

March 11, 2021

George Haley  
george@haleyfamily.org

**Subject: Rockery Retaining Wall Recommendations**  
**Legends at Hawkins Creek Lot 2**  
**6682 East Chaparral Road**  
**Weber County, Utah**  
**CG Project No.: 259-001**

Mr. Haley,

At your request, Christensen Geotechnical has prepared this letter to present recommendations for construction of rockery retaining walls at Legends at Hawkins Creek Lot 2 located at 6682 East Chaparral Road in Weber County, Utah. Based on a site plan by Habitations Residential Design Group (Habitations), we understand that four rockery retaining walls are planned to be constructed north and west of the proposed house at the site. The location of the rockeries is shown on the attached site plan, Plate 1. Rockery 1 is to be up to 11 feet in height (10 feet exposed). Where the rockery height exceeds 6 feet, the rockery will be broken into two tiers. The lower tier will be up to 5 feet in height (4 feet exposed) and the upper tier will be up to 7 feet in height (6 feet exposed). The grade above this rockery will be nearly level. The grade below will slope down at a grade of about 35 percent. Rockery 2 is to be up to 13 feet in height (12 feet exposed) and is to be broken into three tiers with each tier 5 feet in height (4 feet exposed). The grade above this rockery will be nearly level. The grade below will slope down at a grade of about 35 percent. Rockery 3 is to be located west of the proposed house on the lot, below the driveway. This rockery is to be up to 12 feet in height (11 feet exposed). Where the rockery height exceeds 6 feet the rockery will be broken into two tiers. The lower tier will be up to 7 feet in height (6 feet exposed) and the upper tier will be up to 6 feet in height (5 feet exposed). The grade above this rockery will be nearly level. The grade below will slope down at a grade of about 35 percent. Rockery 4 will be located west of the proposed house above the driveway. This rockery is to be up to 11 feet in height (10 feet exposed). Where the rockery height exceeds 6 feet the rockery will be broken into two tiers. The lower tier will be up to 7 feet in height (6 feet exposed) and the upper tier will be up to 5 feet in height (4 feet exposed). The grade below the bottom tier will be nearly level. The grade above this rockery will slope up at a grade of 35 percent.

Stability of the proposed rockery was assessed as generally outlined in the FHWA “Rockery Design and Construction Guidelines” published November of 2006. Our analysis included rockery overturning, sliding, bearing capacity, and global stability.

## **Soil Conditions**

Based on the geotechnical report for the lot by Christensen Geotechnical dated November 20, 2020, subsurface conditions at the site consist of 1½ to 3 feet of topsoil overlying sandstone bedrock. We have assumed that excavated sandstone will be placed behind the rockeries and that this material will consist of Sandy Lean CLAY (CL). We have assumed a soil strength for the retained soils to consist of an angle of internal friction of 28 degrees with a cohesion of 100 psf. The bedrock was assumed to have a strength consisting of a cohesion of 13,000 psf. The rockeries were 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**

Seismic stability analysis of the rockeries 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 (ATC) web-based application used to develop spectral response values, the PGA was estimated to be 0.331g which was utilized in our seismic global and internal stability modeling.

## **Overturning, Sliding and Bearing Capacity**

Engineering analysis of the proposed rockeries included analyzing overturning, sliding, and bearing capacity. Lateral earth pressures were calculated using the Coulomb method and the rockeries were assessed under static and seismic conditions. 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, minimum factor of safety requirements are typically 1.5 for overturning, 1.1 for sliding, and 2.0 for bearing capacity. Results of our analyses indicate that these safety factors were met for the proposed rockeries with the recommendations presented in this letter.

## **Global Stability**

The global stability of the proposed rockery retaining walls 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 described in this letter. The rockeries were 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 0.331g. 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, were considered acceptable. Our analyses indicate that these safety factors are achieved for the rockeries when constructed as recommended in this letter. The results of the global stability analyses are presented on Plates 2 through 9.

## **Recommendations**

Based on our analyses, it is our opinion that the planned rockery retaining walls can perform adequately if constructed properly. In order for the rockeries at this site to perform properly, the recommendations presented below should 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" sheets, Plates 10 through 14.
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.
7. Final landscaping should be such that vegetation with large root systems are not planted above the rock facing and watering set such that only the top 6 inches of the soil remains moist in the irrigation season.
8. A drain should be constructed at the base of each tier as shown on Plates 10 through 14.

A detail of the rockeries is shown on Plates 10 through 14.

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

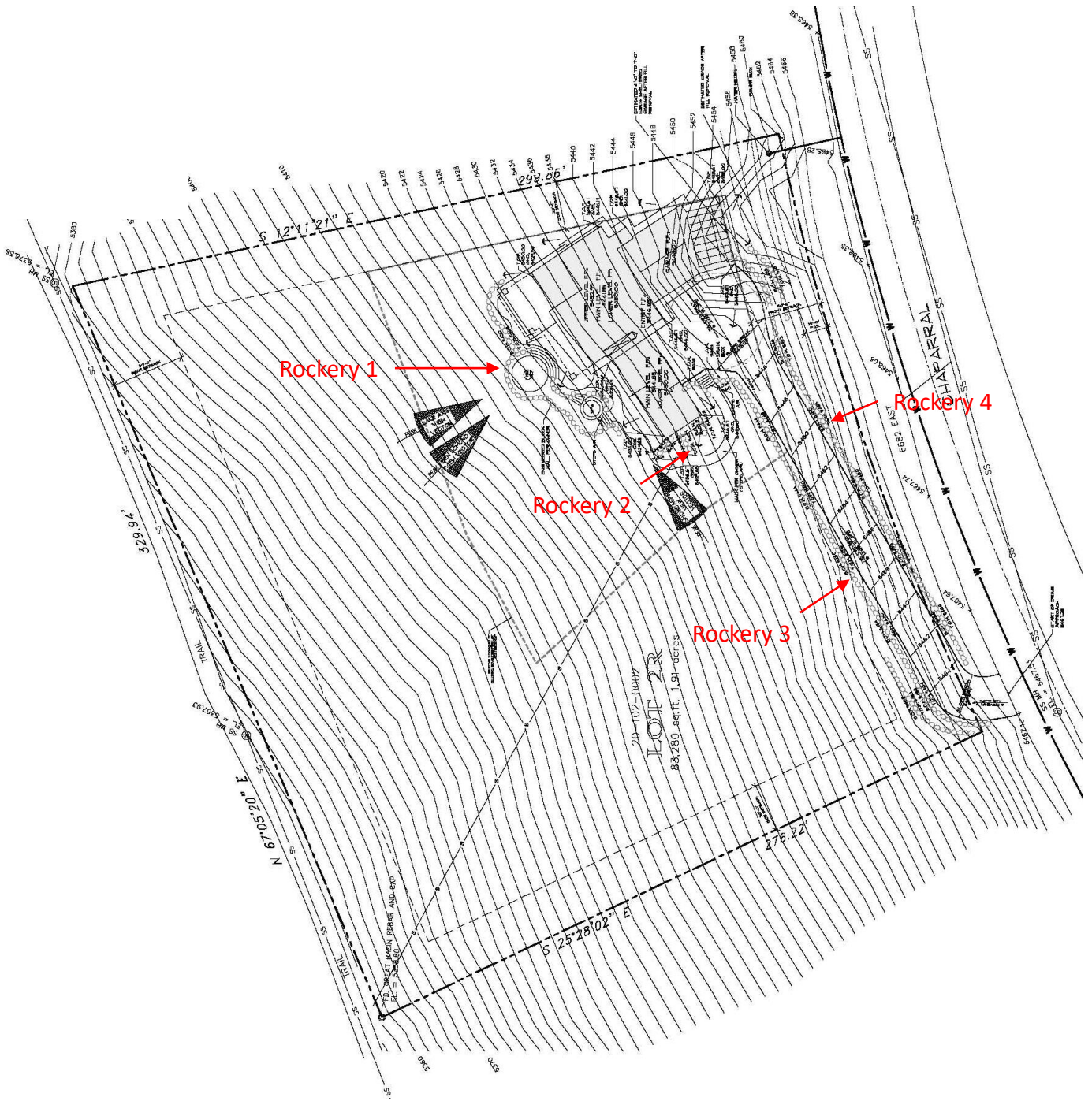
It should be understood that our analyses assumed that soils behind the rockeries will remain unsaturated and that grading above and below the rockeries will not allow ponding of water or concentrated surface flows in the vicinity of the rockery. Saturation of the soil behind the rockeries can cause rockery failure and concentrated surface water flows can erode soils behind the rocks. Irrigation behind the rockeries should be kept to a minimum, broken irrigation systems should be repaired immediately, roof drains should be directed away from the rockeries, and proper grading should be maintained to direct surface water away from the rockeries. 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

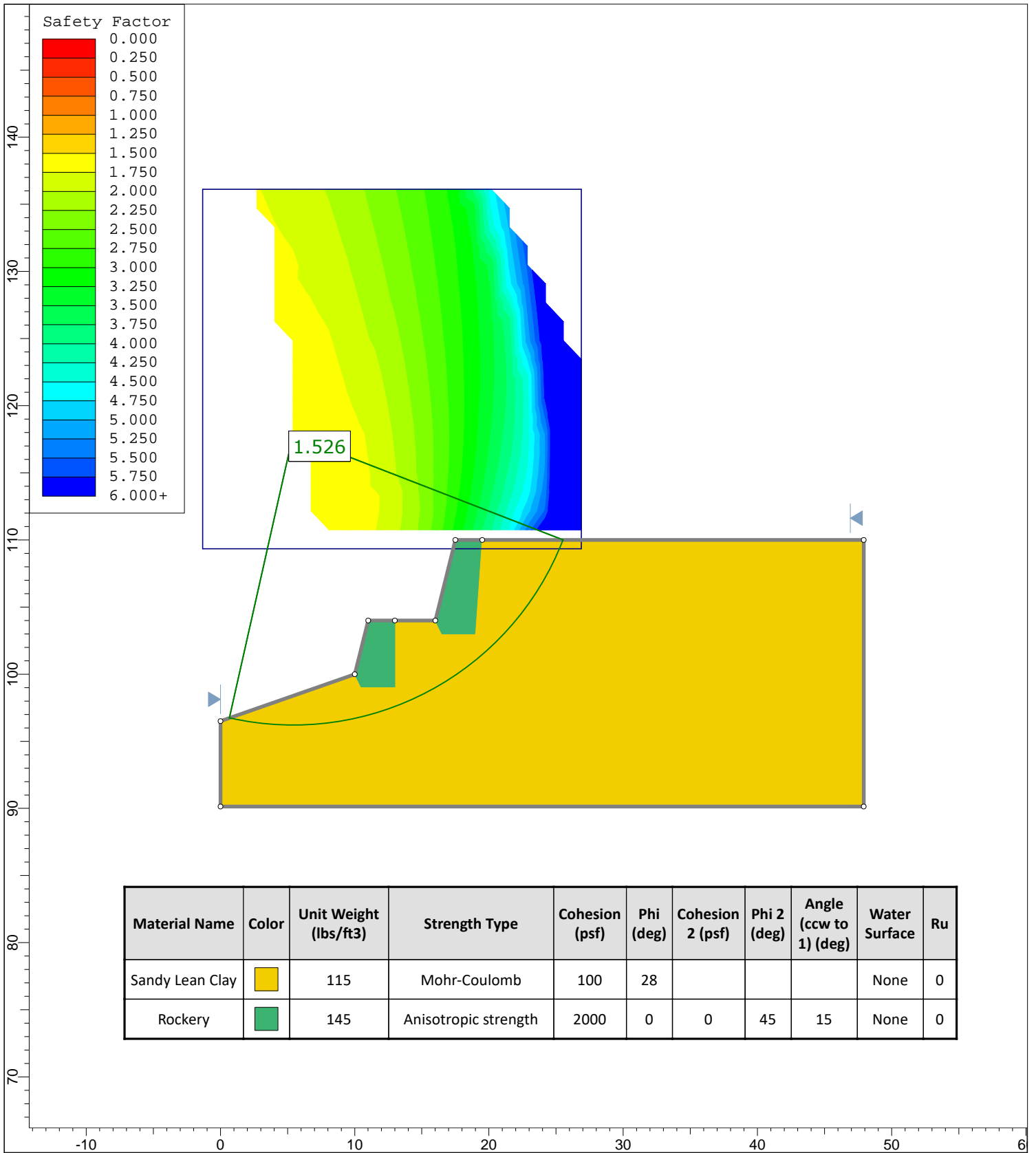


Base Map: Habitations Residential Design Group

Drawing Not to Scale



	<p>George Haley Legends at Hawkins Creek Lot 2 Weber County, Utah Project No. 259-001</p>	<p>Plate <b>1</b></p>
		<p>Site Plan</p>

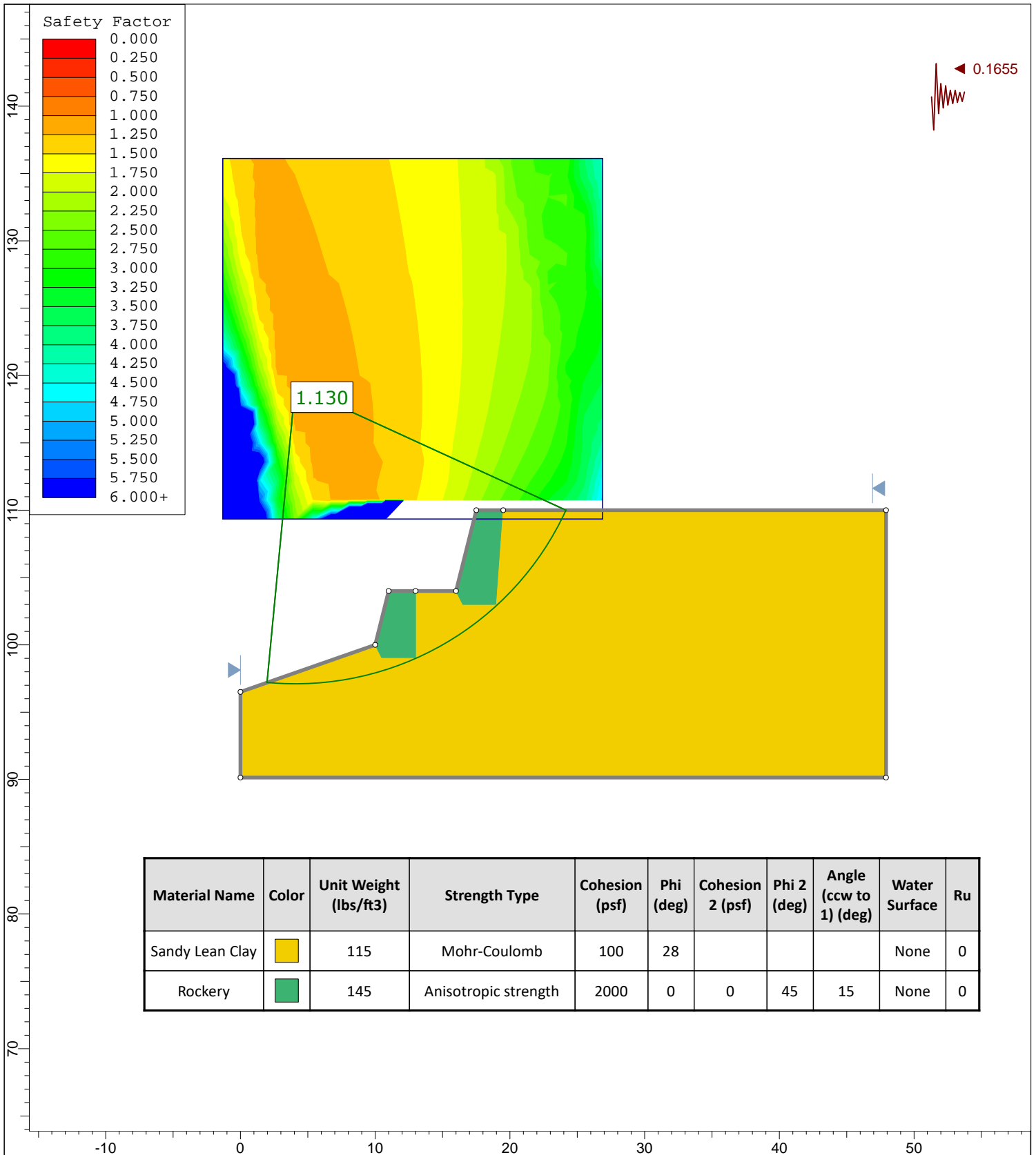


### Rockery 1 - Static



George Haley  
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Plate  
**2**

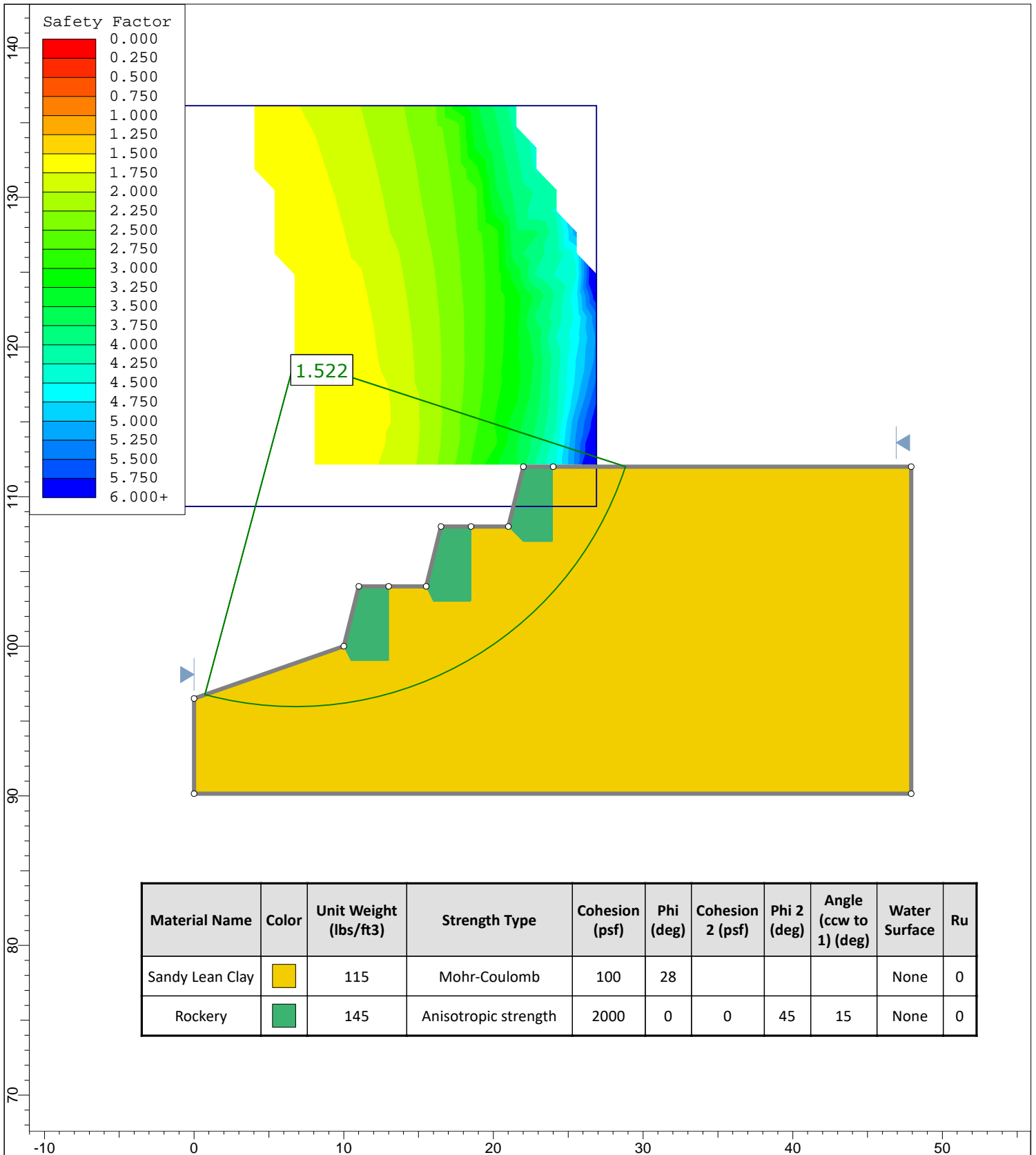


### Rockery 1 - Pseudo Static



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Plate  
**3**



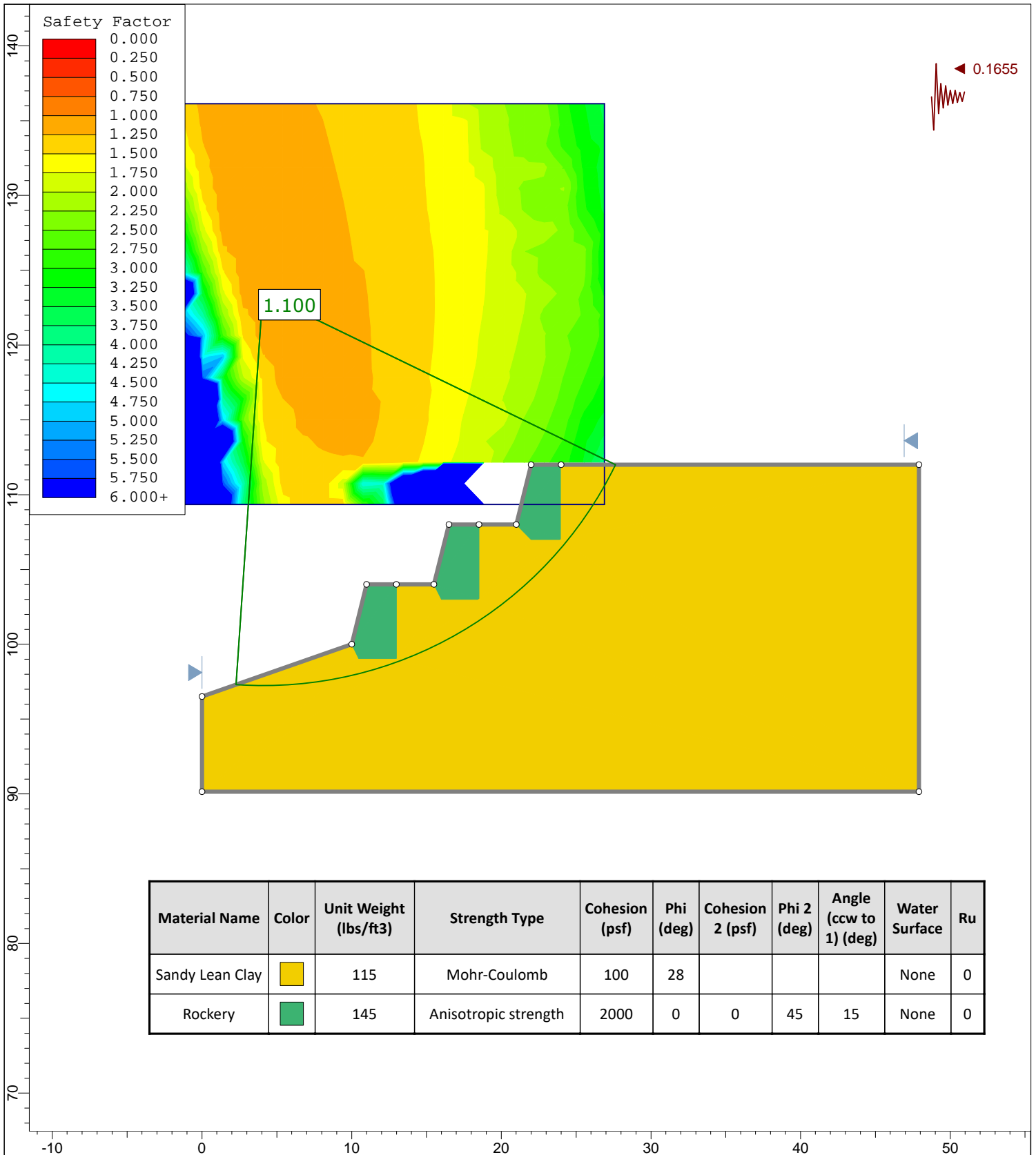
### Rockery 2 - Static



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Plate  
**4**



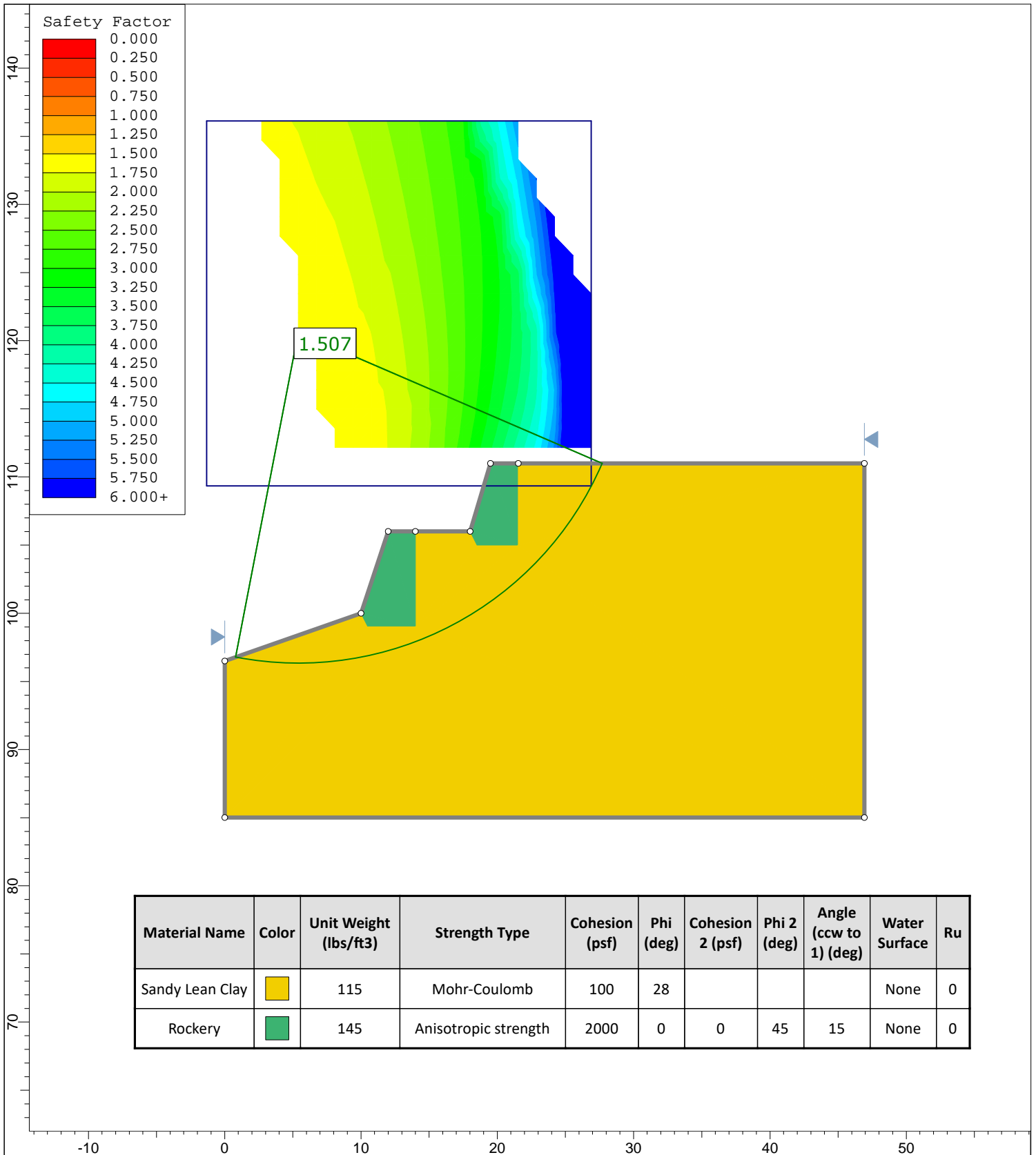


### Rockery 2 - Pseudo Static



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Plate  
**5**

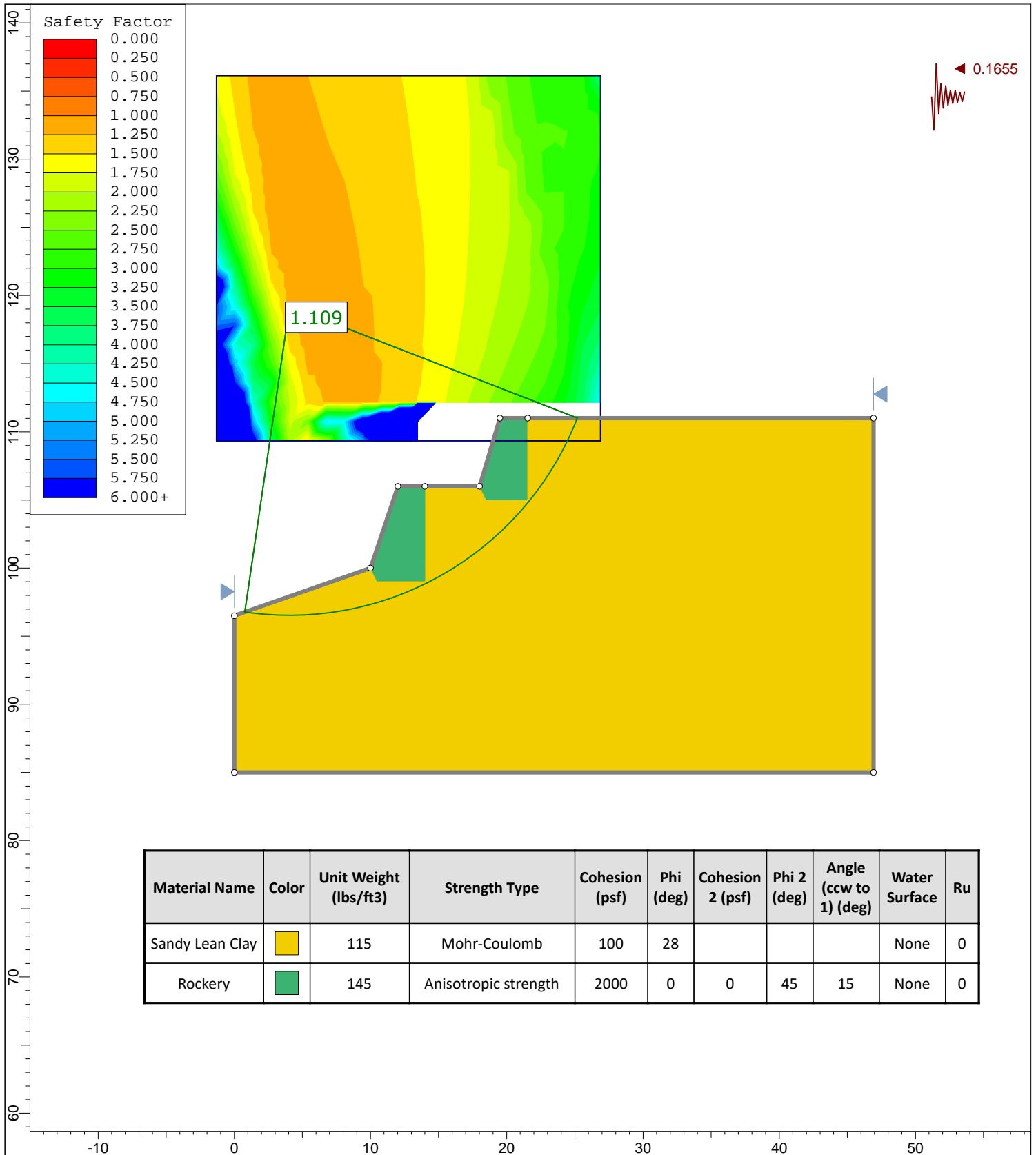


### Rockery 3 - Static



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Plate  
**6**



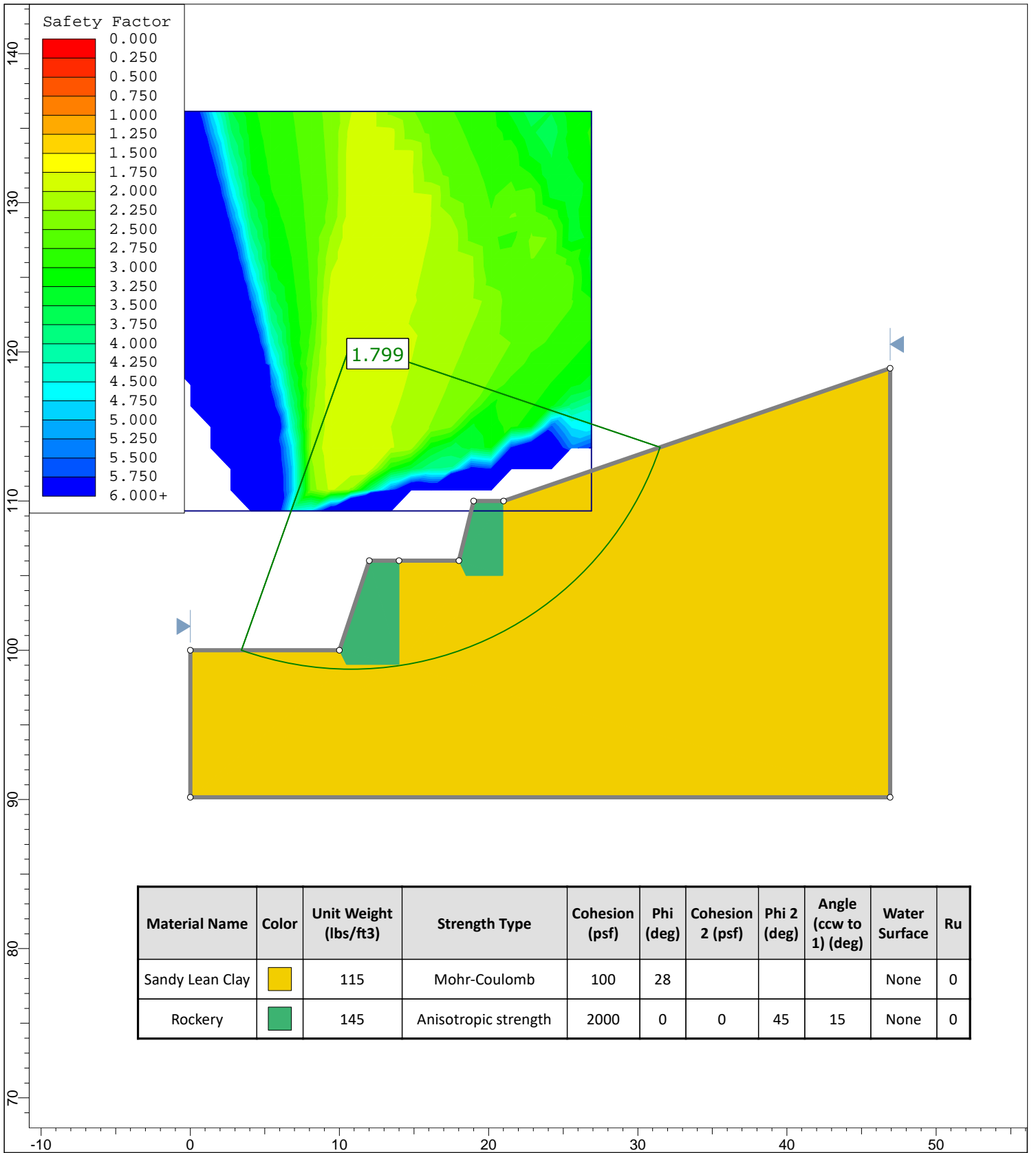
Material Name	Color	Unit Weight (lbs/ft <sup>3</sup> )	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)	Angle (ccw to 1) (deg)	Water Surface	Ru
Sandy Lean Clay	<span style="display:inline-block; width:15px; height:15px; background-color:yellow;"></span>	115	Mohr-Coulomb	100	28				None	0
Rockery	<span style="display:inline-block; width:15px; height:15px; background-color:green;"></span>	145	Anisotropic strength	2000	0	0	45	15	None	0

### Rockery 3 - Pseudo Static



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Plate  
**7**

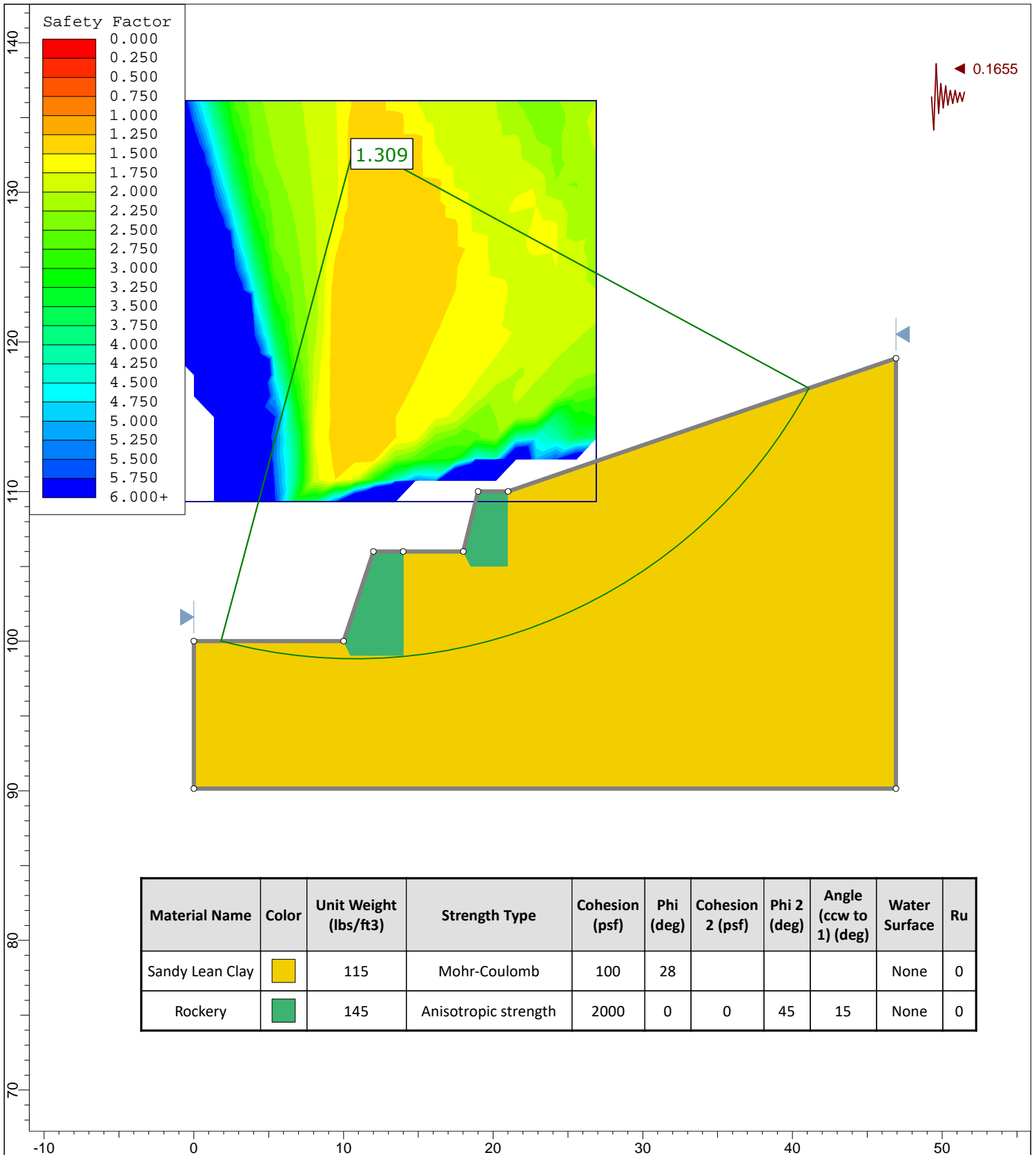


### Rockery 4 - Static



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Plate  
**8**



### Rockery 4 - Pseudo Static

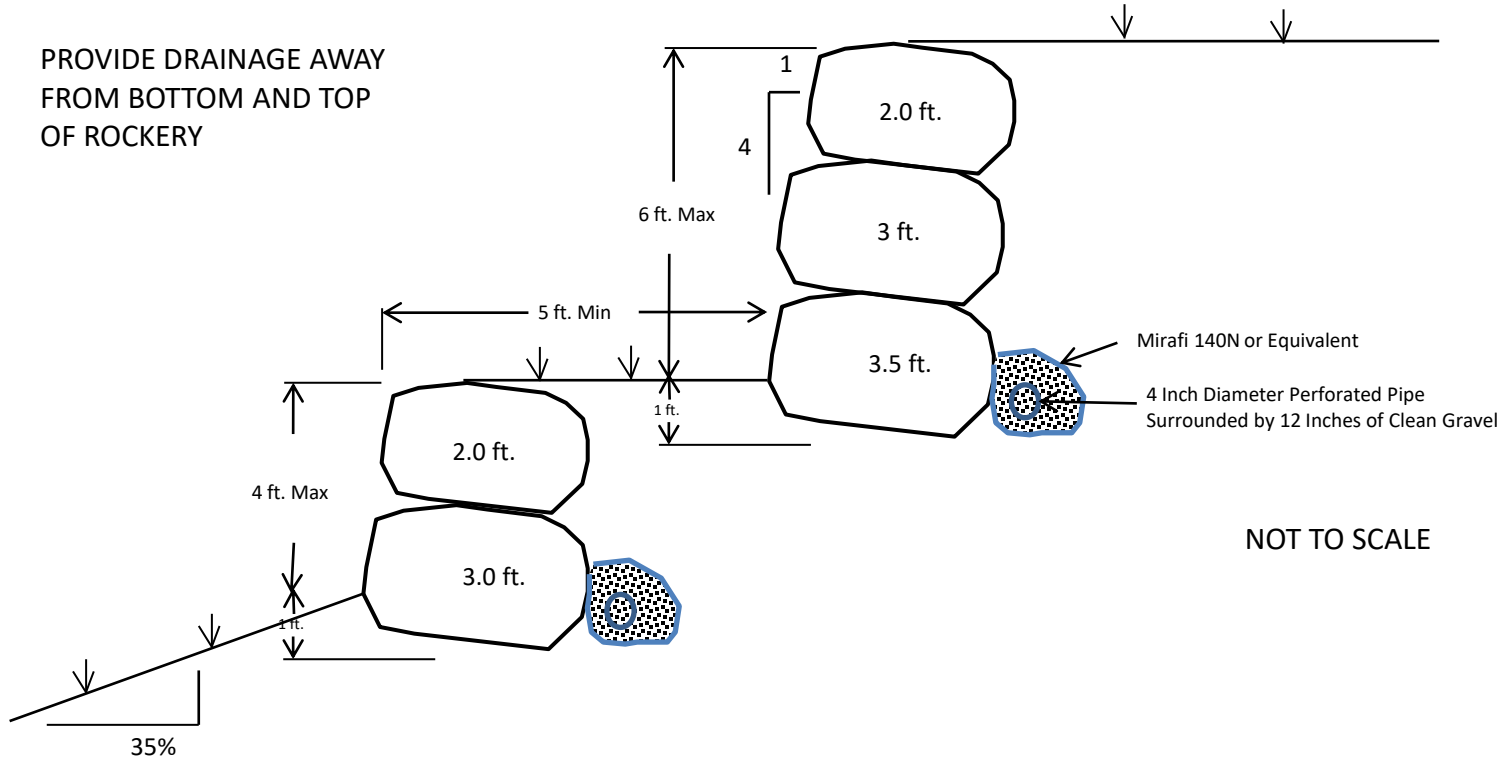


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Plate  
**9**

# ROCKERY 1 DETAIL

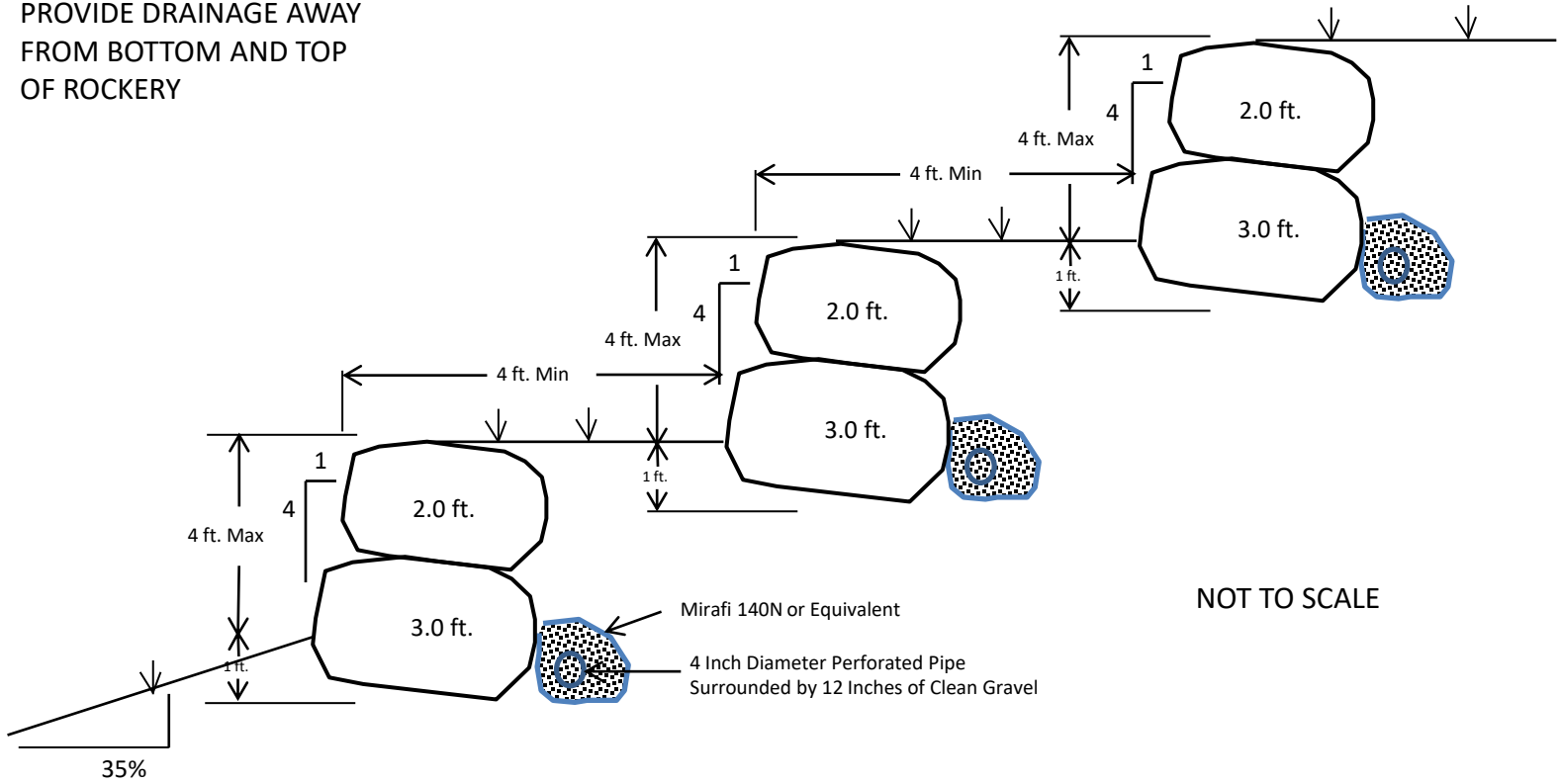
PROVIDE DRAINAGE AWAY FROM BOTTOM AND TOP OF ROCKERY



NOT TO SCALE

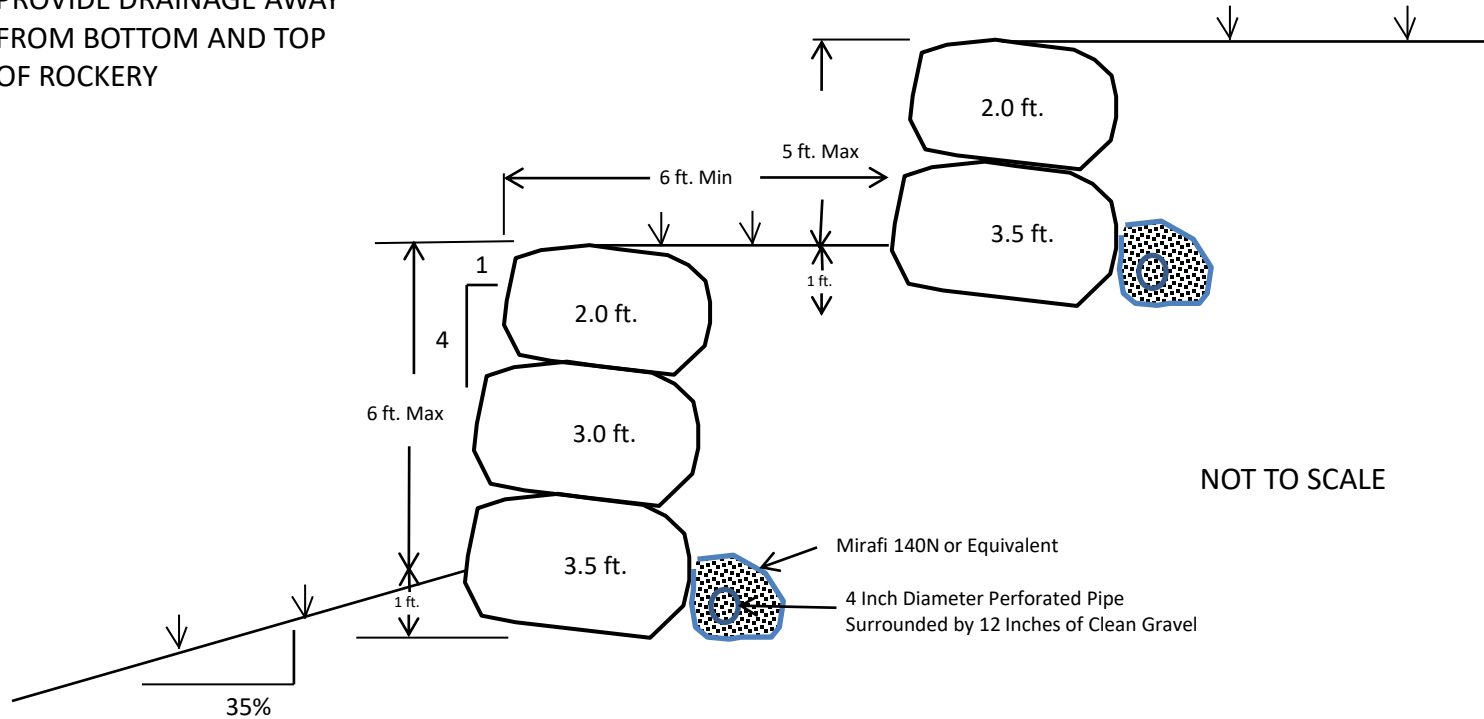
# ROCKERY 2 DETAIL

PROVIDE DRAINAGE AWAY FROM BOTTOM AND TOP OF ROCKERY



# ROCKERY 3 DETAIL

PROVIDE DRAINAGE AWAY FROM BOTTOM AND TOP OF ROCKERY





# ROCKERY 4 DETAIL

PROVIDE DRAINAGE AWAY FROM BOTTOM AND TOP OF ROCKERY

