ROCKERY DESIGN PACKAGE
LIGHTHOUSE HEIGHTS SUBDIVISION
ELK RIDGE, UTAH

PROJECT AERIAL VIEW
REFERENCE IMAGE FROM GOOGLE EARTH PRO,
IMAGE DATE AUGUST 28, 2021

DESIGN PACKAGE CONTENTS		
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	2	PLAN VIEW
	3	TYPICAL SECTION VIEW
	4	CONSTRUCTION SPECIFICATIONS & NOTES
	5	DESIGN CRITERIA
	6	SITE PHOTOS
DESIGN CALCULATION PACKAGE	SECTION 2	STABILITY CALCULATIONS
	SECTION 3	GLOBAL STABILITY RESULTS

NOTE: THIS PLAN SET HAS BEEN PREPARED WITH COLOR LINE-TYPES TO MAKE SOME DETAILS AND SPECIFICATIONS MORE CLEAR. ANY COPIES OF THESE PLANS SHOULD BE MADE IN COLOR.

PREPARED FOR:
RED WOLF ROCK WALLS
P.O. BOX 72
WALLSBURG, UTAH 84082
ATTN: KC JEPPERSON

APPROVED BY: BRADLEY M. JOHNSON, P.E.

PROFESSIONAL ENGINEER
7885637-2202
BRADLEY M. JOHNSON
06/27/2022
ELECTRONIC SEAL
STATE OF UTAH

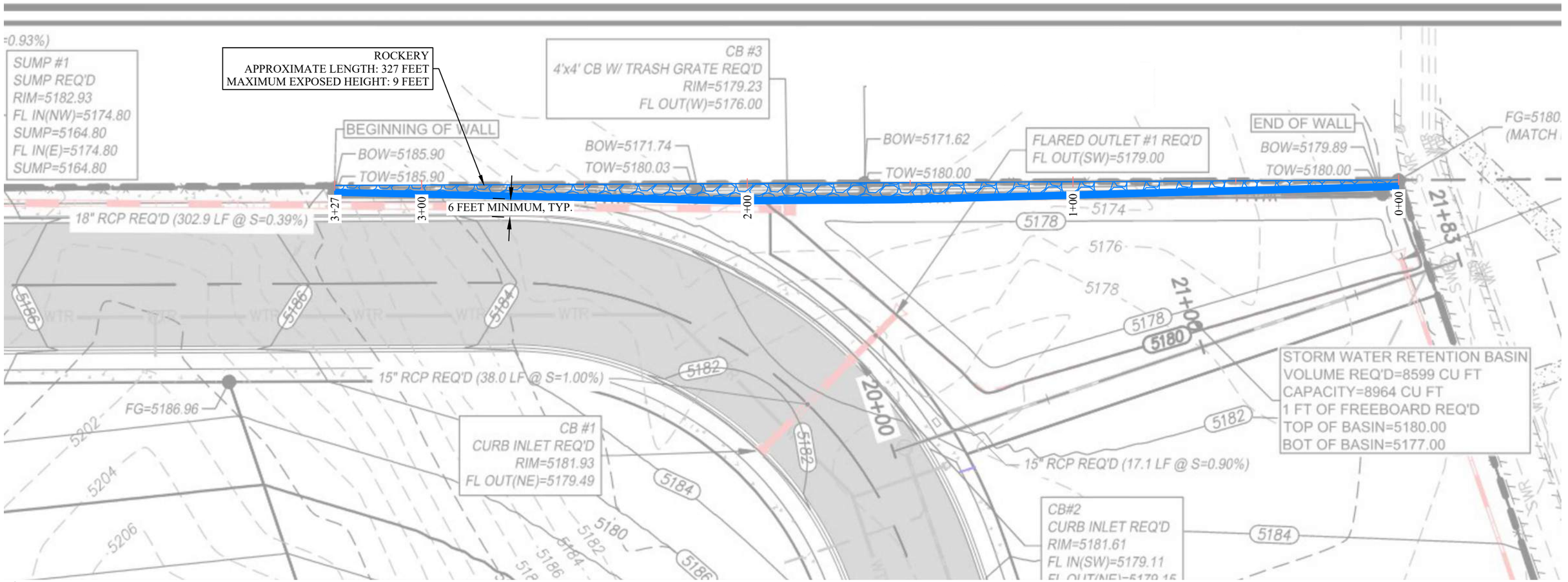
REV	REVISION DESCRIPTION	DATE	BY	CHK
	REVISIONS			

IGES EST. 1998
12429 SOUTH 300 EAST
DRAPER, UTAH 84020
(801) 748-4044

ROCKERY
LIGHTHOUSE HEIGHTS SUBDIVISION
ELK RIDGE, UTAH

COVER SHEET

DESIGNED BY:	DHB	6-27-2022	PLOT SCALE 1=1
DRAWN BY:	DHB	6-27-2022	
CHECKED BY:	BMJ	6-27-2022	DWG SCALE 1"=100'
APPROVED BY:	BMJ	6-27-2022	
IGES PROJECT NO: 02158-117	SHEET NO: 1		REV N/A



N

APPROXIMATE EXTENT OF ROCKERY BATTER

APPROXIMATE EXTENT OF TOP BOULDER IN ROCKERY

0 6 12 18 30 60

SCALE: 1" = 30'

PLAN VIEW

REFERENCE IMAGE PROVIDED BY PEPG CONSULTING, LIGHTHOUSE HEIGHTS SUBDIVISION, GRADING & DRAINAGE PLAN, SHEET C4.0, DATED SEPTEMBER 1, 2021.

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PLAN VIEW

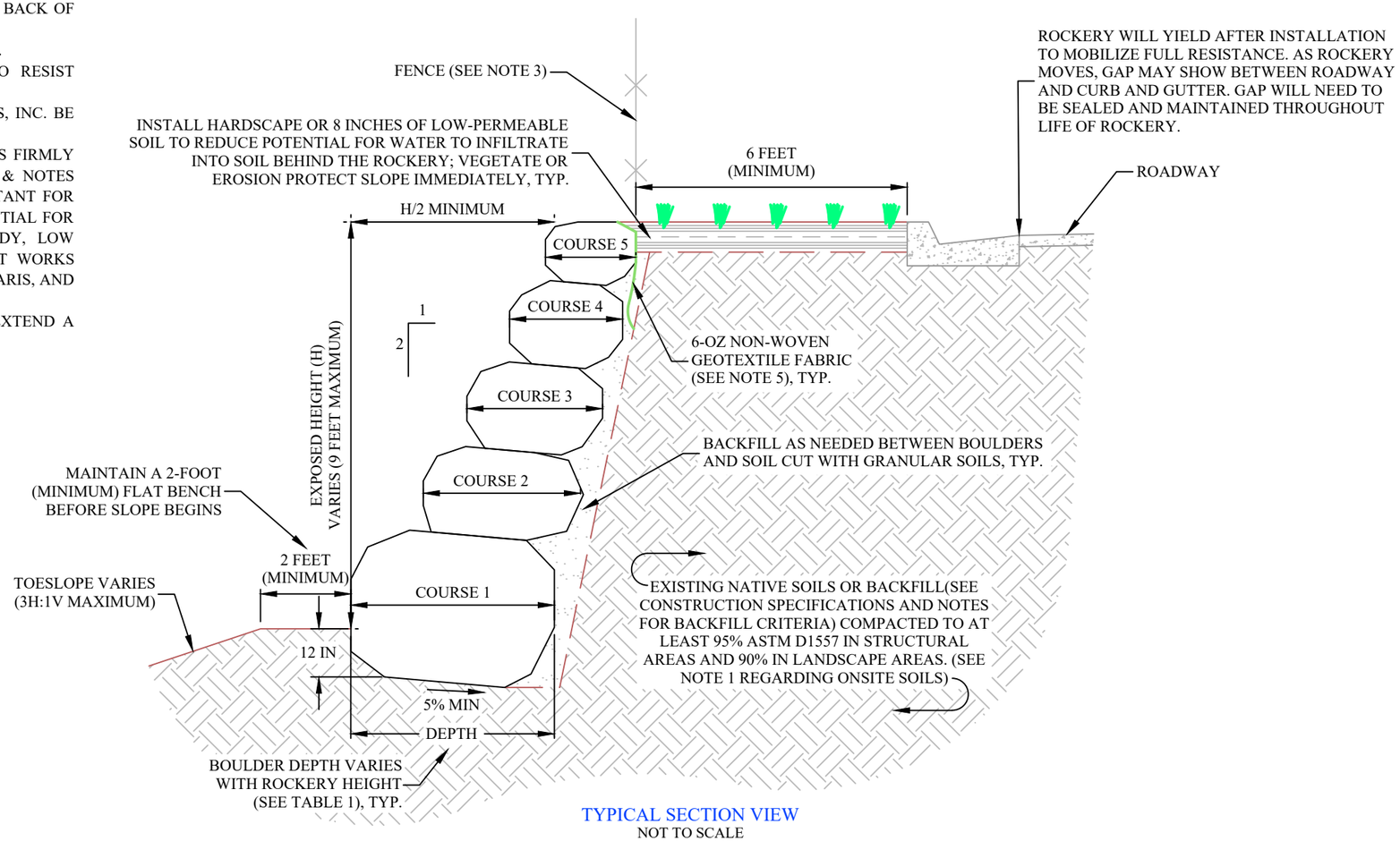
DESIGNED BY: DHB	6-27-2022	PLOT SCALE	1=1
DRAWN BY: DHB	6-27-2022		
CHECKED BY: BMJ	6-27-2022	DWG SCALE	1"=30'
APPROVED BY: BMJ	6-27-2022		
IGES PROJECT NO: 02158-117	SHEET NO: 2	REV	N/A

SECTION VIEW NOTES:

1. SOIL CUT SHOULD BE BENCHED AS NEEDED TO PROTECT WORKERS AND TO COMPLY WITH OSHA REQUIREMENTS.
2. ROCKERIES ARE VULNERABLE TO EROSION AND HYDROSTATIC PRESSURES IMMEDIATELY AFTER INSTALLATION BUT PRIOR TO THE PLACEMENT OF LANDSCAPING/FINISHING ELEMENTS (E.G., LANDSCAPING, HARDSCAPE, CURB & GUTTER, PAVEMENT, ETC.). TO PREVENT DAMAGE TO THE ROCKERY DURING ADDITIONAL SITE WORK, ALL SURFACE DRAINAGE SHOULD BE DIRECTED AWAY FROM THE ROCKERY. EXCESS WATER DURING HEAVY PRECIPITATION EVENTS, IF NOT DRAINED PROPERLY, CAN CAUSE WASHOUTS AT ROCKERY ENDS AND 'BLOWOUTS' OF INTERIOR SECTIONS. THESE PRECAUTIONS SHOULD BE TAKEN DURING AND AFTER ROCKERY CONSTRUCTION, UNTIL THE FINAL SITE DRAINAGE AND LANDSCAPING ARE COMPLETE.
3. WE RECOMMEND THAT AN APPROPRIATE SAFETY FENCE/BARRICADE BE CONSIDERED BY THE OWNER ABOVE THE ROCKERY. DESIGN OF THE FENCE/BARRICADE IS SPECIFICALLY EXCLUDED FROM THIS ENGINEERING. IF THE FENCE POST WILL BE PLACED WITHIN 3 FEET OF THE BACK OF THE BOULDERS, COMPLY WITH THE FOLLOWING RECOMMENDATIONS:
   - 3.1. IF CHAIN LINK FENCE OR RAILING, EXTEND POST A MINIMUM DEPTH OF 36 INCHES.
   - 3.2. IF VINYL, WOOD, PRECAST (OR SIMILAR), USE SLEEVE-IT TYPE SYSTEM TO RESIST OVERTURNING MOMENT OF FENCE SYSTEM.
   - 3.3. WE RECOMMEND THAT ONCE THE FENCING SYSTEM IS DETERMINED THAT IGES, INC. BE CONTACTED TO ACCESS THE IMPACT OF THE FENCE ON THE ROCKERY.
4. ROCKERIES HAVE SOIL PLACED BETWEEN BOULDERS TO ENSURE THAT THE BOULDERS FIRMLY REST ON AT LEAST TWO BOULDERS BENEATH (SEE CONSTRUCTION SPECIFICATIONS & NOTES SHEET FOR DETAILS). KEEPING THE SOIL FROM ERODING AWAY OVER TIME IS IMPORTANT FOR LONG-TERM STABILITY AS WELL AS AESTHETIC REASONS. TO HELP REDUCE THE POTENTIAL FOR THIS SOIL TO ERODE, WE RECOMMEND THAT THE SOIL BE PLANTED WITH HARDY, LOW MAINTENANCE, DROUGHT-TOLERANT VEGETATION. EXAMPLES OF VEGETATION THAT WORKS WELL WITH ROCKERIES INCLUDE SEDUM, AUBRIETA, SEMPERVIVUM, PULSATILLA VULGARIS, AND DIANTHUS.
5. INSTALL 6-OZ NON-WOVEN GEOTEXTILE FABRIC BEHIND THE UPPER BOULDER AND EXTEND A MINIMUM OF 4 INCHES BELOW THE TOP OF SECOND BOULDER DOWN.

TABLE 1
MINIMUM BOULDER DEPTH SCHEDULE

COURSE	BOULDER SIZE (DEPTH) FOR EACH COURSE (COURSE 1 IS BOTTOM COURSE) FOR VARIOUS EXPOSED WALL HEIGHTS (H) [ADD 1-FOOT MINIMUM EMBEDMENT FOR ALL ROCKERY SECTIONS]					
	9-FOOT ROCKERY	8-FOOT ROCKERY	7-FOOT ROCKERY	6-FOOT ROCKERY	5-FOOT ROCKERY	4 FOOT ROCKERY OR LESS
5	2.0 FEET	-	-	-	-	-
4	2.5 FEET	2.0 FEET	2.0 FEET	2.0 FEET	-	-
3	3.0 FEET	2.5 FEET	2.5 FEET	2.0 FEET	2.0 FEET	2.0 FEET
2	3.0 FEET	3.0 FEET	2.5 FEET	2.5 FEET	2.5 FEET	2.0 FEET
1	3.5 FEET	3.5 FEET	3.0 FEET	3.0 FEET	3.0 FEET	3.0 FEET



TYPICAL SECTION VIEW
NOT TO SCALE

REV	REVISION DESCRIPTION	DATE	BY	CHK

REVISIONS

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ROCKERY
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TYPICAL SECTION VIEW

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DRAWN BY:	DHB	6-27-2022	
CHECKED BY:	BMJ	6-27-2022	DWG SCALE NTS
APPROVED BY:	BMJ	6-27-2022	
IGES PROJECT NO: 02158-117		SHEET NO: 3	REV N/A

PROFESSIONAL ENGINEER
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ELECTRONIC SEAL
STATE OF UTAH

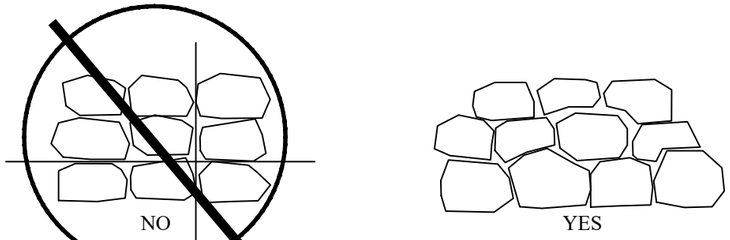
ROCKERY CONSTRUCTION SPECIFICATIONS:

1. GENERAL
   - 1.1. DESIGN AND CONSTRUCTION INFORMATION IS BASED ON SITE GEOMETRY, THE REFERENCED CONSTRUCTION PLAN AND THE ENGINEERING ANALYSIS PERFORMED AS PART OF THE SCOPE OF WORK FOR THIS PROJECT.
   - 1.2. LOCATE AND FULLY RESOLVE ALL CONFLICTS WITH EXISTING AND/OR PROPOSED UTILITIES PRIOR TO ROCKERY CONSTRUCTION.
   - 1.3. COMPLY WITH ALL ASPECTS OF OSHA 1926 SUBPART P APP B, SLOPING AND BENCHING FOR ALL EXCAVATED SLOPES.
   - 1.4. IMPLEMENT THE FOLLOWING MEASURES TO REDUCE THE POTENTIAL FOR HYDROSTATIC PRESSURES TO BUILDUP BEHIND THE ROCKERY:
     - 1.4.1. ESTABLISH HARDSCAPE OR LOW-PERMEABLE SOIL ABOVE ROCKERY AS SHOWN ON TYPICAL SECTION VIEW. BEFORE FINAL LANDSCAPING ELEMENTS ARE COMPLETED AT THE SITE, VEGETATION OR EROSION CONTROL MEASURES MUST BE INSTALLED ABOVE AND BELOW THE ROCKERY IMMEDIATELY FOLLOWING CONSTRUCTION.
     - 1.4.2. INSTALL 6-OZ (MINIMUM) NON-WOVEN GEOTEXTILE FABRIC AS SHOWN IN THE TYPICAL SECTION VIEW TO REDUCE POTENTIAL FOR EROSION AND DRAINAGE CHANNELS TO FORM.
   - 1.5. CONDITIONS SUCH AS LEAKY OR BROKEN IRRIGATION LINES AND/OR UNCONTROLLED RUNOFF FROM IMPROPER SITE GRADING CAN LEAD TO UNDERMINING OR HYDROSTATIC PRESSURES BUILDING UP BEHIND THE ROCKERY, WHICH CAN LEAD TO SLOPE OR BOULDER MOVEMENT.
     - 1.5.1. HYDROSTATIC PRESSURES WERE NOT CONSIDERED IN THE ANALYSIS OF THE ROCKERY AND MUST BE AVOIDED.
     - 1.5.2. ROCKERIES ARE VULNERABLE TO EROSION AND HYDROSTATIC PRESSURES IMMEDIATELY AFTER INSTALLATION BUT PRIOR TO THE PLACEMENT OF THE FINISHING LANDSCAPING ELEMENTS (E.G., LOW-PERMEABLE SOIL OR HARDSCAPE). AS THESE ELEMENTS ARE CRITICAL TO THE OVERALL STABILITY OF THE ROCKERY, THE ROCKERY ARE NOT CONSIDERED COMPLETE UNTIL THEY ARE IN PLACE.
     - 1.5.3. THE OWNER SHALL BE AWARE OF THE RISKS IF THESE OR OTHER CONDITIONS OCCUR THAT COULD SATURATE OR ERODE THE SOIL BEHIND THE ROCKERY OR IF THE FINISHING/LANDSCAPING ELEMENTS ARE NOT INSTALLED IMMEDIATELY FOLLOWING THE INSTALLATION OF THE ROCKERY.
2. MATERIALS
   - 2.1. RETAINED BACKFILL SOILS
     - 2.1.1. APPROVED IMPORTED GRANULAR BACKFILL BORROW OR APPROVED NATIVE SOILS THAT HAVE BEEN SCREENED AND PROCESSED COMPLYING WITH THE FOLLOWING CRITERIA:
       - 2.1.1.1. GRANULAR MATERIALS CONTAINING LESS THEN 35% FINES
       - 2.1.1.2. MAXIMUM NOMINAL PARTICLE SIZE OF 4 INCHES
       - 2.1.1.3. PI OF 6 OR LESS, pH GREATER THAN 3 BUT LESS THAN 9
       - 2.1.1.4. REASONABLY FREE FROM ORGANIC OR OTHER DELETERIOUS MATERIALS
       - 2.1.1.5. MINIMUM EFFECTIVE FRICTION ANGLE OF 32 DEGREES
   - 2.2. USE DURABLE ANGULAR BOULDERS WITH A MINIMUM NOMINAL DIAMETER OF 24 INCHES. MEET ALL MINIMUM DIAMETERS IN ACCORDANCE WITH DESIGN DRAWINGS. ROCKS SHOULD FOLLOW FHWA GUIDELINES:
     - 2.2.1. USE ROCKS THAT ARE HARD, ANGULAR, DURABLE, AND ABLE TO RESIST PHYSICAL, CLIMATIC, AND CHEMICAL DECOMPOSITION.
     - 2.2.2. USE ROCKS THAT ARE ROUGHLY RECTANGULAR, TABULAR, OR CUBIC IN SHAPE; ROUNDED ROCKS AND COBBLES SHOULD NOT BE USED.
     - 2.2.3. ROCKS SHOULD CONSIST OF INTACT BLOCKS WITHOUT OPEN FRACTURES, FOLIATION, OR OTHER PLANES OF WEAKNESS
   - 2.3. GEOTEXTILE FABRIC
     - 2.3.1. 6-OZ. MINIMUM NON-WOVEN
3. INSTALLATION
   - 3.1. ROCKS SHOULD BE STACKED IN GENERAL ACCORDANCE WITH THE ASSOCIATED ROCKERY CONTRACTORS (ARC) AND FHWA ROCKERY CONSTRUCTION GUIDELINES. ARC GUIDELINES ARE GIVEN ON THIS SHEET (SEE GUIDELINES TO THE RIGHT). FHWA GUIDELINES ARE SUMMARIZED AS FOLLOWS:
     - 3.1.1. EACH ROCK SHOULD BEAR ON AT LEAST TWO OTHER ROCKS
     - 3.1.2. EACH ROCK SHOULD HAVE AT LEAST THREE BEARING POINTS - TWO IN FRONT AND ONE IN BACK
     - 3.1.3. THE FRONT-MOST BEARING POINTS FOR EACH ROCK SHOULD BE WITHIN 6 INCHES OF THE AVERAGE FACE OF THE ROCKERY
     - 3.1.4. THE REAR OF THE ROCKS SHOULD BE ALIGNED ALONG AN IMAGINARY VERTICAL PLANE. IF ROCKS LARGER THAN THE MINIMUM SPECIFIED DIAMETERS ARE USED, THEY CAN EXTEND BEYOND THIS IMAGINARY PLANE PROVIDED THEY DO NOT INTERFERE WITH ROCKERY DRAINAGE
     - 3.1.5. THE TOPS OF EACH ROCK SHOULD BE SLOPED BACK AT LEAST 5% TOWARDS THE BACK OF THE ROCKERY
     - 3.1.6. ROCK FACING SHOULD BE STACKED AT A MAXIMUM STEEPNESS OF 1 HORIZONTAL TO 2 VERTICAL
     - 3.1.7. THE BOTTOM ROW OF ROCKS SHOULD BE BURIED (EMBEDDED) A MINIMUM DEPTH OF 12 INCHES FOR ALL ROCKERIES.
   - 3.2. PLACE ROCKERY BACKFILL MATERIAL IN 12-INCH MAXIMUM LOOSE LIFTS AND COMPACT TO A MINIMUM OF 95 PERCENT OF ASTM D1557 (MODIFIED PROCTOR) IN STRUCTURAL AREAS AND 90 PERCENT IN LANDSCAPE AREAS. THINNER LIFTS MAY BE NECESSARY TO ACHIEVE REQUIRED COMPACTION.
     - 3.2.1. PERFORM DENSITY TESTING OF THE BACKFILL SOILS AT 50-FOOT INTERVALS ON EVERY LIFT.
     - 3.2.2. USE ONLY SMALL, WALK-BEHIND TYPE COMPACTION EQUIPMENT WITHIN 3 FEET OF THE BACK OF THE ROCKERY BOULDERS.
     - 3.2.3. IF ANY LOCATIONS EXIST WHERE THE ROCKERY WILL NOT BE PLACED UPON NATIVE SOILS, COMPACT THE FILL TO A MINIMUM OF 95 PERCENT OF ASTM D1557.
   - 3.3. INSTALL 6-OZ NON-WOVEN GEOTEXTILE FABRIC BEHIND THE UPPER BOULDER AS SHOWN ON THE TYPICAL SECTION VIEW SHEET.
4. CONSTRUCTION OBSERVATION
   - 4.1. TO FULFILL ANY APPLICABLE CITY, COUNTY AND/OR STATE AGENCY REQUIREMENTS, AND TO PROTECT THE CONTRACTOR AND DESIGN ENGINEER, IGES, INC., MUST PERFORM PERIODIC CONSTRUCTION OBSERVATIONS.
     - 4.1.1. IF IGES, INC. DOES NOT OBSERVE THE ROCKERY DURING CONSTRUCTION, A FINAL LETTER REGARDING COMPLIANCE OF THE ROCKERY CONSTRUCTION WITH THE DESIGN CRITERIA AND RECOMMENDATIONS CANNOT BE PROVIDED. IF IGES, INC., DOES NOT PERFORM THE PERIODIC CONSTRUCTION OBSERVATIONS OUTLINED ON THIS SHEET, THE ROCKERY CONTRACTOR/OWNER ASSUMES ALL RESPONSIBILITY FOR THE ROCKERY.
   - 4.2. ROCKERY OBSERVATION SCHEDULE:
     - 4.2.1. OBSERVE AND ASSESS THE SUITABILITY OF THE OF THE FOUNDATION BEARING SOILS.
     - 4.2.2. ASSESS THE MINIMUM EMBEDMENT REQUIREMENTS ARE MET.
     - 4.2.3. OBSERVE THE SIZE, POSITION, BATTER, AND PLACEMENT FOR EACH COURSE OF BOULDERS.
     - 4.2.4. OBSERVE THE PLACEMENT OF RETAINED FILL SOILS. OBSERVE THE COMPACTION OF THE RETAINED FILL AND ASSESS WHETHER MINIMUM COMPACTION REQUIREMENTS ARE MET.
     - 4.2.5. OBSERVE THE COMPLETED ROCKERY TO ASSESS FINISHED ROCKERY WALL HEIGHTS, BATTER, BACKSLOPE AND TOESLOPE GRADING CONDITIONS, AND THE SUITABILITY OF EROSION CONTROL MEASURES INSTALLED ABOVE AND BELOW THE ROCKERY.
     - 4.2.6. ALL BACKFILL SOILS CONSISTING OF FREE DRAINING GRANULAR SOILS.
     - 4.2.7. THE CONTRACTOR IS RESPONSIBLE FOR ARRANGING THE CONSTRUCTION OBSERVATIONS AND QUALITY CONTROL.

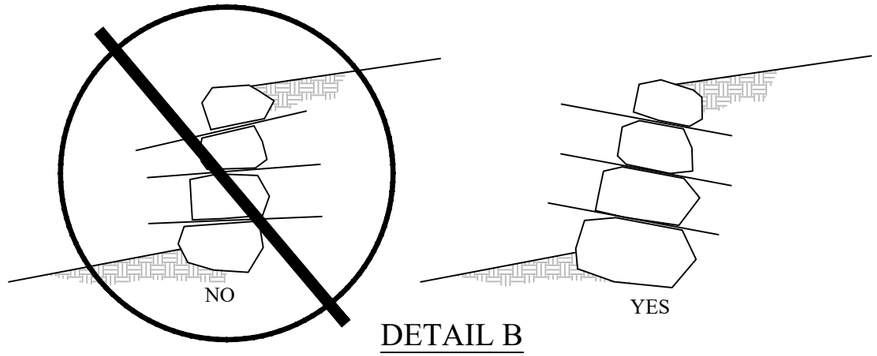
ROCK STACKING CONSTRUCTION GUIDELINES:

ROCKS SHOULD BE STACKED IN GENERAL ACCORDANCE WITH FHWA AND THE ASSOCIATED ROCKERY CONTRACTORS (ARC) ROCKERY CONSTRUCTION GUIDELINES, SUMMARIZED AS FOLLOWS:

- ROCKS SHOULD BE PLACED SO THAT THERE ARE NO CONTINUOUS JOINT PLANES IN EITHER THE VERTICAL OR LATERAL DIRECTION (SEE DETAIL A)
- WHEREVER POSSIBLE, EACH ROCK SHOULD BEAR ON AT LEAST TWO ROCKS BELOW IT
- THE UPPER PLANE OF EACH ROCK BETWEEN COURSES (THE TOP SURFACE OF ROCK), SHOULD SLOPE BACK TOWARDS THE SLOPE FACE AND AWAY FROM THE FACE OF THE ROCKERY (SEE DETAIL B)



DETAIL A



DETAIL B

PROFESSIONAL ENGINEER
7885637-2202
BRADLEY M. JOHNSON
06/27/2022
ELECTRONIC SEAL
STATE OF UTAH

REV	REVISION DESCRIPTION	DATE	BY	CHK
	REVISIONS			

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12429 SOUTH 300 EAST
DRAPER, UTAH 84020
(801) 748-4044

ROCKERY
LIGHTHOUSE HEIGHTS SUBDIVISION
ELK RIDGE, UTAH

CONSTRUCTION SPECIFICATIONS & NOTES

DESIGNED BY:	DHB	6-27-2022	PLOT SCALE	1=1
DRAWN BY:	DHB	6-27-2022		
CHECKED BY:	BMJ	6-27-2022	DWG SCALE	NTS
APPROVED BY:	BMJ	6-27-2022		
IGES PROJECT NO: 02158-117		SHEET NO: 4	REV	N/A

ROCKERY GEOMETRY AND LOADING CONDITIONS			
LENGTH (FEET)	MAXIMUM EXPOSED HEIGHT (FEET)	BACKSLOPE CONDITIONS	SURCHARGE LOADING
327	9	RELATIVELY FLAT	250 PSF (ROADWAY)

SOIL CONDITIONS USED IN DESIGN (ASSUMED)			
EARTH MATERIALS	FRICTION ANGLE	COHESION	UNIT WEIGHT
RETAINED SOIL	32°	100 PSF	125 PCF
FOUNDATION SOIL	32°	100 PSF	125 PCF

NOTES:
1. IGES, 2022, SITE OBSERVATIONS MADE ON JUNE 20, 2022.
2. COHESION USED DURING GLOBAL STABILITY ANALYSES ONLY.

GENERAL NOTES:

1. THE ENGINEERING PRESENTED IN THIS DESIGN PACKAGE IS BASED ON SPECIFIC PRODUCTS (E.G., COMPETENT/DURABLE BOULDERS, SOIL STRENGTHS GIVEN ABOVE, GEOMETRY AND LOADING CONDITIONS GIVEN IN THE TABLE ABOVE, ETC.). ANY SUBSTITUTION OF THE SPECIFIED PRODUCTS WILL INVALIDATE THIS ENGINEERING. ANY CHANGES IN ROCKERY LOCATION, GRADES AT THE TOE OR TOP OF THE ROCKERY, ROCKERY HEIGHTS, AND SOIL PARAMETERS AT THE SITE WILL ALSO INVALIDATE THE ENGINEERING. FIELD ADJUSTMENTS/CHANGES MAY BE NEEDED TO MEET ACTUAL CONDITIONS ONCE CONSTRUCTION COMMENCES. IGES SHOULD BE CONSULTED WHERE FIELD CHANGES ARE REQUIRED.
2. THESE DOCUMENTS ARE INSTRUMENTS OF SERVICE AND SHALL REMAIN THE INTELLECTUAL PROPERTY OF IGES, INC. THE DESIGN PACKAGE HAS BEEN FURNISHED FOR THIS SPECIFIC PROJECT ONLY. ANY PARTY ACCEPTING THIS DOCUMENT DOES SO IN CONFIDENCE AND AGREES THAT NO USE OR RE-USE OF THESE DOCUMENTS (EITHER IN WHOLE OR IN PART) SHALL BE PERMITTED UNLESS EXPRESSLY AUTHORIZED IN WRITING BY IGES, INC.
3. ROCKERIES ARE VULNERABLE TO EROSION AND HYDROSTATIC PRESSURES IMMEDIATELY AFTER INSTALLATION BUT PRIOR TO THE PLACEMENT OF LANDSCAPING/FINISHING ELEMENTS AT THE SITE (E.G., LANDSCAPING, HARDSCAPE, CURB & GUTTER, PAVEMENT, ETC.). TO PREVENT DAMAGE TO THE ROCKERY DURING ADDITIONAL SITE WORK, ALL SURFACE DRAINAGE SHOULD BE DIRECTED AWAY FROM THE ROCKERY. EXCESS WATER DURING HEAVY RAIN EVENTS, IF NOT DRAINED PROPERLY, CAN CAUSE WASHOUTS AT ROCKERY ENDS AND 'BLOWOUTS' OF INTERIOR SECTIONS. THESE PRECAUTIONS SHOULD BE TAKEN DURING ROCKERY CONSTRUCTION, AND AFTER, UNTIL THE FINAL SITE DRAINAGE, LANDSCAPING AND PAVING ARE COMPLETE.

ENGINEERING ANALYSIS USED IN DESIGN	
ANALYSIS	DESIGN REFERENCES/SOFTWARE
EXTERNAL STABILITY	MACK, D.A., SANDERS, S.H. MILLHONE, W.L., FIPPIN, R.L., AND KENNEDY, D.G., 2006, ROCKERY DESIGN AND CONSTRUCTION GUIDLINES, SANDERS & ASSOCIATES GEOSTRUCTURAL ENGINEERING, INC., REPORT NO. FHEW-CFL/TD-06-006, REPORT DATED NOVEMBER, 2006
GLOBAL STABILITY	SLIDE 2 MODELER: ROCSCIENCE, INC., 1998-2022, VERSION 9.023; BUILD DATE MAY 25, 2022

SEISMIC PARAMETERS USED IN DESIGN		
SEISMIC CRITERIA	EXTERNAL & GLOBAL STABILITY	
	DESIGN PGA (As)	k_h
7% IN 75 YEARS	0.391g	0.163g (EXTERNAL) 0.196g (GLOBAL)

SOURCES & NOTES:
1. U.S. GEOLOGICAL SURVEY, U.S. SEISMIC DESIGNMAPS WEB APPLICATION, SITE: http://earthquake.usgs.gov/ws/designmaps, ACCESSED 6-22-2022.
2. SITE CLASS D WAS ASSUMED FOR THE ONSITE SOILS USING 2009 AASHTO GUIDE SPECIFICATIONS. AASHTO SPECIFICATIONS WERE USED AS RECOMMENDED IN THE FHWA ROCKERY DESIGN MANUAL.
3. A MAXIMUM ALLOWABLE SEISMIC DISPLACEMENT THRESHOLD OF 3.91 INCHES ($10*A_S$) WAS USED TO REDUCE THE HORIZONTAL SEISMIC ACCELERATION COEFFICIENT IN ACCORDANCE WITH AASHTO LRFD DESIGN MANUAL METHODOLOGY.
4. ONE-HALF OF THE DESIGN PGA (As) WAS USED TO MODEL THE HORIZONTAL SEISMIC ACCELERATION FOR GLOBAL STABILITY ANALYSES (k_h = 0.163g).

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APPROVED BY:	BMJ	6-27-2022		
IGES PROJECT NO: 02158-117		SHEET NO: 5	REV	N/A

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PHOTOS TAKEN DURING SITE OBSERVATION MADE ON JUNE 20, 2022

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SITE PHOTOS

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CHECKED BY: BMJ	6-27-2022	DWG SCALE NTS
APPROVED BY: BMJ	6-27-2022	
IGES PROJECT NO: 02158-117	SHEET NO: 6	REV N/A

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SECTION 2


PROFESSIONAL ENGINEER
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PROJECT: Elk Ridge Drive Rockery
PROJECT NO.: 02158-117
DATE: 6/22/2022

SECTION: 9-foot Exposed Rockery
SURCHARGE: Roadway

Rockery Geometry & Soil Data:

H_{total} =	10	ft	Total Height of Rockery
H_R =	9	ft	Exposed Height of Rockery
ϕ_s =	32	deg	Soil Friction Angle - Effective
c_s =	0	psf	Cohesion Intercept of soil
γ_s =	125	pcf	Unit weight of the soil
γ_R =	150	pcf	Unit weight of the rock
δ =	32.0	deg	Interface Friction Angle
ψ =	7.1	deg	Back Cut Inclination
μ =	0.70		Frictional Component
μ_{rock} =	0.55		Rock-to-Rock Friction
K_A =	0.226		Active Earth Pressure Coefficient
ν =	63.4	deg	Rockery Face Angle

Slope Geometry: Backslope: 1.0 H 0.0 V

Backslope: β_{eq} = 0.0 deg Eq. Backslope Angle

Soil Cut Angle: α = 82.9 deg Soil Cut Angle

Rockery Face Slope: 1 H 2 V

Broken Back Slope: N

Backslope Rise: 0 ft

Seismic Earth Pressure Coefficient: (Mack et al., 2006)

A =	0.391	Peak Ground Acceleration (7% in 75 years)
d =	3.9 in	(Allowable Displacement)
k_h =	0.163	Use 1/2 of A? N
k_v =	0	(If "N" then use displacement-factored k_h)
θ =	9.24	
K_{AE} =	0.343	

Failure Mechanism	FS Required	FS Obtained	OK
External Sliding	1.5	2.4	OK
External Overturning	2.0	3.8	OK
Individual Rock Overturning	2.0	5.1	OK
Individual Rock Sliding	1.5	2.3	OK
Bearing Capacity	2.0	2.6	OK
Seismic Overturning	1.5	1.6	OK
Seismic Sliding	1.1	1.3	OK
Seismic Bearing Capacity	1.5	2.6	OK

Surcharge:

Uniform: Uniform Applied Surcharge

q_s =	0	psf	
F_s =	0	lbf/ft	(Horizontal Surcharge Load)
y_s =	5	ft	(Surcharge load centroid)

Strip: Strip Load Surcharge

q_s =	250	psf	
x_s =	6	ft	(Distance from soil cut)
W_s =	12	ft	(Width of Strip Load)

F_s = 90 lbf/ft (Horizontal Surcharge Load)

y_s = 2.0 ft

Factor of Safety against Bearing Capacity:

e_{max} =	0.583	q_{max} =	2,540	psf	$e_{s,s}$ =	0.507	FS_{BC} = 2.7
e_s =	-0.553	q_{ult} =	6,691	psf	$q_{max,s}$ =	2,602	$FS_{BC,s}$ = 2.6

Eccentricity Check (static): **OK**

Eccentricity Check (seismic): **OK**

Rocks = 5 (R* - Boulder Height to Width Ratio)

Boulder	B' (ft)	R*	H_R (ft)	H-H' (ft)	ΣW_i	$\Sigma W_i * x_i$	F_H	$F_{H,s}$	F_μ	$F_{\mu,s}$	M_o	$M_{o,s}$	M_r	$M_{r,s}$	FS_{SL}	FS_{OT}	$FS_{SL,S}$	$FS_{OT,S}$
1	3.5	0.7	2.5	10.0	3,970	14,146	1,369	2,799	3,194	3,448	4,351	11,955	16,469	18,010	2.4	3.8	1.3	1.6
2	3.0	0.7	2.2	7.5	2,776	8,147	769	1,667	1,713	1,826	1,849	5,435	9,267	10,004	2.3	5.1	1.1	1.9
3	3.0	0.7	2.2	5.3	1,860	4,200	363	888	1,116	1,172	644	2,084	4,743	5,093	3.1	7.4	1.4	2.5
4	2.5	0.7	1.7	3.1	944	1,527	123	353	551	570	128	492	1,678	1,774	4.5	>10	1.7	3.7
5	2.0	0.7	1.4	1.4	362	362	24	98	205	209	11	64	386	400	8.5	>10	2.2	6.3
6	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

10.0 Total Estimated Height of Rockery

(See Mack, et. al [2006], Rockery Design and Construction Guidelines, Report No. FHWA-CFL/TD-06-006, Report Dated November 2006 - for term definitions and equations)

PROJECT: Elk Ridge Drive Rockery
PROJECT NO.: 02158-117
DATE: 6/22/2022

SECTION: 8-foot Exposed Rockery
SURCHARGE: Roadway

Rockery Geometry & Soil Data:

H_{total} =	9	ft	Total Height of Rockery
H_R =	8	ft	Exposed Height of Rockery
ϕ_s =	32	deg	Soil Friction Angle - Effective
c_s =	0	psf	Cohesion Intercept of soil
γ_s =	125	pcf	Unit weight of the soil
γ_R =	150	pcf	Unit weight of the rock
δ =	32.0	deg	Interface Friction Angle
ψ =	7.1	deg	Back Cut Inclination
μ =	0.70		Frictional Component
μ_{rock} =	0.55		Rock-to-Rock Friction
K_A =	0.226		Active Earth Pressure Coefficient
ν =	63.4	deg	Rockery Face Angle

Slope Geometry: Backslope: 1.0 H 0.0 V

Backslope: β_{eq} = 0.0 deg Eq. Backslope Angle

Soil Cut Angle: α = 82.9 deg Soil Cut Angle

Rockery Face Slope: 1 H 2 V

Broken Back Slope: N

Backslope Rise: 0 ft

Seismic Earth Pressure Coefficient: (Mack et al., 2006)

A =	0.391	Peak Ground Acceleration (7% in 75 years)
d =	3.9 in	(Allowable Displacement)
k_h =	0.163	Use 1/2 of A? N
k_v =	0	(If "N" then use displacement-factored k_h)
θ =	9.24	
K_{AE} =	0.343	

Failure Mechanism	FS Required	FS Obtained	OK
External Sliding	1.5	2.6	OK
External Overturning	2.0	4.2	OK
Individual Rock Overturning	2.0	6.0	OK
Individual Rock Sliding	1.5	2.7	OK
Bearing Capacity	2.0	3.3	OK
Seismic Overturning	1.5	1.7	OK
Seismic Sliding	1.1	1.3	OK
Seismic Bearing Capacity	1.5	3.3	OK

Surcharge:

Uniform: Uniform Applied Surcharge

q_s =	0	psf	
F_s =	0	lbf/ft	(Horizontal Surcharge Load)
y_s =	4.5	ft	(Surcharge load centroid)

Strip: Strip Load Surcharge

q_s =	250	psf	
x_s =	6	ft	(Distance from soil cut)
W_s =	10	ft	(Width of Strip Load)

F_s = 63 lbf/ft (Horizontal Surcharge Load)

y_s = 1.5 ft

Factor of Safety against Bearing Capacity:

e_{max} =	0.583	q_{max} =	2,017	psf	$e_{s,s}$ =	0.450	FS_{BC} = 3.5
e_s =	-0.451	q_{ult} =	6,959	psf	$q_{max,s}$ =	2,143	$FS_{BC,s}$ = 3.3

Eccentricity Check (static): **OK**

Eccentricity Check (seismic): **OK**

Rocks = 4 (R* - Boulder Height to Width Ratio)

Boulder	B' (ft)	R*	H_R (ft)	H-H' (ft)	ΣW_i	$\Sigma W_i * x_i$	F_H	$F_{H,s}$	F_μ	$F_{\mu,s}$	M_o	$M_{o,s}$	M_r	$M_{r,s}$	FS_{SL}	FS_{OT}	$FS_{SL,S}$	$FS_{OT,S}$
1	3.5	0.8	2.8	9.0	3,502	11,175	1,089	2,303	2,784	2,988	3,107	8,729	13,017	14,230	2.6	4.2	1.3	1.7
2	3.0	0.8	2.5	6.2	2,137	5,170	488	1,132	1,299	1,374	993	3,055	5,901	6,377	2.7	6.0	1.3	2.1
3	2.5	0.8	2.1	3.7	1,122	1,913	174	464	662	689	214	767	2,128	2,265	3.8	10.0	1.5	3.0
4	2.0	0.8	1.6	1.6	431	431	34	126	246	251	19	97	464	484	7.2	>10	2.0	5.0
5	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

9.0 Total Estimated Height of Rockery

(See Mack, et. al [2006], Rockery Design and Construction Guidelines, Report No. FHWA-CFL/TD-06-006, Report Dated November 2006 - for term definitions and equations)

PROJECT: Elk Ridge Drive Rockery
PROJECT NO.: 02158-117
DATE: 6/22/2022

SECTION: 7-foot Exposed Rockery
SURCHARGE: Roadway

Rockery Geometry & Soil Data:

H_{total} =	8	ft	Total Height of Rockery
H_R =	7	ft	Exposed Height of Rockery
ϕ_s =	32	deg	Soil Friction Angle - Effective
c_s =	0	psf	Cohesion Intercept of soil
γ_s =	125	pcf	Unit weight of the soil
γ_R =	150	pcf	Unit weight of the rock
δ =	32.0	deg	Interface Friction Angle
ψ =	7.1	deg	Back Cut Inclination
μ =	0.70		Frictional Component
μ_{rock} =	0.55		Rock-to-Rock Friction
K_A =	0.226		Active Earth Pressure Coefficient
ν =	63.4	deg	Rockery Face Angle

Slope Geometry: Backslope: 1.0 H 0.0 V

Backslope: β_{eq} = 0.0 deg Eq. Backslope Angle

Soil Cut Angle: α = 82.9 deg Soil Cut Angle

Rockery Face Slope: 1 H 2 V

Broken Back Slope: N

Backslope Rise: 0 ft

Seismic Earth Pressure Coefficient: (Mack et al., 2006)

A =	0.391	Peak Ground Acceleration (7% in 75 years)
d =	3.9 in	(Allowable Displacement)
k_h =	0.163	Use 1/2 of A? N
k_v =	0	(If "N" then use displacement-factored k_h)
θ =	9.24	
K_{AE} =	0.343	

Failure Mechanism	FS Required	FS Obtained	OK
External Sliding	1.5	2.6	OK
External Overturning	2.0	4.3	OK
Individual Rock Overturning	2.0	6.5	OK
Individual Rock Sliding	1.5	2.8	OK
Bearing Capacity	2.0	3.0	OK
Seismic Overturning	1.5	1.7	OK
Seismic Sliding	1.1	1.4	OK
Seismic Bearing Capacity	1.5	3.4	OK

Surcharge:

Uniform: Uniform Applied Surcharge

q_s =	0	psf	
F_s =	0	lbf/ft	(Horizontal Surcharge Load)
y_s =	4	ft	(Surcharge load centroid)

Strip: Strip Load Surcharge

q_s =	250	psf				
x_s =	6	ft	(Distance from soil cut)	F_s =	34	lbf/ft (Horizontal Surcharge Load)
W_s =	8	ft	(Width of Strip Load)	y_s =	1.0	ft

Factor of Safety against Bearing Capacity:

e_{max} =	0.500	q_{max} =	2,078	psf	$e_{s,s}$ =	0.340	FS_{BC}	3.0
e_s =	-0.497	q_{ult} =	6,191	psf	$q_{max,s}$ =	1,860	$FS_{BC,s}$	3.4

Eccentricity Check (static): **OK**

Eccentricity Check (seismic): **OK**

Rocks = 4 (R* - Boulder Height to Width Ratio)

Boulder	B' (ft)	R*	H_R (ft)	H-H' (ft)	ΣW_i	$\Sigma W_i * x_i$	F_H	$F_{H,s}$	F_μ	$F_{\mu,s}$	M_o	$M_{o,s}$	M_r	$M_{r,s}$	FS_{SL}	FS_{OT}	$FS_{SL,S}$	$FS_{OT,S}$
1	3.0	0.8	2.5	8.0	2,746	7,931	843	1,801	2,185	2,346	2,161	6,151	9,181	10,006	2.6	4.3	1.4	1.7
2	2.5	0.8	1.9	5.4	1,707	3,925	377	886	1,035	1,094	683	2,151	4,402	4,713	2.8	6.5	1.3	2.2
3	2.5	0.8	1.9	3.6	1,074	1,831	162	435	632	657	192	694	2,029	2,156	4.0	>10	1.6	3.2
4	2.0	0.8	1.7	1.7	441	441	36	130	252	257	20	103	476	497	7.0	>10	2.0	4.9
5	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

8.0 Total Estimated Height of Rockery

(See Mack, et. al [2006], Rockery Design and Construction Guidelines, Report No. FHWA-CFL/TD-06-006, Report Dated November 2006 - for term definitions and equations)

PROJECT: Elk Ridge Drive Rockery
PROJECT NO.: 02158-117
DATE: 6/22/2022

SECTION: 6-foot Exposed Rockery
SURCHARGE: Roadway

Rockery Geometry & Soil Data:

H_{total} =	7	ft	Total Height of Rockery
H_R =	6	ft	Exposed Height of Rockery
ϕ_s =	32	deg	Soil Friction Angle - Effective
c_s =	0	psf	Cohesion Intercept of soil
γ_s =	125	pcf	Unit weight of the soil
γ_R =	150	pcf	Unit weight of the rock
δ =	32.0	deg	Interface Friction Angle
ψ =	7.1	deg	Back Cut Inclination
μ =	0.70		Frictional Component
μ_{rock} =	0.55		Rock-to-Rock Friction
K_A =	0.226		Active Earth Pressure Coefficient
ν =	63.4	deg	Rockery Face Angle

Slope Geometry: Backslope: 1.0 H 0.0 V

Backslope: β_{eq} = 0.0 deg Eq. Backslope Angle

Soil Cut Angle: α = 82.9 deg Soil Cut Angle

Rockery Face Slope: 1 H 2 V

Broken Back Slope: N

Backslope Rise: 0 ft

Seismic Earth Pressure Coefficient: (Mack et al., 2006)

A =	0.391	Peak Ground Acceleration (7% in 75 years)
d =	3.9 in	(Allowable Displacement)
k_h =	0.163	Use 1/2 of A? N
k_v =	0	(If "N" then use displacement-factored k_h)
θ =	9.24	
K_{AE} =	0.343	

Failure Mechanism	FS Required	FS Obtained	OK
External Sliding	1.5	2.9	OK
External Overturning	2.0	4.9	OK
Individual Rock Overturning	2.0	6.8	OK
Individual Rock Sliding	1.5	2.9	OK
Bearing Capacity	2.0	4.0	OK
Seismic Overturning	1.5	1.9	OK
Seismic Sliding	1.1	1.4	OK
Seismic Bearing Capacity	1.5	4.6	OK

Surcharge:

Uniform: Uniform Applied Surcharge

q_s =	0	psf	
F_s =	0	lbf/ft	(Horizontal Surcharge Load)
y_s =	3.5	ft	(Surcharge load centroid)

Strip: Strip Load Surcharge

q_s =	250	psf	
x_s =	6	ft	(Distance from soil cut)
W_s =	6	ft	(Width of Strip Load)

F_s = 14 lbf/ft (Horizontal Surcharge Load)

y_s = 0.5 ft

Factor of Safety against Bearing Capacity:

e_{max} =	0.500	q_{max} =	1,615	psf	$e_{s,s}$ =	0.269	FS_{BC} = 4.0
e_s =	-0.441	q_{ult} =	6,335	psf	$q_{max,s}$ =	1,397	$FS_{BC,s}$ = 4.6

Eccentricity Check (static): **OK**

Eccentricity Check (seismic): **OK**

Rocks = 4 (R* - Boulder Height to Width Ratio)

Boulder	B' (ft)	R*	H_R (ft)	H-H' (ft)	ΣW_i	$\Sigma W_i * x_i$	F_H	$F_{H,s}$	F_μ	$F_{\mu,s}$	M_o	$M_{o,s}$	M_r	$M_{r,s}$	FS_{SL}	FS_{OT}	$FS_{SL,S}$	$FS_{OT,S}$
1	3.0	0.7	2.1	7.0	2,284	5,969	633	1,396	1,800	1,923	1,438	4,174	6,913	7,531	2.9	4.9	1.4	1.9
2	2.5	0.7	1.9	4.8	1,406	2,861	298	709	849	895	479	1,523	3,234	3,476	2.9	6.8	1.3	2.3
3	2.0	0.7	1.5	3.0	777	1,208	112	307	456	473	111	420	1,319	1,389	4.1	>10	1.6	3.4
4	2.0	0.7	1.5	1.5	389	389	28	108	221	225	14	76	415	432	7.9	>10	2.1	5.7
5	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

7.0 Total Estimated Height of Rockery

(See Mack, et. al [2006], Rockery Design and Construction Guidelines, Report No. FHWA-CFL/TD-06-006, Report Dated November 2006 - for term definitions and equations)

PROJECT: Elk Ridge Drive Rockery
PROJECT NO.: 02158-117
DATE: 6/22/2022

SECTION: 5-foot Exposed Rockery
SURCHARGE: Roadway

Rockery Geometry & Soil Data:

H_{total} =	6	ft	Total Height of Rockery
H_R =	5	ft	Exposed Height of Rockery
ϕ_s =	32	deg	Soil Friction Angle - Effective
c_s =	0	psf	Cohesion Intercept of soil
γ_s =	125	pcf	Unit weight of the soil
γ_R =	150	pcf	Unit weight of the rock
δ =	32.0	deg	Interface Friction Angle
ψ =	7.1	deg	Back Cut Inclination
μ =	0.70		Frictional Component
μ_{rock} =	0.55		Rock-to-Rock Friction
K_A =	0.226		Active Earth Pressure Coefficient
ν =	63.4	deg	Rockery Face Angle

Slope Geometry: Backslope: 1.0 H 0.0 V

Backslope: β_{eq} = 0.0 deg Eq. Backslope Angle

Soil Cut Angle: α = 82.9 deg Soil Cut Angle

Rockery Face Slope: 1 H 2 V

Broken Back Slope: N

Backslope Rise: 0 ft

Seismic Earth Pressure Coefficient: (Mack et al., 2006)

A =	0.391	Peak Ground Acceleration (7% in 75 years)
d =	3.9 in	(Allowable Displacement)
k_h =	0.163	Use 1/2 of A? N
k_v =	0	(If "N" then use displacement-factored k_h)
θ =	9.24	
K_{AE} =	0.343	

Failure Mechanism	FS Required	FS Obtained	OK
External Sliding	1.5	3.5	OK
External Overturning	2.0	6.2	OK
Individual Rock Overturning	2.0	>10	OK
Individual Rock Sliding	1.5	3.9	OK
Bearing Capacity	2.0	4.3	OK
Seismic Overturning	1.5	2.2	OK
Seismic Sliding	1.1	1.6	OK
Seismic Bearing Capacity	1.5	6.2	OK

Surcharge:

Uniform: Uniform Applied Surcharge

q_s =	0	psf	
F_s =	0	lbf/ft	(Horizontal Surcharge Load)
y_s =	3	ft	(Surcharge load centroid)

Strip: Strip Load Surcharge

q_s =	250	psf				
x_s =	6	ft	(Distance from soil cut)	F_s =	2	lbf/ft (Horizontal Surcharge Load)
W_s =	4	ft	(Width of Strip Load)	y_s =	0.0	ft

Factor of Safety against Bearing Capacity:

e_{max} =	0.500	q_{max} =	1,472	psf	$e_{s,s}$ =	0.141	FS_{BC}	4.3
e_s =	-0.460	q_{ult} =	6,284	psf	$q_{max,s}$ =	1,029	$FS_{BC,s}$	6.2

Eccentricity Check (static): OK

Eccentricity Check (seismic): OK

Rocks = 3 (R* - Boulder Height to Width Ratio)

Boulder	B' (ft)	R*	H_R (ft)	H-H' (ft)	ΣW_i	$\Sigma W_i * x_i$	F_H	$F_{H,s}$	F_μ	$F_{\mu,s}$	M_o	$M_{o,s}$	M_r	$M_{r,s}$	FS_{SL}	FS_{OT}	$FS_{SL,S}$	$FS_{OT,S}$
1	3.0	0.8	2.4	6.0	2,085	4,988	463	1,084	1,609	1,701	922	2,859	5,683	6,134	3.5	6.2	1.6	2.2
2	2.5	0.8	2.0	3.6	1,095	1,852	166	446	645	670	199	720	2,056	2,186	3.9	>10	1.6	3.1
3	2.0	0.8	1.6	1.6	420	420	33	121	239	244	17	91	451	471	7.4	>10	2.1	5.2
4	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

6.0 Total Estimated Height of Rockery

(See Mack, et. al [2006], Rockery Design and Construction Guidelines, Report No. FHWA-CFL/TD-06-006, Report Dated November 2006 - for term definitions and equations)

PROJECT: Elk Ridge Drive Rockery
PROJECT NO.: 02158-117
DATE: 6/22/2022

SECTION: 4-foot Exposed Rockery
SURCHARGE: Roadway

Rockery Geometry & Soil Data:

H_{total} =	5	ft	Total Height of Rockery
H_R =	4	ft	Exposed Height of Rockery
ϕ_s =	32	deg	Soil Friction Angle - Effective
c_s =	0	psf	Cohesion Intercept of soil
γ_s =	125	pcf	Unit weight of the soil
γ_R =	150	pcf	Unit weight of the rock
δ =	32.0	deg	Interface Friction Angle
ψ =	7.1	deg	Back Cut Inclination
μ =	0.70		Frictional Component
μ_{rock} =	0.55		Rock-to-Rock Friction
K_A =	0.226		Active Earth Pressure Coefficient
ν =	63.4	deg	Rockery Face Angle

Slope Geometry: Backslope: 1.0 H 0.0 V

Backslope: β_{eq} = 0.0 deg Eq. Backslope Angle

Soil Cut Angle: α = 82.9 deg Soil Cut Angle

Rockery Face Slope: 1 H 2 V

Broken Back Slope: N

Backslope Rise: 0 ft

Seismic Earth Pressure Coefficient: (Mack et al., 2006)

A =	0.391	Peak Ground Acceleration (7% in 75 years)
d =	3.9 in	(Allowable Displacement)
k_h =	0.163	Use 1/2 of A? N
k_v =	0	(If "N" then use displacement-factored k_h)
θ =	9.24	
K_{AE} =	0.343	

Failure Mechanism	FS Required	FS Obtained	OK
External Sliding	1.5	3.9	OK
External Overturning	2.0	7.3	OK
Individual Rock Overturning	2.0	>10	OK
Individual Rock Sliding	1.5	4.2	OK
Bearing Capacity	2.0	6.7	OK
Seismic Overturning	1.5	2.5	OK
Seismic Sliding	1.1	1.7	OK
Seismic Bearing Capacity	1.5	8.0	OK

Surcharge:

Uniform: Uniform Applied Surcharge

q_s =	0	psf	
F_s =	0	lbf/ft	(Horizontal Surcharge Load)
y_s =	2.5	ft	(Surcharge load centroid)

Strip: Strip Load Surcharge

q_s =	250	psf	
x_s =	6	ft	(Distance from soil cut)
W_s =	2	ft	(Width of Strip Load)

F_s = 0 lbf/ft (Horizontal Surcharge Load)

y_s = 0.0 ft

Factor of Safety against Bearing Capacity:

e_{max} =	0.500	q_{max} =	1,000	psf	$e_{s,s}$ =	0.164	FS_{BC} = 6.7
e_s =	-0.335	q_{ult} =	6,607	psf	$q_{max,s}$ =	829	$FS_{BC,s}$ = 8.0

Eccentricity Check (static): **OK**

Eccentricity Check (seismic): **OK**

Rocks = 3 (R* - Boulder Height to Width Ratio)

Boulder	B' (ft)	R*	H_R (ft)	H-H' (ft)	ΣW_i	$\Sigma W_i * x_i$	F_H	$F_{H,s}$	F_μ	$F_{\mu,s}$	M_o	$M_{o,s}$	M_r	$M_{r,s}$	FS_{SL}	FS_{OT}	$FS_{SL,S}$	$FS_{OT,S}$
1	3.0	0.7	2.2	5.0	1,647	3,453	325	784	1,258	1,323	546	1,747	3,937	4,249	**3.9**	**7.3**	**1.7**	**2.5**
2	2.0	0.7	1.4	2.9	756	1,164	106	294	443	459	102	391	1,269	1,335	**4.2**	**>10**	**1.6**	**3.5**
3	2.0	0.7	1.4	1.4	378	378	27	104	215	219	13	71	403	419	**8.1**	**>10**	**2.1**	**5.9**
4	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	**N/A**	**N/A**	**N/A**
5	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	**N/A**	**N/A**	**N/A**
6	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	**N/A**	**N/A**	**N/A**
7	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	**N/A**	**N/A**	**N/A**
8	0.0	0.0	0.0	N/A	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	**N/A**	**N/A**	**N/A**

5.0 Total Estimated Height of Rockery

(See Mack, et. al [2006], Rockery Design and Construction Guidelines, Report No. FHWA-CFL/TD-06-006, Report Dated November 2006 - for term definitions and equations)

SECTION 3


PROFESSIONAL ENGINEER
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06/27/2022
ELECTRONIC
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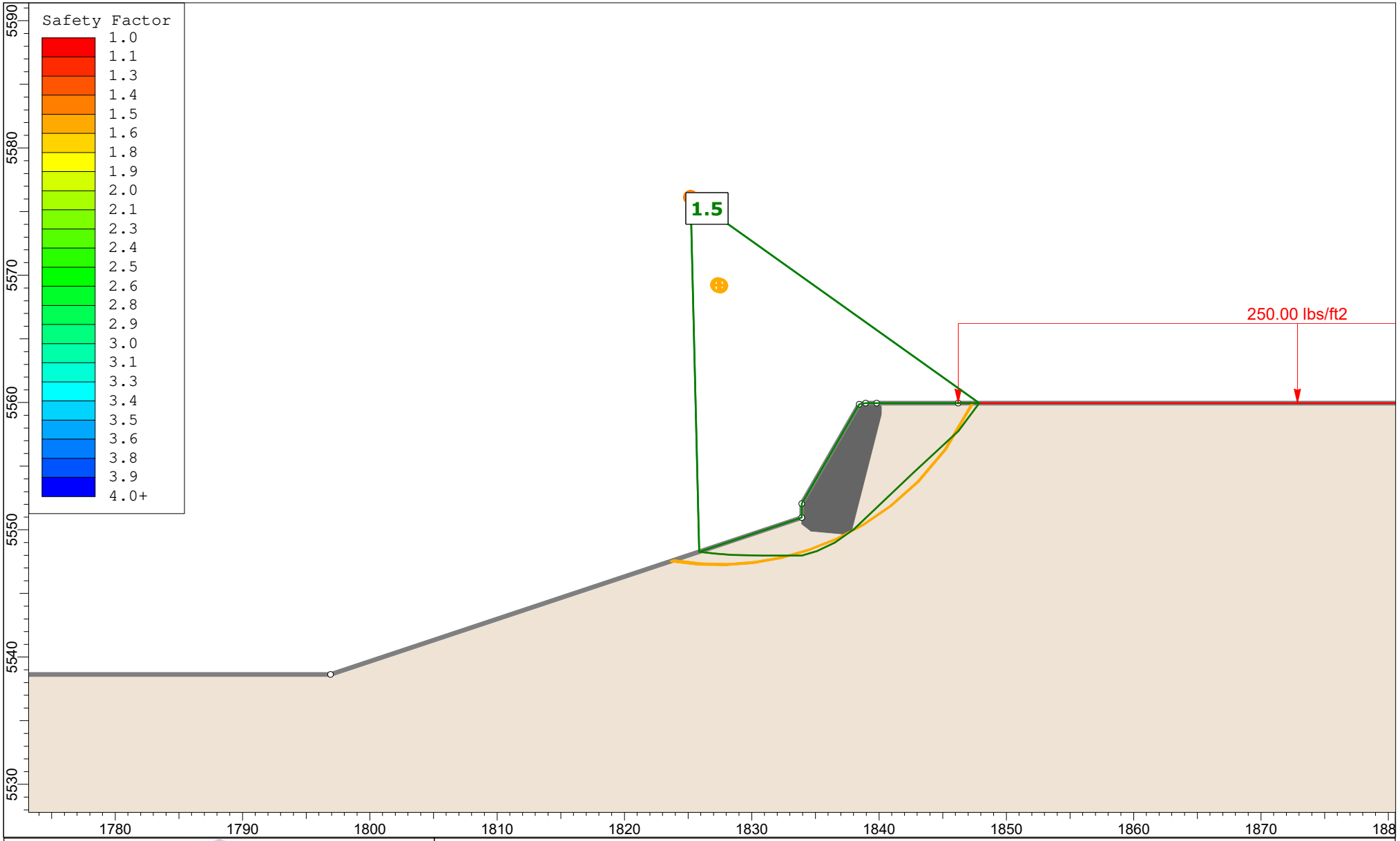
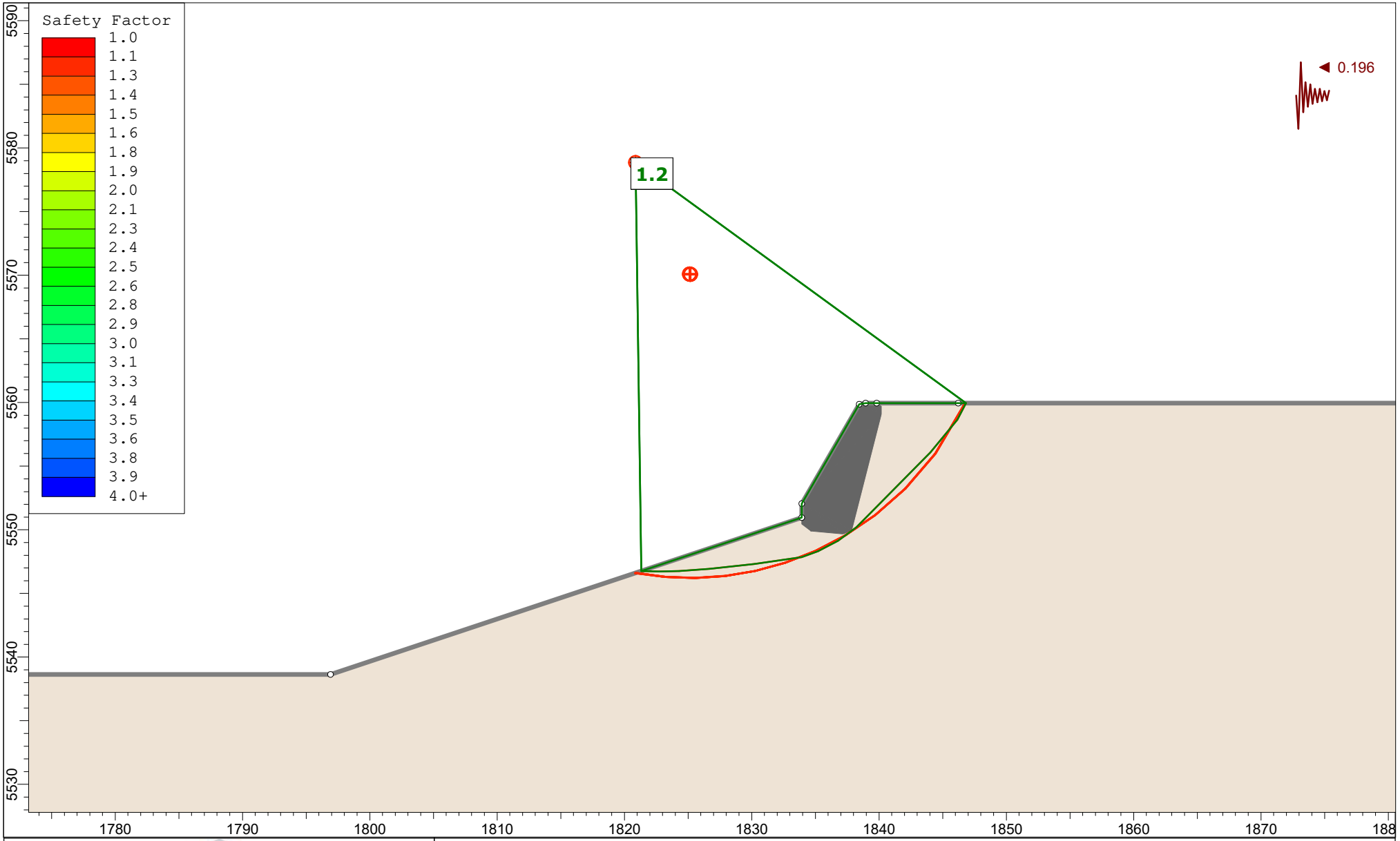
STATE OF UTAH



Project	Elk Ridge Drive Rockery		
Analysis Description	Global Stability Analysis - Static		
Drawn By: David Blake		Scale: 1:125	Company: Intermountain GeoEnvironmental Services, Inc. (IGES) 12429 South 300 East, Draper, Utah 84020
Date: 6/22/2022		File Name: 02158-117.slmd	

SLIDEINTERPRET 9.023



Project	Elk Ridge Drive Rockery		
Analysis Description	Global Stability Analysis - Seismic		
Drawn By: David Blake		Scale: 1:125	Company: Intermountain GeoEnvironmental Services, Inc. (IGES) 12429 South 300 East, Draper, Utah 84020
Date: 6/22/2022		File Name: 02158-117.slmd	

SLIDEINTERPRET 9.023

Slide2 Analysis Information

02158-117

Project Summary

File Name:	02158-117.slmd
Slide2 Modeler Version:	9.023
Project Title:	Elk Ridge Drive Rockery
Analysis:	Global Stability Analysis
Author:	David Blake
Company:	IGES, Inc.
Date Created:	6/22/2022

Currently Open Scenarios

Group Name	Scenario Name	Global Minimum	Compute Time
Group 1	Static	Spencer: 1.484040	00h:00m:03.493s
	Seismic	Spencer: 1.171230	00h:00m:05.772s

Analysis Options

All Open Scenarios

Slices Type:	Vertical
Analysis Methods Used	
	Spencer
Number of slices:	25
Tolerance:	0.005
Maximum number of iterations:	50
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Seismic Loading

Group 1 - Static

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No

Group 1 - Seismic

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No
Seismic Load Coefficient (Horizontal):	0.196

Loading

Group 1 - Static

Distribution:	Constant
Magnitude [psf]:	250
Orientation:	Vertical

Materials

Native	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	125
Cohesion [psf]	100
Friction Angle [deg]	32
Water Surface	Assigned per scenario
Ru Value	0
Rockery	
Color	
Strength Type	Anisotropic strength
Unit Weight [lbs/ft3]	150
Cohesion 1 [psf]	0
Cohesion 2 [psf]	3000
Friction Angle 1 [deg]	45
Friction Angle 2 [deg]	0
Angle from 1 [deg]	-10
Water Surface	Assigned per scenario
Ru Value	0

Materials In Use

Material		Static	Seismic
Native		✓	✓
Rockery		✓	✓

Global Minimums

Group 1 - Static

Method: spencer

FS	1.484040
Axis Location:	1825.180, 5576.108
Left Slip Surface Endpoint:	1825.864, 5548.270
Right Slip Surface Endpoint:	1847.860, 5559.953
Resisting Moment:	280683 lb-ft
Driving Moment:	189135 lb-ft
Resisting Horizontal Force:	8214.92 lb
Driving Horizontal Force:	5535.51 lb
Total Slice Area:	91.7176 ft2
Surface Horizontal Width:	21.9966 ft
Surface Average Height:	4.16963 ft

Group 1 - Seismic

Method: spencer

FS	1.171230
Axis Location:	1820.858, 5578.858
Left Slip Surface Endpoint:	1821.307, 5546.751
Right Slip Surface Endpoint:	1846.812, 5559.953
Resisting Moment:	324908 lb-ft
Driving Moment:	277408 lb-ft
Resisting Horizontal Force:	8432.81 lb
Driving Horizontal Force:	7199.96 lb
Total Slice Area:	97.2174 ft2
Surface Horizontal Width:	25.5056 ft
Surface Average Height:	3.81161 ft