RULE 6.5: GEOTECHNICAL STABILITY EXHIBIT

Colorado Geologic Survey mapping shows the site is consolidated tuft overlaying Pennsylvania Formation bedrock. The Pennsylvania Formation in this area is the Maroon Formation, consisting of sandstone, conglomerate, mudstone, claystone, and thin beds of limestone. Colorado Geologic Survey (CGS) reporting notes, “Unit may generate rockfall hazards where exposed in steep cliffs.” (Streufert et al., 1997, p. 9). There are no mapped faults that pass through the permit area. Based on the hazard note from the CGS, mining in the area should be conducted in a manner that maintains sufficient bench width to contain rockfall from steep excavated surfaces.

There are no structures near the Brown Quarry site and slope stability analysis shows that there will be no offsite slope failures. Mining of the quarry will be conducted in benches in the bedrock limestone. Reclamation will consist of creating mounds backfilled material and soil to reduce runoff and encourage vegetation growth on mined out benches. However, as part of the reclamation plan, a maximum backfilled slope of 2H:1V is included. This maximum reclaimed slope condition is what will be analyzed in this exhibit for slope stability.

The material properties are derived from Table 2.5 in the SME Mining Reference Handbook[1] and site-specific data provided by the operator (see Appendix GS-2). The weathered rock making up the top five feet of the ground in this area is best classified as weathered limestone. The target bedrock is a hard intact limestone. A summary of the material properties can be seen in Table 6.5-1.

Table 6.5-1 Material Properties

Material	Unit Weight (lbs/ft^3)†	Cohesion (lbs/ft^2)*	Friction Angle
Weathered limestone bedrock	163.8	0	35
Intact limestone bedrock	163.8	200,000	35

†From Appendix GS-2.

*From SME Reference Handbook

The maximum reclamation slope condition was analyzed. Mining of the limestone will leave behind intact limestone benches that waste rock and topsoil will be placed upon. The reclamation plan calls for the construction of mounds of this material along the bench as water traps to encourage vegetation growth. Such a backfill scenario does not lend itself to slope stability analysis. Therefore, the reclaimed slope is analyzed assuming each bench is backfilled fully to re-establish the overall slope angle of roughly 2H:1V.

[1] Original source: Hoek and Bray 1977

1. Slope Analysis

Factor of Safety is expressed in terms of strength divided by stress as a ratio. It is arrived at by an iterative computer process where a slope failure is assumed, the strength and stress of that slope failure are calculated, and those values are compared to determine a lowest factor of safety. In the case of the Brown Quarry slope stability analysis, the Bishop's Method of Slices was the iterative calculation used, and the software GALENA was used to model slopes and calculate the factor of safety.

The Bishop's Method of Slices is a fundamental geotechnical engineering approach for analyzing slope stability by dividing a potential sliding mass into vertical slices and calculating the factor of safety against failure. The method identifies a circular failure surface intersecting the slope, then considers the weight of soil, pore water pressures, and forces acting on each slice while making the simplifying assumption that horizontal forces between slices cancel each other out. This iterative method calculates a factor of safety by comparing driving forces that promote failure to resisting forces that maintain stability.

The maximum backfill slope outlined in Exhibit E was used as the basis for the GALENA model. Table GS-1 lists the analysis conducted and their respective factors of safety. The overall slope stability result is represented in Figure GS-1. The resulting FoS in each iteration is greater than 100, as the limestone benches prevent large scale slope failure. However, once the failure circle tested is smaller than a bench in size, the FoS drops to unity. This analysis (Reclaimed Analysis 3 in the data outputs and figures in Appendix GS-1) is then evaluated to identify the geometric extent of a failure circle with a FoS > 1.5, to see if this failure circle extends out far enough to risk offsite damage. Figure GS-2 shows the extent of the FoS > 1.5 failure circle (FoS = 1.6). As the figure shows, this failure circle is entirely contained with its bench.

GALENA data tables and analysis result figures are attached as Appendix GS-1.

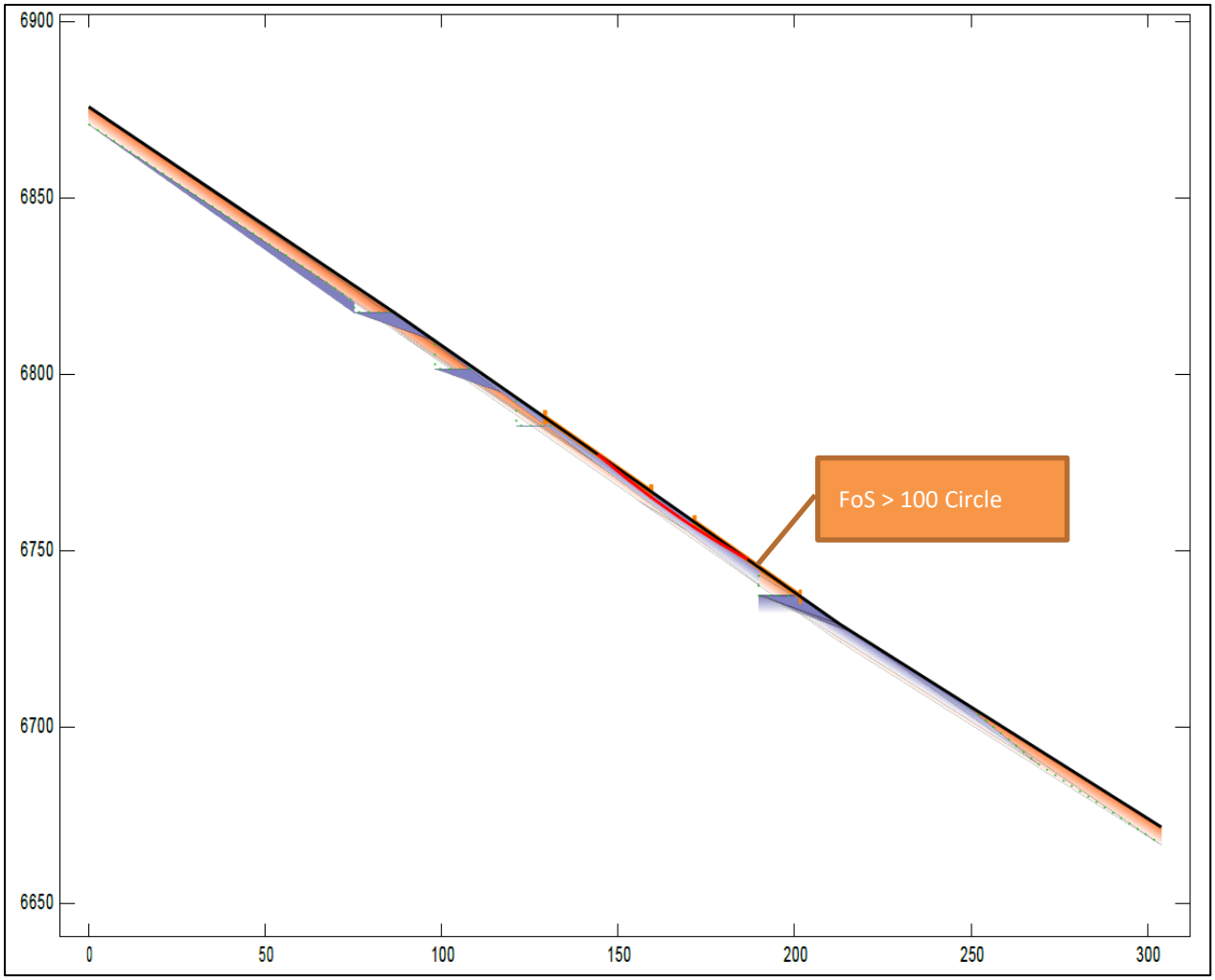


Figure GS-1. GALENA Cross Sections (Overall Reclamation)

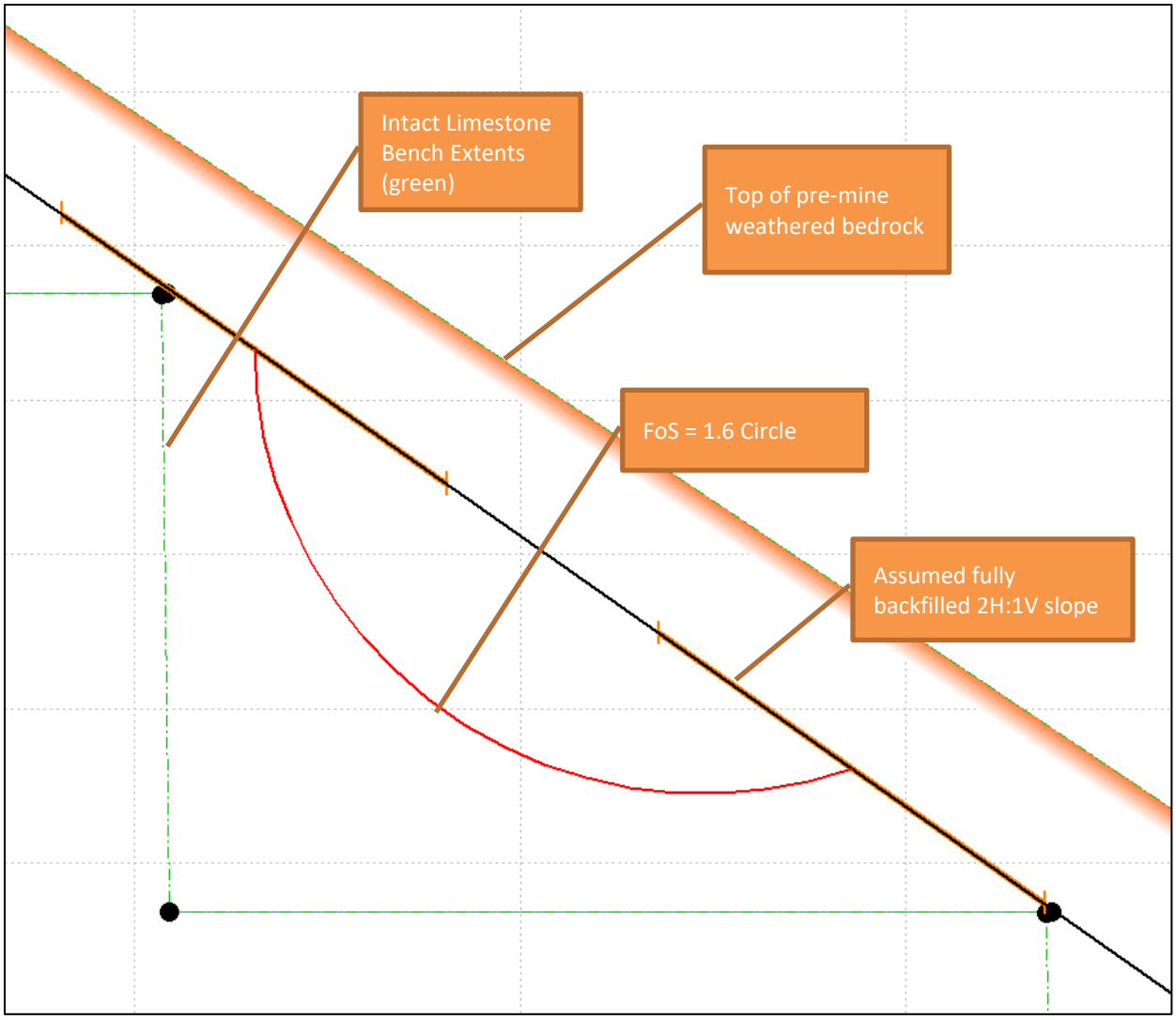


Figure GS-2. GALENA Cross Section (Max. Single Bench Reclamation)

Table GS-1. Factors of Safety for Slope Stability

Slope Condition	Lowest Factor of Safety (static)	Nearest Structure
Large scale slope failure	>100	None
Local bench failure FoS > 1.5	1.6	None

2. Conclusion

The analysis shows that the Brown Quarry reclaimed slopes, even if maximally backfilled to 2H:1V, do not risk offsite damage from slope failure. The overall slope factor of safety is greater than 100, which is greater than the DRMS minimum of 1.5 for this scenario. Reducing the failure circle down to a size that would induce a failure shows a failure within individual bench only, with the FoS > 1.5 failure circle occurring entirely within a bench. Based on this analysis, there is no risk of offsite damage due to slope failure.

The slope stability analysis in this permit has been prepared according to appropriate engineering standards and practices.

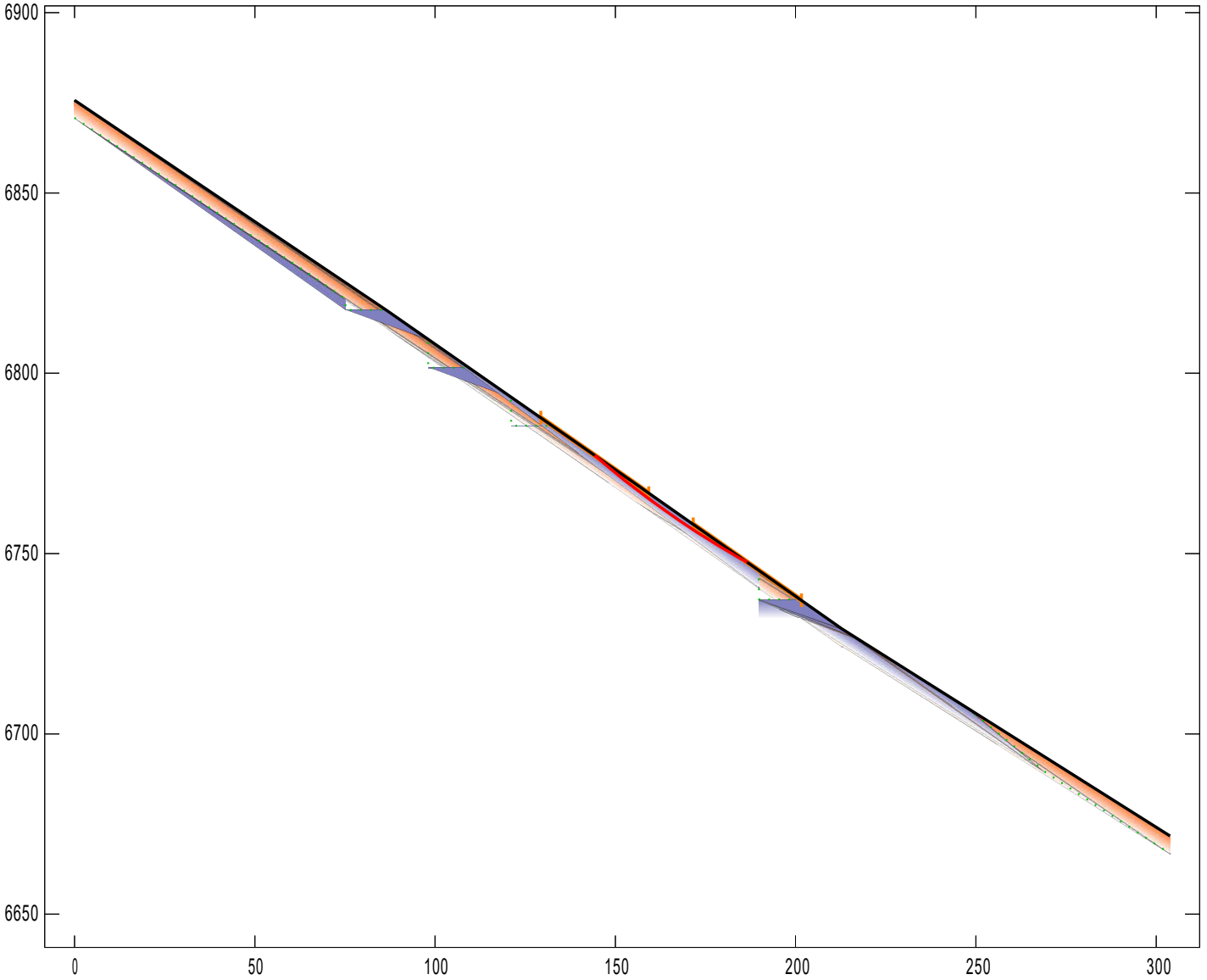
Ben Langenfeld, P.E.

P.E.# 0047151

References

Streufert, R. K., Kirkham, R. M., Schroeder II, T. J., & Widmann, B. L. (1997). *OF-97-02 geologic map of the Dotsero Quadrangle, Eagle and Garfield counties, Colorado*. Colorado Geological Survey. https://doi.org/10.58783/cgs.of9702.sjpl1588

APPENDIX GS-1 GALENA INFORMATION



GALENA Version 7.1

Licensed to: Greg Lewicki and Associates

Material Keys

1: Weathered Bedrock

2: Limestone bedrock

Analysis 1

Multiple Stability Analysis

Method: Bishop Simplified

Surface: Circular

Results

Critical Factor of Safety: Undetermined

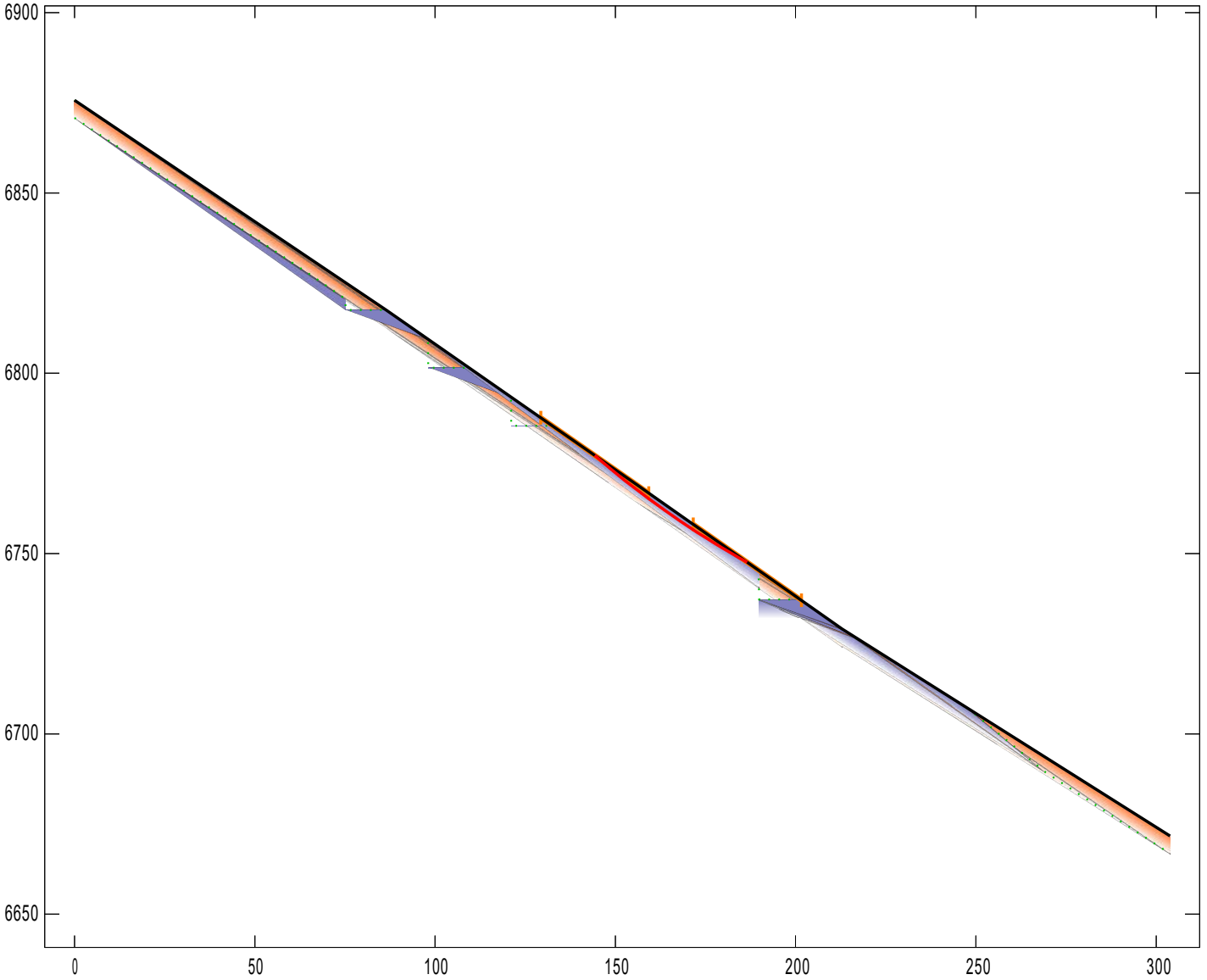
Edited: 11 Mar 2025

Processed: 11 Mar 2025

Project Brown Quarry
Reclaimed Condition

File: E:\Work\GLA Dropbox\Ben Langenfeld\Defiance Stone\Brown Quarry\Slope Stability\Brown Quarry.gmf

Lewicki & Associates



GALENA Version 7.1

Licensed to: Greg Lewicki and Associates

Material Keys

1: Weathered Bedrock

2: Limestone bedrock

Analysis 2

Multiple Stability Analysis

Method: Bishop Simplified

Surface: Circular (Critical Seed)

Results

Critical Factor of Safety: Undetermined

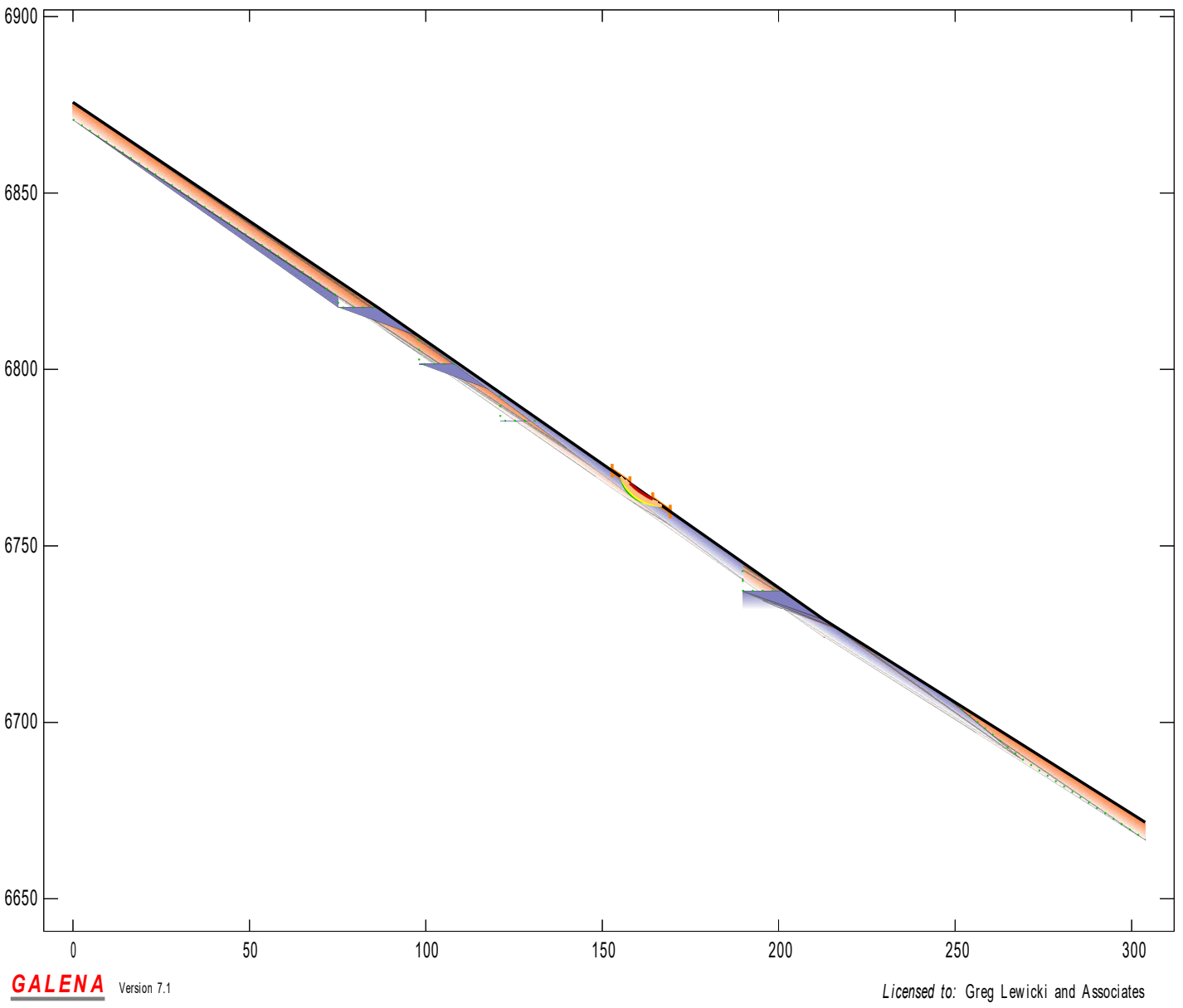
Edited: 11 Mar 2025

Processed: 11 Mar 2025

Project Brown Quarry
Reclaimed Condition

File: E:\Work\GLA Dropbox\Ben Langenfeld\Defiance Stone\Brown Quarry\Slope Stability\Brown Quarry.gmf

Lewicki & Associates



GALENA Version 7.1

Licensed to: Greg Lewicki and Associates

Material Keys

1: Weathered Bedrock

2: Limestone bedrock

Analysis 3

Multiple Stability Analysis

Method: Bishop Simplified

Surface: Circular

Results

Critical Factor of Safety: 1.02

Edited: 11 Mar 2025

Processed: 11 Mar 2025

Project Brown Quarry
Reclaimed Condition

File: E:\Work\GLA Dropbox\Ben Langenfeld\Defiance Stone\Brown Quarry\Slope Stability\Brown Quarry.gmf

Lewicki & Associates

GALENA 7.1 Analysis Results Version: 7.10.1.04 Licensee: Greg Lewicki and Associates

Project: Brown Quarry
File: E:\Work\GLA Dropbox\Ben Langenfeld\Defiance Stone\Brown Quarry\Slope Stability\Brown Quarry.gmf
Processed: 11 Mar 2025 11:10:30

DATA: Analysis 1 - Reclaimed Condition

Material Properties (2 materials)

Material: 1 (Mohr-Coulomb Isotropic) - Weathered Bedrock
Cohesion Phi UnitWeight Ru
0.00 35.0 163.80 Auto
Material: 2 (Mohr-Coulomb Isotropic) - Limestone bedrock
Cohesion Phi UnitWeight Ru
200000.00 35.0 163.80 Auto

Water Properties

Unit weight of water: 62.400 Unit weight of water/medium above ground: 0.000

Material Profiles (2 profiles)

Profile: 1 (2 points) Material beneath: 1 - Weathered Bedrock
0.00 6875.83 303.82 6671.78
Profile: 2 (41 points) Material beneath: 2 - Limestone bedrock
0.00 6870.83 66.42 6826.66 75.13 6820.57 75.13 6817.57 86.56 6817.57
86.50 6817.54 86.60 6809.54 98.03 6809.54 98.07 6801.51 109.51 6801.51
109.45 6801.48 109.55 6793.48 120.98 6793.48 121.02 6793.45 121.12 6785.45
132.46 6785.45 132.60 6785.42 132.50 6777.42 143.93 6777.42 143.87 6777.39
143.97 6769.39 155.41 6769.39 155.35 6769.37 155.45 6761.37 166.88 6761.37
166.82 6761.34 166.92 6753.34 178.36 6753.34 178.30 6753.31 178.40 6745.31
189.83 6745.31 189.77 6745.28 189.87 6737.28 201.30 6737.28 201.45 6737.25
201.35 6729.25 212.78 6729.25 216.35 6726.75 247.42 6707.42 269.41 6689.29
303.82 6666.78

Slope Surface (5 points)

0.00 6875.73 86.50 6817.50 155.50 6769.40 212.90 6729.10 303.82 6671.68

Phreatic Surface (2 points)

0.00 5500.00 350.00 5500.00

Failure Surface

Initial circular surface for critical search defined by: XL,XR,R

Intersects: XL: 144.30 YL: 6777.21 XR: 186.60 YR: 6747.56
Centre: XC: 308.15 YC: 6966.02 Radius: R: 250.00

Variable Restraints

Parameter descriptor: XL XR R
Range of variation: 30.00 30.00 5.00
Trial positions within range: 5 5 10

- -

RESULTS: Analysis 1 - Reclaimed Condition

Bishop Simplified Method of Analysis - Circular Failure Surface
---
Critical Failure Surface Search using Multiple Circle Generation Techniques

Factor of Safety for initial failure surface approximation: 298.667

There were: 251 successful analyses from a total of 251 trial surfaces

Invalid Result - Factor of Safety >= 100

Negative normal stresses exist on the base of one or more slices; examine slice data and consult the GALENA Help utility

Results Summary - Lowest 1 Factor of Safety circles

Circle	X-Left	Y-Left	X-Right	Y-Right	X-Centre	Y-Centre	Radius	FoS	
1	144.30	6777.21	186.60	6747.56	308.15	6966.02	250.00	******	<-- Critical Surface

Critical Failure Surface (circle 1)

Intersects: XL: 144.30 YL: 6777.21 XR: 186.60 YR: 6747.56
Centre: XC: 308.15 YC: 6966.02 Radius: R: 250.00
Generated failure surface: (20 points)

144.30	6777.21	146.37	6775.43	148.45	6773.68	150.56	6771.95	152.68	6770.25
154.82	6768.57	156.98	6766.91	159.16	6765.27	161.36	6763.66	163.57	6762.08
165.80	6760.51	168.05	6758.97	170.31	6757.46	172.59	6755.97	174.89	6754.51
177.20	6753.07	179.53	6751.65	181.87	6750.27	184.23	6748.90	186.60	6747.56

Slice Geometry and Properties - Critical Failure Surface (circle 1, 40 slices)

Slice	X-S	Base						PoreWater	Normal	Test	
	X-Left	Area	Angle	Width	Length	Matl	Cohesion	Phi	Weight	Force	Stress	Factor
1	144.30	0.09	40.6	1.03	1.36	1	0.00	35.0	14.05	0.00	13.57	1.32
2	145.33	0.26	40.6	1.03	1.36	1	0.00	35.0	42.32	0.00	40.87	1.32
3	146.37	0.42	40.0	1.04	1.36	1	0.00	35.0	69.56	0.00	66.57	1.30
4	147.41	0.58	40.0	1.04	1.36	1	0.00	35.0	95.00	0.00	90.92	1.30
5	148.45	0.73	39.4	1.05	1.36	1	0.00	35.0	119.86	0.00	113.67	1.29
6	149.50	0.87	39.4	1.05	1.36	1	0.00	35.0	142.33	0.00	134.99	1.29
7	150.56	1.01	38.8	1.06	1.36	1	0.00	35.0	164.73	0.00	154.87	1.28
8	151.62	1.13	38.8	1.06	1.36	1	0.00	35.0	184.35	0.00	173.31	1.28

9	152.68	1.27	38.1	1.09	1.39	1	0.00	35.0	208.68	0.00	190.40	1.27
10	153.77	1.32	38.1	1.05	1.33	2	200000.00	35.0	216.08	0.00	-318.97	1.27
11	154.82	0.70	37.5	0.53	0.66	2	200000.00	35.0	114.35	0.00	-296.61	1.26
12	155.35	1.12	37.5	0.82	1.03	1	0.00	35.0	183.14	0.00	223.94	1.26
13	156.17	1.16	37.5	0.82	1.03	1	0.00	35.0	190.32	0.00	232.72	1.26
14	156.98	1.61	36.9	1.09	1.36	1	0.00	35.0	263.40	0.00	241.44	1.25
15	158.07	1.67	36.9	1.09	1.36	1	0.00	35.0	272.89	0.00	250.14	1.25
16	159.16	1.73	36.3	1.10	1.36	1	0.00	35.0	283.01	0.00	257.33	1.24
17	160.26	1.77	36.3	1.10	1.36	1	0.00	35.0	289.16	0.00	262.92	1.24
18	161.36	1.81	35.6	1.11	1.36	1	0.00	35.0	296.21	0.00	267.25	1.23
19	162.46	1.83	35.7	1.11	1.36	1	0.00	35.0	299.22	0.00	269.96	1.23
20	163.57	1.67	35.0	1.01	1.23	1	0.00	35.0	273.36	0.00	271.17	1.22
21	164.58	2.03	35.0	1.22	1.49	2	200000.00	35.0	332.13	0.00	-197.43	1.22
22	165.80	1.68	34.4	1.02	1.24	2	200000.00	35.0	275.21	0.00	-188.58	1.21
23	166.82	2.00	34.4	1.23	1.49	1	0.00	35.0	327.08	0.00	266.15	1.21
24	168.05	1.81	33.8	1.13	1.36	1	0.00	35.0	296.22	0.00	261.29	1.20
25	169.18	1.77	33.8	1.13	1.36	1	0.00	35.0	289.34	0.00	255.22	1.20
26	170.31	1.73	33.2	1.14	1.36	1	0.00	35.0	282.57	0.00	247.48	1.19
27	171.45	1.66	33.2	1.14	1.36	1	0.00	35.0	272.27	0.00	238.46	1.19
28	172.59	1.60	32.5	1.15	1.36	1	0.00	35.0	261.99	0.00	227.84	1.18
29	173.74	1.51	32.5	1.15	1.36	1	0.00	35.0	248.03	0.00	215.70	1.18
30	174.89	1.17	31.9	0.94	1.10	1	0.00	35.0	191.06	0.00	203.57	1.18
31	175.82	1.10	31.9	0.94	1.10	1	0.00	35.0	179.59	0.00	191.35	1.18
32	176.76	0.49	31.9	0.44	0.52	2	200000.00	35.0	79.97	0.00	-233.74	1.18
33	177.20	1.15	31.3	1.10	1.29	2	200000.00	35.0	188.57	0.00	-235.03	1.17
34	178.30	1.15	31.3	1.23	1.44	1	0.00	35.0	188.01	0.00	153.02	1.17
35	179.53	0.95	30.7	1.17	1.36	1	0.00	35.0	156.09	0.00	133.06	1.16
36	180.70	0.80	30.6	1.17	1.36	1	0.00	35.0	131.45	0.00	112.06	1.16
37	181.87	0.65	30.0	1.18	1.36	1	0.00	35.0	105.79	0.00	89.62	1.15
38	183.05	0.47	30.0	1.18	1.36	1	0.00	35.0	77.51	0.00	65.65	1.15
39	184.23	0.29	29.4	1.19	1.36	1	0.00	35.0	47.91	0.00	40.34	1.15
40	185.41	0.10	29.4	1.19	1.36	1	0.00	35.0	15.94	0.00	13.42	1.15

X-S Area: 46.82 Path Length: 51.74 X-S Weight: 7668.75

DATA: Analysis 2 - Reclaimed Condition

Material Properties (2 materials)

Material: 1 (Mohr-Coulomb Isotropic) - Weathered Bedrock

Cohesion	Phi	UnitWeight	Ru
0.00	35.0	163.80	Auto

Material: 2 (Mohr-Coulomb Isotropic) - Limestone bedrock

Cohesion	Phi	UnitWeight	Ru
200000.00	35.0	163.80	Auto

Water Properties

Unit weight of water: 62.400 Unit weight of water/medium above ground: 0.000

Material Profiles (2 profiles)

Profile: 1 (2 points) Material beneath: 1 - Weathered Bedrock
0.00 6875.83 303.82 6671.78
Profile: 2 (41 points) Material beneath: 2 - Limestone bedrock
0.00 6870.83 66.42 6826.66 75.13 6820.57 75.13 6817.57 86.56 6817.57
86.50 6817.54 86.60 6809.54 98.03 6809.54 98.07 6801.51 109.51 6801.51
109.45 6801.48 109.55 6793.48 120.98 6793.48 121.02 6793.45 121.12 6785.45
132.46 6785.45 132.60 6785.42 132.50 6777.42 143.93 6777.42 143.87 6777.39
143.97 6769.39 155.41 6769.39 155.35 6769.37 155.45 6761.37 166.88 6761.37
166.82 6761.34 166.92 6753.34 178.36 6753.34 178.30 6753.31 178.40 6745.31
189.83 6745.31 189.77 6745.28 189.87 6737.28 201.30 6737.28 201.45 6737.25
201.35 6729.25 212.78 6729.25 216.35 6726.75 247.42 6707.42 269.41 6689.29
303.82 6666.78

Slope Surface (5 points)

0.00 6875.73 86.50 6817.50 155.50 6769.40 212.90 6729.10 303.82 6671.68

Phreatic Surface (2 points)

0.00 5500.00 350.00 5500.00

Failure Surface (Critical, from previous analysis)

Initial circular surface for critical search defined by: XL,XR,R
Intersects: XL: 144.30 YL: 6777.21 XR: 186.60 YR: 6747.56
Centre: XC: 308.15 YC: 6966.02 Radius: R: 250.00

Variable Restraints

Parameter descriptor: XL XR R
Range of variation: 30.00 30.00 5.00
Trial positions within range: 5 5 10

- -

RESULTS: Analysis 2 - Reclaimed Condition

Bishop Simplified Method of Analysis - Circular Failure Surface
---
Critical Failure Surface Search using Multiple Circle Generation Techniques

Factor of Safety for initial failure surface approximation: 298.667

There were: 251 successful analyses from a total of 251 trial surfaces

Invalid Result - Factor of Safety >= 100

Negative normal stresses exist on the base of one or more slices; examine slice data and consult the GALENA Help utility

Results Summary - Lowest 1 Factor of Safety circles

Circle	X-Left	Y-Left	X-Right	Y-Right	X-Centre	Y-Centre	Radius	FoS	
1	144.30	6777.21	186.60	6747.56	308.15	6966.02	250.00	******	<-- Critical Surface

Critical Failure Surface (circle 1)

Intersects: XL: 144.30 YL: 6777.21 XR: 186.60 YR: 6747.56
Centre: XC: 308.15 YC: 6966.02 Radius: R: 250.00
Generated failure surface: (20 points)

144.30	6777.21	146.37	6775.43	148.45	6773.68	150.56	6771.95	152.68	6770.25
154.82	6768.57	156.98	6766.91	159.16	6765.27	161.36	6763.66	163.57	6762.08
165.80	6760.51	168.05	6758.97	170.31	6757.46	172.59	6755.97	174.89	6754.51
177.20	6753.07	179.53	6751.65	181.87	6750.27	184.23	6748.90	186.60	6747.56

Slice Geometry and Properties - Critical Failure Surface (circle 1, 40 slices)

Slice	X-S			Base					PoreWater	Normal	Test
	X-Left	Area	Angle	Width	Length	Matl	Cohesion	Phi	Weight	Force	Stress	Factor
1	144.30	0.09	40.6	1.03	1.36	1	0.00	35.0	14.05	0.00	13.57	1.32
2	145.33	0.26	40.6	1.03	1.36	1	0.00	35.0	42.32	0.00	40.87	1.32
3	146.37	0.42	40.0	1.04	1.36	1	0.00	35.0	69.56	0.00	66.57	1.30
4	147.41	0.58	40.0	1.04	1.36	1	0.00	35.0	95.00	0.00	90.92	1.30
5	148.45	0.73	39.4	1.05	1.36	1	0.00	35.0	119.86	0.00	113.67	1.29
6	149.50	0.87	39.4	1.05	1.36	1	0.00	35.0	142.33	0.00	134.99	1.29
7	150.56	1.01	38.8	1.06	1.36	1	0.00	35.0	164.73	0.00	154.87	1.28
8	151.62	1.13	38.8	1.06	1.36	1	0.00	35.0	184.35	0.00	173.31	1.28
9	152.68	1.27	38.1	1.09	1.39	1	0.00	35.0	208.68	0.00	190.40	1.27
10	153.77	1.32	38.1	1.05	1.33	2	200000.00	35.0	216.08	0.00	-318.97	1.27
11	154.82	0.70	37.5	0.53	0.66	2	200000.00	35.0	114.35	0.00	-296.61	1.26
12	155.35	1.12	37.5	0.82	1.03	1	0.00	35.0	183.14	0.00	223.94	1.26
13	156.17	1.16	37.5	0.82	1.03	1	0.00	35.0	190.32	0.00	232.72	1.26
14	156.98	1.61	36.9	1.09	1.36	1	0.00	35.0	263.40	0.00	241.44	1.25
15	158.07	1.67	36.9	1.09	1.36	1	0.00	35.0	272.89	0.00	250.14	1.25
16	159.16	1.73	36.3	1.10	1.36	1	0.00	35.0	283.01	0.00	257.33	1.24
17	160.26	1.77	36.3	1.10	1.36	1	0.00	35.0	289.16	0.00	262.92	1.24
18	161.36	1.81	35.6	1.11	1.36	1	0.00	35.0	296.21	0.00	267.25	1.23
19	162.46	1.83	35.7	1.11	1.36	1	0.00	35.0	299.22	0.00	269.96	1.23
20	163.57	1.67	35.0	1.01	1.23	1	0.00	35.0	273.36	0.00	271.17	1.22
21	164.58	2.03	35.0	1.22	1.49	2	200000.00	35.0	332.13	0.00	-197.43	1.22
22	165.80	1.68	34.4	1.02	1.24	2	200000.00	35.0	275.21	0.00	-188.58	1.21
23	166.82	2.00	34.4	1.23	1.49	1	0.00	35.0	327.08	0.00	266.15	1.21
24	168.05	1.81	33.8	1.13	1.36	1	0.00	35.0	296.22	0.00	261.29	1.20
25	169.18	1.77	33.8	1.13	1.36	1	0.00	35.0	289.34	0.00	255.22	1.20
26	170.31	1.73	33.2	1.14	1.36	1	0.00	35.0	282.57	0.00	247.48	1.19
27	171.45	1.66	33.2	1.14	1.36	1	0.00	35.0	272.27	0.00	238.46	1.19
28	172.59	1.60	32.5	1.15	1.36	1	0.00	35.0	261.99	0.00	227.84	1.18
29	173.74	1.51	32.5	1.15	1.36	1	0.00	35.0	248.03	0.00	215.70	1.18
30	174.89	1.17	31.9	0.94	1.10	1	0.00	35.0	191.06	0.00	203.57	1.18
31	175.82	1.10	31.9	0.94	1.10	1	0.00	35.0	179.59	0.00	191.35	1.18
32	176.76	0.49	31.9	0.44	0.52	2	200000.00	35.0	79.97	0.00	-233.74	1.18
33	177.20	1.15	31.3	1.10	1.29	2	200000.00	35.0	188.57	0.00	-235.03	1.17
34	178.30	1.15	31.3	1.23	1.44	1	0.00	35.0	188.01	0.00	153.02	1.17

35	179.53	0.95	30.7	1.17	1.36	1	0.00	35.0	156.09	0.00	133.06	1.16
36	180.70	0.80	30.6	1.17	1.36	1	0.00	35.0	131.45	0.00	112.06	1.16
37	181.87	0.65	30.0	1.18	1.36	1	0.00	35.0	105.79	0.00	89.62	1.15
38	183.05	0.47	30.0	1.18	1.36	1	0.00	35.0	77.51	0.00	65.65	1.15
39	184.23	0.29	29.4	1.19	1.36	1	0.00	35.0	47.91	0.00	40.34	1.15
40	185.41	0.10	29.4	1.19	1.36	1	0.00	35.0	15.94	0.00	13.42	1.15

X-S Area: 46.82 Path Length: 51.74 X-S Weight: 7668.75

DATA: Analysis 3 - Reclaimed Condition

Material Properties (2 materials)

Material: 1 (Mohr-Coulomb Isotropic) - Weathered Bedrock

Cohesion	Phi	UnitWeight	Ru
0.00	35.0	163.80	Auto

Material: 2 (Mohr-Coulomb Isotropic) - Limestone bedrock

Cohesion	Phi	UnitWeight	Ru
200000.00	35.0	163.80	Auto

Water Properties

Unit weight of water: 62.400 Unit weight of water/medium above ground: 0.000

Material Profiles (2 profiles)

Profile: 1 (2 points) Material beneath: 1 - Weathered Bedrock

0.00	6875.83	303.82	6671.78

Profile: 2 (41 points) Material beneath: 2 - Limestone bedrock

0.00	6870.83	66.42	6826.66	75.13	6820.57	75.13	6817.57
86.56	6817.57	86.50	6817.54	86.60	6809.54	98.03	6809.54
98.07	6801.51	109.51	6801.51	109.45	6801.48	109.55	6793.48
120.98	6793.48	121.02	6793.45	121.12	6785.45	132.46	6785.45
132.60	6785.42	132.50	6777.42	143.93	6777.42	143.87	6777.39
143.97	6769.39	155.41	6769.39	155.35	6769.37	155.45	6761.37
166.88	6761.37	166.82	6761.34	166.92	6753.34	178.36	6753.34
178.30	6753.31	178.40	6745.31	189.83	6745.31	189.77	6745.28
189.87	6737.28	201.30	6737.28	201.45	6737.25	201.35	6729.25
212.78	6729.25	216.35	6726.75	247.42	6707.42	269.41	6689.29
303.82	6666.78						

Slope Surface (5 points)

0.00	6875.73	86.50	6817.50	155.50	6769.40	212.90	6729.10	303.82	6671.68

Phreatic Surface (2 points)

0.00	5500.00	350.00	5500.00

Failure Surface

Initial circular surface for critical search defined by: XL,XR,R
Intersects: XL: 155.30 YL: 6769.54 XR: 166.80 YR: 6761.47
Centre: XC: 165.14 YC: 6771.33 Radius: R: 10.00

Variable Restraints

Parameter descriptor: XL XR R
Range of variation: 5.00 5.00 25.00
Trial positions within range: 5 5 10

- -

RESULTS: Analysis 3 - Reclaimed Condition

Bishop Simplified Method of Analysis - Circular Failure Surface
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Critical Failure Surface Search using Multiple Circle Generation Techniques

Factor of Safety for initial failure surface approximation: 167.184

There were: 154 successful analyses from a total of 251 trial surfaces
97 analyses terminated due to unacceptable geometry

Critical (minimum) Factor of Safety: 1.02

Results Summary - Lowest 56 Factor of Safety circles

Circle	X-Left	Y-Left	X-Right	Y-Right	X-Centre	Y-Centre	Radius	FoS	
1	157.80	6767.79	164.30	6763.22	173.78	6783.63	22.50	1.016	<-- Critical Surface
2	157.80	6767.79	164.30	6763.22	172.15	6781.31	19.72	1.021	
3	156.55	6768.66	164.30	6763.22	173.06	6783.94	22.50	1.024	
4	157.80	6767.79	165.55	6762.34	174.31	6783.07	22.50	1.024	
5	157.80	6767.79	164.30	6763.22	170.52	6778.99	16.94	1.030	
6	156.55	6768.66	164.30	6763.22	171.43	6781.61	19.72	1.032	
7	157.80	6767.79	165.55	6762.34	172.68	6780.73	19.72	1.032	
8	157.80	6767.79	166.80	6761.47	174.84	6782.48	22.50	1.033	
9	155.30	6769.54	164.30	6763.22	172.34	6784.24	22.50	1.033	
10	156.55	6768.66	165.55	6762.34	173.59	6783.36	22.50	1.033	
11	155.30	6769.54	165.55	6762.34	172.84	6783.63	22.50	1.045	
12	156.55	6768.66	166.80	6761.47	174.09	6782.75	22.50	1.045	
13	155.30	6769.54	164.30	6763.22	170.68	6781.88	19.72	1.045	
14	157.80	6767.79	166.80	6761.47	173.18	6780.13	19.72	1.045	
15	156.55	6768.66	165.55	6762.34	171.93	6781.00	19.72	1.045	
16	157.80	6767.79	165.55	6762.34	171.02	6778.38	16.94	1.045	
17	156.55	6768.66	164.30	6763.22	169.77	6779.26	16.94	1.045	
18	157.80	6767.79	164.30	6763.22	168.86	6776.63	14.17	1.046	
19	155.30	6769.54	166.80	6761.47	173.33	6783.00	22.50	1.058	
20	156.55	6768.66	166.80	6761.47	172.42	6780.37	19.72	1.060	
21	155.30	6769.54	165.55	6762.34	171.17	6781.25	19.72	1.060	
22	157.80	6767.79	166.80	6761.47	171.51	6777.74	16.94	1.063	
23	155.30	6769.54	164.30	6763.22	169.01	6779.50	16.94	1.063	
24	156.55	6768.66	165.55	6762.34	170.26	6778.62	16.94	1.063	

25	156.55	6768.66	164.30	6763.22	168.10	6776.87	14.17	1.067
26	157.80	6767.79	165.55	6762.34	169.35	6775.99	14.17	1.067
27	157.80	6767.79	164.30	6763.22	167.18	6774.24	11.39	1.074
28	155.30	6769.54	166.80	6761.47	171.64	6780.59	19.72	1.077
29	156.55	6768.66	166.80	6761.47	170.72	6777.95	16.94	1.084
30	155.30	6769.54	165.55	6762.34	169.47	6778.83	16.94	1.084
31	156.55	6768.66	165.55	6762.34	168.55	6776.19	14.17	1.094
32	155.30	6769.54	164.30	6763.22	167.30	6777.07	14.17	1.094
33	157.80	6767.79	166.80	6761.47	169.80	6775.31	14.17	1.094
34	155.30	6769.54	166.80	6761.47	169.91	6778.12	16.94	1.109
35	156.55	6768.66	164.30	6763.22	166.38	6774.42	11.39	1.109
36	157.80	6767.79	165.55	6762.34	167.63	6773.54	11.39	1.109
37	156.55	6768.66	166.80	6761.47	168.98	6775.46	14.17	1.125
38	155.30	6769.54	165.55	6762.34	167.73	6776.34	14.17	1.125
39	157.80	6767.79	164.30	6763.22	165.44	6771.76	8.61	1.139
40	157.80	6767.79	166.80	6761.47	168.03	6772.79	11.39	1.154
41	156.55	6768.66	165.55	6762.34	166.78	6773.67	11.39	1.154
42	155.30	6769.54	164.30	6763.22	165.53	6774.54	11.39	1.154
43	155.30	6769.54	166.80	6761.47	168.12	6775.57	14.17	1.164
44	156.55	6768.66	164.30	6763.22	164.56	6771.83	8.61	1.210
45	157.80	6767.79	165.55	6762.34	165.81	6770.95	8.61	1.210
46	155.30	6769.54	165.55	6762.34	165.89	6773.73	11.39	1.210
47	156.55	6768.66	166.80	6761.47	167.14	6772.85	11.39	1.210
48	155.30	6769.54	166.80	6761.47	166.20	6772.84	11.39	1.279
49	157.80	6767.79	166.80	6761.47	166.11	6770.05	8.61	1.305
50	156.55	6768.66	165.55	6762.34	164.86	6770.93	8.61	1.305
51	155.30	6769.54	164.30	6763.22	163.61	6771.80	8.61	1.305
52	157.80	6767.79	164.30	6763.22	163.51	6769.00	5.83	1.362
53	155.30	6769.54	165.55	6762.34	163.82	6770.78	8.61	1.436
54	156.55	6768.66	164.30	6763.22	162.38	6768.73	5.83	1.615
55	157.80	6767.79	165.55	6762.34	163.63	6767.85	5.83	1.615
56	155.30	6769.54	166.80	6761.47	165.14	6771.33	10.00	******

Critical Failure Surface (circle 1)

Intersects: XL: 157.80 YL: 6767.79 XR: 164.30 YR: 6763.22

Centre: XC: 173.78 YC: 6783.63 Radius: R: 22.50

Generated failure surface: (20 points)

157.80	6767.79	158.10	6767.49	158.40	6767.20	158.71	6766.92	159.03	6766.64
159.35	6766.36	159.67	6766.10	160.00	6765.84	160.34	6765.58	160.68	6765.34
161.02	6765.09	161.37	6764.86	161.72	6764.63	162.08	6764.41	162.44	6764.19
162.80	6763.99	163.17	6763.78	163.54	6763.59	163.92	6763.40	164.30	6763.22

Slice Geometry and Properties - Critical Failure Surface (circle 1, 38 slices)

Slice	X-S	Base						PoreWater	Normal	Test	
	X-Left	Area	Angle	Width	Length	Matl	Cohesion	Phi	Weight	Force	Stress	Factor
1	157.80	0.00	44.7	0.15	0.21	1	0.00	35.0	0.53	0.00	2.09	0.84
2	157.95	0.01	44.7	0.15	0.21	1	0.00	35.0	1.58	0.00	6.27	0.84
3	158.10	0.02	43.6	0.15	0.21	1	0.00	35.0	2.61	0.00	10.37	0.83
4	158.25	0.02	43.5	0.15	0.21	1	0.00	35.0	3.58	0.00	14.21	0.83
5	158.40	0.03	42.6	0.15	0.21	1	0.00	35.0	4.54	0.00	17.97	0.83
6	158.56	0.03	42.6	0.15	0.21	1	0.00	35.0	5.38	0.00	21.31	0.83

7	158.71	0.04	41.5	0.16	0.21	1	0.00	35.0	6.28	0.00	24.79	0.83
8	158.87	0.04	41.6	0.16	0.21	1	0.00	35.0	7.02	0.00	27.69	0.83
9	159.03	0.05	40.4	0.16	0.21	1	0.00	35.0	7.84	0.00	30.89	0.83
10	159.19	0.05	40.4	0.16	0.21	1	0.00	35.0	8.46	0.00	33.31	0.83
11	159.35	0.06	39.3	0.16	0.21	1	0.00	35.0	9.16	0.00	36.06	0.83
12	159.51	0.06	39.4	0.16	0.21	1	0.00	35.0	9.67	0.00	38.01	0.83
13	159.67	0.06	38.3	0.16	0.21	1	0.00	35.0	10.26	0.00	40.27	0.83
14	159.84	0.07	38.2	0.16	0.21	1	0.00	35.0	10.66	0.00	41.88	0.82
15	160.00	0.07	37.2	0.17	0.21	1	0.00	35.0	11.13	0.00	43.69	0.82
16	160.17	0.07	37.3	0.17	0.21	1	0.00	35.0	11.40	0.00	44.68	0.82
17	160.34	0.07	36.2	0.17	0.21	1	0.00	35.0	11.77	0.00	46.11	0.82
18	160.51	0.07	36.1	0.17	0.21	1	0.00	35.0	11.89	0.00	46.65	0.82
19	160.68	0.07	35.2	0.17	0.21	1	0.00	35.0	12.13	0.00	47.49	0.82
20	160.85	0.07	35.0	0.17	0.21	1	0.00	35.0	12.12	0.00	47.50	0.82
21	161.02	0.07	34.0	0.17	0.21	1	0.00	35.0	12.20	0.00	47.80	0.82
22	161.19	0.07	33.9	0.17	0.21	1	0.00	35.0	12.08	0.00	47.37	0.82
23	161.37	0.07	32.9	0.18	0.21	1	0.00	35.0	12.02	0.00	47.10	0.82
24	161.54	0.07	32.9	0.18	0.21	1	0.00	35.0	11.73	0.00	46.00	0.82
25	161.72	0.07	31.8	0.18	0.21	1	0.00	35.0	11.52	0.00	45.19	0.82
26	161.90	0.07	31.8	0.18	0.21	1	0.00	35.0	11.12	0.00	43.62	0.82
27	162.08	0.07	30.8	0.18	0.21	1	0.00	35.0	10.74	0.00	42.19	0.83
28	162.26	0.06	30.9	0.18	0.21	1	0.00	35.0	10.18	0.00	39.93	0.83
29	162.44	0.06	29.7	0.18	0.21	1	0.00	35.0	9.65	0.00	37.95	0.83
30	162.62	0.05	29.7	0.18	0.21	1	0.00	35.0	8.92	0.00	35.08	0.83
31	162.80	0.05	28.7	0.18	0.21	1	0.00	35.0	8.21	0.00	32.33	0.83
32	162.99	0.04	28.6	0.18	0.21	1	0.00	35.0	7.36	0.00	29.00	0.83
33	163.17	0.04	27.7	0.19	0.21	1	0.00	35.0	6.49	0.00	25.61	0.83
34	163.36	0.03	27.6	0.19	0.21	1	0.00	35.0	5.47	0.00	21.59	0.83
35	163.54	0.03	26.5	0.19	0.21	1	0.00	35.0	4.42	0.00	17.50	0.83
36	163.73	0.02	26.5	0.19	0.21	1	0.00	35.0	3.25	0.00	12.86	0.83
37	163.92	0.01	25.3	0.19	0.21	1	0.00	35.0	2.00	0.00	7.96	0.83
38	164.11	0.00	25.5	0.19	0.21	1	0.00	35.0	0.67	0.00	2.65	0.83

X-S Area: 1.87 Path Length: 7.98 X-S Weight: 306.02

APPENDIX GS-2 SITE SPECIFIC DATA

NATURAL STONE INSTITUTE

Report of Physical Property Tests

Test Specimens Provided by: **Defiance Stone Co., LLC**
PO Box 932
Carbondale, CO 81623

Trade Name of Material: **Brown**
Country of Origin: **USA**
Test Procedure: **ASTM C 170 Standard Test Method for Compressive Strength of Dimension Stone**
Procedure modified with regard to specimen count
Rift Orientation: **Perpendicular**
Preconditioning: **Dry**

TEST RESULTS

Specimen Number	Length (in)	Width (in)	Area (in^2)	Load @ Failure (lbs)	Compressive Strength (lbs/in^2)	Compressive Strength (MPa)
Brn-C170-1	3.06	3.00	9.18	180,300	19,640	135.4
Brn-C170-2	3.05	2.99	9.12	142,500	15,630	107.7
Brn-C170-3	3.02	3.00	9.06	125,400	13,840	95.4
Brn-C170-4	3.08	3.01	9.27	198,800	21,450	147.9
				Average Compressive Strength:	**17,640**	**121.6**
				Standard Deviation:	**3,512**	**24.2**
				Coefficient of Variation:	**19.9%**	**19.9%**

Date of Tests: **Monday, 04 March, 2019**
Tests performed by: **R. Lawson**
Report and Data Reviewed by: **C. Muehlbauer**

These tests were performed on a Test Mark Model CM-4000-i720 Hydraulic Testing Machine, Serial No. 160618. Last Date of Calibration: August 21, 2018, traceable to the National Institute of Standards Technology (NIST).

380 E. Lorain Street • Oberlin, OH 44074
440.250.9222
www.naturalstoneinstitute.org

Report of Physical Property Tests

Test Specimens Provided by: **Defiance Stone Co., LLC**
PO Box 932
Carbondale, CO 81623

Trade Name of Material: **Brown**
Country of Origin: **USA**
Test Procedure: **ASTM C 97, Standard Test Method for Absorption and Bulk & Bulk Specific Gravity of Dimension Stone. Pocedure modified with regard to specimen count.**

Specimen Number	Dry Weight (grams)	Saturated Weight (grams)	Suspended Weight (grams)	Absorption (%)	Bulk Specific Gravity	Density (kg/m^3)	Density (lbs/ft^3)
Brn-C97-1	1,165.87	1,172.43	728.78	0.56%	2.628	2,628	164.1
Brn-C97-2	1,155.12	1,162.64	721.28	0.65%	2.617	2,617	163.4
Brn-C97-3	1,147.46	1,152.97	718.54	0.48%	2.641	2,641	164.9
Brn-C97-4	1,170.00	1,178.00	728.79	0.68%	2.605	2,605	162.6
			Average:	**0.59%**	**2.623**	**2,623**	**163.8**
			Standard Deviation:	0.001	0.015	15	1.0
			Coefficient of Variation:	15.3%	0.6%	0.6%	0.6%

Date of Tests: **Wednesday, February 20, 2019**
Tests performed by: **M. Loflin**
Report and Data Reviewed by: **C. Muehlbauer**

These tests were performed on an Ohaus Laboratory Balance Model AX2202/E, Serial No. B614316489. Last Date of Calibration: August 2017, traceable to the National Institute of Standards Technology (NIST).

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