Christensen Geotechnical
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Phone: 801 814-1714

November 9, 2021

Eden Commercial Holdings
Attn: Brandi Hammon
3632 North Wolf Creek Drive
Eden, UT 84310

Subject: Rockery Retaining Wall Recommendations
Wolf Creek Welcome Center Parking Lot
3632 North Wolf Creek Drive
Eden, Utah
CG Project No.: 297-001

Ms. Hammon,

At your request, Christensen Geotechnical has prepared this letter to present recommendations for the construction of a rockery retaining wall at the Wolf Creek Welcome Center which is located at 3632 Wolf Creek Drive in Eden, Utah. Based on a site plan by Gardner Engineering, we understand that a new parking lot is planned east of the existing building and below the existing parking lot. A new rockery retaining wall, between the new parking lot and the existing parking lot, has been proposed as part of the construction.

We assessed the stability of the proposed rockery as generally outlined in the FHWA "Rockery Design and Construction Guidelines" which was published in November of 2006. Our analyses included rockery overturning, sliding, bearing capacity, and global stability.

Soil Conditions
The soils at the location of the retaining wall were observed to consist of Clayey GRAVEL with sand (GC) fill overlying native Lean CLAY (CL). Groundwater was observed within an excavation approximately 14 feet below the existing parking lot. A report by Western Geologic & Environmental LLC (2020), indicates that a recently active landslide is present at the site. The landslide extends from Moose Hollow Drive below the proposed new parking lot into the existing parking lot. Due to the presence of the landslide, our analyses assumed that the strength of the Lean CLAY (CL) soils were reduced to a residual strength. This residual strength was estimated by back calculating a strength assuming that the existing slope has a safety factor of 1. This back calculated strength was estimated to consist of an angle of internal friction of 16.5 degrees and no cohesion. The fill soils overlying the clay were assumed to have a strength consisting of an angle of internal friction of 33 degrees with a cohesion of 50 psf. The imported fill was assumed to have a strength consisting of an angle of internal friction of 38 degrees with a cohesion of 20 psf. The rockery was assumed to have an anisotropic strength with a 2000 psf for the internal rock strength and an angle of internal friction of 45 between the rocks.

Horizontal Ground Acceleration
The seismic stability analysis of the slope and rockery was completed using the peak ground

acceleration (PGA) resulting from an earthquake with a 2 percent probability of exceedance within a 50-year period. Based on the latitude and longitude of the site and the Applied Technology Council's (ATC) web-based application used to develop spectral response values, the PGA was estimated to be 0.496g. This figure was utilized in our seismic global and internal stability modeling.

Overturning, Sliding and Bearing Capacity

The engineering analysis of the proposed rockery included overturning, sliding, and bearing capacity. Lateral earth pressures were calculated using the Coulomb method, and the rockery was assessed under static and seismic conditions. The typical minimum factor of safety requirements for the static condition are 2.0 for overturning, 1.5 for sliding, and 2.5 for bearing capacity. For the seismic condition, the minimum factor of safety requirements are typically 1.5 for overturning, 1.1 for sliding, and 2.0 for bearing capacity. The results of our analyses indicate that with the application of the recommendations presented in this letter, these safety factors are met for the proposed rockery.

Global Stability

The global stability of the proposed rockery retaining wall was analyzed using the Slide computer program and the modified Bishop's method of slices as well as the geometric conditions, soil strengths and rockery construction on the Rockery Detail, Plate 7. Two profiles of the proposed rockery were assessed, an east profile and a west profile. The locations of the profiles are shown on Plate 6, attached. The rockery was assessed under static and pseudo static conditions. The pseudo static condition is used to evaluate stability during a seismic event. As stated above, the peak ground acceleration at this site with a 2 percent probability of exceedance in 50 years is expected to be 0.496g. As is common practice, half of this value was used in our analysis.

Minimum factors of safety of 1.5 and 1.0 for static and seismic conditions, respectively, are typically considered acceptable. Our analyses indicate low factors of safety for both of these conditions due to the landslide at the site. Further analyses indicate that mitigation measures can be taken which will improve the factors of safety higher than they are currently (prior to the proposed development); however, achieving factors of safety of 1.5 and 1.0 for the static and pseudo conditions may not be practical.

Recommendations

Although it may not be practical to achieve adequate factors of safety, the stability of the site can be increased to be significantly higher than it is in its current condition. This can be achieved by removing the majority of the landslide deposits from behind and below the rockery and replacing these deposits with an imported gravel structural fill. We estimate that the landslide deposits extend approximately 8 feet below the bottom of the rockery and extend behind the proposed rockery approximately 70 feet. The gravel structural fill should consist of a relatively well-graded granular soil with a maximum particle size of 4 inches, with a maximum of 50 percent passing the No. 4 sieve and with a maximum of 30 percent passing the No. 200 sieve. The liquid limit of the fines (material passing the No. 200 sieve) should not exceed 20 and the plasticity index should be less than 15. The structural fill should be placed in loose lifts that are a

maximum of 8 inches thick. The moisture content should be within 3 percent of optimum and the fill should be compacted to at least 95 percent of the maximum density as determined by ASTM D 1557.

Once the landslide deposits are removed and replaced with gravel structural fill, our analyses indicate that the rockery and slope will have a static factor of safety of 1.19. The pseudo static analyses indicate that the rockery and slope are likely to fail during a large seismic event. The results of the global stability analyses are presented on Plates 1 through 5. As indicated previously, although the static and pseudo static factors of safety are low, these values are higher than the safety factor values for the slope in its current condition.

In addition to the removal and replacement of the landslide deposits, the recommendations presented below should also be followed:

1. The rock face should slope no steeper than 1/4 to 1 (horizontal to vertical).

2. Minimum rock sizes, maximum tier height, and bench width should follow those outlined on the attached “Rockery Detail,” Plate 7.

3. The rocks should be placed with the largest diameter set horizontally into the slope. No rock should be placed with the largest dimension parallel to the slope.

4. Rocks should have good three-point rock-to-rock contact and no rocks should bear on a downward sloping face of the supporting rock. Larger gaps should be "chinked" with smaller rock or sealed with a cement grout.

5. All rocks should consist of durable rock. Limestone should not be used.

6. Grading to avoid concentrated runoff or ponding of water at the top of the slope and base of the rock face should be performed. The grades should be 2 to 10 percent.

7. The final landscaping should be such that any vegetation with large root systems should not be planted above the rock facing, and watering should be set such that only the top 6 inches of the soil remains moist in the irrigation season.

8. Due to the groundwater at the site, we recommend that a drain be placed within the gravel fill to collect and discharge groundwater.

A detail of the rockery is shown on Plate 7.

If inspection of the construction of the rockery is required, we recommend that inspections occur following placement of the first course of rock, during the placement of the middle rows of rock, and a final inspection after completion of the construction.

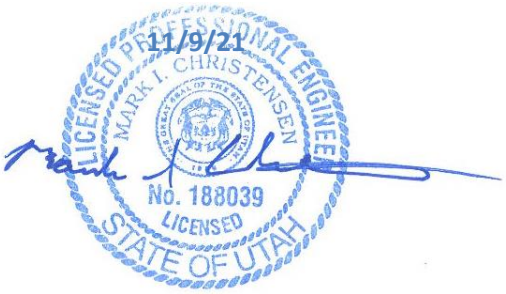
It should be understood that our analyses assumed that soils behind the rockery will remain unsaturated and that the grading above and below the rockery will not allow ponding of water or

concentrated surface flows in the vicinity of the rockery. Any saturation of the soil behind the rockery can cause rockery failure, and concentrated surface water flows can erode soils behind the rocks. Irrigation behind the rockery should be kept to a minimum, broken irrigation systems should be repaired immediately, roof drains should be directed away from the rockery, and proper grading should be maintained to direct surface water away from the rockery.

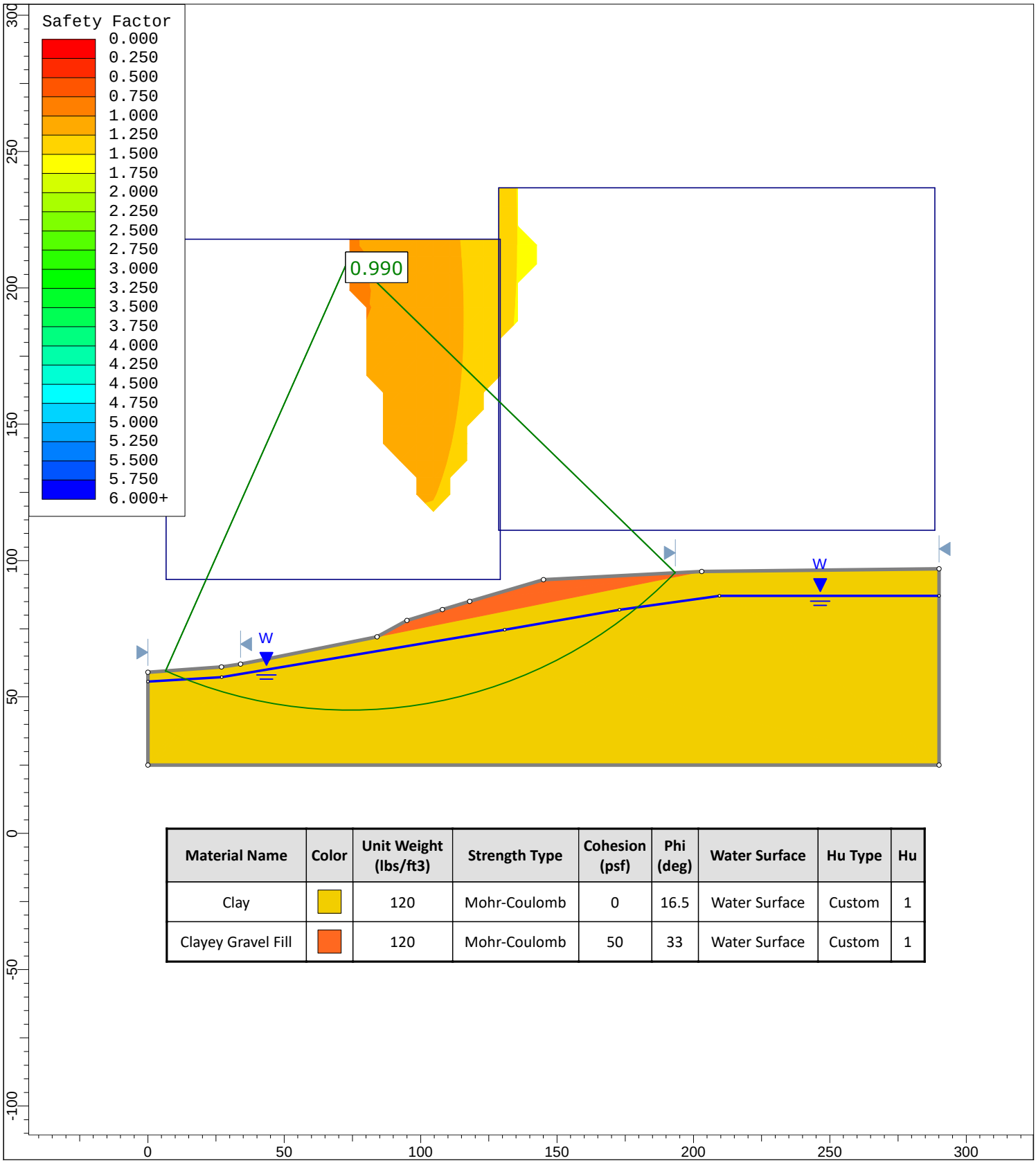
This letter was prepared in accordance with the generally accepted standard of practice at the time this letter was written. No other warranty, expressed or implied, is made.

We appreciate the opportunity of providing our services on this project. If we can answer questions or be of further service, please call.

Sincerely,
Christensen Geotechnical



Mark I. Christensen, P.E.
Principal



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Clay		120	Mohr-Coulomb	0	16.5	Water Surface	Custom	1
Clayey Gravel Fill		120	Mohr-Coulomb	50	33	Water Surface	Custom	1

Back Calculated Soil Strength

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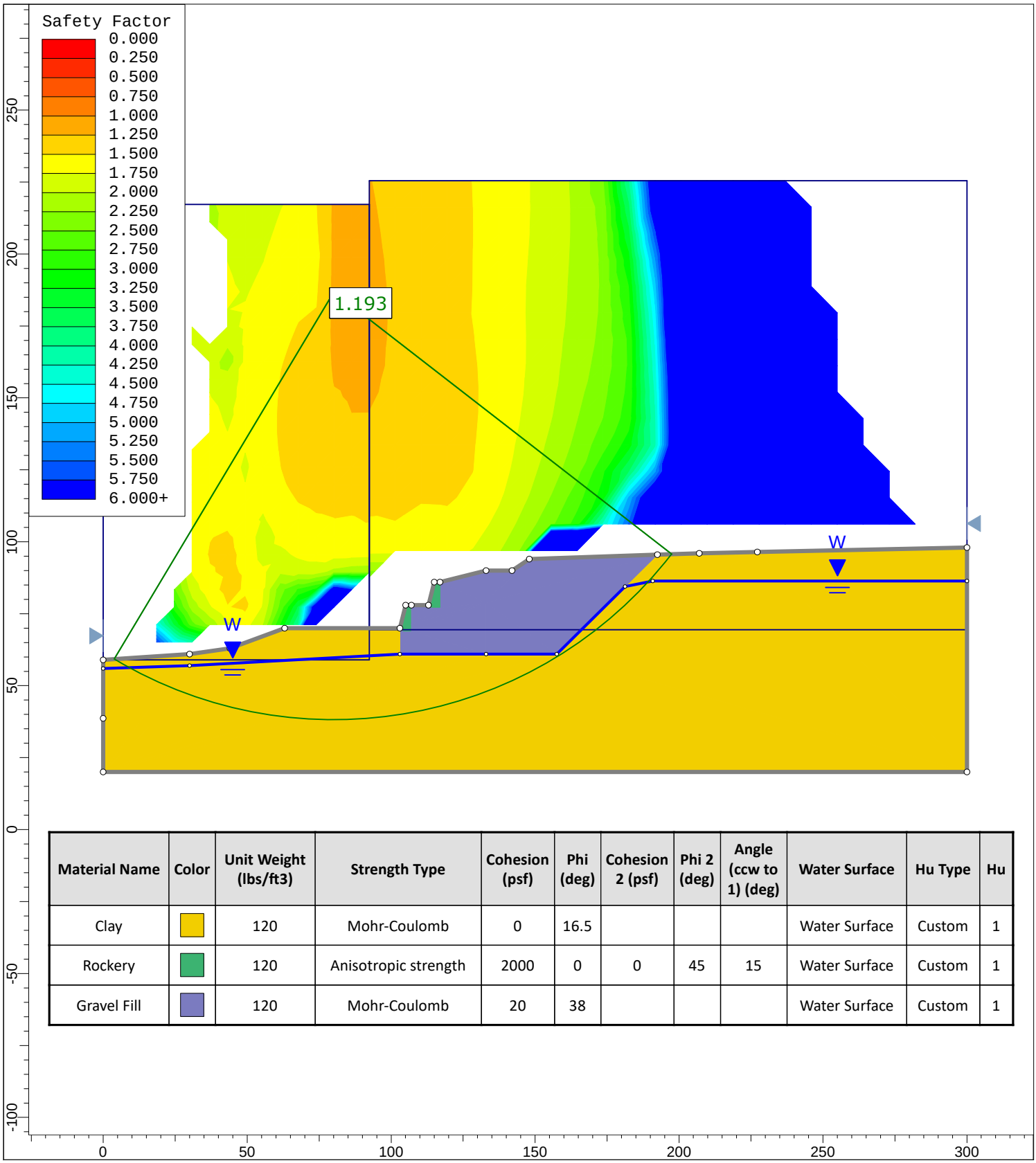
Plate
1



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)	Angle (ccw to 1) (deg)	Water Surface	Hu Type	Hu
Clay		120	Mohr-Coulomb	0	16.5				Water Surface	Custom	1
Rockery		120	Anisotropic strength	2000	0	0	45	15	Water Surface	Custom	1
Gravel Fill		120	Mohr-Coulomb	20	38				Water Surface	Custom	1

West Profile - Static

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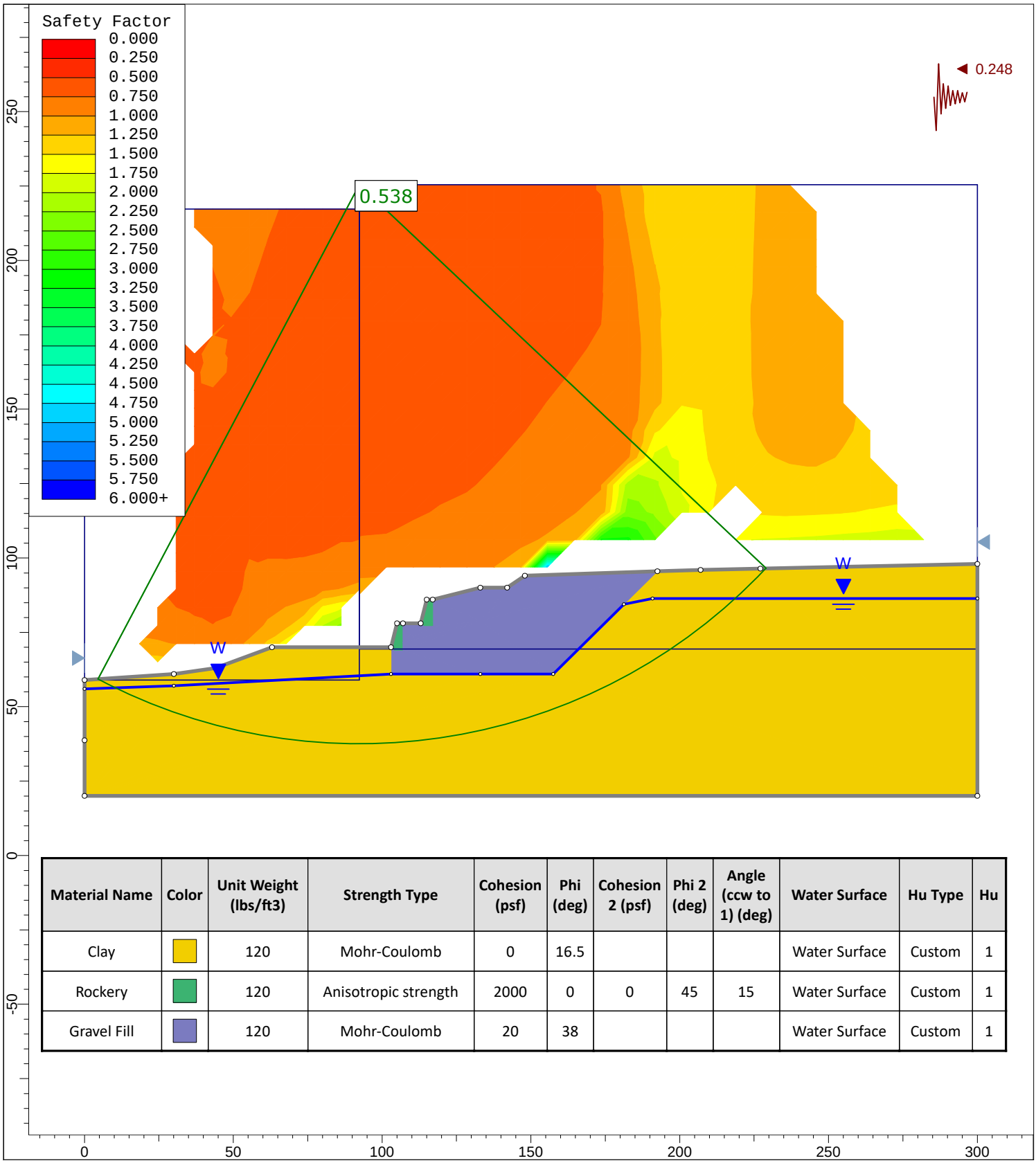
Plate
2



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)	Angle (ccw to 1) (deg)	Water Surface	Hu Type	Hu
Clay		120	Mohr-Coulomb	0	16.5				Water Surface	Custom	1
Rockery		120	Anisotropic strength	2000	0	0	45	15	Water Surface	Custom	1
Gravel Fill		120	Mohr-Coulomb	20	38				Water Surface	Custom	1

West Profile - Pseudo Static

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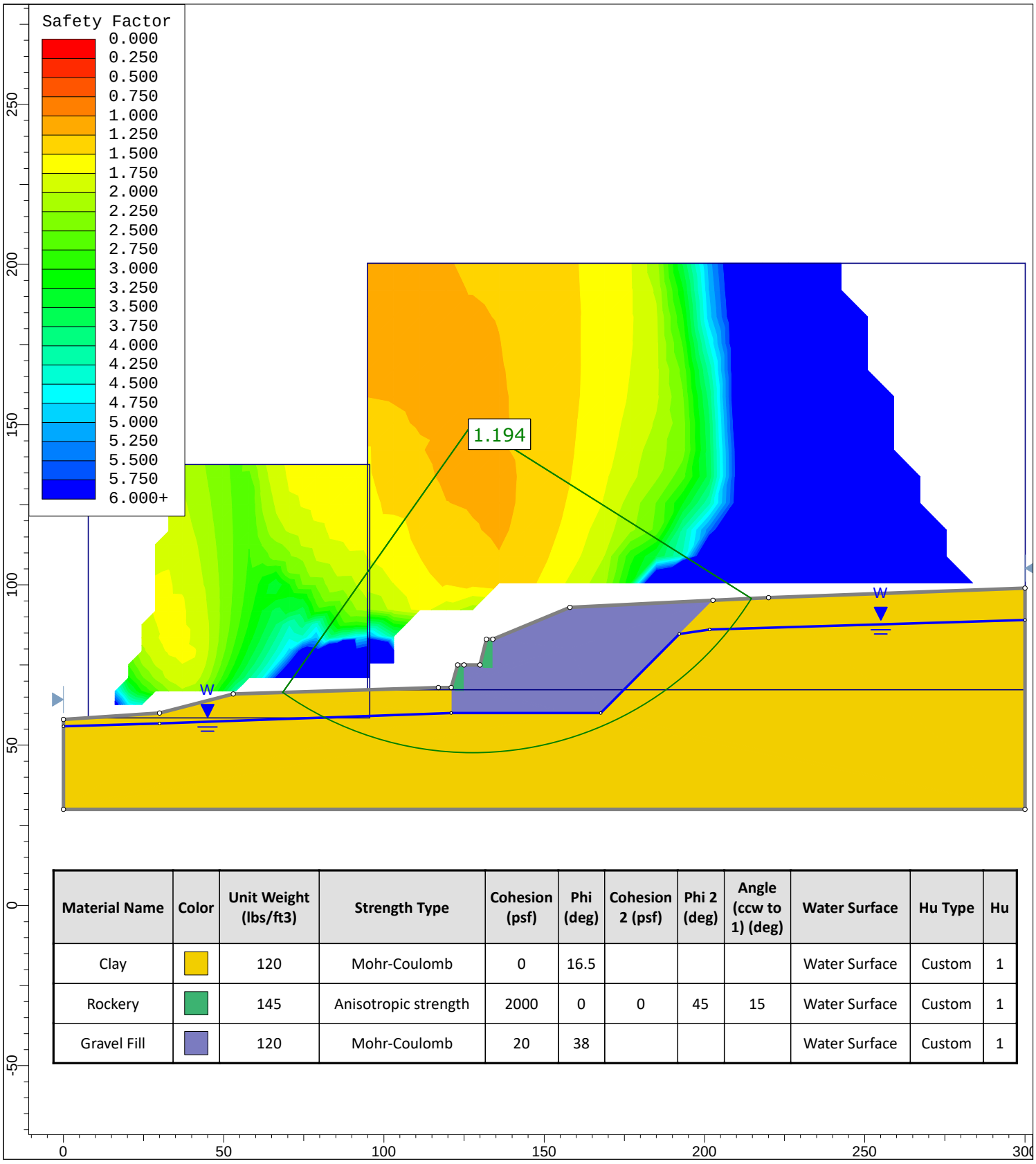
Plate
3



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)	Angle (ccw to 1) (deg)	Water Surface	Hu Type	Hu
Clay		120	Mohr-Coulomb	0	16.5				Water Surface	Custom	1
Rockery		145	Anisotropic strength	2000	0	0	45	15	Water Surface	Custom	1
Gravel Fill		120	Mohr-Coulomb	20	38				Water Surface	Custom	1

East Profile - Static

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Eden, Utah
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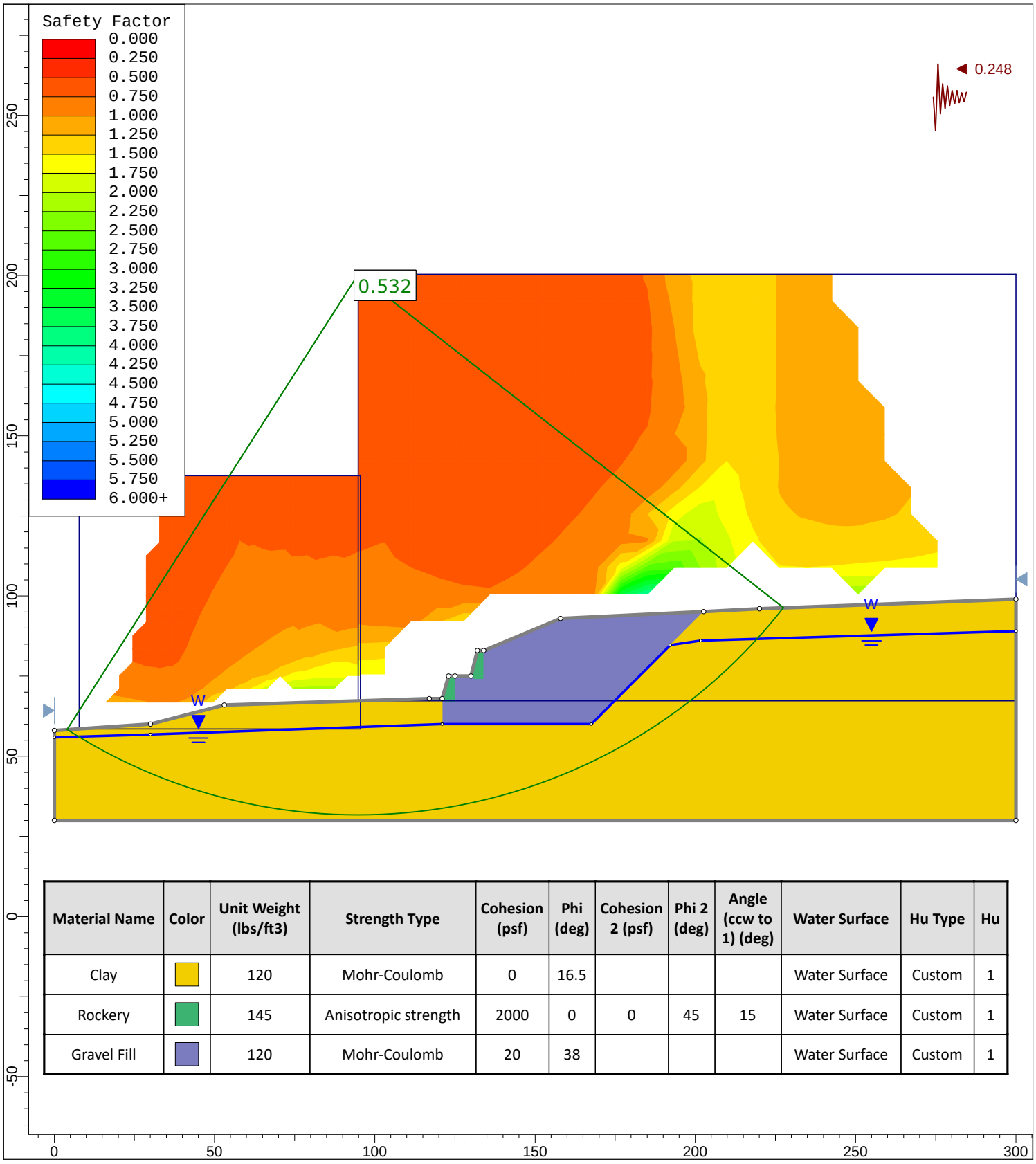
Plate
4



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)	Angle (ccw to 1) (deg)	Water Surface	Hu Type	Hu
Clay		120	Mohr-Coulomb	0	16.5				Water Surface	Custom	1
Rockery		145	Anisotropic strength	2000	0	0	45	15	Water Surface	Custom	1
Gravel Fill		120	Mohr-Coulomb	20	38				Water Surface	Custom	1

East Profile - Pseudo Static

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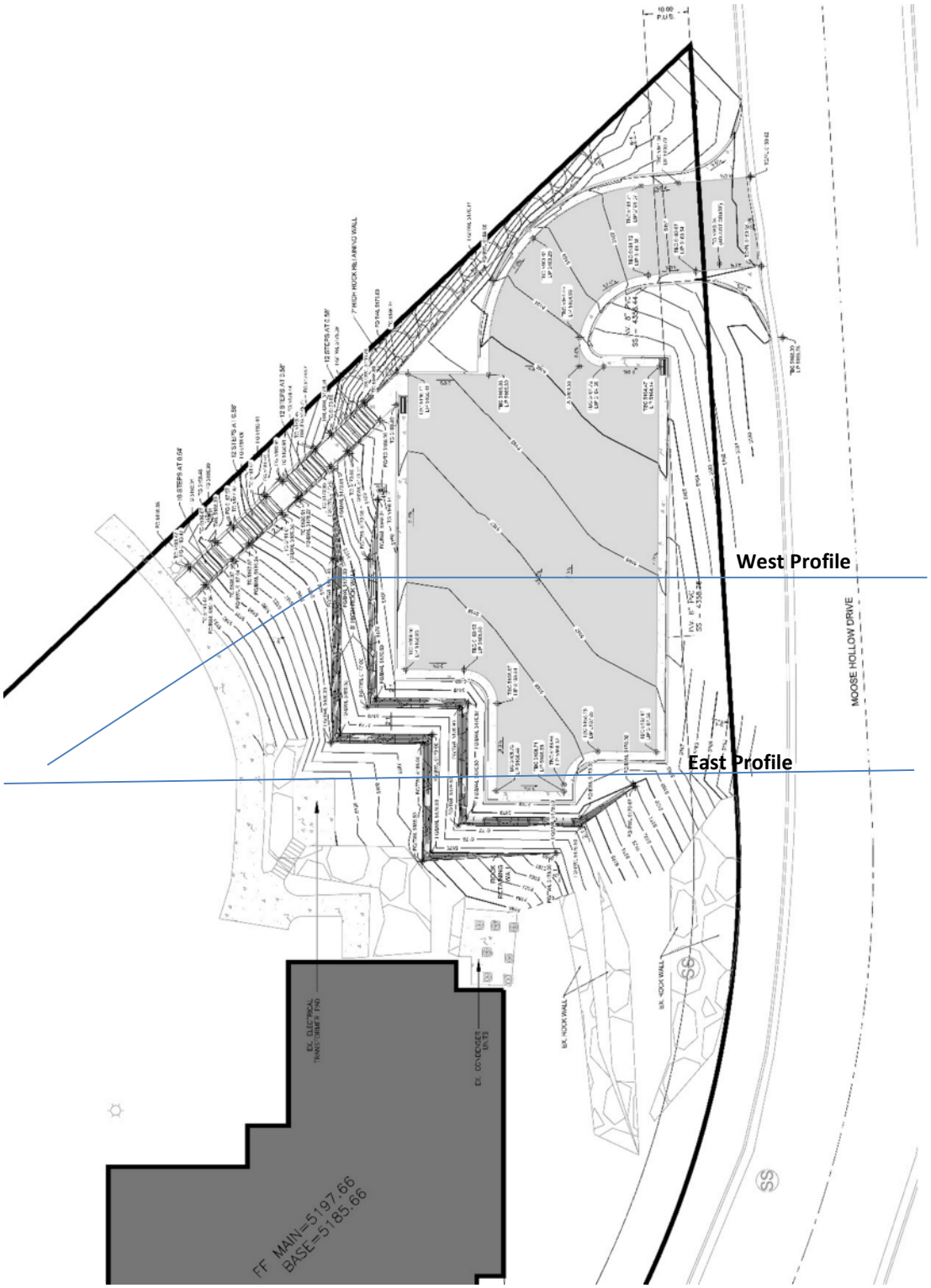
Plate
5



Base Map: Gardner Engineering

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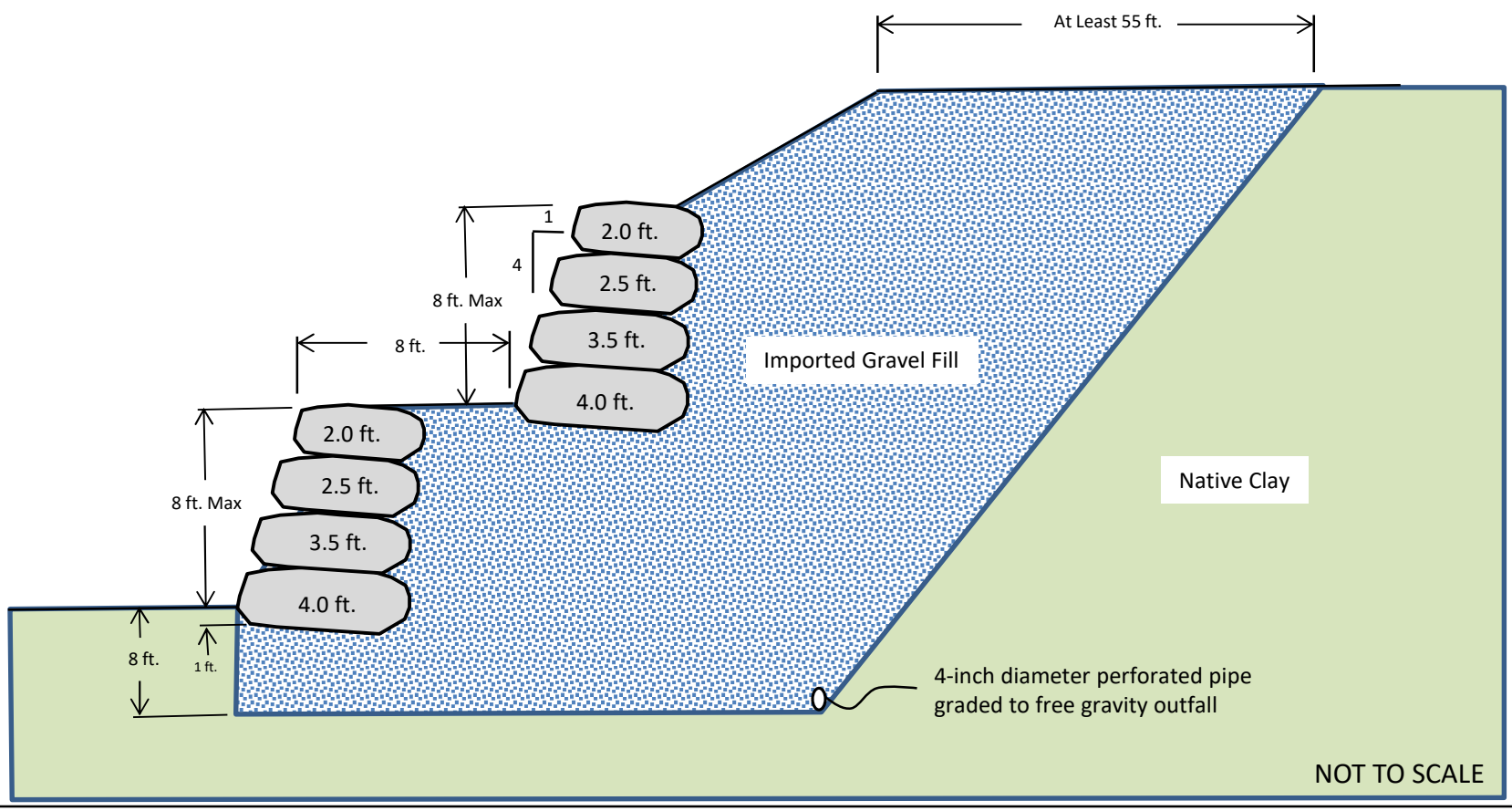
Slope Stability Profile

Drawing Not to Scale

Christensen Geotechnical	Eden Commercial Holdings Wolf Creek Welcome Center Parking Lot Eden, Utah Project No. 297-001 **Site Plan**	Plate 6

ROCKERY DETAIL



Christensen Geotechnical	Eden Commercial Holdings Wolf Creek Welcome Center Parking Lot Eden, Utah Project No. 297-001	Plate 7