
SILT/fine SAND-B3	S=f(depth)	120 pcf	C-Top of Layer: 245 psf	C-Rate of Change: 4.608 psf/ft	Limiting C: 2000 psf	1
SILT/fine SAND-B4	S=f(depth)	120 pcf	C-Top of Layer: 360 psf	C-Rate of Change: 4.608 psf/ft	Limiting C: 2000 psf	1
SILT/fine SAND-B5	S=f(depth)	120 pcf	C-Top of Layer: 595 psf	C-Rate of Change: 3.456 psf/ft	Limiting C: 2000 psf	1

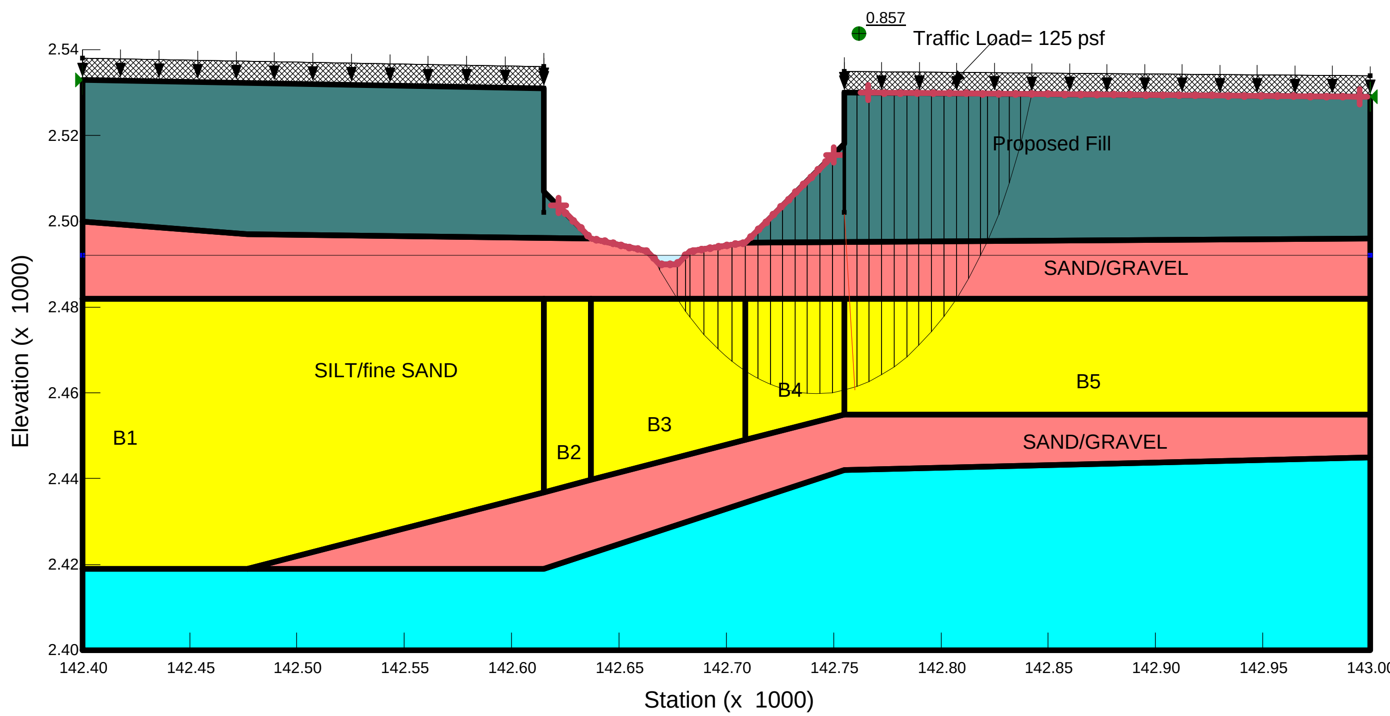

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Figure H.8.18

Resort Creek, Longitudinal
EB Profile between Station 1424+00 to 1430+00

Loading: Seismic (Kh=0, Kv=0), Residual
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)
Lateral force=0.0 kips/ft

Safety Factor = 0.873

S&O

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: S=f(overburden) Unit Weight: 120 pcf Tau/Sigma Ratio: 0.12 Minimum Strength: 0 Piezometric Line: 1

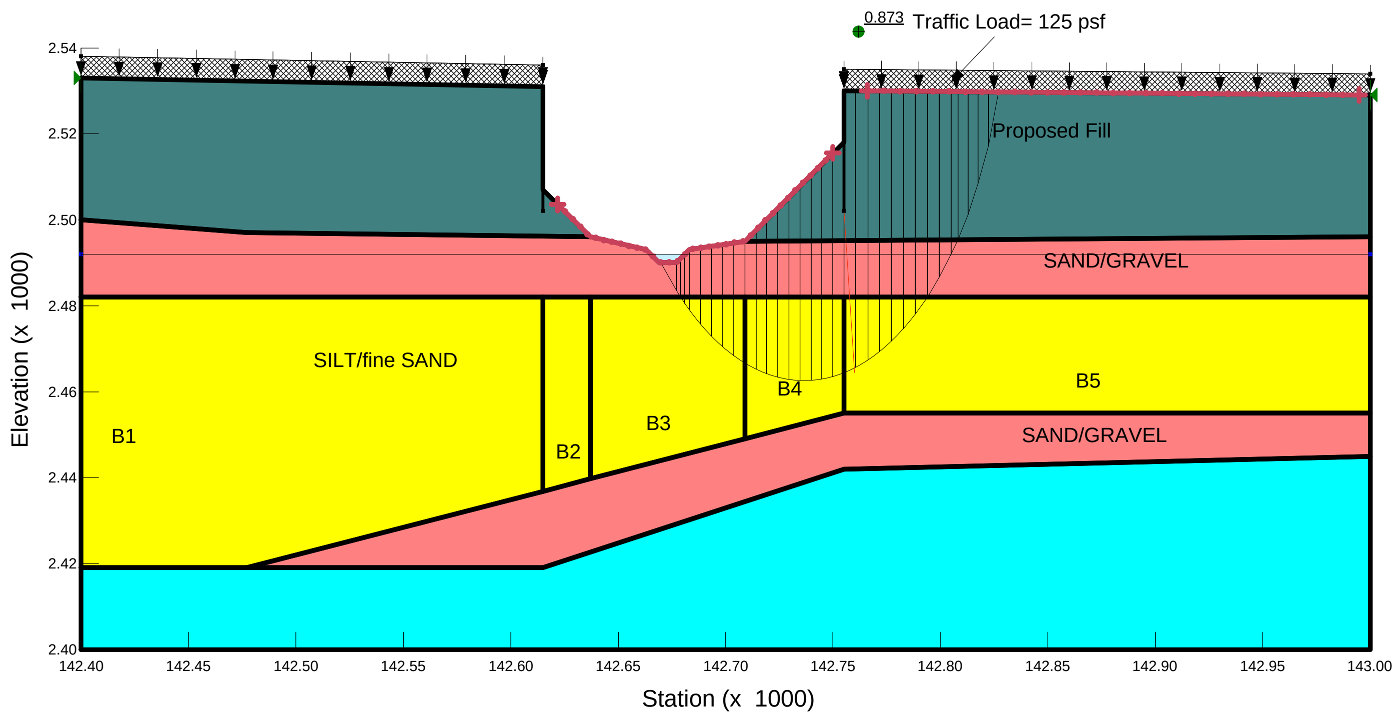

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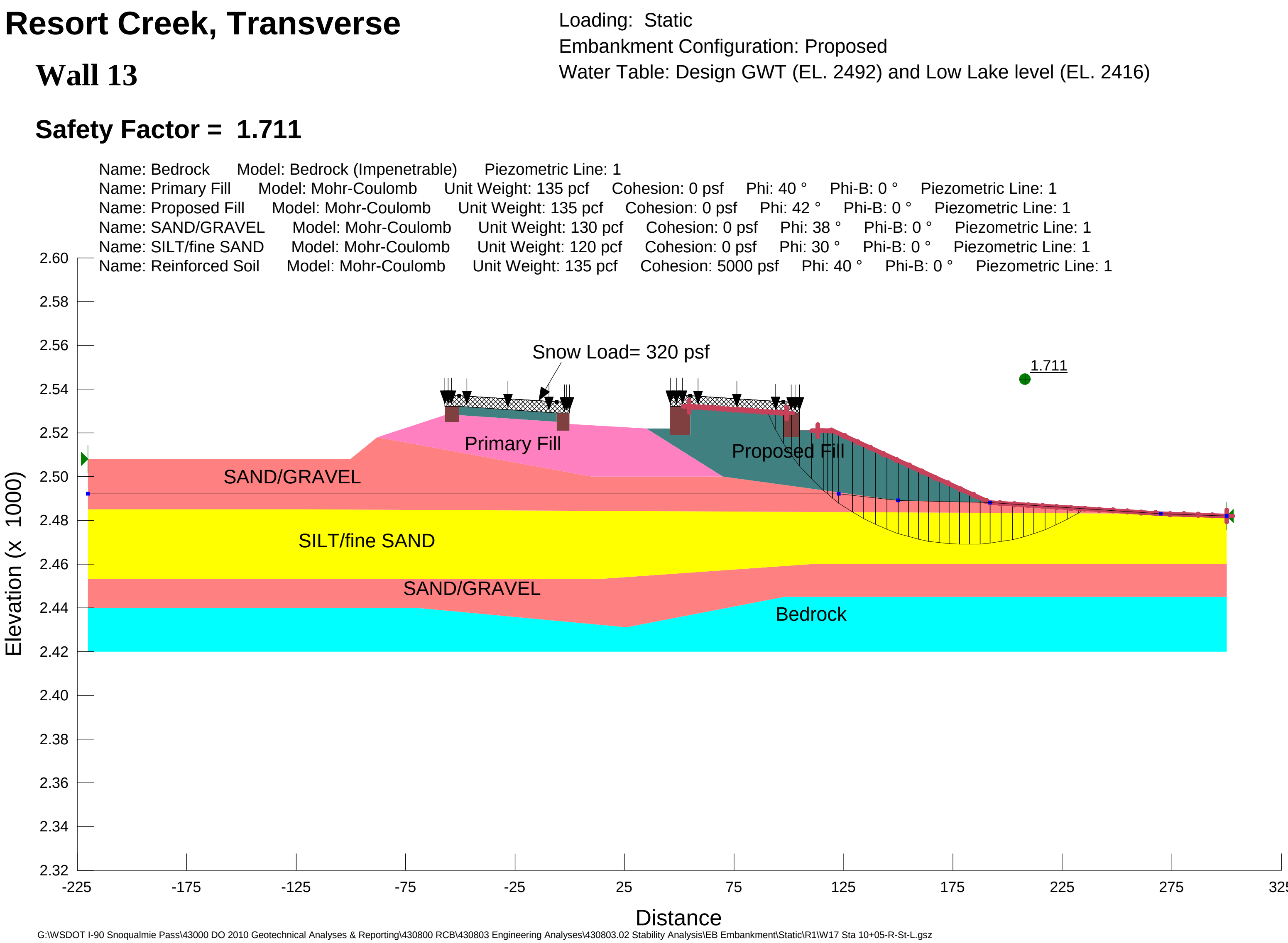
Figure H.8.19



Resort Creek, Transverse
Wall 13
Safety Factor = 1.711
Loading: Static
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 5000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Snow Load= 320 psf
1.711
Primary Fill
Proposed Fill
SAND/GRAVEL
SILT/fine SAND
SAND/GRAVEL
Bedrock
Elevation (x 1000)
2.60
2.58
2.56
2.54
2.52
2.50
2.48
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
-225
-175
-125
-75
-25
25
75
125
175
225
275
325
Distance
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Figure H.8.20

Resort Creek, Transverse

Loading: Static
Embankment Configuration: Proposed
Water Table: High GWT (EL. 2517) and High Lake level (EL. 2517)

Wall 13

Safety Factor = 1.880

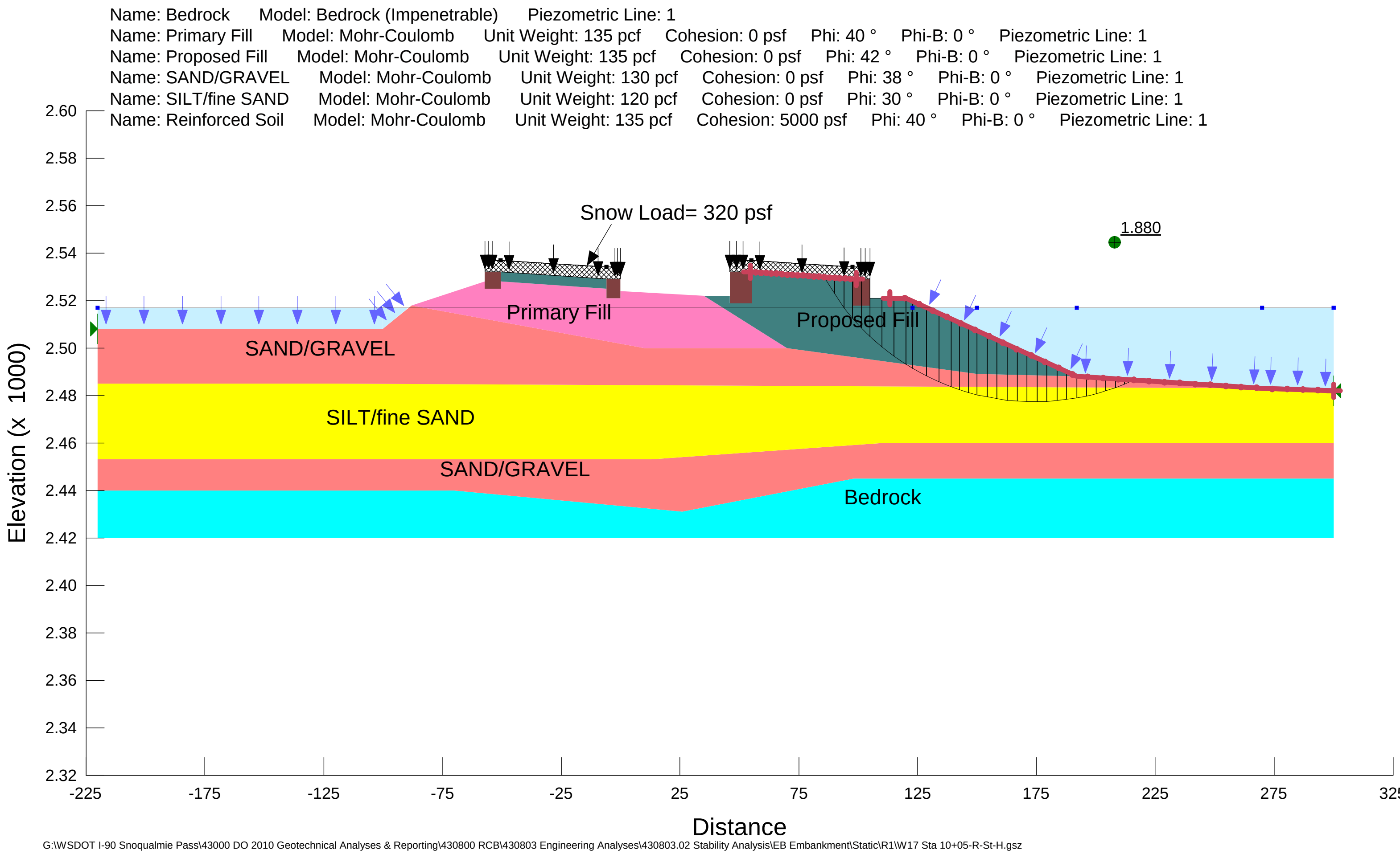

Figure H.8.21

Resort Creek, Transverse

Wall 13

Safety Factor = 1.078

Loading: Seismic (Kh=.175, Kv=0)
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 5000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1

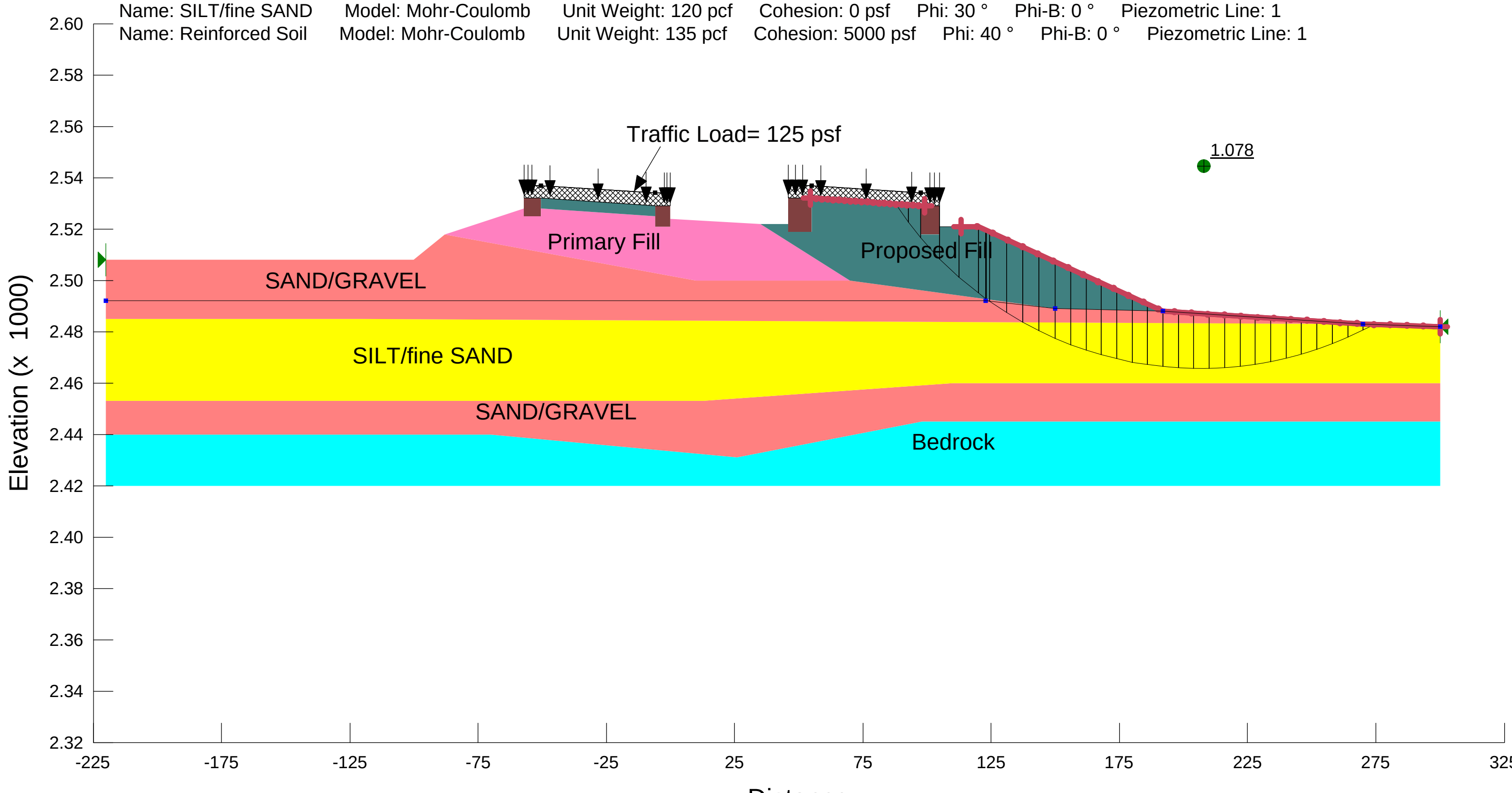

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Figure H.8.22

Kramer

Resort Creek, Transverse
EB Embankment at EB Station 1427+55
Safety Factor = 0.718

Loading: Seismic (Kh=0, Kv=0), Residual
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND-B1 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 350 psf C-Rate of Change: 4.608 psf/ft Limiting C: 2000 psf Piezometric Line:
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 5000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND-B2 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 440 psf C-Rate of Change: 4.608 psf/ft Limiting C: 2000 psf Piezometric Line:
Name: SILT/fine SAND-B3 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 590 psf C-Rate of Change: 3.456 psf/ft Limiting C: 2000 psf Piezometric Line:
Name: SILT/fine SAND-B4 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 450 psf C-Rate of Change: 4.608 psf/ft Limiting C: 2000 psf Piezometric Line:
Name: SILT/fine SAND-B5 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 590 psf C-Rate of Change: 3.456 psf/ft Limiting C: 2000 psf Piezometric Line:
Name: SILT/fine SAND-B6 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 455 psf C-Rate of Change: 4.608 psf/ft Limiting C: 2000 psf Piezometric Line:
Name: SILT/fine SAND-B7 Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 160 psf C-Rate of Change: 4.608 psf/ft Limiting C: 2000 psf Piezometric Line:

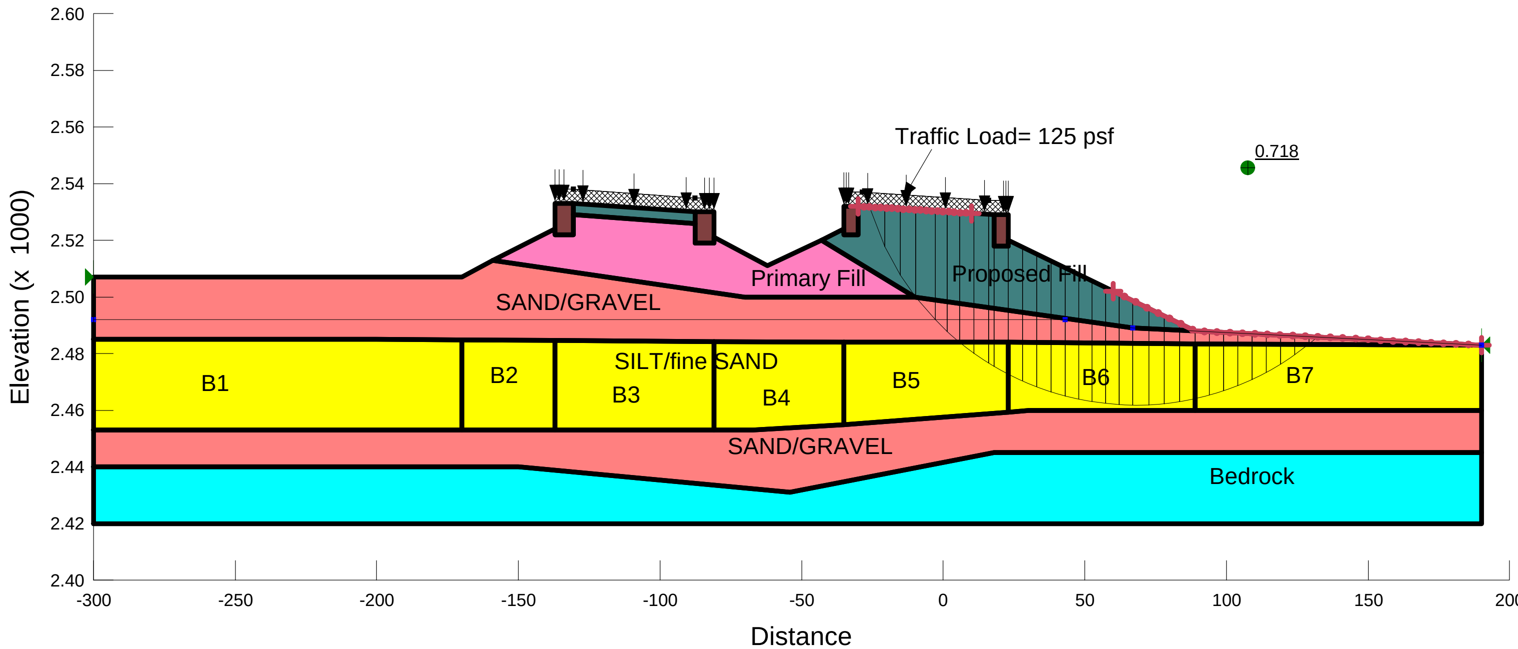

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Figure H.8.23

Resort Creek, Transverse
EB Embankment at EB Station 1427+55

Safety Factor = 0.632

Loading: Seismic (Kh=0, Kv=0), Residual
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)

S & O

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: S=f(overburden) Unit Weight: 120 pcf Tau/Sigma Ratio: 0.12 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 5000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1

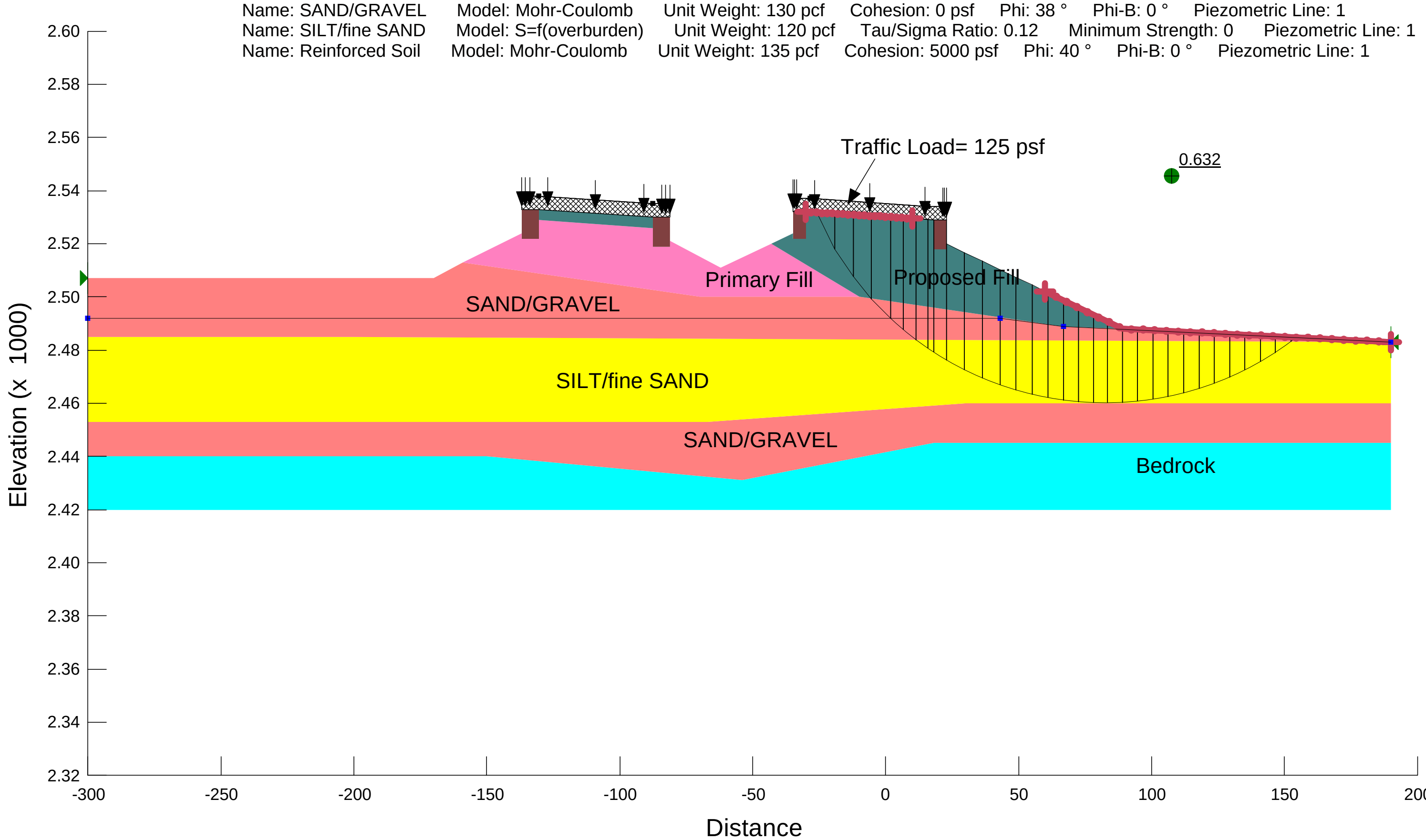

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Figure H.8.24

Resort Creek, Transverse

WB Embankment at EB Station 1427+55

Safety Factor = 1.476

Loading: Static
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)

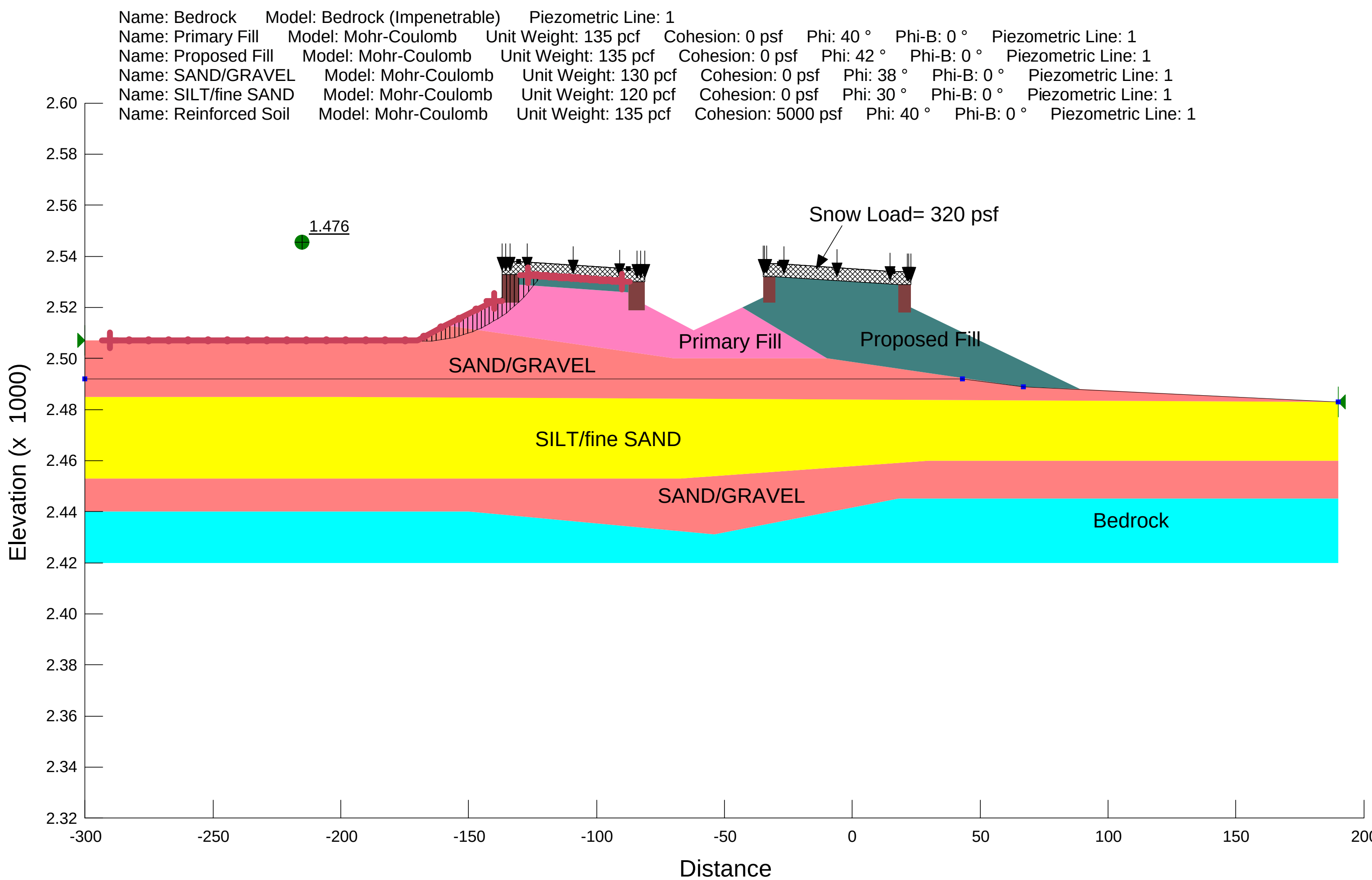

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Figure H.8.25

Resort Creek, Transverse
WB Embankment at EB Station 1427+55
Safety Factor = 1.306

Loading: Static
Embankment Configuration: Proposed
Water Table: High GWT (EL. 2517) and High Lake level (EL. 2517)

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 5000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1

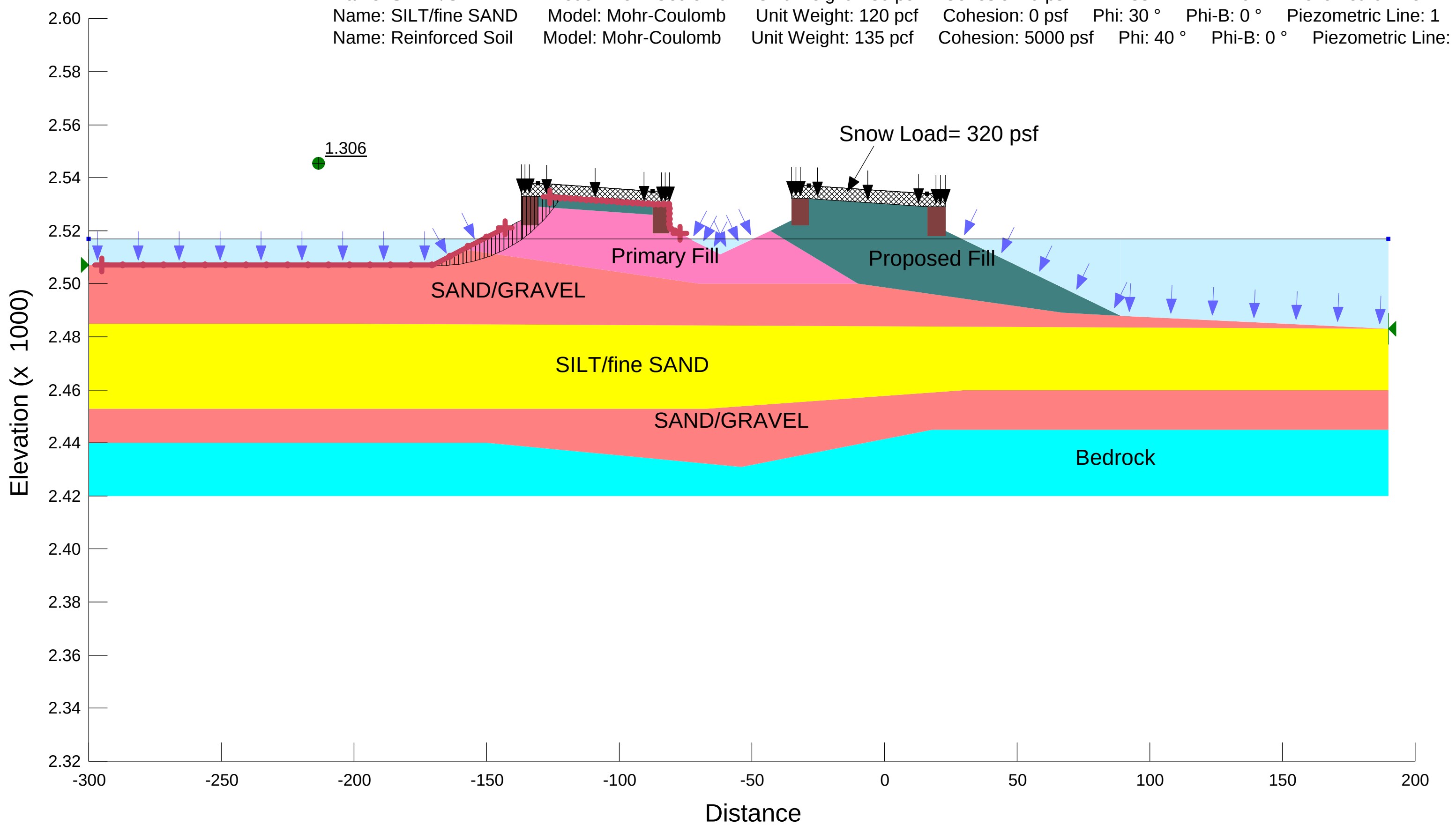

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Figure H.8.26

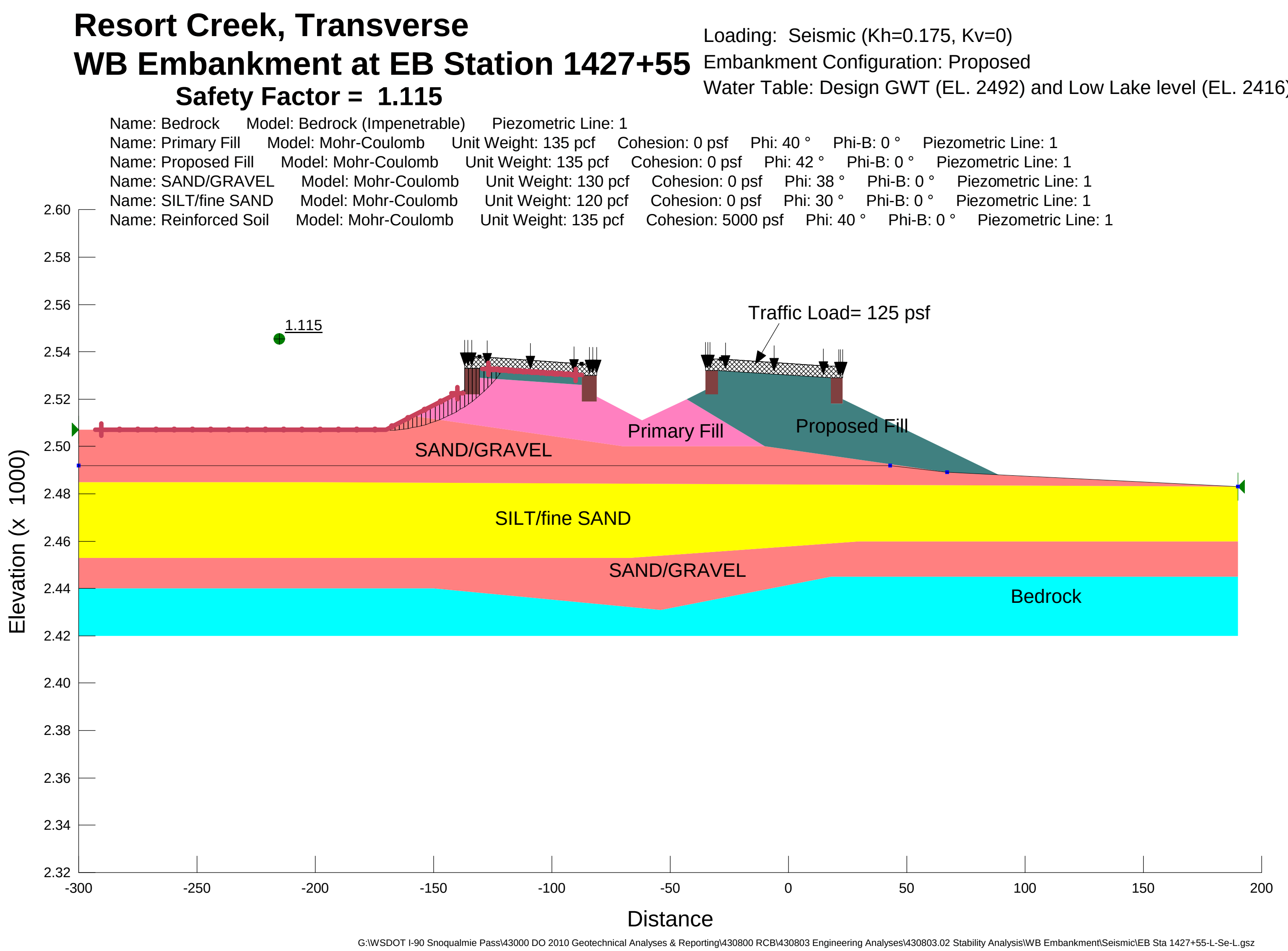

Resort Creek, Transverse
WB Embankment at EB Station 1427+55
Safety Factor = 1.115
Loading: Seismic (Kh=0.175, Kv=0)
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 5000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
1.115
Traffic Load= 125 psf
Primary Fill
Proposed Fill
SAND/GRAVEL
SILT/fine SAND
SAND/GRAVEL
Bedrock
Elevation (x 1000)
2.60
2.58
2.56
2.54
2.52
2.50
2.48
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
-300
-250
-200
-150
-100
-50
0
50
100
150
200
Distance
G:\WSDOT I-90 Snoqualmie Pass\43000 DO 2010 Geotechnical Analyses & Reporting\430800 RCB\430803 Engineering Analyses\430803.02 Stability Analysis\WB Embankment\Seismic\EB Sta 1427+55-L-Se-L.gsz

Figure H.8.27

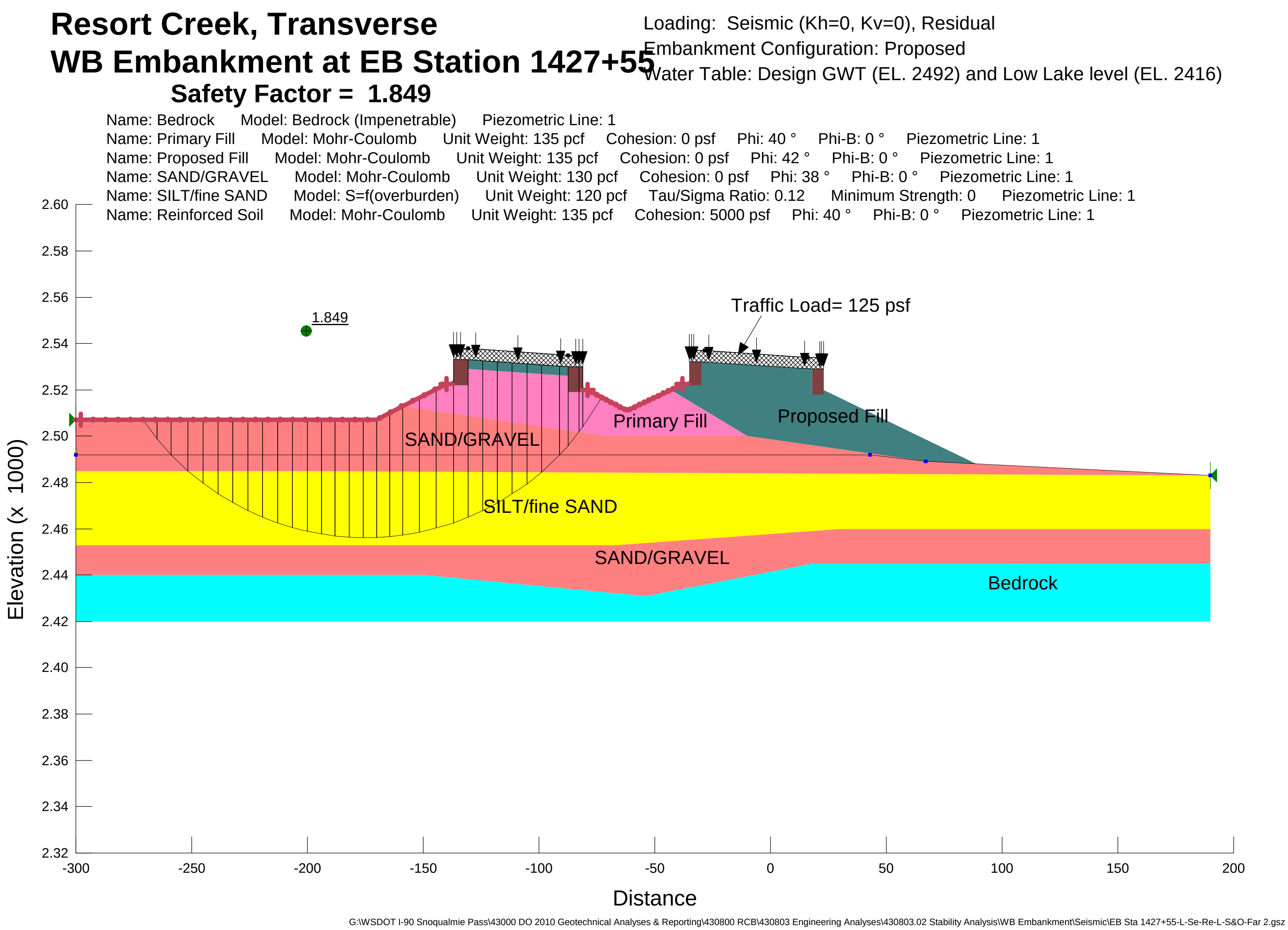

Resort Creek, Transverse
WB Embankment at EB Station 1427+55
Safety Factor = 1.849
Loading: Seismic (Kh=0, Kv=0), Residual
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: S=f(overburden) Unit Weight: 120 pcf Tau/Sigma Ratio: 0.12 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 5000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
1.849
Traffic Load= 125 psf
Primary Fill
Proposed Fill
SAND/GRAVEL
SILT/fine SAND
SAND/GRAVEL
Bedrock
Elevation (x 1000)
2.60
2.58
2.56
2.54
2.52
2.50
2.48
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
-300
-250
-200
-150
-100
-50
0
50
100
150
200
Distance
G:\WSDOT I-90 Snoqualmie Pass\43000 DO 2010 Geotechnical Analyses & Reporting\430800 RCB\430803 Engineering Analyses\430803.02 Stability Analysis\WB Embankment\Seismic\EB Sta 1427+55-L-Se-Re-L-S&O-Far 2.gsz

Figure H.8.28

Resort Creek, Transverse

Wall 12

Safety Factor = 3.087

Loading: Static
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2492) and Low Lake level (EL. 2416)

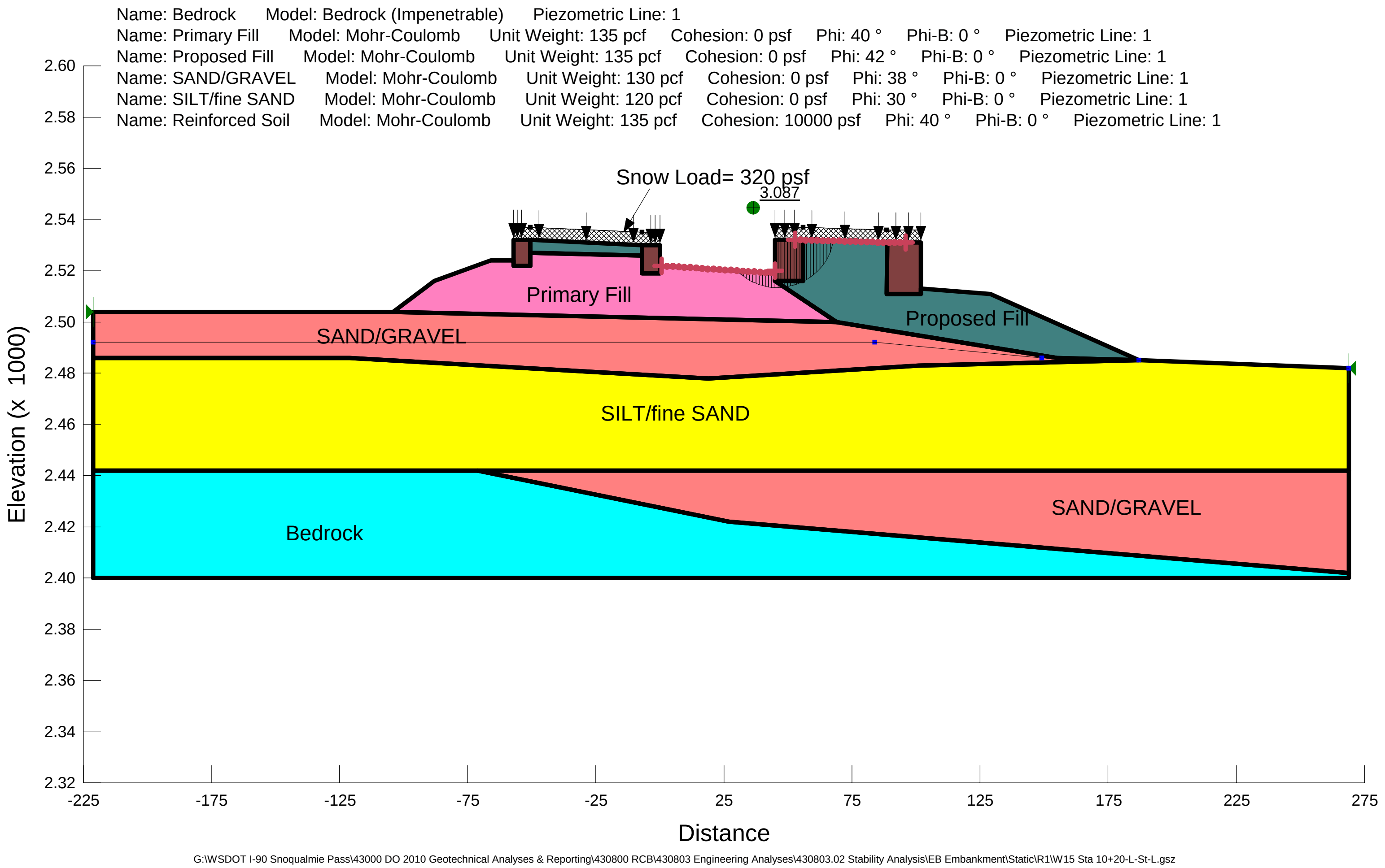
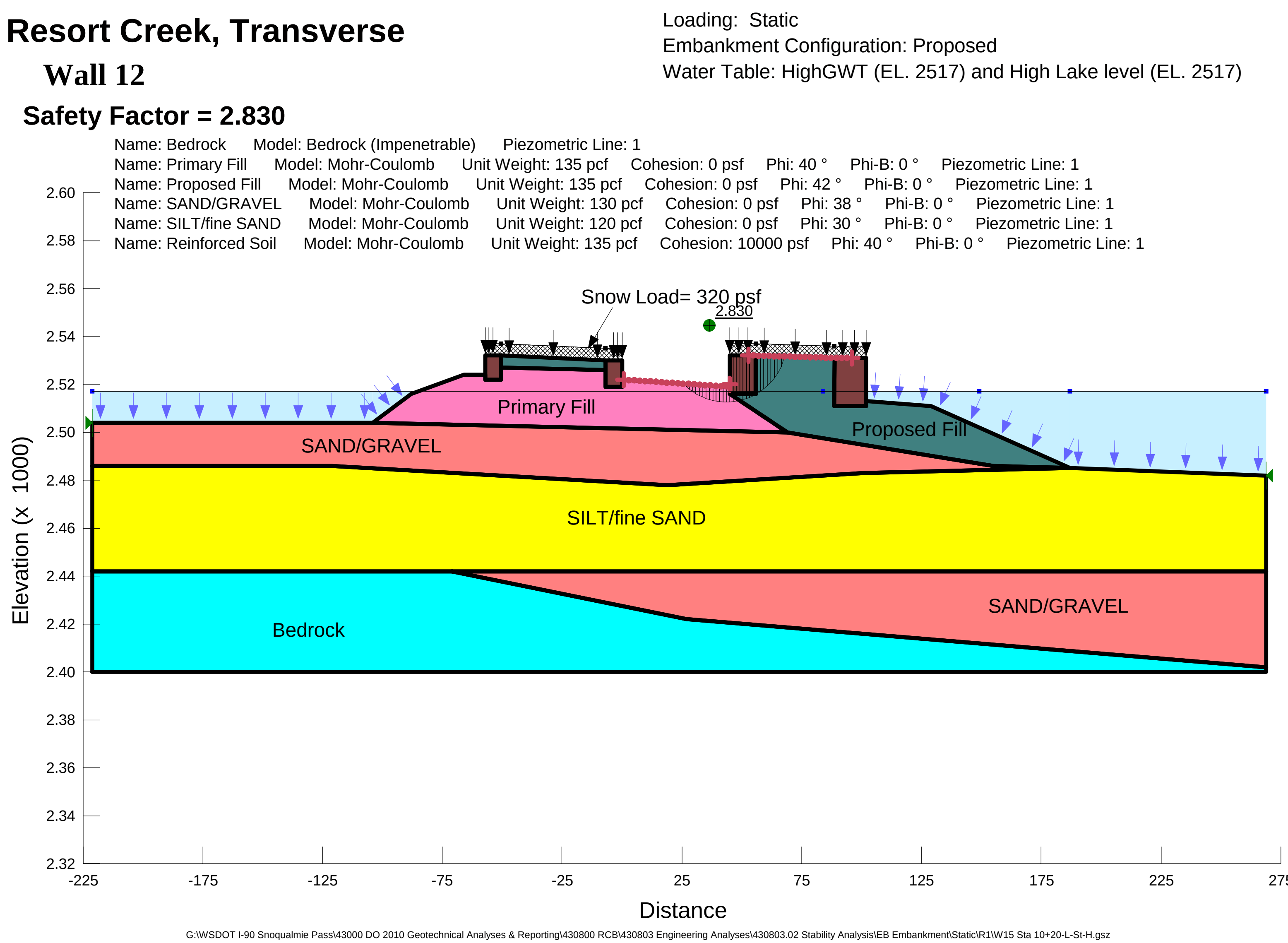
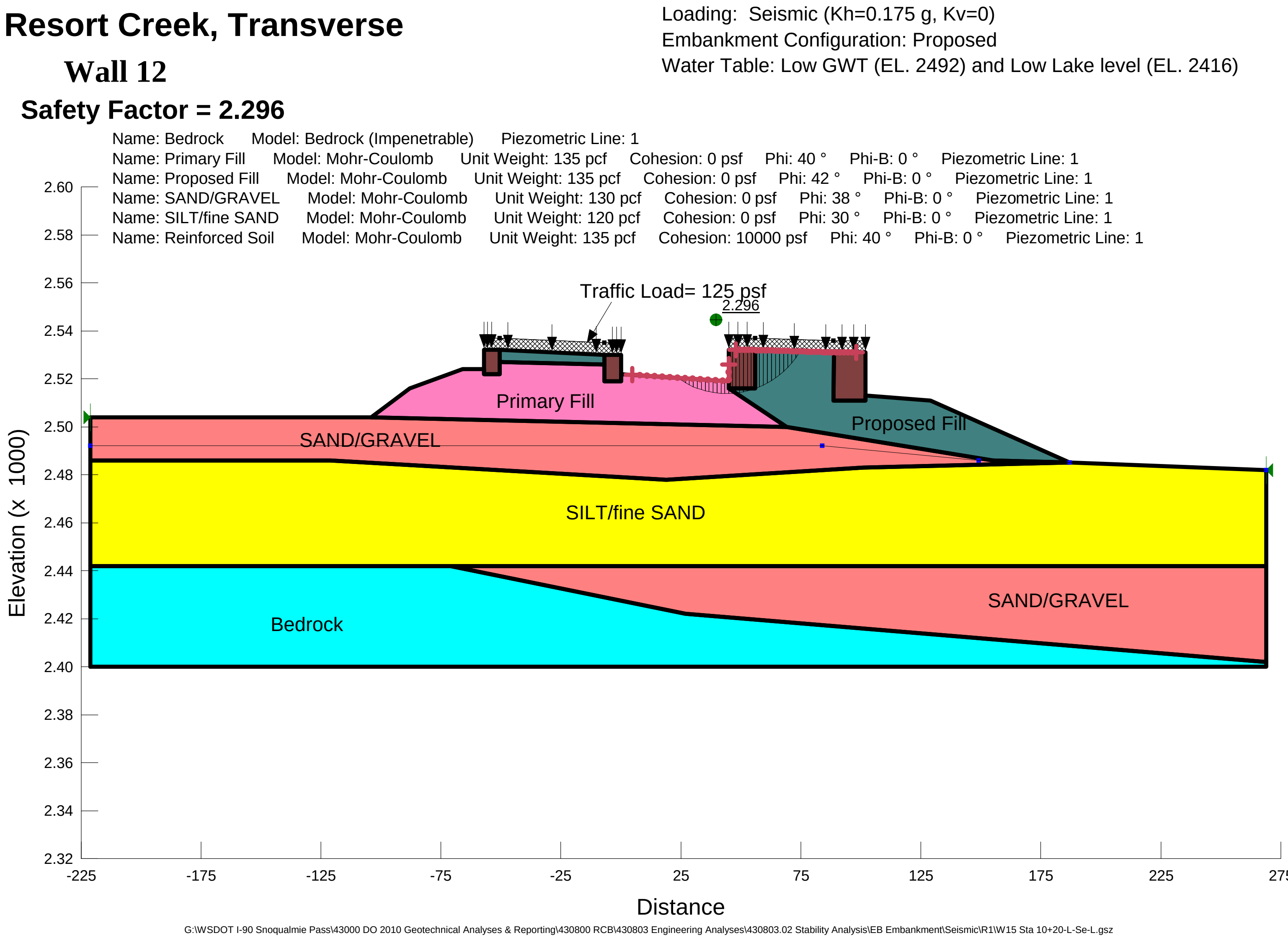


Figure H.8.29



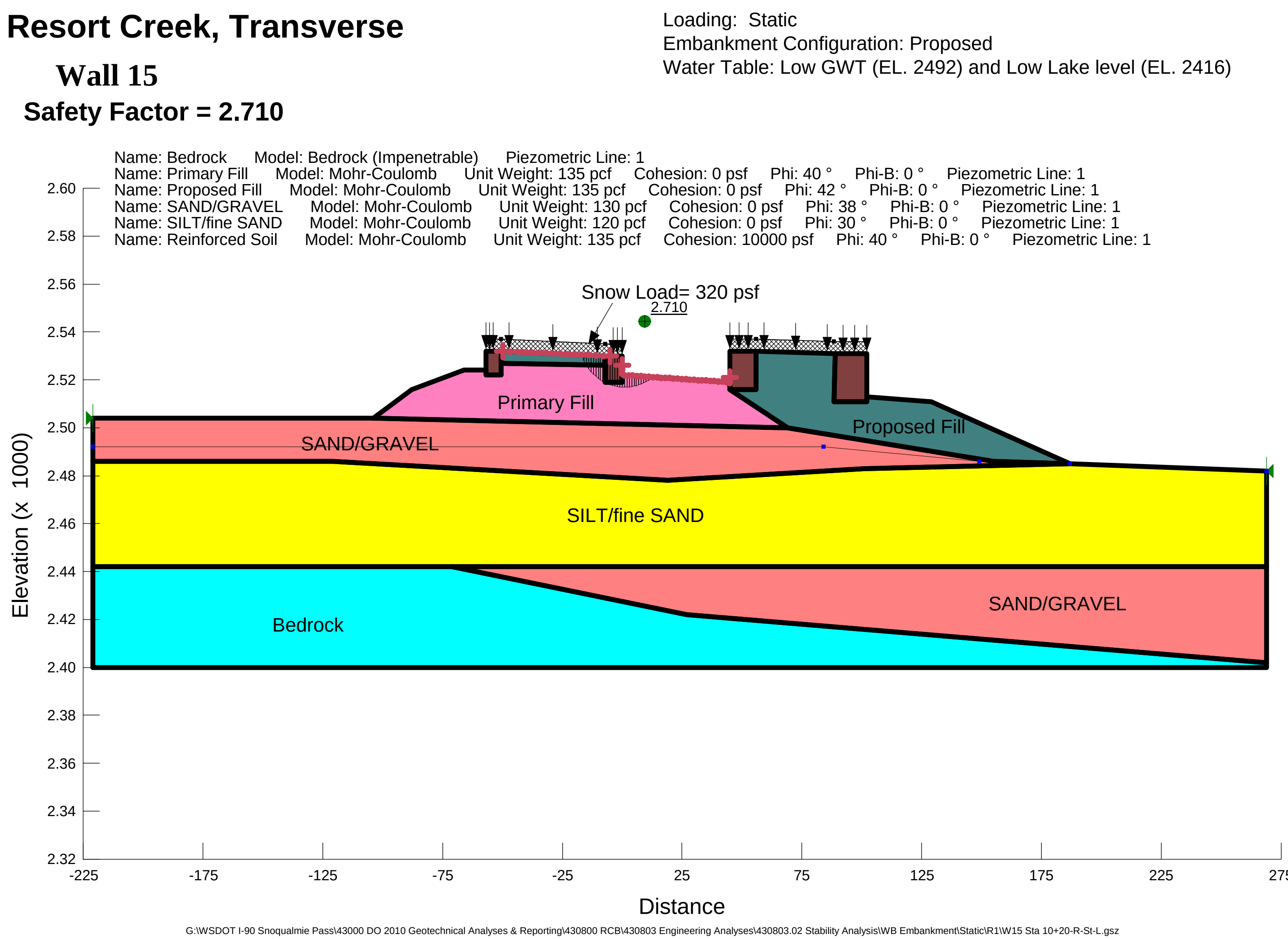
Resort Creek, Transverse
Wall 12
Safety Factor = 2.830
Loading: Static
Embankment Configuration: Proposed
Water Table: HighGWT (EL. 2517) and High Lake level (EL. 2517)
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 10000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Snow Load= 320 psf
2.830
Primary Fill
Proposed Fill
SAND/GRAVEL
SILT/fine SAND
SAND/GRAVEL
Bedrock
Elevation (x 1000)
2.60
2.58
2.56
2.54
2.52
2.50
2.48
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
-225
-175
-125
-75
-25
25
75
125
175
225
275
Distance
G:\WSDOT I-90 Snoqualmie Pass\43000 DO 2010 Geotechnical Analyses & Reporting\430800 RCB\430803 Engineering Analyses\430803.02 Stability Analysis\EB Embankment\Static\R1\W15 Sta 10+20-L-St-H.gsz

Figure H.8.30



Resort Creek, Transverse
Wall 12
Safety Factor = 2.296
Loading: Seismic (Kh=0.175 g, Kv=0)
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2492) and Low Lake level (EL. 2416)
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 10000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Traffic Load= 125 psf
2.296
Primary Fill
Proposed Fill
SAND/GRAVEL
SILT/fine SAND
SAND/GRAVEL
Bedrock
Elevation (x 1000)
2.60
2.58
2.56
2.54
2.52
2.50
2.48
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
-225
-175
-125
-75
-25
25
75
125
175
225
275
Distance
G:\WSDOT I-90 Snoqualmie Pass\43000 DO 2010 Geotechnical Analyses & Reporting\430800 RCB\430803 Engineering Analyses\430803.02 Stability Analysis\EB Embankment\Seismic\R1\W15 Sta 10+20-L-Se-L.gsz

Figure H.8.31



Resort Creek, Transverse
Wall 15
Safety Factor = 2.710
Loading: Static
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2492) and Low Lake level (EL. 2416)
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 10000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Snow Load= 320 psf
2.710
Primary Fill
Proposed Fill
SAND/GRAVEL
SILT/fine SAND
SAND/GRAVEL
Bedrock
Elevation (x 1000)
2.60
2.58
2.56
2.54
2.52
2.50
2.48
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
-225
-175
-125
-75
-25
25
75
125
175
225
275
Distance
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Figure H.8.32

Resort Creek, Transverse

Wall 15

Safety Factor = 2.690

Loading: Static
Embankment Configuration: Proposed
Water Table: High GWT (EL. 2492) and High Lake level (EL. 2416)

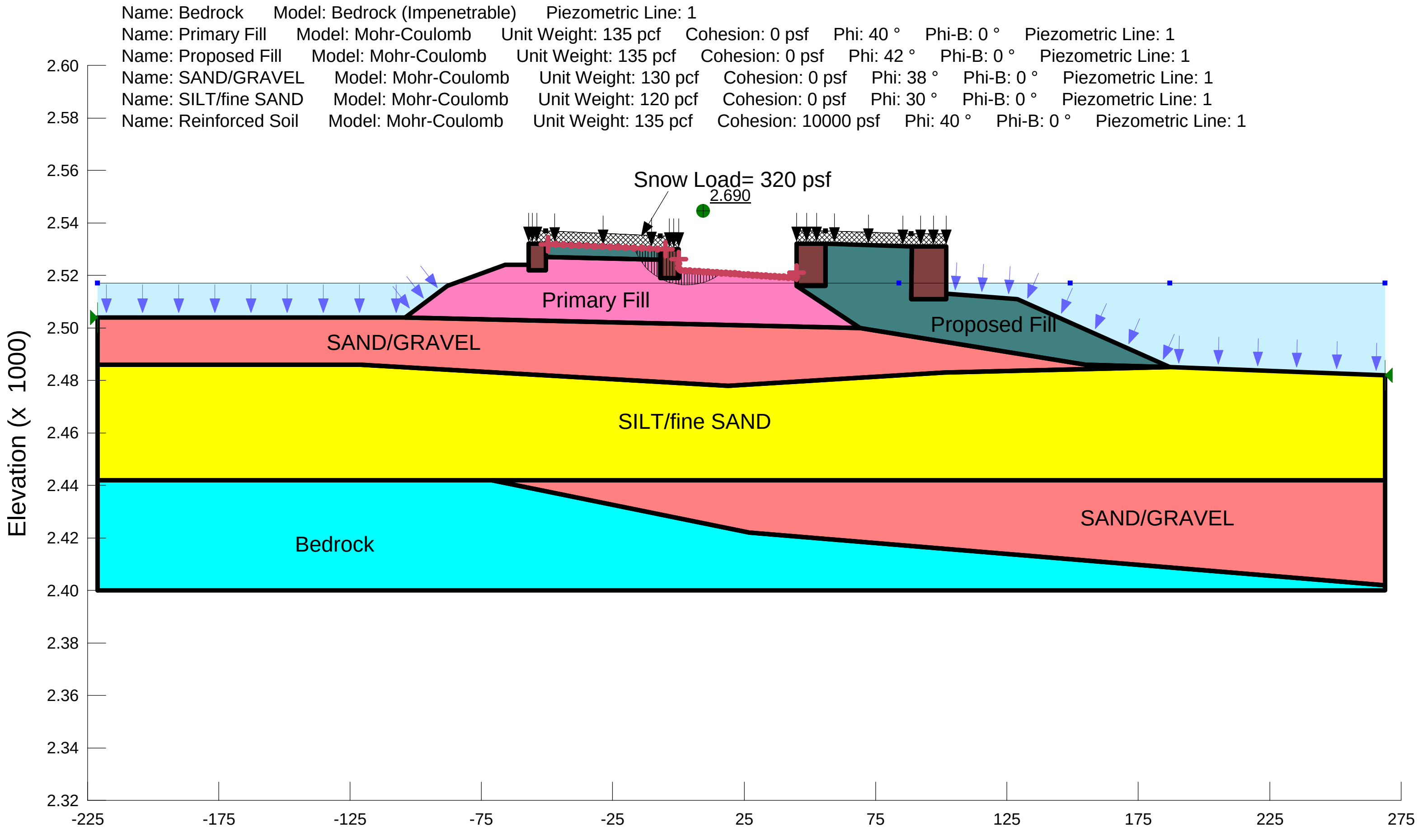

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Figure H.8.33

Resort Creek, Transverse

Loading: Seismic (Kh=0.175 g, Kv=0)
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2492) and Low Lake level (EL. 2416)

Wall 15

Safety Factor = 2.041

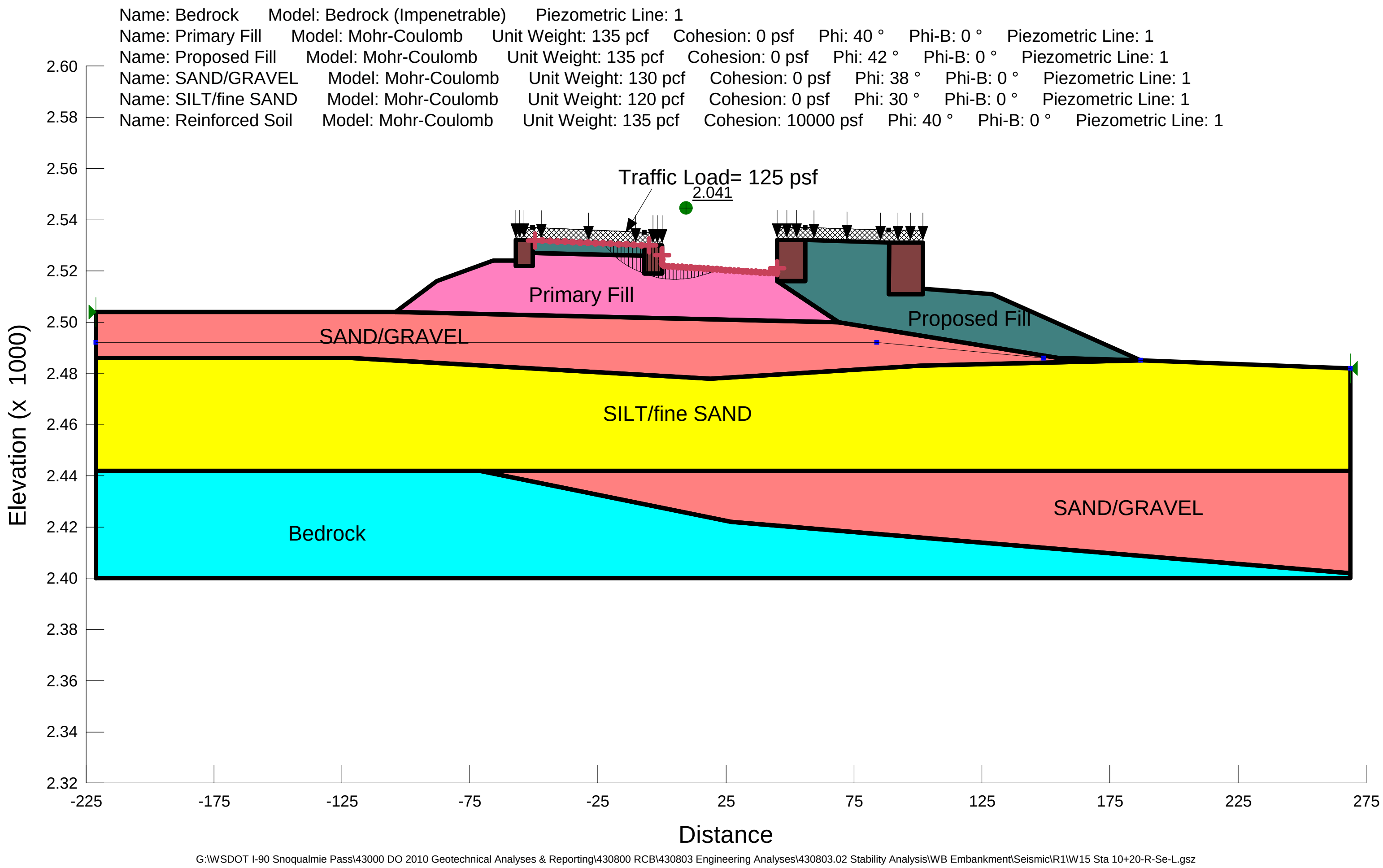

Figure H.8.34

Resort Creek, Transverse

Loading: Static
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)

Wall 14

Safety Factor = 3.117

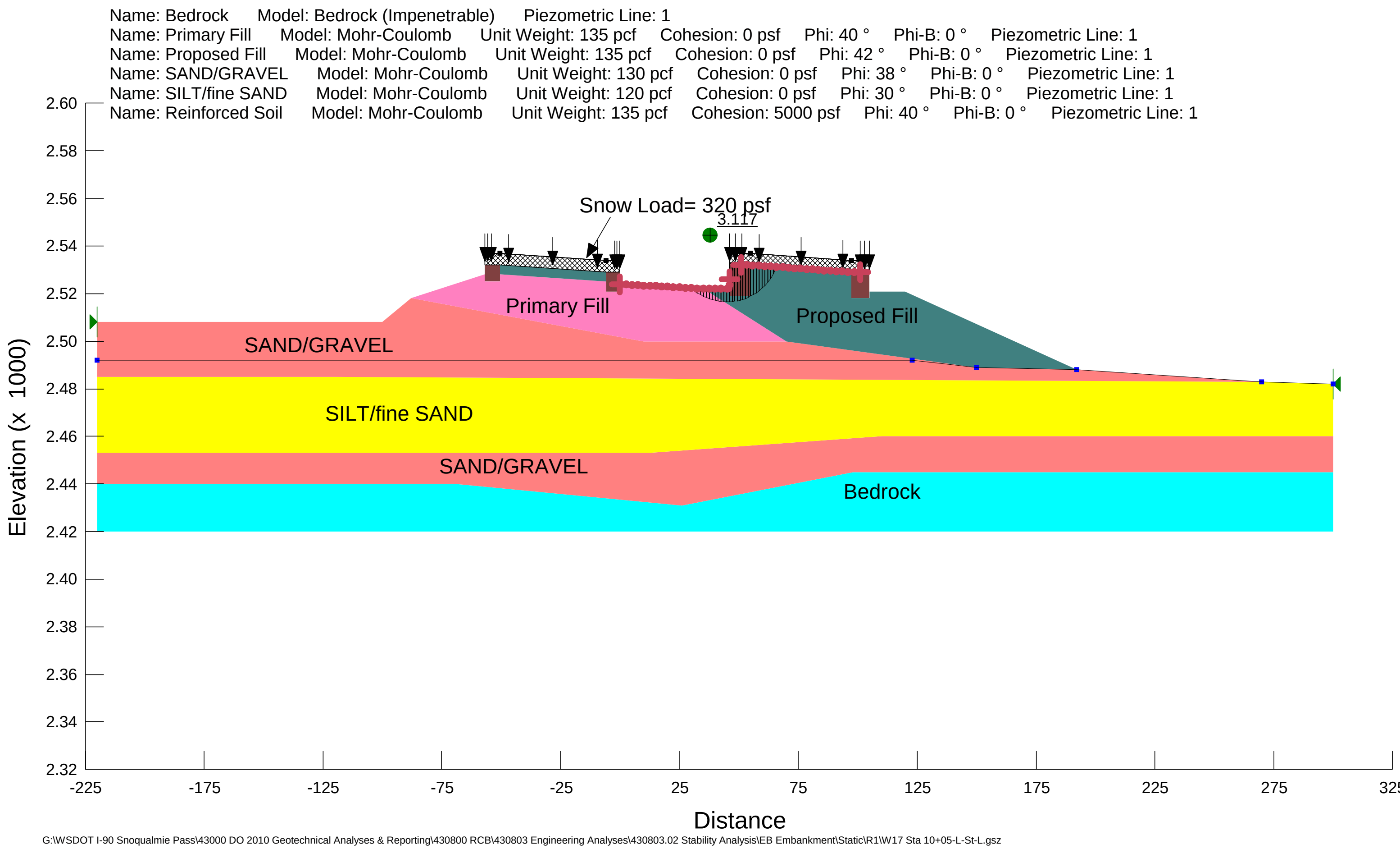

Figure H.8.35

Resort Creek, Transverse

Wall 14

Loading: Static
Embankment Configuration: Proposed
Water Table: High GWT (EL. 2517) and High Lake level (EL. 2517)

Safety Factor = 3.093

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 5000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1

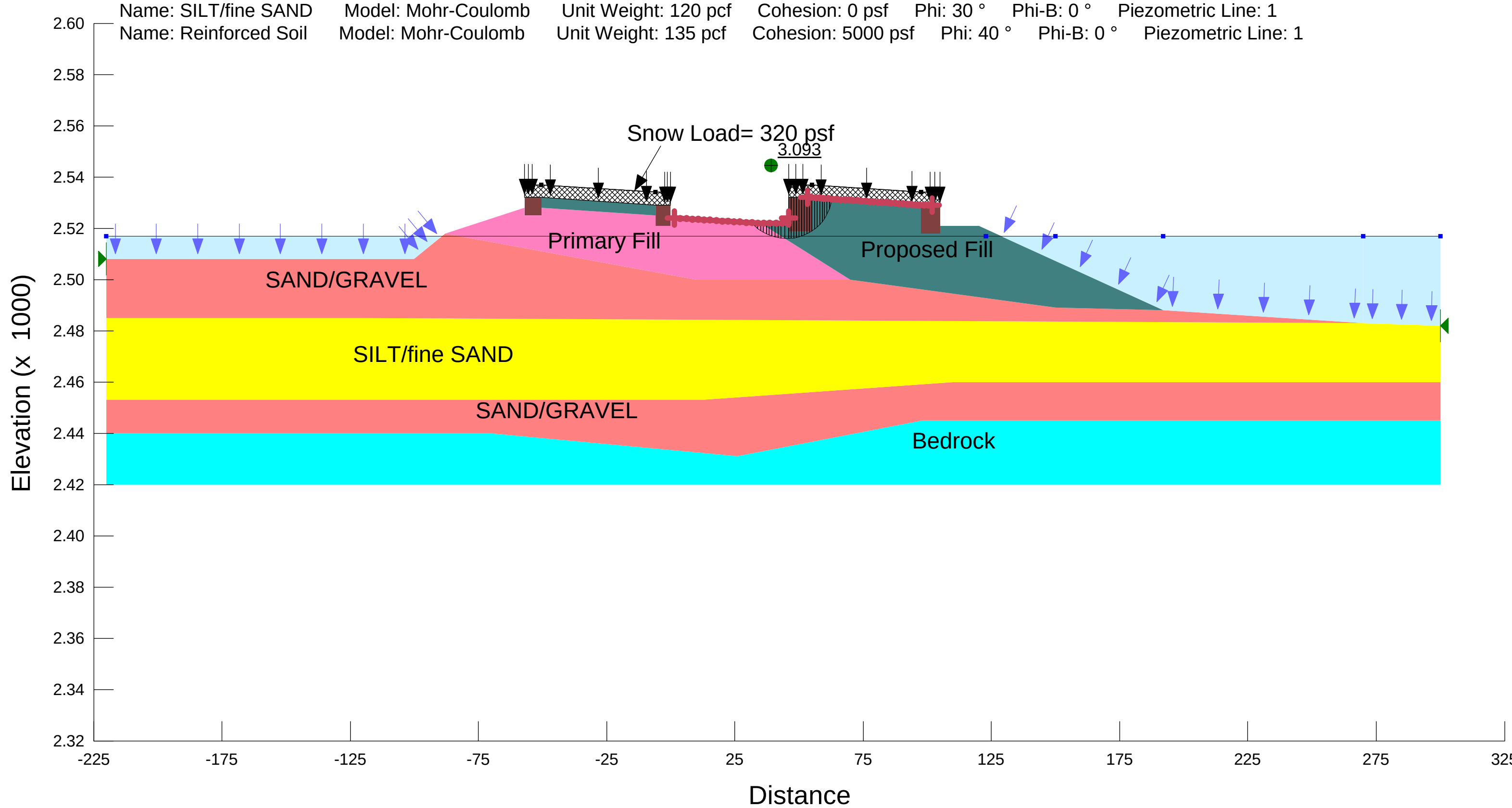

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Figure H.8.36

Resort Creek, Transverse

Wall 14

Safety Factor = 2.358

Loading: Seismic (Kh=.175, Kv=0)
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)

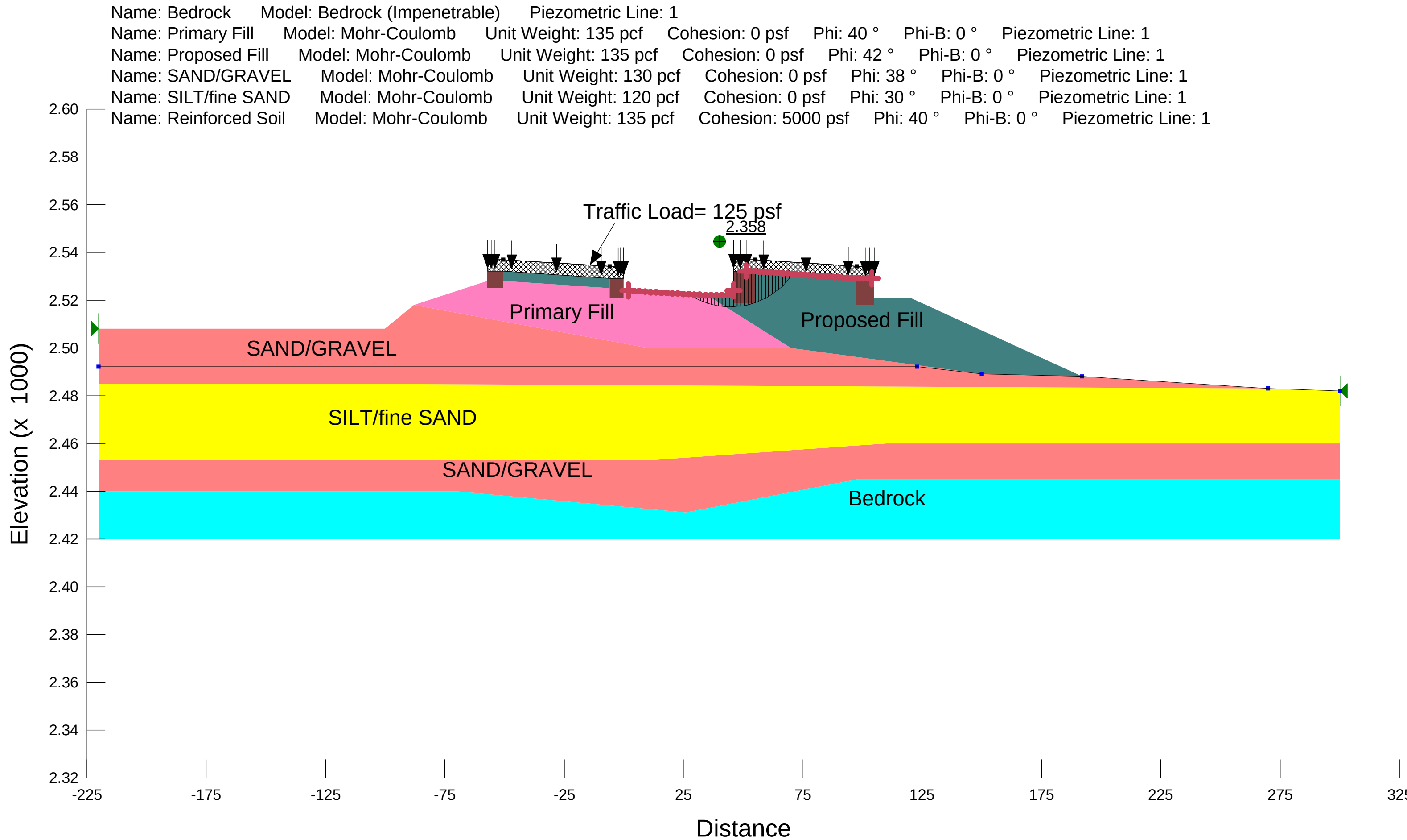

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Figure H.8.37

Resort Creek, Transverse

Wall 17

Safety Factor = 3.113

Loading: Static
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 5000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1

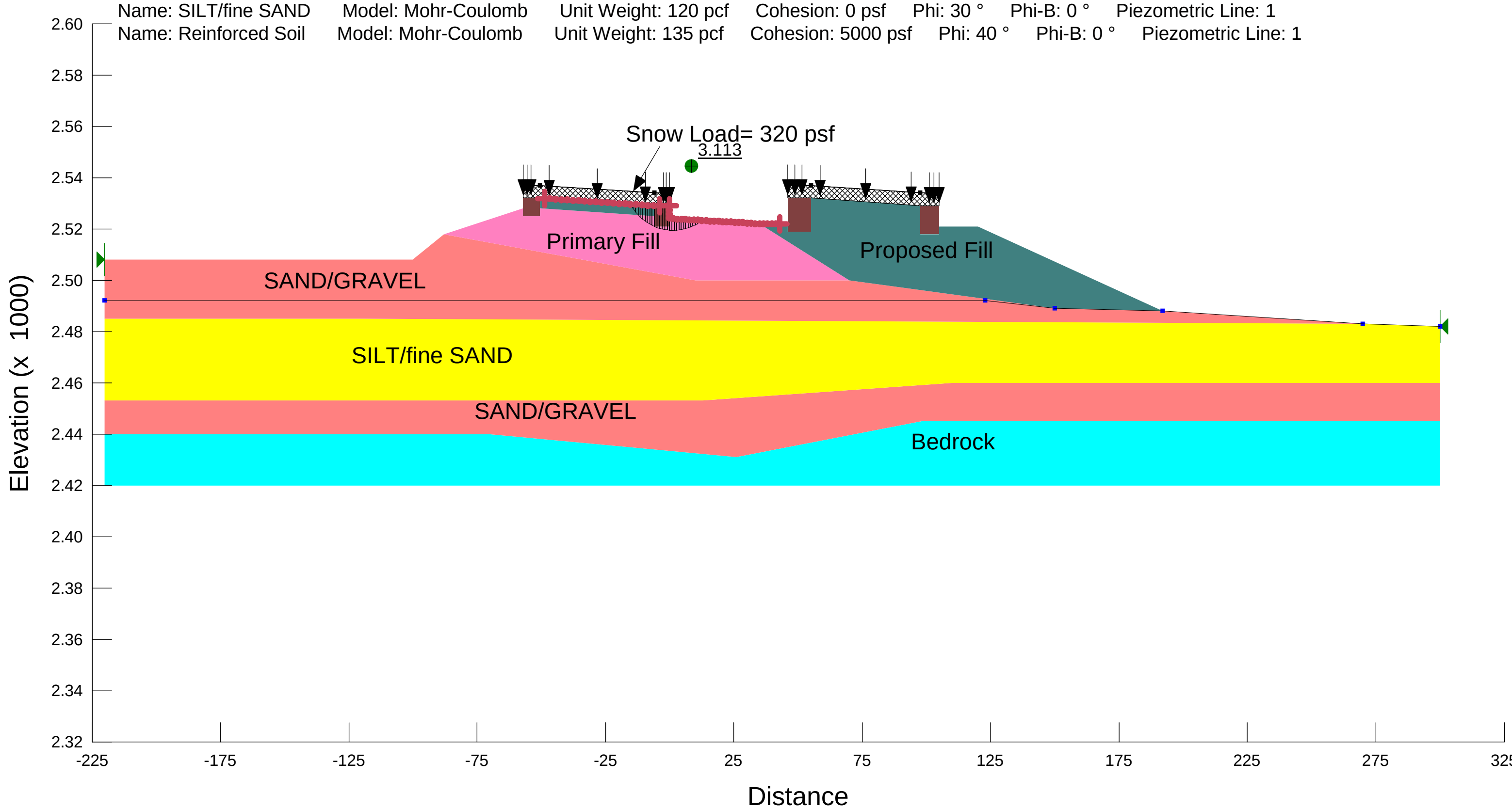

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Figure H.8.38

Resort Creek, Transverse

Wall 17

Safety Factor = 3.113

Loading: Static
Embankment Configuration: Proposed
Water Table: High GWT (EL. 2517) and High Lake level (EL. 2517)

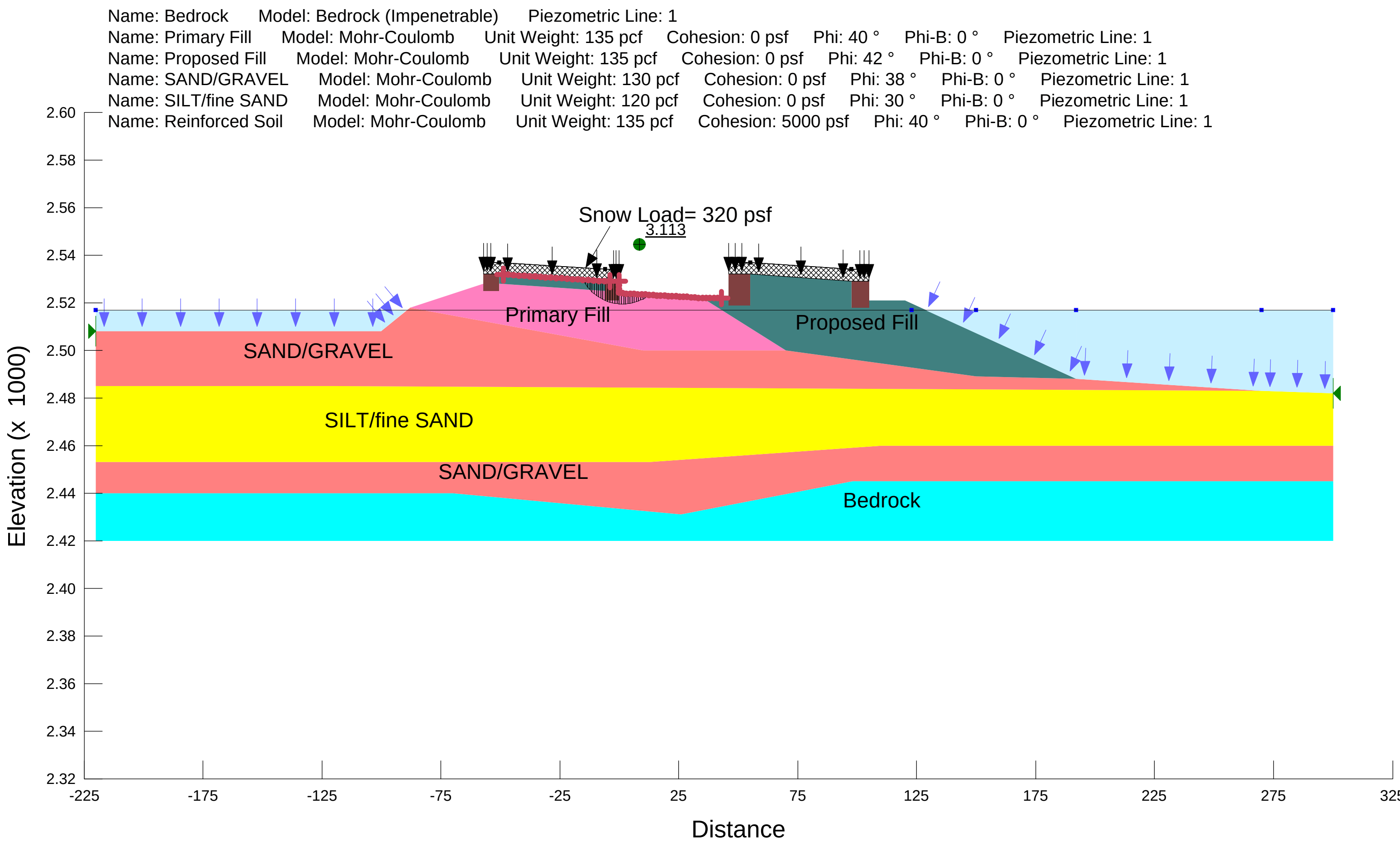

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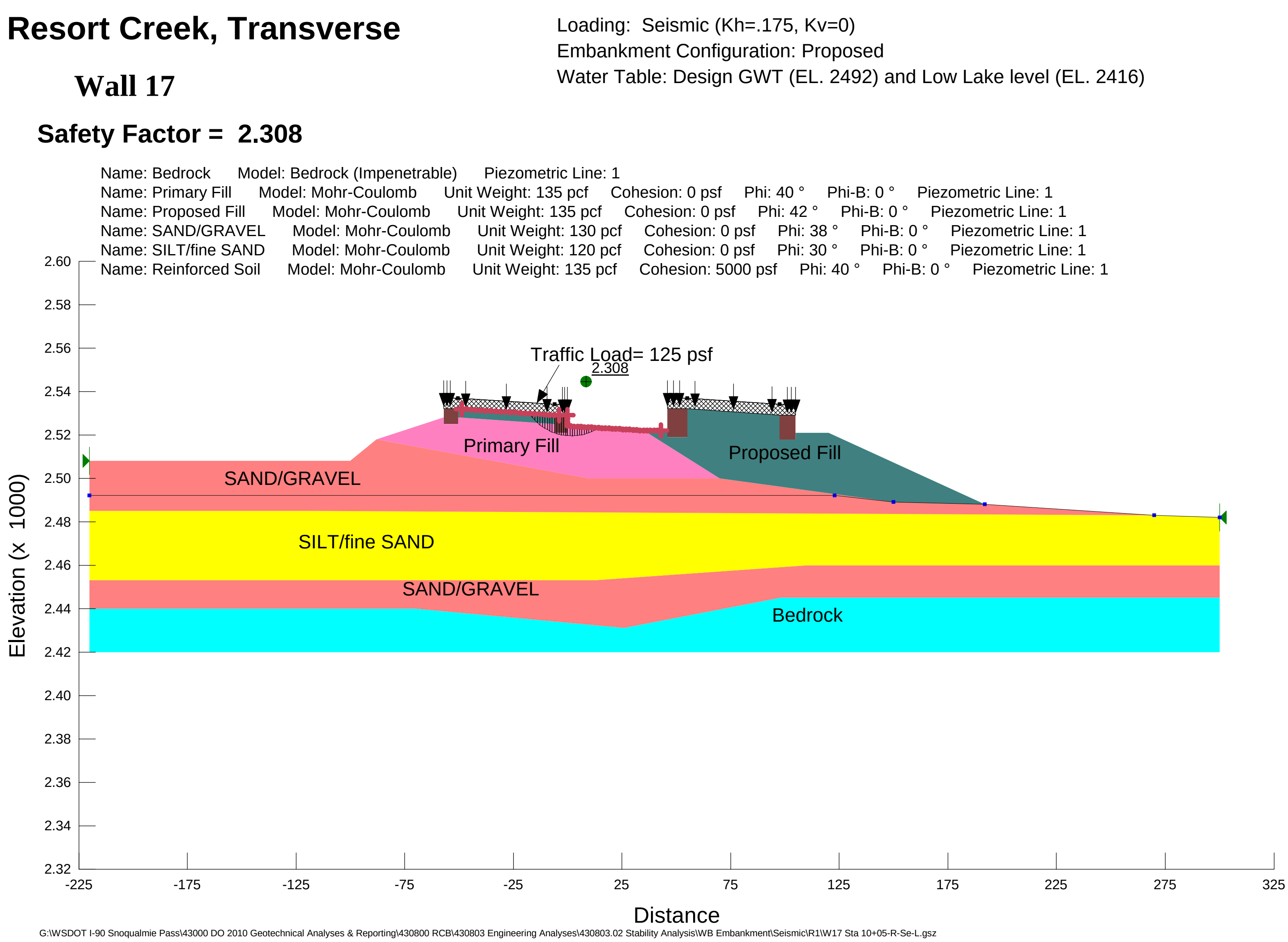
Figure H.8.39



Resort Creek, Transverse
Wall 17
Safety Factor = 2.308
Loading: Seismic (Kh=.175, Kv=0)
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 5000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Traffic Load= 125 psf
2.308
Primary Fill
Proposed Fill
SAND/GRAVEL
SILT/fine SAND
SAND/GRAVEL
Bedrock
Elevation (x 1000)
2.60
2.58
2.56
2.54
2.52
2.50
2.48
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
-225
-175
-125
-75
-25
25
75
125
175
225
275
325
Distance
G:\WSDOT I-90 Snoqualmie Pass\43000 DO 2010 Geotechnical Analyses & Reporting\430800 RCB\430803 Engineering Analyses\430803.02 Stability Analysis\WB Embankment\Seismic\R1\W17 Sta 10+05-R-Se-L.gsz

Figure H.8.40

Resort Creek, Longitudinal
EB Profile between Station 1424+00 to 1430+00

Safety Factor =1.10

Shear Force=48 kips/ft

Kramer

Loading: Seismic (Kh=0, Kv=0), Residual Strength
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2485) and Low Lake level (EL. 2416)
Lateral force=0.0 kips/ft

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND-Outside Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 640 psf C-Rate of Increase: 3.456 Limiting C: 2000 psf Piezometric Line: 1
Name: SILT/fine SAND-Center Model: S=f(depth) Unit Weight: 120 pcf C-Top of Layer: 270 psf C-Rate of Increase: 4.608 Limiting C: 2000 psf Piezometric Line: 1

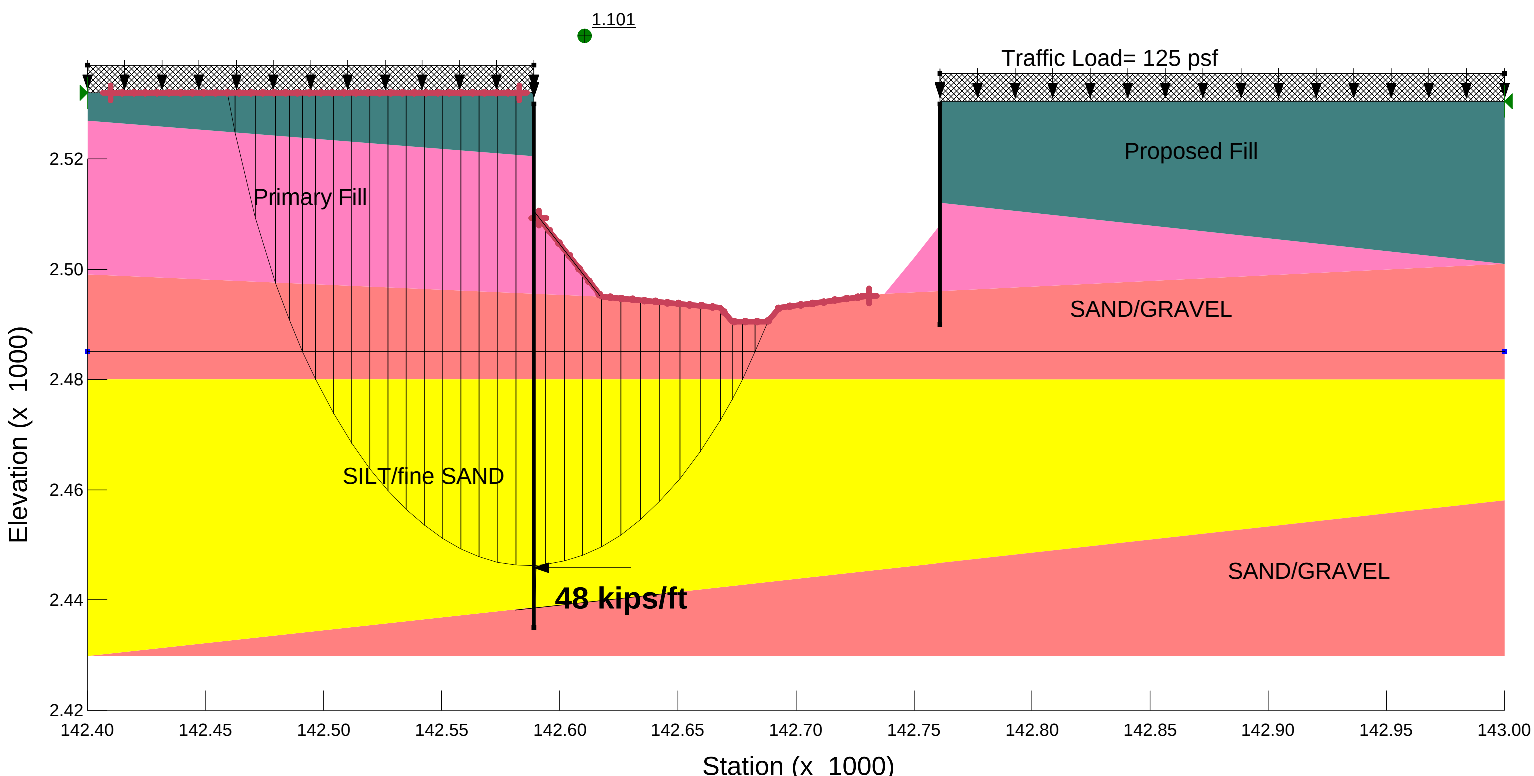


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Figure H.8.41

Resort Creek, Transverse
EB Embankment at EB Station 1426+15
Safety Factor = 1.117

Loading: Seismic (Kh=0, Kv=0), Residual
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2492) and Low Lake level (EL. 2416)

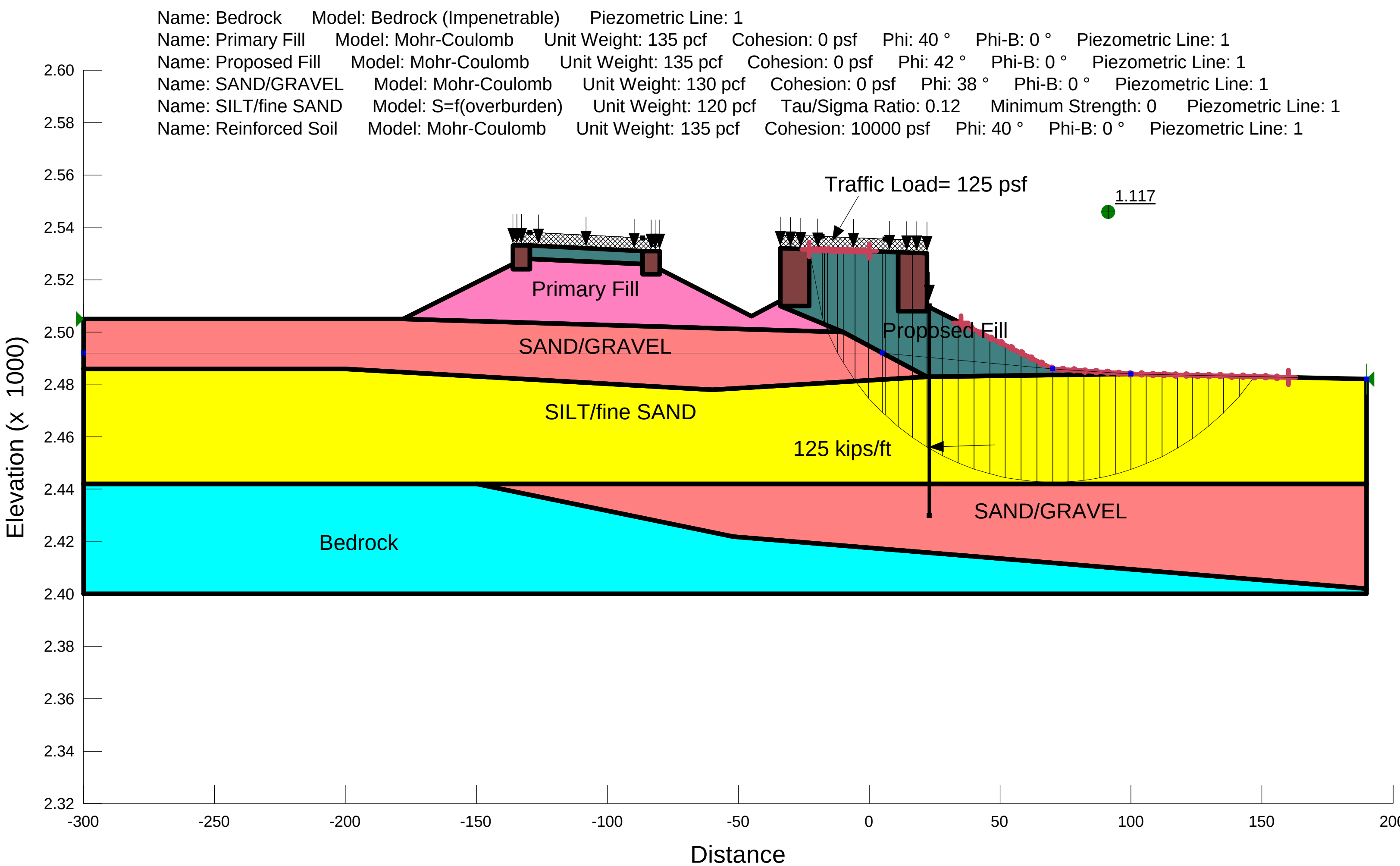

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Figure H.8.42

Resort Creek, Transverse
EB Embankment at EB Station 1427+55

Safety Factor = 1.119

Loading: Seismic (Kh=0, Kv=0), Residual
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2492) and Low Lake level (EL. 2416)

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: S=f(overburden) Unit Weight: 120 pcf Tau/Sigma Ratio: 0.12 Minimum Strength: 0 Piezometric Line: 1
Name: Reinforced Soil Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 5000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1

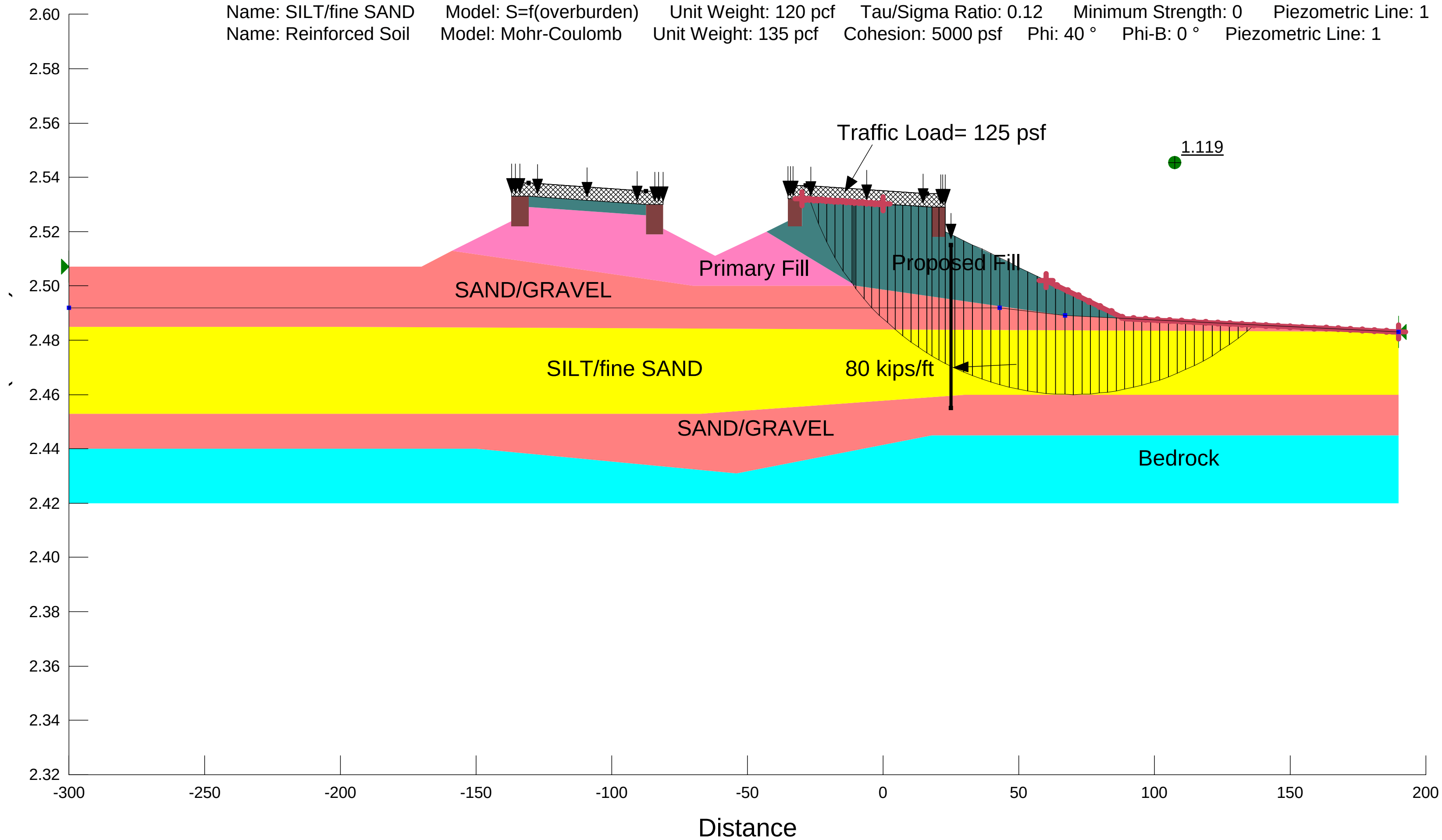

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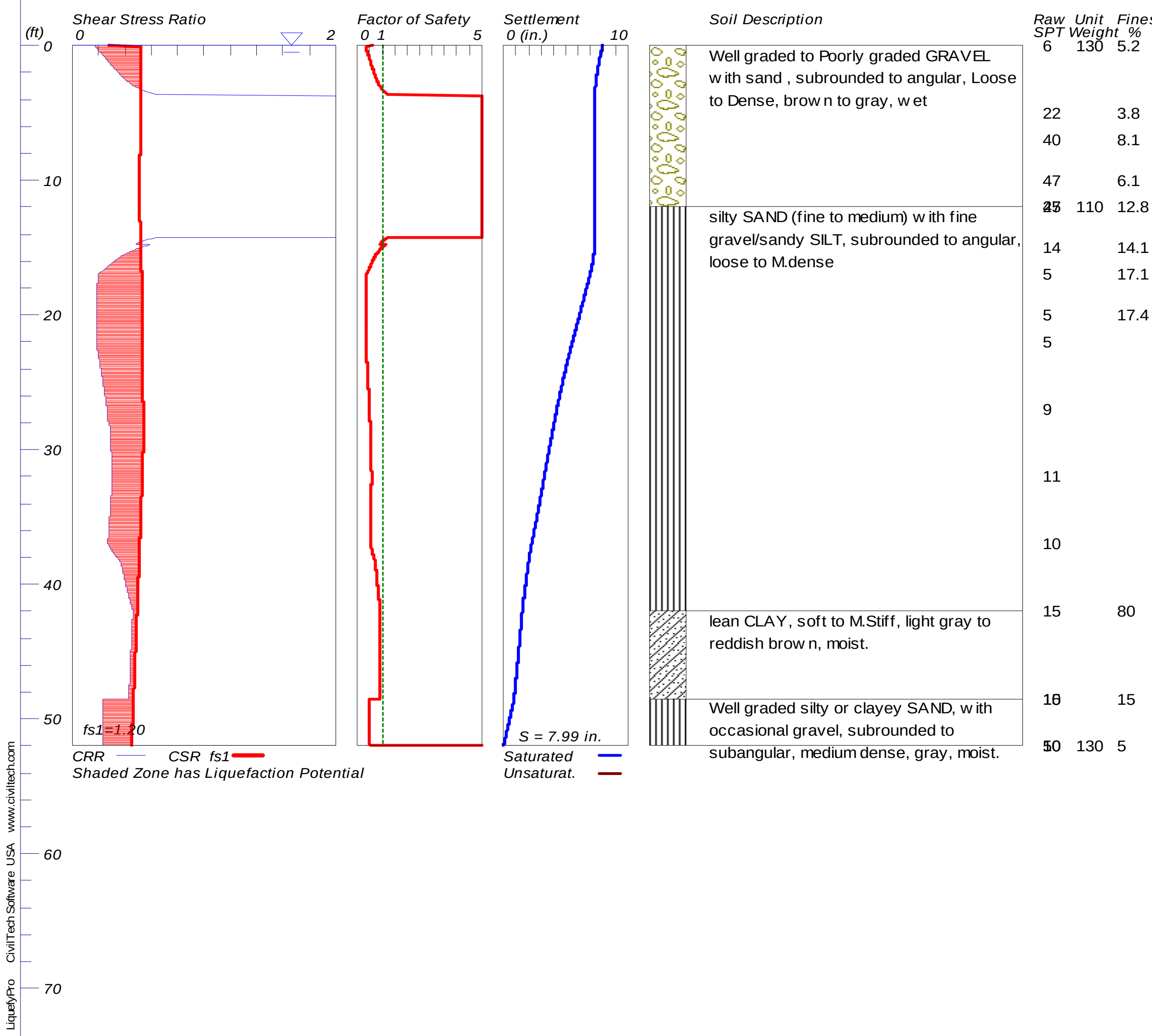
Figure H.8.43

LIQUEFACTION ANALYSIS

WSDOT I-90 Snoqualmie Pass

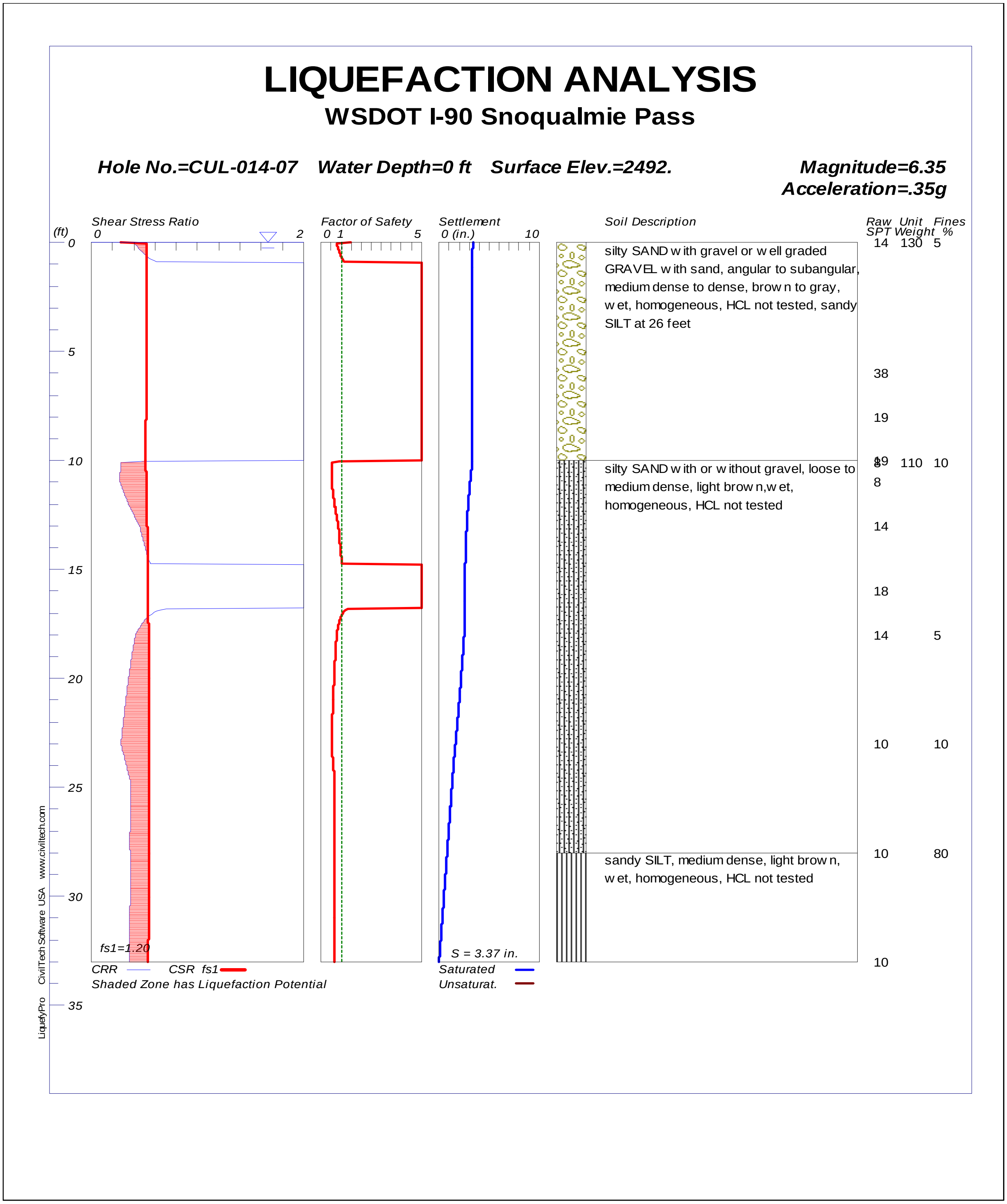
Hole No.=CUL-012-07   Water Depth=0 ft   Surface Elev.=2493.

Magnitude=6.35
Acceleration=.35g



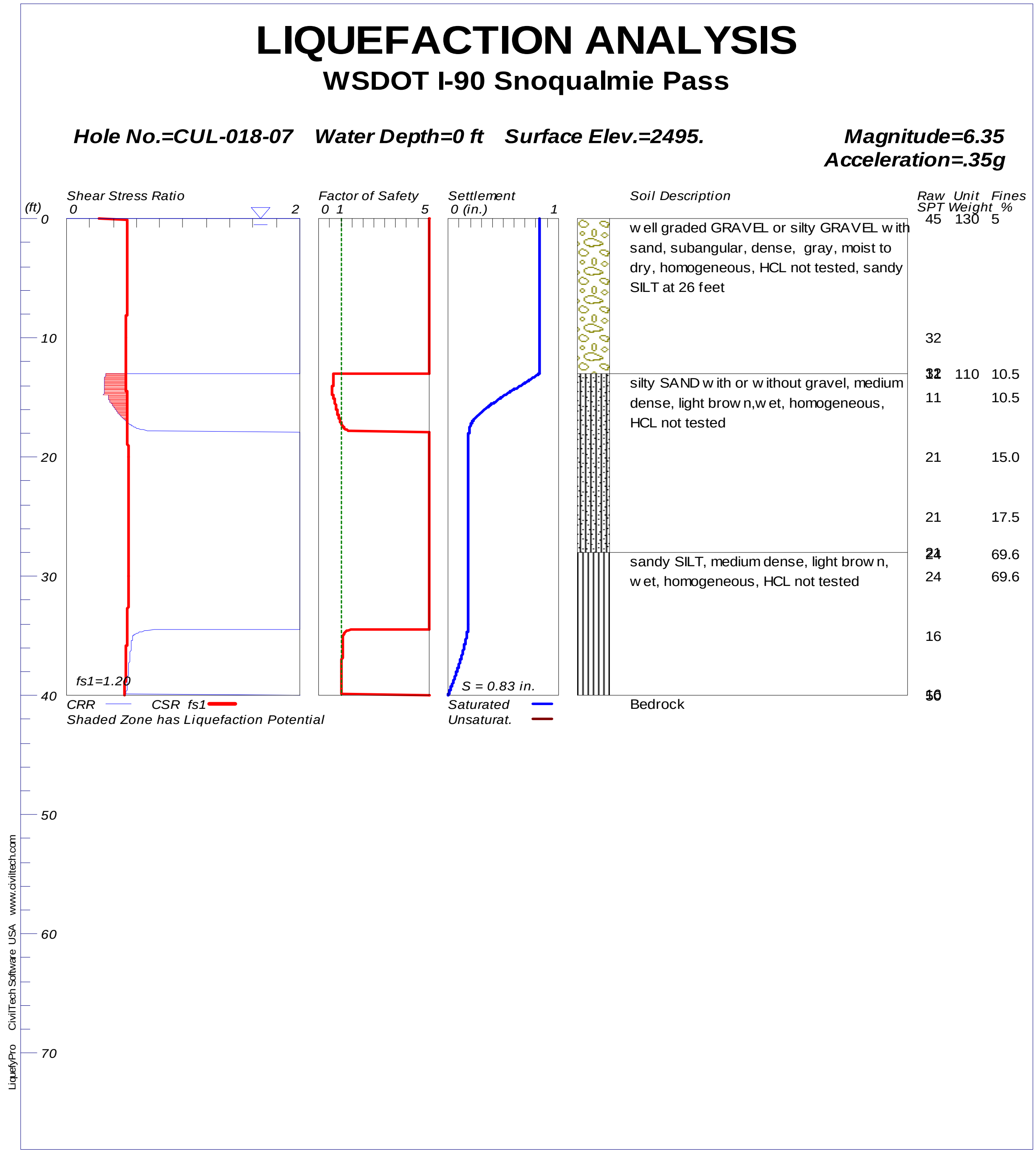
Job No.:33758638

Liquefaction Analysis Results at Boring CUL-012-07



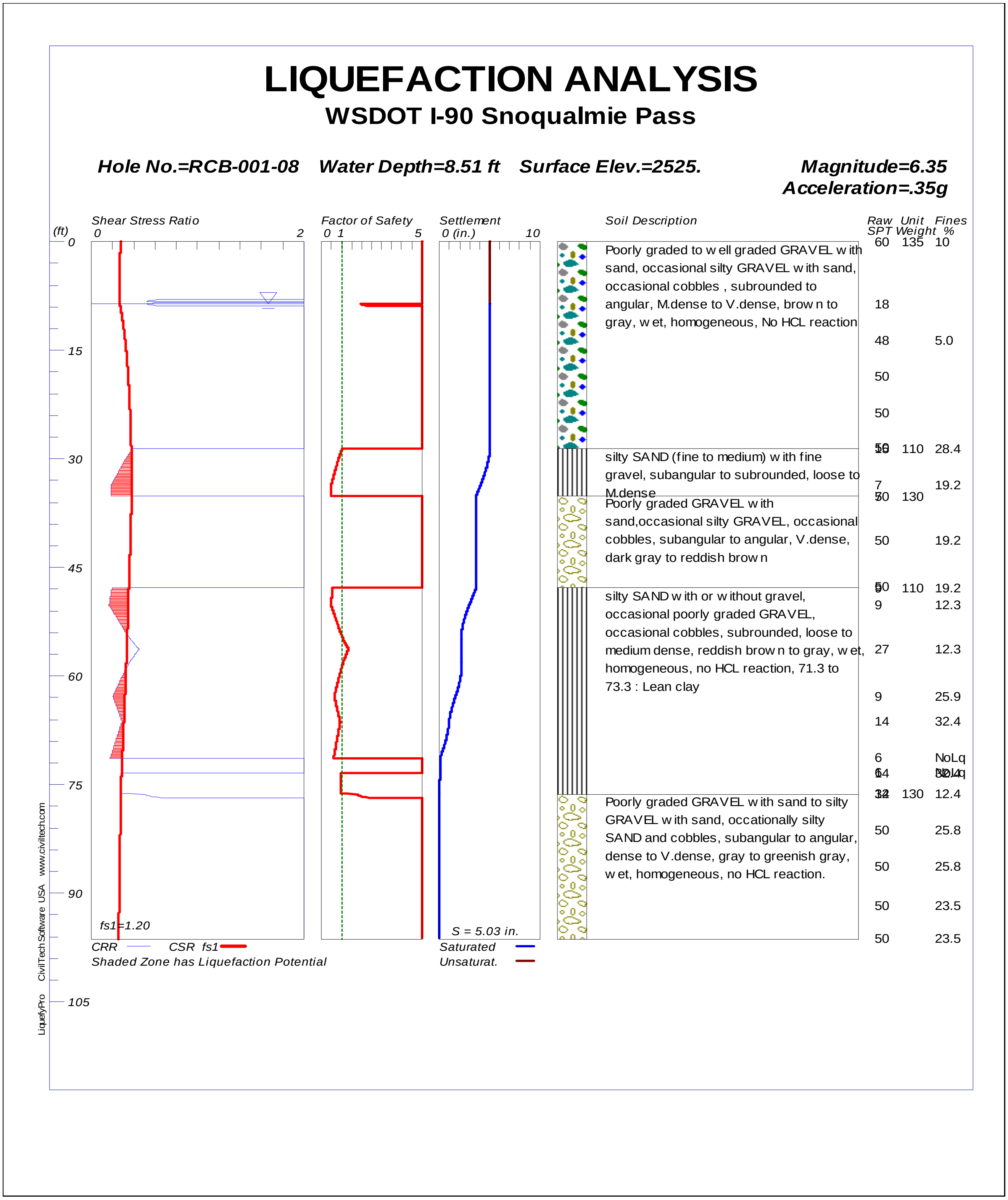
Job No.:33758638

Liquefaction Analysis Results at Boring CUL-014-07



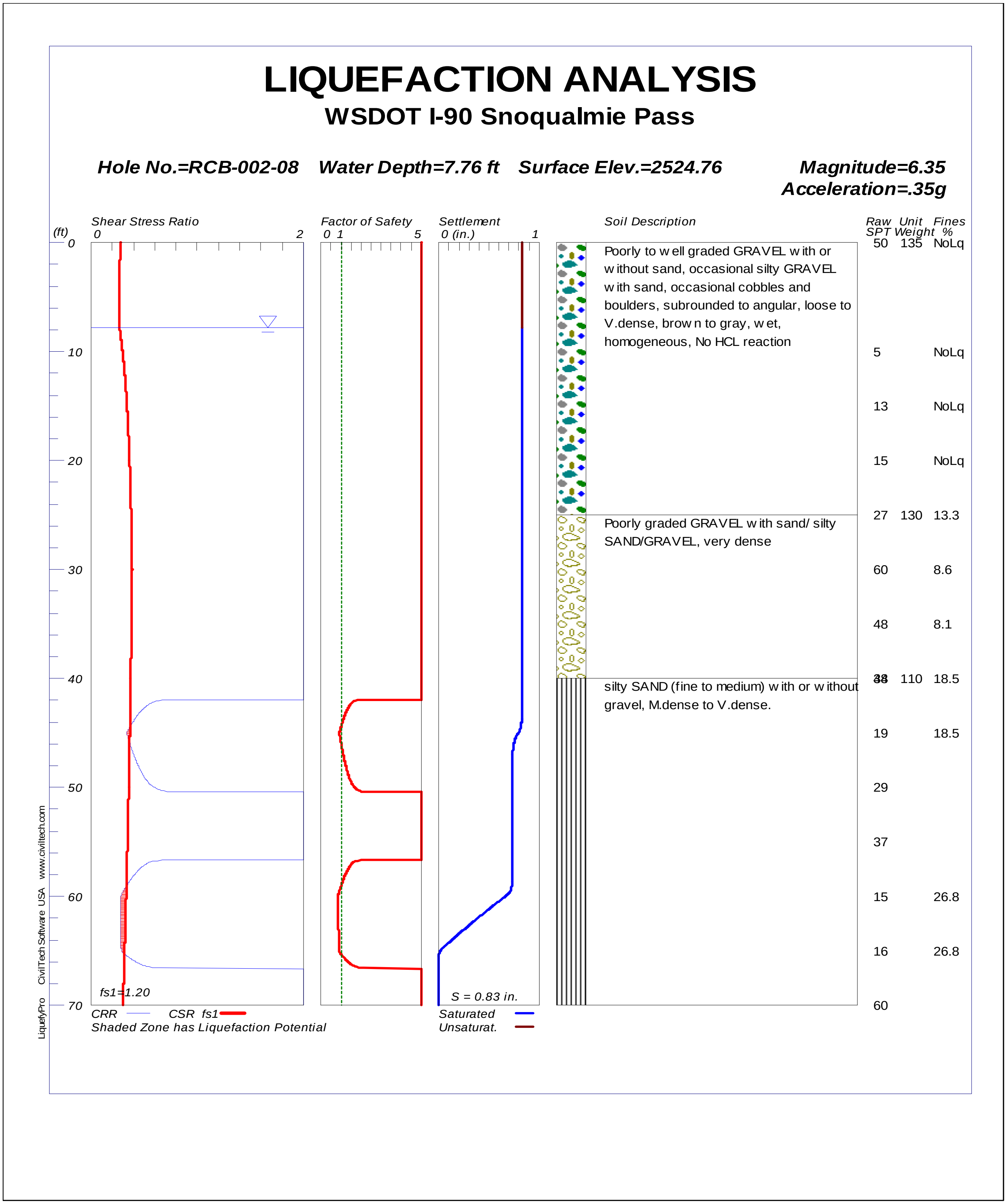
Job No.:33758638

Liquefaction Analysis Results at Boring CUL-018-07



Job No.:33758638

Liquefaction Analysis Results at Boring RCB-001-08



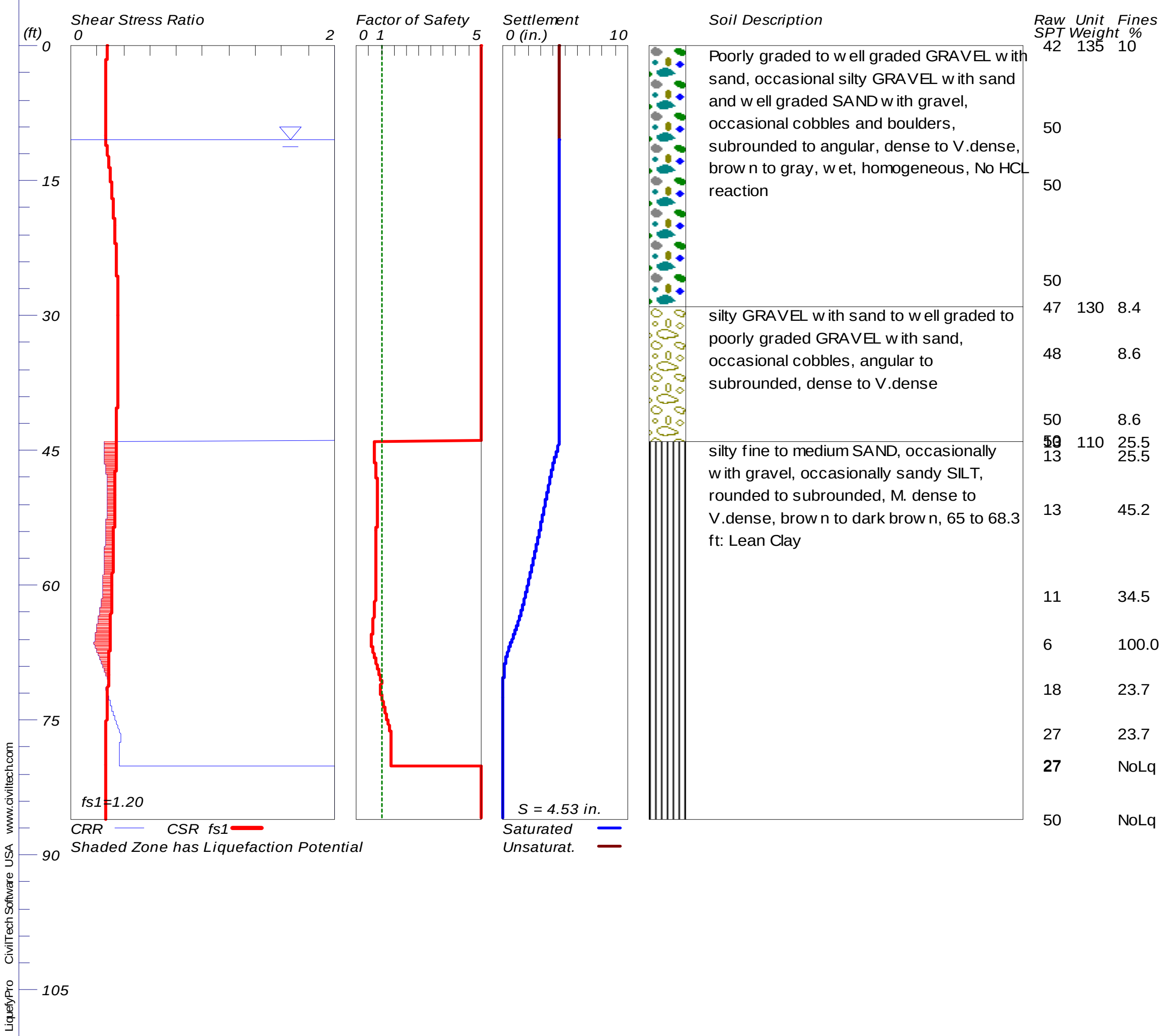
Job No.:33758638

Liquefaction Analysis Results at Boring RCB-002-08

LIQUEFACTION ANALYSIS

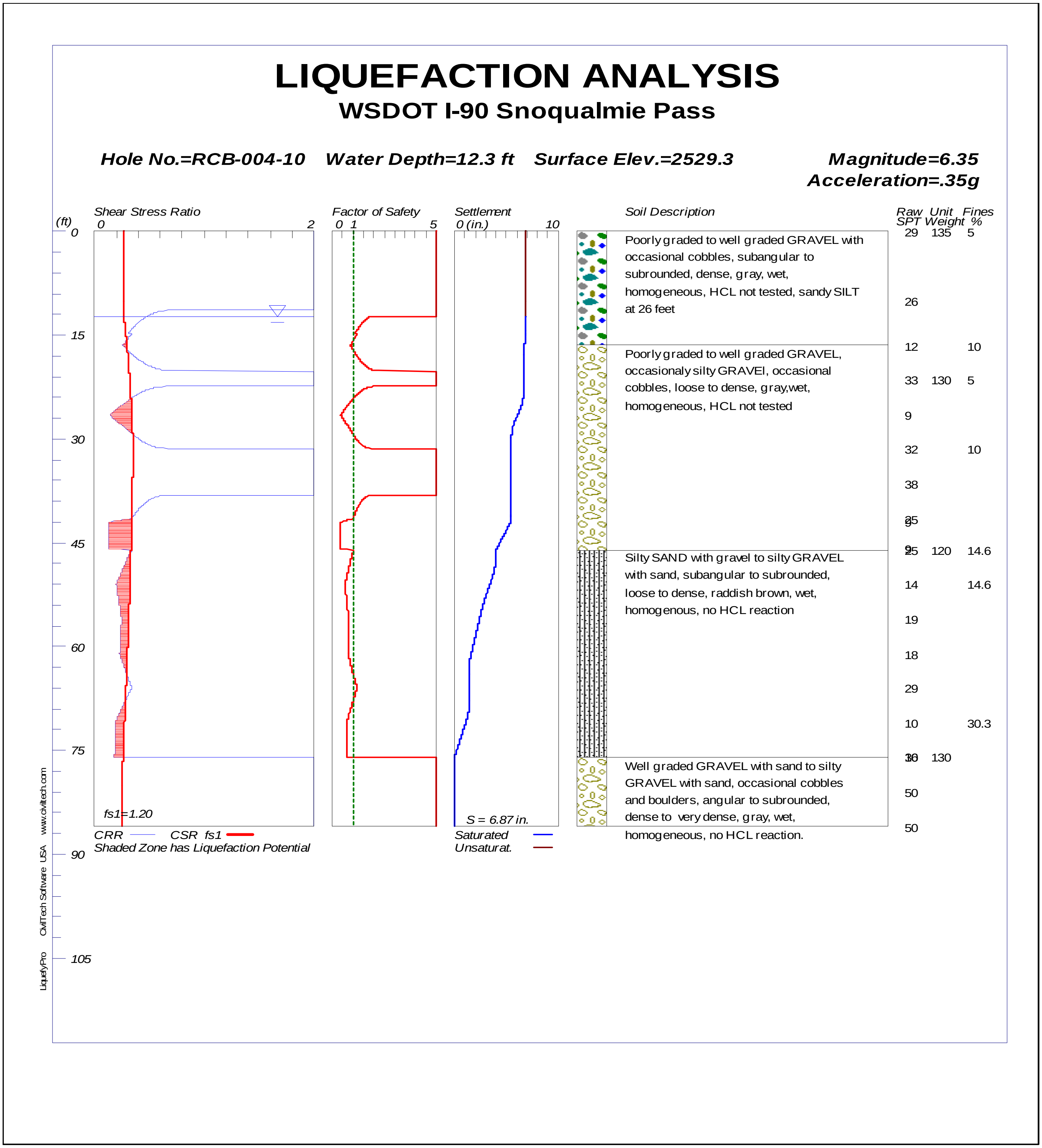
WSDOT I-90 Snoqualmie Pass

Hole No.=RCB-003-08 (OW)   Water Depth=10.49 ft   Surface Elev.=2527.   Magnitude=6.35
Acceleration=.35g



Job No.:33758638

Liquefaction Analysis Results at Boring RCB-003-08 (OW)



Job No.:3378662

Liquefaction Analysis Results at Boring RCB-004-10

APPENDIX H.9
Stability Analysis Results – Embankments

Embankment, Transverse
EB Embankment at EB Station 1421+84
Safety Factor = 1.52

Loading: Static
Embankment Configuration: Proposed
Water Table: High GWT (EL. 2517) and High Lake level (EL. 2517)

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1

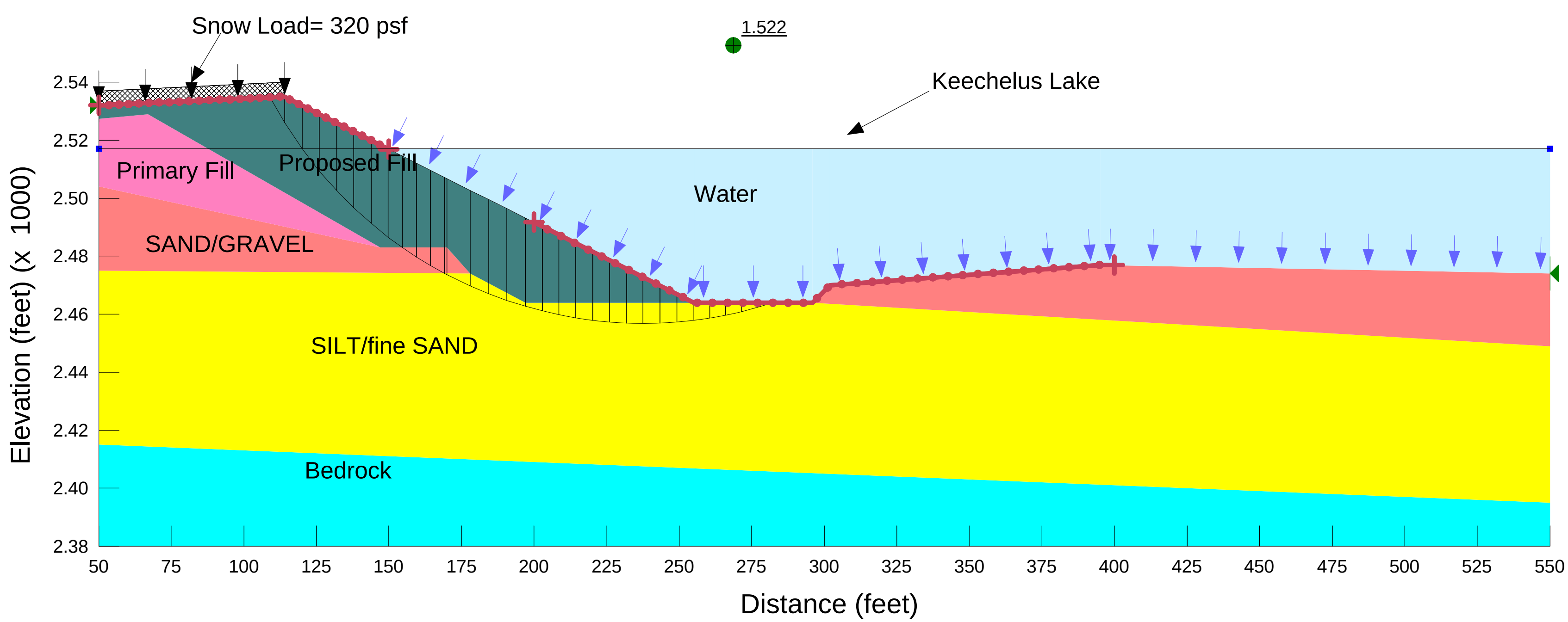


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Figure H.9.1

Embankment, Transverse
EB Embankment at EB Station 1421+84
Safety Factor = 1.27

Loading: Static
Embankment Configuration: Proposed
Water Table: Low GWT (EL. 2492) and Low Lake level (EL. 2416)

Name	Model	Unit Weight	Cohesion	Phi	Phi-B	Piezometric Line
Name: Bedrock	Model: Bedrock (Impenetrable)					Piezometric Line: 1
Name: Primary Fill	Model: Mohr-Coulomb	Unit Weight: 135 pcf	Cohesion: 0 psf	Phi: 40 °	Phi-B: 0 °	Piezometric Line: 1
Name: Proposed Fill	Model: Mohr-Coulomb	Unit Weight: 135 pcf	Cohesion: 0 psf	Phi: 42 °	Phi-B: 0 °	Piezometric Line: 1
Name: SAND/GRAVEL	Model: Mohr-Coulomb	Unit Weight: 130 pcf	Cohesion: 0 psf	Phi: 38 °	Phi-B: 0 °	Piezometric Line: 1
Name: SILT/fine SAND	Model: Mohr-Coulomb	Unit Weight: 110 pcf	Cohesion: 0 psf	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1

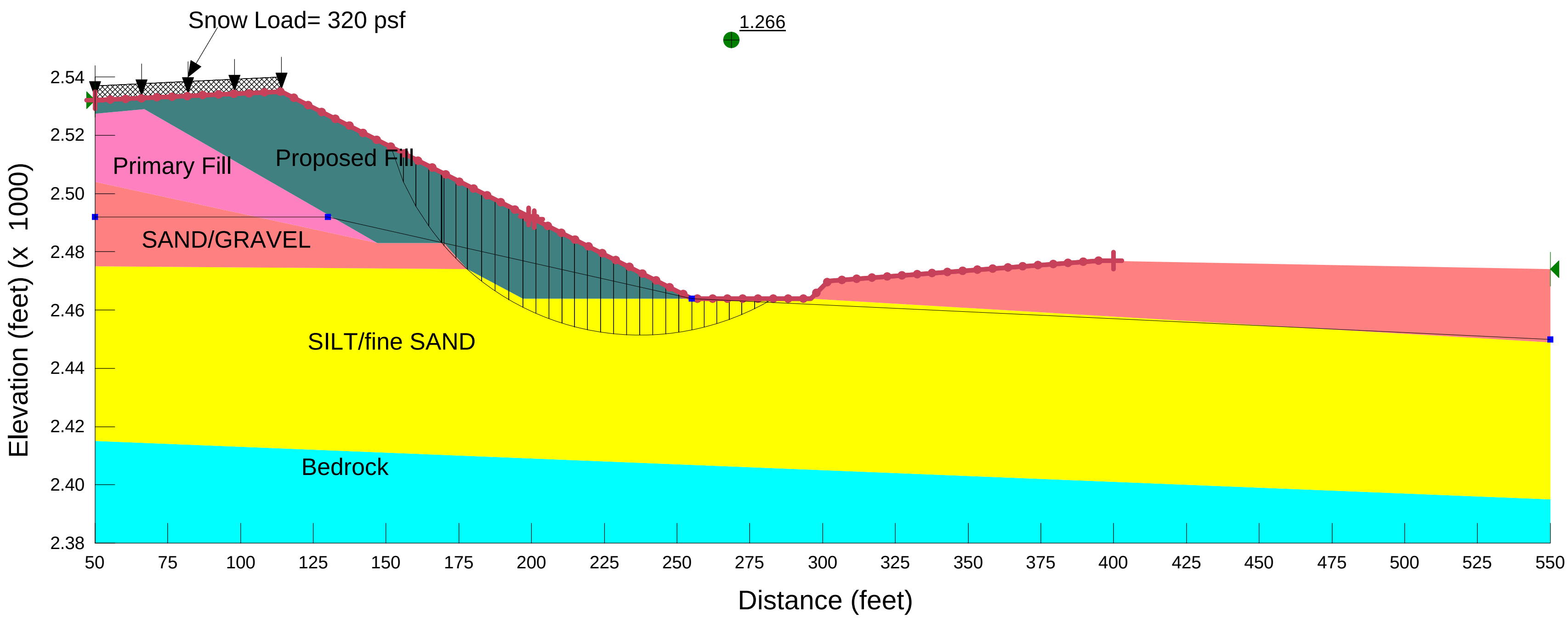

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Figure H.9.2

Embankment, Transverse
EB Embankment at AE Station 121+03
Safety Factor = 1.09

Loading: Static
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2506.5) and Low Lake level (EL. 2416)

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 6000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line:

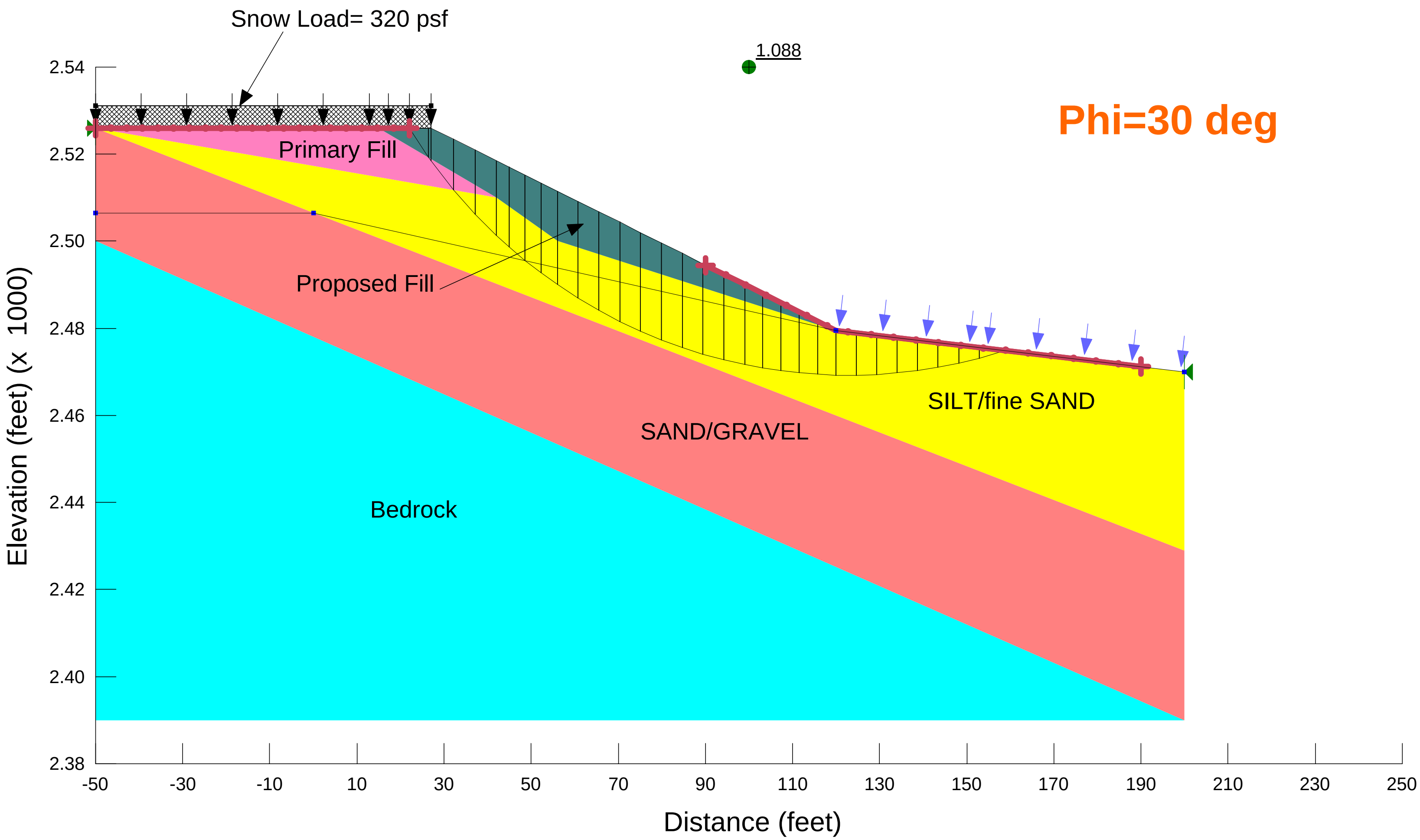

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Figure H.9.3

Embankment, Transverse
EB Embankment at AE Station 121+03
Safety Factor = 1.26

Loading: Static
Embankment Configuration: Proposed
Water Table: Design GWT (EL. 2506.5) and Low Lake level (EL. 2416)

Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Primary Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 0 psf Phi: 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: SAND/GRAVEL Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion: 0 psf Phi: 38 ° Phi-B: 0 ° Piezometric Line: 1
Name: SILT/fine SAND Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 34 ° Phi-B: 0 ° Piezometric Line: 1
Name: Reinforced Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 6000 psf Phi: 40 ° Phi-B: 0 ° Piezometric Line: 1

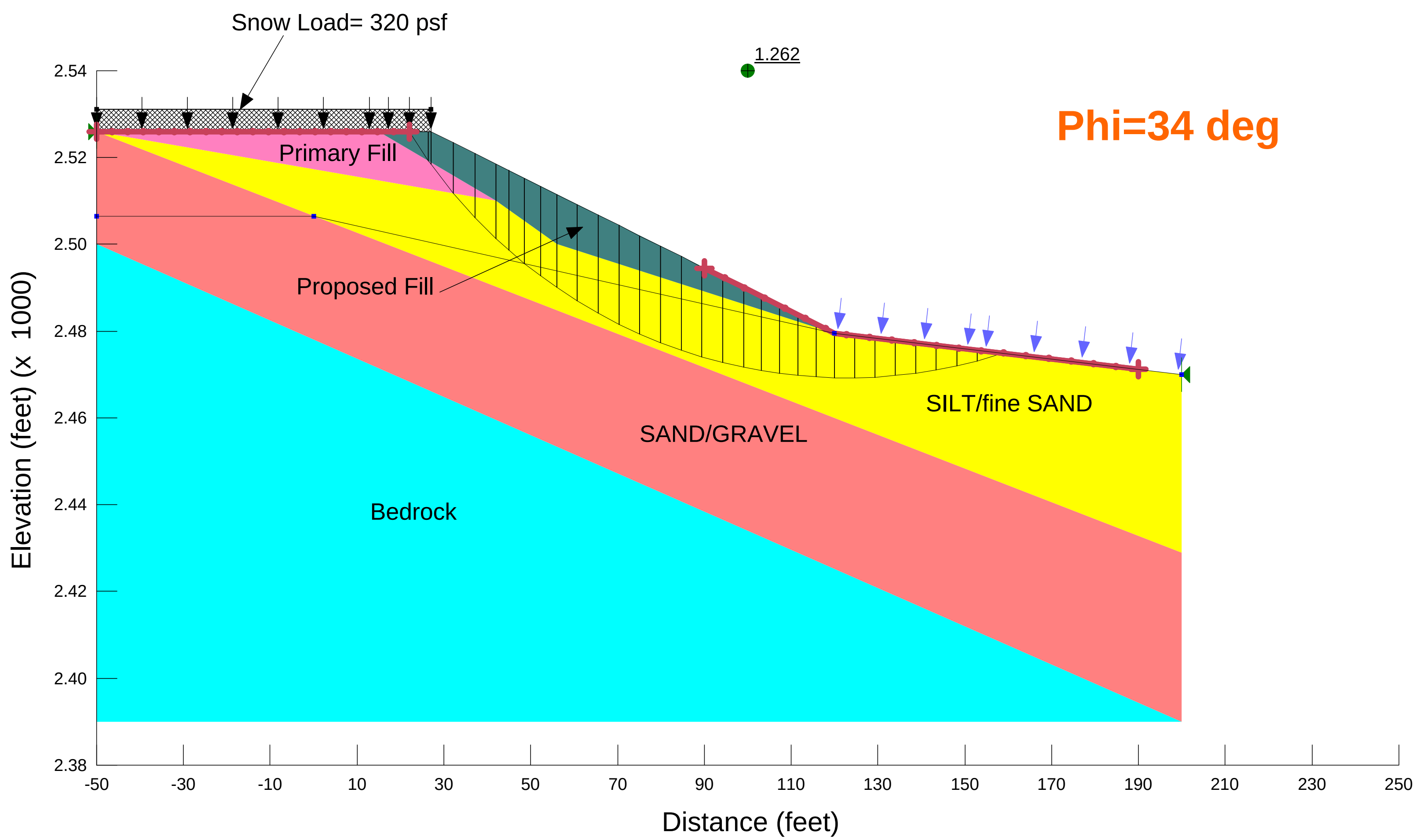

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Figure H.9.4

APPENDIX H.10
Stability Analysis Results – MP 59.7 Unnamed Creek Crossing

I-90 Snoqualmie Pass East Project
Gravity Wall at Station 111+35 (W2010+00)
Slope Stability Analysis - Static

Loading: Static
Gravity Wall Configuration: Proposed
Lake Water Level EL. 2517

Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Gravity Wall Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 10000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Clayey Silt Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 200 Phi: 30 Phi-B: 0 Piezometric Line: 1

Factor of Safety = 1.13

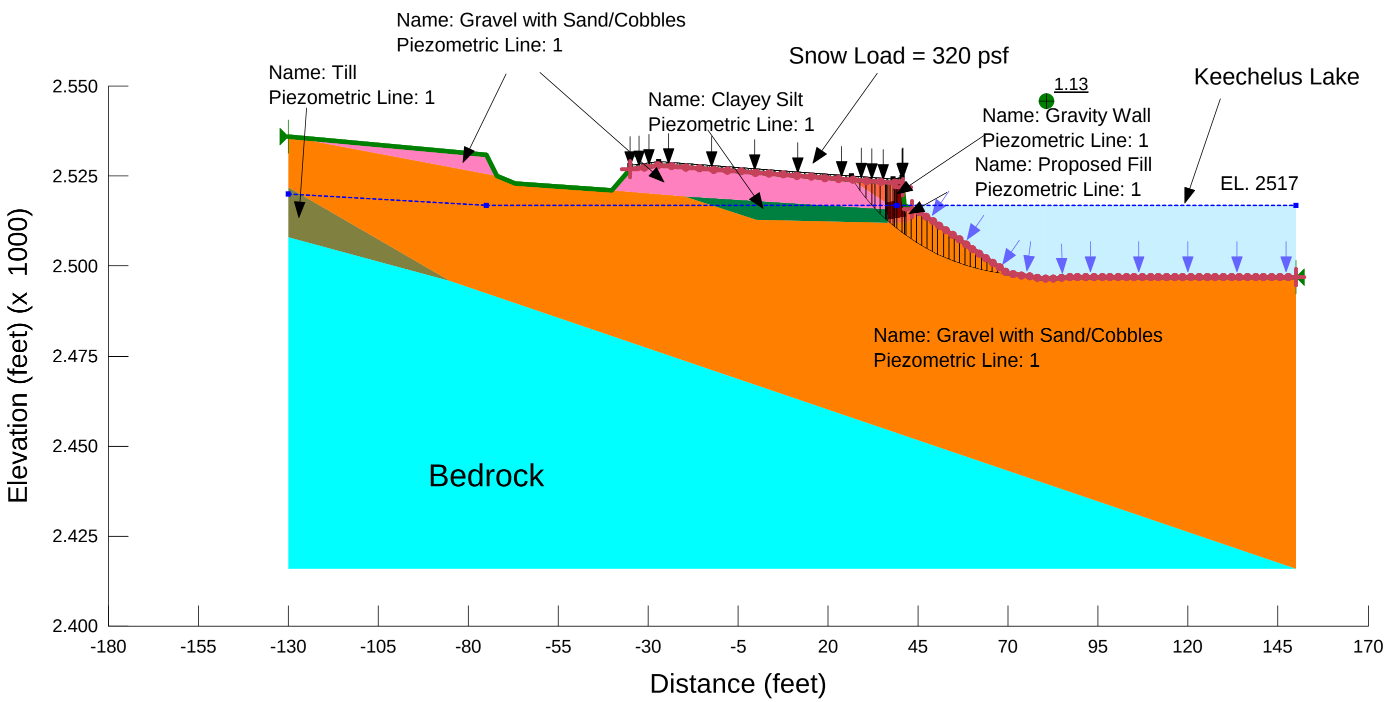

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Figure H.10.1

I-90 Snoqualmie Pass East Project
Gravity Wall at Station 111+35 (W2010+00)
Slope Stability Analysis - Seismic

Loading: Seismic kh = 0.175
Gravity Wall Configuration: Proposed
Lake Water Level EL. 2467

Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Gravity Wall Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 10000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Clayey Silt Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 200 Phi: 30 Phi-B: 0 Piezometric Line: 1

Factor of Safety = 0.96

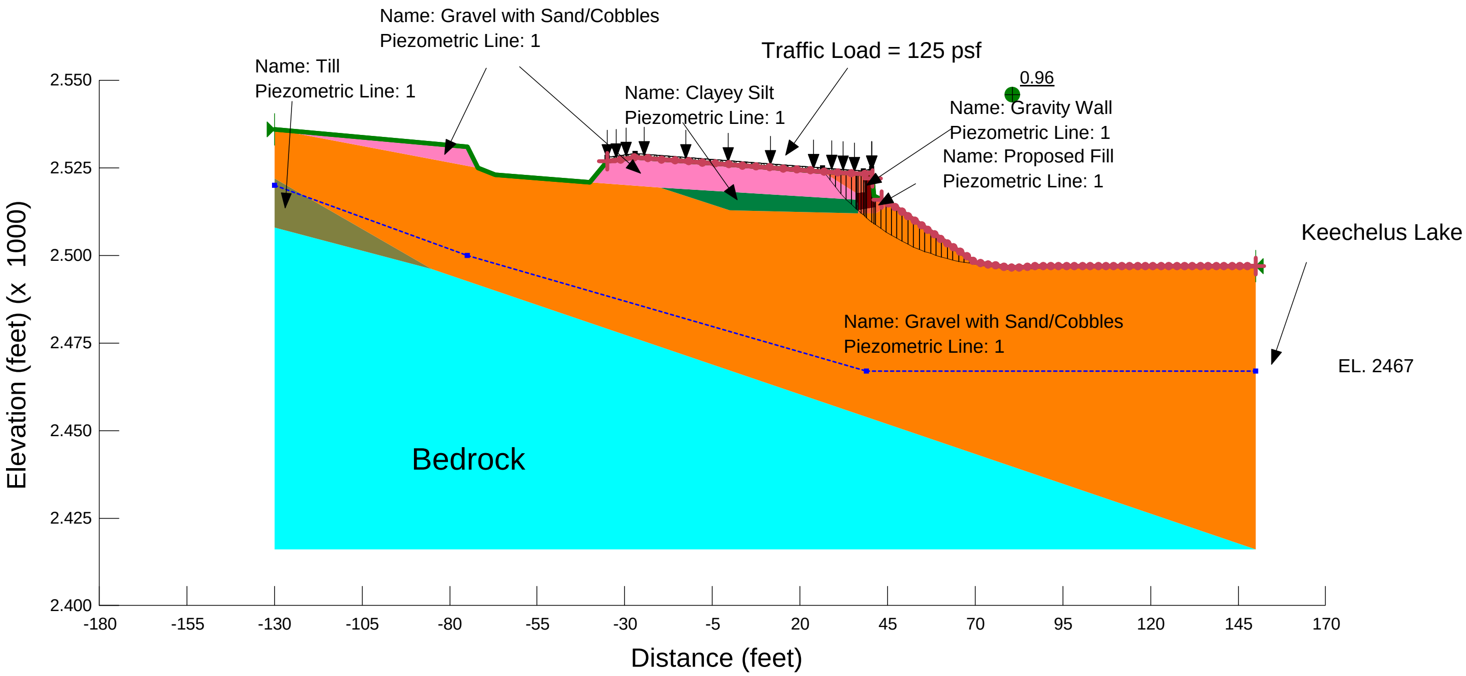

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Figure H.10.2

I-90 Snoqualmie Pass East Project
Gravity Wall at Station 111+40 (W20 10+05)
Slope Stability Analysis - Static

Loading: Static
Gravity Wall Configuration: Proposed
Lake Water Level EL. 2517

Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Gravity Wall Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 10000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Clayey Silt Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 200 Phi: 30 Phi-B: 0 Piezometric Line: 1

Factor of Safety = 1.30

File Name: A111 Sta EB 111+40-Wall, High Water, 5 Blocks.gsz
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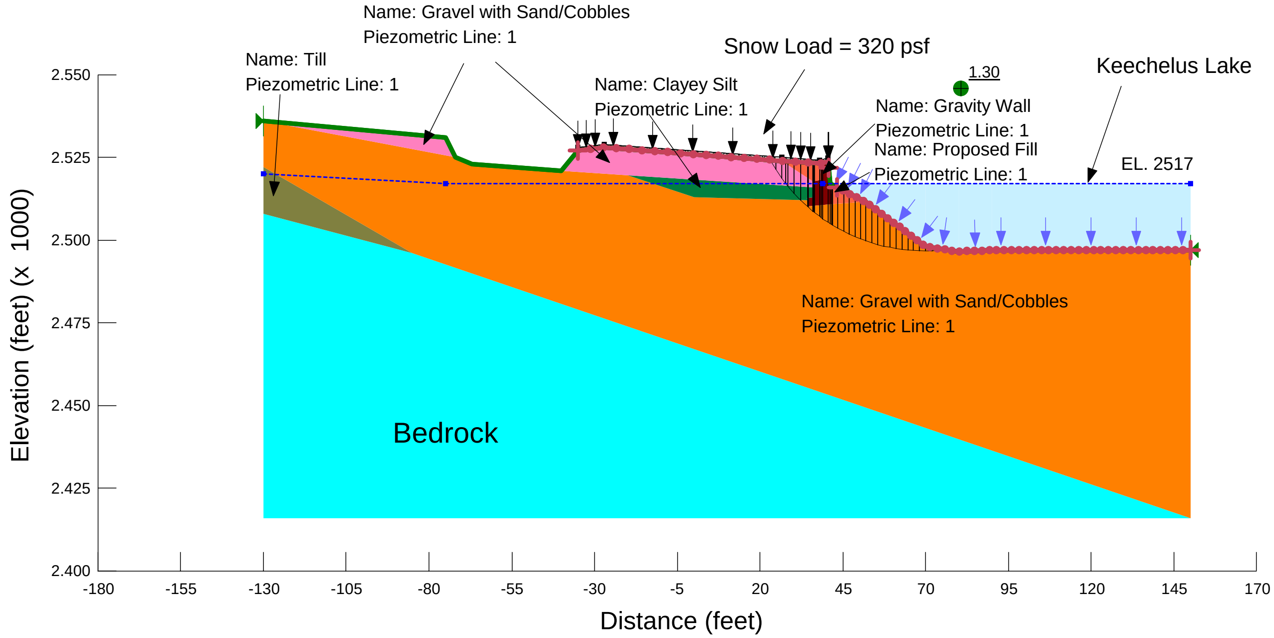

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Figure H.10.3

I-90 Snoqualmie Pass East Project
Gravity Wall at Station 111+40 (W20 10+05)
Slope Stability Analysis - Static

Loading: Static
Gravity Wall Configuration: Proposed
Lake Water Level EL. 2416

Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Gravity Wall Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 10000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Clayey Silt Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 200 Phi: 30 Phi-B: 0 Piezometric Line: 1

Factor of Safety = 1.46

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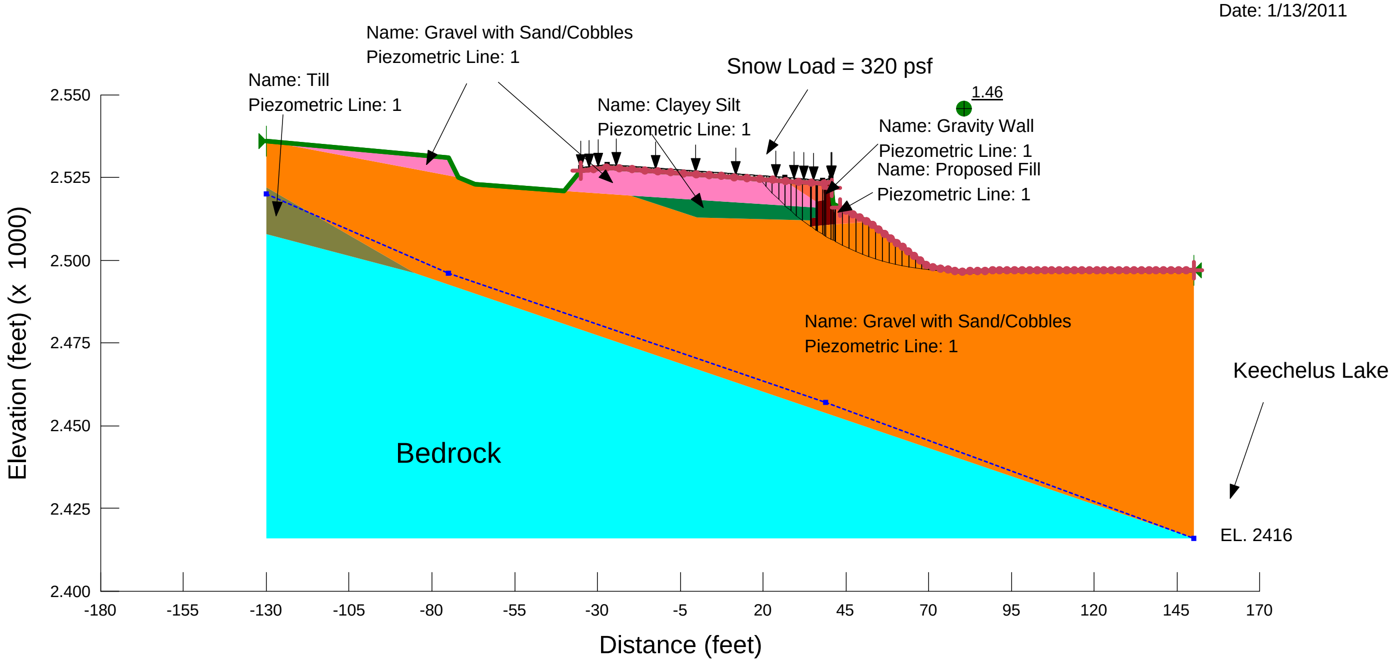

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Figure H.10.4

I-90 Snoqualmie Pass East Project
Gravity Wall at Station 111+40 (W20 10+05)
Slope Stability Analysis - Seismic

Loading: Seismic kh = 0.175
Gravity Wall Configuration: Proposed
Lake Water Level EL. 2467

Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Gravity Wall Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 10000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Clayey Silt Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 200 Phi: 30 Phi-B: 0 Piezometric Line: 1

Factor of Safety = 1.09

File Name: A333 Sta EB 111+40-Wall, Ave Water, 5 Blocks.gsz
Date: 1/13/2011

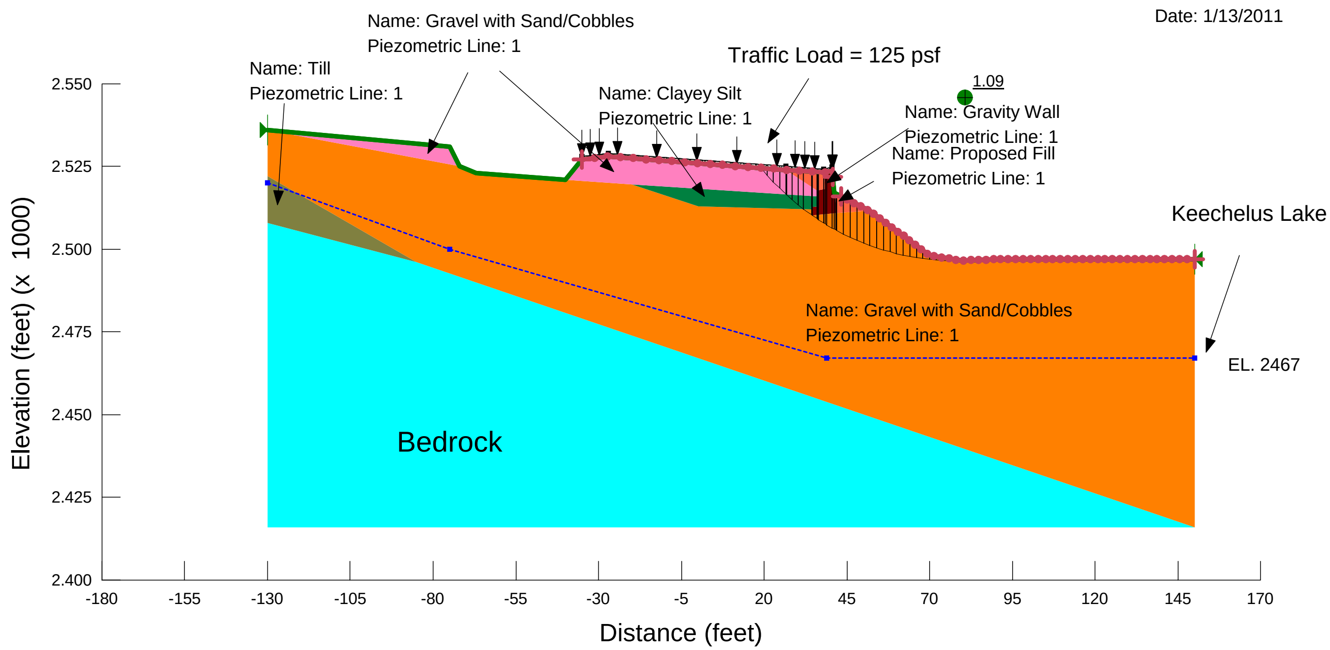

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Figure H.10.5

I-90 Snoqualmie Pass East Project
Gravity Wall at Station 111+40 (W20 10+05)
Slope Stability Analysis - Static

Loading: Static
Gravity Wall Configuration: Proposed
Lake Water Level EL. 2517

Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Gravity Wall Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 10000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Clayey Silt Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 200 Phi: 30 Phi-B: 0 Piezometric Line: 1

Factor of Safety = 1.41

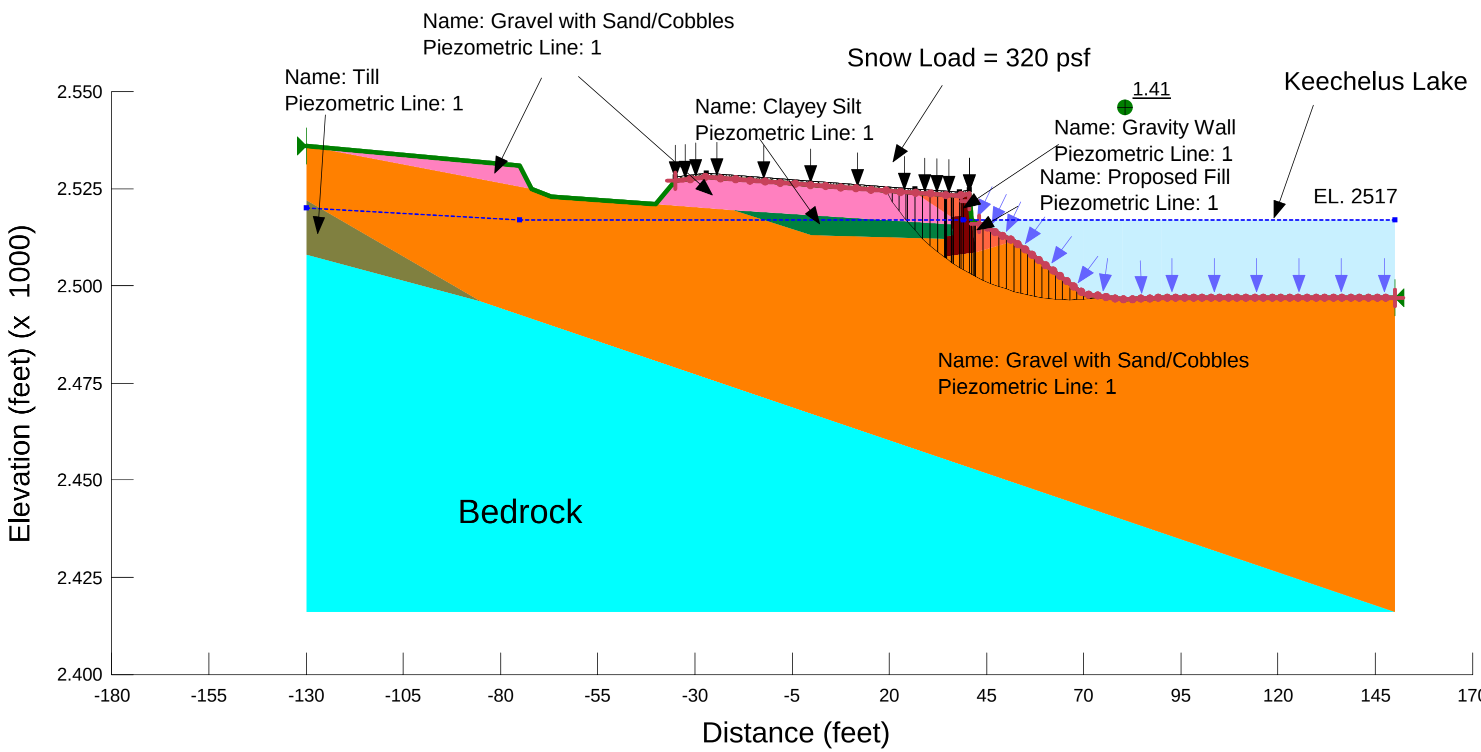

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Figure H.10.6

I-90 Snoqualmie Pass East Project
Gravity Wall at Station 111+40 (W20 10+05)
Slope Stability Analysis - Seismic

Loading: Seismic kh = 0.175
Gravity Wall Configuration: Proposed
Lake Water Level EL. 2467

Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Gravity Wall Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 10000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Clayey Silt Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 200 Phi: 30 Phi-B: 0 Piezometric Line: 1

Factor of Safety = 1.19

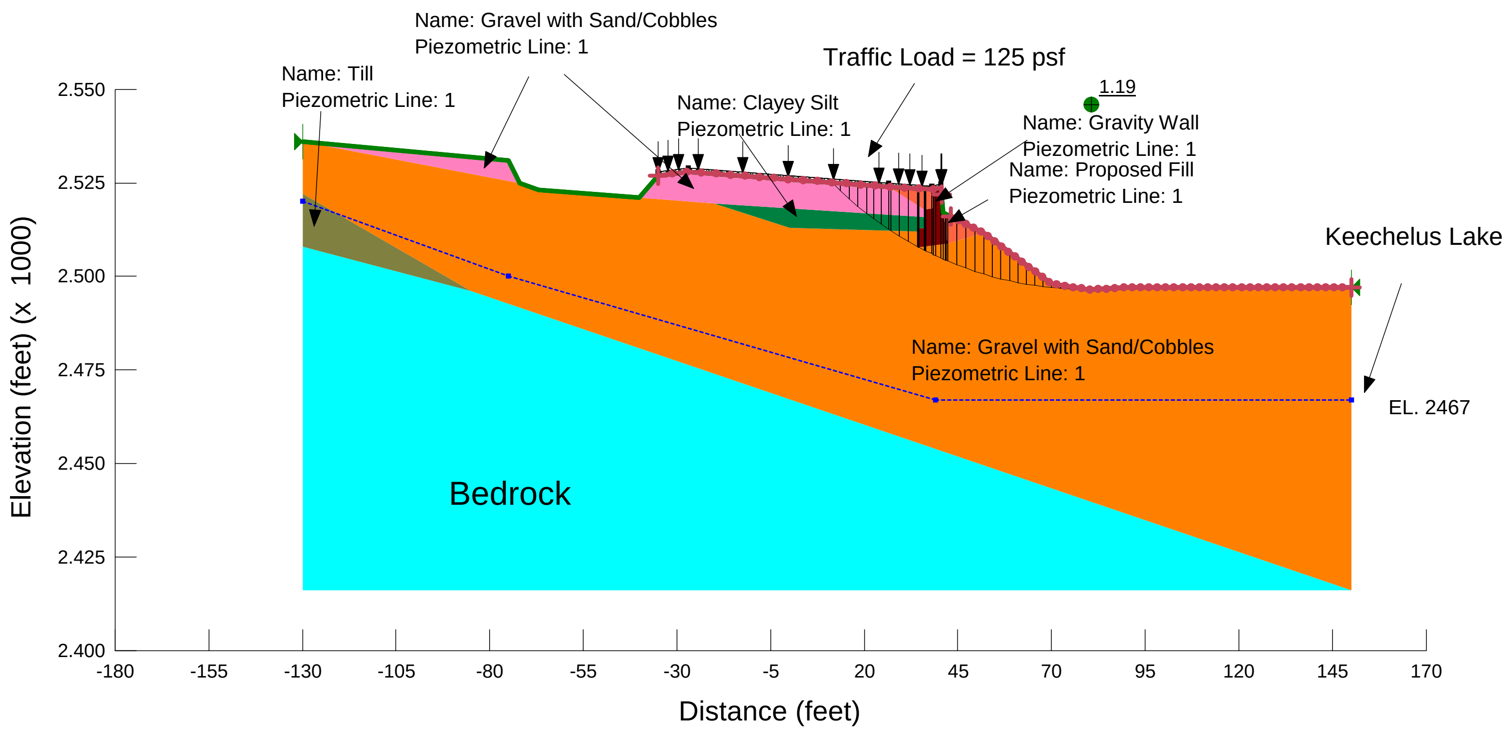

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Figure H.10.7

I-90 Snoqualmie Pass East Project
Gravity Wall at Station 111+40 (W20 10+05)
Slope Stability Analysis - Static

Loading: Static
Gravity Wall Configuration: Proposed
Lake Water Level EL. 2517

Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Gravity Wall Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 10000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Clayey Silt Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 200 Phi: 30 Phi-B: 0 Piezometric Line: 1

Factor of Safety = 1.22

File Name: A1 Sta EB 111+35-Wall, High Water, 4 Blocks, 10ft High Toe Berm
Date: 1/14/2011

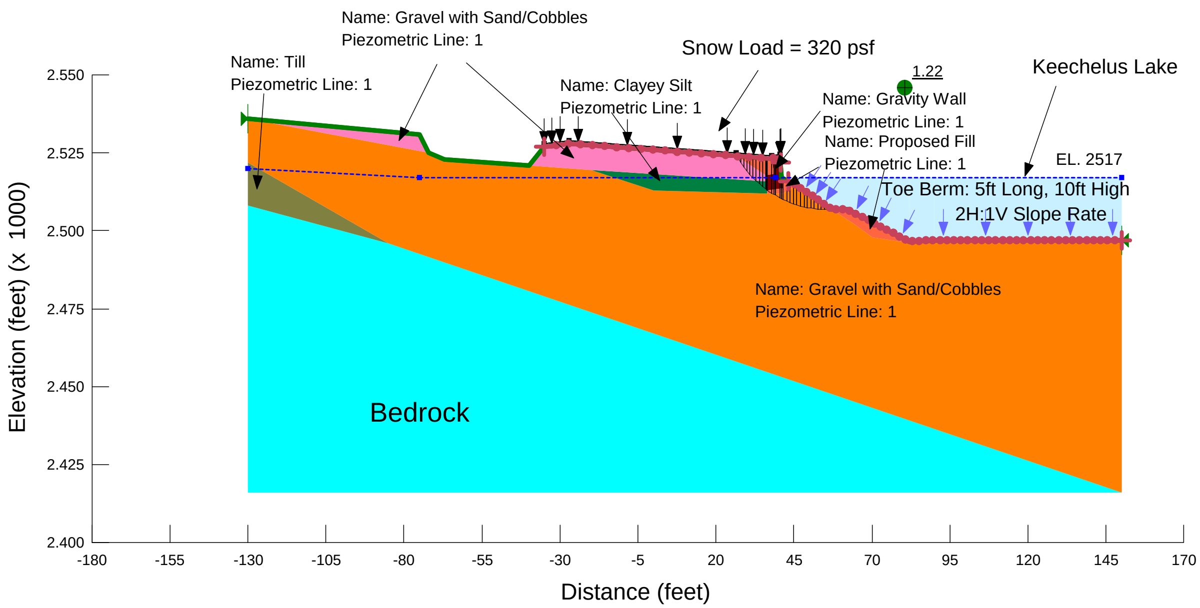

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Figure H.10.8

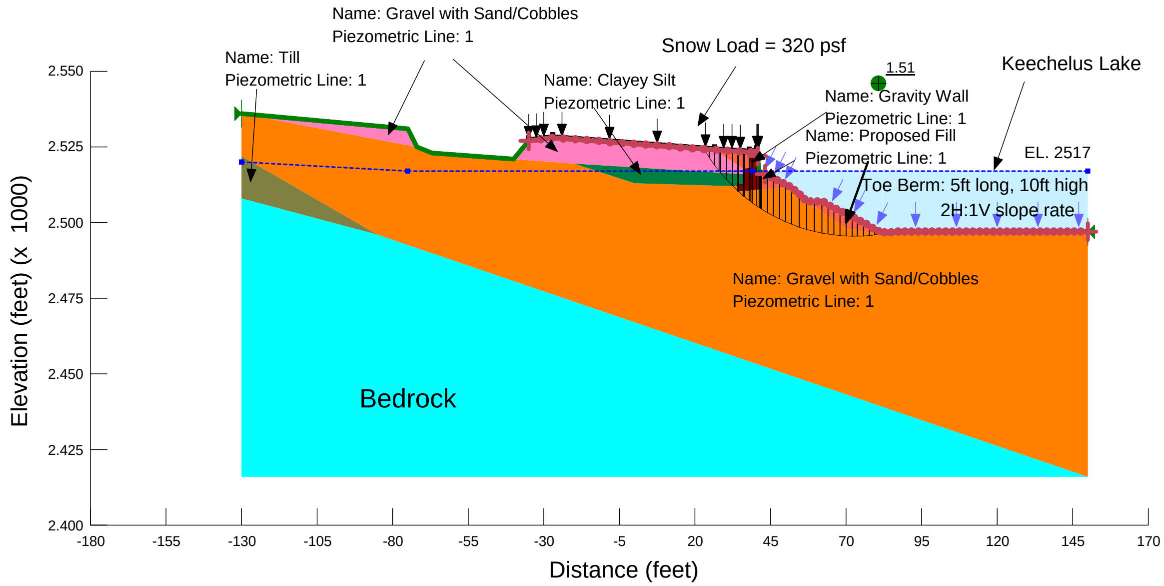
I-90 Snoqualmie Pass East Project
Gravity Wall at Station 111+40 (W20 10+05)
Slope Stability Analysis - Static

Loading: Static
Gravity Wall Configuration: Proposed
Lake Water Level EL. 2517

Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Gravity Wall Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 10000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Clayey Silt Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 200 Phi: 30 Phi-B: 0 Piezometric Line: 1

Factor of Safety = 1.51

File Name: A111 Sta EB 111+40-Wall, High Water, 5 Blocks, 10ft High Toe Berm.gsz
Date: 1/14/2011



Directory: Y:\43000 DO 2010 Geotechnical Analyses & Reporting\431700 MP 59.7 Crossing\431702 Engineering Analyses\431702.01 Wall Stability\SlopeW\Static\1-13-11\\A111 Sta EB 111+40-Wall, High Water, 5 Blocks, 10ft High Toe Berm.gsz

Figure H.10.9

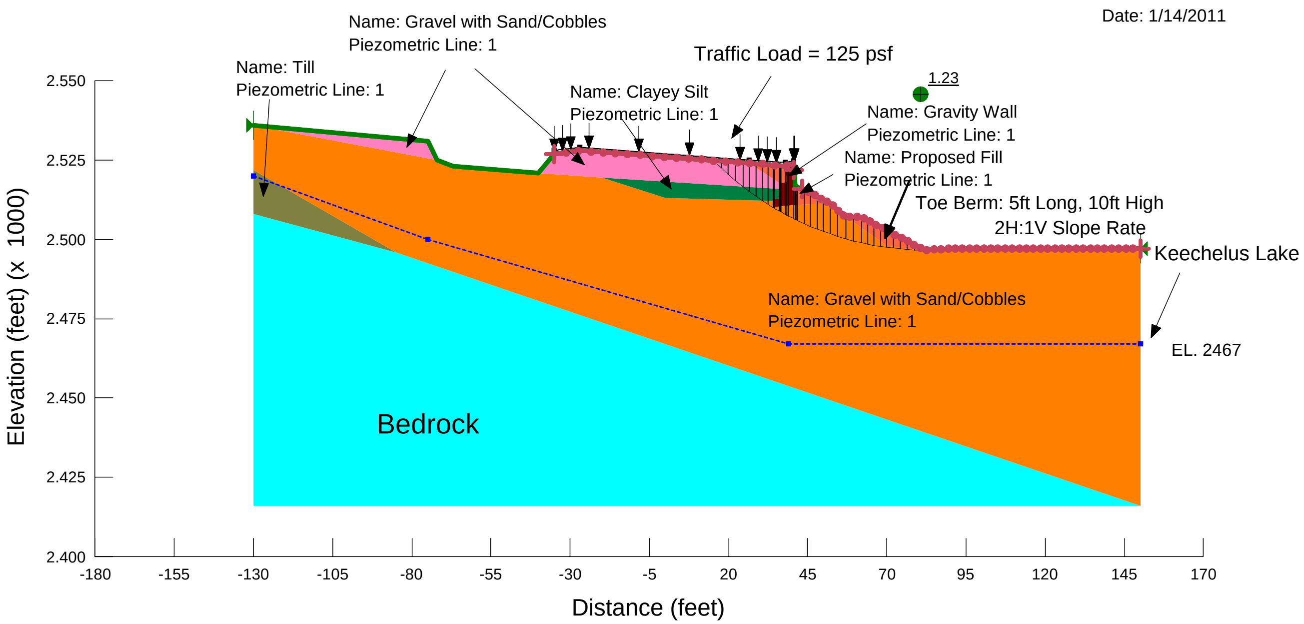
I-90 Snoqualmie Pass East Project
Gravity Wall at Station 111+40 (W20 10+05)
Slope Stability Analysis - Seismic

Loading: Seismic kh = 0.175
Gravity Wall Configuration: Proposed
Lake Water Level EL. 2467

Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 38 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 42 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Gravity Wall Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 10000 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Gravel with Sand/Cobbles Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Clayey Silt Model: Mohr-Coulomb Unit Weight: 120 Cohesion: 0 Phi: 30 Phi-B: 0 Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 200 Phi: 30 Phi-B: 0 Piezometric Line: 1

Factor of Safety = 1.23

File Name: A333 Sta EB 111+40-Wall, Ave Water, 5 Blocks, 10ft High Toe Berm.gsz
Date: 1/14/2011



Directory: Y:\43000 DO 2010 Geotechnical Analyses & Reporting\431700 MP 59.7 Crossing\431702 Engineering Analyses\431702.01 Wall Stability\SlopeW\Seismic\1-13-11\\A333 Sta EB 111+40-Wall, Ave Water, 5 Blocks, 10ft High Toe Berm.gsz

Figure H.10.10

APPENDIX H.11
W&N Wall 10 Stability Analysis Dated November 13, 2010

TECHNICAL MEMORANDUM

November 13, 2010

TO: Mr. Scott Golbek, P.E., WSDOT South Central Region
Mr. Dave Walker, P.E., URS Corporation

FR: Norman I. Norrish (Wyllie & Norrish Rock Engineers Inc.)

RE: Wall 10 Rock Cut Stability Evaluation
Phase 1C I-90 Snoqualmie Pass East project

At your verbal request, Wyllie & Norrish Rock Engineers Inc. has evaluated the stability of the rock cut that will form the eastern abutment for the proposed Wall 10. The wall will be located at Station 1363+50 LW at the eastbound end of the replacement snowshed (Figure 1). The purpose of the wall is to retain backfill behind the snowshed and to direct snow avalanches toward the snowshed and away from the I-90 grade. The proposed wall height is approximately 60 feet with a crest elevation of ±2593 feet. The proposed length is 30 feet measured at the top of wall. (Figure 2).

In accordance with Washington State Department of Transportation (WSDOT) design policy, a global stability evaluation of the rock cut abutment is required. W&N performed the evaluation under URS Corporation contract 131491UB, Work Order 222670-US, Task Order DQ. In preparation of this report, W&N discussed the conceptual Wall 10 layout with Mr. Guy Horchy or URS Corp and Mr. Luong Tran of WSDOT and made a site reconnaissance visit.

Background & Available Data

A global stability evaluation for a rock cut is a two-part process. The first step is to assess the structural geology to determine if adversely-oriented discontinuities are present at the specific site. If the finding is in the affirmative, then a stability calculation is required to quantify the resisting and disturbing forces to determine if the stability margin meets agency guidelines which may vary according to the criticality of the structure or slope. If controlling structure is not present, the cut will be stable because the rock mass strength greatly exceeds the disturbing forces for slopes of modest height.

For the Wall 10 evaluation, structural data was obtained from the following report:

> Wyllie & Norrish, April, 2009: I-90 Snoqualmie Pass East Phase 1C – Rock Slope Engineering Final Report.

In the referenced report, the Phase 1C alignment was subdivided into a number of "Design Sectors" within which geologic conditions and highway geometric conditions were reasonably consistent. Wall 10, located at 1363+50 LW is at the boundary between Design Sectors VIII and IX as designated in the alignment report. Structural geologic data was selected from the two design sectors to be as directly relevant to the Wall 10 location as practical. The selected data included:

1. Structural data derived from televiewer logging of borehole RKS-09-07 located at 1363+61 LW, 80 feet left, elevation 2620.3 feet.
2. Structural mapping of the face at Station 1363+75.
3. Sirovision face mapping from Stations Numbers 227 and 228.

The borehole logs and photographs, COBL televiewer records, structural mapping and Sirovision data are attached as Appendix A.

Structural Analysis

Borehole RKS-09-07 reported moderately weak (R2) to moderately strong (R3) meta-welded lapilli dacite tuff. The rock mass was slightly weathered to fresh. Fracture frequencies averaged two per foot with a few intervals reporting 6 to 8 fractures per foot. A possible flow boundary was intercepted at a depth of 68.5 feet. Conditions of the existing rock slope at the Wall 10 location are shown in Figure 3.

The composite structural data set for the sources listed above comprised 395 discontinuity measurements. The stereonet representation of the data is shown in Figure 4. Set 3 is the most prominent discontinuity and is steeply-dipping and oblique to the existing and proposed cut slopes (see also Figure 3). Sets 2 and 4 are inclined into the slope and are inconsequential to stability. Set 1 is the least well-developed but is adversely oriented with an average inclination of 35° out-of-slope. This inclination is less than the friction angle for typical joints and thus under drained slope conditions would be nominally stable. Given the diminutive nature of Set 1 and the limited reported persistence measurements, it is anticipated that Set 1 could control localized face stability but is unlikely to govern overall slope stability. Similarly, the intersection of Sets 1 and 3 could form wedges with a line-of-intersection plunging at about 30 degrees, well below the average friction angle for either joint set.

It is concluded that on the basis of the available structural data the proposed cut slope in the vicinity of Wall 10 should be stable against overall structurally-controlled failure modes (planar, wedge, topple). This assertion does not rule out the potential for a persistent, low-shear strength feature such as a flow boundary that may be discovered during excavation. Accordingly, responsive stabilization contingencies may be required when actual rock conditions are exposed. To provide for face stability, stabilization of blocks defined by Set 1 or by the combination of Sets 1 and 3, slope reinforcement will be required.

Wall 10 Face Stabilization Recommendations

Figure 5 illustrates the stabilization program for the east portal area of the replacement snowshed as presented in W&N, 2009. The program consisted of crest dowels, 25-foot pattern dowels (12 ½ ft hor x

12 ft vert) extending down to nominal elevation 2545 feet. In addition, provisional quantities for spot rock bolts and spot rock dowels were specified. Immediately to the east of the portal the pattern dowel length was increased to 40 feet and cable net slope protection was stipulated to control rockfall.

Based on the site specific structural analysis for Wall 10 and the previous slope stabilization recommendations for Design Sectors VIII and IX, the following additional recommendations are provided for Wall 10:

1. The wall designer should anticipate that the final rock face will have a high degree of irregularity with deviations from the design neat line as great as 5 to 10 feet. The concrete-forms must be able to tolerate this deviation. If advantageous, a leveling-course of fiber reinforced shotcrete could be applied to the trace width of the wall down the rock cut face.
2. Between every row of prescribed pattern dowels (12-foot vertical spacing), add supplemental cement-grouted rock bolts as shown in Figure 5.
3. The minimum length of the supplemental rock bolts should be 25 feet, excluding the bond zone.
4. Supplemental rock bolts should be drilled through a reinforced bearing bearing-gusset and post tensioned to the required load. The bearing gusset could be cast-in-place concrete with the wall or reinforced shotcrete applied after the wall is cast.
5. The supplemental rock bolts should be oriented at 45° (nominal) to the centerline of the wall and inclined at -15°.
6. The number and capacity of the supplemental bolts will depend on the wall forces to be resisted. Rock bolt bond zone capacity should be based on an <u>allowable</u> bond stress of 100 psi for R2-R3 intact rock strength (3.6 to 15 ksi).

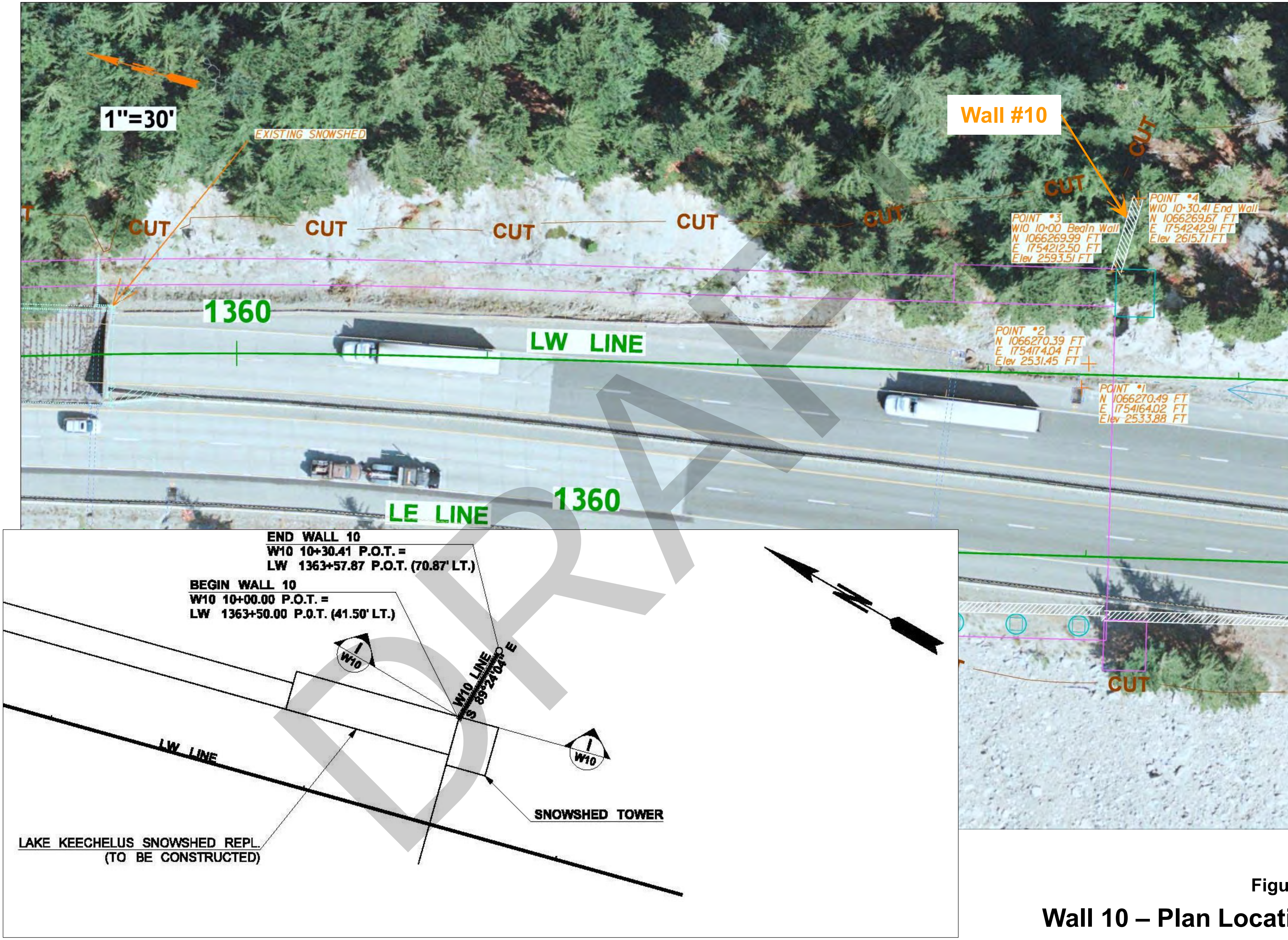
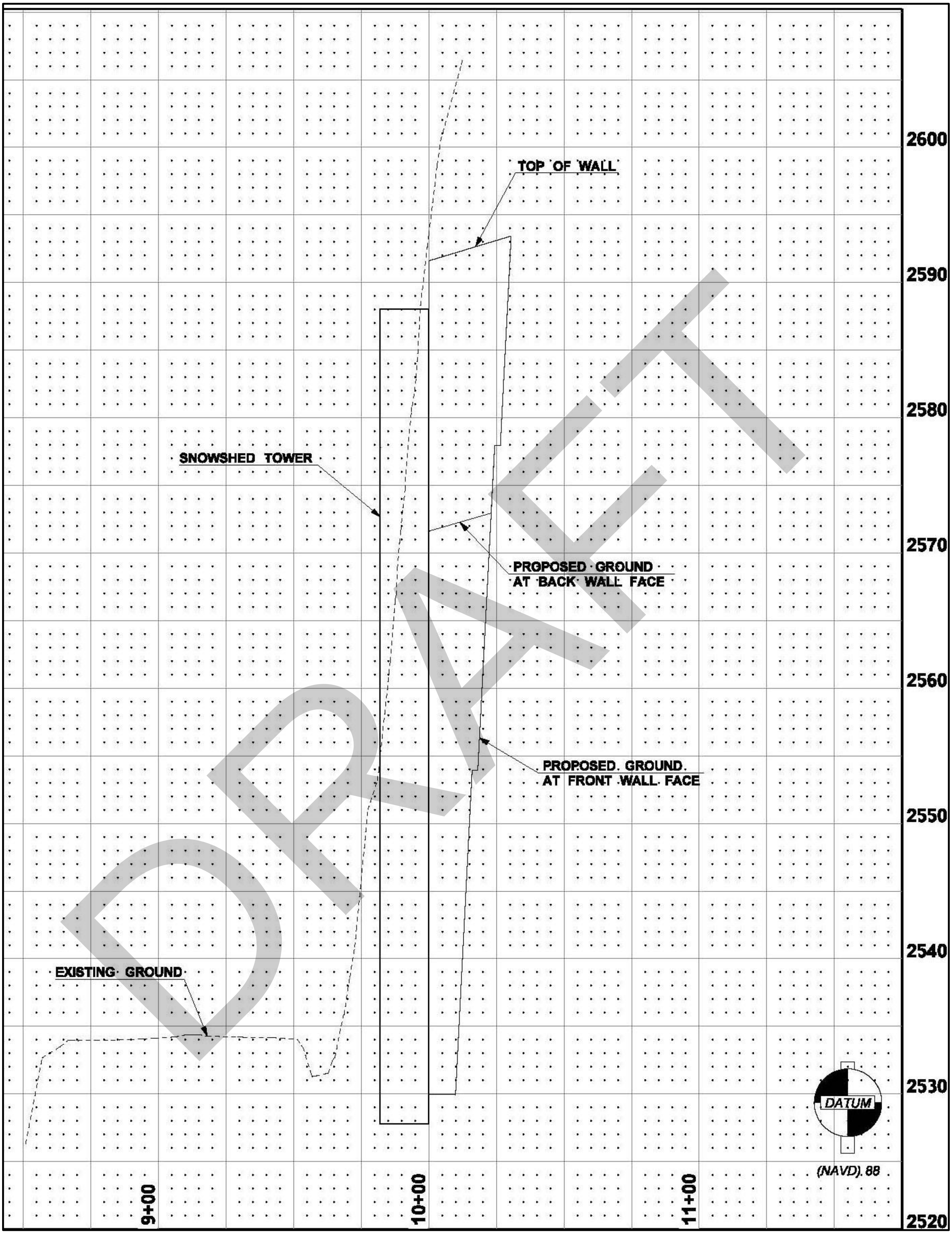


Figure 1

Wall 10 – Plan Location

Project No. 062-2002 Date: November, 2010



Project No. 062-2002 Date: November, 2010

Figure 2

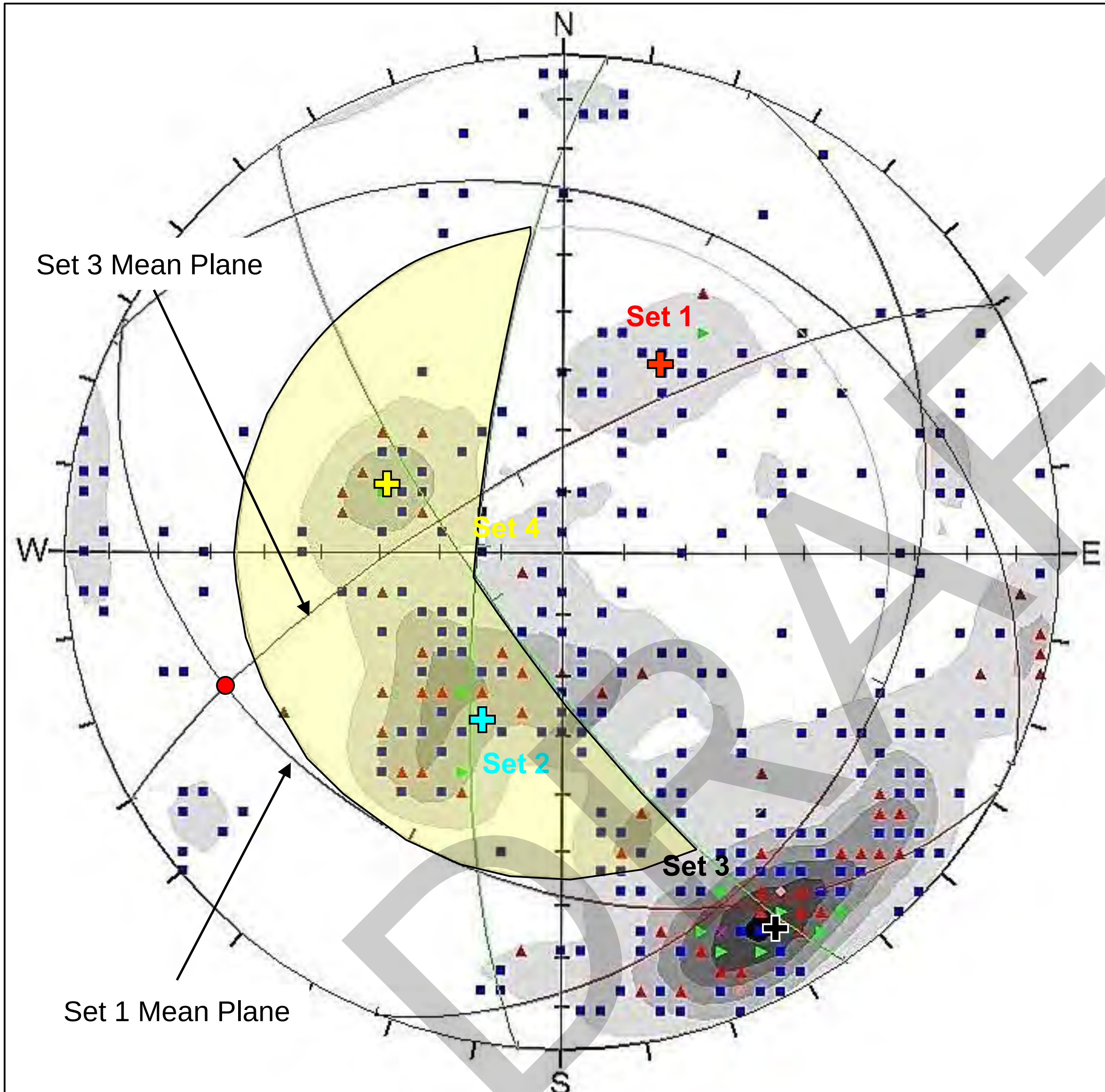
Wall 10 - Section

I-90 Snoqualmie Pass East
Hyak to Keechelus Dam

Photo Date: October 26, 2010 View Eastbound

Figure 3

Wall 10 Site Location

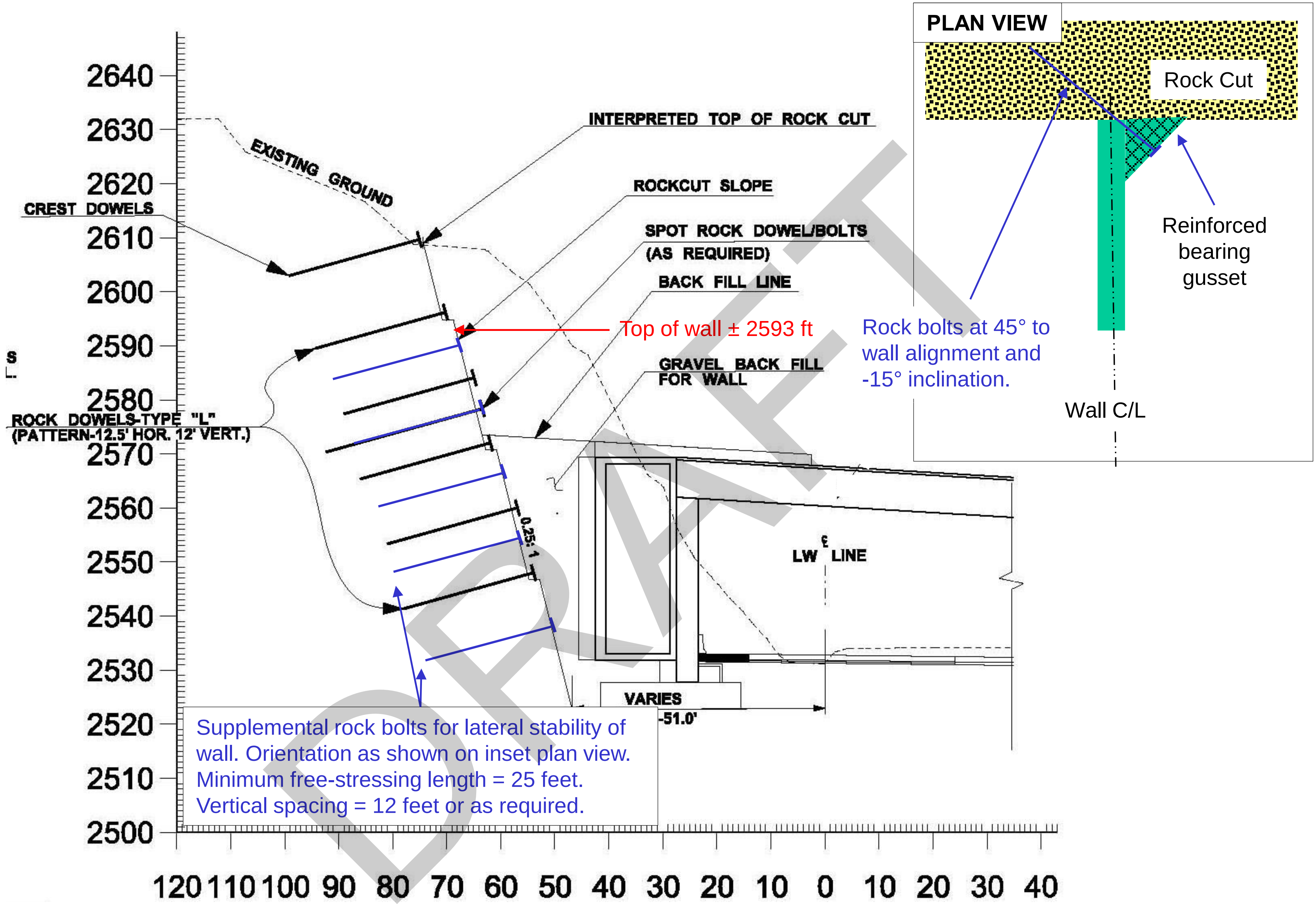


Mean Set Orientations

Set	Pole Symbol	Dip	Dip Dir
1	✚	35º	208º
2	✚	30º	025º
3	✚	75º	330º
4	✚	31º	112º

Figure 4

Wall 10 – Kinematic Analysis



Project No. 062-2002 Date: January 2009

Figure 5

Wall 10 – Stabilization Plan

I-90 Snoqualmie Pass East
Hyak to Keechelus Dam

APPENDIX H.12
Wall 9 Compound Stability Analysis

Appendix H.12
Wall 9 Compound Stability Analysis

INTRODUCTION

The memorandum describes compound stability analyses conducted for Wall 9 at the west portal of the snowshed. Wall 9 is a tiered MSE wall with a total height of 45 feet. The lowest, middle, and upper tiers are designated 9A, 9B, and 9C, respectively.

The purpose of the analysis was to develop reinforcement requirements to provide compound stability. A compound stability analysis considers potential failure surfaces that pass through both retained soil and the reinforced wall backfill.

URS previously provided information for Wall 9 including the results of global stability analyses and soil parameters for wall design in a preliminary technical memorandum dated August 25, 2010. That memorandum was included as part of an information package provided to potential wall designers by WSDOT on August 30, 2010.

METHOD OF ANALYSIS

Compound stability was evaluated using a two-dimensional plane strain analysis and the computer program SLOPE/W. Target factors of safety of 1.3 for static loading and 1.1 for seismic loading were used. The static factor of safety is based on guidance in the GDM, Section 15.4.2.11 for walls that are not deemed “critical.”

An interpreted critical cross section perpendicular to the roadway alignment at LW Sta. 1352+30 was analyzed. The analysis was used to select minimum reinforcement lengths and long-term reinforcement tensile strength and frictional properties needed to achieve the target factors of safety.

The adequacy of the reinforcement in the direction parallel to the roadway was also checked. An interpreted critical cross section at W9A 10+14 was analyzed. The analysis conditions included the minimum wall reinforcement selected for the critical perpendicular cross section.

Wall and Subsurface Conditions

The subsurface stratigraphy was taken from cross section SSD 4-4’ at LW 1352+66. The following soil and wall properties were used in the analysis.

Soil Layers	Saturated Unit Weights (pcf)	Effective Shear Strength Parameters	
		Cohesion (psf)	Friction Angle (degrees)
Wall Backfill	135	0	40
Sand and Gravel (Existing Slope)	135	100	40
Concrete Panel	150	72,000	0
Bedrock	Assumed that failure does not occur in this layer.		

Strength properties for the sands and gravel of the existing slope were taken from Allen and Badger (2009), who backanalyzed the properties using a limit equilibrium stability analysis and assuming the existing slope factor of safety under static conditions equal to approximately 1.05.

URS included resisting forces from the portion of the wall reinforcement outside of the calculated failure plane and from the wall facing. A cohesion value equal to 72,000 psf was assumed for the wall facing.

Appendix H.12
Wall 9 Compound Stability Analysis

The reinforcement was modeled using the fabric option in SLOPE/W, assuming a vertical spacing of 2.5 feet between the reinforcement layers. The reinforcement length selected considered a preference to limit the amount of rock excavation required and was constrained to be the same for both strip and grid reinforcements.

SLOPE/W calculates the pullout resistance per unit width, P_r, using an interaction factor, F.

$$P_r = L_e F \sigma_v' \tan\varphi$$

Where

L_e = length of reinforcement contributing to pullout resistance

σ_v' = effective overburden pressure

φ = wall backfill friction angle

The interaction factor, F, is equal to:

$$F = \Phi F^* R_c \alpha C / \tan\varphi$$

Where

Φ = pullout resistance factor

F^* = pullout friction factor ((LRFD Figure 11.10.6.3.2-1)

R_c = reinforcement coverage ratio = width of reinforcement divided by center-to-center horizontal spacing of reinforcement

α = scale effect correction factor = 1 for steel reinforcement

C = overall reinforcement surface area geometry factor = 2 for strip and grid reinforcement

For α equal to 1.0 and C equal to 2, the expression for F reduces to:

$$F = 2\Phi F^* R_c / \tan\varphi$$

Combined friction factors, F^*R_c, of 0.21 and 0.42 were selected as representative of both strip and grid reinforcements. A value of $\tan\varphi$ equal to 0.84 was used for a wall backfill friction angle, φ, equal to 40 degrees. Pullout resistance factors, Φ, of 1.0 and 0.8 were used for static and seismic loading, respectively (AASHTO 2007).

SLOPE/W calculates the factor of safety for various trial failure surfaces and provides as output the minimum factor of safety and corresponding pullout resistances of each reinforcement layer.

The total required long-term, unfactored tensile capacity of the reinforcement was calculated for the zone within which extended reinforcement for pullout resistance was needed. The tensile capacity for each zone was calculated assuming that each reinforcement layer must have a tensile capacity that is at least equal to the maximum computed pullout resistance for any single reinforcement layer within the zone.

RESULTS

Based on limit equilibrium analyses at LW Sta. 1352+30, additional wall reinforcement will be needed in certain zones of the wall to provide for an acceptable factor of safety against a compound stability failure. The minimum reinforcement lengths and minimum long-term reinforcement tensile strength and frictional properties are shown in Figure 1.

Based on limit equilibrium analyses performed at cross sections parallel to the roadway at W9A 10+14, the selected reinforcement is adequate for the direction parallel to the roadway. Factors of safety of 1.41 for static loading and 1.16 for seismic loading were calculated at W9A 10+14 assuming the selected reinforcement as shown in Figure 1.

Graphical results of the analyses are provided in Figures 2 through 9.

REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). 2007. AASHTO LRFD Bridge Design Specifications. Fourth Edition.

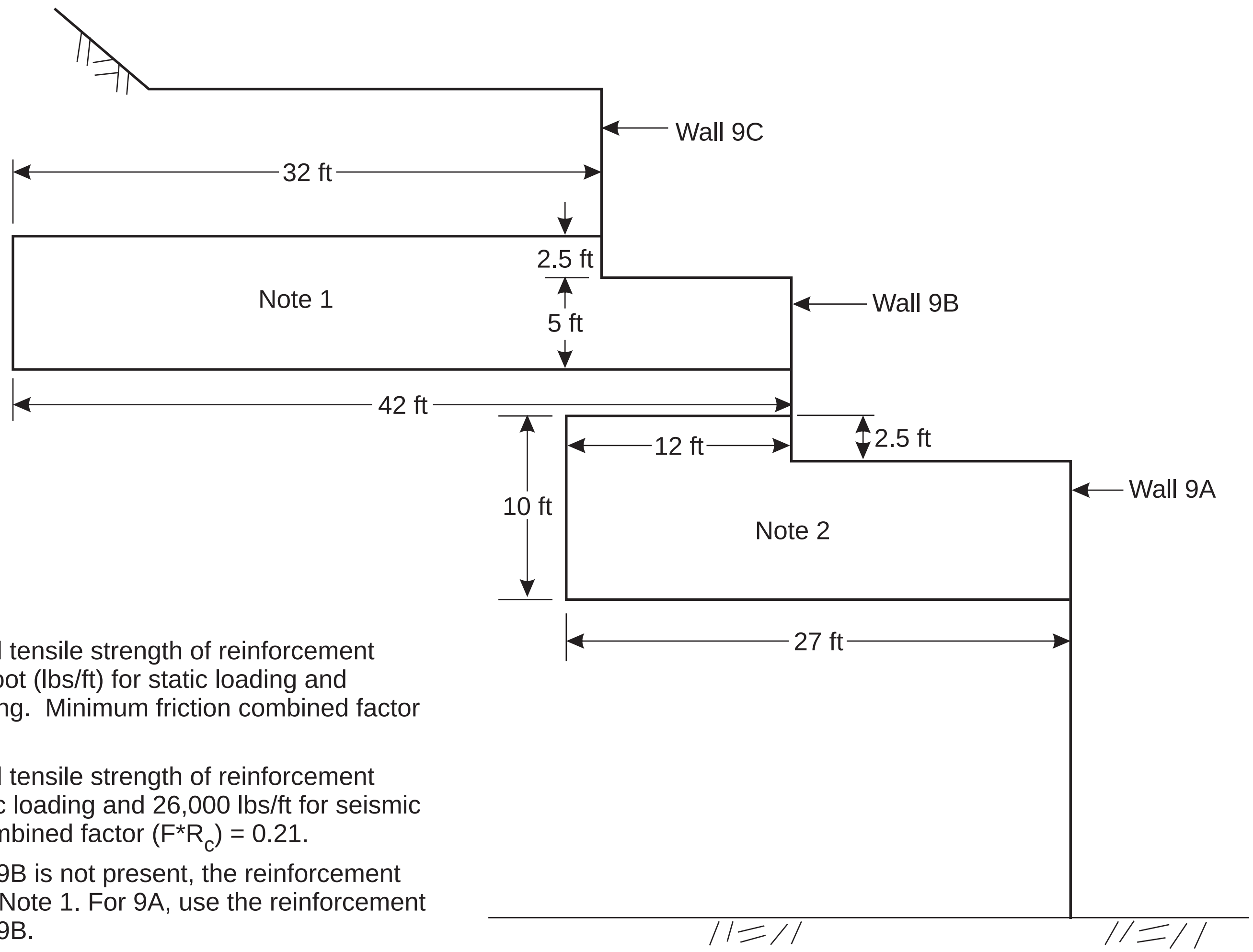
Allen, T.M. and Badger, T.C. 2009. Memorandum: SR-90, MP 57 to 58 Vicinity. Snoqualmie Pass East – Phase 1B. Overburden Thickness and Cut Slope Recommendations. August 31, 2009.

Table 1
Summary of Stability Results – Wall 9 Compound Stability

Station	Direction Relative to Road Alignment	Location		Calculated Factor of Safety		Figure No.
		Upper Wall	Lower Wall	Static	Seismic	
LE 1352+30	Perpendicular	9C	9B	1.46	1.09	2 - 3
		9B	9A	1.45	1.08	4 - 5
		9A	NA	1.38	1.02	6 - 7
W9A 10+14	Parallel	9C	9A	1.41	1.16	8 - 9

NA = not applicable

33758662_45.cdr



Notes

1. Minimum long-term combined tensile strength of reinforcement layers = 60,000 pounds per foot (lbs/ft) for static loading and 75,000 lbs/ft for seismic loading. Minimum friction combined factor (F^*R_c) = 0.42.
2. Minimum long-term combined tensile strength of reinforcement layers = 15,000 lbs/ft for static loading and 26,000 lbs/ft for seismic loading. Minimum friction combined factor (F^*R_c) = 0.21.
3. For wall sections where Wall 9B is not present, the reinforcement requirements are provided in Note 1. For 9A, use the reinforcement requirements shown for Wall 9B.

   F^* = Reinforcement pullout friction factor.

   R_c = Reinforcement coverage ratio.

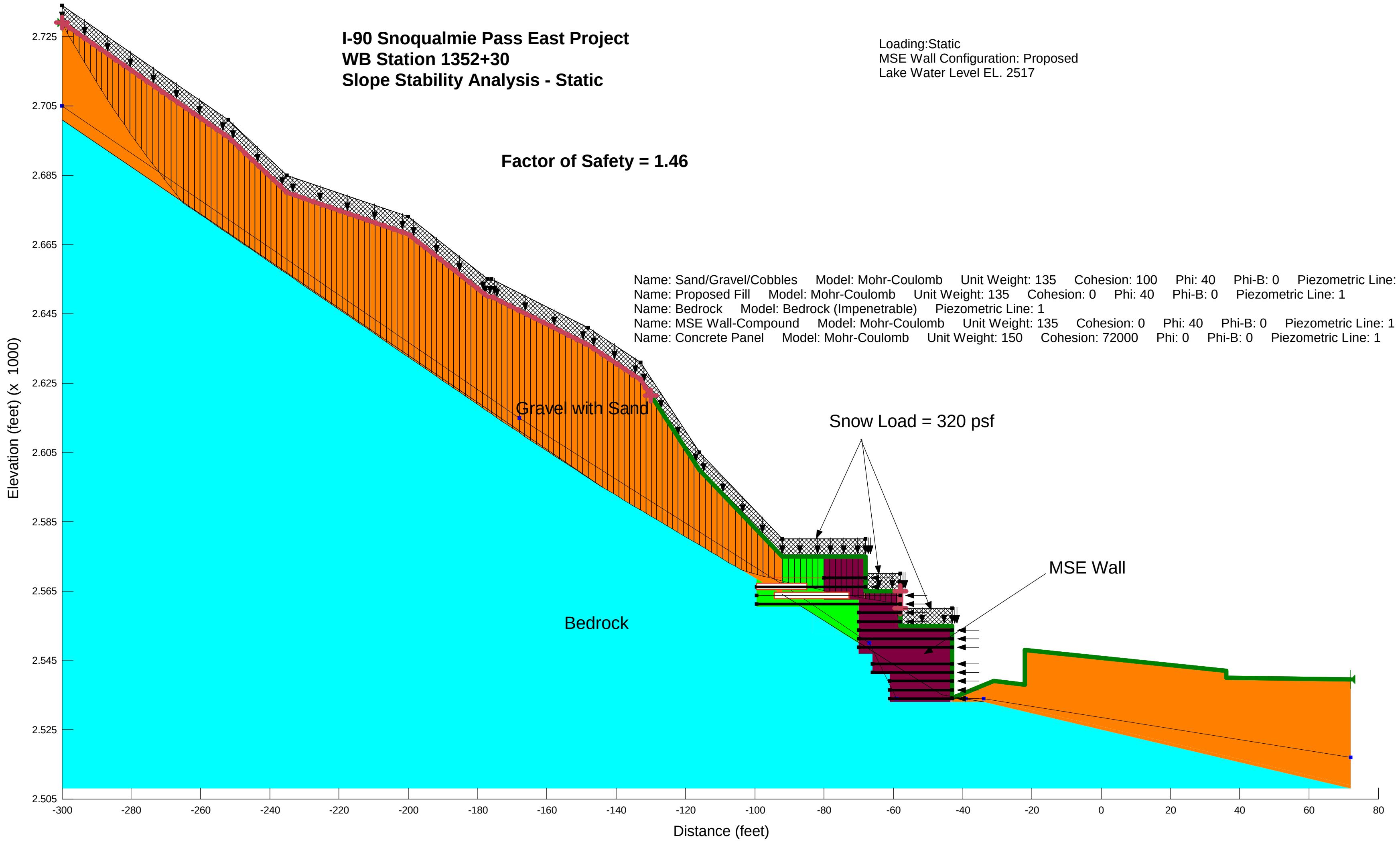
Figure 1

Recommended Reinforcement for Compound Stability - Wall 9

Job No. 33758662

URS

WSDOT I-90 Snoqualmie Pass East
2010 Geotechnical Analysis and Reporting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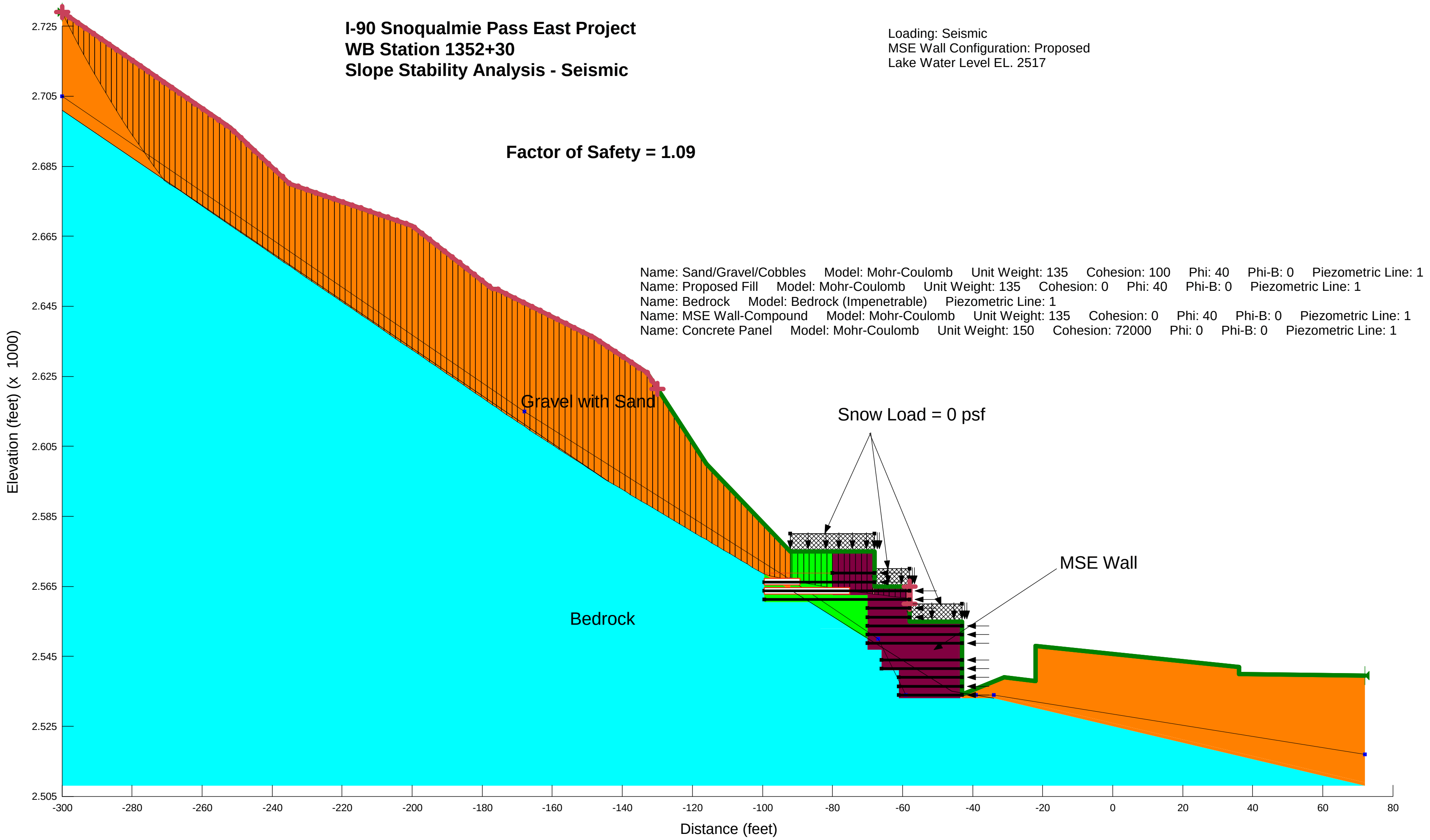
WB Station 1352+30
Slope Stability Analysis - Static
Loading:Static
MSE Wall Configuration: Proposed
Lake Water Level EL. 2517
Factor of Safety = 1.46
Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 100 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: MSE Wall-Compound Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Concrete Panel Model: Mohr-Coulomb Unit Weight: 150 Cohesion: 72000 Phi: 0 Phi-B: 0 Piezometric Line: 1
Gravel with Sand
Snow Load = 320 psf
MSE Wall
Bedrock
Elevation (feet) (x 1000)
2.725
2.705
2.685
2.665
2.645
2.625
2.605
2.585
2.565
2.545
2.525
2.505
Distance (feet)
-300 -280 -260 -240 -220 -200 -180 -160 -140 -120 -100 -80 -60 -40 -20 0 20 40 60 80

Figure 2


I-90 Snoqualmie Pass East Project
WB Station 1352+30
Slope Stability Analysis - Seismic
Loading: Seismic
MSE Wall Configuration: Proposed
Lake Water Level EL. 2517
Factor of Safety = 1.09
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Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: MSE Wall-Compound Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Concrete Panel Model: Mohr-Coulomb Unit Weight: 150 Cohesion: 72000 Phi: 0 Phi-B: 0 Piezometric Line: 1
Gravel with Sand
Snow Load = 0 psf
MSE Wall
Bedrock
Elevation (feet) (x 1000)
Distance (feet)
2.725
2.705
2.685
2.665
2.645
2.625
2.605
2.585
2.565
2.545
2.525
2.505
-300
-280
-260
-240
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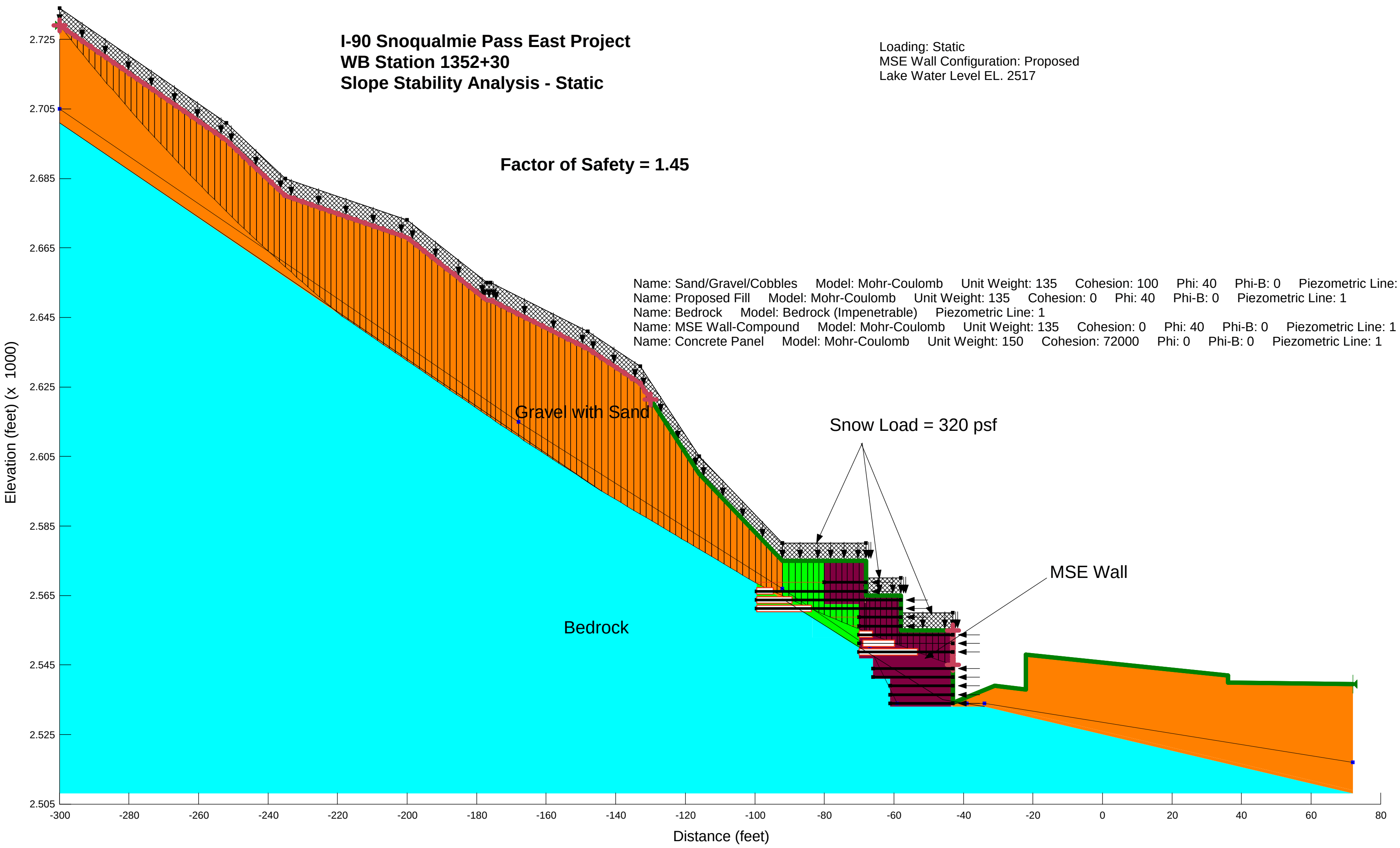
-40
-20
0
20
40
60
80

Figure 3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WB Station 1352+30
Slope Stability Analysis - Static
Loading: Static
MSE Wall Configuration: Proposed
Lake Water Level EL. 2517
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Name: MSE Wall-Compound Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Concrete Panel Model: Mohr-Coulomb Unit Weight: 150 Cohesion: 72000 Phi: 0 Phi-B: 0 Piezometric Line: 1
Gravel with Sand
Snow Load = 320 psf
MSE Wall
Bedrock
Elevation (feet) (x 1000)
2.725
2.705
2.685
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2.645
2.625
2.605
2.585
2.565
2.545
2.525
2.505
Distance (feet)
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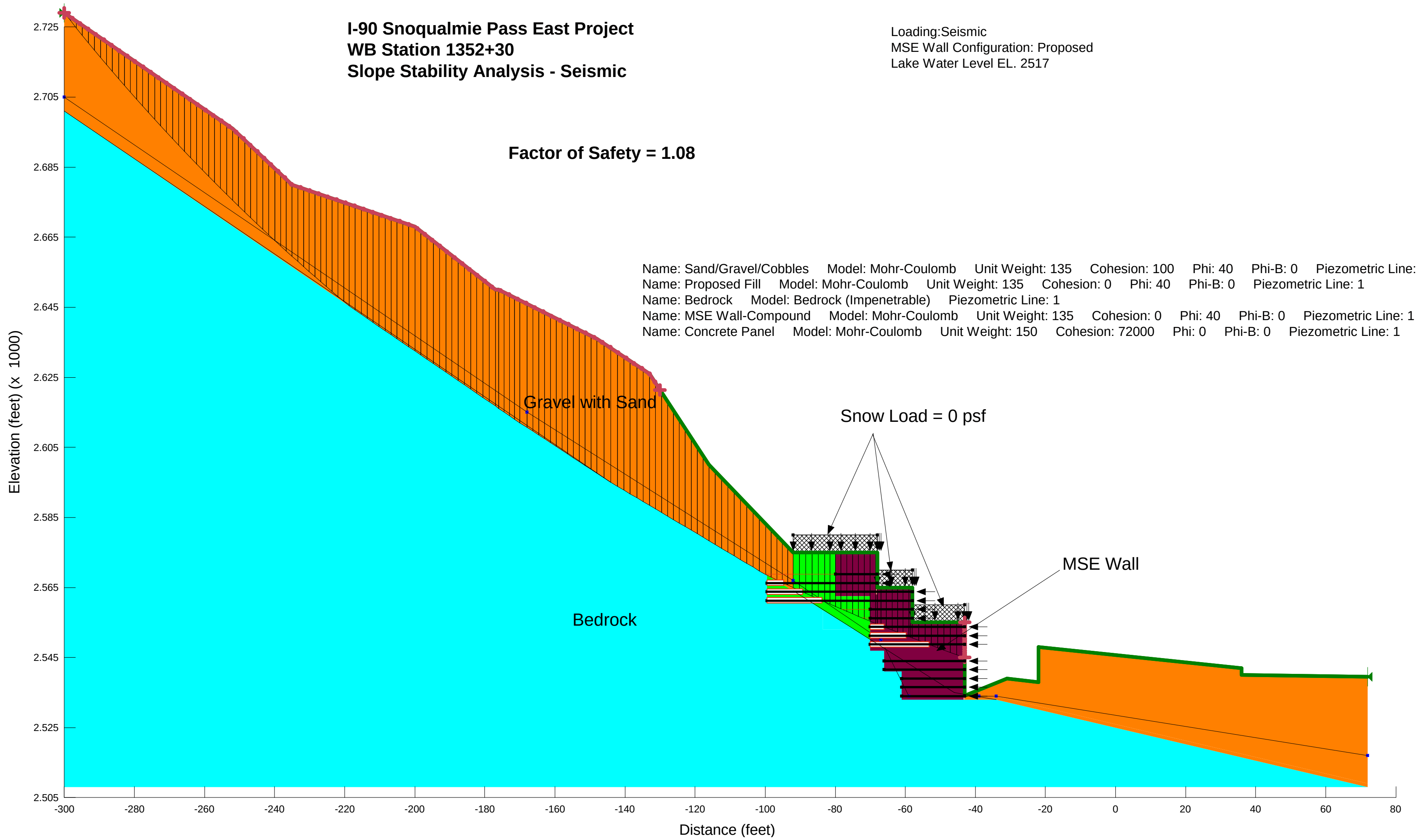
Figure 4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WB Station 1352+30
Slope Stability Analysis - Seismic
Loading:Seismic
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Name: MSE Wall-Compound Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Concrete Panel Model: Mohr-Coulomb Unit Weight: 150 Cohesion: 72000 Phi: 0 Phi-B: 0 Piezometric Line: 1
Gravel with Sand
Snow Load = 0 psf
MSE Wall
Bedrock
Elevation (feet) (x 1000)
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2.685
2.665
2.645
2.625
2.605
2.585
2.565
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2.525
2.505
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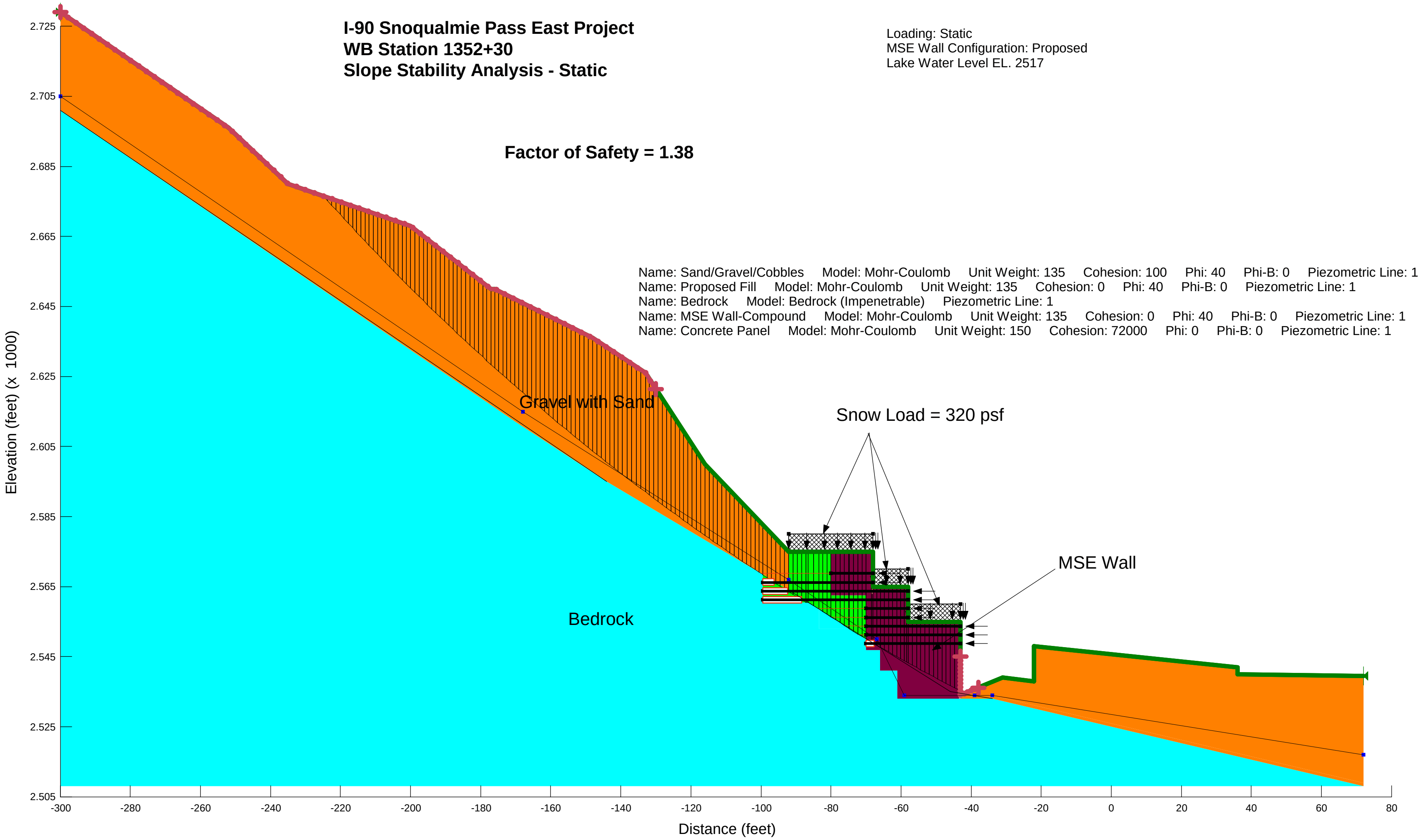
Distance (feet)

Figure 5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WB Station 1352+30
Slope Stability Analysis - Static
Loading: Static
MSE Wall Configuration: Proposed
Lake Water Level EL. 2517
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Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: MSE Wall-Compound Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Concrete Panel Model: Mohr-Coulomb Unit Weight: 150 Cohesion: 72000 Phi: 0 Phi-B: 0 Piezometric Line: 1
Gravel with Sand
Snow Load = 320 psf
MSE Wall
Bedrock
Elevation (feet) (x 1000)
Distance (feet)
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2.705
2.685
2.665
2.645
2.625
2.605
2.585
2.565
2.545
2.525
2.505
-300 -280 -260 -240 -220 -200 -180 -160 -140 -120 -100 -80 -60 -40 -20 0 20 40 60 80

Figure 6

Note: Bottom reinforcement will increase the FOS

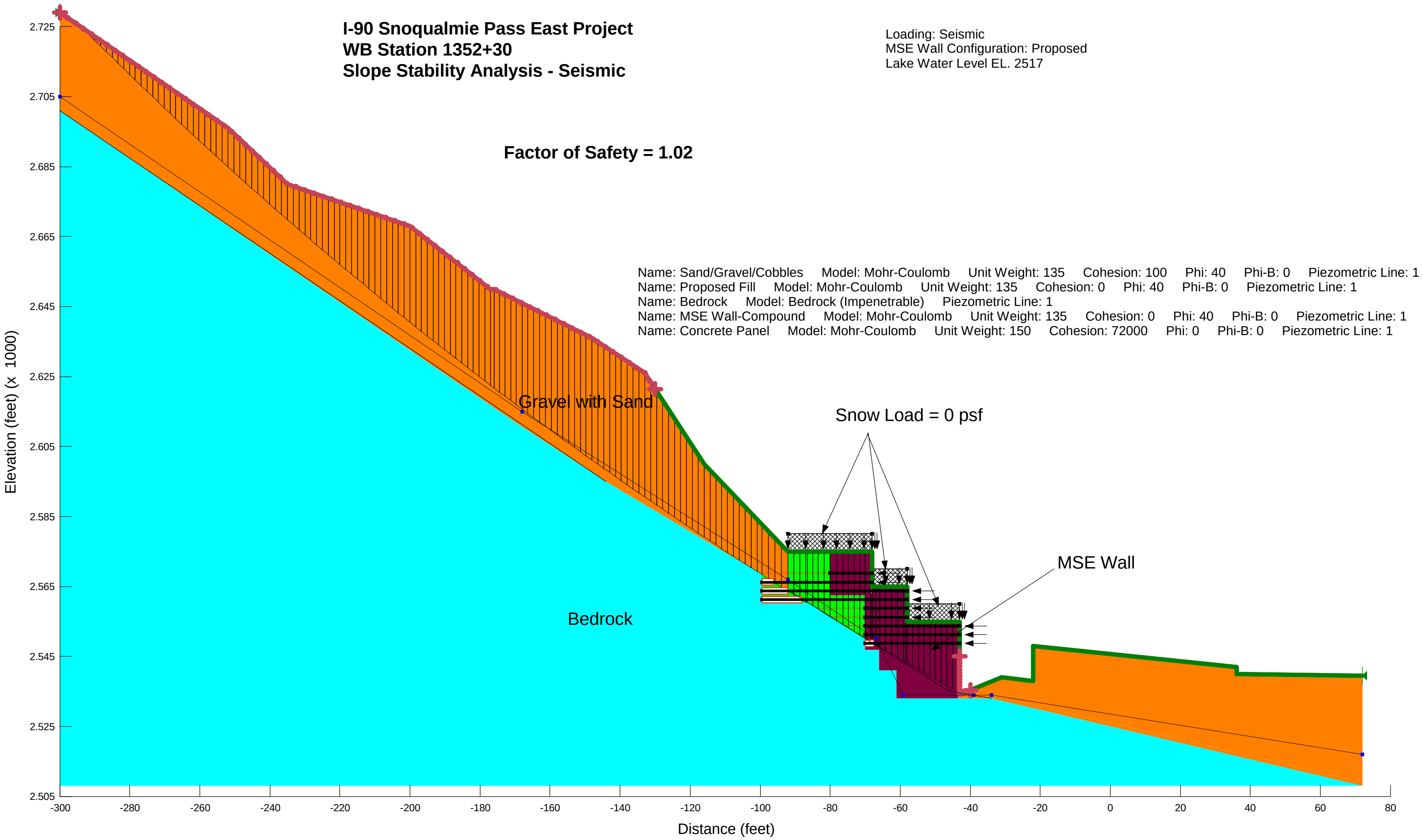
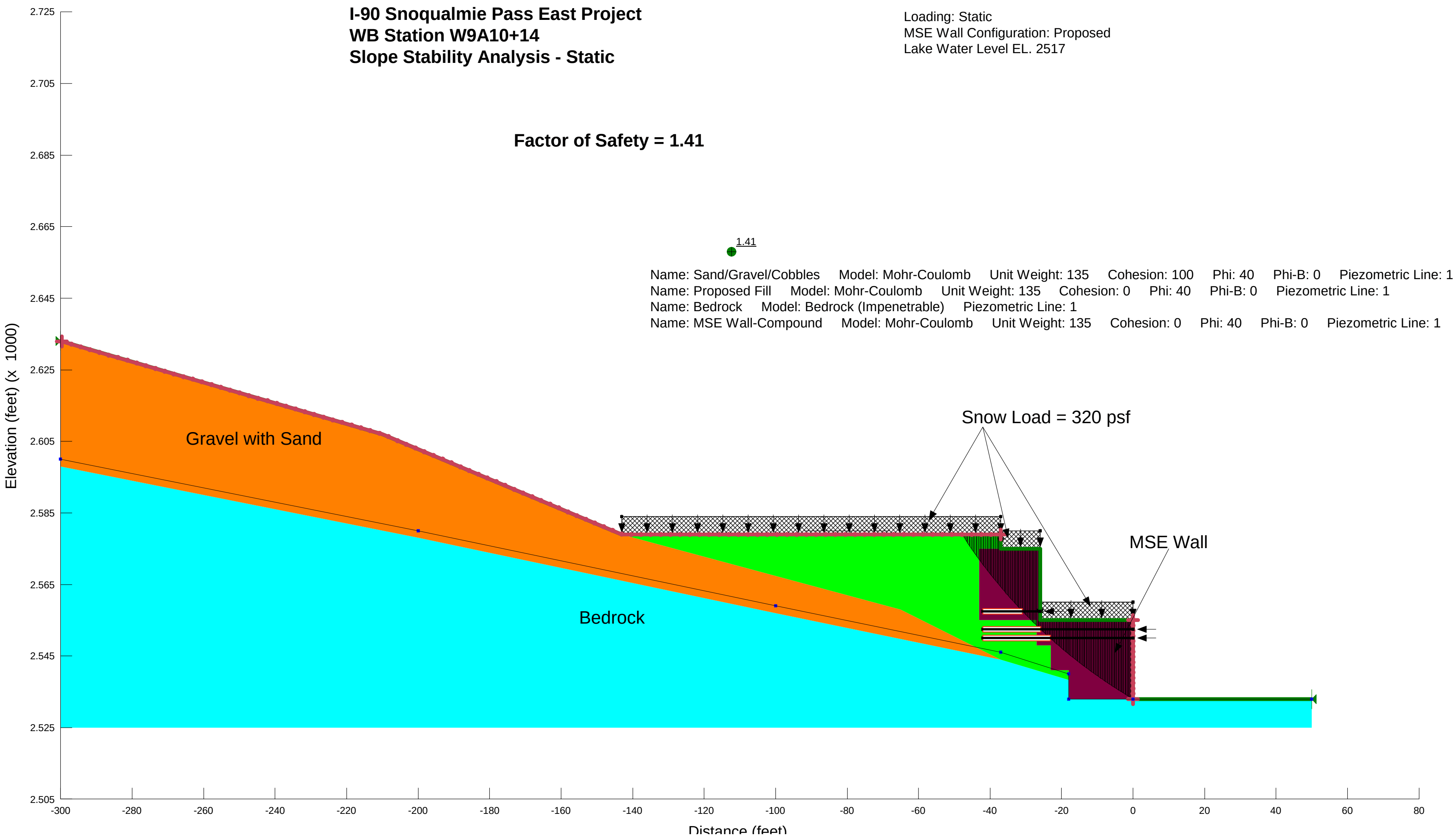


Figure 7


I-90 Snoqualmie Pass East Project
WB Station W9A10+14
Slope Stability Analysis - Static
Loading: Static
MSE Wall Configuration: Proposed
Lake Water Level EL. 2517
Factor of Safety = 1.41
1.41
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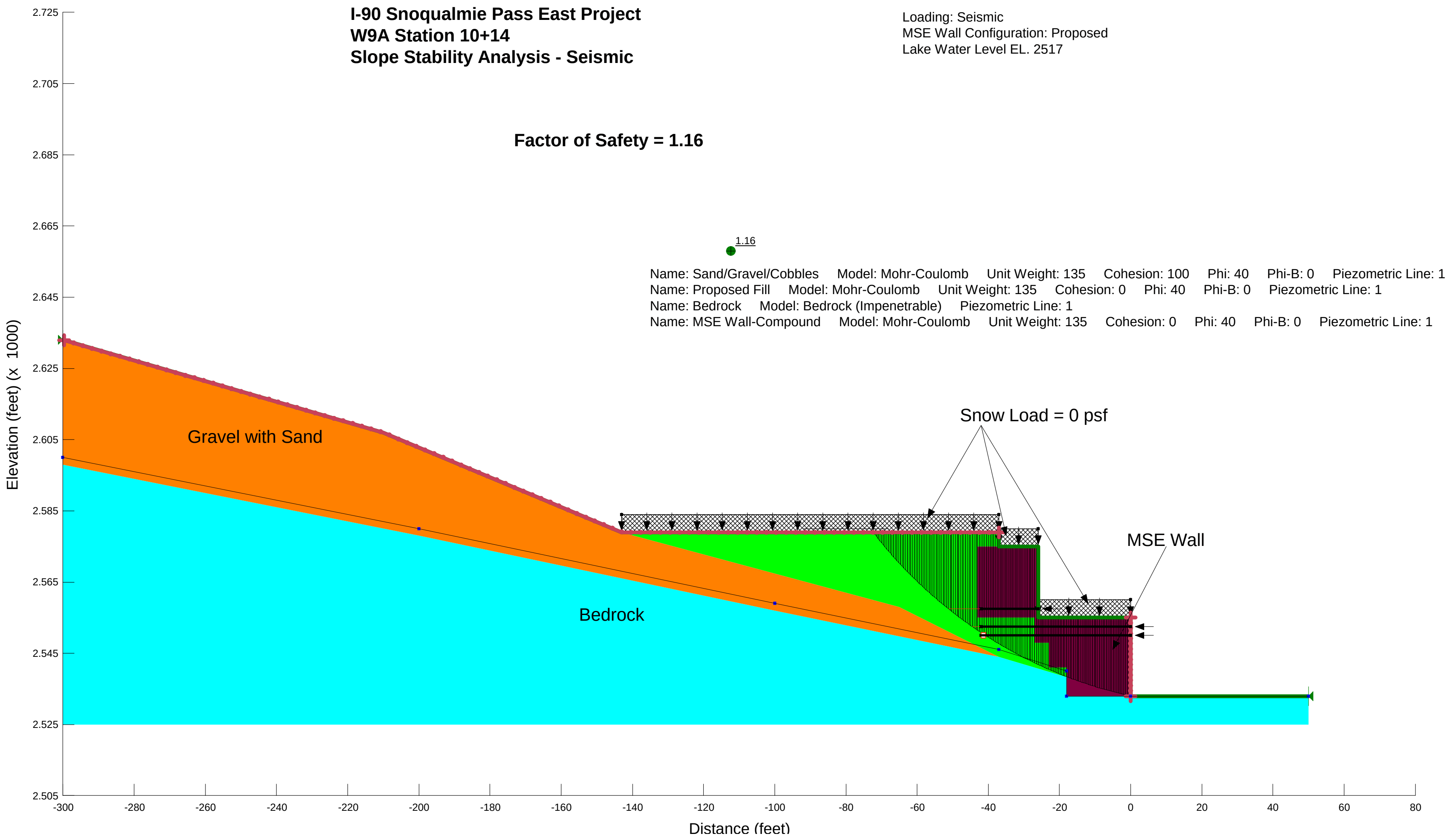
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: MSE Wall-Compound Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Snow Load = 320 psf
MSE Wall
Gravel with Sand
Bedrock
Elevation (feet) (x 1000)
Distance (feet)

Figure 8



I-90 Snoqualmie Pass East Project
W9A Station 10+14
Slope Stability Analysis - Seismic
Loading: Seismic
MSE Wall Configuration: Proposed
Lake Water Level EL. 2517
Factor of Safety = 1.16
1.16
Name: Sand/Gravel/Cobbles Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 100 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Name: Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: MSE Wall-Compound Model: Mohr-Coulomb Unit Weight: 135 Cohesion: 0 Phi: 40 Phi-B: 0 Piezometric Line: 1
Gravel with Sand
Snow Load = 0 psf
MSE Wall
Bedrock
Elevation (feet) (x 1000)
2.725
2.705
2.685
2.665
2.645
2.625
2.605
2.585
2.565
2.545
2.525
2.505
-300
-280
-260
-240
-220
-200
-180
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
60
80
Distance (feet)

Figure 9