

# Calculation Cover Sheet

Client: Ohio Department of Transportation, District 10

Project: **MEG-33-7.61/7.87 (Task Order 10-6)**  
**PID 118508**

HDR Project No: 10399415

Rev: 0

Calculation No: 1

Page: 1 of 255

Title: Rockfall Mitigation Analyses and Design

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Purpose: Perform rockfall analyses in support of the modifications to the existing rock cut slope along the westbound travel lane of US Route 33 (US 33) between approximate Sta.379+00 to Sta. 397+00 to reduce the potential for rockfall hazards.

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Originator: DCM

Date: 5/20/2024

Checked by: AKB

Date: 5/22/2024

QC Review by: DMV

Date: 5/24/2024

## Summary

1. From photographs provided by the Ohio Department of Transportation (ODOT), we understand that rockfall occurring from the existing cut slope located along the left side of US 33 between approximately Sta. 379+00 and Sta. 397+00 has travelled beyond the catchment and has come to rest upon the paved outside shoulder and right travel lane. In addition, fly rock due to shattering or breaking of the rock on impact has continued across both travel lanes, with some rock making it as far as the inside shoulder. Based on review of the photographs from ODOT as well as observations gathered during HDR's site reconnaissance performed on May 2, 2024, this rockfall hazard is the result of weathering and erosion of incompetent rock units (claystone and shale) which are undermining the more competent sandstone layers within the existing rock cuts. The first cut is located between approximately Sta. 379+00 to Sta. 385+50 (roughly Milepost (MP) 7.61), with a near vertical sandstone bluff located close to the top of the slope and underlain by erodible claystone. The bottom of this sandstone layer is located at roughly El 873 based on the survey that ODOT had performed at the site. Similarly, a sandstone bluff is also present in the second cut slope located within the project limits between roughly Sta. 393+00 and Sta. 397+00 (about MP 7.87). This sandstone layer is described as extremely arenaceous shale with many

sandstone seams on the historic soil profile sheets (discussed later) and as similarly observed during the site reconnaissance. The bottom of this layer is at approximate El 818 to El. 820 based upon the survey as well as GPS data obtained during HDR's site reconnaissance.

2. A subsurface exploration program was not performed for the current project task order. Rather, a visual reconnaissance of the existing rock cuts was performed and compared to the historic borings that were available on ODOT's Transportation Information Mapping System (TIMS) performed in support of the original construction of US 33. A total of 13 graphical boring logs from the MEG-33-3.50 project are located within the current project limits as shown on the historic soil profile sheets presented later in this calculation package. Nine of the 13 borings were terminated at refusal within approximately 7 feet to 11.5 feet of the existing ground surface with another two borings, located at Sta. 392+75 and Sta. 395+75, terminated upon refusal at depths of approximately 18 feet and 15.5 feet below the ground surface, respectively. The encountered overburden material as reported on these graphic logs consisted of Silty Clay (A-6a), Silt and Clay (A-6b), and Clay (A-7-6), as well as weathered sandstone, claystone, and shale that was augerable.

Rock coring was performed at the remaining two historic borings located at Sta. 379+50, 125' LT and Sta. 393+25. These borings were extended to approximately 100 feet below the pre-existing ground surface. The profiles as encountered consisted primarily of interbedded layers of shale and indurated clay (claystone) of the Monongahela Group, as well as the two sandstone layers mentioned previously. In comparing these two borings, the bedrock appears to be relatively flat-lying, although their lithology may vary within the bedrock unit and/or their elevations may vary over the length of the project due to regional dipping or local structural undulations.

The generalized geologic profile developed for the design sections for the MP 7.61 cut and the MP 7.87 cut is assumed to be as depicted graphically on the attached cross-sections. This interpreted stratigraphy is primarily based on the historic borings and the recent site reconnaissance, supplemented with the as-built drawings and recent survey data. These as built drawings from the MEG-33-3.79 project indicate the original rock-cut slope consisted of 1H:1V slope extending from a 10-foot-wide catchment to a 2H:1V slope through the soil overburden. Reconstructing the original slope geometries on the cross-sections developed from the recent survey indicates significant weathering and loss within multiple bedrock units, particularly the various shale and claystone units. These principal bedrock units are shown on the Rock Cut Design Sections at Sta. 382+00 and Sta. 395+50.

3. The design of rock cuts in sedimentary bedrock with varying durability and strength is based on many factors. Using guidance provided in ODOT's Geotechnical Design Manual and ODOT's Rock Slope Design Guide, the proposed remediation of the existing rock cuts to minimize the potential for rockfall were designed utilizing the recent survey (topographic) information, visual observations and data collected during our site reconnaissance, and engineering judgement. The basic features of our approach are:
  - The placement of a 20-foot-wide lithologic bench at the base of competent or durable sandstone rock units underlain by nondurable or incompetent units to prevent undercutting. While the underlying incompetent units would suggest the need for only a 10-foot-wide

bench, a 20-foot wide bench was ultimately selected in consultation with the District to create a sufficiently wide working platform during construction.

- Maintaining the existing slope below the proposed lithologic bench given the right of way constraints as well as the reduced risk of rockfalls from the underlying bedrock units.
- Providing the appropriate cut slope angles in the bedrock units above the lithologic bench to reduce the most likely mode of failure (toppling, wedge, raveling, undercutting) for the various bedrock units encountered, while also being as steep as possible.

In developing the cut slope angles for the principal rock units, the Rock Slope Design Guide defines a competent rock unit as

- a. Limestone or sandstone visually described as moderately strong or stronger
- b. Limestone or sandstone visually described as very weak, weak, or slightly strong with a unit weight of 140 pcf or greater, or a unit weight less than 140 pcf, but with a second cycle slake durability index (SDI) of 85 percent or greater, and
- c. Any siltstone with a second cycle SDI greater than 85 percent.

An incompetent rock unit is defined as shale or claystone, or a competent lithologic unit described as slightly strong, weak, or very weak, with a unit weight less than 140 pcf, and an SDI less than 85 percent. As laboratory testing was not available, HDR reviewed the historic bedrock descriptions along with our visual observations, field measurements, and judgement to classify the sandstone as a durable rock unit with the shale and claystone units to be incompetent units. A cut slope angle of 1H:1V was applied to the sandstone units, while a cut slope angle of 2H:1V was applied for the incompetent design units.

(Note: Due to right of way restrictions, a 1H:1V slope angle is proposed within the claystone above approximate El 841 within the MP 7.87 shale. This is based on the existing cut slope currently standing at or close to a 1H:1V in this material, as well as the 20-foot lithologic bench below that should reduce any slumps that may occur from being transported downslope and into the travel lanes.)

4. To determine the final recommended cut slope angles for each rock unit, the Colorado Rockfall Simulation Program (CRSP) was used to analyze the stability of the rock cuts at Sta. 382+00 for the existing rock cut near MP 7.61 and at Sta. 395+50 for the existing rock cut near MP 7.87. CRSP simulates rocks falling down a slope, predicts the rockfall behavior in the form of statistical distribution of velocity, kinetic energy, and bounce height, and is used for locating and designing rockfall mitigation. The program evaluates random variations of the slope angle ( $\phi$ ) based on a maximum probable variation in the slope ( $\theta_{max}$ ) at the point of impact along the slope. This slope variation is based on field observations of the surface roughness and the radius of the falling rock. Slope conditions are further defined by normal and tangential coefficients assigned to the slope material ( $R_n$  and  $R_T$ ). Given the randomness of the CRSP output due to the algorithm (CRSP Version 4), five (5) simulations were performed using 1000 rocks per simulation for each section. The maximum velocity, bounce height and kinetic energy were recorded at each of the analysis points to determine the general behavior of the rock along the slope.

5. The CRSP analyses were performed assuming the upper sandstone bluffs at each respective rock cut as the rock fall generators. The representative rock size and shape observed along the toe of the slope and as shown in the ODOT provided site photos were used in the CRSP analysis and included the following:
  - 4 ft diameter by 1 ft thick discoidal rocks,
  - 2 ft diameter by 3 ft thick discoidal rocks,
  - 1.5 ft diameter by 0.5 ft thick discoidal rocks, and
  - 1 ft diameter by 1 ft thick discoidal rocks.

Photographs of the observed rockfall sizes and shapes present on the slopes and within the catchment during HDR's site reconnaissance and as shown in the site photographs provided by ODOT supporting these sizes are provided.

6. Parameters (normal and tangent coefficients) selected for the CRSP analyses were in general accordance with the guidance provided in the Rock Slope Design Guide, the CRSP manual, our site observations, and our experience in similar geologic conditions in southwest Ohio. The surface roughness for the various material types were selected to represent both the initial and long-term slope condition based on published guidance, observed field conditions, measured field values, and engineering judgement. As recent rock fall had occurred, CRSP analyses for the existing slope conditions were performed, with the parameters modified to produce similar results to those observed in the field. Once these values were finalized, additional CRSP analyses were performed for the short-term and long-term post-construction conditions. Specific information on these analyses is attached.
7. Based on the CRSP analyses, the proposed slope modifications satisfy ODOT's criteria of 95% catchment at the edge of the pavement at both the Sta. 382+00 and Sta. 395+50 design sections. Summary tables of the five runs of 1000 rocks each for the various combinations of conditions are provided in the attachments. However, while the analyses indicate a catchment of 95%, long-term maintenance along the lower slope and ditch line will likely be required. This should include the removal of any rock fall debris and talus build-up to maintain the geometry of the existing catchment.

# MEG-33-7.61

## Sta. 379+00 to Sta. 385+00

### Rockfall Analysis

#### Design Notes and Assumptions:

Preliminary rock slope parameters were developed based on published information in the ODOT Geotechnical Design Manual (GDM) and ODOT Rock Slope Design Guide. These values were modified with the Colorado Rockfall Simulation Program (CRSP) to reflect the observed rockfall within the catchment as well as that within the paved shoulder and travel lane based on the photographs provided by the District.

Boulder sizes were based on measurements taken during HDR's site reconnaissance and the aforementioned ODOT photographs. The modeled sizes included discoidal boulders of the following dimensions:

- 4 ft diameter, 1 ft thickness
- 2 ft diameter, 1 ft thickness
- 1.5 ft diameter, 0.5 ft thickness
- 1 ft diameter, 1 ft thickness

The back calculated values developed based on the existing slope geometries were used in subsequent CRSP models except for those layers that were modified based on the proposed benching and cut slope scheme. The analyses performed included the following:

- After Construction (Short Term)
- Long Term (Weathered Lithological Bench)
- Long Term (Weathered Lithological Bench with Talus Build-up)

#### After Construction (Short Term)

An assumed 10 ft wide lithological bench was modeled at the base of the sandstone rock layer/top of the claystone layer. The sandstone rock face above the bench was modeled at a 1H:1V with the overlying soil overburden set back to a 2H:1V slope.

#### Long Term (Weathered Lithological Bench)

An additional analysis was performed assuming a 30% loss of the 10 ft wide lithological bench due to erosion and weathering. An approximately 1.25H:1V slope was modeled below the weathered bench and extending to the lower, existing slope.


#### Long Term (Weathered Lithological Bench with Talus Build-up)

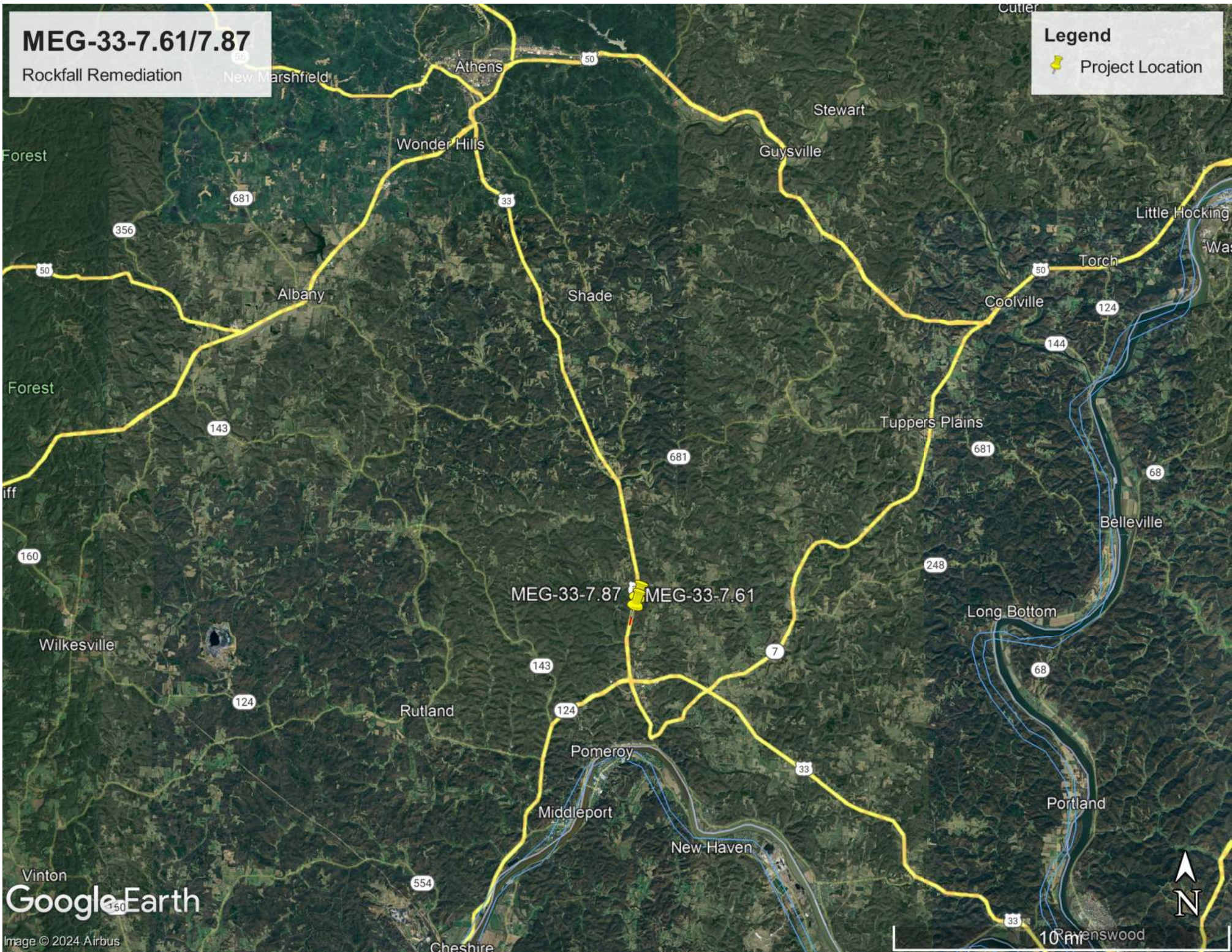
An additional analysis was performed assuming a 30% loss of the 10 ft wide lithological bench due to erosion and weathering as well as talus build up along the lithological bench at the base of the proposed 1H:1V sandstone cut slope.

# MEG-33-7.61/7.87

Rockfall Remediation

**Legend**



-  Project Location



# MEG-33-7.61/7.87

Rockfall Remediation

## Legend

-  Rock Slope Limits (approx.)
-  Beginning of Project (approx.)



MEG-33-7.61  
Sta. 379+00 to Sta. 385+00

Cut Slope Photographs from  
HDR's Site Reconnaissance



60      E      90      120      SE      150

☀ 111°E (T)    📍 39.087819, -82.015783 ±1ft

Rockfall  
Generator



02 May 2024, 6:31:10 PM



☉ 108°E (T) ● 39.087696, -82.015782 ±13ft



Rockfall  
Generator

02 May 2024, 12:50:09 PM

NE

E

SE

S

30

60

90

120

150

180

☀ 106°E (T) ● 39.088018, -82.015535 ±0ft



Rockfall  
Generator



Lower  
Sandstone  
Layer

02 May 2024, 1:44:01 PM

SE

S

SW

W

120

150

180

210

240

270

190°S (T) • 39.087903, -82.015494 ±1ft

Lower Sandstone Layer Profile  
(Surface Roughness)

02 May 2024, 1:24:43 PM

MEG-33-7.61  
Sta. 379+00 to Sta.  
385+00

Photographs and  
Measurements of  
Representative  
Rockfall

150 180 210 240  
S SW

☉ 202°S (T) ☉ 39.087798, -82.015556 ±1ft



4 ft x 1 ft Discoidal Boulder



2 ft x 1 ft Discoidal Boulder



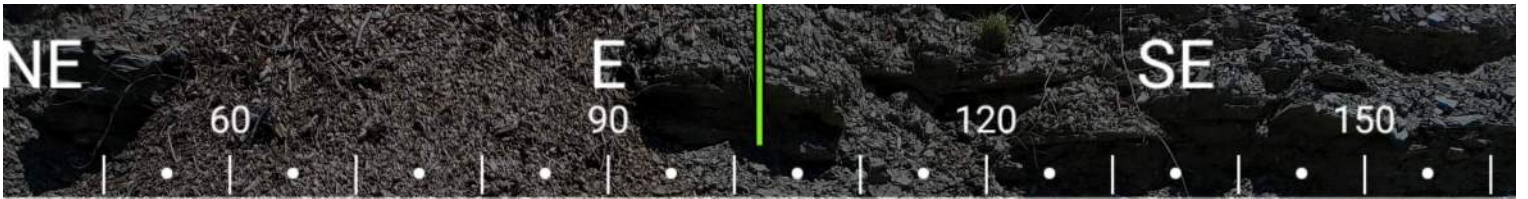
1 ft x 1 ft Discoidal Boulder

Sta. 381+50 to 382+50  
(approximately)

1.5 ft x 0.5 ft Discoidal Boulder



02 May 2024, 1:12:57 PM



☉ 102°E (T) ☉ 39.087685, -82.015643 ±12ft



Sta. 382+00 (approximately)  
4 ft x 1 ft Discoloidal Boulder in Catchment

02 May 2024, 12:49:30 PM

E  
90

SE

S  
180

SW

120

150

210

240

☀ 174°S (T) • 39.087796, -82.015556 ±1ft

Sta. 382+00 (approximately)

Boulder in Catchment  
1.5 ft diameter  
0.5 ft thickness

02 May 2024, 1:12:32 PM





98°E (T) 39.087818, -82.015606 ±1ft



Sta. 382+00 (approximately)

Boulder in Catchment  
2 ft diameter  
1 ft thickness

02 May 2024, 1:10:20 PM



☀ 150°SE (T) ● 39.088124, -82.015405 ±1ft



Sta. 382+00 (approximately)  
Surface Roughness  
10 inches over 3 feet span  
(shown in picture)  
8 inches over 4 feet span  
(no picture available)

02 May 2024, 6:42:44 PM

SE

S

SW

20

150

110

210

☀ 180°S (T) ☉ 39.088114, -82.01541 ±1ft



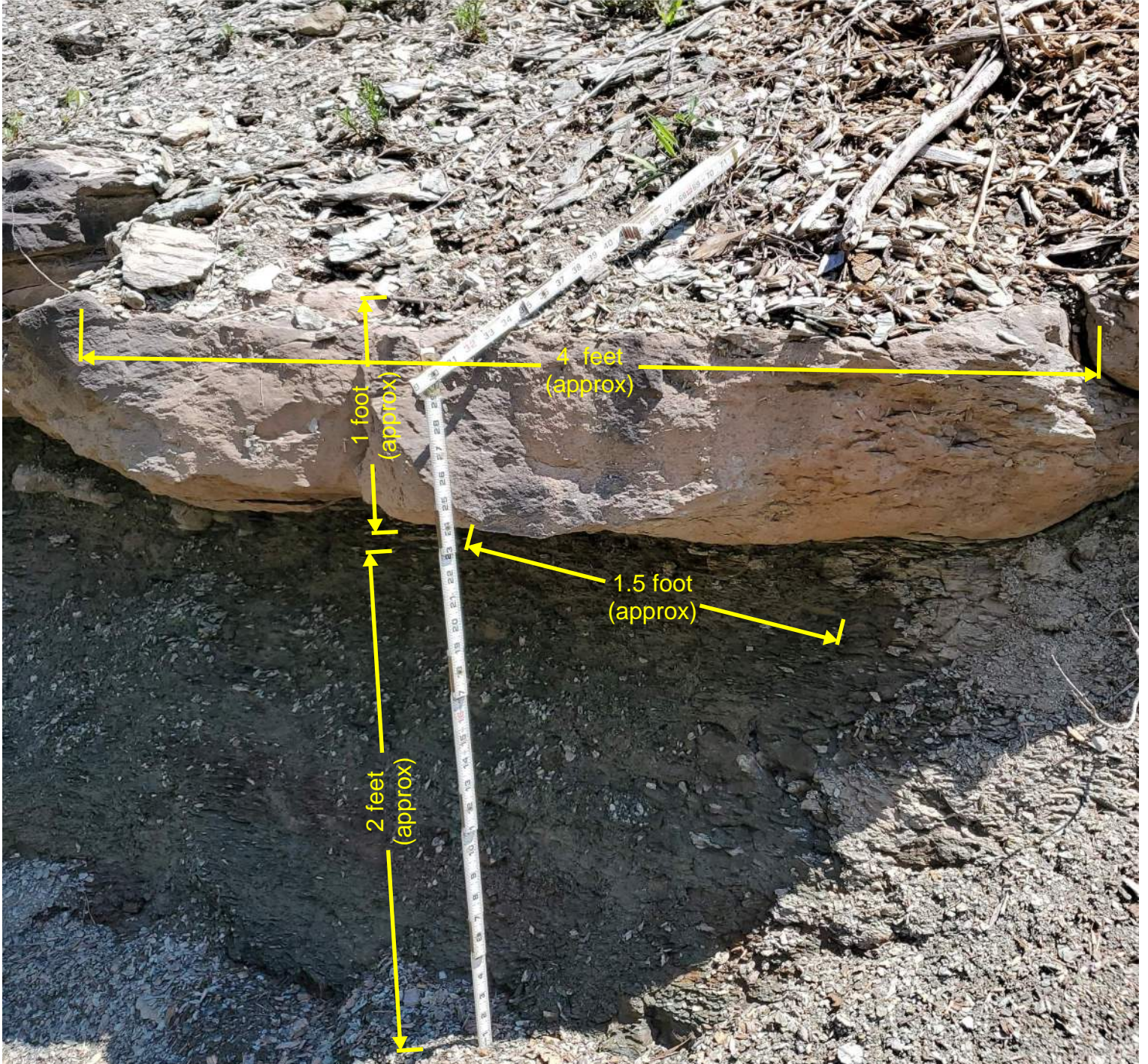
Sta. 382+00 (approximately)

Surface Roughness  
14 inches over 3 feet Span

02 May 2024, 6:50:19 PM



☉ 81°E (T) ● 39.088094, -82.015463 ±1ft



Sta. 382+00 (approximately)  
Undercutting  
12 inch thick rock overhang  
18 inch (into Slope)  
24 inches (height above slope)

02 May 2024, 1:54:07 PM

N

NE

E

0

30

60

90

☉ 54°NE (T) ☉ 39.083466, -82.016741 ±1ft



3 to 4 feet (approx)

1 foot (approx)

2 foot (approx)

2 feet (approx)

Sta. 397+00 (approximately)

Undercutting  
 12 inch thick rock overhang  
 24 inch (into slope)  
 24 inches (height above slope)

**NOTE:**  
 Access to the sandstone bluff near Sta. 379+00 to Sta 385+00 was not possible during the site reconnaissance. These measurements near Sta. 393+00 to Sta. 397+00 were used as supplemental references.

02 May 2024, 3:42:38 PM

SE

S

SW

150

180

210

240

☉ 184°S (T) ● 39.083515, -82.016731 ±2ft

1 foot (approx)

2 foot (approx)

3 to 4 feet (approx)

Sta. 397+00 (approximately)

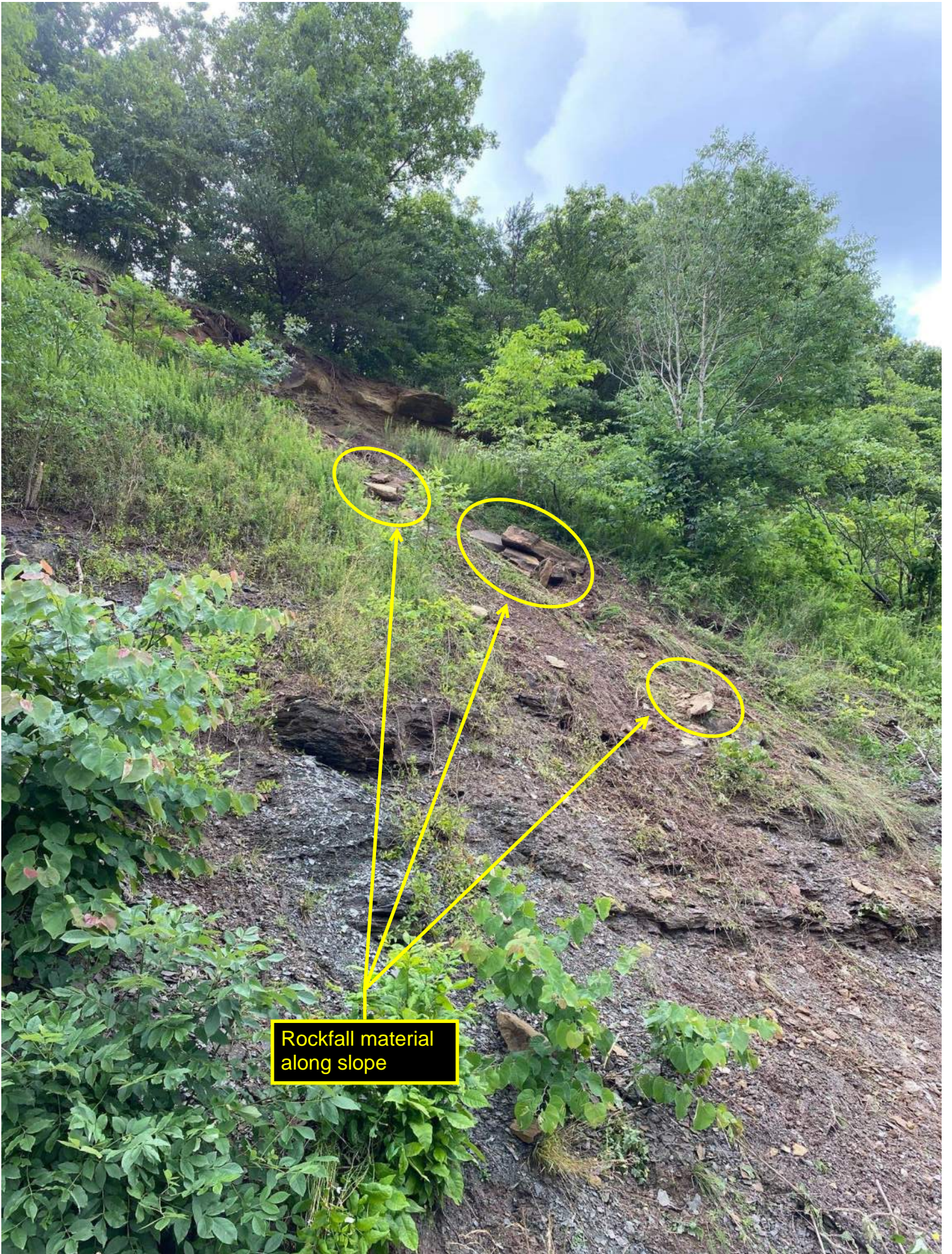
Undercutting  
12 inch thick rock overhang  
24 inch (into slope)  
36 to 48 inches (height above slope)

**NOTE:**

Access to the sandstone bluff near Sta. 379+00 to Sta 385+00 was not possible during the site reconnaissance. These measurements near Sta. 393+00 to Sta. 397+00 were used as supplemental references.

02 May 2024, 4:07:19 PM

ODOT  
Provided Site  
Photographs



Rockfall material along slope





Rockfall material  
within Catchment  
and in Pavement



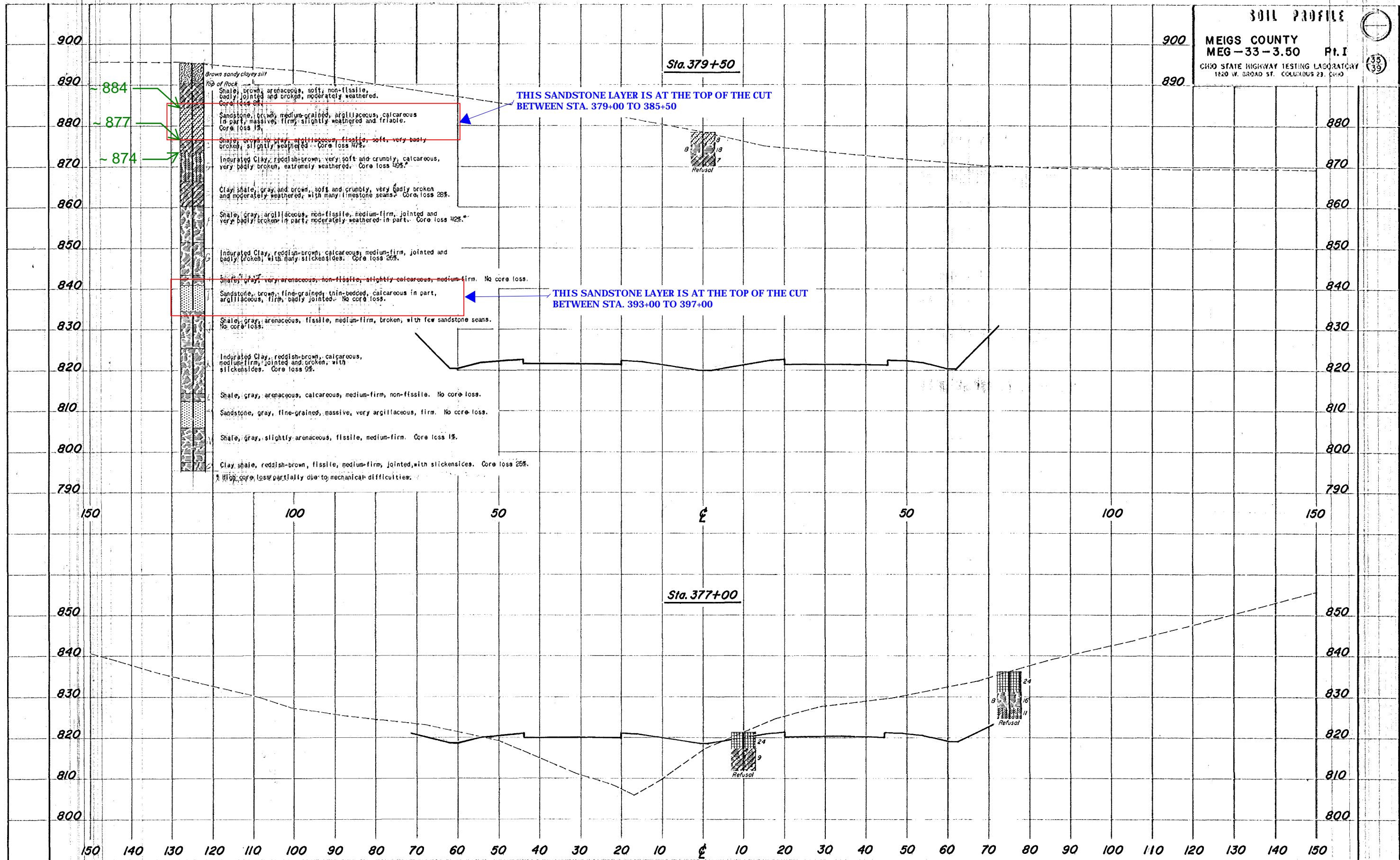


Rockfall material within Catchment and in Pavement

Historic Data  
MEG-33-3.50

SOIL PROFILE

MEIGS COUNTY  
MEG-33-3.50 Pt. I  
OHIO STATE HIGHWAY TESTING LABORATORY  
1820 W. BROAD ST. COLUMBUS 23, OHIO



Sta. 379+50

Sta. 377+00

THIS SANDSTONE LAYER IS AT THE TOP OF THE CUT  
BETWEEN STA. 379+00 TO 385+50

THIS SANDSTONE LAYER IS AT THE TOP OF THE CUT  
BETWEEN STA. 393+00 TO 397+00

Brown sandy clayey silt

Top of Rock

Shale, brown, arenaceous, soft, non-fissile, badly jointed and broken, moderately weathered. Core loss 38%.

Sandstone, brown, medium-grained, argillaceous, calcareous in part, massive, firm, slightly weathered and friable. Core loss 18%.

Shale, brown to gray, argillaceous, fissile, soft, very badly broken, slightly weathered. Core loss 47%.

Indurated Clay, reddish-brown, very soft and crumbly, calcareous, very badly broken, extremely weathered. Core loss 49%.

Clay shale, gray and brown, soft and crumbly, very badly broken and moderately weathered, with many limestone seams. Core loss 28%.

Shale, gray, argillaceous, non-fissile, medium-firm, jointed and very badly broken in part, moderately weathered in part. Core loss 42%.

Indurated Clay, reddish-brown, calcareous, medium-firm, jointed and badly broken, with many slickensides. Core loss 26%.

Shale, gray, very arenaceous, non-fissile, slightly calcareous, medium-firm. No core loss.

Sandstone, brown, fine-grained, thin-bedded, calcareous in part, argillaceous, firm, badly jointed. No core loss.

Shale, gray, arenaceous, fissile, medium-firm, broken, with few sandstone seams. No core loss.

Indurated Clay, reddish-brown, calcareous, medium-firm, jointed and broken, with slickensides. Core loss 9%.

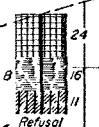
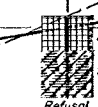
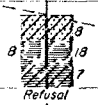
Shale, gray, arenaceous, calcareous, medium-firm, non-fissile. No core loss.

Sandstone, gray, fine-grained, massive, very argillaceous, firm. No core loss.

Shale, gray, slightly arenaceous, fissile, medium-firm. Core loss 1%.

Clay shale, reddish-brown, fissile, medium-firm, jointed, with slickensides. Core loss 25%.

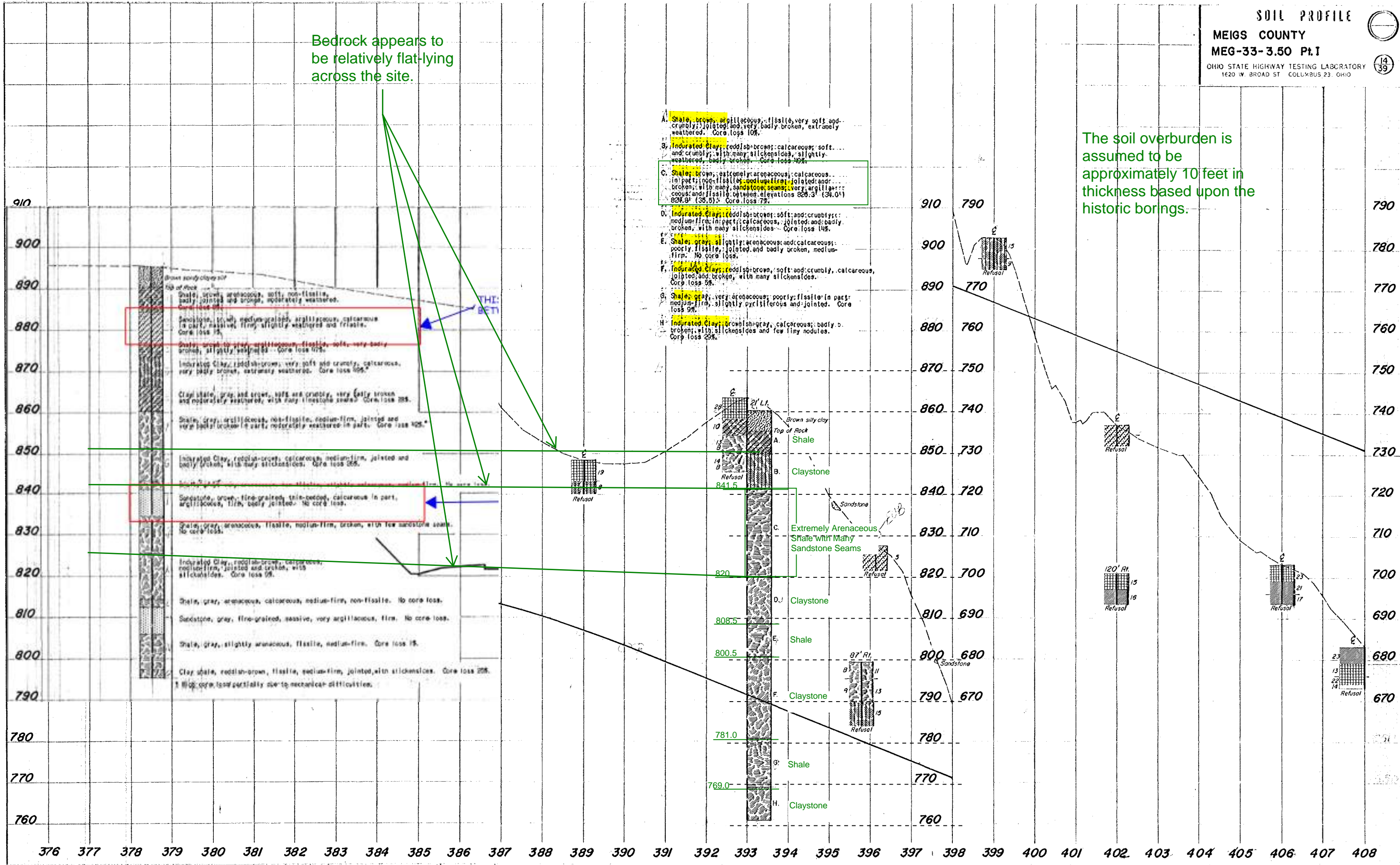
\* High core loss partially due to mechanical difficulties.



150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

900  
890  
880  
870  
860  
850  
840  
830  
820  
810  
800  
790

900  
890  
880  
870  
860  
850  
840  
830  
820  
810  
800  
790



Bedrock appears to be relatively flat-lying across the site.

The soil overburden is assumed to be approximately 10 feet in thickness based upon the historic borings.

- A. Shale, brown, argillaceous, fissile, very soft and crumbly, jointed and very badly broken, extremely weathered. Core loss 10%.
- B. Indurated Clay, reddish-brown, calcareous, soft, and crumbly, with many slickensides, slightly weathered, badly broken. Core loss 10%.
- C. Shale, brown, extremely arenaceous, calcareous, in part, non-fissile, medium-firm, jointed and broken, with many sandstone seams, very argillaceous, and fissile between elevations 828.3' (34.0') and 824.8' (35.5'). Core loss 7%.
- D. Indurated Clay, reddish-brown, soft and crumbly, medium-firm, in part, calcareous, jointed and badly broken, with many slickensides. Core loss 14%.
- E. Shale, gray, slightly arenaceous and calcareous, poorly fissile, jointed and badly broken, medium-firm. No core loss.
- F. Indurated Clay, reddish-brown, soft and crumbly, calcareous, jointed and broken, with many slickensides. Core loss 5%.
- G. Shale, gray, very arenaceous, poorly fissile in part, medium-firm, slightly pyritic and jointed. Core loss 9%.
- H. Indurated Clay, brownish-gray, calcareous, badly broken, with slickensides and few tiny nodules. Core loss 29%.

Top of Rock  
 Shale, brown, argillaceous, soft, non-fissile, badly jointed and broken, moderately weathered. Core loss 10%.

Sandstone, brown, medium-grained, argillaceous, calcareous in part, massive, firm, slightly weathered and fissile. Core loss 1%.

Shale, brown to gray, argillaceous, fissile, soft, very badly broken, slightly weathered. Core loss 10%.

Indurated Clay, reddish-brown, very soft and crumbly, calcareous, very badly broken, extremely weathered. Core loss 10%.

Clay shale, gray and brown, soft and crumbly, very easily broken and moderately weathered, with many limestone seams. Core loss 25%.

Shale, gray, argillaceous, non-fissile, medium-firm, jointed and very badly broken in part, moderately weathered in part. Core loss 10%.

Indurated Clay, reddish-brown, calcareous, medium-firm, jointed and badly broken, with many slickensides. Core loss 25%.

Sandstone, brown, fine-grained, thin-bedded, calcareous in part, argillaceous, firm, poorly jointed. No core loss.

Shale, gray, arenaceous, fissile, medium-firm, broken, with few sandstone seams. No core loss.

Indurated Clay, reddish-brown, calcareous, medium-firm, jointed and broken, with slickensides. Core loss 5%.

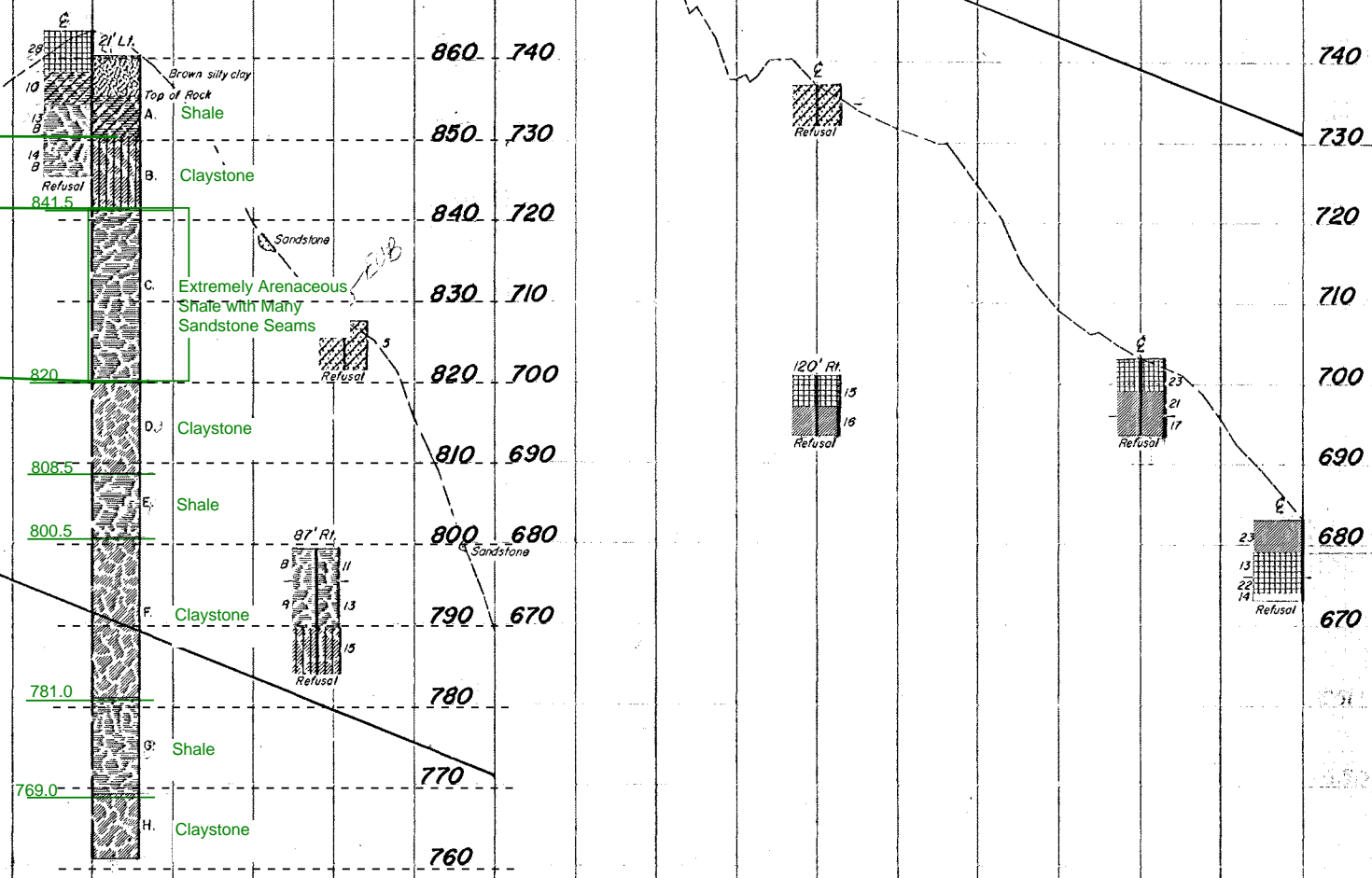
Shale, gray, arenaceous, calcareous, medium-firm, non-fissile. No core loss.

Sandstone, gray, fine-grained, massive, very argillaceous, firm. No core loss.

Shale, gray, slightly arenaceous, fissile, medium-firm. Core loss 1%.

Clay shale, reddish-brown, fissile, medium-firm, jointed, with slickensides. Core loss 25%.

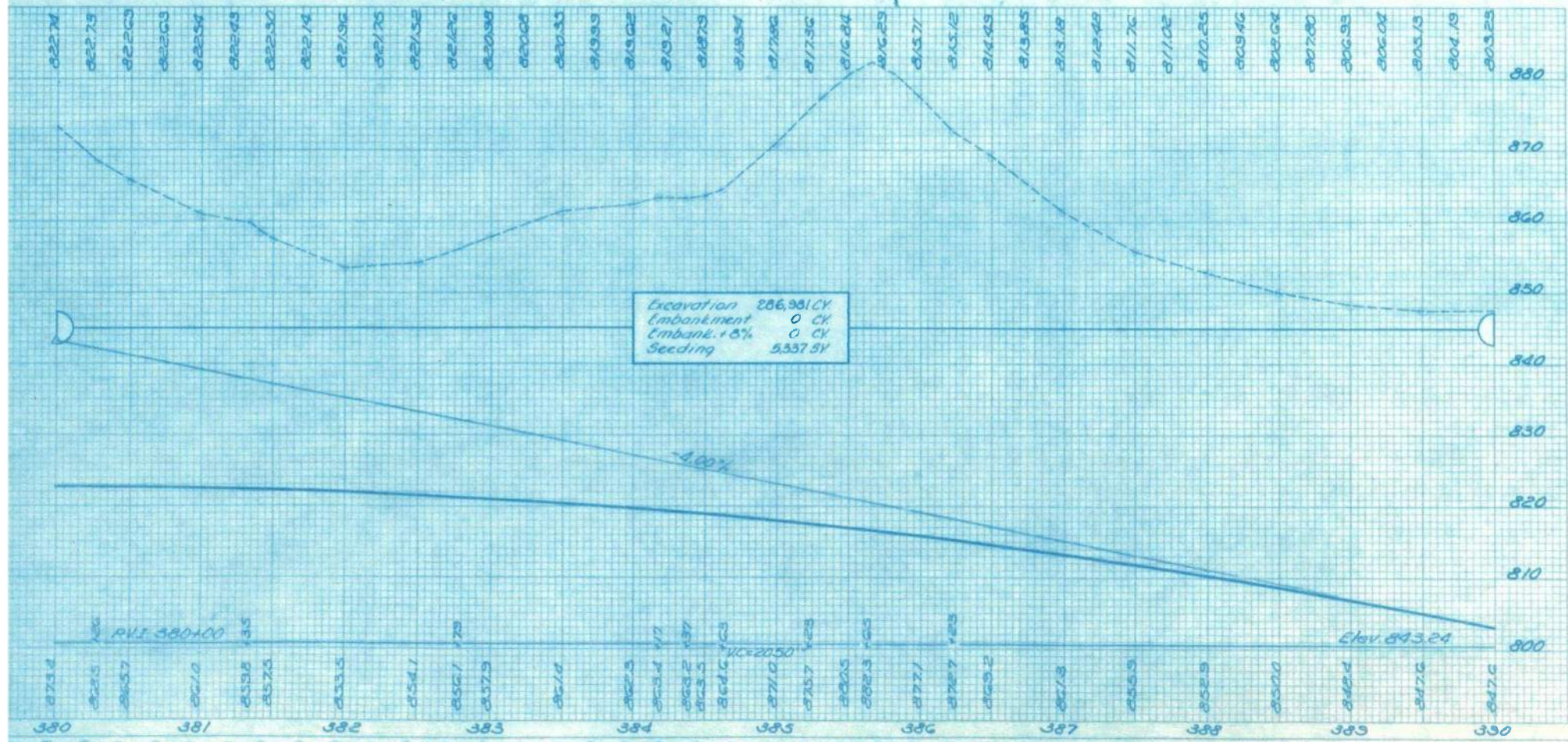
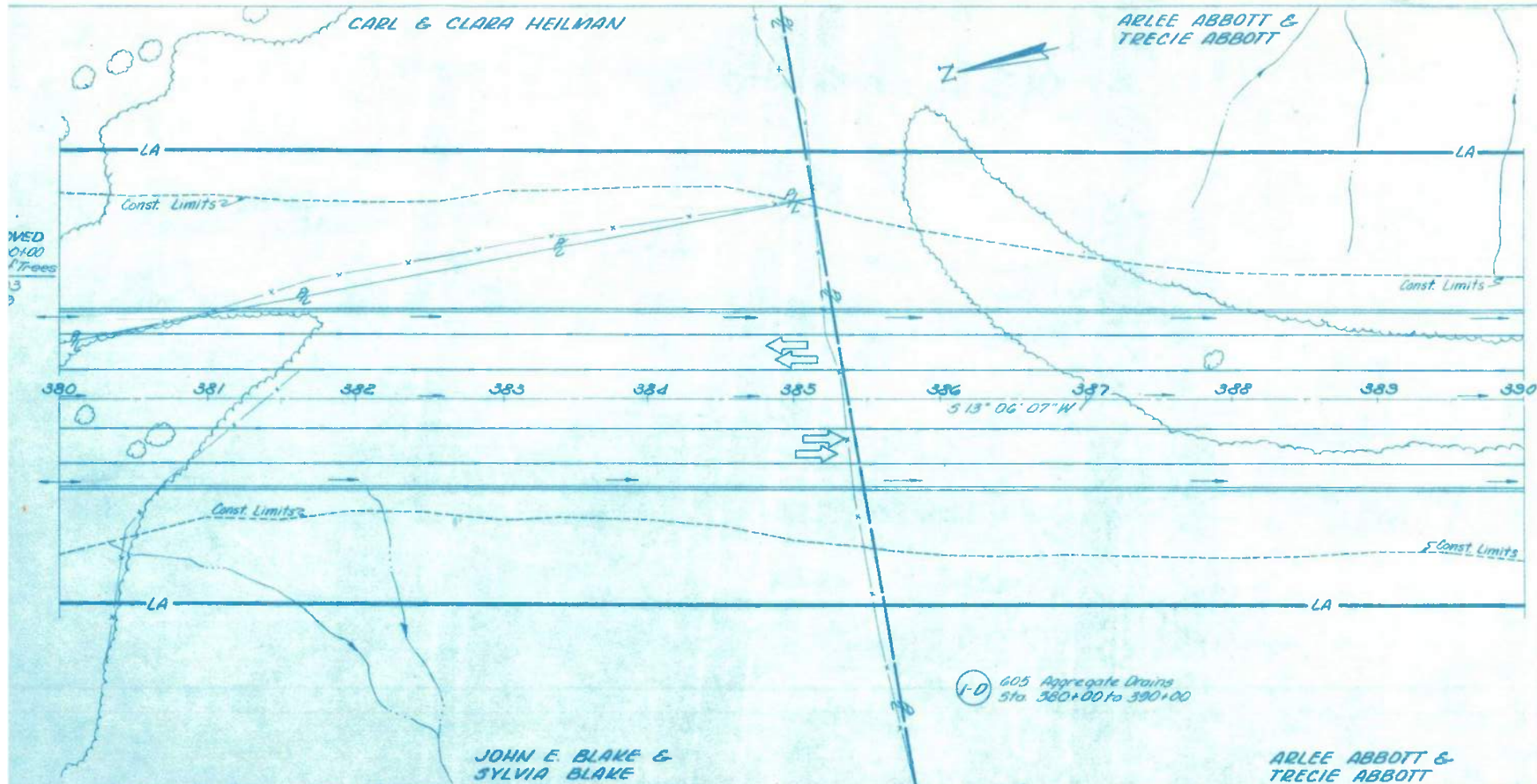
Top core loss partially due to mechanical difficulties.



Existing Plans  
MEG-33-3.79

CARL & CLARA HEILMAN

ARLEE ABBOTT & TRECIE ABBOTT

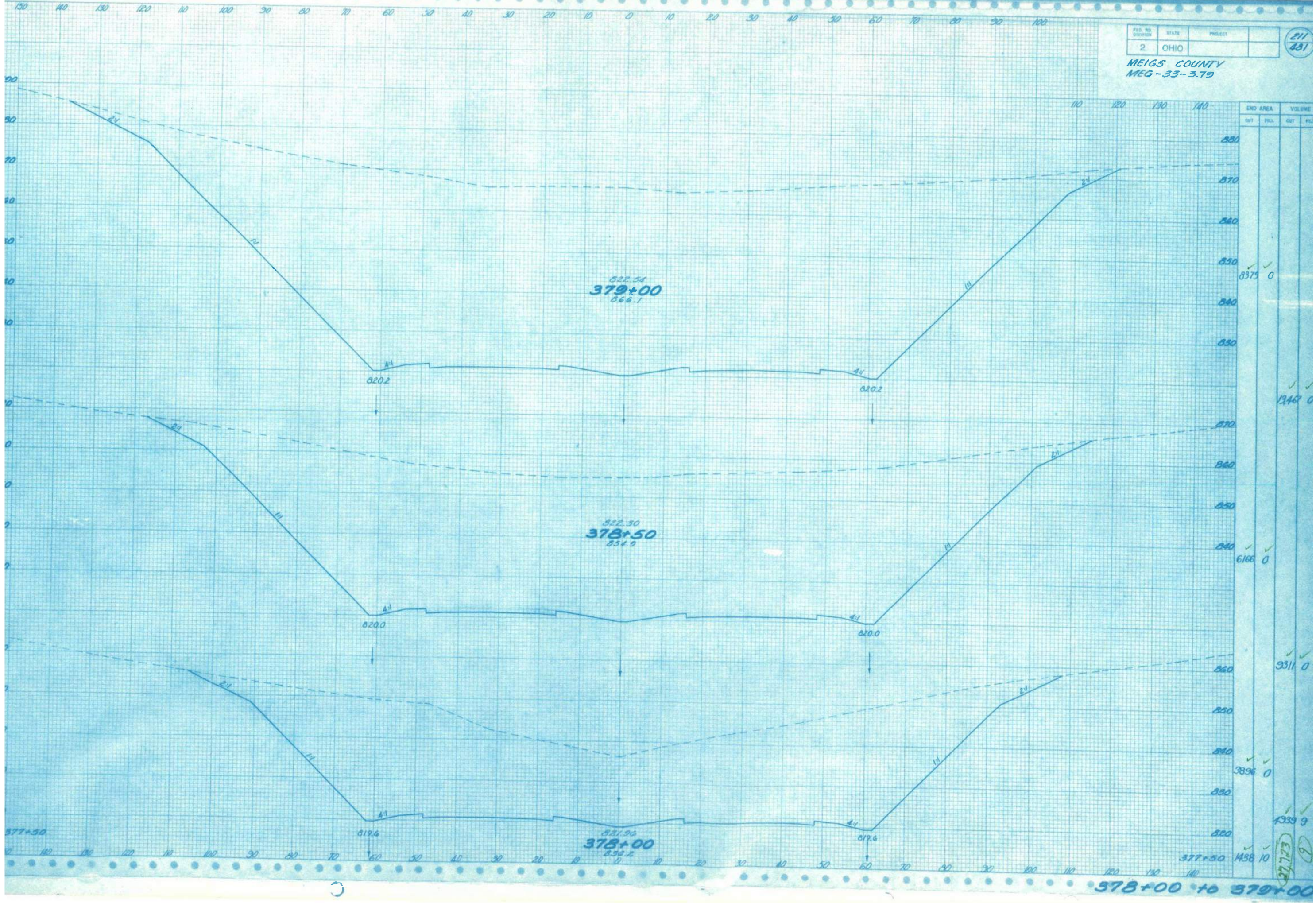


ESTIMATED QUANTITIES

REF. NO.	STATION TO STATION	SIDE	UNITS
1-D	380+00 to 390+00	PRV	605 Aggregate Drains L.F. 1360

TOTALS TO SHEET NO. 56

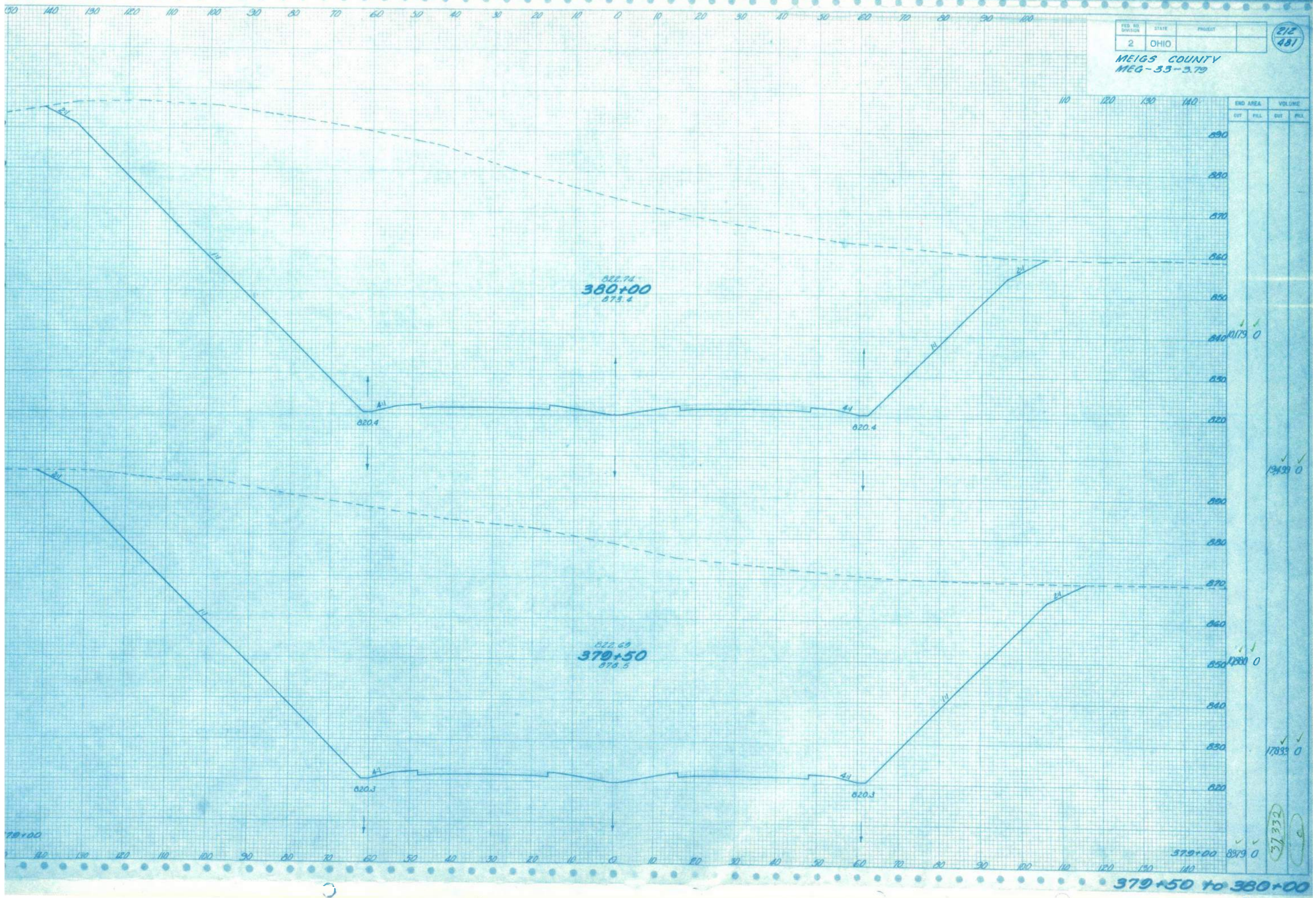




FED. RD. DIVISION	STATE	PROJECT
2	OHIO	

212  
481

MEIGS COUNTY  
MEG-33-3.79

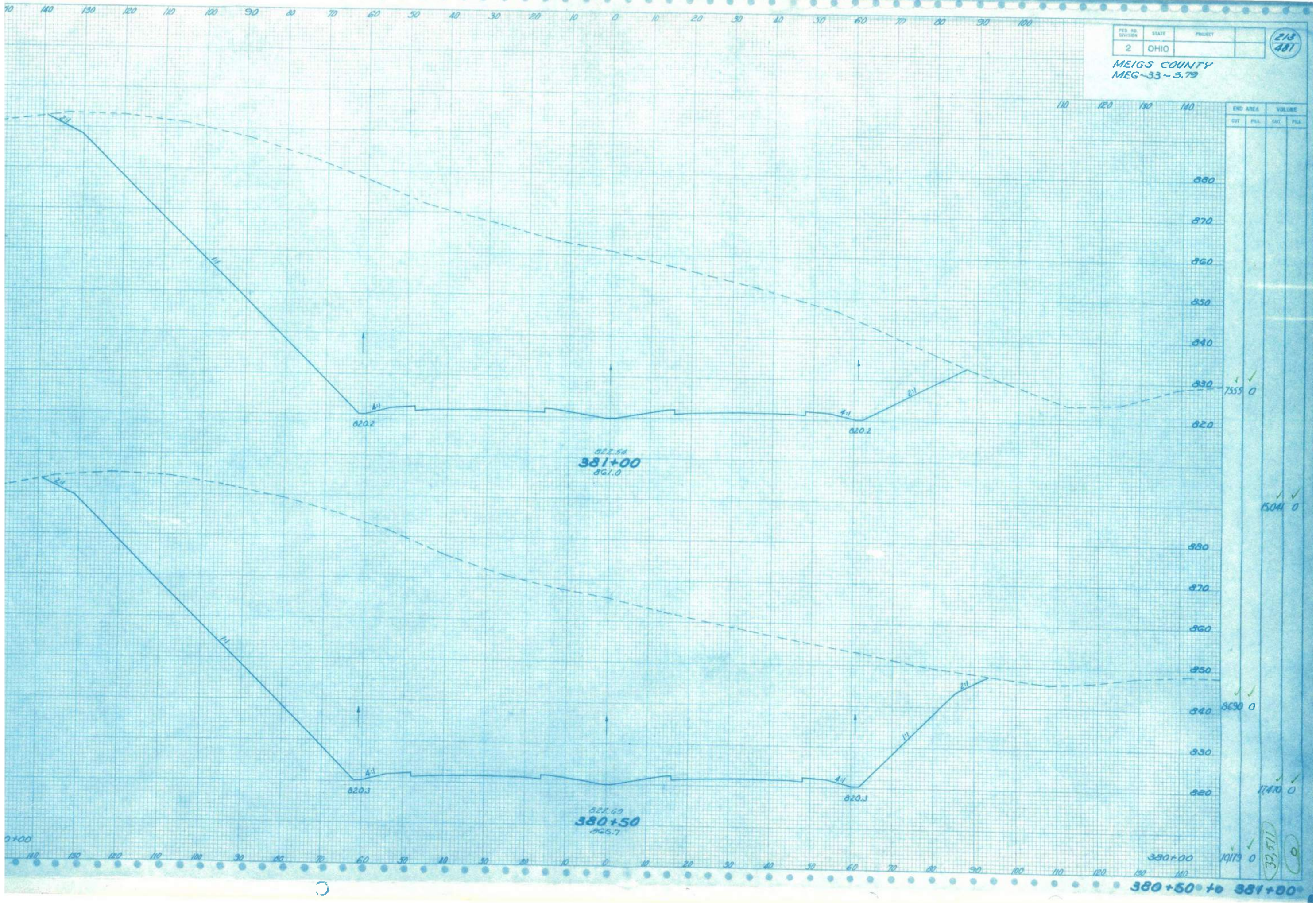


END AREA	VOLUME	
	OUT	FILL
890		
880		
870		
860		
850		
840	1179.0	
830		
820		
810		1949.0
800		
890		
880		
870		
860		
850	1280.0	
840		
830		1783.0
820		
810		
800		
790		
780		
770		
760		
750		
740		
730		
720		
710		
700		
690		
680		
670		
660		
650		
640		
630		
620		
610		
600		
590		
580		
570		
560		
550		
540		
530		
520		
510		
500		
490		
480		
470		
460		
450		
440		
430		
420		
410		
400		
390		
380		
370		
360		
350		
340		
330		
320		
310		
300		
290		
280		
270		
260		
250		
240		
230		
220		
210		
200		
190		
180		
170		
160		
150		
140		
130		
120		
110		
100		
90		
80		
70		
60		
50		
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20		
10		
0		
10		
20		
30		
40		
50		
60		
70		
80		
90		
100		
110		
120		
130		
140		
150		

379+50 to 380+00

27332

MEIGS COUNTY  
MEG-33-3.79



END AREA		VOLUME	
CUT	FILL	CUT	FILL
		7555.0	0
		1504.0	0
		8690.0	0
		1740.0	0
		19175.0	0

822.54  
381+00  
861.0

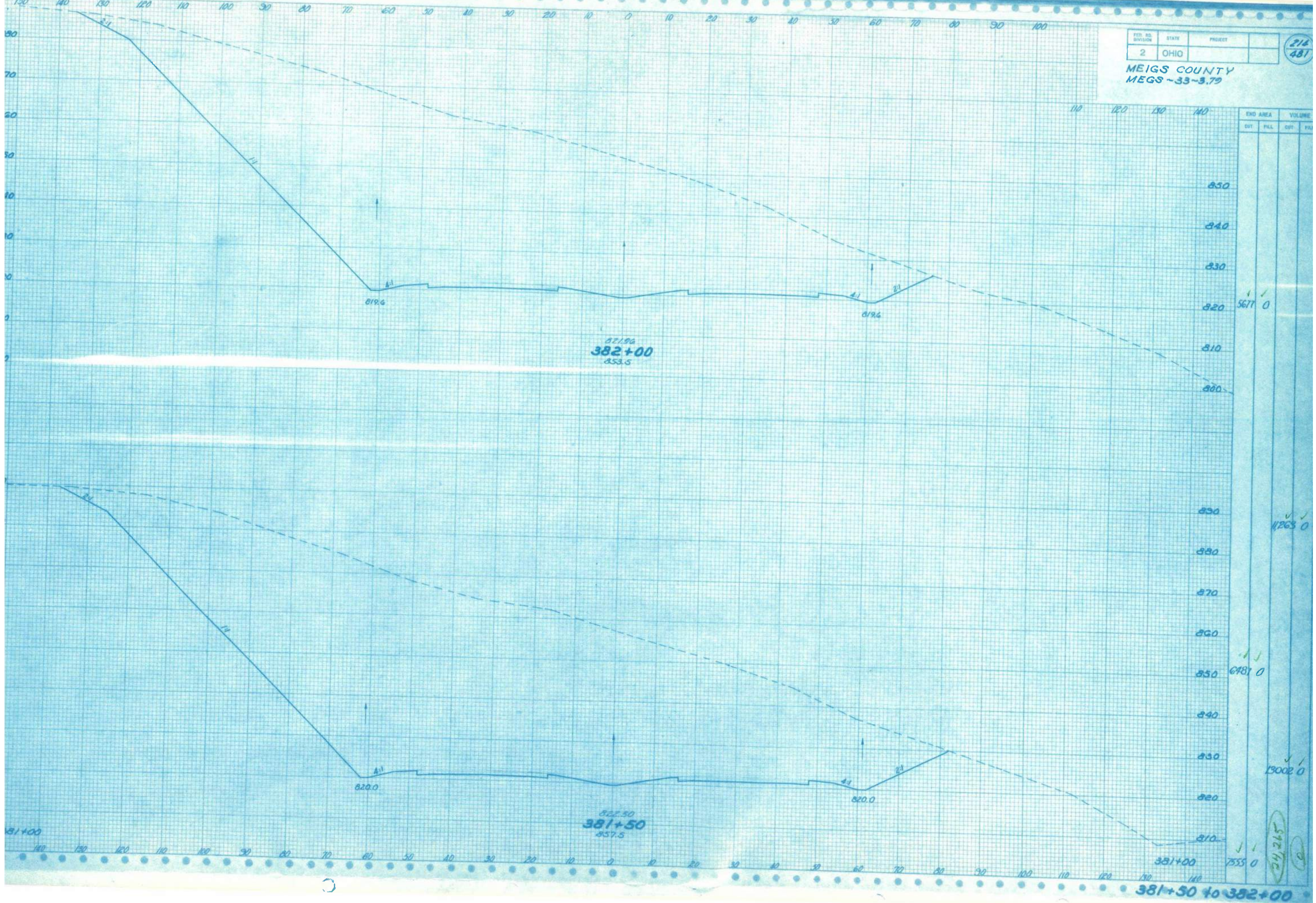
827.69  
380+50  
866.7

380+50 to 381+00

FED. RD. DIVISION	STATE	PROJECT
2	OHIO	

216  
487

MEIGS COUNTY  
MEGS-33-3.79

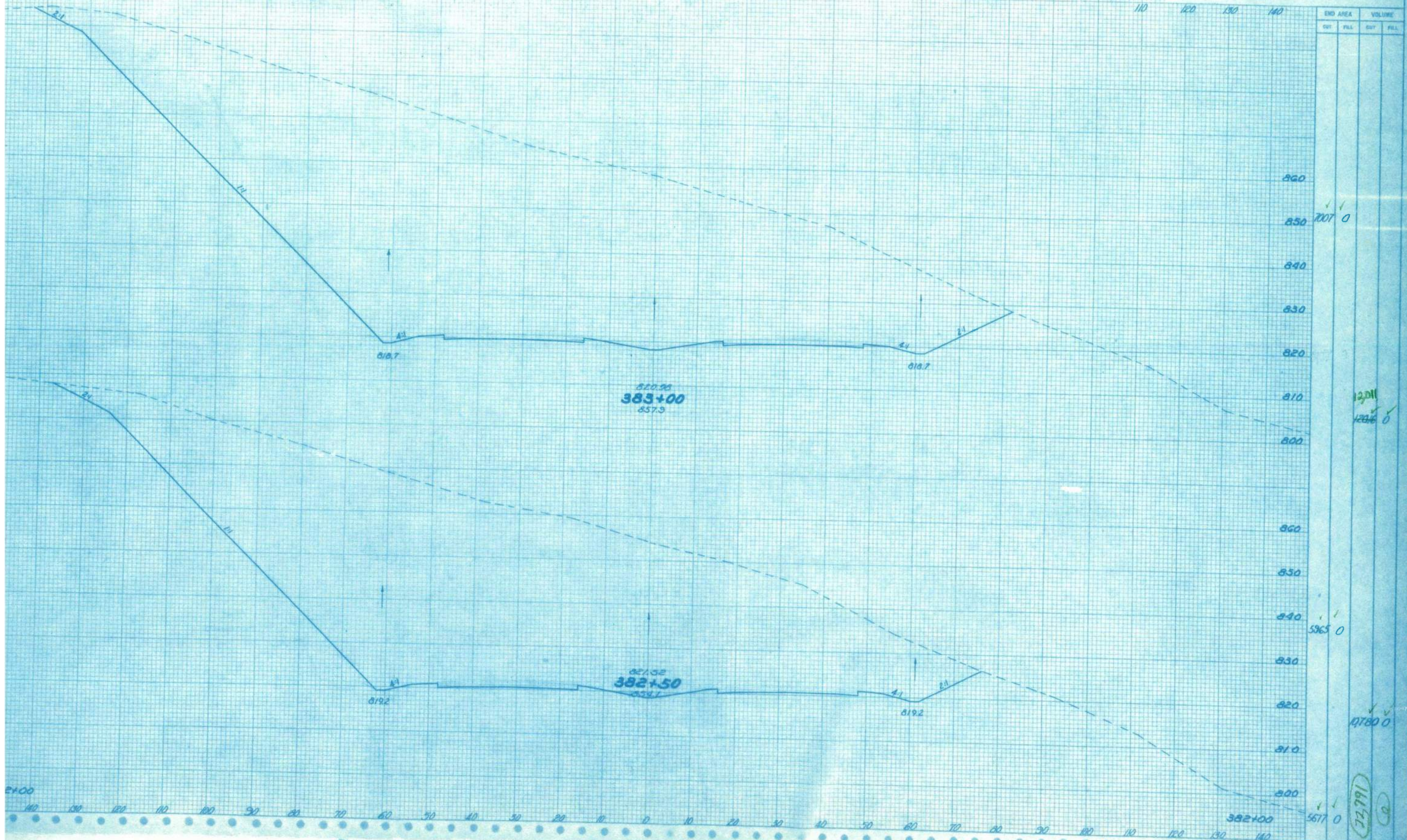


381+50 to 382+00

FED. RD. DIVISION	STATE	PROJECT
2	OHIO	

215  
481

MEIGS COUNTY  
MEG-33-3.79



END AREA	VOLUME	
	DIT	FILL
7007.0		
12211.0		
5965.0		
1780.0		
5677.0		

820.36  
383+00  
857.3

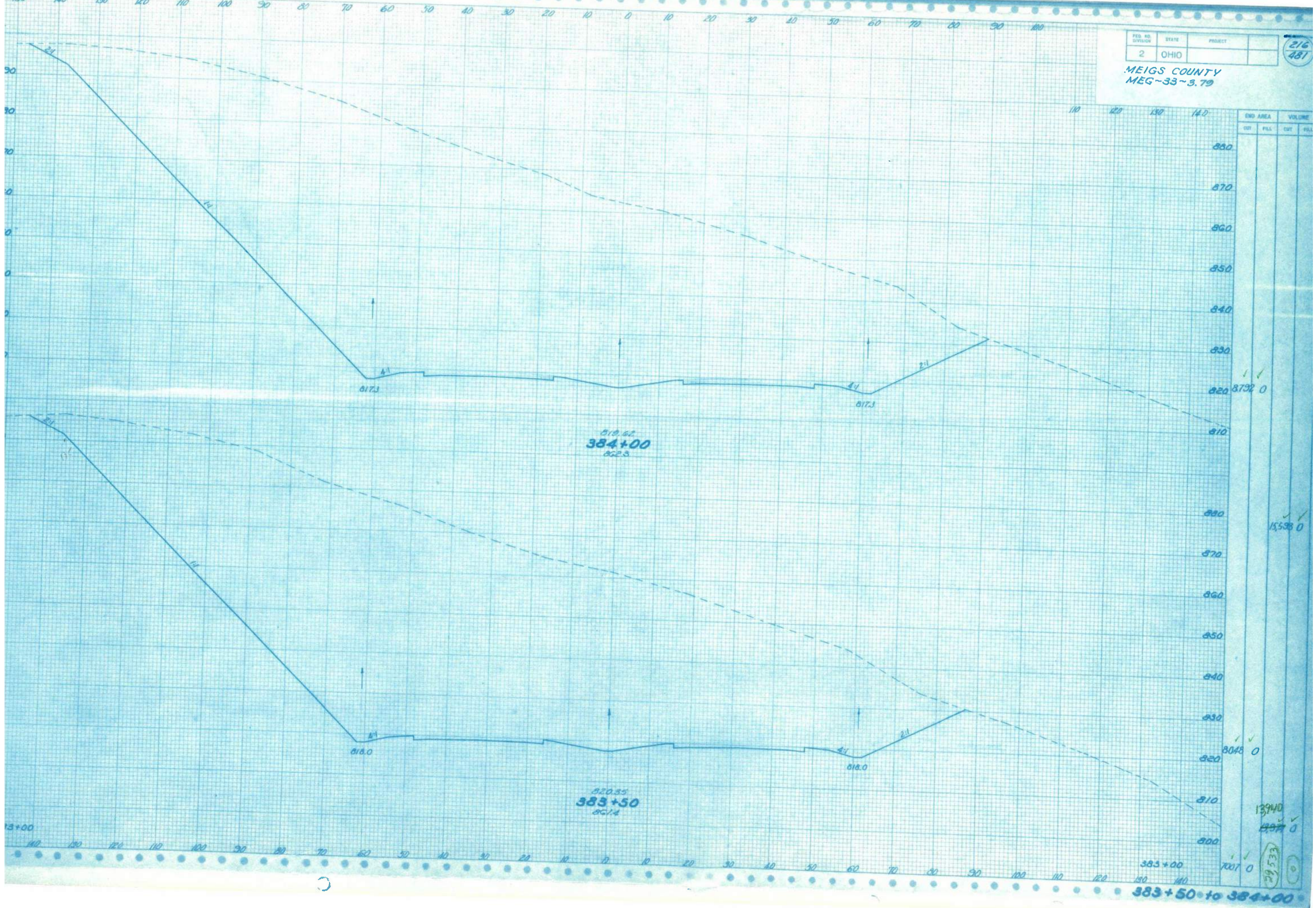
821.52  
382+50  
854.7

382+50 to 383+00

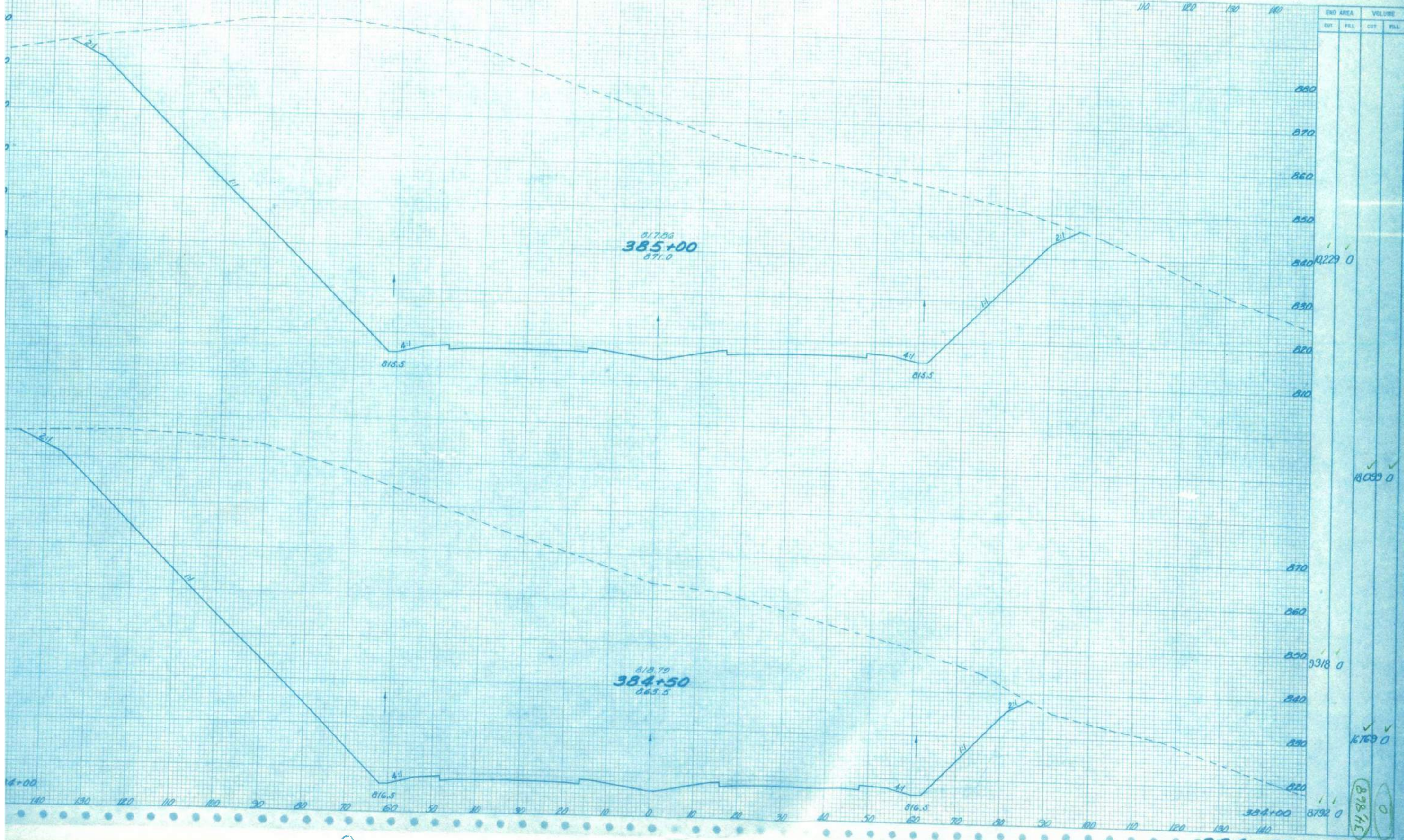
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MEIGS COUNTY  
MEG-33-3.79

216  
481



MEIGS COUNTY  
MEG-33-3.79



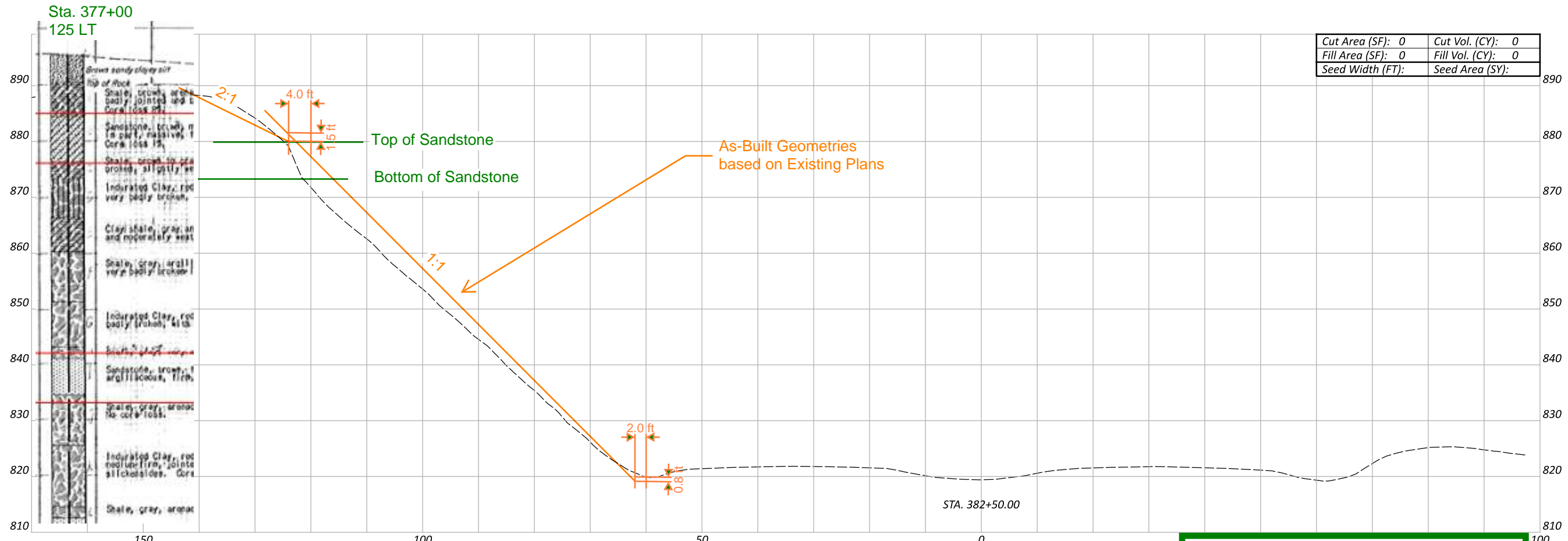
384+00 to 385+00

MEG-33-7.61  
CRSP Rockfall Analysis

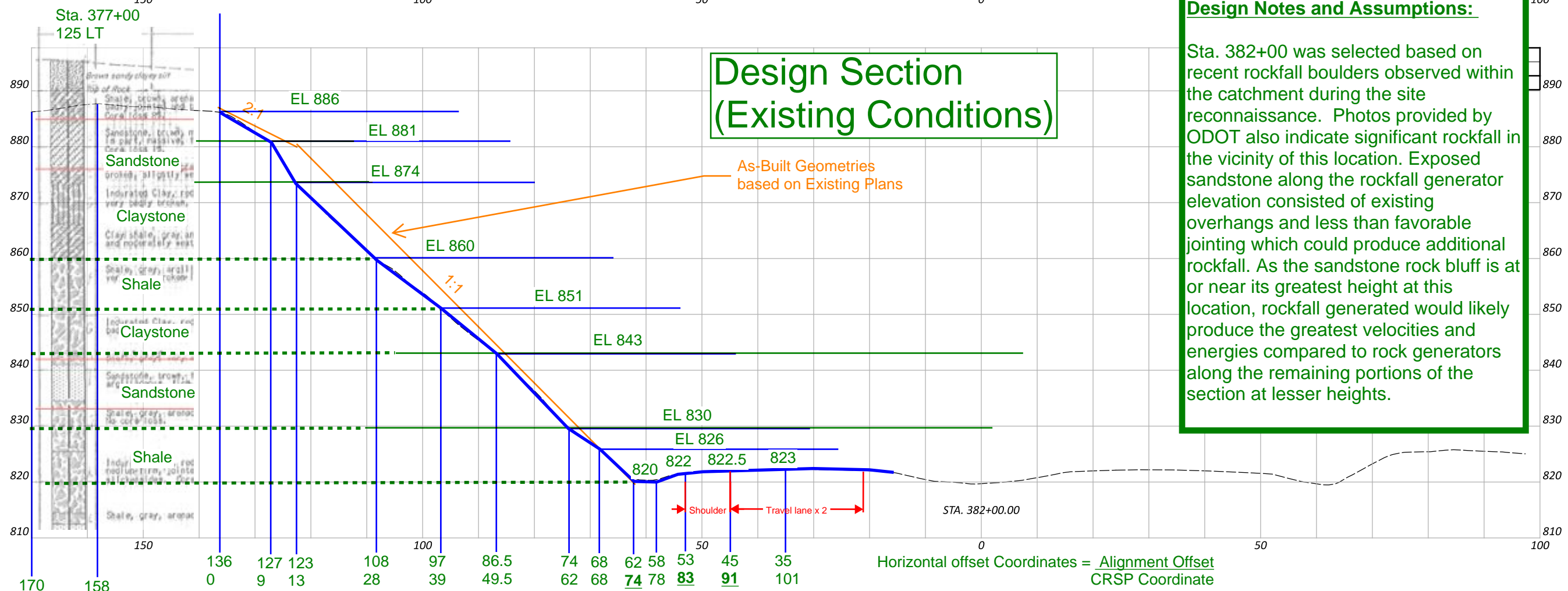
Sta. 382+00







Cut Area (SF):	0	Cut Vol. (CY):	0
Fill Area (SF):	0	Fill Vol. (CY):	0
Seed Width (FT):		Seed Area (SY):	



**Design Section  
(Existing Conditions)**

**Design Notes and Assumptions:**  
 Sta. 382+00 was selected based on recent rockfall boulders observed within the catchment during the site reconnaissance. Photos provided by ODOT also indicate significant rockfall in the vicinity of this location. Exposed sandstone along the rockfall generator elevation consisted of existing overhangs and less than favorable jointing which could produce additional rockfall. As the sandstone rock bluff is at or near its greatest height at this location, rockfall generated would likely produce the greatest velocities and energies compared to rock generators along the remaining portions of the section at lesser heights.

170	158	136	127	123	108	97	86.5	74	68	62	58	53	45	35	0	50	100
0	9	13	28	39	49.5	62	68	74	68	74	78	83	91	101			

Horizontal offset Coordinates = Alignment Offset  
 CRSP Coordinate

Sheet Totals	118508	
Seeding	Cut	Fill
P.0	0	0

Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Existing Conditions**  
 Subject: **Sta. 832+00**

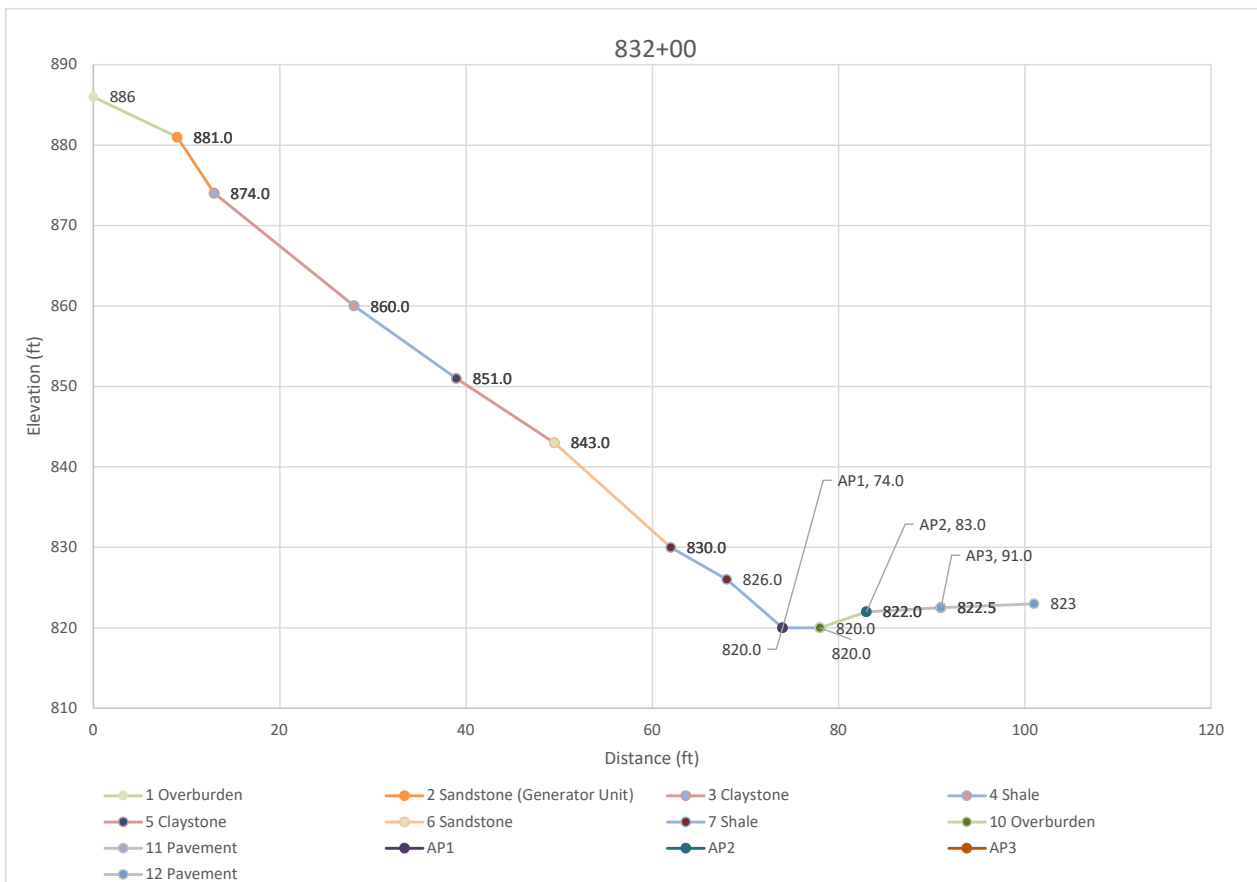
Computed: **DCM** Date: **5/13/24**  
 Checked: **AKB** Date: **5/17/24**  
 Page: **1** of **2**

	<u>X</u>	<u>Y</u>	<u>Description</u>
Analysis Pt 1 =	AP1	74.0	Toe of Slope @ Catchment
Analysis Pt 2 =	AP2	83.0	Edge of Pavement
Analysis Pt 3 =	AP3	91.0	Edge of Travel Lane

**CRSP Assumptions:** Analysis using long-term conditions  
 ≥95% rockfall retained at Analysis Pt 2 design criteria  
 Roughness based on field measurements and experience with bedrock of the Monongahela Group  
 Rock shape is discoidal, 1 feet to 4 feet

Upper Zone Ymax: 881    Δ Elev.  
 Upper Zone Ymin: 874    7

	Cell	Surface R	Tangent C	Normal C	Begin X	Begin Y	End X	End Y
1 Overburden	1	2	0.65	0.15	0	886	9	881
2 Sandstone (Generator Unit)	2	2	0.9	0.25	9.0	881.0	13.0	874.0
3 Claystone	3	0.25	0.75	0.15	13.0	874.0	28.0	860.0
4 Shale	4	0.5	0.75	0.15	28.0	860.0	39.0	851.0
5 Claystone	5	0.25	0.75	0.15	39.0	851.0	49.5	843.0
6 Sandstone	6	1.5	0.9	0.25	49.5	843.0	62.0	830.0
7 Shale	7	0.5	0.75	0.15	62.0	830.0	68.0	826.0
8 Shale	8	0.5	0.75	0.15	68.0	826.0	74	820
9 Shale	9	0.5	0.75	0.15	74.0	820.0	78	820
10 Overburden	10	2	0.65	0.15	78.0	820.0	83	822
11 Pavement	11	0	1	1	83.0	822.0	91	822.5
12 Pavement	12	0	1	1	91.0	822.5	101	823



Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Existing Conditions**  
 Subject: **Sta. 832+00**

Computed: **DCM** Date: **5/13/24**  
 Checked: **AKB** Date: **5/17/24**  
 Page: **2** of **2**

Overburden  
Claystone and Shale  
Sandstone

**Table 503-2. Hardness reference guide with CRSP coefficient values (Modified from Woodard, 2004)**

Hardness Input Code	Consistency	Field Identification	Normal Coefficient Values (Rn)	Tangential Coefficient Values (Rt)
1	Very soft	Easily penetrated several inches by fist	0.10	0.50
2	Soft	Easily penetrated several inches by thumb	0.10	0.55
3	Firm	Can be penetrated several inches by thumb with moderate effort	0.15	0.65
4	Stiff	Readily indented by thumb but penetrated only with great effort	0.15	0.70
5	Very stiff	Readily indented by thumbnail	0.20	0.75
6	Hard	Indented with difficulty by thumbnail	0.20	0.80-0.85
7	Very weak rock	Can be curved with a knife. Can be excavated readily with a point of a pick. Pieces 1 inch (25 mm) or more in thickness can be broken by finger pressure. Can be scratched by fingernail.	0.15	0.75
8	Weak rock	Can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure.	0.15	0.75
9	Slightly strong rock	Can be grooved or gouged 0.05 inch (2 mm) deep by firm pressure of a knife or pick point. Can be excavated in small chips to pieces about 1-inch (25 mm) maximum size by hard blows of the point of a geologist's pick.	0.20	0.80
10	Moderately strong rock	Can be scratched with a knife or pick. Grooves or gouges to 1/4" (6mm) deep can be excavated by hand blows of a geologist's pick. Requires moderate hammer blows to detach hand specimen.	0.25	0.85
11	Strong rock	Can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach hand specimen. Sharp and resistant edges are present on hand specimen.	0.25-0.30	0.9
12	Very strong rock	Cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0
13	Extremely strong rock	Cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0

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OHIO DEPARTMENT OF TRANSPORTATION  
Rock Slope Design Guide

**Table 503-1. CRSP Coefficient Guide for Normal and Tangential Coefficient (from Jones, et al., 2000)**

Description of Slope	Normal Coefficient (Rn)	Remarks
Smooth hard surfaces and paving	0.60-1.0	-For short slopes try lower values in applicable range
Most bedrock and boulder fields	0.15-0.30	
Talus and firm soil slopes	0.12-0.20	-If max. velocity/KE* are design criteria, use lower values in range; if avg. velocity/KE* are design criteria, use higher values in range
Soft soil slopes**	0.10-0.20	

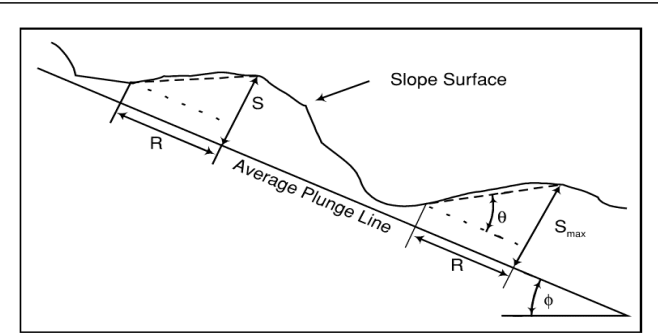
\*KE = kinetic energy  
 \*\*Soft soil slope coefficients were extrapolated from other slope types due to lack of data

Description of Slope	Tangential Coefficient (Rt)	Remarks
Smooth hard surfaces and paving	0.90-1.0	-Rt is not very sensitive compared to Rn, but may be important for hard or significantly vegetated slopes
Most bedrock and boulder fields	0.75-0.95	
Talus and firm soil slopes	0.65-0.95	
Soft soil slopes*	0.50-0.80	-Use lower Rt as the density of vegetation on the slope increases

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For Pavement Use 1.0 for Rn and Rt



**Figure 2. Surface roughness (S) established as the perpendicular variation from an average plunge line (defined by slope angle  $\phi$ ) over a distance equal to the radius of the rock (R). Maximum slope variation ( $\theta_{max}$ ) is defined by S and R (Pfeiffer, 1989; Pfeiffer et al., 1991; 1995).**

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_4x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 12  
Analysis Point 1 X-Coordinate: 74  
Analysis Point 2 X-Coordinate: 83  
Analysis Point 3 X-Coordinate: 91  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 874

Remarks: Sta. 382+00 Existing

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	886	9	881
2.	2	.9	.25	9	881	13	874
3.	.25	.75	.15	13	874	28	860
4.	.5	.75	.15	28	860	39	851
5.	.25	.75	.15	39	851	49.5	843
6.	1.5	.9	.25	49.5	843	62	830
7.	.5	.75	.15	62	830	68	826
8.	.5	.75	.15	68	826	74	820
9.	.5	.75	.15	74	820	78	820
10.	2	.65	.15	78	820	83	822
11.	0	1	1	83	822	91	822.5
12.	0	1	1	91	822.5	101	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_4x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 12  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 4 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_4x1 Disc.doc

Analysis Point 1: X = 74, Y = 820

Total Rocks Passing Analysis Point: 516

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	38.16	61958
75%	40.34	68150
90%	42.29	73720
95%	43.46	77063
98%	44.78	80816

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 47.71	Maximum: 8.5	Maximum: 86957
Average: 38.16	Average: 3.21	Average: 61958
Minimum: 29.34	G. Mean: 2.27	Std. Dev.: 9170
Std. Dev.: 3.22	Std. Dev.: 3.61	

Remarks: Sta. 382+00 Existing

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_4x1 Disc.doc

Analysis Point 2: X = 83, Y = 822

Total Rocks Passing Analysis Point: 276

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	9.1	5759
75%	11.51	8334
90%	13.68	10650
95%	14.98	12040
98%	16.44	13600

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 17.69	Maximum: 1.61	Maximum: 16951
Average: 9.1	Average: .28	Average: 5759
Minimum: 1.59	G. Mean: .11	Std. Dev.: 3813
Std. Dev.: 3.57	Std. Dev.: 7.42	

Remarks: Sta. 382+00 Existing

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_4x1 Disc.doc

Analysis Point 3: X = 91, Y = 822

Total Rocks Passing Analysis Point: 244

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	9.97	5362
75%	12.5	7855
90%	14.78	10098
95%	16.15	11444
98%	17.69	12955

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 18.35	Maximum: 1.13	Maximum: 16284
Average: 9.97	Average: .25	Average: 5362
Minimum: 1.67	G. Mean: .1	Std. Dev.: 3692
Std. Dev.: 3.76	Std. Dev.: 6.92	

Remarks: Sta. 382+00 Existing

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_4x1 Disc.doc

Velocity Units: ft/sec

Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
--------	-----------	-----------	-----------	-----------------	-----------------

1.	No rocks	past end of cell			
2.	22	12	4.26	2	0
3.	28	14	9.03	0	0
4.	34	27	2.1	1	0
5.	35	29	2.13	0	0
6.	43	34	4.52	8	2
7.	43	34	3.05	7	2
8.	48	38	3.22	8	3
9.	46	27	9.19	5	0
10.	18	9	3.57	2	0
11.	18	10	3.76	1	0
12.	17	10	3.51	1	0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_4x1 Disc.doc

X Interval

Rocks Stopped

0 To 10 ft	1
10 To 20 ft	0
20 To 30 ft	482
30 To 40 ft	0
40 To 50 ft	1
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	83
80 To 90 ft	182
90 To 100 ft	43
100 To 101 ft	5



CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_2x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 12  
Analysis Point 1 X-Coordinate: 74  
Analysis Point 2 X-Coordinate: 83  
Analysis Point 3 X-Coordinate: 91  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 874

Remarks: Sta. 382+00 Existing

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	886	9	881
2.	2	.9	.25	9	881	13	874
3.	.25	.75	.15	13	874	28	860
4.	.5	.75	.15	28	860	39	851
5.	.25	.75	.15	39	851	49.5	843
6.	1.5	.9	.25	49.5	843	62	830
7.	.5	.75	.15	62	830	68	826
8.	.5	.75	.15	68	826	74	820
9.	.5	.75	.15	74	820	78	820
10.	2	.65	.15	78	820	83	822
11.	0	1	1	83	822	91	822.5
12.	0	1	1	91	822.5	101	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_2x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 12  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 2 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_2x1 Disc.doc

Analysis Point 1: X = 74, Y = 820

Total Rocks Passing Analysis Point: 976

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	34.45	12644
75%	37.56	14746
90%	40.36	16636
95%	42.04	17771
98%	43.93	19045

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 48.35</b>	<b>Maximum: 11.01</b>	<b>Maximum: 22267</b>
Average: 34.45	Average: 4.04	Average: 12644
Minimum: 21.12	G. Mean: 3.13	Std. Dev.: 3112
Std. Dev.: 4.61	Std. Dev.: 2.71	

Remarks: Sta. 382+00 Existing

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_2x1 Disc.doc

Analysis Point 2: X = 83, Y = 822

Total Rocks Passing Analysis Point: 192

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	8.22	1241
75%	10.96	2134
90%	13.43	2937
95%	14.91	3420
98%	16.57	3961

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

<b>Maximum: 39.49</b>	<b>Maximum: 2.09</b>	<b>Maximum: 15303</b>
Average: 8.22	Average: .31	Average: 1241
Minimum: .54	G. Mean: .11	Std. Dev.: 1322
Std. Dev.: 4.06	Std. Dev.: 7.97	

Remarks: Sta. 382+00 Existing

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_2x1 Disc.doc

Analysis Point 3: X = 91, Y = 822

Total Rocks Passing Analysis Point: 165

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	8.74	1085
75%	11.4	1739
90%	13.78	2328
95%	15.22	2681
98%	16.83	3077

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

<b>Maximum: 24.52</b>	<b>Maximum: 3.13</b>	<b>Maximum: 7286</b>
Average: 8.74	Average: .29	Average: 1085
Minimum: 1.76	G. Mean: .11	Std. Dev.: 968
Std. Dev.: 3.93	Std. Dev.: 7.16	

Remarks: Sta. 382+00 Existing

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_2x1 Disc.doc

Velocity Units: ft/sec

Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
--------	-----------	-----------	-----------	-----------------	-----------------

1.	No rocks	past end of cell			
2.	20	10	3.76	3	0
3.	29	23	1.69	1	0
4.	32	27	2.53	3	1
5.	36	30	2.15	3	0
6.	44	33	6.97	11	2
7.	45	31	5.23	10	2
8.	48	34	4.61	11	4
9.	47	27	10.2	8	1
10.	39	8	4.06	2	0
11.	25	9	3.93	3	0
12.	25	9	3.7	2	0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_2x1 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	1
10 To 20 ft	23
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	412
80 To 90 ft	396
90 To 100 ft	38
100 To 101 ft	2

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_15x05 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 12  
Analysis Point 1 X-Coordinate: 74  
Analysis Point 2 X-Coordinate: 83  
Analysis Point 3 X-Coordinate: 91  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 874

Remarks: Sta. 382+00 Existing

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	886	9	881
2.	2	.9	.25	9	881	13	874
3.	.25	.75	.15	13	874	28	860
4.	.5	.75	.15	28	860	39	851
5.	.25	.75	.15	39	851	49.5	843
6.	1.5	.9	.25	49.5	843	62	830
7.	.5	.75	.15	62	830	68	826
8.	.5	.75	.15	68	826	74	820
9.	.5	.75	.15	74	820	78	820
10.	2	.65	.15	78	820	83	822
11.	0	1	1	83	822	91	822.5
12.	0	1	1	91	822.5	101	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_15x05 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 12  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1.5 ft  
Thickness: .5 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_15x05 Disc.doc

Analysis Point 1: X = 74, Y = 820

Total Rocks Passing Analysis Point: 952

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	32.12	3101	2.56
75%	36.08	3786	5.17
90%	39.64	4403	7.52
95%	41.78	4773	8.92
98%	44.19	5188	10.5

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 47.73	Maximum: 10.57	Maximum: 6049
Average: 32.12	Average: 3.75	Average: 3101
Minimum: 13.4	G. Mean: 2.56	Std. Dev.: 1014
Std. Dev.: 5.87	Std. Dev.: 3.86	

Remarks: Sta. 382+00 Existing

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_15x05 Disc.doc

Analysis Point 2: X = 83, Y = 822

Total Rocks Passing Analysis Point: 109

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	8.76	371	0.11
75%	11.51	620	5.19
90%	13.98	844	9.76
95%	15.47	979	12.51
98%	17.13	1130	15.59

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 34.2	Maximum: 1.31	Maximum: 3376
Average: 8.76	Average: .29	Average: 371
Minimum: 3.17	G. Mean: .11	Std. Dev.: 369
Std. Dev.: 4.07	Std. Dev.: 7.53	

Remarks: Sta. 382+00 Existing

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_15x05 Disc.doc

Analysis Point 3: X = 91, Y = 822

Total Rocks Passing Analysis Point: 95

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	8.87	312
75%	11.52	502
90%	13.9	672
95%	15.33	774
98%	16.94	889

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 23.83	Maximum: 3.17	Maximum: 1951
Average: 8.87	Average: .34	Average: 312
Minimum: 1.19	G. Mean: .16	Std. Dev.: 280
Std. Dev.: 3.92	Std. Dev.: 5.6	

Remarks: Sta. 382+00 Existing

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_15x05 Disc.doc

Velocity Units: ft/sec

Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
--------	-----------	-----------	-----------	-----------------	-----------------

1.	No rocks	past end of cell			
2.	19	10	3.71	3	0
3.	29	23	1.81	2	0
4.	33	26	2.91	4	1
5.	36	28	2.69	4	0
6.	44	31	7.88	12	3
7.	44	29	6.12	10	2
8.	48	32	5.87	11	3
9.	46	24	10.87	7	1
10.	34	9	4.07	1	0
11.	24	9	3.92	3	0
12.	25	9	4.1	2	0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_15x05 Disc.doc

X Interval

Rocks Stopped

0 To 10 ft	9
10 To 20 ft	39
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	512
80 To 90 ft	341
90 To 100 ft	18
100 To 101 ft	3



CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_1x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 12  
Analysis Point 1 X-Coordinate: 74  
Analysis Point 2 X-Coordinate: 83  
Analysis Point 3 X-Coordinate: 91  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 874

Remarks: Sta. 382+00 Existing

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	886	9	881
2.	2	.9	.25	9	881	13	874
3.	.25	.75	.15	13	874	28	860
4.	.5	.75	.15	28	860	39	851
5.	.25	.75	.15	39	851	49.5	843
6.	1.5	.9	.25	49.5	843	62	830
7.	.5	.75	.15	62	830	68	826
8.	.5	.75	.15	68	826	74	820
9.	.5	.75	.15	74	820	78	820
10.	2	.65	.15	78	820	83	822
11.	0	1	1	83	822	91	822.5
12.	0	1	1	91	822.5	101	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_1x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 12  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_1x1 Disc.doc

Analysis Point 1: X = 74, Y = 820

Total Rocks Passing Analysis Point: 857

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	28.46	2206
75%	33.35	2881
90%	37.75	3487
95%	40.39	3852
98%	43.35	4261

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 44.44	Maximum: 9.37	Maximum: 4831
Average: 28.46	Average: 2.8	Average: 2206
Minimum: 7.7	G. Mean: 1.82	Std. Dev.: 999
Std. Dev.: 7.24	Std. Dev.: 3.93	

Remarks: Sta. 382+00 Existing

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_1x1 Disc.doc

Analysis Point 2: X = 83, Y = 822

Total Rocks Passing Analysis Point: 43

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	7.01	230
75%	9.25	362
90%	11.27	480
95%	12.48	552
98%	13.84	631

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 16.68	Maximum: 1.62	Maximum: 935
Average: 7.01	Average: .25	Average: 230
Minimum: .95	G. Mean: .07	Std. Dev.: 194
Std. Dev.: 3.32	Std. Dev.: 9.8	

Remarks: Sta. 382+00 Existing

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_1x1 Disc.doc

Analysis Point 3: X = 91, Y = 822

Total Rocks Passing Analysis Point: 34

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	7.72	211
75%	10.15	346
90%	12.34	468
95%	13.66	541
98%	15.13	623

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 16.82	Maximum: 1	Maximum: 861
Average: 7.72	Average: .23	Average: 211
Minimum: 2.37	G. Mean: .09	Std. Dev.: 200
Std. Dev.: 3.61	Std. Dev.: 6.82	

Remarks: Sta. 382+00 Existing

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_1x1 Disc.doc

Velocity Units: ft/sec

Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
--------	-----------	-----------	-----------	-----------------	-----------------

1.	No rocks	past end of cell			
2.	19	9	3.69	3	0
3.	29	21	2.31	2	0
4.	32	23	4.13	5	1
5.	34	26	3.68	4	0
6.	43	28	8.54	10	2
7.	44	25	7.6	8	2
8.	44	28	7.24	9	2
9.	43	18	10.16	5	0
10.	17	7	3.32	2	0
11.	17	8	3.61	1	0
12.	16	7	3.71	1	0

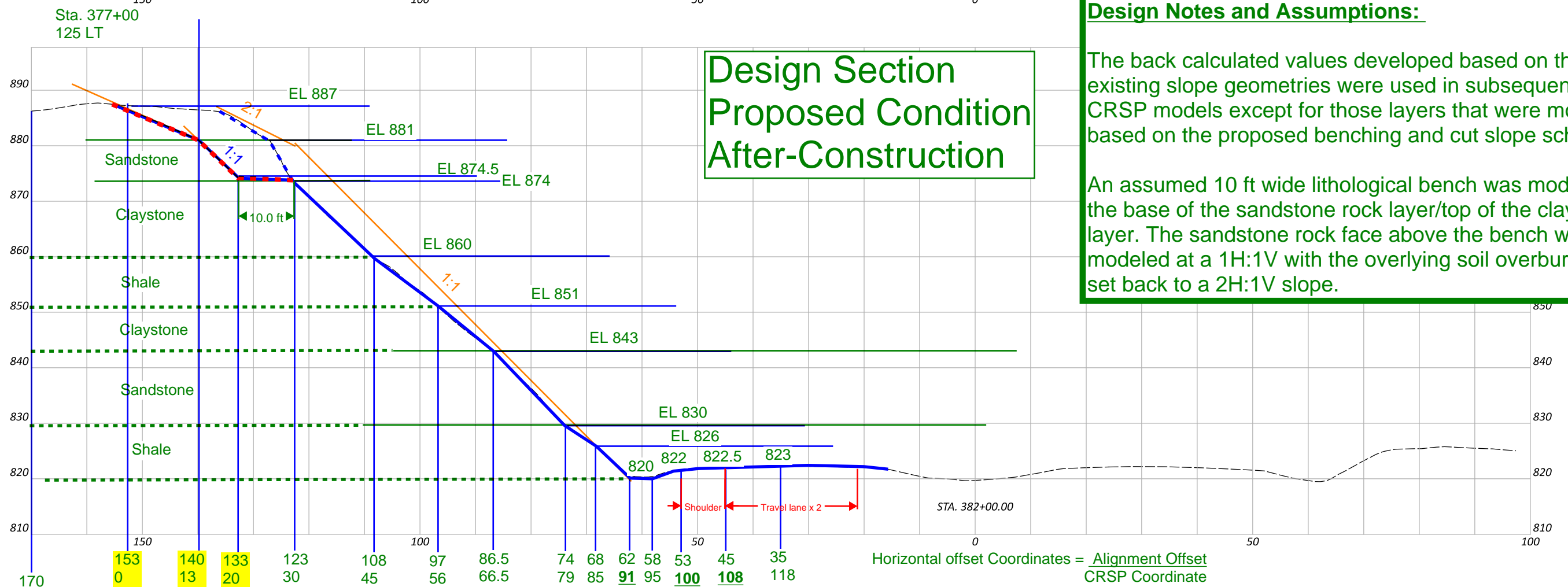
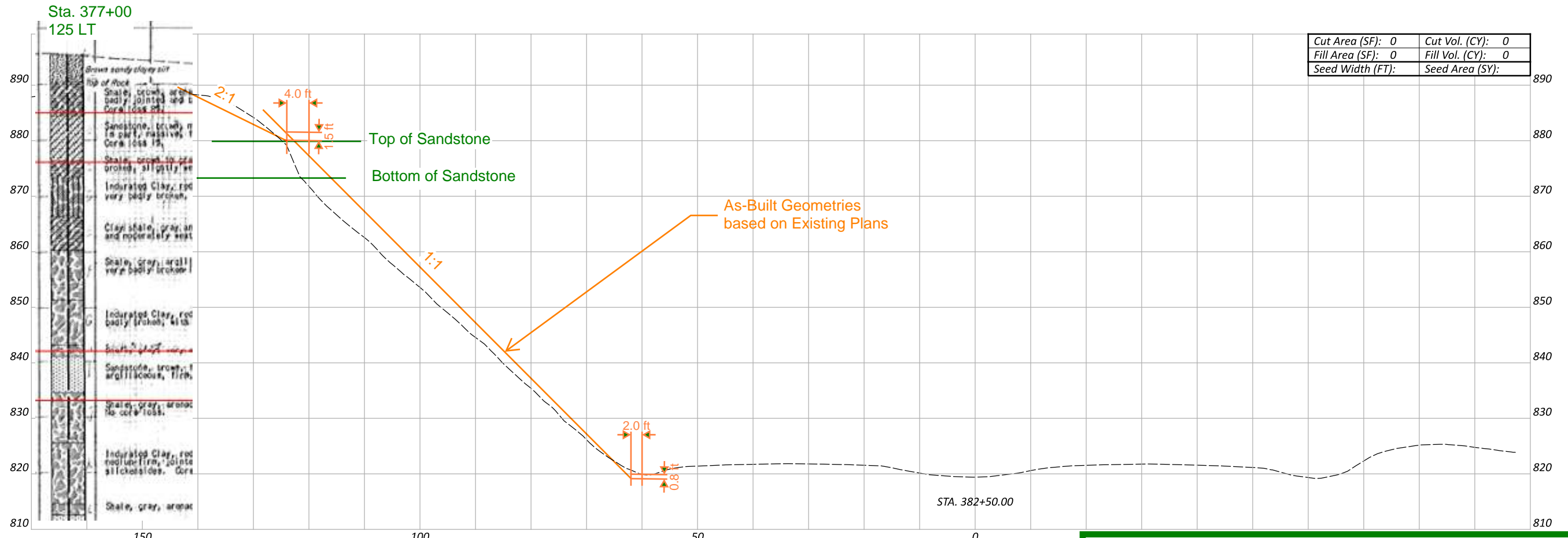
CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Existing\_1x1 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	29
13. To 20 ft	113
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	1
60 To 70 ft	0
70 To 80 ft	577
80 To 90 ft	245
90 To 100 ft	11
100 To 101 ft	0



MEG-33-(7.61)(7.87)

MODEL: CLK\_33 - 382+00.00 [Sheet] PAPER SIZE: 34x22 (in.) DATE: 4/30/2024 TIME: 4:12:53 PM USER: TMMILLS  
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**Design Section  
Proposed Condition  
After-Construction**

**Design Notes and Assumptions:**  
 The back calculated values developed based on the existing slope geometries were used in subsequent CRSP models except for those layers that were modified based on the proposed benching and cut slope scheme.  
 An assumed 10 ft wide lithological bench was modeled at the base of the sandstone rock layer/top of the claystone layer. The sandstone rock face above the bench was modeled at a 1H:1V with the overlying soil overburden set back to a 2H:1V slope.

CROSS SECTIONS US 33  
 STA. 382+00 TO STA. 382+50

DESIGN AGENCY



DESIGNER  
TDM

REVIEWER  
PID MM-DD-YY

PROJECT ID  
118508

SHEET TOTAL  
P.0 0

Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Proposed - Short Term**  
 Subject: **Sta. 832+00**

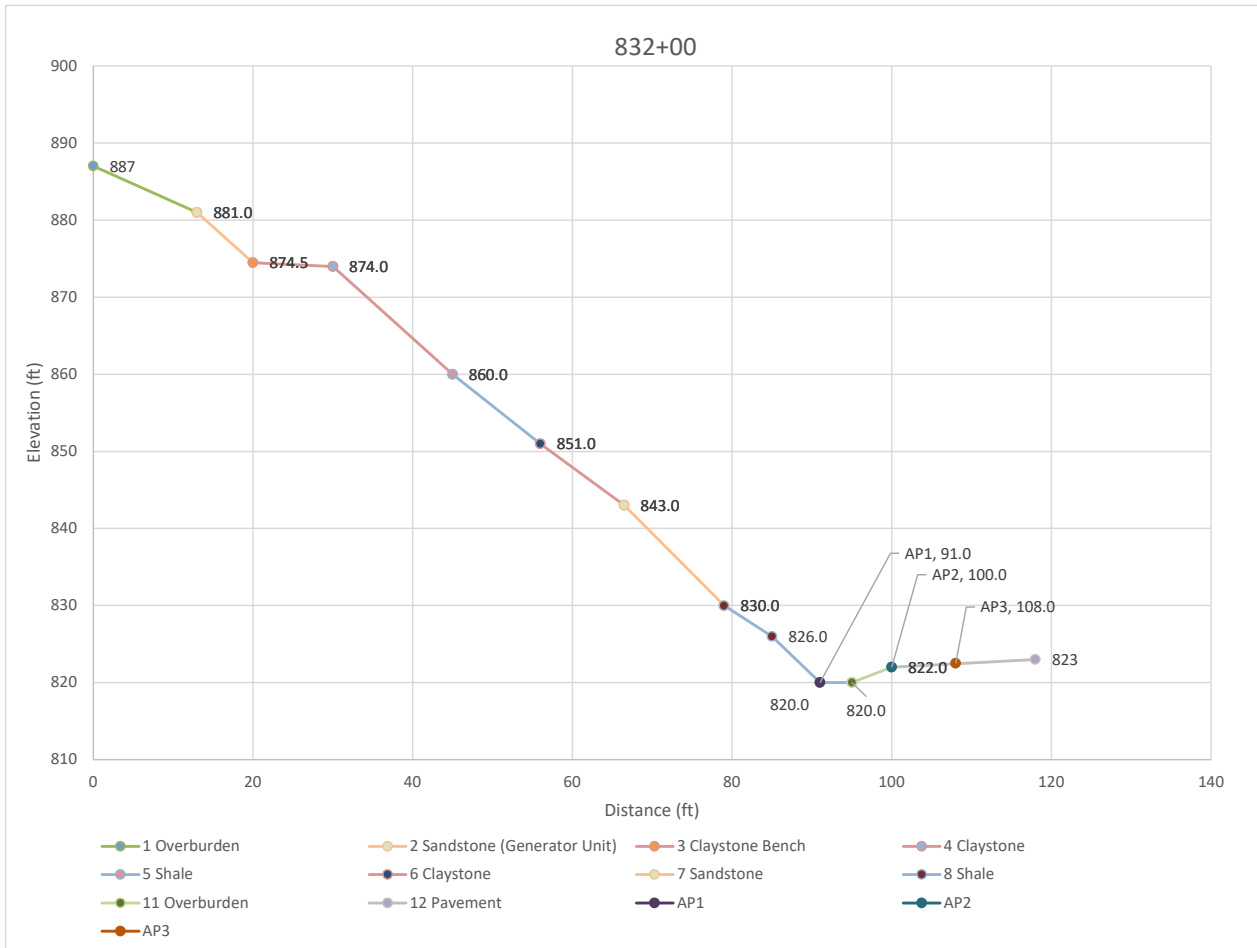
Computed: **DCM** Date: **5/13/24**  
 Checked: **AKB** Date: **5/17/24**  
 Page: **1** of **2**

	<b>X</b>	<b>Y</b>	<b>Description</b>
Analysis Pt 1 =	AP1	91.0	Toe of Slope @ Catchment
Analysis Pt 2 =	AP2	100.0	Edge of Pavement
Analysis Pt 3 =	AP3	108.0	Edge of Travel Lane

**CRSP Assumptions:** Analysis using short-term conditions  
 ≥95% rockfall retained at Analysis Pt 3 design criteria  
 Roughness based on field measurements and experience with bedrock of the Monongahela Group  
 Rock shape is discoidal, 1 feet to 4 feet

Upper Zone Ymax: 881 Δ Elev.  
 Upper Zone Ymin: 874 7

	Cell	Surface R	Tangent C	Normal C	Begin X	Begin Y	End X	End Y
1 Overburden	1	2	0.65	0.15	0	887	13.0	881.0
2 Sandstone (Generator Unit)	2	0.25	0.9	0.25	13.0	881.0	20.0	874.5
3 Claystone Bench	3	0.15	0.75	0.15	20.0	874.5	30.0	874.0
4 Claystone	4	0.25	0.75	0.15	30.0	874.0	45.0	860.0
5 Shale	5	0.5	0.75	0.15	45.0	860.0	56.0	851.0
6 Claystone	6	0.25	0.75	0.15	56.0	851.0	66.5	843.0
7 Sandstone	7	1.5	0.9	0.25	66.5	843.0	79.0	830.0
8 Shale	8	0.5	0.75	0.15	79.0	830.0	85.0	826.0
9 Shale	9	0.5	0.75	0.15	85.0	826.0	91.0	820.0
10 Shale	10	0.5	0.75	0.15	91.0	820.0	95.0	820.0
11 Overburden	11	2	0.65	0.15	95.0	820.0	100.0	822.0
12 Pavement	12	0	1	1	100.0	822.0	108.0	822.5
13 Pavement	13	0	1	1	108.0	822.5	118.0	823



Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Proposed - Short Term**  
 Subject: **Sta. 832+00**

Computed: **DCM** Date: **5/13/24**  
 Checked: **AKB** Date: **5/17/24**  
 Page: **2** of **2**

Overburden  
Claystone and Shale  
Sandstone

**Table 503-2. Hardness reference guide with CRSP coefficient values (Modified from Woodard, 2004)**

Hardness Input Code	Consistency	Field Identification	Normal Coefficient Values (Rn)	Tangential Coefficient Values (Rt)
1	Very soft	Easily penetrated several inches by fist	0.10	0.50
2	Soft	Easily penetrated several inches by thumb	0.10	0.55
3	Firm	Can be penetrated several inches by thumb with moderate effort	0.15	0.65
4	Stiff	Readily indented by thumb but penetrated only with great effort	0.15	0.70
5	Very stiff	Readily indented by thumbnail	0.20	0.75
6	Hard	Indented with difficulty by thumbnail	0.20	0.80-0.85
7	Very weak rock	Can be carved with a knife. Can be excavated readily with a point of a pick. Pieces 1 inch (25 mm) or more in thickness can be broken by finger pressure. Can be scratched by fingernail.	0.15	0.75
8	Weak rock	Can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure.	0.15	0.75
9	Slightly strong rock	Can be grooved or gouged 0.05 inch (2 mm) deep by firm pressure of a knife or pick point. Can be excavated in small chips to pieces about 1-inch (25 mm) maximum size by hard blows of the point of a geologist's pick.	0.20	0.80
10	Moderately strong rock	Can be scratched with a knife or pick. Grooves or gouges to 1/2" (6mm) deep can be excavated by hand blows of a geologist's pick. Requires moderate hammer blows to detach hand specimen.	0.25	0.85
11	Strong rock	Can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach hand specimen. Sharp and resistant edges are present on hand specimen.	0.25-0.30	0.9
12	Very strong rock	Cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0
13	Extremely strong rock	Cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0

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OHIO DEPARTMENT OF TRANSPORTATION  
Rock Slope Design Guide

**Table 503-1. CRSP Coefficient Guide for Normal and Tangential Coefficient (from Jones, et al., 2000)**

Description of Slope	Normal Coefficient (Rn)	Remarks
Smooth hard surfaces and paving	0.60-1.0	-For short slopes try lower values in applicable range
Most bedrock and boulder fields	0.15-0.30	
Talus and firm soil slopes	0.12-0.20	-If max. velocity/KE* are design criteria, use lower values in range; if avg. velocity/KE* are design criteria, use higher values in range
Soft soil slopes**	0.10-0.20	

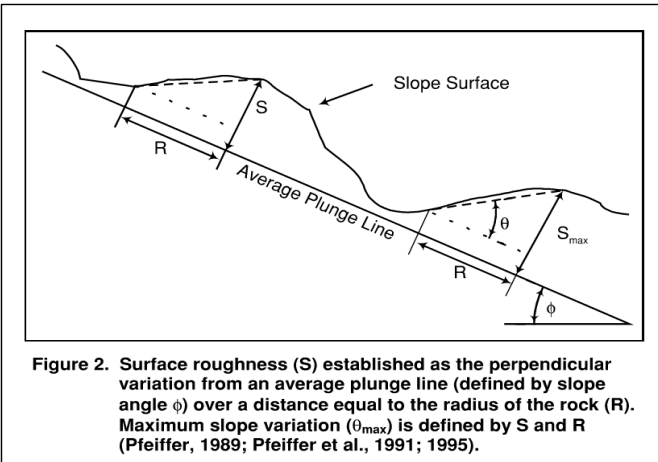
\*KE = kinetic energy  
 \*\*Soft soil slope coefficients were extrapolated from other slope types due to lack of data

Description of Slope	Tangential Coefficient (Rt)	Remarks
Smooth hard surfaces and paving	0.90-1.0	Rt is not very sensitive compared to Rn, but may be important for hard or significantly vegetated slopes
Most bedrock and boulder fields	0.75-0.95	
Talus and firm soil slopes	0.65-0.95	
Soft soil slopes*	0.50-0.80	-Use lower Rt as the density of vegetation on the slope increases

OHIO DEPARTMENT OF TRANSPORTATION  
Rock Slope Design Guide

January 2016  
Page 5-5

For Pavement Use 1.0 for Rn and Rt



Colorado Rockfall Simulation Program Manual  
(CDOT-SYMB-CGS-99-1, March 2000)



CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_4x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 13  
Analysis Point 1 X-Coordinate: 91  
Analysis Point 2 X-Coordinate: 100  
Analysis Point 3 X-Coordinate: 108  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 874.5

Remarks: Sta. 382+00 Proposed After Construction

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	887	13	881
2.	0.25	.9	.25	13	881	20	874.5
3.	0.15	0.75	0.15	20	874.5	30	874
4.	0.25	.75	.15	30	874	45	860
5.	0.5	.75	.15	45	860	56	851
6.	0.25	.75	.15	56	851	66.5	843
7.	1.5	.9	.25	66.5	843	79	830
8.	0.5	.75	.15	79	830	85	826
9.	0.5	.75	.15	85	826	91	820
10.	0.5	.75	.15	91	820	95	820
11.	2	.65	.15	95	820	100	822
12.	0	1	1	100	822	108	822.5
13.	0	1	1	108	822.5	118	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_4x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 13  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 4 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_4x1 Disc.doc

Analysis Point 1: X = 91, Y = 820

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	41.15	70102
75%	41.15	70102
90%	41.15	70102
95%	41.15	70102
98%	41.15	70102

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 41.15	Maximum: .85	Maximum: 70102
Average: 41.15	Average: .85	Average: 70102
Minimum: 41.15	G. Mean: .85	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed After Construction

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_4x1 Disc.doc

Analysis Point 2: X = 100, Y = 822

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	14.46	12164
75%	14.46	12164
90%	14.46	12164
95%	14.46	12164
98%	14.46	12164

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 14.46	Maximum: .1	Maximum: 12164
Average: 14.46	Average: .1	Average: 12164
Minimum: 14.46	G. Mean: .1	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed After Construction

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_4x1 Disc.doc

Analysis Point 3: X = 108, Y = 822

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
---	-------------------	----------------

50%	15.27	11316	0
75%	15.27	11316	0.68
90%	15.27	11316	1.28
95%	15.27	11316	1.65
98%	15.27	11316	2.06

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 15.27	Maximum: 0	Maximum: 11316
Average: 15.27	Average: 0	Average: 11316
Minimum: 15.27	G. Mean: 0	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed After Construction

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_4x1 Disc.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce Ht.

1.	No rocks	past end of cell				
2.	17	12	2.61	2	0	
3.	9	6	1.86	0	-1	
4.	18	6	4.43	0	-1	
5.	26	26	0	0	-1	
6.	27	27	0	0	-1	
7.	32	32	0	1	0	
8.	36	36	0	1	0	
9.	41	41	0	1	0	
10.	23	23	0	0	0	
11.	14	14	0	0	0	
12.	15	15	0	0	0	
13.	14	14	0	0	0	

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_4x1 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	1
14. To 20 ft	0
20 To 30 ft	989
30 To 40 ft	0
40 To 50 ft	9
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 118 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_2x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 13  
Analysis Point 1 X-Coordinate: 91  
Analysis Point 2 X-Coordinate: 100  
Analysis Point 3 X-Coordinate: 108  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 874.5

Remarks: Sta. 382+00 Proposed After Construction

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	887	13	881
2.	0.25	.9	.25	13	881	20	874.5
3.	0.15	0.75	0.15	20	874.5	30	874
4.	0.25	.75	.15	30	874	45	860
5.	0.5	.75	.15	45	860	56	851
6.	0.25	.75	.15	56	851	66.5	843
7.	1.5	.9	.25	66.5	843	79	830
8.	0.5	.75	.15	79	830	85	826
9.	0.5	.75	.15	85	826	91	820
10.	0.5	.75	.15	91	820	95	820
11.	2	.65	.15	95	820	100	822
12.	0	1	1	100	822	108	822.5
13.	0	1	1	108	822.5	118	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_2x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 13  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 2 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_2x1 Disc.doc

Analysis Point 1: X = 91, Y = 820

Total Rocks Passing Analysis Point: 194

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	33.6	11998
75%	37.22	14378
90%	40.48	16519
95%	42.44	17805
98%	44.63	19247

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 45.04</b>	<b>Maximum: 9.75</b>	<b>Maximum: 19519</b>
Average: 33.6	Average: 4.2	Average: 11998
Minimum: 18.83	G. Mean: 3.26	Std. Dev.: 3525
Std. Dev.: 5.37	Std. Dev.: 2.66	

Remarks: Sta. 382+00 Proposed After Construction

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_2x1 Disc.doc

Analysis Point 2: X = 100, Y = 822

Total Rocks Passing Analysis Point: 32

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	7.89	1081
75%	10.26	1631
90%	12.39	2125
95%	13.67	2422
98%	15.11	2756

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 15.52	Maximum: .81	Maximum: 3421
Average: 7.89	Average: .2	Average: 1081
Minimum: 1.45	G. Mean: .07	Std. Dev.: 814
Std. Dev.: 3.51	Std. Dev.: 8.12	

Remarks: Sta. 382+00 Proposed After Construction

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_2x1 Disc.doc

Analysis Point 3: X = 108, Y = 822

Total Rocks Passing Analysis Point: 26

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	8.58	986
75%	10.72	1494
90%	12.65	1951
95%	13.8	2226
98%	15.1	2534

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 16.09	Maximum: .76	Maximum: 3157
Average: 8.58	Average: .2	Average: 985
Minimum: 3.33	G. Mean: .08	Std. Dev.: 753
Std. Dev.: 3.17	Std. Dev.: 7.24	

Remarks: Sta. 382+00 Proposed After Construction

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_2x1 Disc.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce Ht.

1.	No rocks	past end of cell				
2.	17	12	3.2	1	0	
3.	10	6	1.64	0	-1	
4.	25	22	1.38	1	0	
5.	31	26	2.61	3	0	
6.	35	29	2.09	2	0	
7.	43	31	7.37	9	2	
8.	43	29	5.38	8	2	
9.	45	34	5.37	10	4	
10.	43	26	9.94	5	1	
11.	16	8	3.51	1	0	
12.	16	9	3.17	1	0	
13.	15	8	3.44	1	0	

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_2x1 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	1
14. To 20 ft	0
20 To 30 ft	706
30 To 40 ft	99
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	162
100 To 110 ft	6
110 To 118 ft	4



CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_15x05 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 13  
Analysis Point 1 X-Coordinate: 91  
Analysis Point 2 X-Coordinate: 100  
Analysis Point 3 X-Coordinate: 108  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 874.5

Remarks: Sta. 382+00 Proposed After Construction

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	887	13	881
2.	0.25	.9	.25	13	881	20	874.5
3.	0.15	0.75	0.15	20	874.5	30	874
4.	0.25	.75	.15	30	874	45	860
5.	0.5	.75	.15	45	860	56	851
6.	0.25	.75	.15	56	851	66.5	843
7.	1.5	.9	.25	66.5	843	79	830
8.	0.5	.75	.15	79	830	85	826
9.	0.5	.75	.15	85	826	91	820
10.	0.5	.75	.15	91	820	95	820
11.	2	.65	.15	95	820	100	822
12.	0	1	1	100	822	108	822.5
13.	0	1	1	108	822.5	118	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_15x05 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 13  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1.5 ft  
Thickness: 0.5 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_15x05 Disc.doc

Analysis Point 1: X = 91, Y = 820

Total Rocks Passing Analysis Point: 286

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	32.37	3144	2.75
75%	36.37	3825	4.5
90%	39.97	4437	6.07
95%	42.13	4805	7.01
98%	44.56	5217	8.06

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy	
<b>Maximum: 45.2</b>	<b>Maximum: 8.08</b>	<b>Maximum: 5550</b>	
Average: 32.37	Average: 3.5	Average: 3144	
Minimum: 16.93	G. Mean: 2.75	Std. Dev.: 1007	
Std. Dev.: 5.92	Std. Dev.: 2.58		

Remarks: Sta. 382+00 Proposed After Construction

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_15x05 Disc.doc

Analysis Point 2: X = 100, Y = 822

Total Rocks Passing Analysis Point: 30

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	8.82	363	0.1
75%	11.15	526	5.02
90%	13.25	672	9.45
95%	14.51	760	12.1
98%	15.92	858	15.08

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 16.22	Maximum: .73	Maximum: 985
Average: 8.82	Average: .23	Average: 363
Minimum: 2.84	G. Mean: .1	Std. Dev.: 240
Std. Dev.: 3.45	Std. Dev.: 7.29	

Remarks: Sta. 382+00 Proposed After Construction

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_15x05 Disc.doc

Analysis Point 3: X = 108, Y = 822

Total Rocks Passing Analysis Point: 28

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	8.87	300
75%	11.18	451
90%	13.27	588
95%	14.52	670
98%	15.92	762

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 15.95	Maximum: .89	Maximum: 878
Average: 8.87	Average: .25	Average: 300
Minimum: 2.78	G. Mean: .12	Std. Dev.: 224
Std. Dev.: 3.43	Std. Dev.: 5.55	

Remarks: Sta. 382+00 Proposed After Construction

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_15x05 Disc.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce Ht.

1.	No rocks	past end of cell				
2.	18	11	3.23	1	0	
3.	10	6	1.58	0	-1	
4.	26	22	1.52	1	0	
5.	31	25	2.97	3	1	
6.	34	28	2.48	3	0	
7.	42	31	7.2	10	2	
8.	43	29	5.97	8	2	
9.	45	32	5.92	8	3	
10.	44	23	11.05	5	0	
11.	16	9	3.45	1	0	
12.	16	9	3.43	1	0	
13.	15	8	3.49	1	0	

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_15x05 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	1
14. To 20 ft	0
20 To 30 ft	712
30 To 40 ft	1
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	256
100 To 110 ft	4
110 To 118 ft	3

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_1x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 13  
Analysis Point 1 X-Coordinate: 91  
Analysis Point 2 X-Coordinate: 100  
Analysis Point 3 X-Coordinate: 108  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 874.5

Remarks: Sta. 382+00 Proposed After Construction

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	887	13	881
2.	0.25	.9	.25	13	881	20	874.5
3.	0.15	0.75	0.15	20	874.5	30	874
4.	0.25	.75	.15	30	874	45	860
5.	0.5	.75	.15	45	860	56	851
6.	0.25	.75	.15	56	851	66.5	843
7.	1.5	.9	.25	66.5	843	79	830
8.	0.5	.75	.15	79	830	85	826
9.	0.5	.75	.15	85	826	91	820
10.	0.5	.75	.15	91	820	95	820
11.	2	.65	.15	95	820	100	822
12.	0	1	1	100	822	108	822.5
13.	0	1	1	108	822.5	118	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_1x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 13  
Rock Density: 165 lb/ft<sup>3</sup>  
Rock Shape: Discoidal  
Diameter: 1 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_1x1 Disc.doc

Analysis Point 1: X = 91, Y = 820

Total Rocks Passing Analysis Point: 157

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	27.74	2113	1.49
75%	32.7	2769	5.09
90%	37.16	3360	8.32
95%	39.84	3714	10.27
98%	42.85	4112	12.45

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 43.33</b>	<b>Maximum: 7.15</b>	<b>Maximum: 4468</b>
Average: 27.74	Average: 2.64	Average: 2113
Minimum: 11.17	G. Mean: 1.49	Std. Dev.: 972
Std. Dev.: 7.35	Std. Dev.: 5.33	

Remarks: Sta. 382+00 Proposed After Construction

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_1x1 Disc.doc

Analysis Point 2: X = 100, Y = 822

Total Rocks Passing Analysis Point: 14

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	6.43	189	0.11
75%	8.05	268	4.15
90%	9.52	339	7.78
95%	10.4	382	9.97
98%	11.38	430	12.41

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 10.61	Maximum: .9	Maximum: 451
Average: 6.43	Average: .25	Average: 189
Minimum: 2.05	G. Mean: .11	Std. Dev.: 116
Std. Dev.: 2.41	Std. Dev.: 5.99	

Remarks: Sta. 382+00 Proposed After Construction

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_1x1 Disc.doc

Analysis Point 3: X = 108, Y = 822

Total Rocks Passing Analysis Point: 11

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	6.87	154
75%	8.28	221
90%	9.55	280
95%	10.31	316
98%	11.17	356

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 11.27	Maximum: .7	Maximum: 388
Average: 6.87	Average: .29	Average: 154
Minimum: 4.53	G. Mean: .22	Std. Dev.: 97
Std. Dev.: 2.09	Std. Dev.: 2.32	

Remarks: Sta. 382+00 Proposed After Construction

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_1x1 Disc.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce Ht.

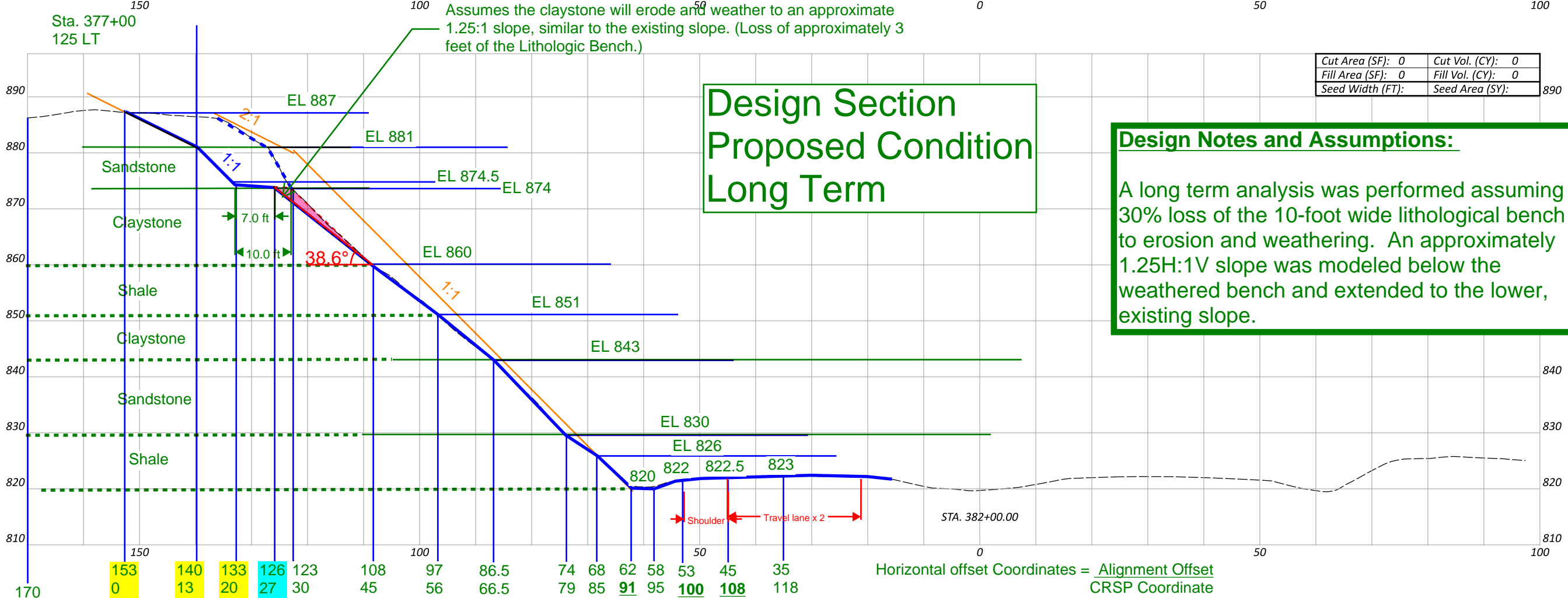
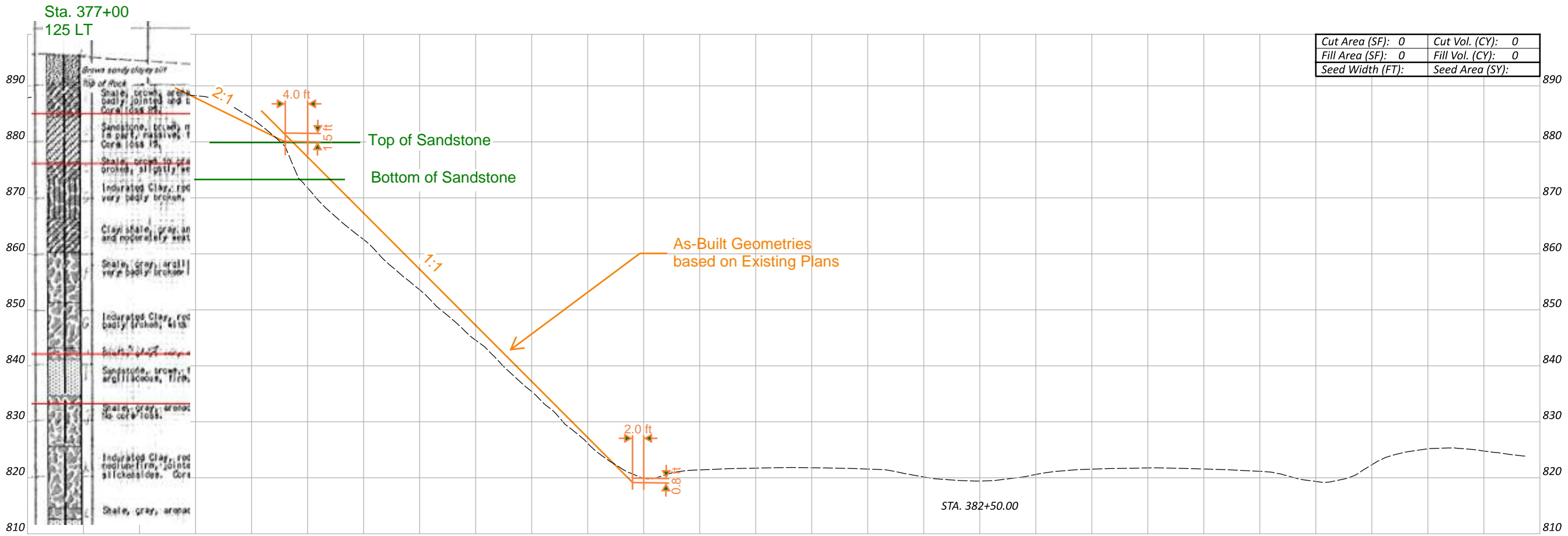
1.	No rocks	past end of cell				
2.	17	10	3.2	1	0	
3.	9	5	1.44	0	-1	
4.	25	20	2.16	2	0	
5.	31	22	4.29	4	1	
6.	32	25	3.6	3	0	
7.	40	28	8.42	9	3	
8.	42	25	7.71	8	1	
9.	43	28	7.35	7	2	
10.	40	18	9.81	4	0	
11.	11	6	2.41	1	0	
12.	11	7	2.09	1	0	
13.	12	7	2.58	0	0	

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\20240508\_MEG-33-7.61-7.87\_Sta38200\_Proposed\_1x1 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	1
14. To 20 ft	1
20 To 30 ft	841
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	143
100 To 110 ft	3
110 To 118 ft	2







CROSS SECTIONS US 33  
 STA. 382+00 TO STA. 382+50

DESIGN AGENCY



DESIGNER  
TDM  
 REVIEWER  
PID MM-DD-YY  
 PROJECT ID  
118508  
 SHEET TOTAL  
P.0 0

Sheet Totals			118508	
Seeding	Cut	Fill	SHEET	TOTAL
			P.0	0

Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Proposed - Long Term (1.25H:1V)**  
 Subject: **Sta. 832+00**

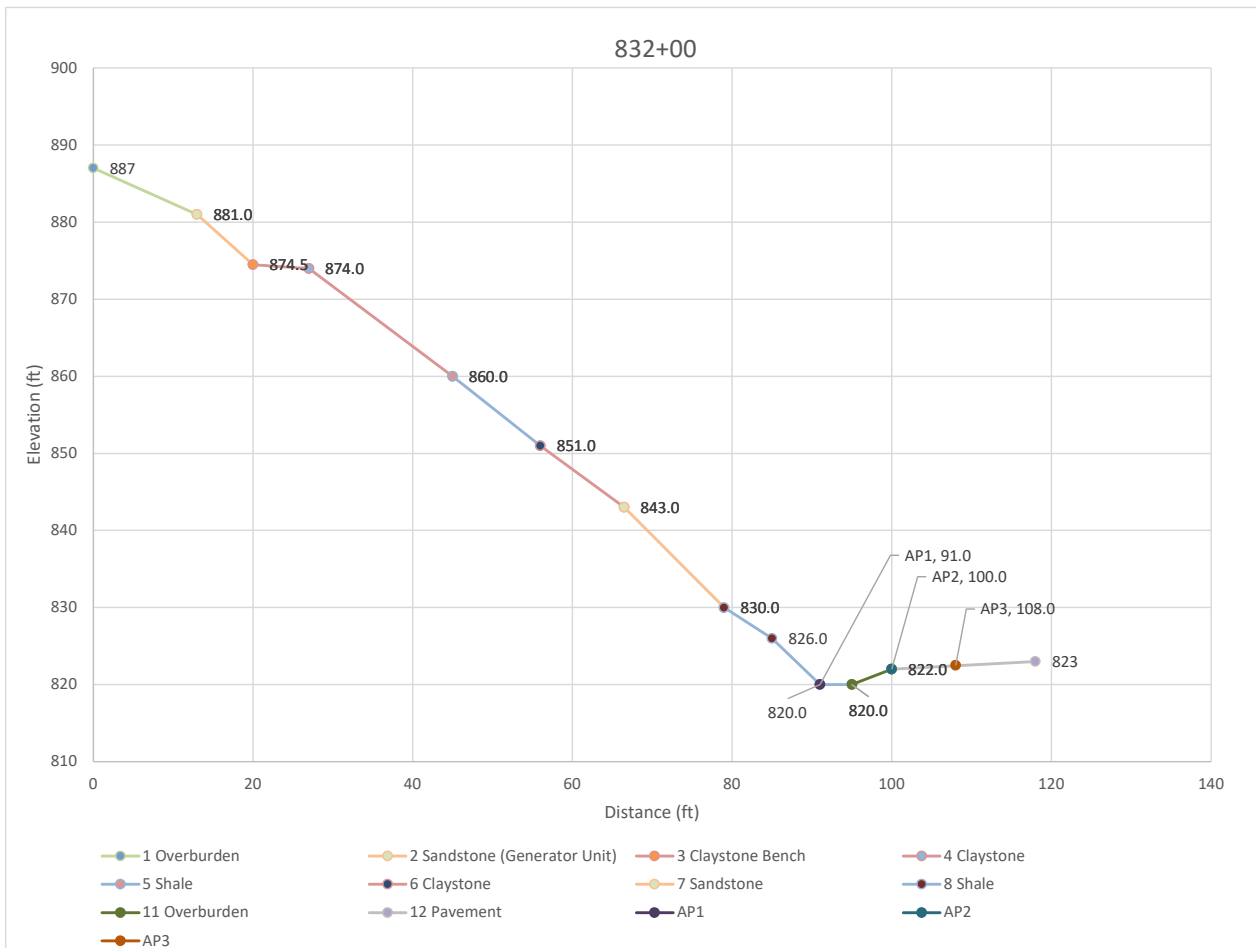
Computed: **DCM** Date: **5/13/24**  
 Checked: **AKB** Date: **5/17/24**  
 Page: **1** of **2**

	<b>X</b>	<b>Y</b>	<b>Description</b>
Analysis Pt 1 =	AP1	91.0	Toe of Slope @ Catchment
Analysis Pt 2 =	AP2	100.0	Edge of Pavement
Analysis Pt 3 =	AP3	108.0	Edge of Travel Lane

**CRSP Assumptions:** Analysis using long-term conditions  
 ≥95% rockfall retained at Analysis Pt 3 design criteria  
 Roughness based on field measurements and experience with bedrock of the Monongahela Group  
 Rock shape is discoidal, 1 feet to 4 feet

Upper Zone Ymax: 881    Δ Elev.  
 Upper Zone Ymin: 874    7

	Cell	Surface R	Tangent C	Normal C	Begin X	Begin Y	End X	End Y
1 Overburden	1	2	0.65	0.15	0	887	13.0	881.0
2 Sandstone (Generator Unit)	2	2	0.9	0.25	13.0	881.0	20.0	874.5
3 Claystone Bench	3	0.25	0.75	0.15	20.0	874.5	27.0	874.0
4 Claystone	4	0.25	0.75	0.15	27.0	874.0	45.0	860.0
5 Shale	5	0.5	0.75	0.15	45.0	860.0	56.0	851.0
6 Claystone	6	0.25	0.75	0.15	56.0	851.0	66.5	843.0
7 Sandstone	7	1.5	0.9	0.25	66.5	843.0	79.0	830.0
8 Shale	8	0.5	0.75	0.15	79.0	830.0	85.0	826.0
9 Shale	9	0.5	0.75	0.15	85.0	826.0	91.0	820.0
10 Shale	10	0.5	0.75	0.15	91.0	820.0	95.0	820.0
11 Overburden	11	2	0.65	0.15	95.0	820.0	100.0	822.0
12 Pavement	12	0	1	1	100.0	822.0	108.0	822.5
13 Pavement	13	0	1	1	108.0	822.5	118.0	823.0



Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Proposed - Long Term (1.25H:1V)**  
 Subject: **Sta. 832+00**

Computed: **DCM** Date: **5/13/24**  
 Checked: **AKB** Date: **5/17/24**  
 Page: **2** of **2**

Overburden  
Claystone and Shale  
Sandstone

**Table 503-2. Hardness reference guide with CRSP coefficient values (Modified from Woodard, 2004)**

Hardness Input Code	Consistency	Field Identification	Normal Coefficient Values (Rn)	Tangential Coefficient Values (Rt)
1	Very soft	Easily penetrated several inches by fist	0.10	0.50
2	Soft	Easily penetrated several inches by thumb	0.10	0.55
3	Firm	Can be penetrated several inches by thumb with moderate effort	0.15	0.65
4	Stiff	Readily indented by thumb but penetrated only with great effort	0.15	0.70
5	Very stiff	Readily indented by thumbnail	0.20	0.75
6	Hard	Indented with difficulty by thumbnail	0.20	0.80-0.85
7	Very weak rock	Can be carved with a knife. Can be excavated readily with a point of a pick. Pieces 1 inch (25 mm) or more in thickness can be broken by finger pressure. Can be scratched by fingernail.	0.15	0.75
8	Weak rock	Can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure.	0.15	0.75
9	Slightly strong rock	Can be grooved or gouged 0.05 inch (2 mm) deep by firm pressure of a knife or pick point. Can be excavated in small chips to pieces about 1-inch (25 mm) maximum size by hard blows of the point of a geologist's pick.	0.20	0.80
10	Moderately strong rock	Can be scratched with a knife or pick. Grooves or gouges to 1/2" (6mm) deep can be excavated by hand blows of a geologist's pick. Requires moderate hammer blows to detach hand specimen.	0.25	0.85
11	Strong rock	Can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach hand specimen. Sharp and resistant edges are present on hand specimen.	0.25-0.30	0.9
12	Very strong rock	Cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0
13	Extremely strong rock	Cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0

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OHIO DEPARTMENT OF TRANSPORTATION  
Rock Slope Design Guide

**Table 503-1. CRSP Coefficient Guide for Normal and Tangential Coefficient (from Jones, et al., 2000)**

Description of Slope	Normal Coefficient (Rn)	Remarks
Smooth hard surfaces and paving	0.60-1.0	-For short slopes try lower values in applicable range
Most bedrock and boulder fields	0.15-0.30	
Talus and firm soil slopes	0.12-0.20	-If max. velocity/KE* are design criteria, use lower values in range; if avg. velocity/KE* are design criteria, use higher values in range
Soft soil slopes**	0.10-0.20	

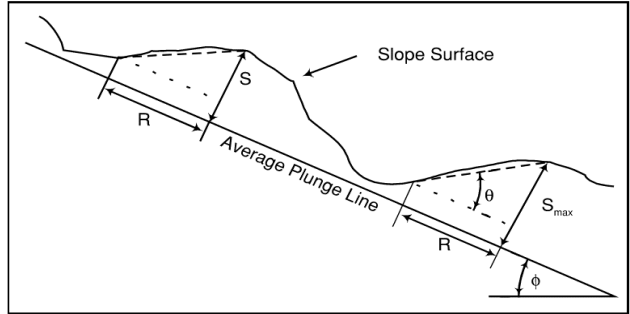
\*KE = kinetic energy  
 \*\*Soft soil slope coefficients were extrapolated from other slope types due to lack of data

Description of Slope	Tangential Coefficient (Rt)	Remarks
Smooth hard surfaces and paving	0.90-1.0	-Rt is not very sensitive compared to Rn, but may be important for hard or significantly vegetated slopes
Most bedrock and boulder fields	0.75-0.95	
Talus and firm soil slopes	0.65-0.95	
Soft soil slopes*	0.50-0.80	-Use lower Rt as the density of vegetation on the slope increases

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Rock Slope Design Guide

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For Pavement Use 1.0 for Rn and Rt



**Figure 2. Surface roughness (S) established as the perpendicular variation from an average plunge line (defined by slope angle  $\phi$ ) over a distance equal to the radius of the rock (R). Maximum slope variation ( $\theta_{max}$ ) is defined by S and R (Pfeiffer, 1989; Pfeiffer et al., 1991; 1995).**

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 13  
Analysis Point 1 X-Coordinate: 91  
Analysis Point 2 X-Coordinate: 100  
Analysis Point 3 X-Coordinate: 108  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 874.5

Remarks: Sta. 382+00 Proposed Long Term

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	887	13	881
2.	2	.9	.25	13	881	20	874.5
3.	.25	0.75	0.15	20	874.5	27	874
4.	.25	.75	.15	27	874	45	860
5.	.5	.75	.15	45	860	56	851
6.	.25	.75	.15	56	851	66.5	843
7.	1.5	.9	.25	66.5	843	79	830
8.	.5	.75	.15	79	830	85	826
9.	.5	.75	.15	85	826	91	820
10.	.5	.75	.15	91	820	95	820
11.	2	.65	.15	95	820	100	822
12.	0	1	1	100	822	108	822.5
13.	0	1	1	108	822.5	118	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 13  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 4 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc.doc

Analysis Point 1: X = 91, Y = 820

Total Rocks Passing Analysis Point: 10

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	37.57	60811
75%	39.55	67291
90%	41.33	73120
95%	42.4	76619
98%	43.6	80547

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 40.72</b>	<b>Maximum: 7</b>	<b>Maximum: 71190</b>
Average: 37.57	Average: 3.18	Average: 60811
Minimum: 31.86	G. Mean: 2.4	Std. Dev.: 9597
Std. Dev.: 2.93	Std. Dev.: 2.34	

Remarks: Sta. 382+00 Proposed Long Term

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc.doc

Analysis Point 2: X = 100, Y = 822

Total Rocks Passing Analysis Point: 6

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	9.22	5475
75%	11.53	7761
90%	13.61	9817
95%	14.85	11052
98%	16.25	12437

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 13.9	Maximum: .58	Maximum: 10824
Average: 9.22	Average: .19	Average: 5475
Minimum: 4.62	G. Mean: .12	Std. Dev.: 3385
Std. Dev.: 3.42	Std. Dev.: 3.27	

Remarks: Sta. 382+00 Proposed Long Term

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc.doc

Analysis Point 3: X = 108, Y = 822

Total Rocks Passing Analysis Point: 5

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	10.48	5376
75%	12.45	7424
90%	14.23	9266
95%	15.3	10372
98%	16.5	11613

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 14.57	Maximum: .31	Maximum: 10223
Average: 10.48	Average: .15	Average: 5376
Minimum: 6.91	G. Mean: .06	Std. Dev.: 3033
Std. Dev.: 2.93	Std. Dev.: 10.89	

Remarks: Sta. 382+00 Proposed Long Term

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce Ht.

1.	No rocks	past end of cell				
2.	18	10	3.16	2	0	
3.	12	6	1.95	0	-1	
4.	23	20	5.12	0	0	
5.	28	27	1.16	1	0	
6.	30	29	1.19	0	0	
7.	41	34	4.65	4	1	
8.	41	34	3.62	5	1	
9.	41	38	2.93	7	3	
10.	41	27	8.71	4	0	
11.	14	9	3.42	1	0	
12.	15	10	2.93	0	0	
13.	14	9	3.34	0	0	

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	1
14. To 20 ft	12
20 To 30 ft	875
30 To 40 ft	101
40 To 50 ft	1
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	4
100 To 110 ft	1
110 To 118 ft	0



CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 13  
Analysis Point 1 X-Coordinate: 91  
Analysis Point 2 X-Coordinate: 100  
Analysis Point 3 X-Coordinate: 108  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 874.5

Remarks: Sta. 382+00 Proposed Long Term

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	887	13	881
2.	2	.9	.25	13	881	20	874.5
3.	.25	0.75	0.15	20	874.5	27	874
4.	.25	.75	.15	27	874	45	860
5.	.5	.75	.15	45	860	56	851
6.	.25	.75	.15	56	851	66.5	843
7.	1.5	.9	.25	66.5	843	79	830
8.	.5	.75	.15	79	830	85	826
9.	.5	.75	.15	85	826	91	820
10.	.5	.75	.15	91	820	95	820
11.	2	.65	.15	95	820	100	822
12.	0	1	1	100	822	108	822.5
13.	0	1	1	108	822.5	118	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 13  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 2 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc.doc

Analysis Point 1: X = 91, Y = 820

Total Rocks Passing Analysis Point: 38

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	34.5	12499
75%	37.81	14675
90%	40.79	16632
95%	42.58	17807
98%	44.59	19126

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 45.85</b>	<b>Maximum: 7.78</b>	<b>Maximum: 20885</b>
Average: 34.5	Average: 3.6	Average: 12499
Minimum: 25.04	G. Mean: 2.87	Std. Dev.: 3222
Std. Dev.: 4.91	Std. Dev.: 2.25	

Remarks: Sta. 382+00 Proposed Long Term

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc.doc

Analysis Point 2: X = 100, Y = 822

Total Rocks Passing Analysis Point: 5

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	9.28	1380
75%	11.14	1773
90%	12.81	2128
95%	13.81	2340
98%	14.94	2579

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 13.97	Maximum: .8	Maximum: 2381
Average: 9.28	Average: .18	Average: 1380
Minimum: 7.05	G. Mean: .03	Std. Dev.: 583
Std. Dev.: 2.75	Std. Dev.: 11.51	

Remarks: Sta. 382+00 Proposed Long Term

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc.doc

Analysis Point 3: X = 108, Y = 822

Total Rocks Passing Analysis Point: 5

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
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50%	9.12	1029	0.18
75%	10.27	1296	1.88
90%	11.31	1537	3.4
95%	11.93	1681	4.31
98%	12.63	1843	5.34

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 11.6	Maximum: .86	Maximum: 1666
Average: 9.12	Average: .28	Average: 1029
Minimum: 7.13	G. Mean: .18	Std. Dev.: 395
Std. Dev.: 1.7	Std. Dev.: 2.51	

Remarks: Sta. 382+00 Proposed Long Term

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce Ht.

1.	No rocks	past end of cell				
2.	17	8	3.1	2	0	
3.	9	5	1.54	0	-1	
4.	24	21	1.39	1	0	
5.	31	25	2.7	2	1	
6.	32	28	2	2	0	
7.	42	32	7.26	9	2	
8.	41	30	5.01	8	2	
9.	46	35	4.91	8	3	
10.	44	22	11.35	4	0	
11.	14	9	2.75	1	0	
12.	12	9	1.7	1	0	
13.	11	8	1.95	1	0	

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	1
14. To 20 ft	403
20 To 30 ft	558
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	33
100 To 110 ft	0
110 To 118 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 13  
Analysis Point 1 X-Coordinate: 91  
Analysis Point 2 X-Coordinate: 100  
Analysis Point 3 X-Coordinate: 108  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 874.5

Remarks: Sta. 382+00 Proposed Long Term

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	887	13	881
2.	2	.9	.25	13	881	20	874.5
3.	.25	0.75	0.15	20	874.5	27	874
4.	.25	.75	.15	27	874	45	860
5.	.5	.75	.15	45	860	56	851
6.	.25	.75	.15	56	851	66.5	843
7.	1.5	.9	.25	66.5	843	79	830
8.	.5	.75	.15	79	830	85	826
9.	.5	.75	.15	85	826	91	820
10.	.5	.75	.15	91	820	95	820
11.	2	.65	.15	95	820	100	822
12.	0	1	1	100	822	108	822.5
13.	0	1	1	108	822.5	118	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 13  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1.5 ft  
Thickness: 0.5 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc.doc

Analysis Point 1: X = 91, Y = 820

Total Rocks Passing Analysis Point: 41

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	32.05	3061	2.01
75%	36.4	3787	5.15
90%	40.3	4441	7.97
95%	42.65	4834	9.66
98%	45.28	5274	11.56

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 43.54</b>	<b>Maximum: 7.92</b>	<b>Maximum: 4987</b>
Average: 32.05	Average: 3.18	Average: 3061
Minimum: 19.68	G. Mean: 2.01	Std. Dev.: 1076
Std. Dev.: 6.43	Std. Dev.: 4.64	

Remarks: Sta. 382+00 Proposed Long Term

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc.doc

Analysis Point 2: X = 100, Y = 822

Total Rocks Passing Analysis Point: 2

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	8.96	357	0.02
75%	8.96	357	0.69
90%	8.96	357	1.3
95%	8.96	357	1.66
98%	8.96	357	2.07

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 9.36	Maximum: .31	Maximum: 377
Average: 8.96	Average: .15	Average: 357
Minimum: 8.56	G. Mean: .02	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed Long Term

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc.doc

Analysis Point 3: X = 108, Y = 822

Total Rocks Passing Analysis Point: 2

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
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50%	8.74	265	0.23
75%	8.74	265	0.91
90%	8.74	265	1.51
95%	8.74	265	1.88
98%	8.74	265	2.29

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 9.38	Maximum: .27	Maximum: 304
Average: 8.74	Average: .23	Average: 265
Minimum: 8.1	G. Mean: .23	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed Long Term

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce Ht.

1.	No rocks	past end of cell				
2.	17	7	3.16	2	0	
3.	10	5	1.7	0	-1	
4.	23	20	1.47	1	0	
5.	29	24	3.02	3	1	
6.	35	28	2.39	3	0	
7.	41	29	7.55	7	3	
8.	39	28	6.66	7	2	
9.	44	32	6.43	8	3	
10.	43	20	10.88	3	0	
11.	9	9	0	0	0	
12.	9	9	0	0	0	
13.	9	8	0	0	0	

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	1
14. To 20 ft	482
20 To 30 ft	476
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	39
100 To 110 ft	0
110 To 118 ft	0



CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 13  
Analysis Point 1 X-Coordinate: 91  
Analysis Point 2 X-Coordinate: 100  
Analysis Point 3 X-Coordinate: 108  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 874.5

Remarks: Sta. 382+00 Proposed Long Term

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	887	13	881
2.	2	.9	.25	13	881	20	874.5
3.	.25	0.75	0.15	20	874.5	27	874
4.	.25	.75	.15	27	874	45	860
5.	.5	.75	.15	45	860	56	851
6.	.25	.75	.15	56	851	66.5	843
7.	1.5	.9	.25	66.5	843	79	830
8.	.5	.75	.15	79	830	85	826
9.	.5	.75	.15	85	826	91	820
10.	.5	.75	.15	91	820	95	820
11.	2	.65	.15	95	820	100	822
12.	0	1	1	100	822	108	822.5
13.	0	1	1	108	822.5	118	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 13  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc.doc

Analysis Point 1: X = 91, Y = 820

Total Rocks Passing Analysis Point: 12

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	25.78	1852	1.49
75%	32.29	2654	4
90%	38.14	3375	6.27
95%	41.65	3808	7.62
98%	45.59	4294	9.15

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 41.82</b>	<b>Maximum: 4.74</b>	<b>Maximum: 3913</b>
Average: 25.78	Average: 2.27	Average: 1852
Minimum: 9.9	G. Mean: 1.49	Std. Dev.: 1187
Std. Dev.: 9.64	Std. Dev.: 3.72	

Remarks: Sta. 382+00 Proposed Long Term

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc.doc

Analysis Point 2: X = 100, Y = 822

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	6.93	146	0.03
75%	6.93	146	0.7
90%	6.93	146	1.31
95%	6.93	146	1.67
98%	6.93	146	2.08

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 6.93	Maximum: .03	Maximum: 146
Average: 6.93	Average: .03	Average: 146
Minimum: 6.93	G. Mean: .03	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed Long Term

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc.doc

Analysis Point 3: X = 108, Y = 822

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
---	-------------------	----------------

50%	5.04	74	0.07
75%	5.04	74	0.74
90%	5.04	74	1.35
95%	5.04	74	1.71
98%	5.04	74	2.12

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 5.04	Maximum: .07	Maximum: 74
Average: 5.04	Average: .07	Average: 74
Minimum: 5.04	G. Mean: .07	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed Long Term

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce Ht.

1.	No rocks		past end of cell			
2.	16	7	3.07	2	0	
3.	8	5	1.65	0	0	
4.	22	20	1.49	1	0	
5.	27	21	3.86	3	1	
6.	30	24	2.93	2	0	
7.	38	27	5.66	8	3	
8.	37	21	9.53	5	2	
9.	42	26	9.64	5	2	
10.	14	10	2.3	1	0	
11.	7	7	0	0	0	
12.	5	5	0	0	0	
13.	No rocks		past end of cell			

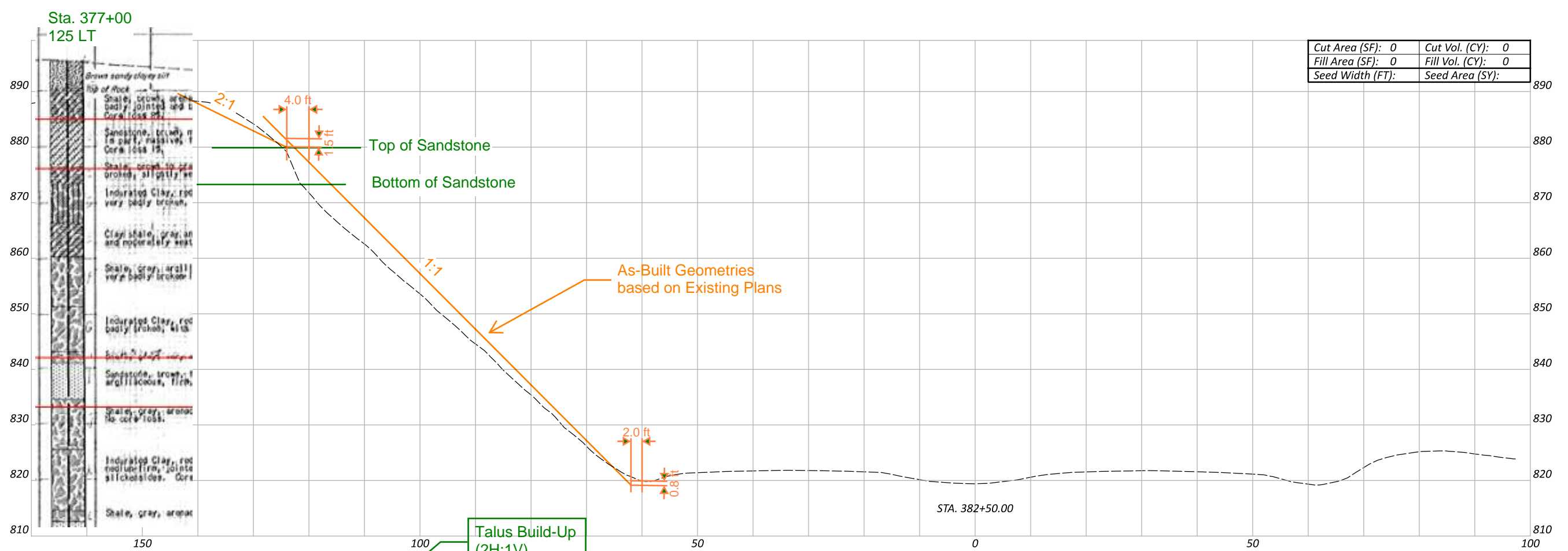
CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	1
14. To 20 ft	648
20 To 30 ft	339
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	11
100 To 110 ft	0
110 To 118 ft	1

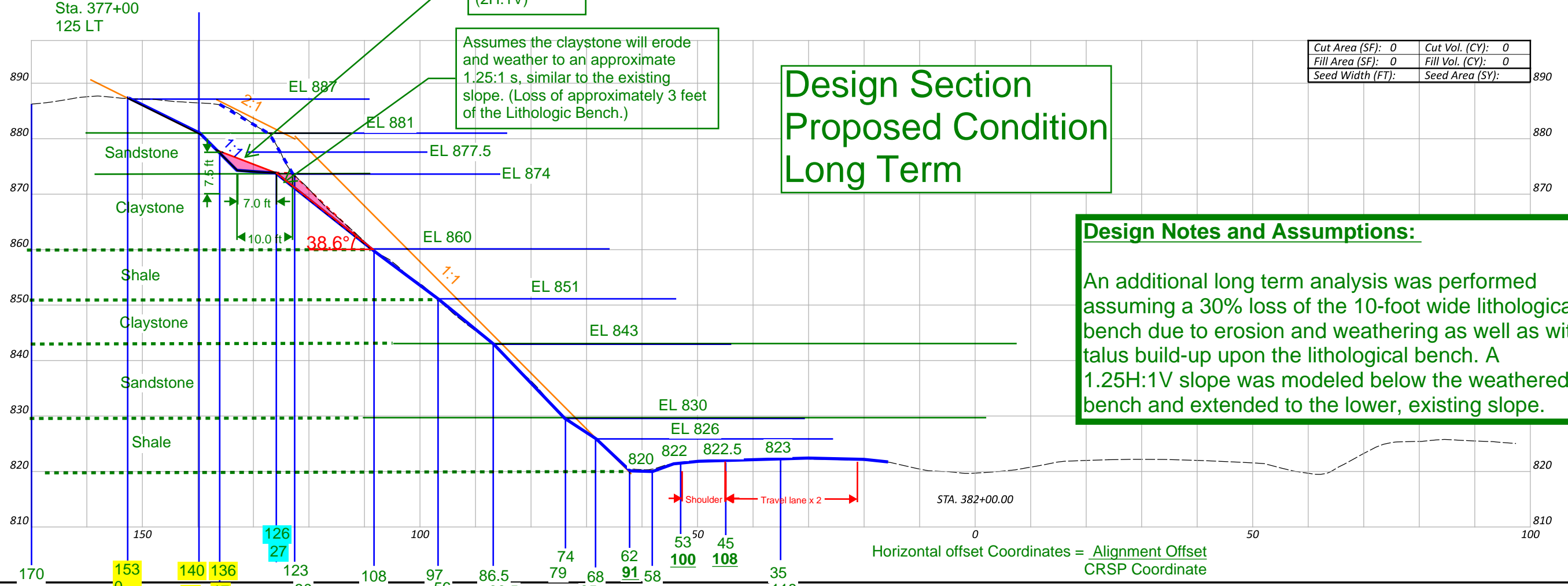


MEG-33-(7.61)(7.87)

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Cut Area (SF):	0	Cut Vol. (CY):	0
Fill Area (SF):	0	Fill Vol. (CY):	0
Seed Width (FT):		Seed Area (SY):	



Cut Area (SF):	0	Cut Vol. (CY):	0
Fill Area (SF):	0	Fill Vol. (CY):	0
Seed Width (FT):		Seed Area (SY):	

CROSS SECTIONS US 33  
 STA. 382+00 TO STA. 382+50

DESIGN AGENCY



DESIGNER

TDM

REVIEWER

PJD MM-DD-YY

PROJECT ID

118508

Sheet Totals			SHEET	TOTAL
Seeding	Cut	Fill		

Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Proposed - Long Term (1.25H:1V) with Talus Build-up**  
 Subject: **Sta. 832+00**

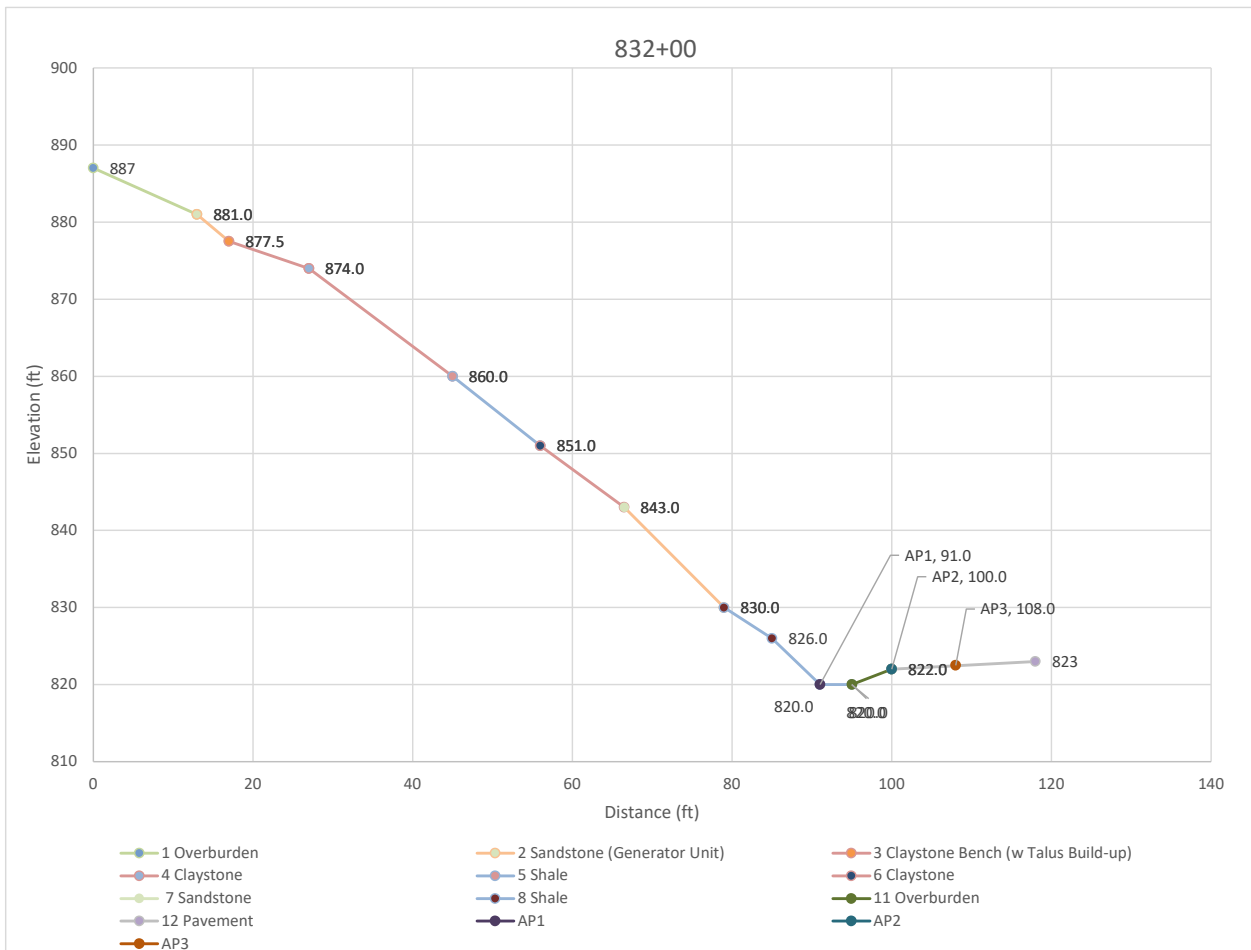
Computed: **DCM** Date: **5/13/24**  
 Checked: **AKB** Date: **5/17/24**  
 Page: **1** of **2**

	<u>X</u>	<u>Y</u>	<u>Description</u>
Analysis Pt 1 =	AP1	91.0	Toe of Slope @ Catchment
Analysis Pt 2 =	AP2	100.0	Edge of Pavement
Analysis Pt 3 =	AP3	108.0	Edge of Travel Lane

**CRSP Assumptions:** Analysis using long-term conditions  
 ≥95% rockfall retained at Analysis Pt 3 design criteria  
 Roughness based on field measurements and experience with bedrock of the Monongahela Group  
 Rock shape is discoidal, 1 feet to 4 feet

Upper Zone Ymax: 881    Δ Elev.  
 Upper Zone Ymin: 874    7

	Cell	Surface R	Tangent C	Normal C	Begin X	Begin Y	End X	End Y
1 Overburden	1	2	0.65	0.15	0	887	13.0	881.0
2 Sandstone (Generator Unit)	2	2	0.9	0.25	13.0	881.0	17.0	877.5
3 Claystone Bench (w Talus Build-up)	3	2	0.65	0.15	17.0	877.5	27.0	874.0
4 Claystone	4	0.25	0.75	0.15	27.0	874.0	45.0	860.0
5 Shale	5	0.5	0.75	0.15	45.0	860.0	56.0	851.0
6 Claystone	6	0.25	0.75	0.15	56.0	851.0	66.5	843.0
7 Sandstone	7	1.5	0.9	0.25	66.5	843.0	79.0	830.0
8 Shale	8	0.5	0.75	0.15	79.0	830.0	85.0	826.0
9 Shale	9	0.5	0.75	0.15	85.0	826.0	91.0	820.0
10 Shale	10	0.5	0.75	0.15	91.0	820.0	95.0	820.0
11 Overburden	11	2	0.65	0.15	95.0	820.0	100.0	822.0
12 Pavement	12	0	1	1	100.0	822.0	108.0	822.5
13 Pavement	13	0	1	1	108.0	822.5	118.0	823



Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Proposed - Long Term (1.25H:1V) with Talus Build-**  
 Subject: **Sta. 832+00**

Computed: **DCM** Date: **5/13/24**  
 Checked: **AKB** Date: **5/17/24**  
 Page: **2** of **2**

Overburden  
Claystone and Shale  
Sandstone

**Table 503-2. Hardness reference guide with CRSP coefficient values (Modified from Woodard, 2004)**

Hardness Input Code	Consistency	Field Identification	Normal Coefficient Values (Rn)	Tangential Coefficient Values (Rt)
1	Very soft	Easily penetrated several inches by fist	0.10	0.50
2	Soft	Easily penetrated several inches by thumb	0.10	0.55
3	Firm	Can be penetrated several inches by thumb with moderate effort	0.15	0.65
4	Stiff	Readily indented by thumb but penetrated only with great effort	0.15	0.70
5	Very stiff	Readily indented by thumbnail	0.20	0.75
6	Hard	Indented with difficulty by thumbnail	0.20	0.80-0.85
7	Very weak rock	Can be carved with a knife. Can be excavated readily with a point of a pick. Pieces 1 inch (25 mm) or more in thickness can be broken by finger pressure. Can be scratched by fingernail.	0.15	0.75
8	Weak rock	Can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure.	0.15	0.75
9	Slightly strong rock	Can be grooved or gouged 0.05 inch (2 mm) deep by firm pressure of a knife or pick point. Can be excavated in small chips to pieces about 1-inch (25 mm) maximum size by hard blows of the point of a geologist's pick.	0.20	0.80
10	Moderately strong rock	Can be scratched with a knife or pick. Grooves or gouges to 1/2" (6mm) deep can be excavated by hand blows of a geologist's pick. Requires moderate hammer blows to detach hand specimen.	0.25	0.85
11	Strong rock	Can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach hand specimen. Sharp and resistant edges are present on hand specimen.	0.25-0.30	0.9
12	Very strong rock	Cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0
13	Extremely strong rock	Cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0

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OHIO DEPARTMENT OF TRANSPORTATION  
Rock Slope Design Guide

**Table 503-1. CRSP Coefficient Guide for Normal and Tangential Coefficient (from Jones, et al., 2000)**

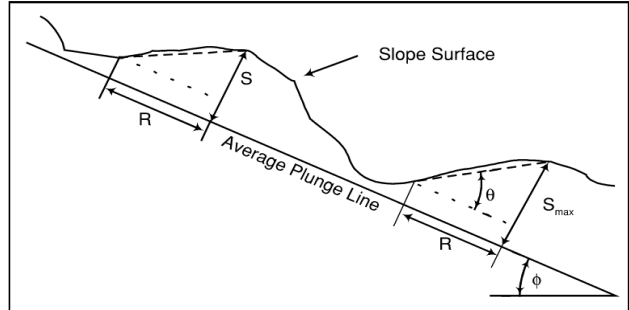
Description of Slope	Normal Coefficient (Rn)	Remarks
Smooth hard surfaces and paving	0.60-1.0	-For short slopes try lower values in applicable range
Most bedrock and boulder fields	0.15-0.30	-If max. velocity/KE* are design criteria, use lower values in range; if avg. velocity/KE* are design criteria, use higher values in range
Talus and firm soil slopes	0.12-0.20	
Soft soil slopes**	0.10-0.20	

\*KE = kinetic energy  
 \*\*Soft soil slope coefficients were extrapolated from other slope types due to lack of data

Description of Slope	Tangential Coefficient (Rt)	Remarks
Smooth hard surfaces and paving	0.90-1.0	-Rt is not very sensitive compared to Rn, but may be important for hard or significantly vegetated slopes
Most bedrock and boulder fields	0.75-0.95	
Talus and firm soil slopes	0.65-0.95	
Soft soil slopes*	0.50-0.80	-Use lower Rt as the density of vegetation on the slope increases

OHIO DEPARTMENT OF TRANSPORTATION  
Rock Slope Design Guide

January 2016  
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**Figure 2. Surface roughness (S) established as the perpendicular variation from an average plunge line (defined by slope angle  $\phi$ ) over a distance equal to the radius of the rock (R). Maximum slope variation ( $\theta_{max}$ ) is defined by S and R (Pfeiffer, 1989; Pfeiffer et al., 1991; 1995).**

Colorado Rockfall Simulation Program Manual  
(CDOT-SYMB-CGS-99-1, March 2000)

For Pavement Use 1.0 for Rn and Rt



CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc\_with Talus.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 13  
Analysis Point 1 X-Coordinate: 91  
Analysis Point 2 X-Coordinate: 100  
Analysis Point 3 X-Coordinate: 108  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 877.5

Remarks: Sta. 382+00 Proposed Long Term with Talus Buildup

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	887	13	881
2.	2	.9	.25	13	881	17	877.5
3.	2	.65	.15	17	877.5	27	874
4.	.25	.75	.15	27	874	45	860
5.	.5	.75	.15	45	860	56	851
6.	.25	.75	.15	56	851	66.5	843
7.	1.5	.9	.25	66.5	843	79	830
8.	.5	.75	.15	79	830	85	826
9.	.5	.75	.15	85	826	91	820
10.	.5	.75	.15	91	820	95	820
11.	2	.65	.15	95	820	100	822
12.	0	1	1	100	822	108	822.5
13.	0	1	1	108	822.5	118	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc\_with Talus.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 13  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 4 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc\_with Talus.doc

Analysis Point 1: X = 91, Y = 820

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	38.04	61257
75%	38.04	61257
90%	38.04	61257
95%	38.04	61257
98%	38.04	61257

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 38.04	Maximum: .46	Maximum: 61257
Average: 38.04	Average: .46	Average: 61257
Minimum: 38.04	G. Mean: .46	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed Long Term with Talus Buildup

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc\_with Talus.doc

Analysis Point 2: X = 100, Y = 822

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	6.63	2411
75%	6.63	2411
90%	6.63	2411
95%	6.63	2411
98%	6.63	2411

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 6.63	Maximum: .19	Maximum: 2411
Average: 6.63	Average: .19	Average: 2411
Minimum: 6.63	G. Mean: .19	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed Long Term with Talus Buildup

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc\_with Talus.doc

Analysis Point 3: X = 108, Y = 822

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
---	-------------------	----------------

50%	4.28	920	0.29
75%	4.28	920	0.97
90%	4.28	920	1.58
95%	4.28	920	1.94
98%	4.28	920	2.35

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 4.28	Maximum: .29	Maximum: 920
Average: 4.28	Average: .29	Average: 920
Minimum: 4.28	G. Mean: .29	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed Long Term with Talus Buildup

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc\_with Talus.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce Ht.

1.	No rocks	past end of cell			
2.	14	8	2.52	2	0
3.	11	5	1.83	0	0
4.	16	16	0	0	-1
5.	22	22	0	0	0
6.	23	23	0	0	-1
7.	31	31	0	0	0
8.	33	33	0	0	-1
9.	38	38	0	0	0
10.	20	20	0	0	0
11.	7	7	0	0	0
12.	4	4	0	0	0
13.	No rocks	past end of cell			

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_4x1 Disc\_with Talus.doc

X Interval	Rocks Stopped
0 To 10 ft	1
14. To 20 ft	452
20 To 30 ft	521
30 To 40 ft	25
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 118 ft	1

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc\_with Talus.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 13  
Analysis Point 1 X-Coordinate: 91  
Analysis Point 2 X-Coordinate: 100  
Analysis Point 3 X-Coordinate: 108  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 877.5

Remarks: Sta. 382+00 Proposed Long Term with Talus Buildup

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	887	13	881
2.	2	.9	.25	13	881	17	877.5
3.	2	.65	.15	17	877.5	27	874
4.	.25	.75	.15	27	874	45	860
5.	.5	.75	.15	45	860	56	851
6.	.25	.75	.15	56	851	66.5	843
7.	1.5	.9	.25	66.5	843	79	830
8.	.5	.75	.15	79	830	85	826
9.	.5	.75	.15	85	826	91	820
10.	.5	.75	.15	91	820	95	820
11.	2	.65	.15	95	820	100	822
12.	0	1	1	100	822	108	822.5
13.	0	1	1	108	822.5	118	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc\_with Talus.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 13  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 2 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc\_with Talus.doc

Analysis Point 1: X = 91, Y = 820

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	35.53	12726
75%	35.53	12726
90%	35.53	12726
95%	35.53	12726
98%	35.53	12726

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 35.53</b>	<b>Maximum: 5.52</b>	<b>Maximum: 12726</b>
Average: 35.53	Average: 5.52	Average: 12726
Minimum: 35.53	G. Mean: 5.52	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed Long Term with Talus Buildup

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc\_with Talus.doc

Analysis Point 2: X = 100, Y = 822

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	5.4	414
75%	5.4	414
90%	5.4	414
95%	5.4	414
98%	5.4	414

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 5.4	Maximum: 0	Maximum: 414
Average: 5.4	Average: -.09	Average: 414
Minimum: 5.4	G. Mean: 0	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed Long Term with Talus Buildup

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc\_with Talus.doc

Analysis Point 3: X = 108, Y = 822

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
---	-------------------	----------------

50%	4.03	178	0
75%	4.03	178	0.68
90%	4.03	178	1.28
95%	4.03	178	1.65
98%	4.03	178	2.06

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
------------------------------	--------------------	----------------

Maximum: 4.03	Maximum: 0	Maximum: 178
Average: 4.03	Average: -.03	Average: 178
Minimum: 4.03	G. Mean: 0	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 382+00 Proposed Long Term with Talus Buildup

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc\_with Talus.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce Ht.

1.	No rocks	past end of cell			
2.	13	6	2.38	1	0
3.	7	5	0	0	-1
4.	19	19	0	0	0
5.	26	26	0	2	1
6.	28	28	0	1	0
7.	27	27	0	4	3
8.	31	31	0	5	4
9.	36	36	0	6	5
10.	39	39	0	1	1
11.	5	5	0	0	-1
12.	4	4	0	0	-1
13.	No rocks	past end of cell			

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_2x1 Disc\_with Talus.doc

X Interval	Rocks Stopped
0 To 10 ft	1
14. To 20 ft	923
20 To 30 ft	75
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 118 ft	1



CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc\_with Talus.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 13  
Analysis Point 1 X-Coordinate: 91  
Analysis Point 2 X-Coordinate: 100  
Analysis Point 3 X-Coordinate: 108  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 877.5

Remarks: Sta. 382+00 Proposed Long Term with Talus Buildup

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	887	13	881
2.	2	.9	.25	13	881	17	877.5
3.	2	.65	.15	17	877.5	27	874
4.	.25	.75	.15	27	874	45	860
5.	.5	.75	.15	45	860	56	851
6.	.25	.75	.15	56	851	66.5	843
7.	1.5	.9	.25	66.5	843	79	830
8.	.5	.75	.15	79	830	85	826
9.	.5	.75	.15	85	826	91	820
10.	.5	.75	.15	91	820	95	820
11.	2	.65	.15	95	820	100	822
12.	0	1	1	100	822	108	822.5
13.	0	1	1	108	822.5	118	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc\_with Talus.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 13  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1.5 ft  
Thickness: 0.5 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc\_with Talus.doc

Analysis Point 1: X = 91, Y = 820

NO ROCKS PAST ANALYSIS POINT 1

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc\_with Talus.doc

Analysis Point 2: X = 100, Y = 822

NO ROCKS PAST ANALYSIS POINT 2

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc\_with Talus.doc

Analysis Point 3: X = 108, Y = 822

NO ROCKS PAST ANALYSIS POINT 3

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc\_with Talus.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
--------	-----------	-----------	-----------	-----------------	-----------------

1. No rocks	past end of cell			
2. 13	6	2.33	1	0
3. No rocks	past end of cell			
4. No rocks	past end of cell			
5. No rocks	past end of cell			
6. No rocks	past end of cell			
7. No rocks	past end of cell			
8. No rocks	past end of cell			
9. No rocks	past end of cell			
10. No rocks	past end of cell			
11. No rocks	past end of cell			
12. No rocks	past end of cell			
13. No rocks	past end of cell			

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_15x05 Disc\_with Talus.doc

X Interval	Rocks Stopped
0 To 10 ft	1
14. To 20 ft	958
20 To 30 ft	41
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 118 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc\_with Talus.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 13  
Analysis Point 1 X-Coordinate: 91  
Analysis Point 2 X-Coordinate: 100  
Analysis Point 3 X-Coordinate: 108  
Initial Y-Top Starting Zone Coordinate: 881  
Initial Y-Base Starting Zone Coordinate: 877.5

Remarks: Sta. 382+00 Proposed Long Term with Talus Buildup

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	2	.65	.15	0	887	13	881
2.	2	.9	.25	13	881	17	877.5
3.	2	.65	.15	17	877.5	27	874
4.	.25	.75	.15	27	874	45	860
5.	.5	.75	.15	45	860	56	851
6.	.25	.75	.15	56	851	66.5	843
7.	1.5	.9	.25	66.5	843	79	830
8.	.5	.75	.15	79	830	85	826
9.	.5	.75	.15	85	826	91	820
10.	.5	.75	.15	91	820	95	820
11.	2	.65	.15	95	820	100	822
12.	0	1	1	100	822	108	822.5
13.	0	1	1	108	822.5	118	823

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc\_with Talus.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 13  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc\_with Talus.doc

Analysis Point 1: X = 91, Y = 820

NO ROCKS PAST ANALYSIS POINT 1

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc\_with Talus.doc

Analysis Point 2: X = 100, Y = 822

NO ROCKS PAST ANALYSIS POINT 2

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc\_with Talus.doc

Analysis Point 3: X = 108, Y = 822

NO ROCKS PAST ANALYSIS POINT 3

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc\_with Talus.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
--------	-----------	-----------	-----------	-----------------	-----------------

1. No rocks	past end of cell		
2. 13	5	2.2	1
3. No rocks	past end of cell		0
4. No rocks	past end of cell		
5. No rocks	past end of cell		
6. No rocks	past end of cell		
7. No rocks	past end of cell		
8. No rocks	past end of cell		
9. No rocks	past end of cell		
10. No rocks	past end of cell		
11. No rocks	past end of cell		
12. No rocks	past end of cell		
13. No rocks	past end of cell		

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 382+00\202405013\_MEG-33-7.61-7.87\_Sta38200\_Proposed-Long Term\_1x1 Disc\_with Talus.doc

X Interval	Rocks Stopped
0 To 10 ft	1
14. To 20 ft	995
20 To 30 ft	4
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 118 ft	0

**MEG-33-7.61/7.8  
Proposed Benching**

**Sta. 379+00 to Sta. 385+00**

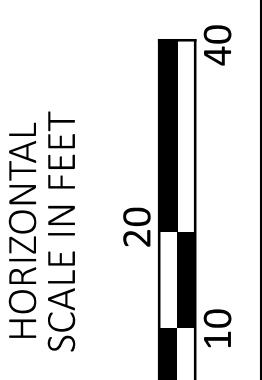
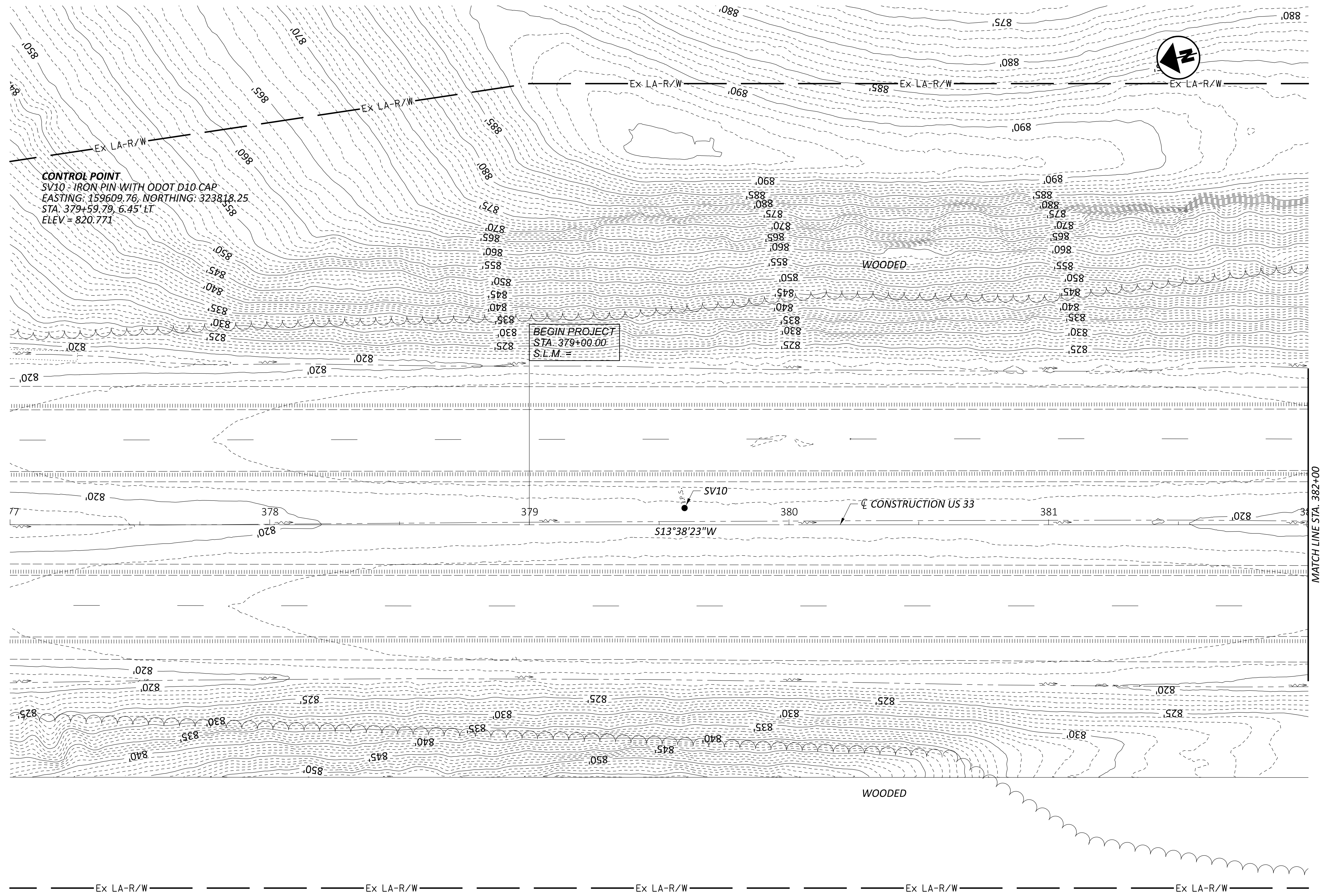
Due to difficulties in accessing the upper sandstone bluff, GIS locations obtained during site reconnaissance were considered approximate and used as a general reference and for note taking purposes.



## Site Reconnaissance Notes and Observations

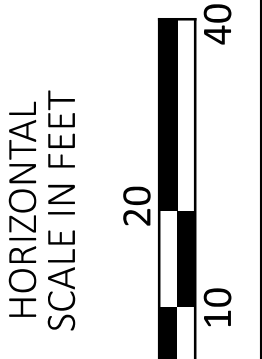
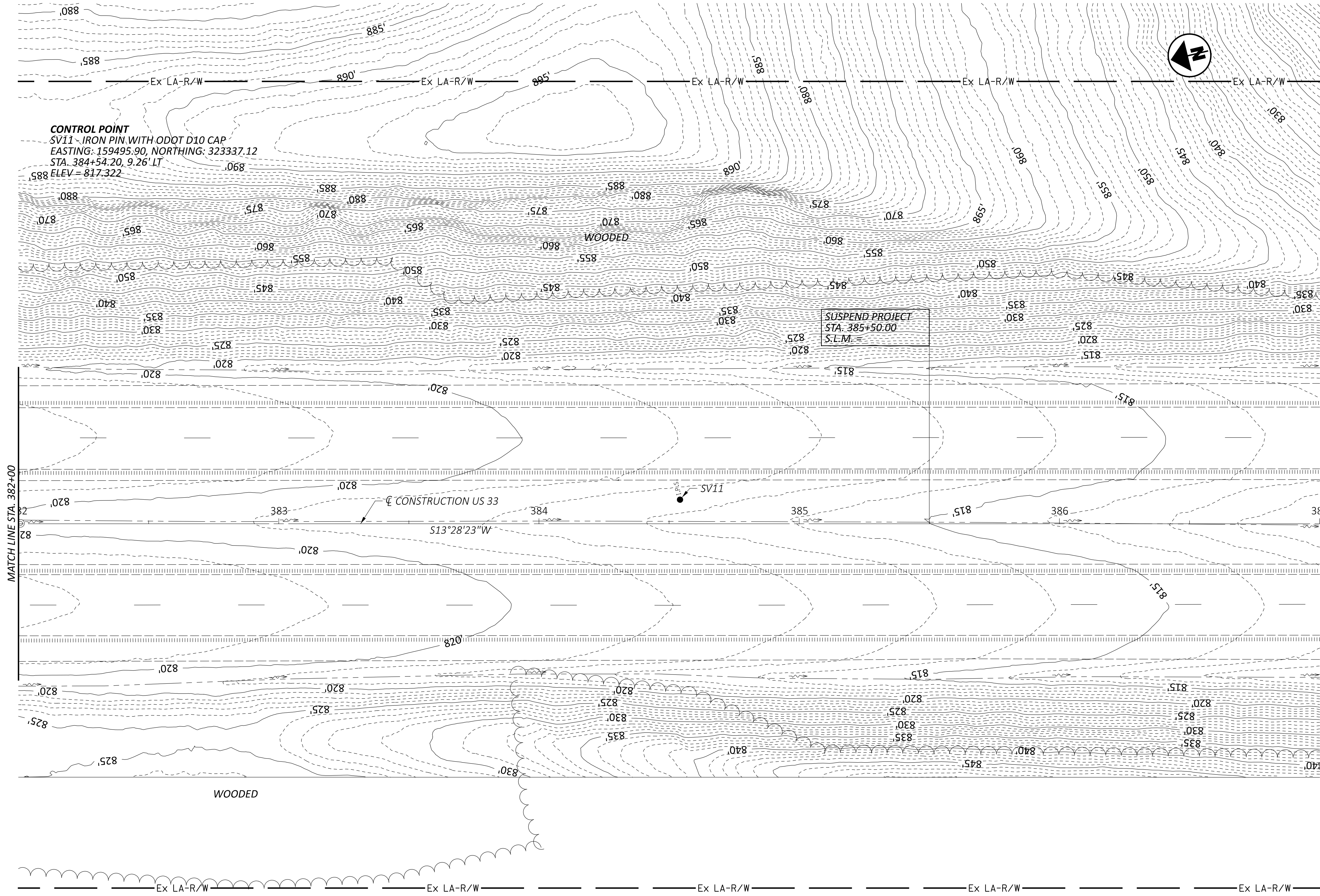
Imported GIS Data based on points taken by HDR using EOS Arrow Gold survey equipment and ESRI Field Maps App





PLAN US 33  
STA. 379+00 TO STA. 382+00

DESIGN AGENCY	
<b>HR</b>	
DESIGNER	TDM
REVIEWER	
PROJECT ID	MM-DD-YY
	118508
SHEET	TOTAL
P.6	20



PLAN US 33  
STA. 382+00 TO STA. 385+50

DESIGN AGENCY



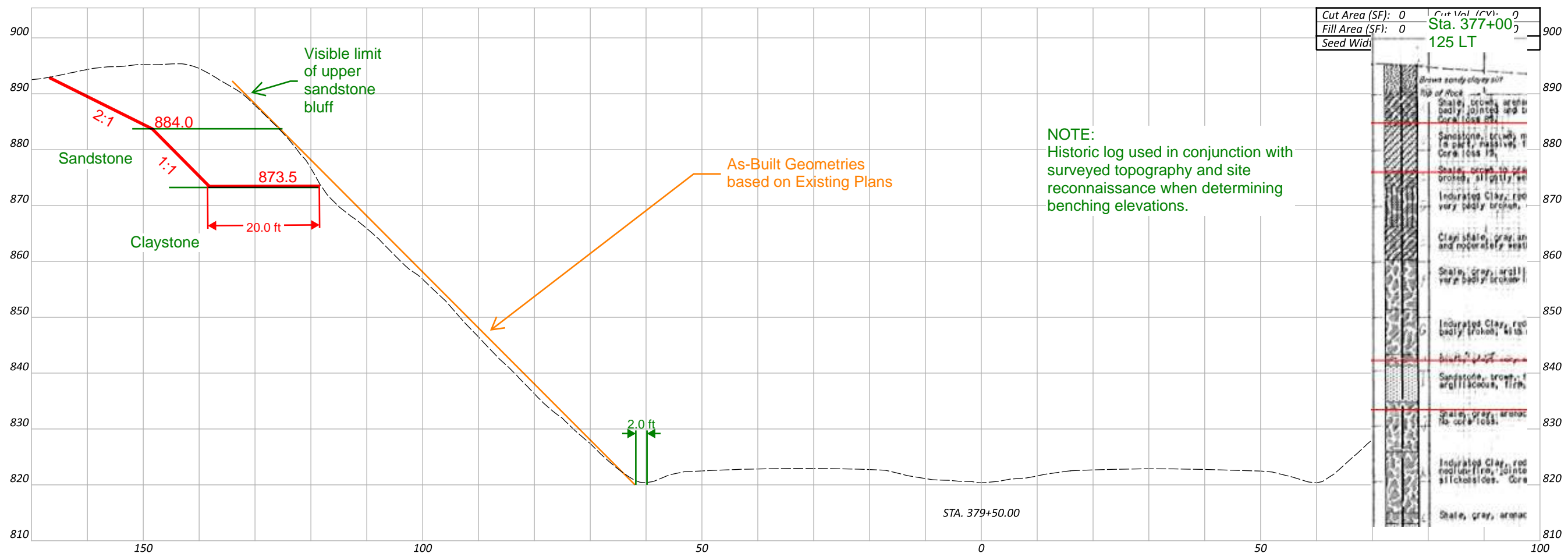
DESIGNER  
TDM

REVIEWER

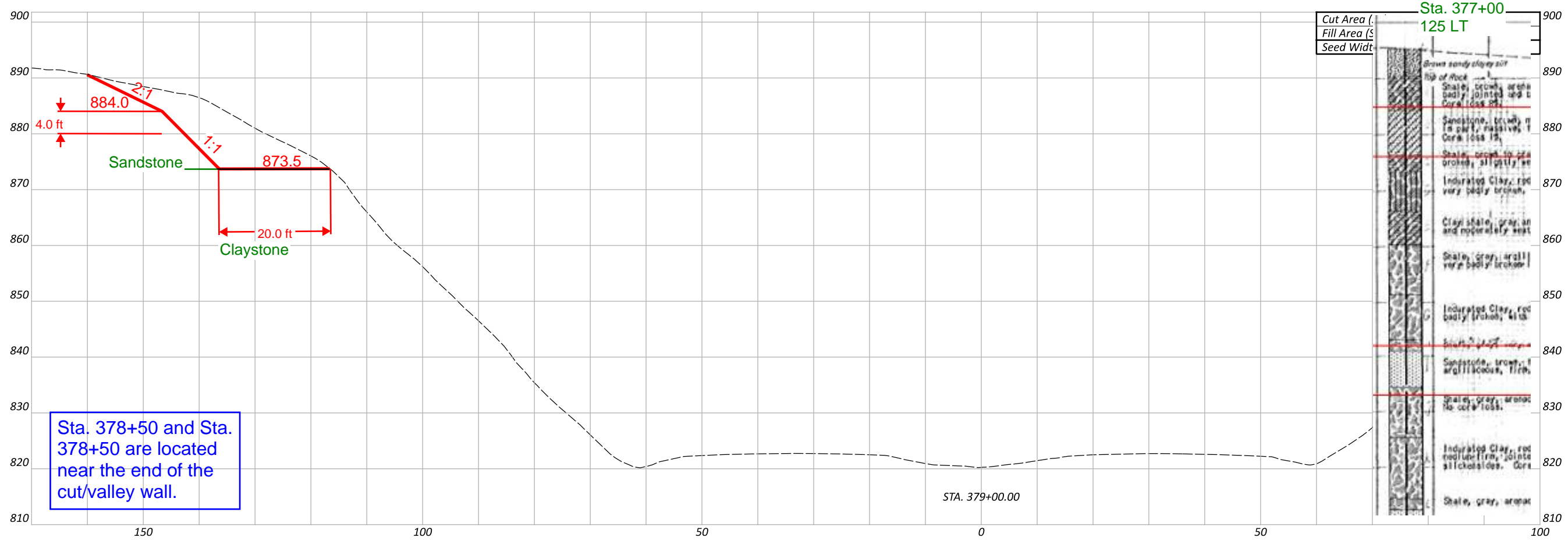
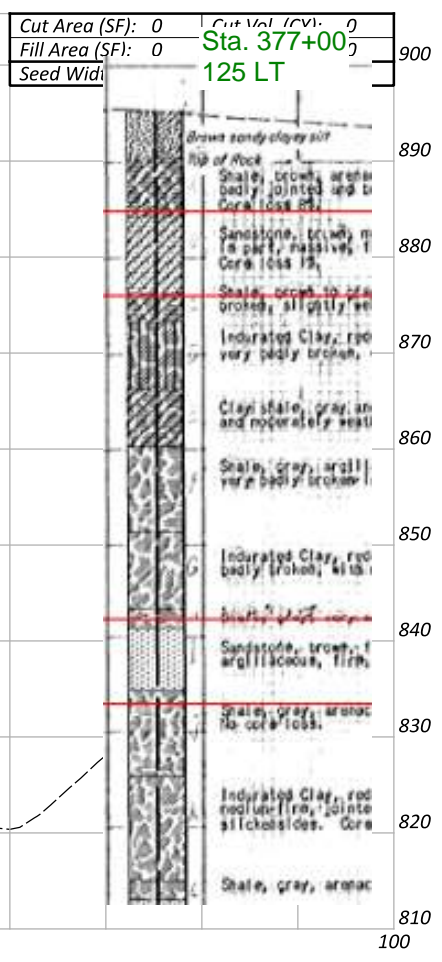
PJD MM-DD-YY

PROJECT ID  
118508

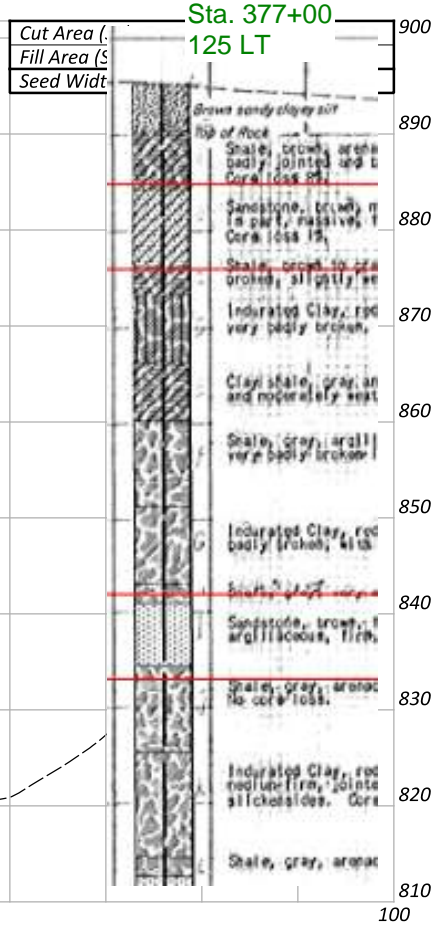
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**NOTE:**  
 Historic log used in conjunction with surveyed topography and site reconnaissance when determining benching elevations.



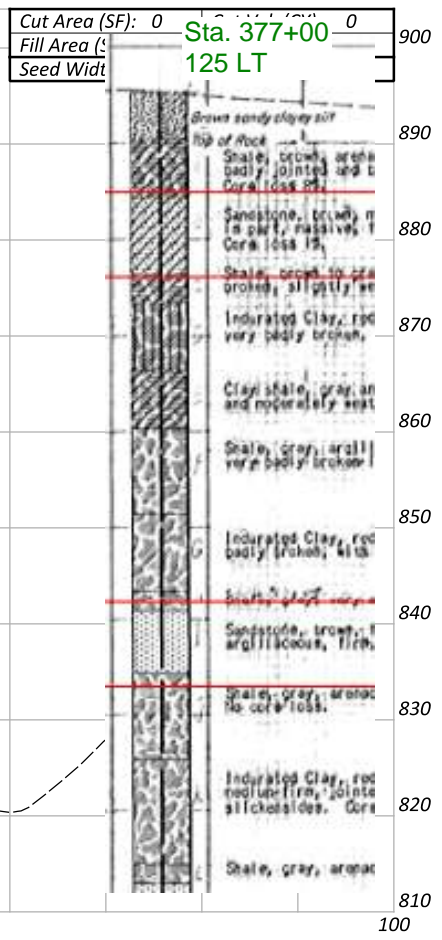
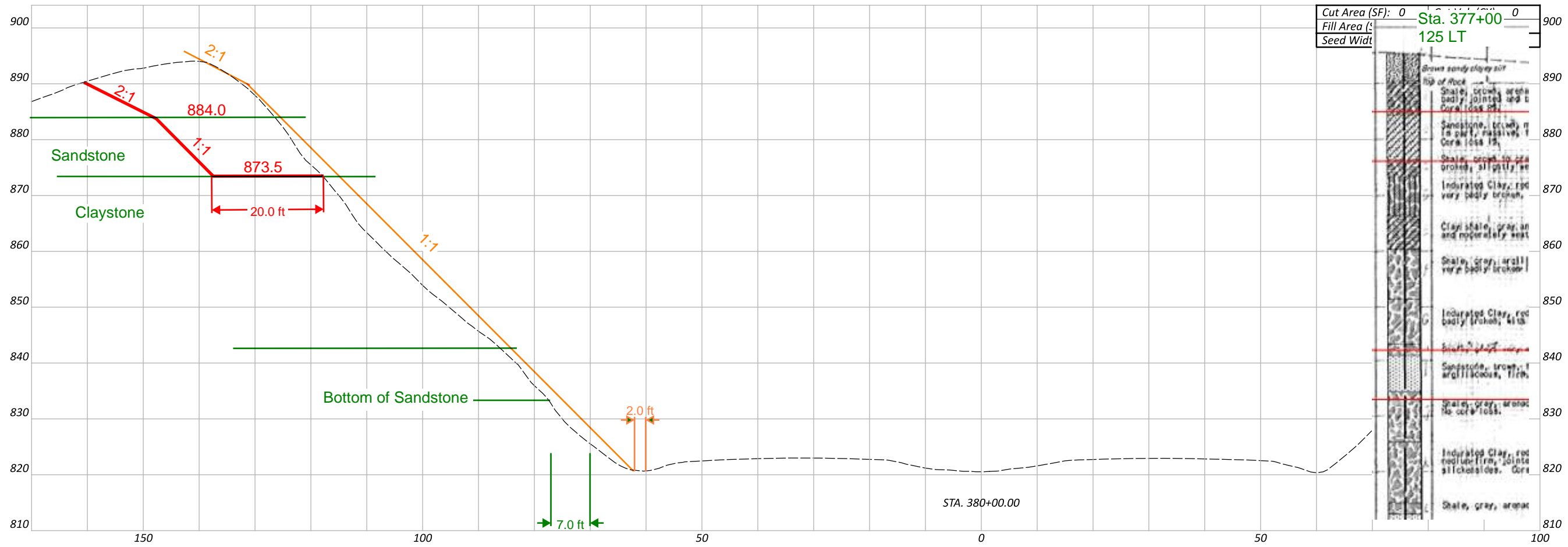
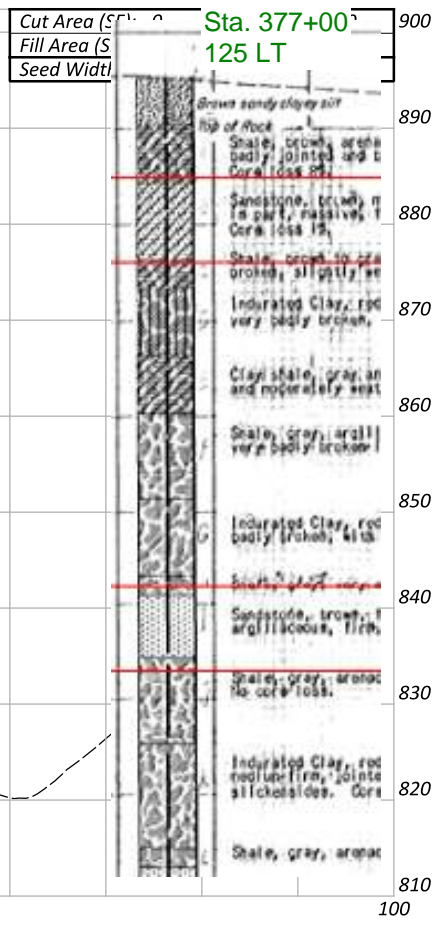
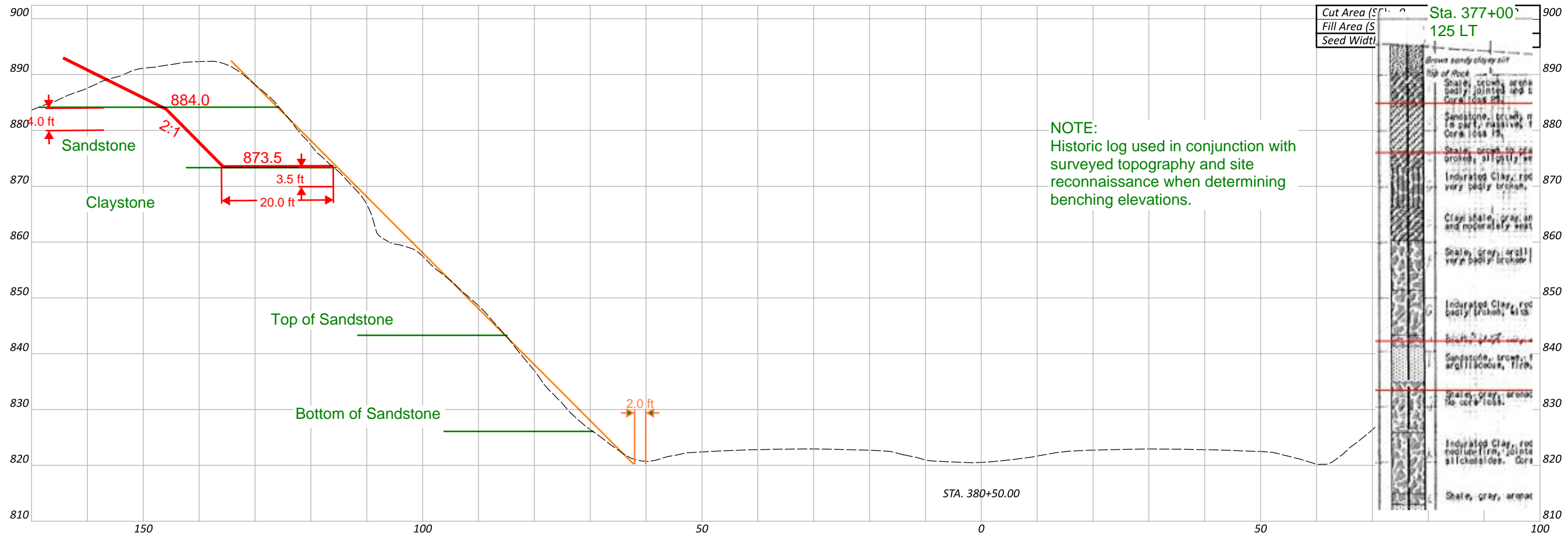
Sta. 378+50 and Sta. 379+50 are located near the end of the cut/valley wall.



Sheet Totals			SHEET TOTAL	
Seeding	Cut	Fill	P.0	0

MEG-33-(7.61)(7.87)

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NOTE:  
 Historic log used in conjunction with surveyed topography and site reconnaissance when determining benching elevations.

CROSS SECTIONS US 33  
 STA. 380+00 TO STA. 380+50

DESIGN AGENCY



DESIGNER

TDM

REVIEWER

PJD MM-DD-YY

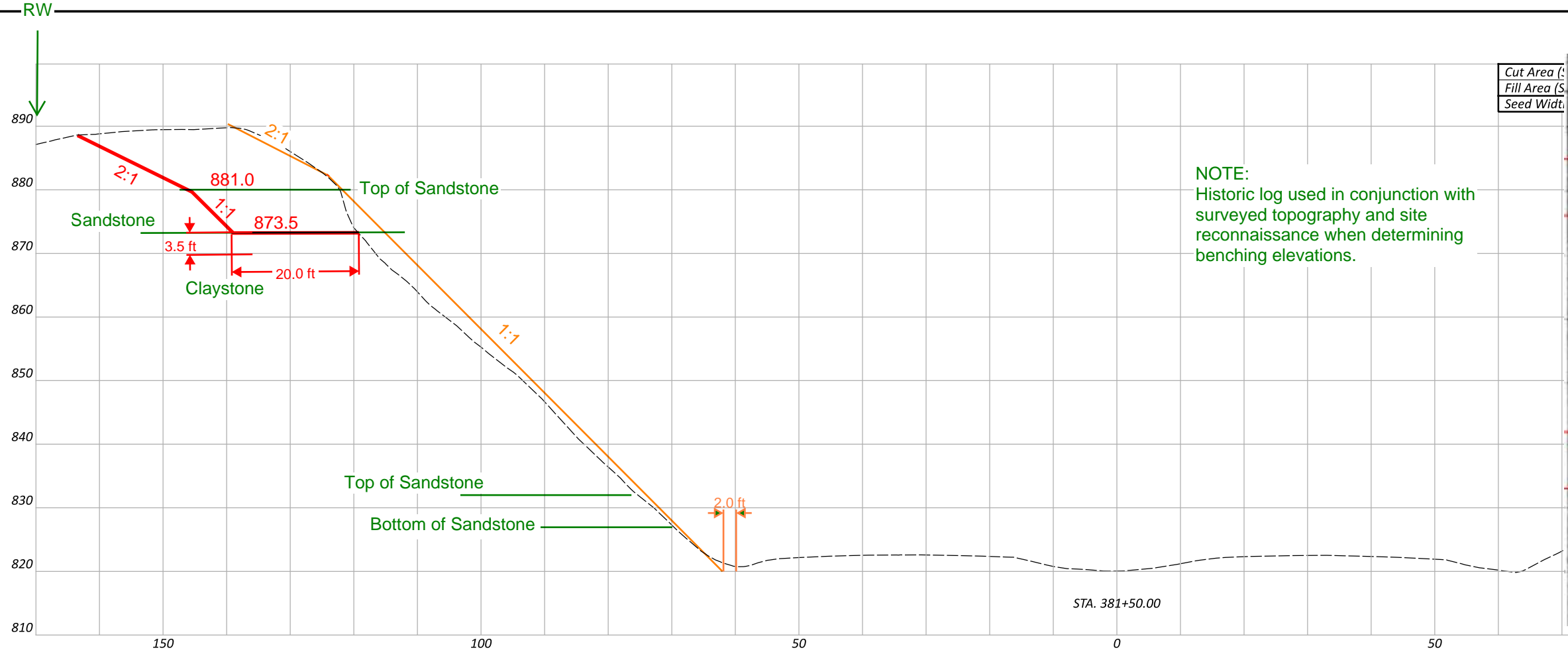
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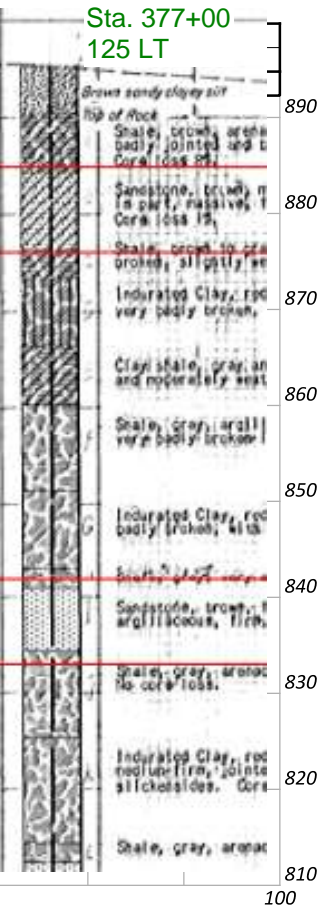
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MEG-33-(7.61)(7.87)

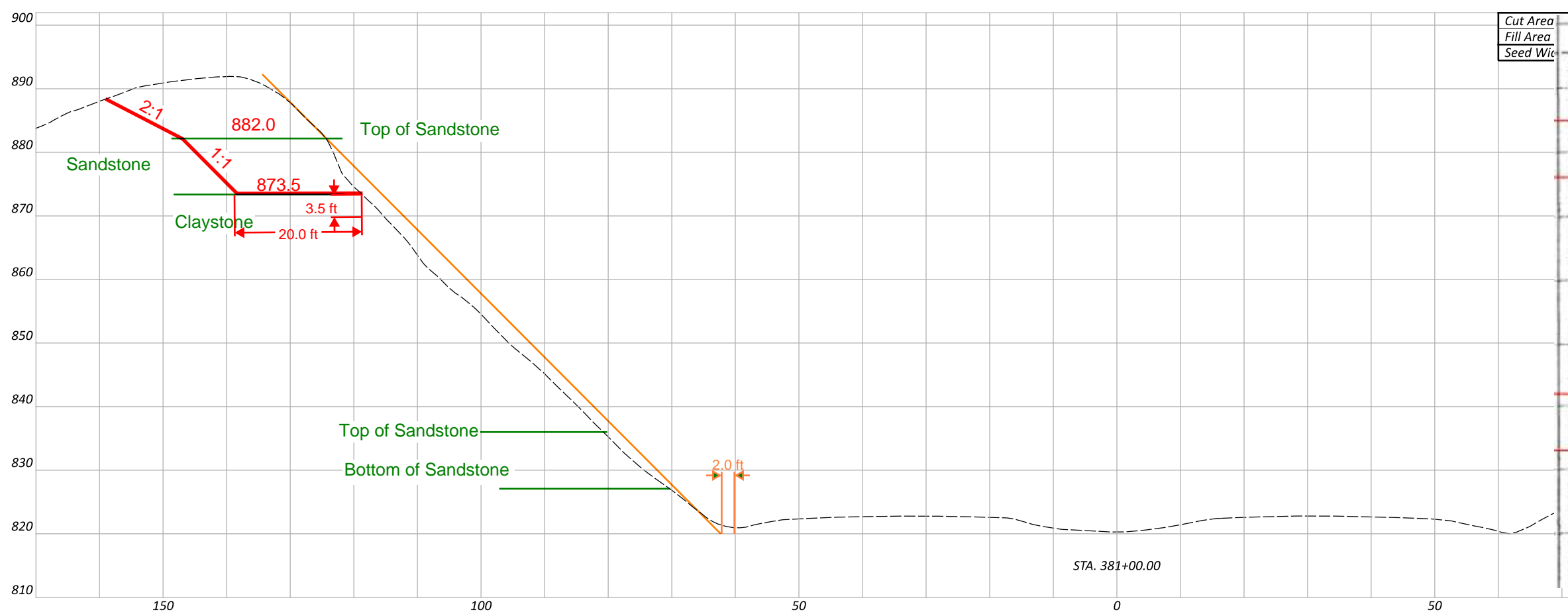
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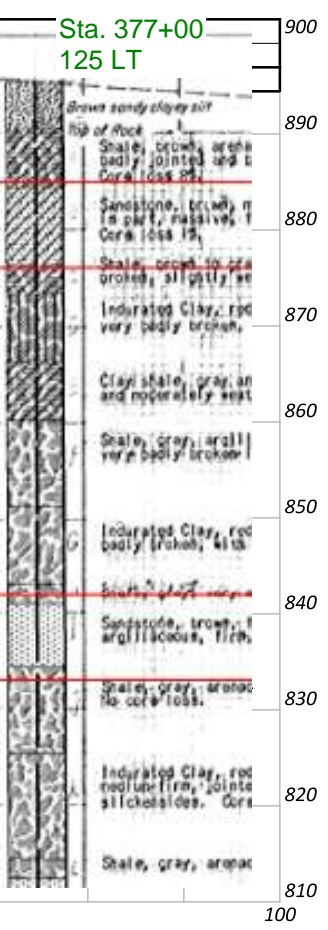
Cut Area (S)  
 Fill Area (S)  
 Seed Wid.



NOTE:  
 Historic log used in conjunction with surveyed topography and site reconnaissance when determining benching elevations.



Cut Area  
 Fill Area  
 Seed Wid.



CROSS SECTIONS US 33  
 STA. 381+00 TO STA. 381+50

DESIGN AGENCY



DESIGNER  
 TDM

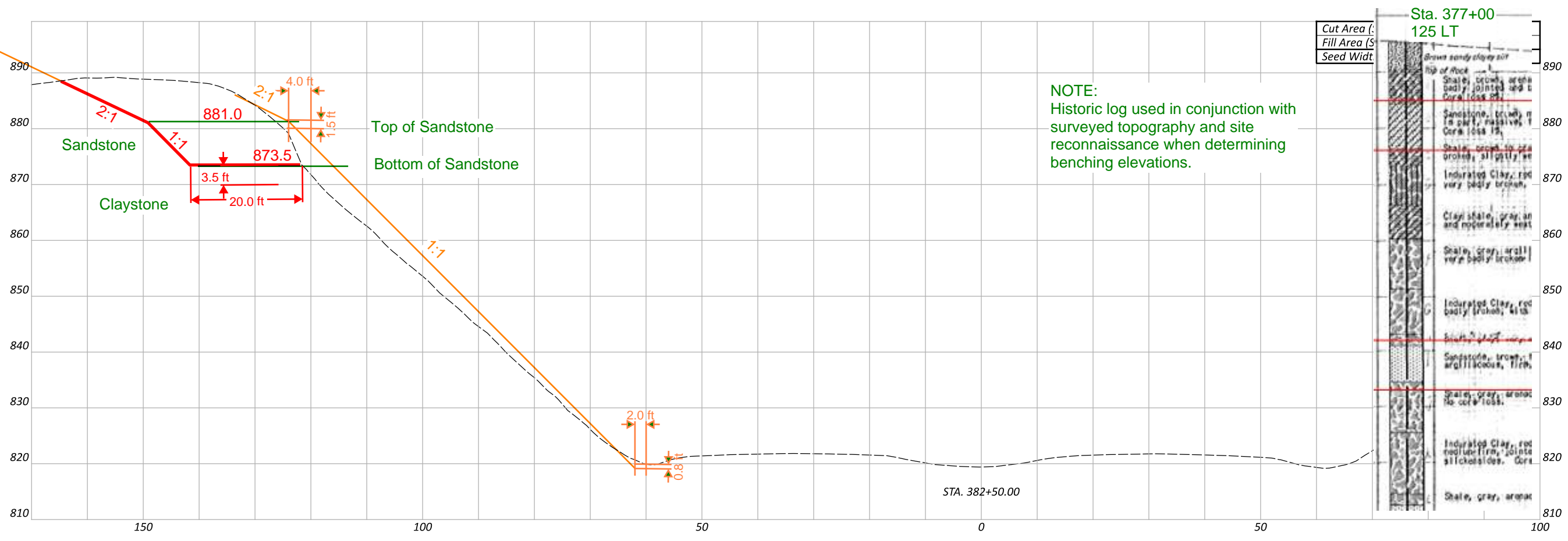
REVIEWER  
 PID MM-DD-YY

PROJECT ID  
 118508

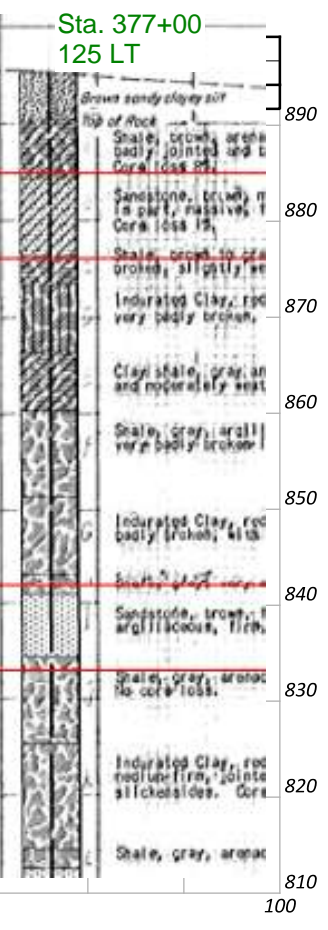
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Seeding	Cut	Fill	P.0	0

MEG-33-(7.61)(7.87)

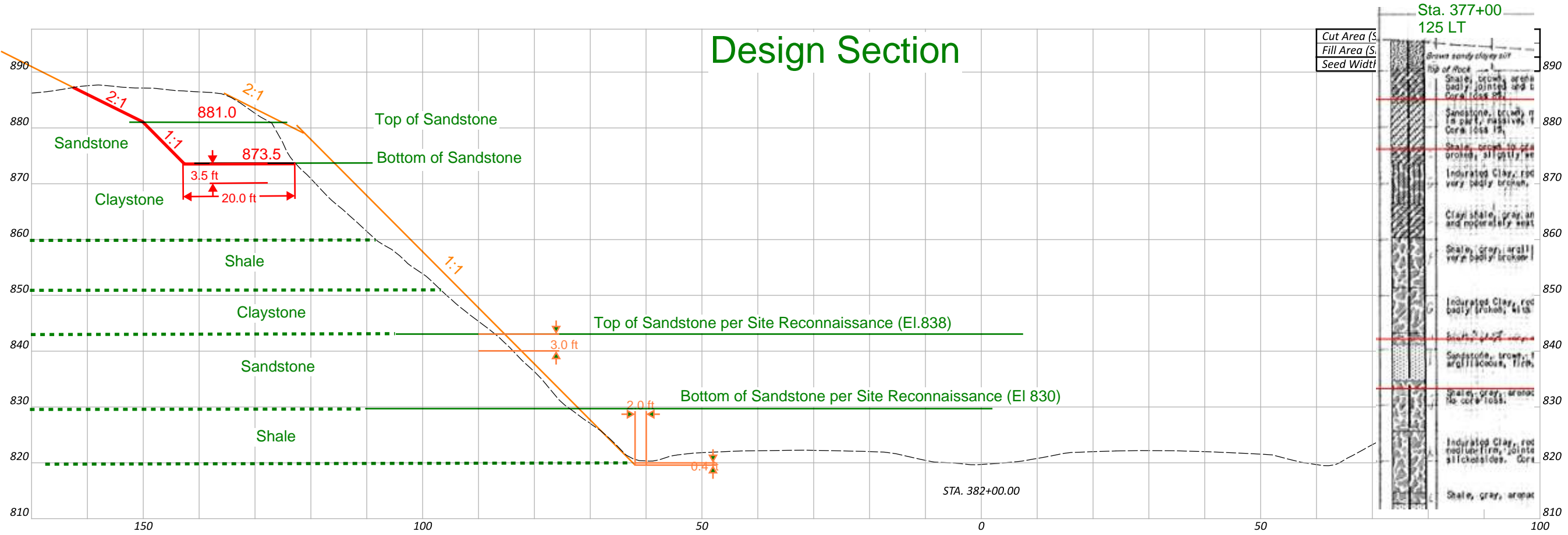
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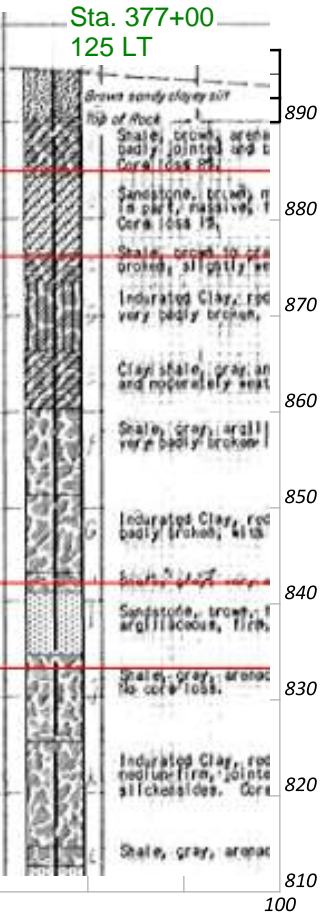
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Fill Area (S)	
Seed Width	



## Design Section



Cut Area (S)	
Fill Area (S)	
Seed Width	



CROSS SECTIONS US 33  
 STA. 382+00 TO STA. 382+50

DESIGN AGENCY



DESIGNER

TDM

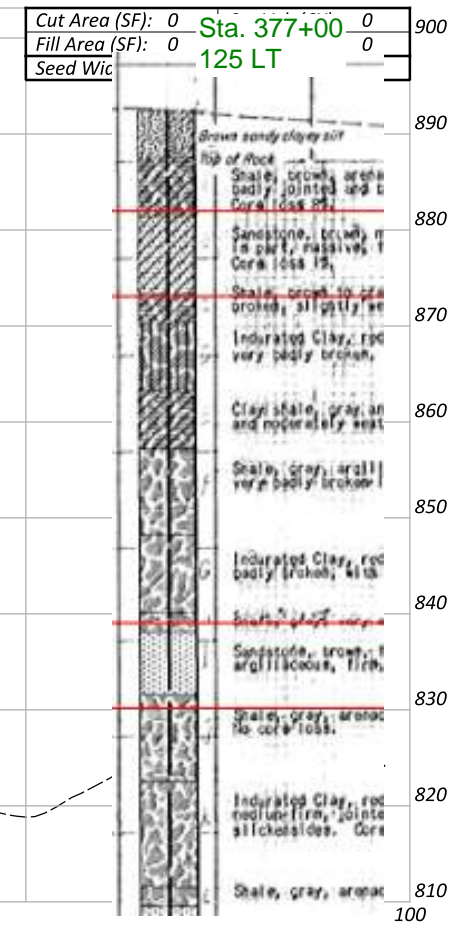
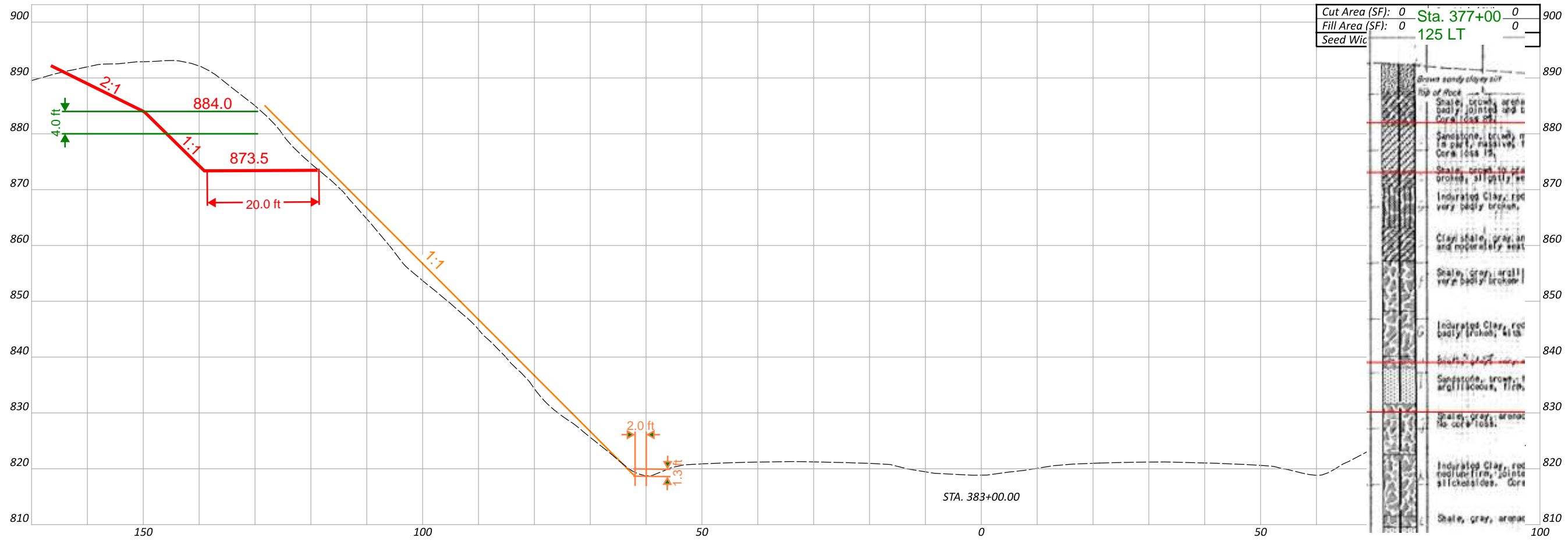
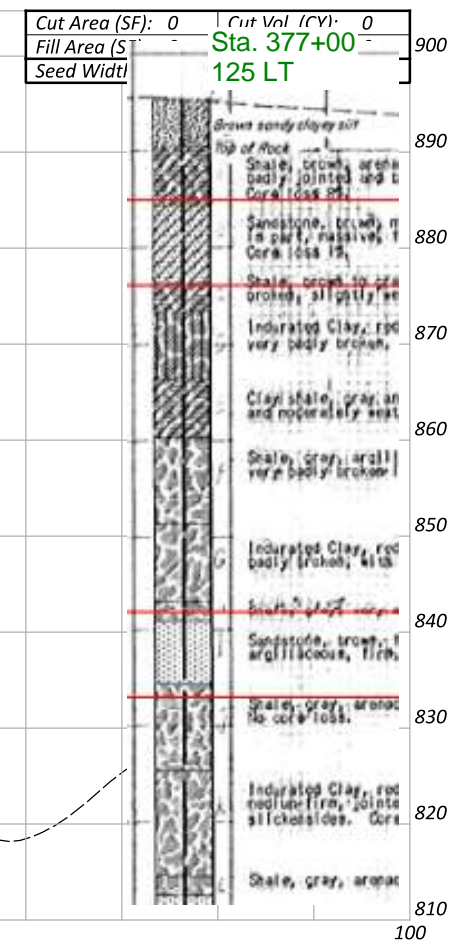
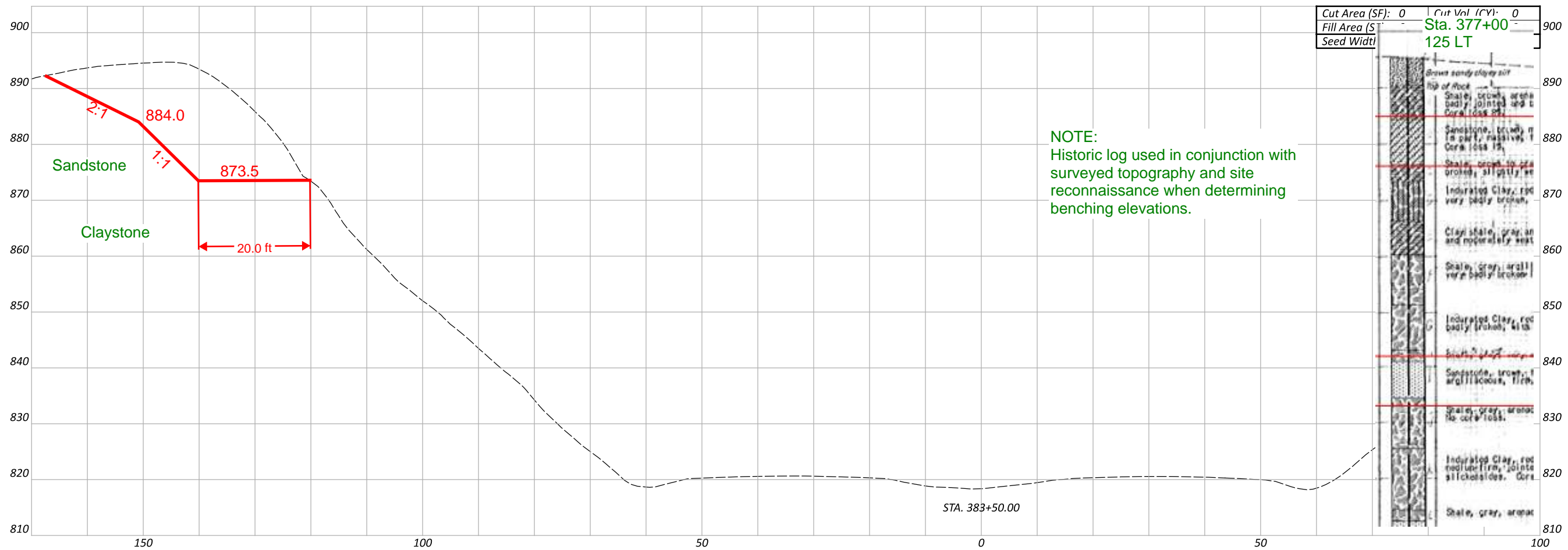
REVIEWER

PJD MM-DD-YY

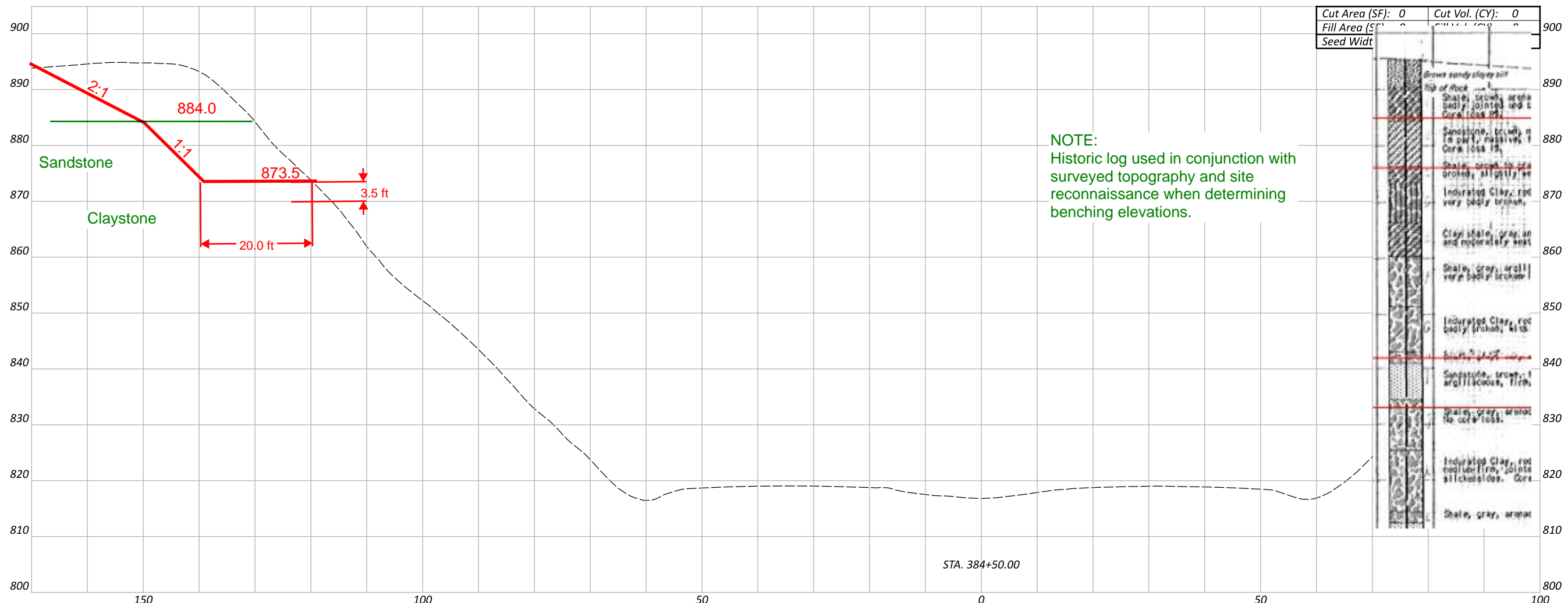
PROJECT ID

118508

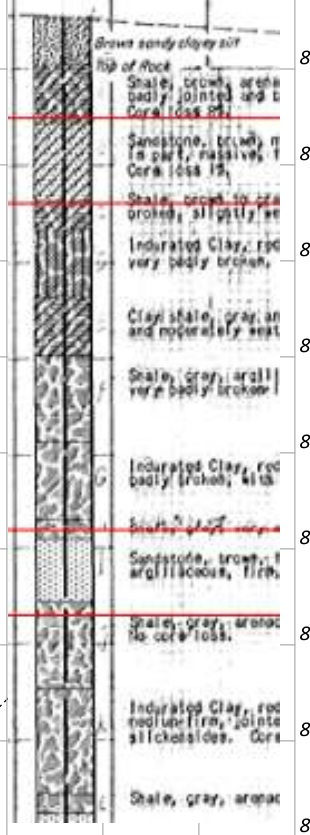
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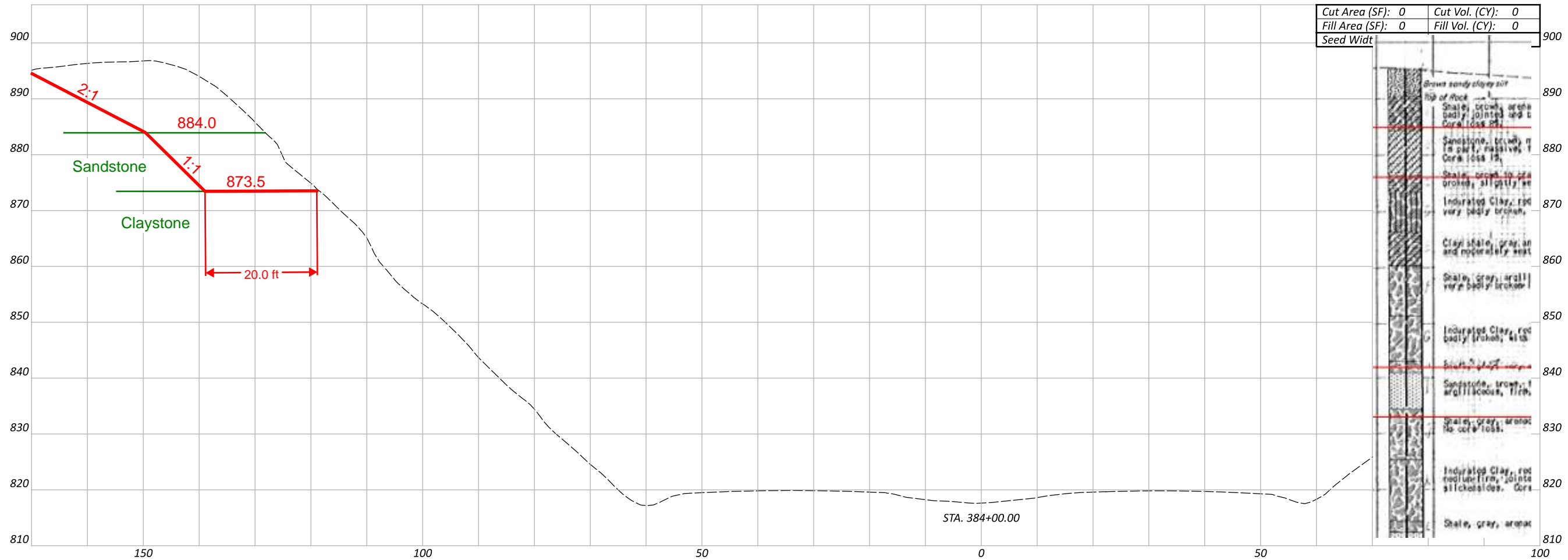
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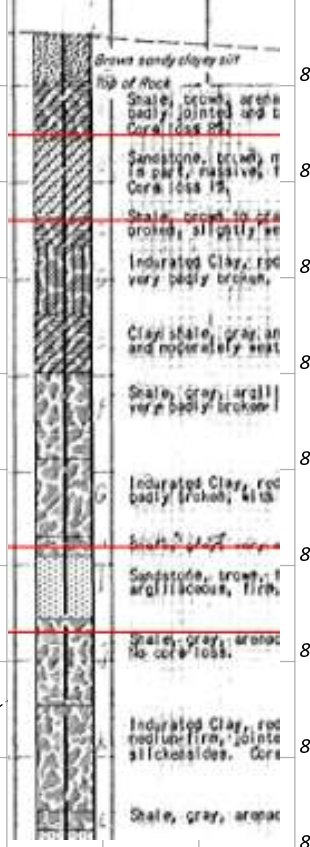
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Seed Wid:			



NOTE:  
 Historic log used in conjunction with surveyed topography and site reconnaissance when determining benching elevations.

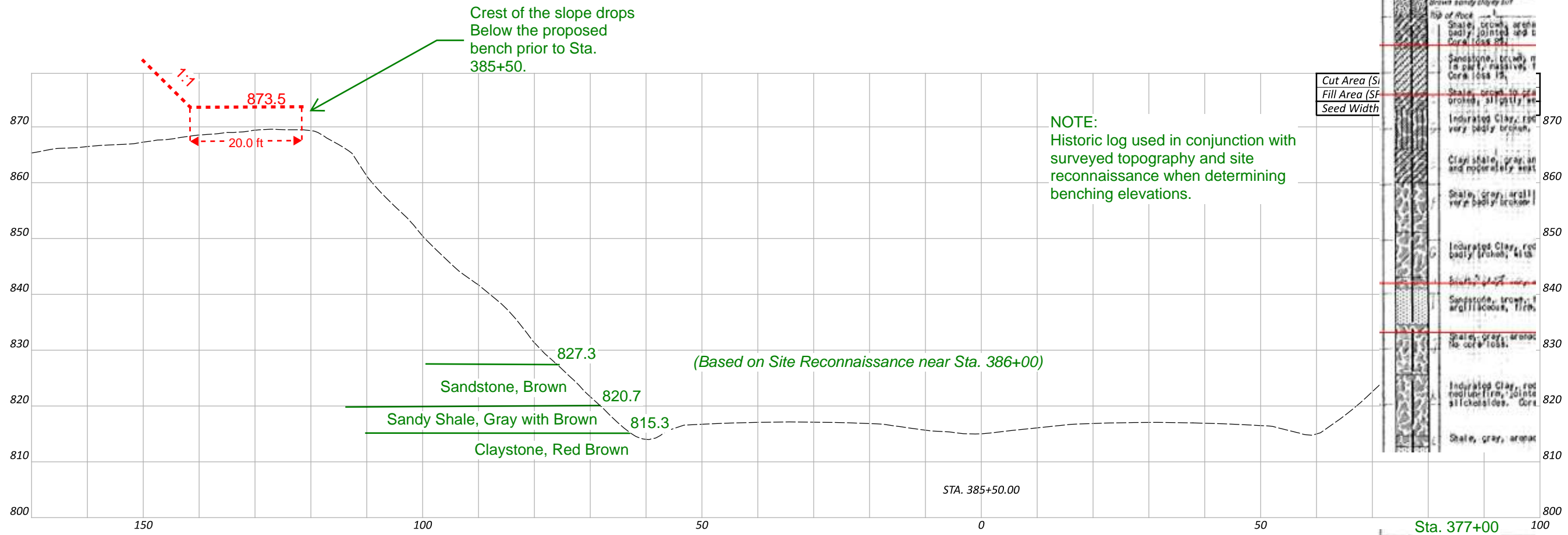


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Seed Wid:			

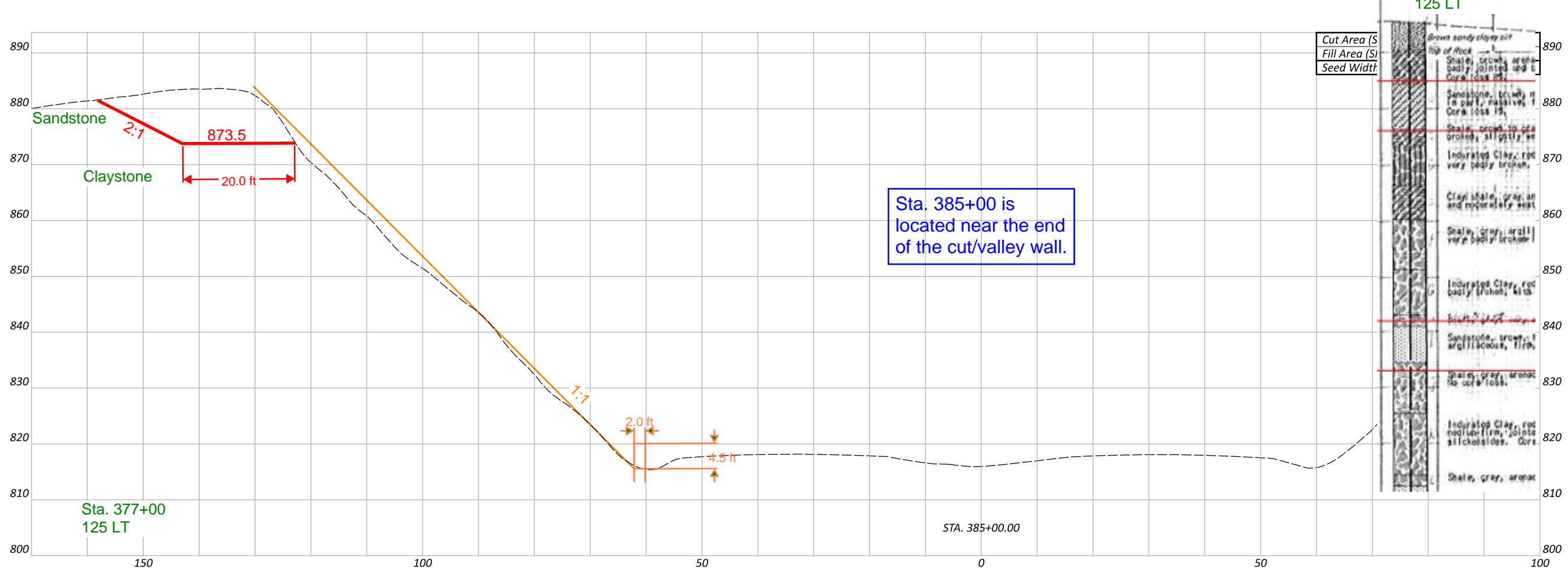
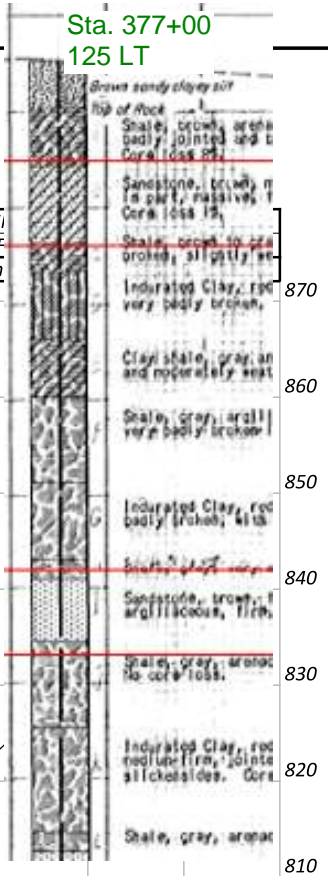


Sheet Totals			SHEET	TOTAL
Seeding	Cut	Fill		
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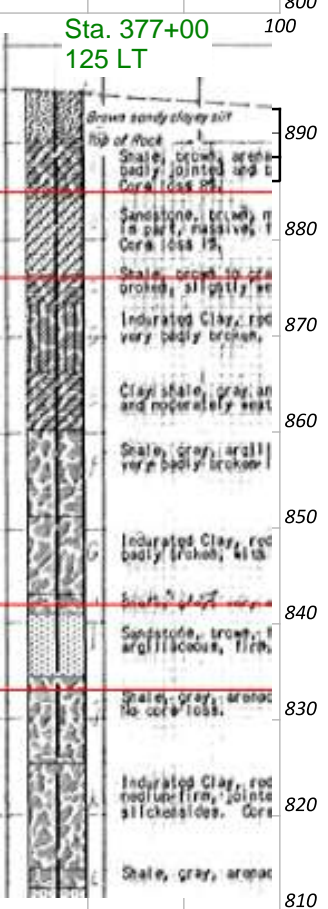




Cut Area (S)  
 Fill Area (SF)  
 Seed Width



Cut Area (S)  
 Fill Area (SF)  
 Seed Width



Sheet Totals			SHEET TOTAL	
Seeding	Cut	Fill	P.0	0

# MEG-33-7.87

## Sta. 393+00 to Sta. 397+00

### Rockfall Analysis

#### Design Notes and Assumptions:

Preliminary rock slope parameters were developed based on published information in the ODOT Geotechnical Design Manual (GDM) and ODOT Rock Slope Design Guide. These values were modified with the Colorado Rockfall Simulation Program (CRSP) to reflect the observed rockfall within the catchment as well as that within the paved shoulder and travel lane based on the photographs provided by the District.

Boulder sizes were based on measurements taken during HDR's site reconnaissance and the aforementioned ODOT photographs. The modeled sizes included discoidal boulders of the following dimensions:

- 4 ft diameter, 1 ft thickness
- 2 ft diameter, 1 ft thickness
- 1.5 ft diameter, 0.5 ft thickness
- 1 ft diameter, 1 ft thickness

The back calculated values developed based on the existing slope geometries were used in subsequent CRSP models except for those layers that were modified based on the proposed benching and cut slope scheme. The analyses performed included the following:

- After Construction (Short Term)
- Long Term (Weathered Lithological Bench)
- Long Term (Weathered Lithological Bench with Talus Build-up)

#### **After Construction (Short Term)**

An assumed 10 ft wide lithological bench was modeled at the base of the sandstone rock layer/top of the claystone layer. The sandstone rock face above the bench was modeled at a 1H:1V with the overlying soil overburden set back to a 2H:1V slope.

#### **Long Term (Weathered Lithological Bench)**

An additional analysis was performed assuming a 30% loss of the 10 ft wide lithological bench due to erosion and weathering. An approximately 1.25H:1V slope was modeled below the weathered bench and extending to the lower, existing slope.

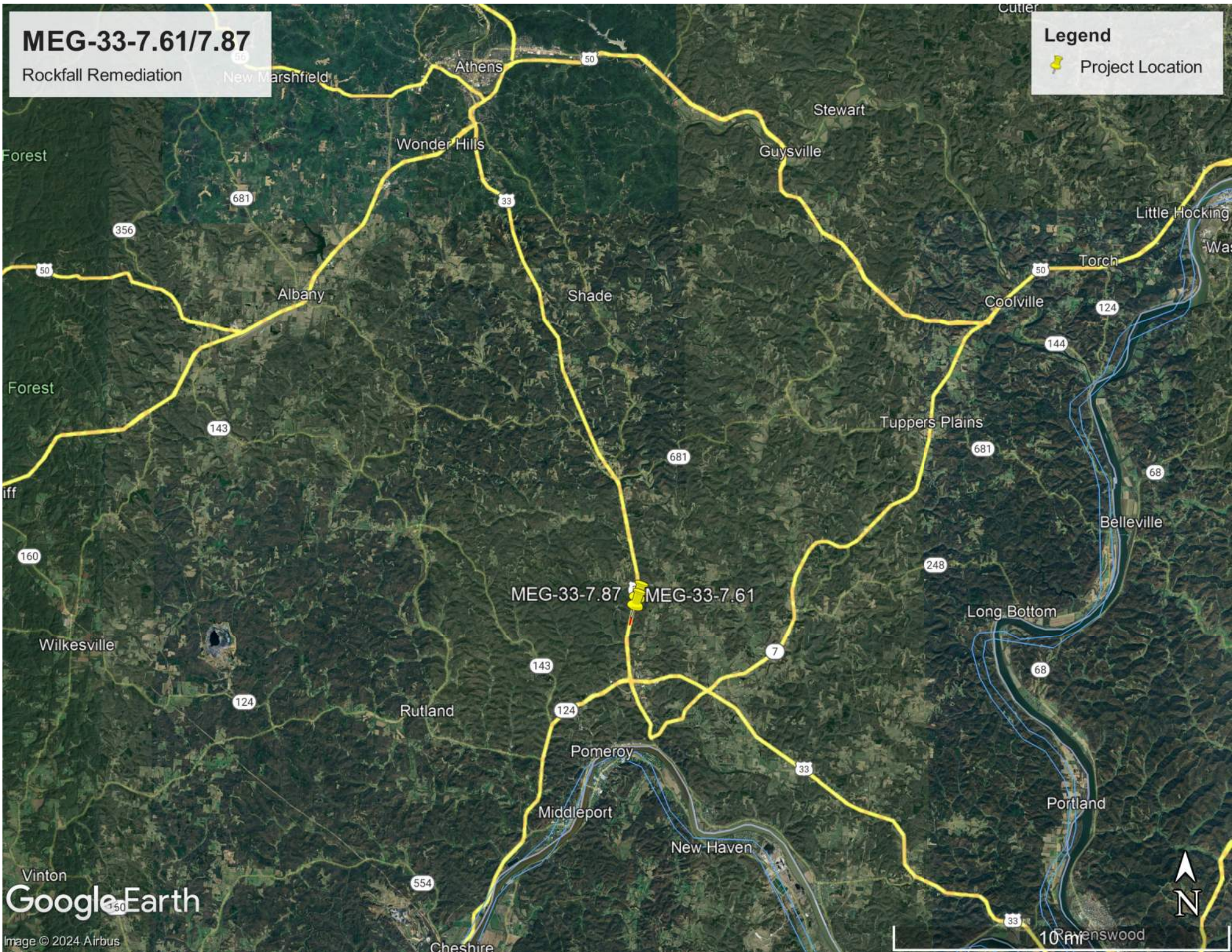
#### **Long Term (Weathered Lithological Bench with Talus Build-up)**

An additional analysis was performed assuming a 30% loss of the 10 ft wide lithological bench due to erosion and weathering as well as talus build up along the lithological bench at the base of the proposed 1H:1V sandstone cut slope.

# MEG-33-7.61/7.87

Rockfall Remediation



**Legend**  
📍 Project Location



# MEG-33-7.61/7.87

Rockfall Remediation

## Legend

-  Rock Slope Limits (approx.)
-  Beginning of Project (approx.)



MEG-33-7.61

MEG-33-7.87

33

MEG-33-7.87  
Sta. 393+00 to Sta. 397+00  
Slope Photos

NE

E

SE

S

30

60

90

120

150

180

☀ 100°E (T) ● 39.083629, -82.017137 ±18ft

Rockfall  
Generator

02 May 2024, 4:50:33 PM

60

E

90

SE

120

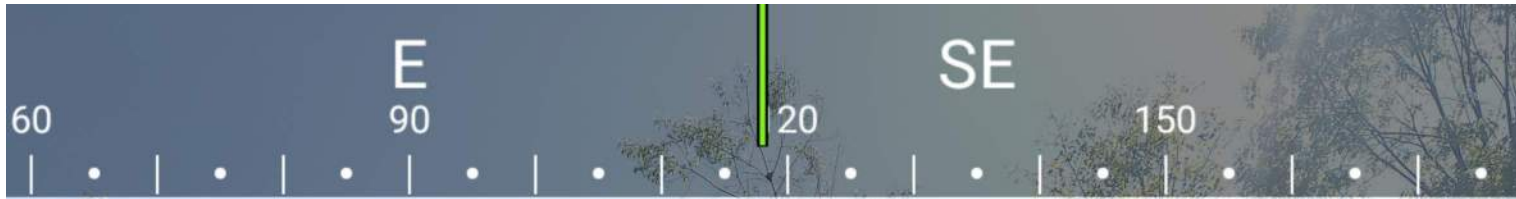
150

☀ 108°E (T) ● 39.083775, -82.016871 ±0ft

Rockfall  
Generator



02 May 2024, 4:55:54 PM



☉ 118°E (T) ● 39.086496, -82.016008 ±0ft

Rockfall  
Generator



02 May 2024, 12:10:52 PM



E  
90

SE

S  
180

SW

120

150

210

240

162°SE (T) • 39.083658, -82.01692 ±56ft

Lower Sandstone Layer Profile  
(Approx EI 790 - 802)  
(Surface Roughness)

02 May 2024, 5:06:02 PM

NW

330

N

0

NE

30

60

E

90

120

☀ 32°N (T) ● 39.082921, -82.017128 ±0ft

Exposed Bedrock

Existing Catchment

02 May 2024, 5:22:35 PM



MEG-33-7.87  
Sta. 393+00 to Sta. 397+00

Photographs and  
Measurements of  
Representative Rockfall

150 180 210 240  
S SW

☉ 202°S (T) ☉ 39.087798, -82.015556 ±1ft



4 ft x 1 ft Discoidal Boulder



2 ft x 1 ft Discoidal Boulder



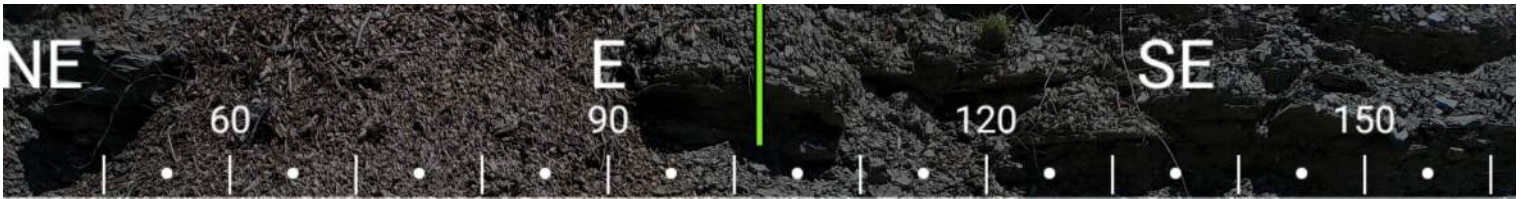
1 ft x 1 ft Discoidal Boulder

Sta. 381+50 to 382+50  
(approximately)

1.5 ft x 0.5 ft Discoidal Boulder



02 May 2024, 1:12:57 PM



☉ 102°E (T) ☉ 39.087685, -82.015643 ±12ft



Sta. 382+00 (approximately)  
4 ft x 1 ft Discoloidal Boulder in Catchment

02 May 2024, 12:49:30 PM

E  
90

SE

S  
180

SW

120

150

210

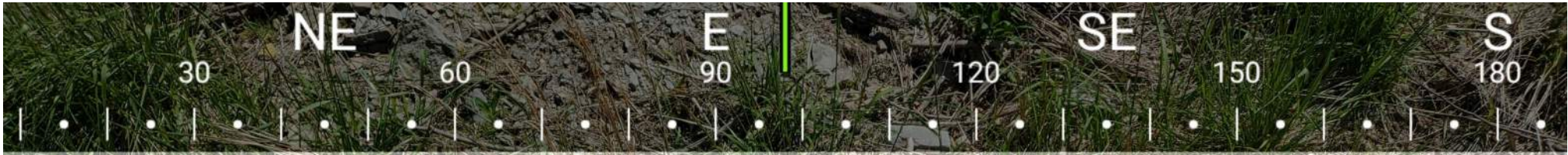
240

☀ 174°S (T) • 39.087796, -82.015556 ±1ft

Sta. 382+00 (approximately)

Boulder in Catchment  
1.5 ft diameter  
0.5 ft thickness

02 May 2024, 1:12:32 PM



98°E (T) 39.087818, -82.015606 ±1ft



Sta. 382+00 (approximately)

Boulder in Catchment  
2 ft diameter  
1 ft thickness

02 May 2024, 1:10:20 PM



☀ 150°SE (T) ● 39.088124, -82.015405 ±1ft



Sta. 382+00 (approximately)

Surface Roughness  
10 inches over 3 feet Span  
(shown in picture)

8 inches over 4 feet span  
(no picture available)

02 May 2024, 6:42:44 PM



SE

S

SW

20

150

110

210

☀ 180°S (T) ☉ 39.088114, -82.01541 ±1ft



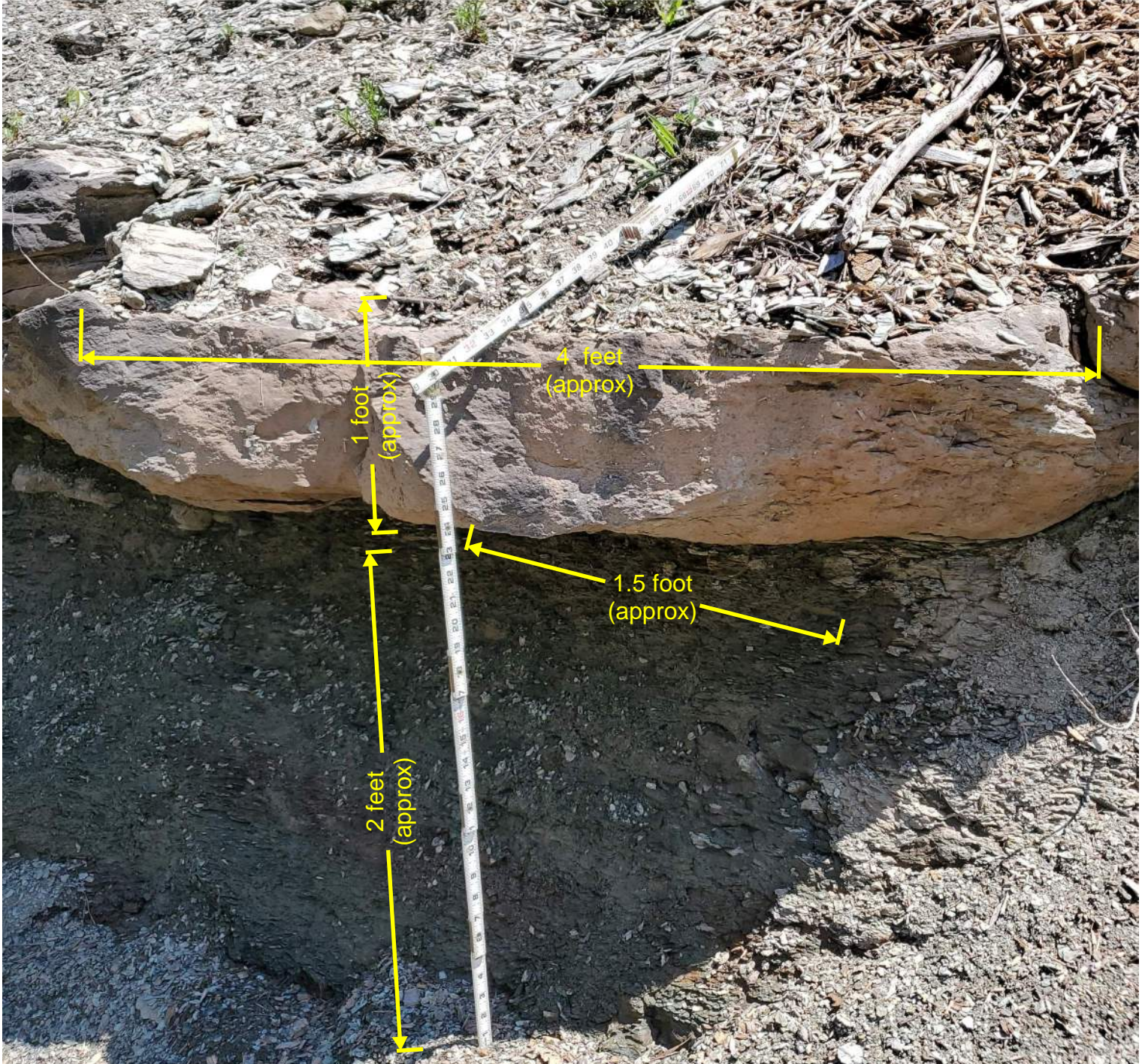
Sta. 382+00 (approximately)

Surface Roughness  
14 inches over 3 feet Span

02 May 2024, 6:50:19 PM



☉ 81°E (T) ● 39.088094, -82.015463 ±1ft



Sta. 382+00 (approximately)  
Undercutting  
12 inch thick rock overhang  
18 inch (into Slope)  
24 inches (height above slope)

02 May 2024, 1:54:07 PM

N

NE

E

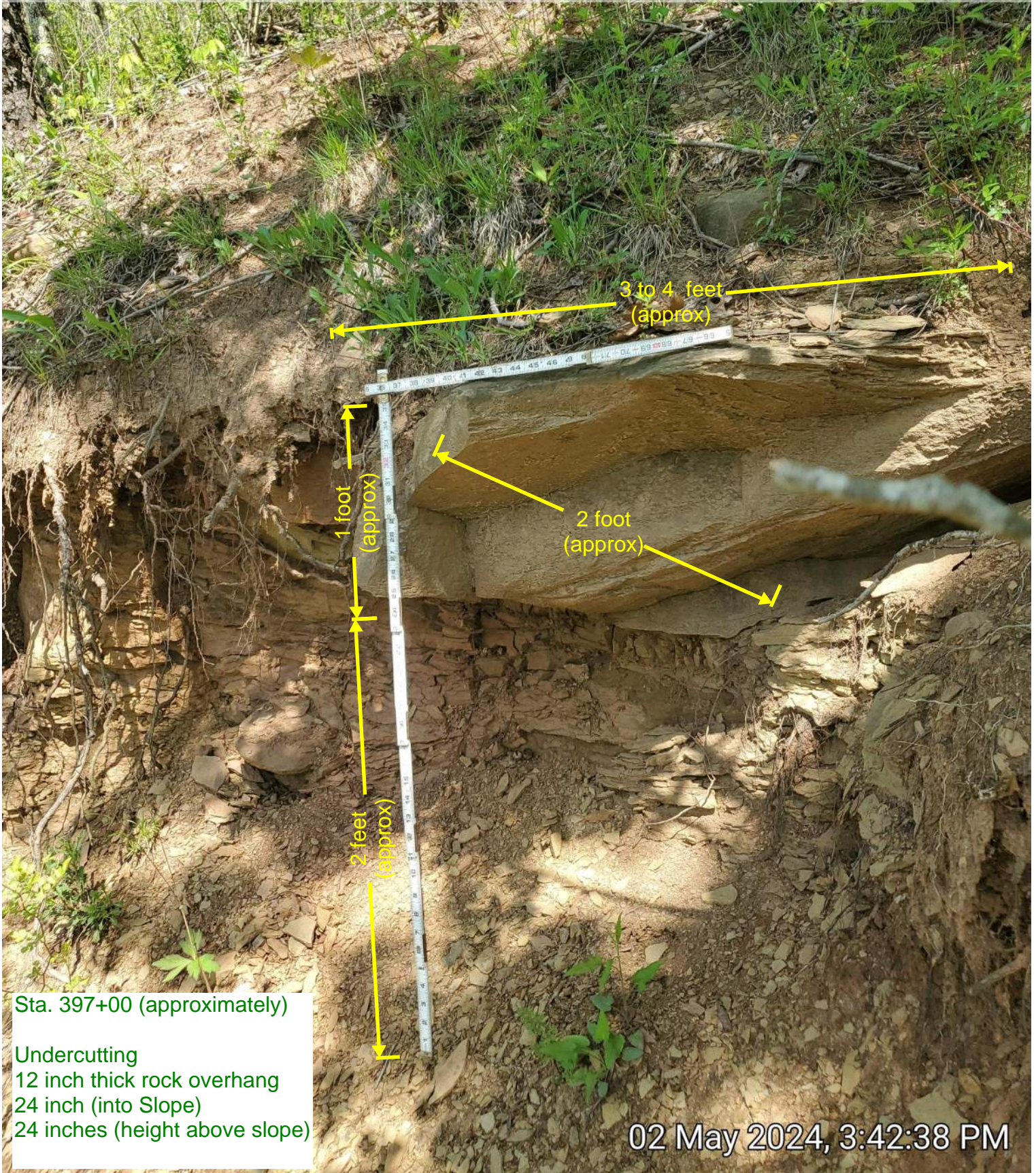
0

30

60

90

☉ 54°NE (T) ☉ 39.083466, -82.016741 ±1ft



3 to 4 feet (approx)

1 foot (approx)

2 foot (approx)

2 feet (approx)

Sta. 397+00 (approximately)

Undercutting  
 12 inch thick rock overhang  
 24 inch (into Slope)  
 24 inches (height above slope)

02 May 2024, 3:42:38 PM

SE

S

SW

150

180

210

240

☉ 184°S (T) ● 39.083515, -82.016731 ±2ft



1 foot (approx)



2 foot (approx)

3 to 4 feet (approx)

Sta. 397+00 (approximately)

Undercutting  
 12 inch thick rock overhang  
 24 inch (into Slope)  
 36 to 48 inches (height above slope)

02 May 2024, 4:07:19 PM

E  
90

SE

S  
180

SW

120

150

210

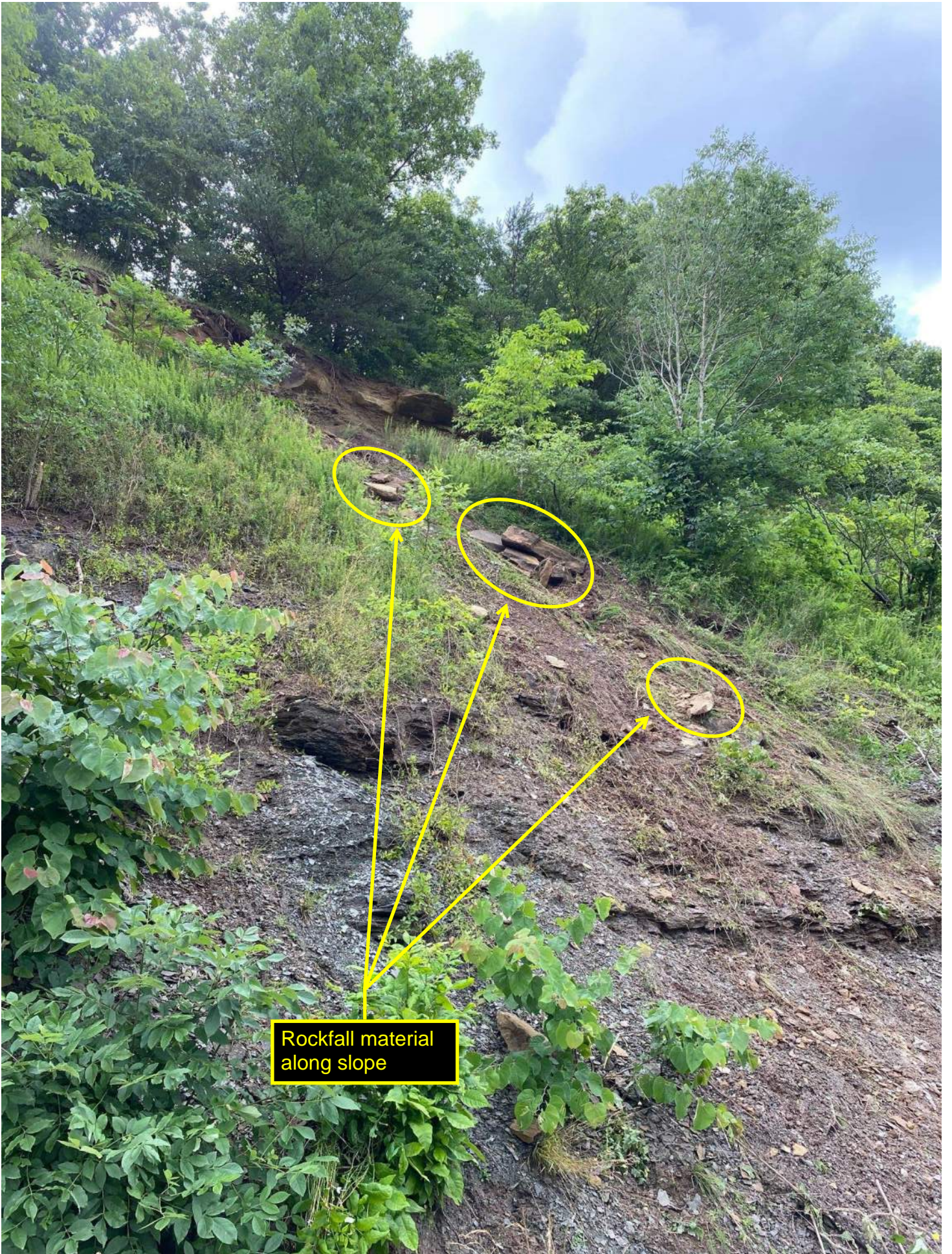
240

162°SE (T) • 39.083658, -82.01692 ±56ft

Lower Sandstone Layer Profile  
(Approx EI 790 - 802)  
(Surface Roughness)

02 May 2024, 5:06:02 PM

ODOT  
Provided Site  
Photographs



Rockfall material along slope





Rockfall material  
within Catchment  
and in Pavement



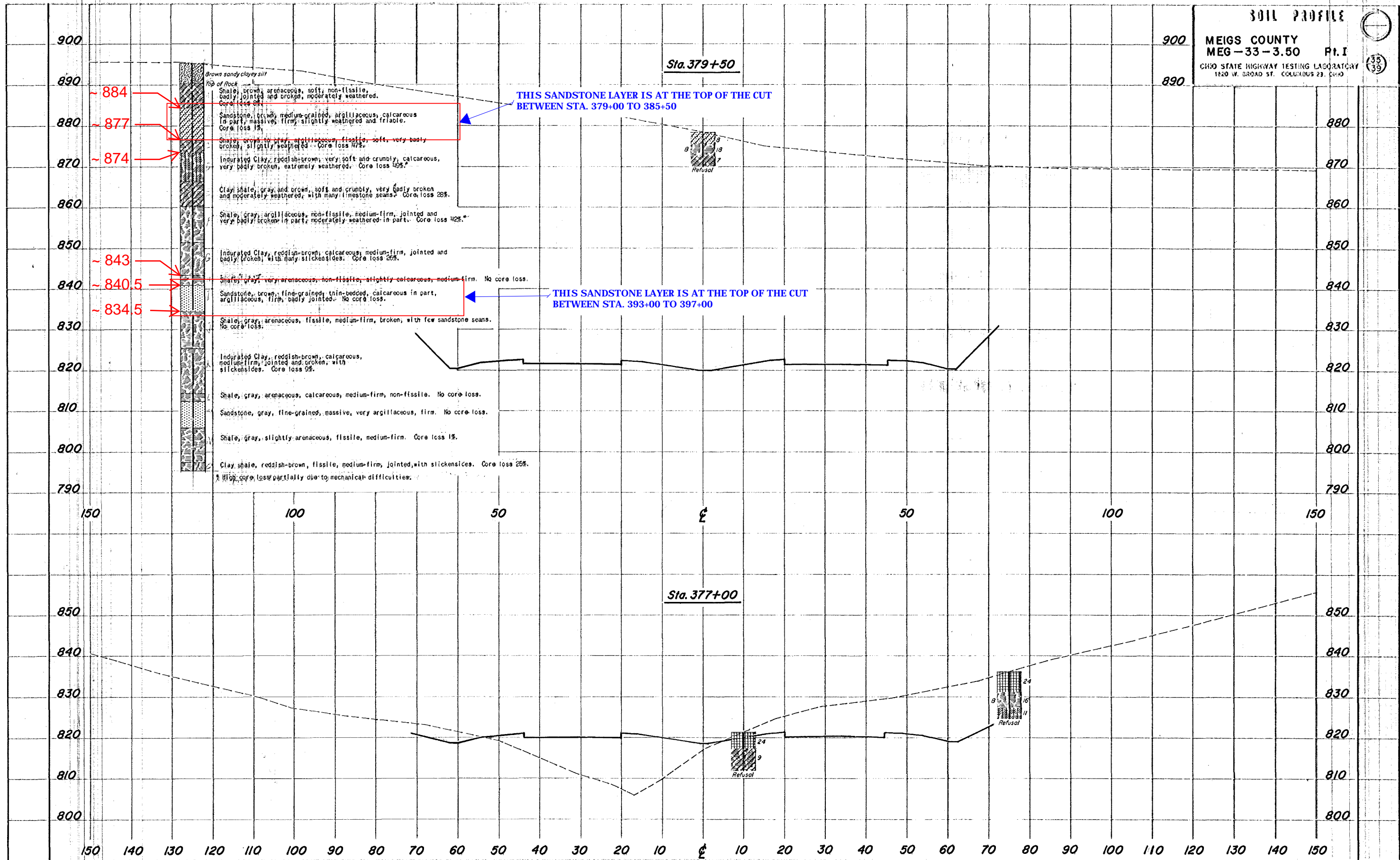


Rockfall material within Catchment and in Pavement

Historic Data  
MEG - 33 -3.50

SOIL PROFILE

MEIGS COUNTY  
MEG-33-3.50 Pt. I  
OHIO STATE HIGHWAY TESTING LABORATORY  
1820 W. BROAD ST. COLUMBUS 23, OHIO



Sta. 379+50

Sta. 377+00

THIS SANDSTONE LAYER IS AT THE TOP OF THE CUT  
BETWEEN STA. 379+00 TO 385+50

THIS SANDSTONE LAYER IS AT THE TOP OF THE CUT  
BETWEEN STA. 393+00 TO 397+00

Brown sandy clayey silt

Top of Rock

Shale, brown, arenaceous, soft, non-fissile, badly jointed and broken, moderately weathered. Core loss 38%.

Sandstone, brown, medium-grained, argillaceous, calcareous in part, massive, firm, slightly weathered and friable. Core loss 18%.

Shale, brown to gray, argillaceous, fissile, soft, very badly broken, slightly weathered. Core loss 47%.

Indurated Clay, reddish-brown, very soft and crumbly, calcareous, very badly broken, extremely weathered. Core loss 49%.

Clay shale, gray and brown, soft and crumbly, very badly broken and moderately weathered, with many limestone seams. Core loss 28%.

Shale, gray, argillaceous, non-fissile, medium-firm, jointed and very badly broken in part, moderately weathered in part. Core loss 42%.

Indurated Clay, reddish-brown, calcareous, medium-firm, jointed and badly broken, with many slickensides. Core loss 26%.

Shale, gray, very arenaceous, non-fissile, slightly calcareous, medium-firm. No core loss.

Sandstone, brown, fine-grained, thin-bedded, calcareous in part, argillaceous, firm, badly jointed. No core loss.

Shale, gray, arenaceous, fissile, medium-firm, broken, with few sandstone seams. No core loss.

Indurated Clay, reddish-brown, calcareous, medium-firm, jointed and broken, with slickensides. Core loss 9%.

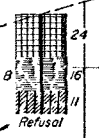
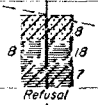
Shale, gray, arenaceous, calcareous, medium-firm, non-fissile. No core loss.

Sandstone, gray, fine-grained, massive, very argillaceous, firm. No core loss.

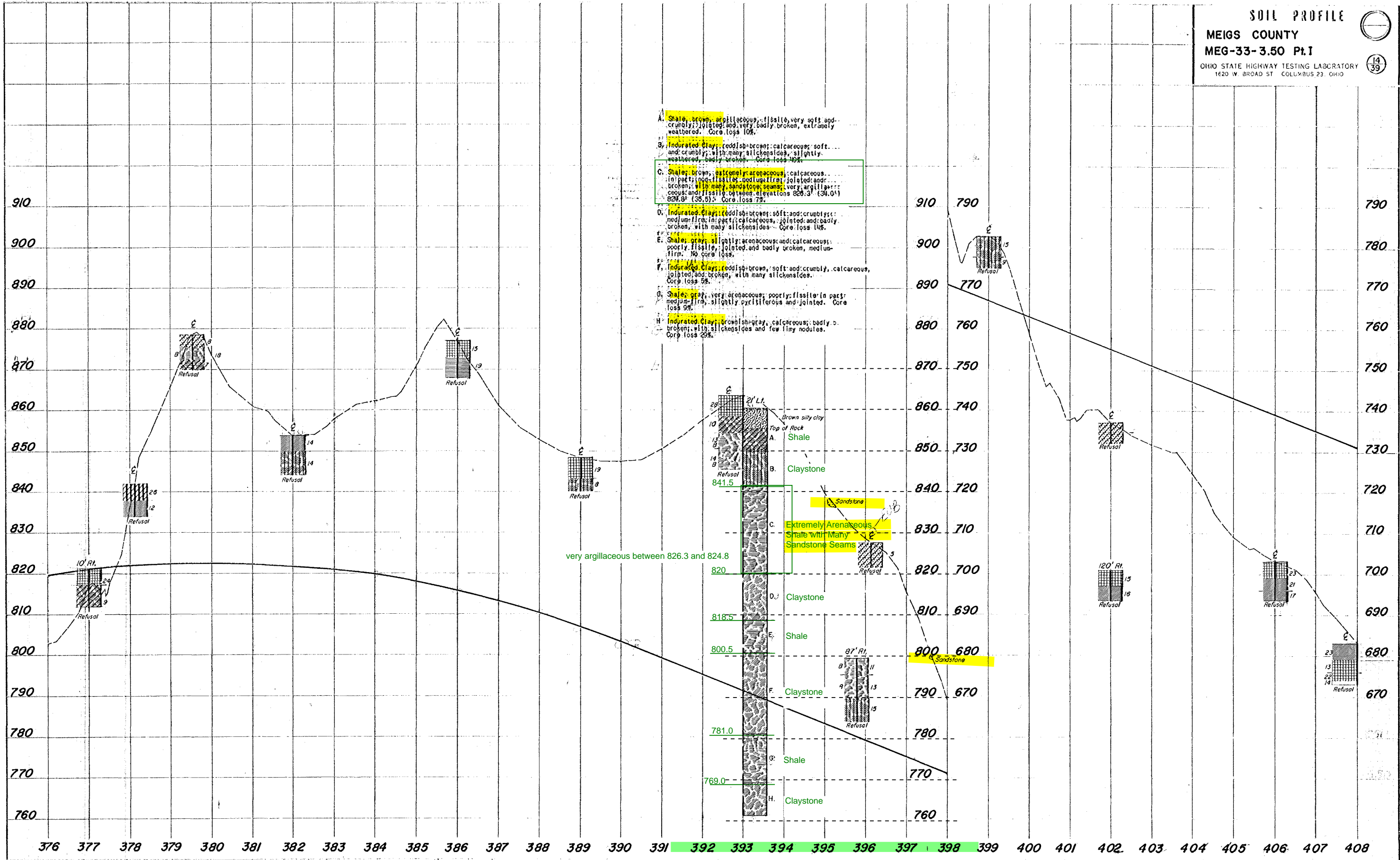
Shale, gray, slightly arenaceous, fissile, medium-firm. Core loss 1%.

Clay shale, reddish-brown, fissile, medium-firm, jointed, with slickensides. Core loss 25%.

\* High core loss partially due to mechanical difficulties.



- A. Shale, brown, argillaceous, fissile, very soft and crumbly; jointed and very badly broken, extraneously weathered. Core loss 10%.
- B. Indurated Clay, reddish-brown; calcareous; soft and crumbly; with many slickensides, slightly weathered, badly broken. Core loss 10%.
- C. Shale, brown, extremely arenaceous; calcareous in part; fissile; bedded; jointed and broken; with many sandstone seams; very argillaceous and fissile between elevations 826.3' (34.0') and 824.8' (35.5)'. Core loss 7%.
- D. Indurated Clay, reddish-brown; soft and crumbly; medium firm; in part; calcareous, jointed and badly broken, with many slickensides. Core loss 14%.
- E. Shale, gray, slightly arenaceous and calcareous; poorly fissile, jointed and badly broken, medium firm. No core loss.
- F. Indurated Clay, reddish-brown, soft and crumbly, calcareous, jointed and broken, with many slickensides. Core loss 5%.
- G. Shale, gray, very arenaceous; poorly fissile in part; medium firm, slightly pyritic and jointed. Core loss 9%.
- H. Indurated Clay, brownish-gray, calcareous; badly broken; with slickensides and few tiny nodules. Core loss 29%.



very argillaceous between 826.3 and 824.8

Sandstone

Extremely Arenaceous Shale with Many Sandstone Seams

Sandstone

Existing Plans  
MEG - 33 -3.79

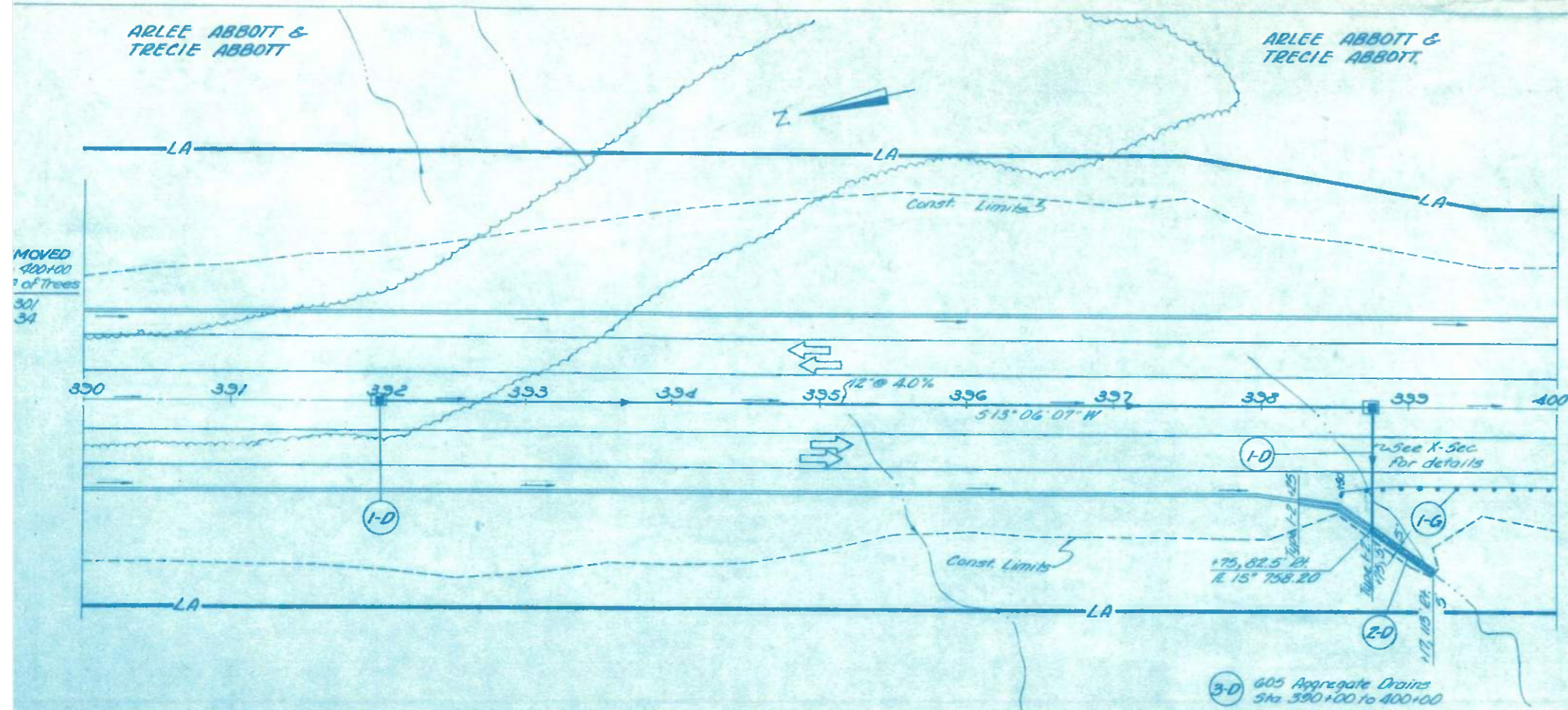
ARLEE ABBOTT &  
TRECIE ABBOTT

ARLEE ABBOTT &  
TRECIE ABBOTT

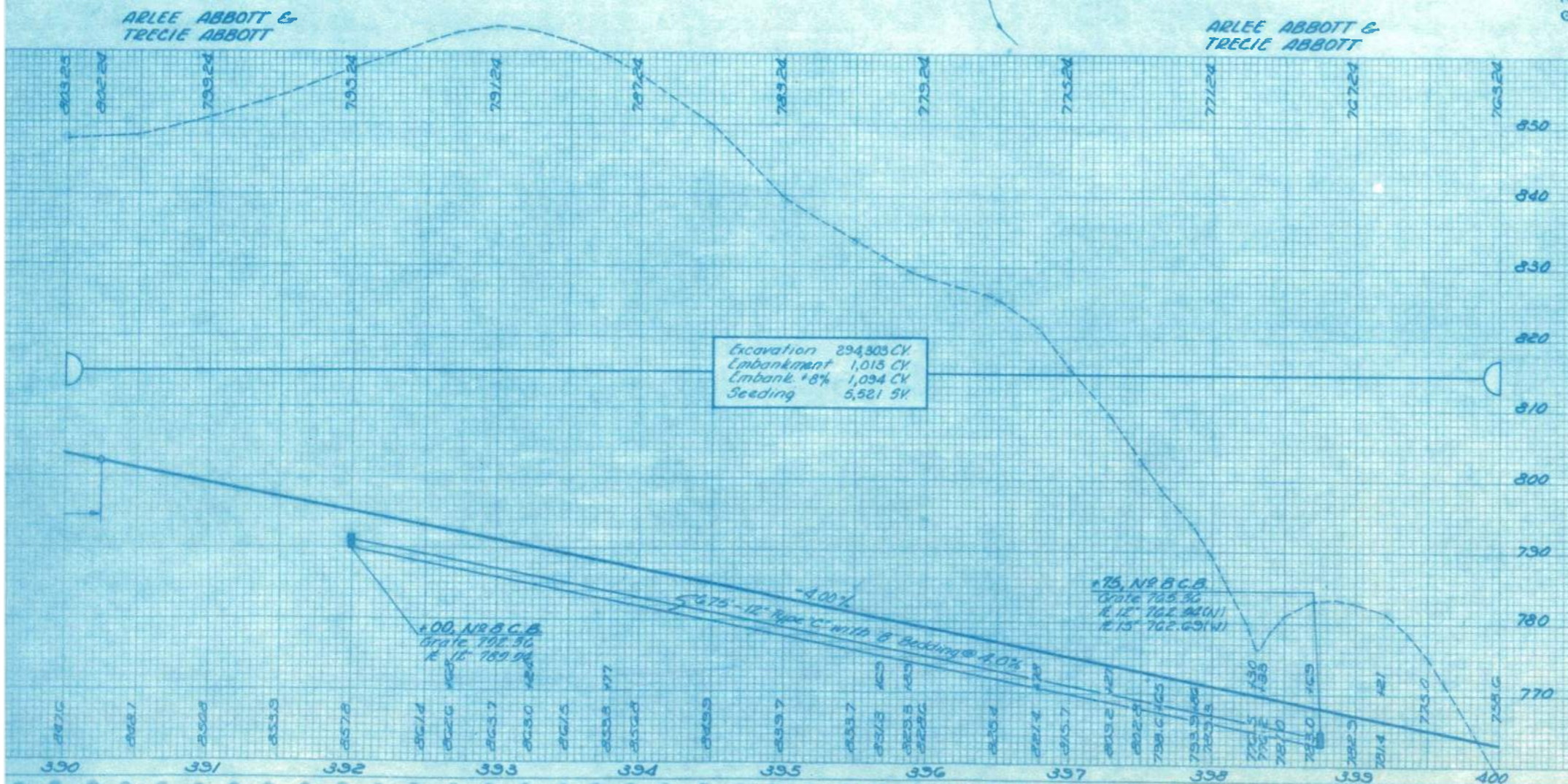
FED. RD. DIVISION	STATE	PROJECT
2	OHIO	

MEIGS COUNTY MEG-33-370

56  
481



© 7070.5 Type C  
With Class 'B' Backfill



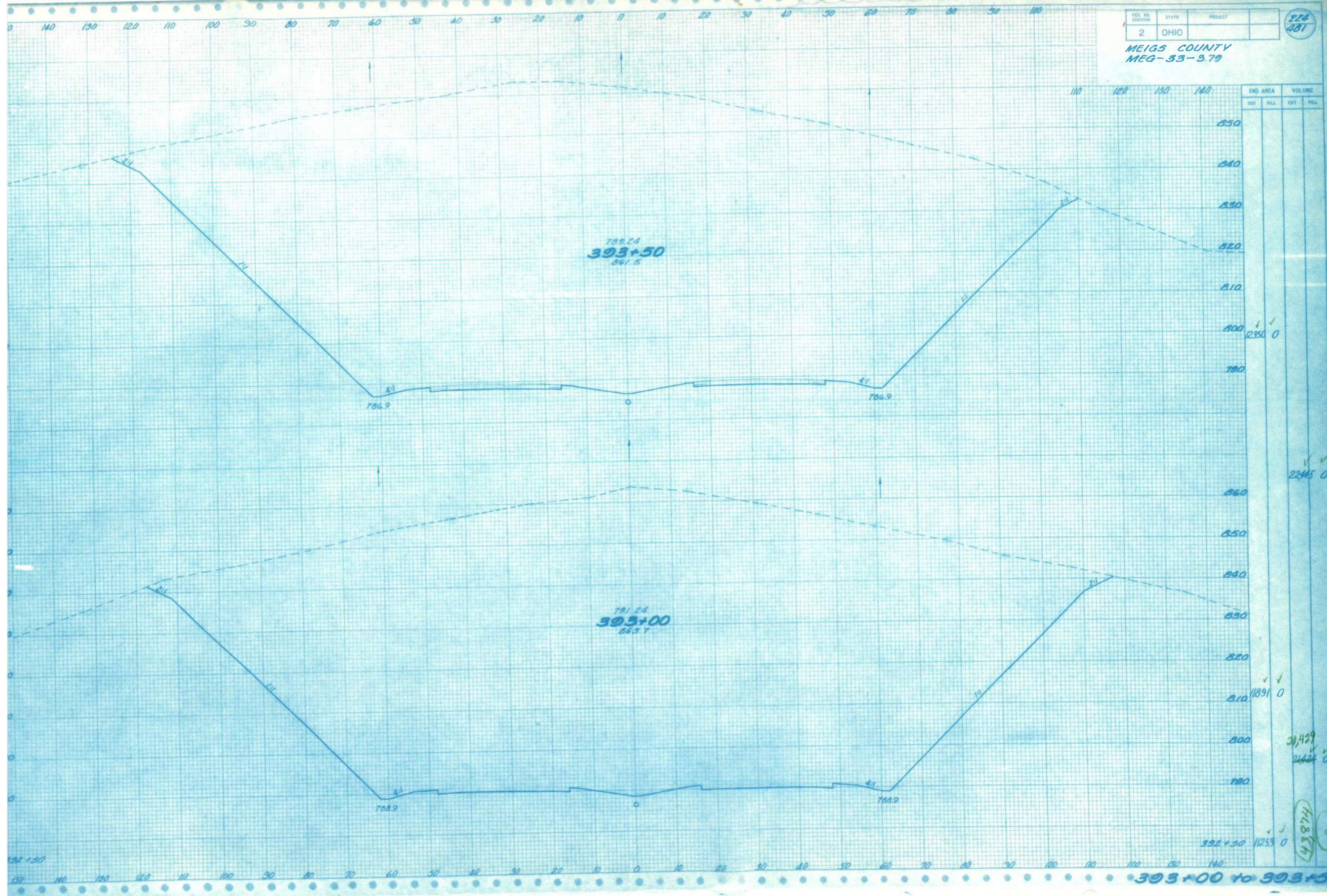
ESTIMATED QUANTITIES

REF. NO.	STATION TO STATION	QUANTITIES	UNIT
1-D	392+00 to 398+75	1.0	FT
2-D	398+25 to 399+17	2.0	FT
3-D	399+00 to 400+00	3.0	FT
1-G	399+50 to 400+00	1.0	FT
600		1.0	FT
601		1.0	FT
602		1.0	FT
603		1.0	FT
604		1.0	FT
605		1.0	FT
606		1.0	FT
607		1.0	FT
608		1.0	FT
609		1.0	FT
610		1.0	FT
611		1.0	FT
612		1.0	FT
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615		1.0	FT
616		1.0	FT
617		1.0	FT
618		1.0	FT
619		1.0	FT
620		1.0	FT
621		1.0	FT
622		1.0	FT
623		1.0	FT
624		1.0	FT
625		1.0	FT
626		1.0	FT
627		1.0	FT
628		1.0	FT
629		1.0	FT
630		1.0	FT

FED. RD. DIVISION	STATE	PROJECT
2	OHIO	

224  
481

MEIGS COUNTY  
MEG-33-3.79



789.24  
**393+50**  
861.5

791.24  
**393+00**  
865.7

4187H  
4187H

393+00 to 393+50



140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100

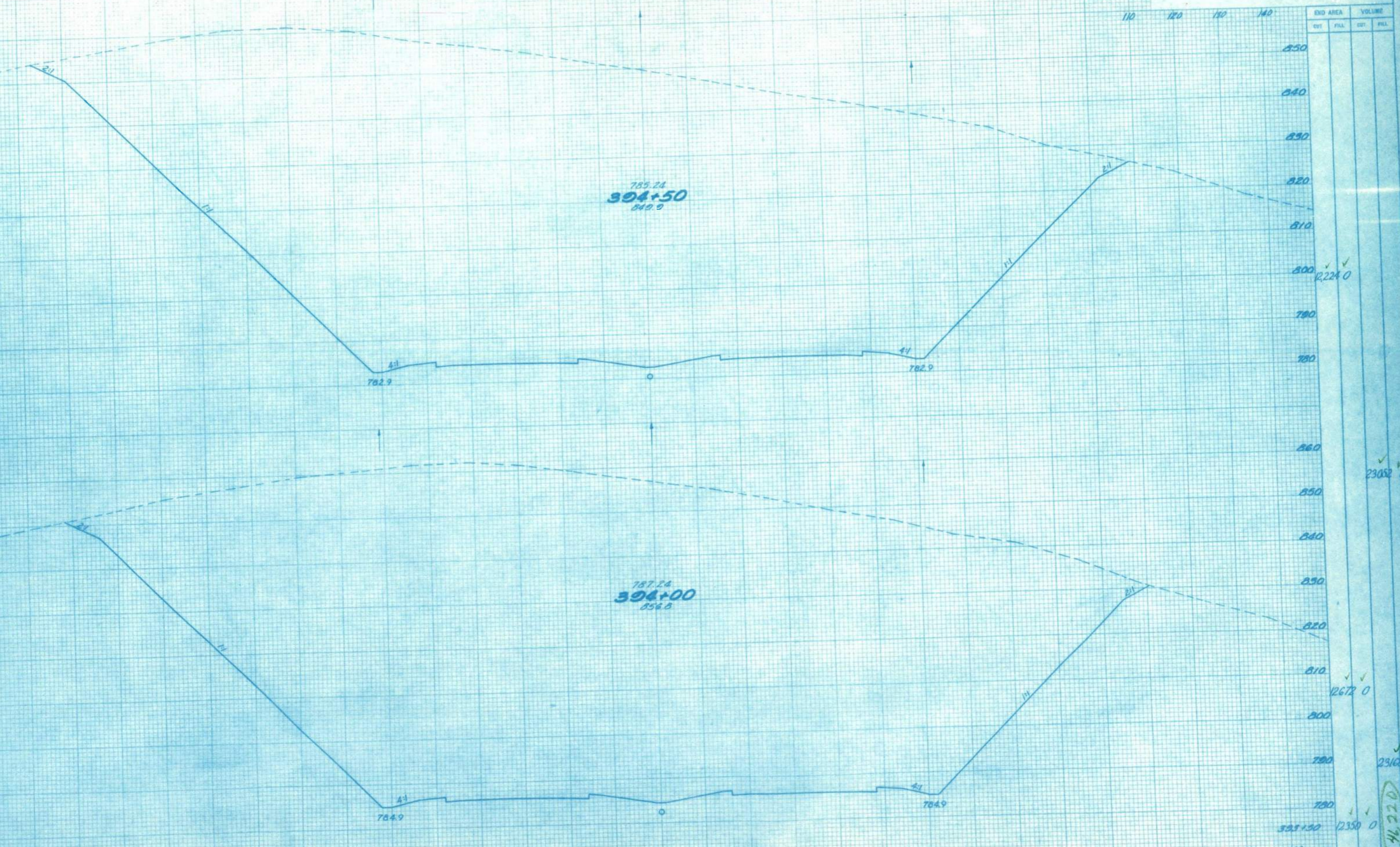
FED. NO. DIVISION	STATE	PROJECT
2	OHIO	

225  
481

MEIGS COUNTY  
MEG-33-3.79

110 120 130 140

END AREA		VOLUME	
CUT	FILL	CUT	FILL

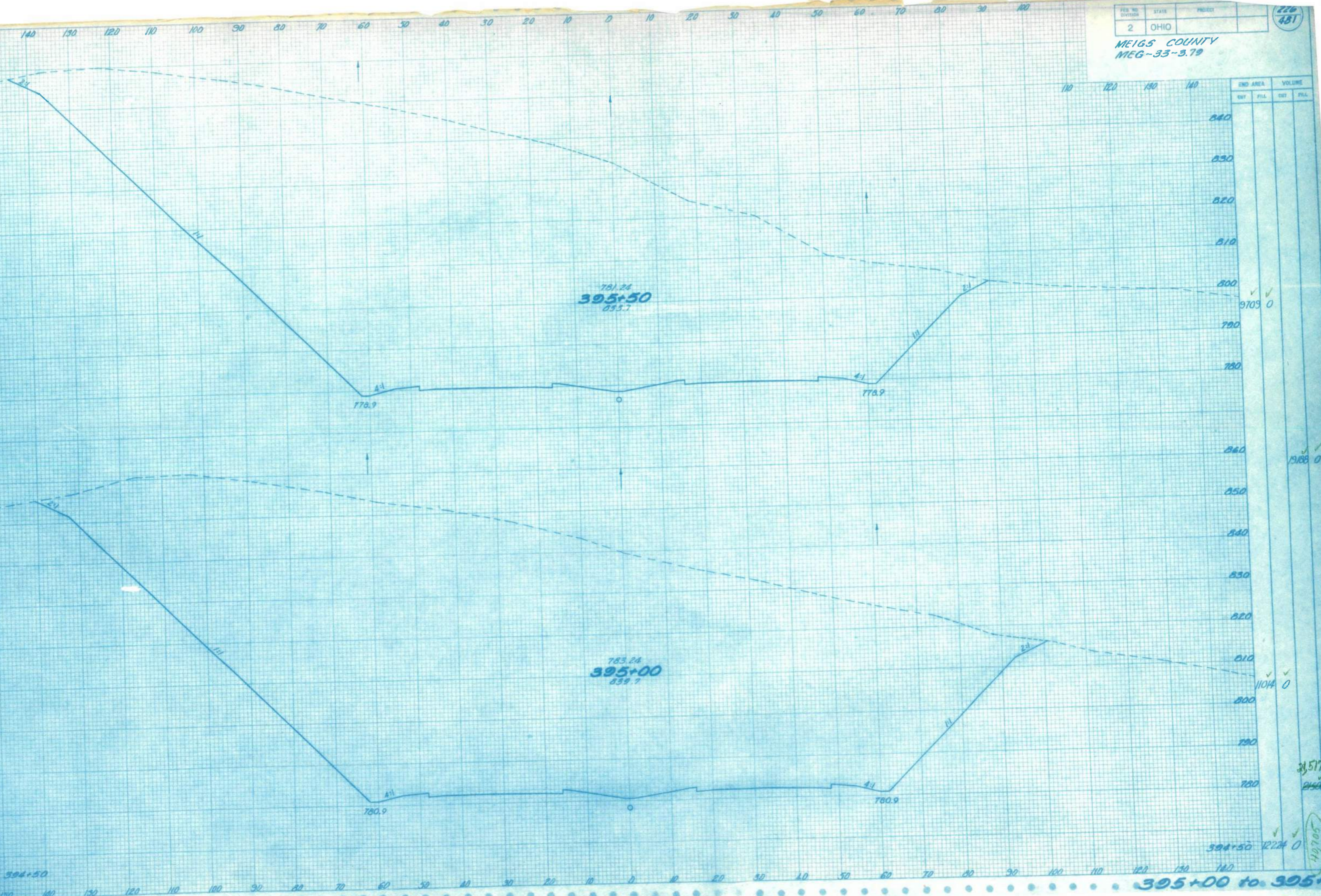


850			
840			
830			
820			
810			
800	✓	✓	2,224.0
790			
780			
860			
850			
840			
830			
820			
810	✓	✓	12,672.0
800			
790			
780			
394+50	✓	✓	23,168.0
394+00	✓	✓	12,350.0

46,220

140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 394+00 to 394+50

MEIGS COUNTY  
MEG-33-3.79

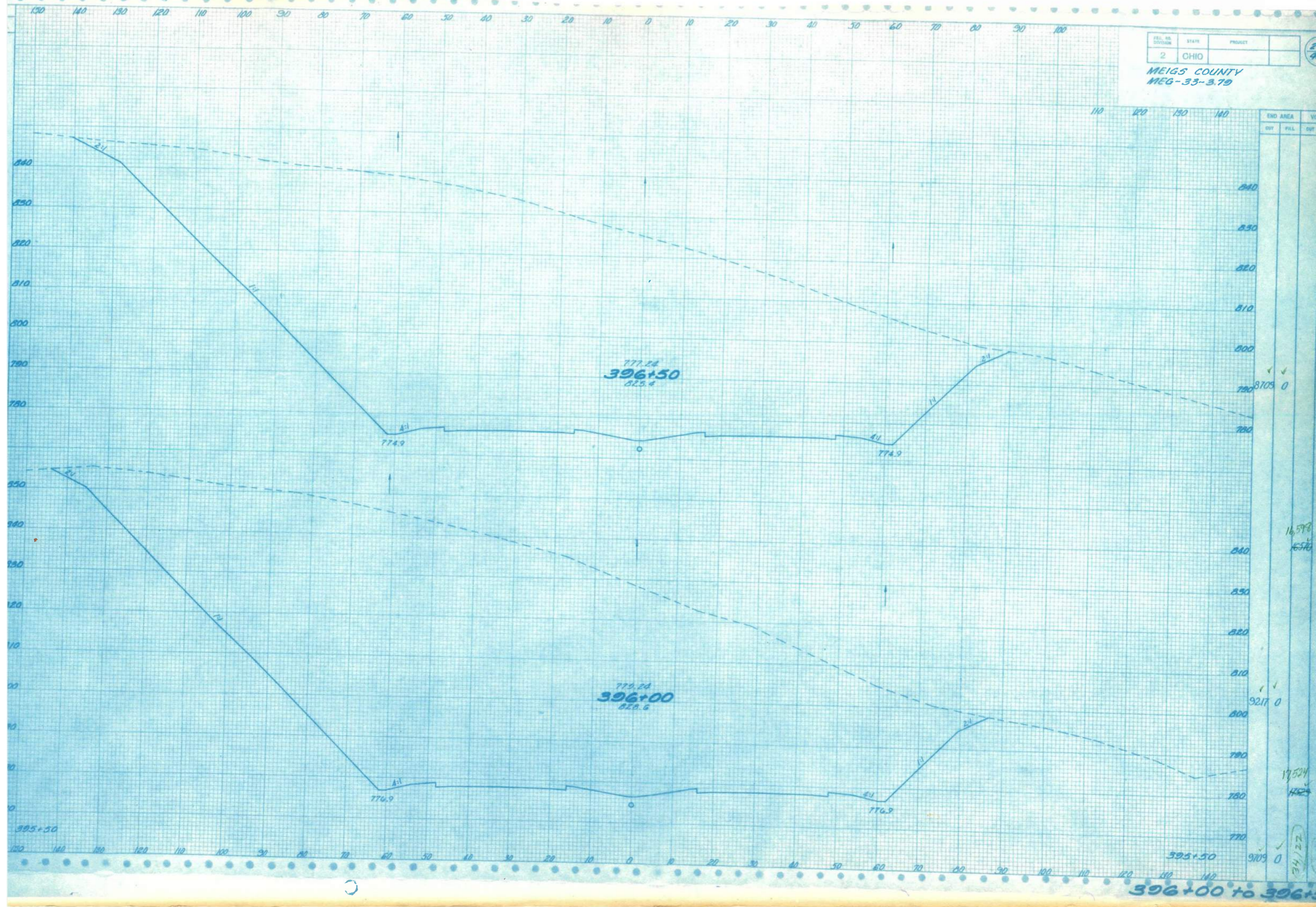


END AREA	VOLUME	
	CUT	FILL
860		
850		
820		
810		
800	9709	0
790		
780		
860		
850		
840		
830		
820		
810	11044	0
800		
790		
780		
860		
850		
840		
830		
820		
810		
800		
790		
780		
860		
850		
840		
830		
820		
810		
800		
790		
780		

395+50 12224 0  
 395+00 to 395+50

FEED NO.	STATE	PROJECT
2	CHIO	

MEIGS COUNTY  
MEG-33-3.79

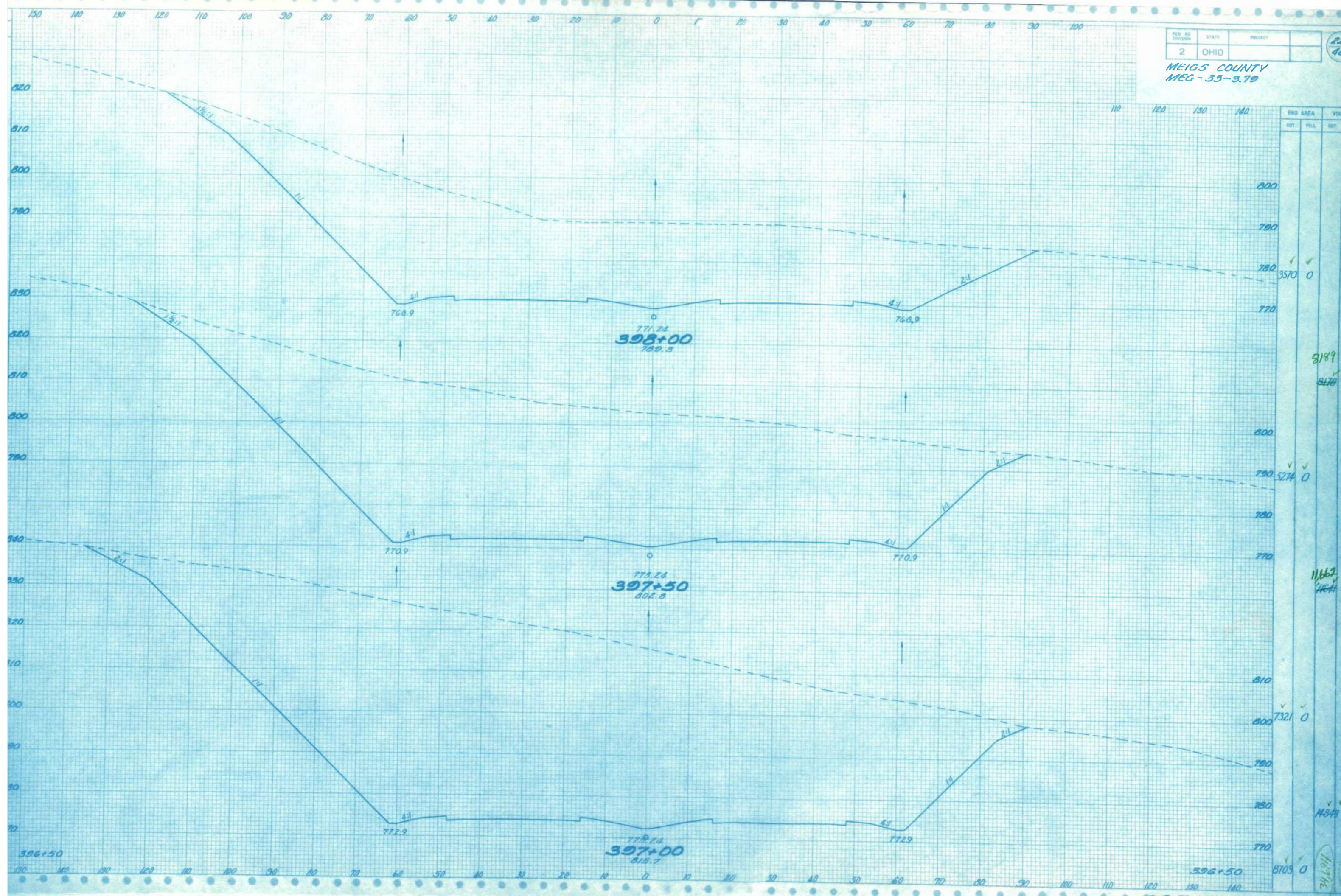


END AREA	VOL	
	DIT	FILL
8709.0	✓	✓
16576		
17524	✓	✓
152		
9217.0		
9709.0	✓	✓

396+00 to 396+

PER. NO. DIVISION	STATE	PROJECT
2	OHIO	

MEIGS COUNTY  
MEG-33-3.79



END AREA	VOL.		
	CUT	FILL	OUT
3570	0	0	0
3199	0	0	0
5274	0	0	0
11662	0	0	0
7321	0	0	0
14378	0	0	0
8709	0	0	0

397+00 to 398+00

MEG-33-7.87  
CRSP Rock Fall Analysis

Sta. 395+50

Slope and Station: STA 395+50  
Existing Conditions

# Existing Conditions

CALCULATED: DCM  
CHECKED: AKB  
DATE: 5/13/2024  
DATE: 5/21/2024

Total Rocks: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 3  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

**Description**      **Location**      **Description**  
Analysis Point 1 = 70.0      Toe of Slope @ Catchment  
Analysis Point 2 = 80.0      Edge of Pavement  
Analysis Point 3 = 89.0      Edge of Travel Lane

4' Dia x 1' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane					
	Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing				
	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point			
	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)			
4' x 1' Discoidal Rock (2073 lb)	50.54	7.77	95817	129.91	999	99.9	10.18	0.44	5654	7.67	37	3.7	11.45	0.60	5977	8.10	36	3.6
4' x 1' Discoidal Rock (2073 lb)	49.81	7.88	93106	126.23	999	99.9	9.67	0.83	5403	7.33	37	3.7	11.95	0.67	5980	8.11	33	3.3
4' x 1' Discoidal Rock (2073 lb)	50.52	7.70	94454	128.06	999	99.9	9.73	0.48	4986	6.76	40	4.0	10.56	0.45	4734	6.42	37	3.7
4' x 1' Discoidal Rock (2073 lb)	50.25	7.80	95571	129.58	999	99.9	9.65	0.60	5252	7.12	27	2.7	11.66	0.32	6015	8.16	25	2.5
4' x 1' Discoidal Rock (2073 lb)	49.26	7.93	88892	120.52	999	99.9	9.56	0.40	5136	6.96	30	3.0	10.94	0.55	5542	7.51	26	2.6
<b>AVERAGE:</b>	<b>50.08</b>	<b>7.82</b>	<b>93568</b>	<b>126.86</b>	<b>999.0</b>	<b>99.9</b>	<b>9.76</b>	<b>0.55</b>	<b>5286</b>	<b>7.17</b>	<b>34.2</b>	<b>3.4</b>	<b>11.31</b>	<b>0.52</b>	<b>5650</b>	<b>7.66</b>	<b>31.4</b>	<b>3.1</b>
<b>MAXIMUM:</b>	<b>50.54</b>	<b>7.93</b>	<b>95817</b>	<b>129.91</b>	<b>999.0</b>	<b>99.9</b>	<b>10.18</b>	<b>0.83</b>	<b>5654</b>	<b>7.67</b>	<b>40.0</b>	<b>4.0</b>	<b>11.95</b>	<b>0.67</b>	<b>6015</b>	<b>8.16</b>	<b>37.0</b>	<b>3.7</b>
<b>MINIMUM:</b>	<b>49.26</b>	<b>7.70</b>	<b>88892</b>	<b>120.52</b>	<b>999.0</b>	<b>99.9</b>	<b>9.56</b>	<b>0.40</b>	<b>4986</b>	<b>6.76</b>	<b>27.0</b>	<b>2.7</b>	<b>10.56</b>	<b>0.32</b>	<b>4734</b>	<b>6.42</b>	<b>25.0</b>	<b>2.5</b>

meets 95%

2' Dia x 1' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane					
	Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing				
	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point			
	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)			
2' x 1' Discoidal Rock (518 lb)	49.67	9.97	22255	30.17	999	99.9	11.08	0.26	1537	2.08	3	0.3	11.24	0.48	1367	1.85	3	0.3
2' x 1' Discoidal Rock (518 lb)	49.60	9.04	22544	30.57	999	99.9	9.66	0.10	1454	1.97	3	0.3	12.07	0.40	1643	2.23	3	0.3
2' x 1' Discoidal Rock (518 lb)	49.19	9.84	22148	30.03	999	99.9	13.20	0.47	21	0.03	9	0.9	12.86	0.41	1914	2.60	9	0.9
2' x 1' Discoidal Rock (518 lb)	48.40	9.51	20978	28.44	999	99.9	20.89	0.72	5380	7.29	11	1.1	21.09	0.73	5369	7.28	10	1.0
2' x 1' Discoidal Rock (518 lb)	48.94	10.18	22393	30.36	999	99.9	18.76	0.76	4245	5.76	6	0.6	18.24	0.53	4015	5.44	6	0.6
<b>AVERAGE:</b>	<b>49.16</b>	<b>9.71</b>	<b>22064</b>	<b>29.91</b>	<b>999.0</b>	<b>99.9</b>	<b>14.72</b>	<b>0.46</b>	<b>2527</b>	<b>3.43</b>	<b>6.4</b>	<b>0.6</b>	<b>15.10</b>	<b>0.51</b>	<b>2862</b>	<b>3.88</b>	<b>6.2</b>	<b>0.6</b>
<b>MAXIMUM:</b>	<b>49.67</b>	<b>10.18</b>	<b>22544</b>	<b>30.57</b>	<b>999.0</b>	<b>99.9</b>	<b>20.89</b>	<b>0.76</b>	<b>5380</b>	<b>7.29</b>	<b>11.0</b>	<b>1.1</b>	<b>21.09</b>	<b>0.73</b>	<b>5369</b>	<b>7.28</b>	<b>10.0</b>	<b>1.0</b>
<b>MINIMUM:</b>	<b>48.40</b>	<b>9.04</b>	<b>20978</b>	<b>28.44</b>	<b>999.0</b>	<b>99.9</b>	<b>9.66</b>	<b>0.10</b>	<b>21</b>	<b>0.03</b>	<b>3.0</b>	<b>0.3</b>	<b>11.24</b>	<b>0.40</b>	<b>1367</b>	<b>1.85</b>	<b>3.0</b>	<b>0.3</b>

meets 95%

1.5' Dia x 0.5' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane					
	Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing				
	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point			
	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)			
1.5' x 0.5' Discoidal Rock (146 lb)	48.46	9.89	6082	8.25	995	99.5	14.23	0.30	711	0.96	5	0.5	14.67	0.45	724	0.98	5	0.5
1.5' x 0.5' Discoidal Rock (146 lb)	48.14	10.38	5906	8.01	995	99.5	10.15	0.35	405	0.55	2	0.2	10.78	0.37	394	0.53	2	0.2
1.5' x 0.5' Discoidal Rock (146 lb)	46.97	10.18	5554	7.53	984	98.4	6.14	0.06	135	0.18	1	0.1	6.35	0.05	135	0.18	1	0.1
1.5' x 0.5' Discoidal Rock (146 lb)	47.63	9.09	5733	7.77	986	98.6	14.99	0.30	812	1.10	2	0.2	15.49	0.25	813	1.10	2	0.2
1.5' x 0.5' Discoidal Rock (146 lb)	48.66	9.96	6061	8.22	990	99.0	17.20	1.06	1003	1.36	5	0.5	16.70	0.40	944	1.28	5	0.5
<b>AVERAGE:</b>	<b>47.97</b>	<b>9.90</b>	<b>5867</b>	<b>7.95</b>	<b>990.0</b>	<b>99.0</b>	<b>12.54</b>	<b>0.41</b>	<b>613</b>	<b>0.83</b>	<b>3.0</b>	<b>0.3</b>	<b>12.80</b>	<b>0.30</b>	<b>602</b>	<b>0.82</b>	<b>3.0</b>	<b>0.3</b>
<b>MAXIMUM:</b>	<b>48.66</b>	<b>10.38</b>	<b>6082</b>	<b>8.25</b>	<b>995.0</b>	<b>99.5</b>	<b>17.20</b>	<b>1.06</b>	<b>1003</b>	<b>1.36</b>	<b>5.0</b>	<b>0.5</b>	<b>16.70</b>	<b>0.45</b>	<b>944</b>	<b>1.28</b>	<b>5.0</b>	<b>0.5</b>
<b>MINIMUM:</b>	<b>46.97</b>	<b>9.09</b>	<b>5554</b>	<b>7.53</b>	<b>984.0</b>	<b>98.4</b>	<b>6.14</b>	<b>0.06</b>	<b>135</b>	<b>0.18</b>	<b>1.0</b>	<b>0.1</b>	<b>6.35</b>	<b>0.05</b>	<b>135</b>	<b>0.18</b>	<b>1.0</b>	<b>0.1</b>

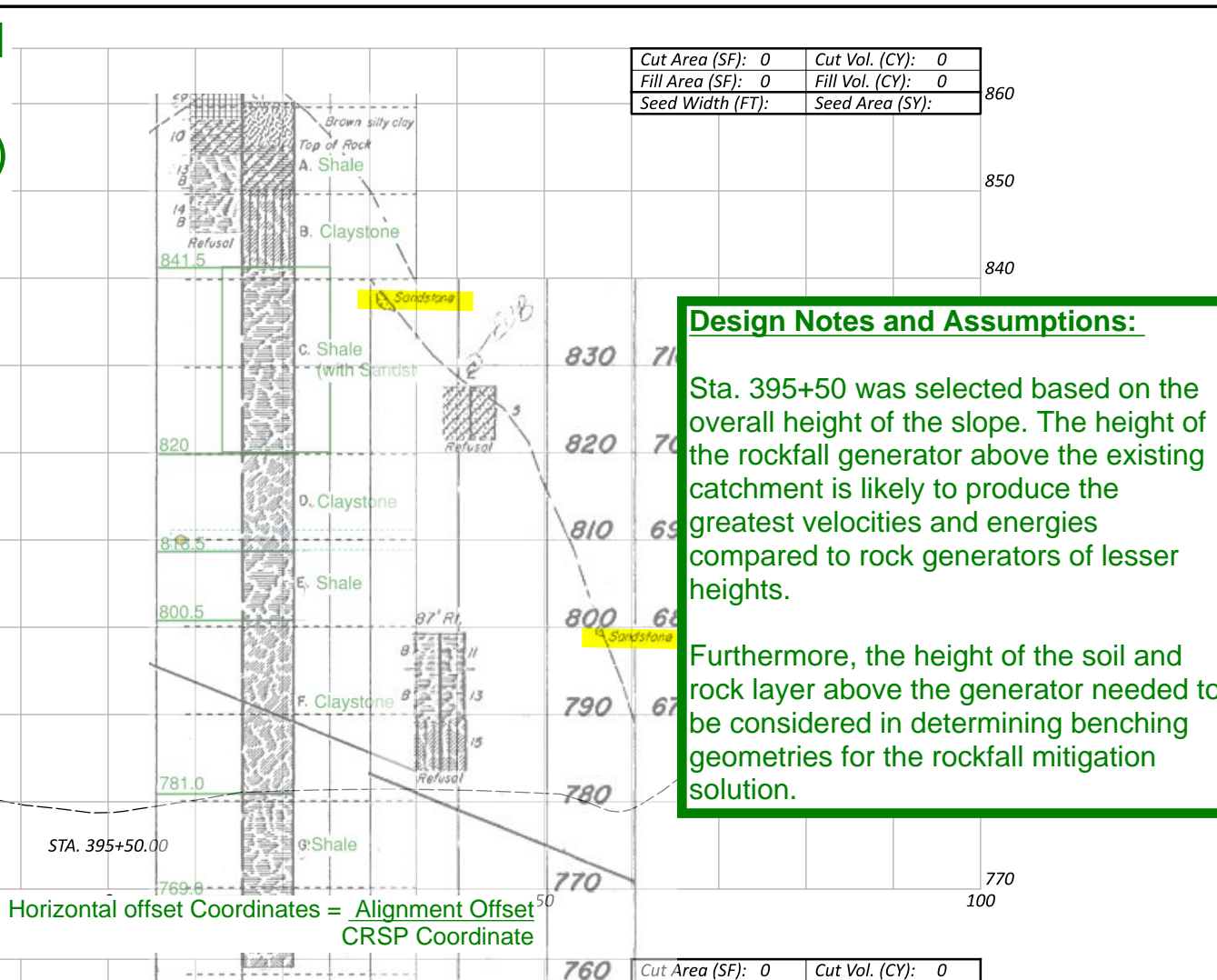
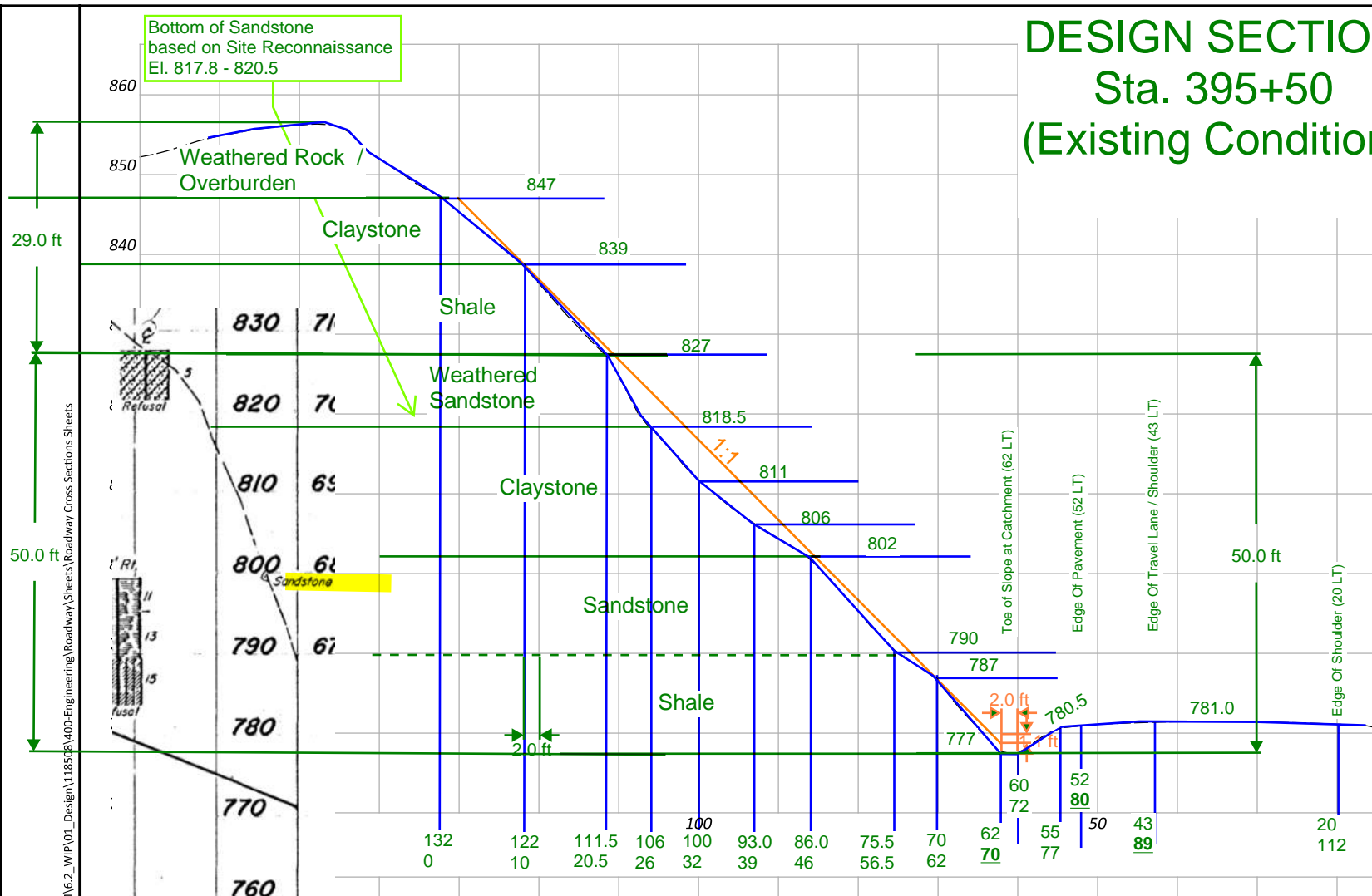
meets 95%

1' Dia x 1' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane					
	Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing				
	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point			
	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)			
1' x 1' Discoidal Rock (130 lb)	45.48	9.19	4553	6.17	841.0	84.1	0.00	0.00	0	0.00	0.0	0.0	0.00	0.00	0	0.00	0.0	0.0
1' x 1' Discoidal Rock (130 lb)	46.05	9.12	4744	6.43	820.0	82.0	0.00	0.00	0	0.00	0.0	0.0	0.00	0.00	0	0.00	0.0	0.0
1' x 1' Discoidal Rock (130 lb)	45.12	10.48	4516	6.12	837.0	83.7	15.68	0.43	751	1.02	3.0	0.3	15.59	0.49	733	0.99	3.0	0.3
1' x 1' Discoidal Rock (130 lb)	46.21	9.21	4728	6.41	837.0	83.7	9.09	0.28	304	0.41	1.0	0.1	8.82	0.59	233	0.32	1.0	0.1
1' x 1' Discoidal Rock (130 lb)	45.26	9.64	4772	6.47	835.0	83.5	6.53	0.03	129	0.17	1.0	0.1	6.35	0.10	120	0.16	1.0	0.1
<b>AVERAGE:</b>	<b>45.62</b>	<b>9.53</b>	<b>4663</b>	<b>6.32</b>	<b>834.0</b>	<b>83.4</b>	<b>6.3</b>	<b>0.1</b>	<b>236.8</b>	<b>0.3</b>	<b>1.0</b>	<b>0.1</b>	<b>6.2</b>	<b>0.2</b>	<b>217.2</b>	<b>0.3</b>	<b>1.0</b>	<b>0.1</b>
<b>MAXIMUM:</b>	<b>46.21</b>	<b>10.48</b>	<b>4772</b>	<b>6.47</b>	<b>841.0</b>	<b>84.1</b>	<b>15.7</b>	<b>0.4</b>	<b>751.0</b>	<b>1.0</b>	<b>3.0</b>	<b>0.3</b>	<b>15.6</b>	<b>0.6</b>	<b>733.0</b>	<b>1.0</b>	<b>3.0</b>	<b>0.3</b>
<b>MINIMUM:</b>	<b>45.12</b>	<b>9.12</b>	<b>4516</b>	<b>6.12</b>	<b>820.0</b>	<b>82.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>

meets 95%

NOTE: CRSP Input/Output values provided for final analysis for each respective boulder size

# DESIGN SECTION Sta. 395+50 (Existing Condition)

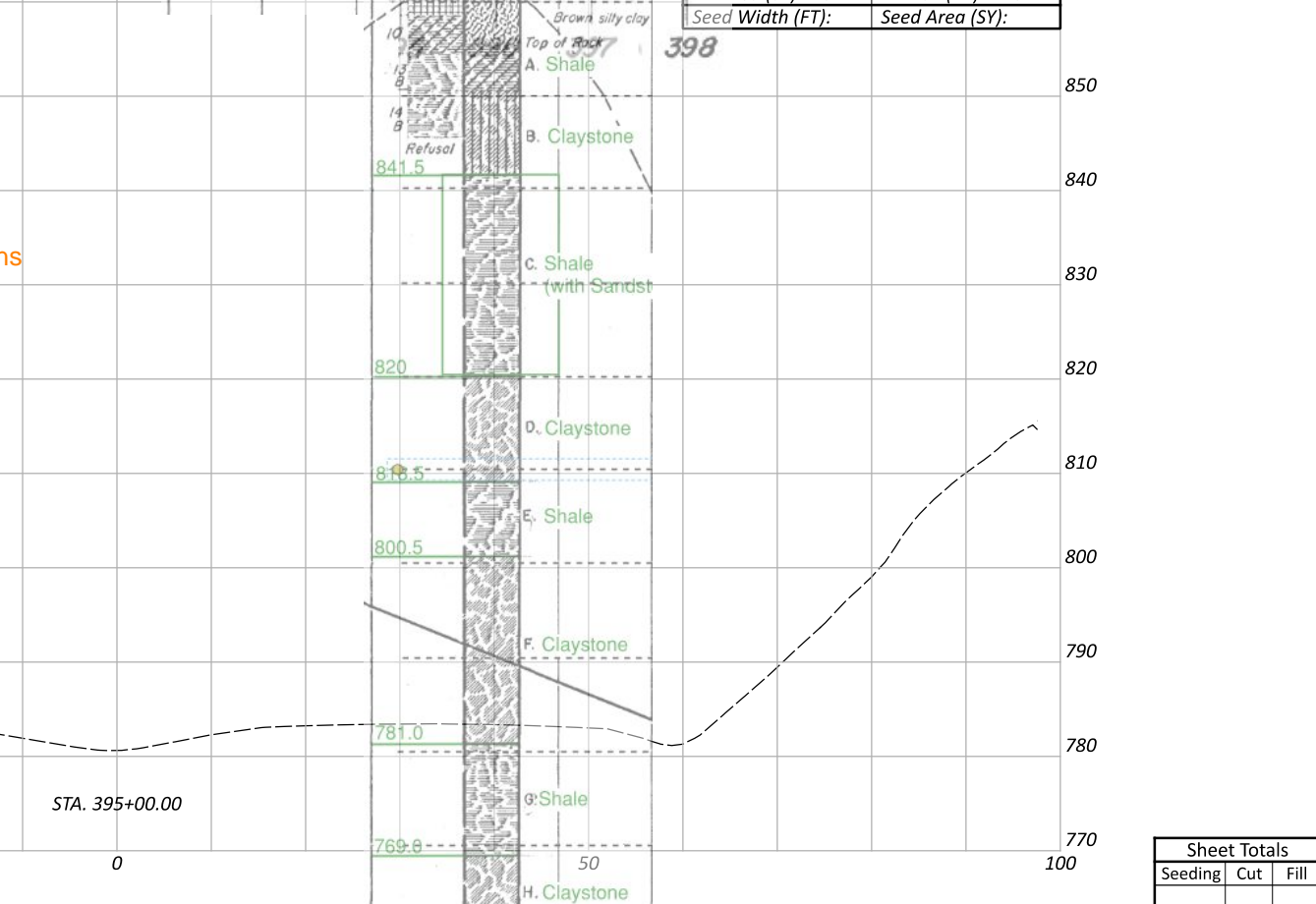
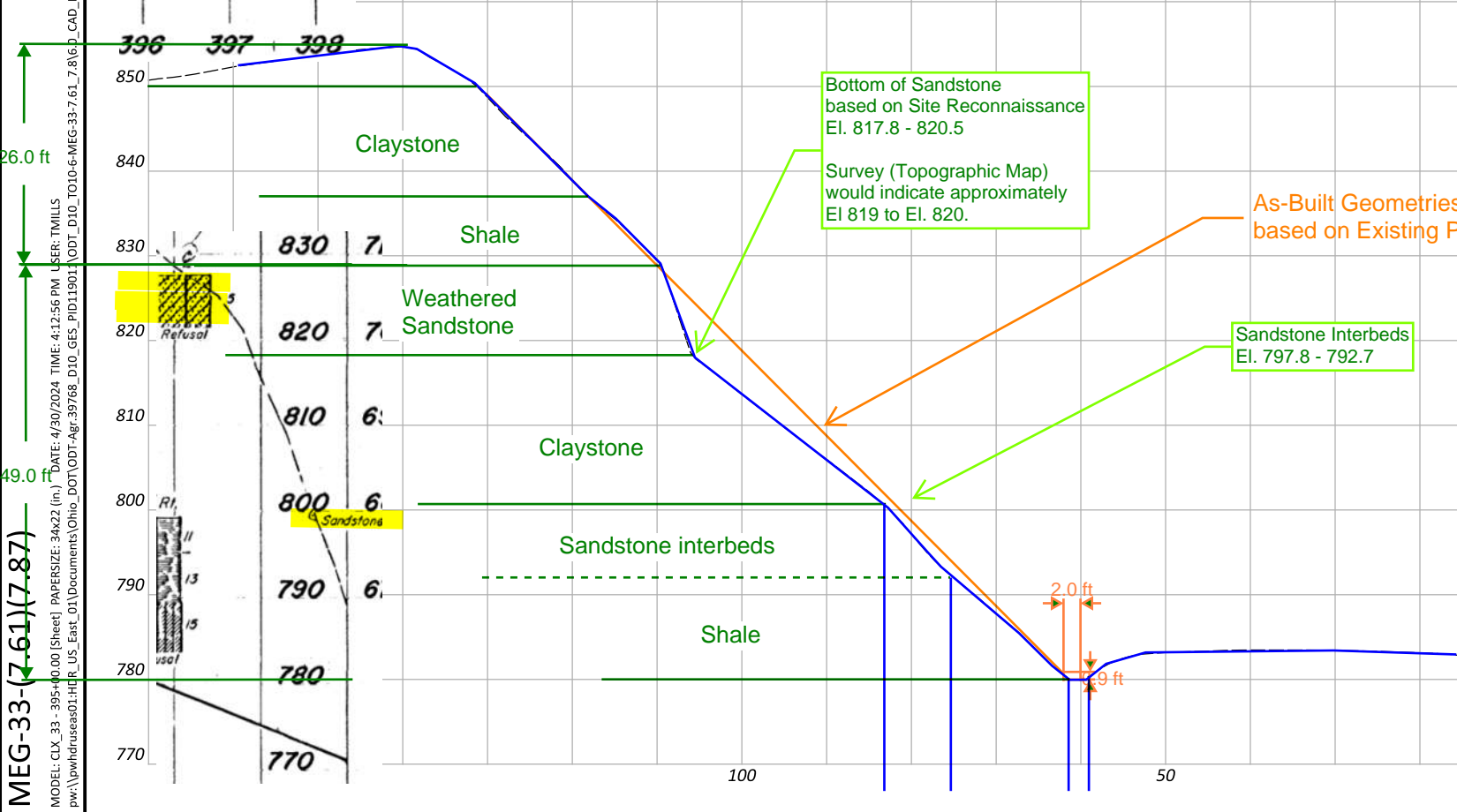


Cut Area (SF):	0	Cut Vol. (CY):	0
Fill Area (SF):	0	Fill Vol. (CY):	0
Seed Width (FT):		Seed Area (SY):	

**Design Notes and Assumptions:**

Sta. 395+50 was selected based on the overall height of the slope. The height of the rockfall generator above the existing catchment is likely to produce the greatest velocities and energies compared to rock generators of lesser heights.

Furthermore, the height of the soil and rock layer above the generator needed to be considered in determining benching geometries for the rockfall mitigation solution.



Cut Area (SF):	0	Cut Vol. (CY):	0
Fill Area (SF):	0	Fill Vol. (CY):	0
Seed Width (FT):		Seed Area (SY):	

MEG-33-(7.61)(7.87)

MODEL: CLK\_33 - 395+50.00 [Sheet] PAPER SIZE: 34x22 (in.) DATE: 4/30/2024 TIME: 4:12:56 PM USER: TMMILLS  
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CROSS SECTIONS US 33  
STA. 395+00 TO STA. 395+50

DESIGN AGENCY	HR		
DESIGNER	TDM		
REVIEWER	PJD MM-DD-YY		
PROJECT ID	118508		
Sheet Totals			
Seeding	Cut	Fill	SHEET TOTAL
			P.O 0

Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Existing Conditions**  
 Subject: **Sta. 395+50**

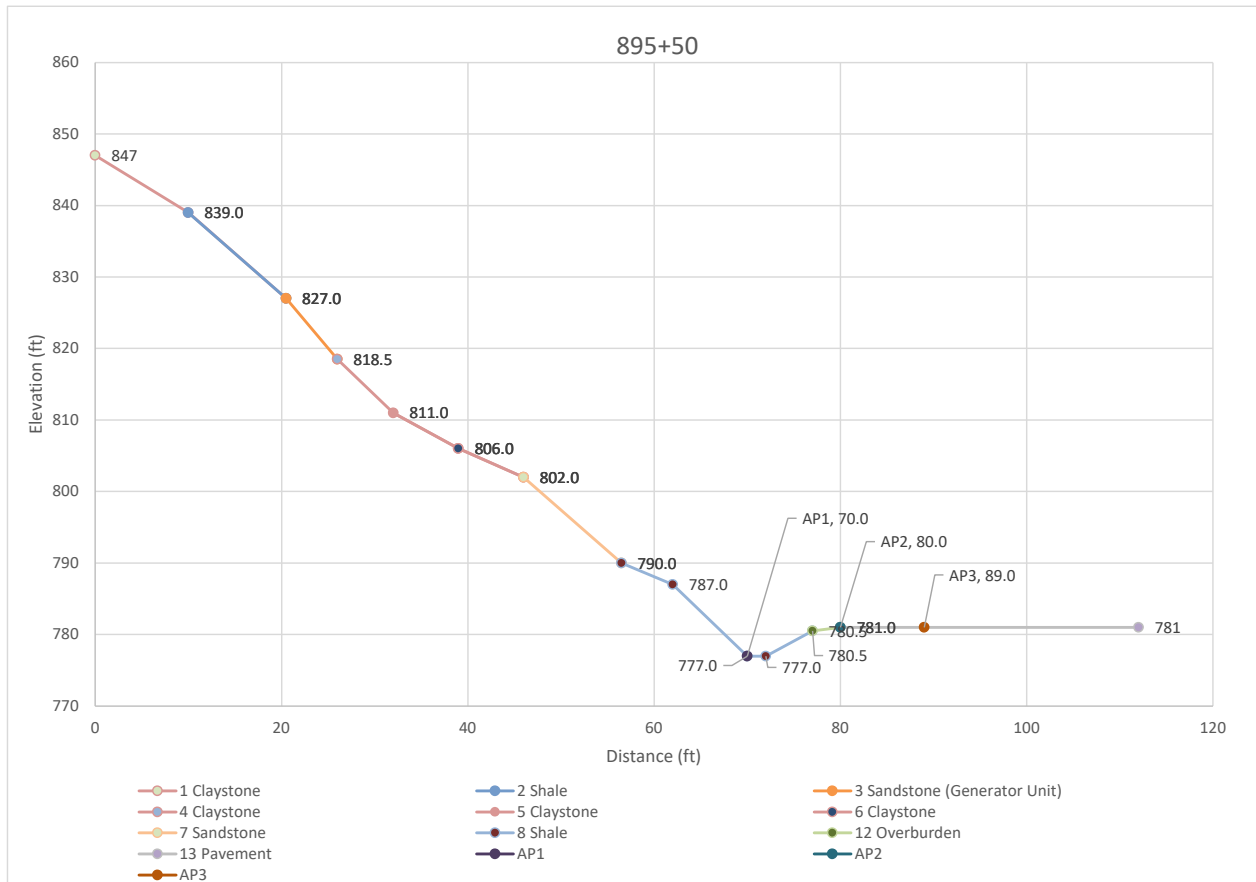
Computed: **DCM** Date: **05/13/24**  
 Checked: **AKB** Date: **05/21/24**  
 Page: **1** of **2**

	<b>X</b>	<b>Y</b>	<b>Description</b>	
Analysis Pt 1 =	AP1	70.0	777	Toe of Slope @ Catchment
Analysis Pt 2 =	AP2	80.0	781	Edge of Pavement
Analysis Pt 3 =	AP3	89.0	781	Edge of Travel Lane

**CRSP Assumptions:** Analysis using long-term conditions  
 ≥95% rockfall retained at Analysis Pt 2 design criteria  
 Roughness based on field measurements and experience with bedrock of the Monongahela Group  
 Rock shape is discoidal, 1 feet to 4 feet

Upper Zone Ymax: 839      Δ Elev.  
 Upper Zone Ymin: 818.5      20.5

	Cell	Surface R	Tangent C	Normal C	Begin X	Begin Y	End X	End Y
1 Claystone	1	0.5	0.75	0.15	0	847	10.0	839.0
2 Shale	2	0.75	0.75	0.15	10.0	839.0	20.5	827.0
3 Sandstone (Generator Unit)	3	1.5	0.9	0.25	20.5	827.0	26.0	818.5
4 Claystone	4	0.5	0.75	0.15	26.0	818.5	32.0	811.0
5 Claystone	5	0.5	0.75	0.15	32.0	811.0	39.0	806.0
6 Claystone	6	0.5	0.75	0.15	39.0	806.0	46.0	802.0
7 Sandstone	7	1.0	0.9	0.25	46.0	802.0	56.5	790.0
8 Shale	8	0.75	0.75	0.15	56.5	790.0	62.0	787.0
9 Shale	9	0.75	0.75	0.15	62.0	787.0	70.0	777.0
10 Shale	10	0.75	0.75	0.15	70.0	777.0	72.0	777.0
11 Shale	11	0.75	0.75	0.15	72.0	777.0	77.0	780.5
12 Overburden	12	2	0.65	0.15	77.0	780.5	80.0	781.0
13 Pavement	13	0	1	1	80.0	781.0	89	781
14 Pavement	14	0	1	1	89.0	781.0	112	781





Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Existing Conditions**  
 Subject: **Sta. 395+50**

Computed: **DCM** Date: **5/13/24**  
 Checked: **AKB** Date: **5/21/24**  
 Page: **2** of **2**

Overburden  
Claystone and Shale  
Sandstone

**Table 503-2. Hardness reference guide with CRSP coefficient values (Modified from Woodard, 2004)**

Hardness Input Code	Consistency	Field Identification	Normal Coefficient Values (Rn)	Tangential Coefficient Values (Rt)
1	Very soft	Easily penetrated several inches by fist	0.10	0.50
2	Soft	Easily penetrated several inches by thumb	0.10	0.55
3	Firm	Can be penetrated several inches by thumb with moderate effort	0.15	0.65
4	Stiff	Readily indented by thumb but penetrated only with great effort	0.15	0.70
5	Very stiff	Readily indented by thumbnail	0.20	0.75
6	Hard	Indented with difficulty by thumbnail	0.20	0.80-0.85
7	Very weak rock	Can be carved with a knife. Can be excavated readily with a point of a pick. Pieces 1 inch (25 mm) or more in thickness can be broken by finger pressure. Can be scratched by fingernail.	0.15	0.75
8	Weak rock	Can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure.	0.15	0.75
9	Slightly strong rock	Can be grooved or gouged 0.05 inch (2 mm) deep by firm pressure of a knife or pick point. Can be excavated in small chips to pieces about 1-inch (25 mm) maximum size by hard blows of the point of a geologist's pick.	0.20	0.80
10	Moderately strong rock	Can be scratched with a knife or pick. Grooves or gouges to 1/4" (6mm) deep can be excavated by hand blows of a geologist's pick. Requires moderate hammer blows to detach hand specimen.	0.25	0.85
11	Strong rock	Can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach hand specimen. Sharp and resistant edges are present on hand specimen.	0.25-0.30	0.9
12	Very strong rock	Cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0
13	Extremely strong rock	Cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0

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**Table 503-1. CRSP Coefficient Guide for Normal and Tangential Coefficient (from Jones, et al., 2000)**

Description of Slope	Normal Coefficient (Rn)	Remarks
Smooth hard surfaces and paving	0.60-1.0	For short slopes try lower values in applicable range
Most bedrock and boulder fields	0.15-0.30	
Talus and firm soil slopes	0.12-0.20	-If max. velocity/KE* are design criteria, use lower values in range; if avg. velocity/KE* are design criteria, use higher values in range
Soft soil slopes**	0.10-0.20	

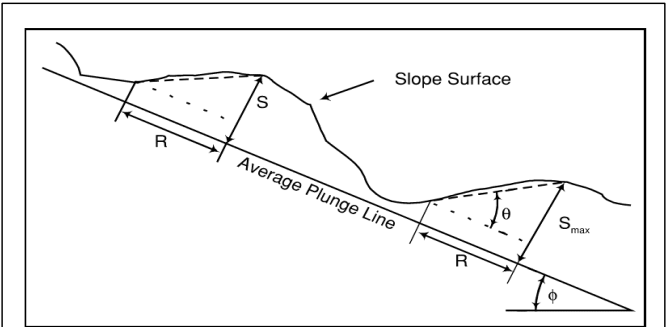
\*KE = kinetic energy  
 \*\*Soft soil slope coefficients were extrapolated from other slope types due to lack of data

Description of Slope	Tangential Coefficient (Rt)	Remarks
Smooth hard surfaces and paving	0.90-1.0	Rt is not very sensitive compared to Rn, but may be important for hard or significantly vegetated slopes
Most bedrock and boulder fields	0.75-0.95	
Talus and firm soil slopes	0.65-0.95	
Soft soil slopes*	0.50-0.80	-Use lower Rt as the density of vegetation on the slope increases

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For Pavement Use 1.0 for Rn and Rt



**Figure 2. Surface roughness (S) established as the perpendicular variation from an average plunge line (defined by slope angle  $\phi$ ) over a distance equal to the radius of the rock (R). Maximum slope variation ( $\theta_{max}$ ) is defined by S and R (Pfeiffer, 1989; Pfeiffer et al., 1991; 1995).**

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 70  
Analysis Point 2 X-Coordinate: 80  
Analysis Point 3 X-Coordinate: 89  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 818.5

Remarks: Sta. 395+50 Existing

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.5	.75	.15	0	847	10	839
2.	.75	.75	.15	10	839	20.5	827
3.	1.5	.9	.25	20.5	827	26	818.5
4.	.5	.75	.15	26	818.5	32	811
5.	.5	.75	.15	32	811	39	806
6.	.5	.75	.15	39	806	46	802
7.	1	.9	.25	46	802	56.5	790
8.	.75	.75	.15	56.5	790	62	787
9.	.75	.75	.15	62	787	70	777
10.	.75	.75	.15	70	777	72	777
11.	.75	.75	.15	72	777	77	780.5
12.	2	.65	.15	77	780.5	80	781
13.	0	1	1	80	781	89	781
14.	0	1	1	89	781	112	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 3  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 4 ft

Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\EI 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_EI 839\_Existing.dat

Analysis Point 1: X = 70, Y = 777

Total Rocks Passing Analysis Point: 999

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	33.5	47663
75%	36.87	56894
90%	39.9	65198
95%	41.71	70183
98%	43.75	75778

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 49.26</b>	<b>Maximum: 7.93</b>	<b>Maximum: 88892</b>
Average: 33.5	Average: 4.43	Average: 47663
Minimum: 24.22	G. Mean: 3.19	Std. Dev.:
13672		
Std. Dev.: 4.98	Std. Dev.: 4	

Remarks: Sta. 395+50 Existing

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\EI 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_EI 839\_Existing.dat

Analysis Point 2: X = 80, Y = 781

Total Rocks Passing Analysis Point: 30

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	5.84	2287
75%	7.6	3550

90%	9.19	4686	10.4
95%	10.15	5368	13.35
98%	11.22	6133	16.66

Velocity (ft/sec)                      Bounce Height (ft)                      Kinetic Energy (ft-lb)

Maximum: 9.56                      Maximum: .4                      Maximum: 5136  
Average: 5.84                      Average: .11                      Average: 2287  
Minimum: 2.53                      G. Mean: .04                      Std. Dev.: 1870  
Std. Dev.: 2.62                      Std. Dev.: 8.08

Remarks: Sta. 395+50 Existing

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Analysis Point 3: X = 89, Y = 781

Total Rocks Passing Analysis Point: 26

Cumulative Probability                      Velocity (ft/sec)                      Energy (ft-lb)  
Bounce Ht. (ft)

50%	6.76	2394	0.08
75%	8.39	3476	3.77
90%	9.85	4448	7.08
95%	10.73	5032	9.08
98%	11.72	5688	11.31

Velocity (ft/sec)                      Bounce Height (ft)                      Kinetic Energy (ft-lb)

Maximum: 10.94                      Maximum: .55                      Maximum: 5542  
Average: 6.76                      Average: .17                      Average: 2394  
Minimum: 2.83                      G. Mean: .08                      Std. Dev.: 1601  
Std. Dev.: 2.41                      Std. Dev.: 5.46

Remarks: Sta. 395+50 Existing

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Velocity Units: ft/sec          Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce Ht.

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1.	No rocks	past end of cell			
2.	24	15	4.18	2	0
3.	32	19	6.22	6	1
4.	37	25	4.29	6	0
5.	38	25	3.31	3	0
6.	33	25	2.56	1	0
7.	43	35	3.12	7	2
8.	44	29	6.02	5	0
9.	49	34	4.98	8	4
10.	49	31	7.22	7	2
11.	13	6	2.47	0	0
12.	10	6	2.62	0	0
13.	11	7	2.41	1	0
14.	10	7	2.49	0	0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

X Interval	Rocks Stopped
0 To 10 ft	1
15. To 20 ft	0
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	972
80 To 90 ft	1
90 To 100 ft	0
100 To 110 ft	0
110 To 112 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 70  
Analysis Point 2 X-Coordinate: 80  
Analysis Point 3 X-Coordinate: 89  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 818.5

Remarks: Sta. 395+50 Existing

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.5	.75	.15	0	847	10	839
2.	.75	.75	.15	10	839	20.5	827
3.	1.5	.9	.25	20.5	827	26	818.5
4.	.5	.75	.15	26	818.5	32	811
5.	.5	.75	.15	32	811	39	806
6.	.5	.75	.15	39	806	46	802
7.	1	.9	.25	46	802	56.5	790
8.	.75	.75	.15	56.5	790	62	787
9.	.75	.75	.15	62	787	70	777
10.	.75	.75	.15	70	777	72	777
11.	.75	.75	.15	72	777	77	780.5
12.	2	.65	.15	77	780.5	80	781
13.	0	1	1	80	781	89	781
14.	0	1	1	89	781	112	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 3  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 2 ft

Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Analysis Point 1: X = 70, Y = 777

Total Rocks Passing Analysis Point: 999

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	30.69	9732
75%	34.32	11932
90%	37.59	13911
95%	39.55	15099
98%	41.75	16432

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 48.94	Maximum: 10.18	Maximum: 22393
Average: 30.69	Average: 4.11	Average: 9732
Minimum: 15.48	G. Mean: 2.83	Std. Dev.: 3258
Std. Dev.: 5.38	Std. Dev.: 4.23	

Remarks: Sta. 395+50 Existing

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Analysis Point 2: X = 80, Y = 781

Total Rocks Passing Analysis Point: 6

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	10.32	1643
75%	13.33	2543
90%	16.04	3353

95%	17.66	3840	20.61
98%	19.48	4386	25.71

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
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Maximum: 18.76	Maximum: .76	Maximum: 4245
Average: 10.32	Average: .35	Average: 1643
Minimum: 5.66	G. Mean: .12	Std. Dev.: 1333
Std. Dev.: 4.45	Std. Dev.: 12.45	

Remarks: Sta. 395+50 Existing

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Analysis Point 3: X = 89, Y = 781

Total Rocks Passing Analysis Point: 6

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
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50%	11.19	1640	0.15
75%	13.95	2478	3.16
90%	16.44	3232	5.86
95%	17.93	3685	7.49
98%	19.61	4193	9.31

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
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Maximum: 18.24	Maximum: .53	Maximum: 4015
Average: 11.19	Average: .28	Average: 1640
Minimum: 5.74	G. Mean: .15	Std. Dev.: 1241
Std. Dev.: 4.09	Std. Dev.: 4.46	

Remarks: Sta. 395+50 Existing

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of



Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_El  
839\_Existing.dat

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce  
Ht.

1.	No rocks	past end of cell				
2.	24	13	4.35	2		0
3.	32	16	6.42	6		1
4.	36	23	4.43	7		1
5.	36	22	3.46	3		0
6.	32	22	3.22	2		0
7.	41	31	5.01	8		2
8.	43	25	7.06	6		1
9.	49	31	5.38	10		4
10.	49	28	9.07	9		2
11.	34	12	10.86	2		0
12.	19	10	4.45	1		0
13.	18	11	4.09	1		0
14.	18	11	4.2	0		0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-  
7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-  
33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_El 839\_Existing.dat

X Interval	Rocks Stopped
0 To 10 ft	1
15. To 20 ft	0
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	3
70 To 80 ft	990
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 112 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 70  
Analysis Point 2 X-Coordinate: 80  
Analysis Point 3 X-Coordinate: 89  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 818.5

Remarks: Sta. 395+50 Existing

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.5	.75	.15	0	847	10	839
2.	.75	.75	.15	10	839	20.5	827
3.	1.5	.9	.25	20.5	827	26	818.5
4.	.5	.75	.15	26	818.5	32	811
5.	.5	.75	.15	32	811	39	806
6.	.5	.75	.15	39	806	46	802
7.	1	.9	.25	46	802	56.5	790
8.	.75	.75	.15	56.5	790	62	787
9.	.75	.75	.15	62	787	70	777
10.	.75	.75	.15	70	777	72	777
11.	.75	.75	.15	72	777	77	780.5
12.	2	.65	.15	77	780.5	80	781
13.	0	1	1	80	781	89	781
14.	0	1	1	89	781	112	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 3  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1.5 ft

Thickness: 0.5 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\EI 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_EI 839\_Existing.dat

Analysis Point 1: X = 70, Y = 777

Total Rocks Passing Analysis Point: 990

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	28.44	2367
75%	32.6	2987
90%	36.33	3545
95%	38.58	3880
98%	41.09	4256

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 48.66</b>	<b>Maximum: 9.96</b>	<b>Maximum: 6061</b>
Average: 28.44	Average: 3.49	Average: 2367
Minimum: 11.24	G. Mean: 2.12	Std. Dev.: 918
Std. Dev.: 6.15	Std. Dev.: 4.86	

Remarks: Sta. 395+50 Existing

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\EI 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_EI 839\_Existing.dat

Analysis Point 2: X = 80, Y = 781

Total Rocks Passing Analysis Point: 5

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	7.5	298
75%	11.21	567
90%	14.55	808

95%	16.55	953	7.39
98%	18.8	1116	9.19

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
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Maximum: 17.2	Maximum: 1.06	Maximum: 1003
Average: 7.5	Average: .3	Average: 298
Minimum: 3.76	G. Mean: .13	Std. Dev.: 397
Std. Dev.: 5.49	Std. Dev.: 4.41	

Remarks: Sta. 395+50 Existing

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Analysis Point 3: X = 89, Y = 781

Total Rocks Passing Analysis Point: 5

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	8.57	307
75%	12.04	556
90%	15.17	781
95%	17.05	915
98%	19.16	1066

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
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Maximum: 16.7	Maximum: .4	Maximum: 944
Average: 8.57	Average: .15	Average: 307
Minimum: 4.21	G. Mean: .04	Std. Dev.: 369
Std. Dev.: 5.15	Std. Dev.: 11.02	

Remarks: Sta. 395+50 Existing

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of

Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_El  
839\_Existing.dat

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce  
Ht.

1.	No rocks	past end of cell			
2.	23	12	4.26	2	0
3.	31	16	6.45	6	1
4.	36	21	4.57	7	1
5.	35	20	3.76	3	0
6.	31	20	3.82	3	0
7.	41	28	6.02	9	2
8.	43	22	7.41	8	1
9.	49	28	6.15	10	3
10.	47	24	10.2	8	1
11.	31	9	9.23	2	0
12.	17	8	5.49	1	0
13.	17	9	5.15	0	0
14.	17	8	5.04	0	0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-  
7.61\_7.87\CRSP Analyses\Sta 395+50\El 839 Top of Generator\20240514\_MEG-  
33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_El 839\_Existing.dat

X Interval	Rocks Stopped
0 To 10 ft	1
15. To 20 ft	0
20 To 30 ft	9
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	5
70 To 80 ft	980
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 112 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 70  
Analysis Point 2 X-Coordinate: 80  
Analysis Point 3 X-Coordinate: 89  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 818.5

Remarks: Sta. 395+50 Existing

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.5	.75	.15	0	847	10	839
2.	.75	.75	.15	10	839	20.5	827
3.	1.5	.9	.25	20.5	827	26	818.5
4.	.5	.75	.15	26	818.5	32	811
5.	.5	.75	.15	32	811	39	806
6.	.5	.75	.15	39	806	46	802
7.	1	.9	.25	46	802	56.5	790
8.	.75	.75	.15	56.5	790	62	787
9.	.75	.75	.15	62	787	70	777
10.	.75	.75	.15	70	777	72	777
11.	.75	.75	.15	72	777	77	780.5
12.	2	.65	.15	77	780.5	80	781
13.	0	1	1	80	781	89	781
14.	0	1	1	89	781	112	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 3  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1 ft

Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Analysis Point 1: X = 70, Y = 777

Total Rocks Passing Analysis Point: 835

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	24.62	1611
75%	29.43	2165
90%	33.75	2663
95%	36.35	2962
98%	39.26	3298

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 46.26</b>	<b>Maximum: 9.64</b>	<b>Maximum: 4772</b>
Average: 24.62	Average: 2.69	Average: 1611
Minimum: 6.75	G. Mean: 1.51	Std. Dev.: 820
Std. Dev.: 7.12	Std. Dev.: 4.98	

Remarks: Sta. 395+50 Existing

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Analysis Point 2: X = 80, Y = 781

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	6.53	129
75%	6.53	129
90%	6.53	129

95%	6.53	129	1.67
98%	6.53	129	2.08

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
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Maximum: 6.53	Maximum: .03	Maximum: 129
Average: 6.53	Average: .03	Average: 129
Minimum: 6.53	G. Mean: .03	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 395+50 Existing

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Existing.dat

Analysis Point 3: X = 89, Y = 781

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	6.35	120
75%	6.35	120
90%	6.35	120
95%	6.35	120
98%	6.35	120

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
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Maximum: 6.35	Maximum: .1	Maximum: 120
Average: 6.35	Average: .1	Average: 120
Minimum: 6.35	G. Mean: .1	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 395+50 Existing

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of



Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_El  
839\_Existing.dat

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #    Max. Vel.    Avg. Vel.    S.D. Vel.    Max. Bounce Ht.    Avg. Bounce  
Ht.

1.	No rocks	past end of cell				
2.	21	11	4.26	2		0
3.	30	14	6.06	5		1
4.	35	20	5.08	7		1
5.	36	17	4.44	4		0
6.	32	16	4.58	3		0
7.	39	24	7.17	8		2
8.	40	18	7.87	6		0
9.	46	25	7.12	10		2
10.	43	20	10.44	8		1
11.	10	7	0	0		0
12.	7	7	0	0		0
13.	6	6	0	0		0
14.	6	6	0	0		0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-  
7.61\_7.87\CRSP Analyses\Sta 395+50\El 839 Top of Generator\20240514\_MEG-  
33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_El 839\_Existing.dat

X Interval	Rocks Stopped
0 To 10 ft	1
15. To 20 ft	77
20 To 30 ft	60
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	22
60 To 70 ft	8
70 To 80 ft	831
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 112 ft	0

# After Construction

Slope and Station: **STA 395+50**  
**After Construction - Short Term Conditions**

**CALCULATED:** DCM **DATE:** 5/13/2024  
**CHECKED:** AKB **DATE:** 5/21/2024

Total Rocks: 1000  
 Starting Velocity in X-Direction: 1 ft/sec  
 Starting Velocity in Y-Direction: -1 ft/sec  
 Starting Cell Number: 2  
 Ending Cell Number: 14  
 Rock Density: 165 lb/ft<sup>3</sup>

Description	Location	Description
Analysis Point 1 =	74.5	Toe of Slope @ Catchment
Analysis Point 2 =	84.5	Edge of Pavement
Analysis Point 3 =	93.5	Edge of Travel Lane

4' Dia x 1' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane					
	Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing				
	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point			
	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)			
4' x 1' Discoidal Rock (2073 lb)	41.56	7.13	65584	88.92	89	8.9	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0	0.0	
4' x 1' Discoidal Rock (2073 lb)	41.30	7.55	64591	87.57	85	8.5	6.00	0.05	1814	2.46	1	0.1	6.59	0.00	1990	2.70	1	0.1
4' x 1' Discoidal Rock (2073 lb)	42.00	7.74	67350	91.31	99	9.9	6.84	0.09	2272	3.08	4	0.4	7.08	0.00	2335	3.17	4	0.4
4' x 1' Discoidal Rock (2073 lb)	41.60	7.42	66274	89.86	105	10.5	6.84	0.07	2259	3.06	3	0.3	7.11	0.13	2276	3.09	3	0.3
4' x 1' Discoidal Rock (2073 lb)	41.33	7.41	63821	86.53	97	9.7	5.61	0.27	1574	2.13	2	0.2	5.76	0.13	1451	1.97	2	0.2
<b>AVERAGE:</b>	<b>41.56</b>	<b>7.45</b>	<b>65524</b>	<b>88.84</b>	<b>95.0</b>	<b>9.5</b>	<b>5.06</b>	<b>0.10</b>	<b>1584</b>	<b>2.15</b>	<b>2.0</b>	<b>0.2</b>	<b>5.31</b>	<b>0.05</b>	<b>1610</b>	<b>2.18</b>	<b>2.0</b>	<b>0.2</b>
<b>MAXIMUM:</b>	<b>42.00</b>	<b>7.74</b>	<b>67350</b>	<b>91.31</b>	<b>105.0</b>	<b>10.5</b>	<b>6.84</b>	<b>0.27</b>	<b>2272</b>	<b>3.08</b>	<b>4.0</b>	<b>0.4</b>	<b>7.11</b>	<b>0.13</b>	<b>2335</b>	<b>3.17</b>	<b>4.0</b>	<b>0.4</b>
<b>MINIMUM:</b>	<b>41.30</b>	<b>7.13</b>	<b>63821</b>	<b>86.53</b>	<b>85.0</b>	<b>8.5</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>

meets 95%

2' Dia x 1' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane					
	Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing				
	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point			
	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)			
2' x 1' Discoidal Rock (518 lb)	46.05	8.87	19158	25.97	721	72.1	15.25	0.14	2900	3.93	3	0.3	15.50	0.21	2900	3.93	3	0.3
2' x 1' Discoidal Rock (518 lb)	45.87	9.89	18780	25.46	725	72.5	15.43	0.21	3021	4.10	3	0.3	16.12	0.18	3097	4.20	3	0.3
2' x 1' Discoidal Rock (518 lb)	46.00	9.35	18848	25.55	728	72.8	3.97	0.11	239	0.32	1	0.1	4.78	0.07	257	0.35	1	0.1
2' x 1' Discoidal Rock (518 lb)	43.33	9.37	17312	23.47	724	72.4	11.24	0.48	1707	2.31	9	0.9	12.49	0.44	1770	2.40	9	0.9
2' x 1' Discoidal Rock (518 lb)	44.29	9.44	17397	23.59	732	73.2	12.28	0.45	2026	2.75	3	0.3	12.95	0.43	2024	2.74	3	0.3
<b>AVERAGE:</b>	<b>45.11</b>	<b>9.38</b>	<b>18299</b>	<b>24.81</b>	<b>726.0</b>	<b>72.6</b>	<b>11.63</b>	<b>0.28</b>	<b>1979</b>	<b>2.68</b>	<b>3.8</b>	<b>0.4</b>	<b>12.37</b>	<b>0.27</b>	<b>2010</b>	<b>2.72</b>	<b>3.8</b>	<b>0.4</b>
<b>MAXIMUM:</b>	<b>46.05</b>	<b>9.89</b>	<b>19158</b>	<b>25.97</b>	<b>732.0</b>	<b>73.2</b>	<b>15.43</b>	<b>0.48</b>	<b>3021</b>	<b>4.10</b>	<b>9.0</b>	<b>0.9</b>	<b>16.12</b>	<b>0.44</b>	<b>3097</b>	<b>4.20</b>	<b>9.0</b>	<b>0.9</b>
<b>MINIMUM:</b>	<b>43.33</b>	<b>8.87</b>	<b>17312</b>	<b>23.47</b>	<b>721.0</b>	<b>72.1</b>	<b>3.97</b>	<b>0.11</b>	<b>239</b>	<b>0.32</b>	<b>1.0</b>	<b>0.1</b>	<b>4.78</b>	<b>0.07</b>	<b>257</b>	<b>0.35</b>	<b>1.0</b>	<b>0.1</b>

meets 95%

1.5' Dia x 0.5' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane					
	Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing				
	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point			
	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)			
1.5' x 0.5' Discoidal Rock (146 lb)	46.56	9.50	5484	7.44	698	69.8	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0	0.0
1.5' x 0.5' Discoidal Rock (146 lb)	45.31	9.20	5045	6.84	701	70.1	14.82	0.14	781	1.06	1	0.1	15.25	0.08	786	1.07	1	0.1
1.5' x 0.5' Discoidal Rock (146 lb)	41.82	9.17	4660	6.32	695	69.5	4.77	0.19	89	0.12	2	0.2	5.79	0.03	104	0.14	2	0.2
1.5' x 0.5' Discoidal Rock (146 lb)	43.62	9.24	4705	6.38	701	70.1	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0	0.0
1.5' x 0.5' Discoidal Rock (146 lb)	41.99	10.16	4597	6.23	696	69.6	10.89	0.00	423	0.57	1	0.1	11.27	0.04	421	0.57	1	0.1
<b>AVERAGE:</b>	<b>43.86</b>	<b>9.45</b>	<b>4898</b>	<b>6.64</b>	<b>698.2</b>	<b>69.8</b>	<b>6.10</b>	<b>0.07</b>	<b>259</b>	<b>0.35</b>	<b>0.8</b>	<b>0.1</b>	<b>6.46</b>	<b>0.03</b>	<b>262</b>	<b>0.36</b>	<b>0.8</b>	<b>0.1</b>
<b>MAXIMUM:</b>	<b>46.56</b>	<b>10.16</b>	<b>5484</b>	<b>7.44</b>	<b>701.0</b>	<b>70.1</b>	<b>14.82</b>	<b>0.19</b>	<b>781</b>	<b>1.06</b>	<b>2.0</b>	<b>0.2</b>	<b>15.25</b>	<b>0.08</b>	<b>786</b>	<b>1.07</b>	<b>2.0</b>	<b>0.2</b>
<b>MINIMUM:</b>	<b>41.82</b>	<b>9.17</b>	<b>4597</b>	<b>6.23</b>	<b>695.0</b>	<b>69.5</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>

meets 95%

1' Dia x 1' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane					
	Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing				
	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kj	Analysis Point			
	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)			
1' x 1' Discoidal Rock (130 lb)	40.64	9.20	3945	5.35	533	53.3	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0	0.0
1' x 1' Discoidal Rock (130 lb)	41.24	9.39	3906	5.30	560	56.0	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0	0.0
1' x 1' Discoidal Rock (130 lb)	40.53	9.29	3941	5.34	544	54.4	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0	0.0
1' x 1' Discoidal Rock (130 lb)	40.75	9.09	3952	5.36	542	54.2	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0	0.0
1' x 1' Discoidal Rock (130 lb)	42.86	8.06	4102	5.56	540	54.0	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0	0.0
<b>AVERAGE:</b>	<b>41.20</b>	<b>9.01</b>	<b>3969</b>	<b>5.38</b>	<b>543.8</b>	<b>54.4</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>MAXIMUM:</b>	<b>42.86</b>	<b>9.39</b>	<b>4102</b>	<b>5.56</b>	<b>560.0</b>	<b>56.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>MINIMUM:</b>	<b>40.53</b>	<b>8.06</b>	<b>3906</b>	<b>5.30</b>	<b>533.0</b>	<b>53.3</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>

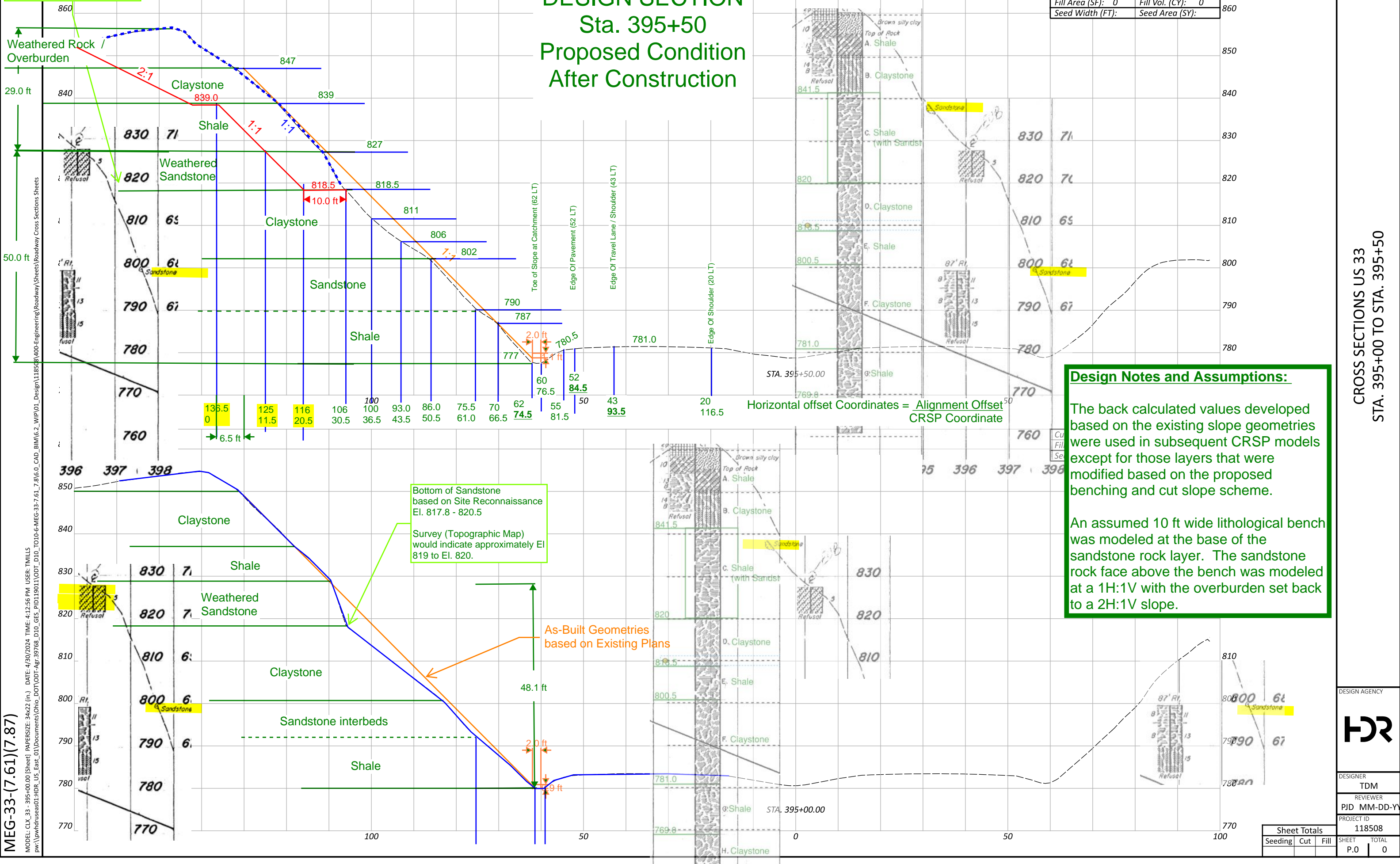
meets 95%

NOTE: CRSP Input/Output values provided for final analysis for each respective boulder size

Bottom of Sandstone based on Site Reconnaissance El. 817.8 - 820.5

# DESIGN SECTION Sta. 395+50 Proposed Condition After Construction

Cut Area (SF):	0	Cut Vol. (CY):	0
Fill Area (SF):	0	Fill Vol. (CY):	0
Seed Width (FT):		Seed Area (SY):	



**Design Notes and Assumptions:**

The back calculated values developed based on the existing slope geometries were used in subsequent CRSP models except for those layers that were modified based on the proposed benching and cut slope scheme.

An assumed 10 ft wide lithological bench was modeled at the base of the sandstone rock layer. The sandstone rock face above the bench was modeled at a 1H:1V with the overburden set back to a 2H:1V slope.

MEG-33-(7.61)(7.87)

MODEL: CLK\_33 - 395+00.00 [Sheet] PAPER SIZE: 34x22 (in.) DATE: 4/30/2024 TIME: 4:12:56 PM USER: TMMILLS  
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CROSS SECTIONS US 33  
STA. 395+00 TO STA. 395+50

DESIGN AGENCY	
DESIGNER	TDM
REVIEWER	
PROJECT ID	MM-DD-YY
SHEET TOTAL	118508
P.O.	0

Sheet Totals		
Seeding	Cut	Fill

Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Proposed - Short Term**  
 Subject: **Sta. 395+50**

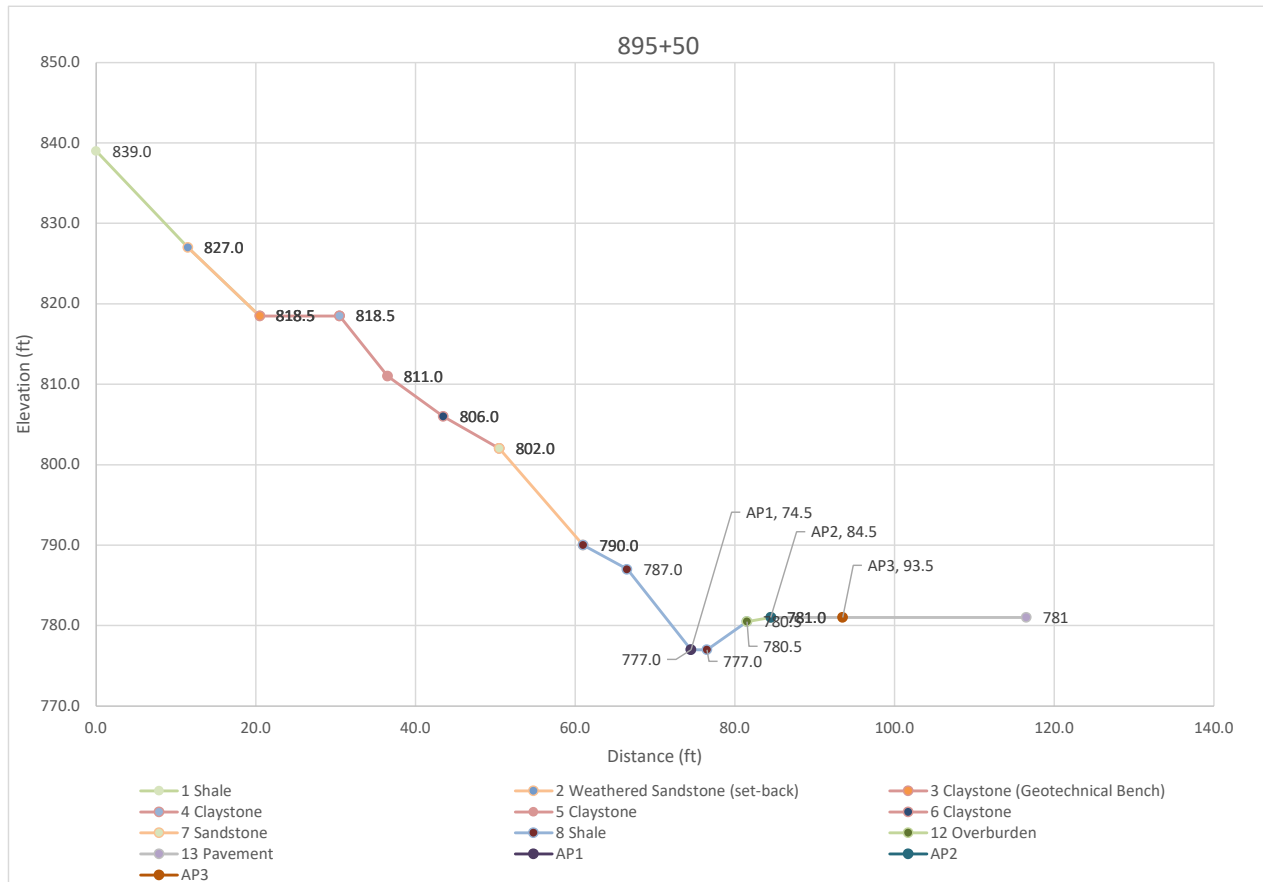
Computed: **DCM** Date: **05/13/24**  
 Checked: **AKB** Date: **05/21/24**  
 Page: **1** of **2**

	<b>X</b>	<b>Y</b>	<b>Description</b>
Analysis Pt 1 = AP1	74.5	777	Toe of Slope @ Catchment
Analysis Pt 2 = AP2	84.5	781	Edge of Pavement
Analysis Pt 3 = AP3	93.5	781	Edge of Travel Lane

**CRSP Assumptions:** Analysis using Short Term Conditions  
 ≥95% rockfall retained at Analysis Pt 2 design criteria  
 Roughness based on field measurements and experience with bedrock of the Monongahela Group  
 Rock shape is discoidal, 1 feet to 4 feet

Upper Zone Ymax: 839 Δ Elev.  
 Upper Zone Ymin: 818.5 20.5

	Cell	Surface R	Tangent C	Normal C	Begin X	Begin Y	End X	End Y
1 Shale	1	0.25	0.75	0.15	0.0	839.0	11.5	827.0
2 Weathered Sandstone (set-back)	2	0.25	0.9	0.25	11.5	827.0	20.5	818.5
3 Claystone (Geotechnical Bench)	3	0.15	0.75	0.15	20.5	818.5	30.5	818.5
4 Claystone	4	0.5	0.75	0.15	30.5	818.5	36.5	811.0
5 Claystone	5	0.5	0.75	0.15	36.5	811.0	43.5	806.0
6 Claystone	6	0.5	0.75	0.15	43.5	806.0	50.5	802.0
7 Sandstone	7	1.0	0.9	0.25	50.5	802.0	61.0	790.0
8 Shale	8	0.75	0.75	0.15	61.0	790.0	66.5	787.0
9 Shale	9	0.75	0.75	0.15	66.5	787.0	74.5	777.0
10 Shale	10	0.75	0.75	0.15	74.5	777.0	76.5	777.0
11 Shale	11	0.75	0.75	0.15	76.5	777.0	81.5	780.5
12 Overburden	12	2.0	0.65	0.15	81.5	780.5	84.5	781.0
13 Pavement	13	0	1	1	84.5	781.0	93.5	781
14 Pavement	14	0	1	1	93.5	781.0	116.5	781



Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Proposed - Short Term**  
 Subject: **Sta. 395+50**

Computed: **DCM** Date: **5/13/24**  
 Checked: **AKB** Date: **5/21/24**  
 Page: **2** of **2**

Overburden  
Claystone and Shale  
Sandstone

**Table 503-2. Hardness reference guide with CRSP coefficient values (Modified from Woodard, 2004)**

Hardness Input Code	Consistency	Field Identification	Normal Coefficient Values (Rn)	Tangential Coefficient Values (Rt)
1	Very soft	Easily penetrated several inches by fist	0.10	0.50
2	Soft	Easily penetrated several inches by thumb	0.10	0.55
3	Firm	Can be penetrated several inches by thumb with moderate effort	0.15	0.65
4	Stiff	Readily indented by thumb but penetrated only with great effort	0.15	0.70
5	Very stiff	Readily indented by thumbnail	0.20	0.75
6	Hard	Indented with difficulty by thumbnail	0.20	0.80-0.85
7	Very weak rock	Can be carved with a knife. Can be excavated readily with a point of a pick. Pieces 1 inch (25 mm) or more in thickness can be broken by finger pressure. Can be scratched by fingernail.	0.15	0.75
8	Weak rock	Can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure.	0.15	0.75
9	Slightly strong rock	Can be grooved or gouged 0.05 inch (2 mm) deep by firm pressure of a knife or pick point. Can be excavated in small chips to pieces about 1-inch (25 mm) maximum size by hard blows of the point of a geologist's pick.	0.20	0.80
10	Moderately strong rock	Can be scratched with a knife or pick. Grooves or gouges to 1/4" (6mm) deep can be excavated by hand blows of a geologist's pick. Requires moderate hammer blows to detach hand specimen.	0.25	0.85
11	Strong rock	Can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach hand specimen. Sharp and resistant edges are present on hand specimen.	0.25-0.30	0.9
12	Very strong rock	Cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0
13	Extremely strong rock	Cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0

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**Table 503-1. CRSP Coefficient Guide for Normal and Tangential Coefficient (from Jones, et al., 2000)**

Description of Slope	Normal Coefficient (Rn)	Remarks
Smooth hard surfaces and paving	0.60-1.0	For short slopes try lower values in applicable range
Most bedrock and boulder fields	0.15-0.30	
Talus and firm soil slopes	0.12-0.20	-If max. velocity/KE* are design criteria, use lower values in range; if avg. velocity/KE* are design criteria, use higher values in range
Soft soil slopes**	0.10-0.20	

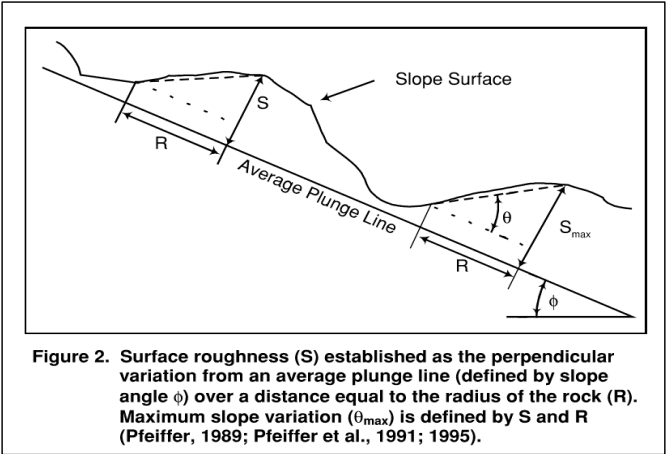
\*KE = kinetic energy  
 \*\*Soft soil slope coefficients were extrapolated from other slope types due to lack of data

Description of Slope	Tangential Coefficient (Rt)	Remarks
Smooth hard surfaces and paving	0.90-1.0	Rt is not very sensitive compared to Rn, but may be important for hard or significantly vegetated slopes
Most bedrock and boulder fields	0.75-0.95	
Talus and firm soil slopes	0.65-0.95	
Soft soil slopes*	0.50-0.80	-Use lower Rt as the density of vegetation on the slope increases

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For Pavement Use 1.0 for Rn and Rt



**Figure 2. Surface roughness (S) established as the perpendicular variation from an average plunge line (defined by slope angle  $\phi$ ) over a distance equal to the radius of the rock (R). Maximum slope variation ( $\theta_{max}$ ) is defined by S and R (Pfeiffer, 1989; Pfeiffer et al., 1991; 1995).**

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 74.5  
Analysis Point 2 X-Coordinate: 84.5  
Analysis Point 3 X-Coordinate: 93.5  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 818.5

Remarks: Sta. 395+50 Proposed (Short Term)

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.25	.75	.15	0	839	11.5	827
2.	.25	.9	.25	11.5	827	20.5	818.5
3.	.15	.75	.15	20.5	818.5	30.5	818.5
4.	.5	.75	.15	30.5	818.5	36.5	811
5.	.5	.75	.15	36.5	811	43.5	806
6.	.5	.75	.15	43.5	806	50.5	802
7.	1	.9	.25	50.5	802	61	790
8.	.75	.75	.15	61	790	66.5	787
9.	.75	.75	.15	66.5	787	74.5	777
10.	.75	.75	.15	74.5	777	76.5	777
11.	.75	.75	.15	76.5	777	81.5	780.5
12.	2	.65	.15	81.5	780.5	84.5	781
13.	0	1	1	84.5	781	93.5	781
14.	0	1	1	93.5	781	116.5	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 4 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Analysis Point 1: X = 74.5, Y = 777

Total Rocks Passing Analysis Point: 97

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	31.97	41736
75%	34.44	47836
90%	36.67	53323
95%	38	56617
98%	39.5	60314

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 41.33	Maximum: 7.41	Maximum: 63821
Average: 31.97	Average: 4.4	Average: 41736
Minimum: 25.1	G. Mean: 4.01	Std. Dev.: 9034
Std. Dev.: 3.66	Std. Dev.: 1.65	

Remarks: Sta. 395+50 Proposed (Short Term)

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Analysis Point 2: X = 84.5, Y = 781

Total Rocks Passing Analysis Point: 2

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	4.62	1262
75%	4.62	1262
90%	4.62	1262
95%	4.62	1262
98%	4.62	1262

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 5.61	Maximum: .27	Maximum: 1574
Average: 4.62	Average: .17	Average: 1262
Minimum: 3.64	G. Mean: .14	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 395+50 Proposed (Short Term)

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Analysis Point 3: X = 93.5, Y = 781

Total Rocks Passing Analysis Point: 2

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	5.06	1179
75%	5.06	1179
90%	5.06	1179
95%	5.06	1179
98%	5.06	1179

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 5.76	Maximum: .13	Maximum: 1451
Average: 5.06	Average: .13	Average: 1179
Minimum: 4.36	G. Mean: .13	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	



Remarks: Sta. 395+50 Proposed (Short Term)

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1. 20	6		2.55	2	0
2. 27	11		3.44	2	-1
3. 15	7		2.59	0	-1
4. 24	19		1.98	4	0
5. 23	20		1.27	1	0
6. 24	21		1.24	1	0
7. 36	31		3.1	5	1
8. 37	25		3.53	2	0
9. 41	32		3.66	7	4
10. 41	31		7.16	6	2
11. 10	7		2.24	0	0
12. 6	5		0	0	0
13. 6	5		0	0	0
14. 6	5		0	0	0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

X Interval	Rocks Stopped
0 To 10 ft	0
15. To 20 ft	0
20 To 30 ft	890
30 To 40 ft	13
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	79
80 To 90 ft	16
90 To 100 ft	0
100 To 110 ft	0
110 To 116.5 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP  
Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP  
Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 74.5  
Analysis Point 2 X-Coordinate: 84.5  
Analysis Point 3 X-Coordinate: 93.5  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 818.5

Remarks: Sta. 395+50 Proposed (Short Term)

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.25	.75	.15	0	839	11.5	827
2.	.25	.9	.25	11.5	827	20.5	818.5
3.	.15	.75	.15	20.5	818.5	30.5	818.5
4.	.5	.75	.15	30.5	818.5	36.5	811
5.	.5	.75	.15	36.5	811	43.5	806
6.	.5	.75	.15	43.5	806	50.5	802
7.	1	.9	.25	50.5	802	61	790
8.	.75	.75	.15	61	790	66.5	787
9.	.75	.75	.15	66.5	787	74.5	777
10.	.75	.75	.15	74.5	777	76.5	777
11.	.75	.75	.15	76.5	777	81.5	780.5
12.	2	.65	.15	81.5	780.5	84.5	781
13.	0	1	1	84.5	781	93.5	781
14.	0	1	1	93.5	781	116.5	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task  
10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of  
Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1  
839\_Proposed ST.dat

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 2 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Analysis Point 1: X = 74.5, Y = 777

Total Rocks Passing Analysis Point: 732

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	30.22	9221
75%	33.56	11039
90%	36.56	12674
95%	38.36	13656
98%	40.39	14758

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 44.29	Maximum: 9.44	Maximum: 17397
Average: 30.22	Average: 3.72	Average: 9221
Minimum: 14.68	G. Mean: 2.55	Std. Dev.: 2692
Std. Dev.: 4.95	Std. Dev.: 3.91	

Remarks: Sta. 395+50 Proposed (Short Term)

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Analysis Point 2: X = 84.5, Y = 781

Total Rocks Passing Analysis Point: 3

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	7.73	927	0.08
75%	7.73	927	0.76
90%	7.73	927	1.37
95%	7.73	927	1.73
98%	7.73	927	2.14

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 12.28</b>	<b>Maximum: .45</b>	<b>Maximum: 2026</b>
Average: 7.73	Average: .18	Average: 927
Minimum: 5.35	G. Mean: .08	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 395+50 Proposed (Short Term)

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Analysis Point 3: X = 93.5, Y = 781

Total Rocks Passing Analysis Point: 3

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	7.84	900	0.14
75%	7.84	900	0.81
90%	7.84	900	1.42
95%	7.84	900	1.78
98%	7.84	900	2.19

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 12.95</b>	<b>Maximum: .43</b>	<b>Maximum: 2024</b>
Average: 7.84	Average: .22	Average: 900
Minimum: 4.78	G. Mean: .14	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 395+50 Proposed (Short Term)

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1. 22	14		4.18	1	0
2. 29	19		5.75	1	0
3. 19	11		3.4	0	-1
4. 24	20		2.34	7	2
5. 33	20		4.21	6	0
6. 26	20		2.38	2	0
7. 38	29		4.99	7	2
8. 39	23		5.62	4	1
9. 44	30		4.95	9	3
10. 41	26		10.12	8	1
11. 31	8		7.71	0	0
12. 12	8		0	0	0
13. 13	8		0	0	0
14. 13	8		0	0	0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

X Interval	Rocks Stopped
0 To 10 ft	1
15. To 20 ft	0
20 To 30 ft	261
30 To 40 ft	6
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	670
80 To 90 ft	59
90 To 100 ft	0
100 To 110 ft	0
110 To 116.5 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 74.5  
Analysis Point 2 X-Coordinate: 84.5  
Analysis Point 3 X-Coordinate: 93.5  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 818.5

Remarks: Sta. 395+50 Proposed (Short Term)

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.25	.75	.15	0	839	11.5	827
2.	.25	.9	.25	11.5	827	20.5	818.5
3.	.15	.75	.15	20.5	818.5	30.5	818.5
4.	.5	.75	.15	30.5	818.5	36.5	811
5.	.5	.75	.15	36.5	811	43.5	806
6.	.5	.75	.15	43.5	806	50.5	802
7.	1	.9	.25	50.5	802	61	790
8.	.75	.75	.15	61	790	66.5	787
9.	.75	.75	.15	66.5	787	74.5	777
10.	.75	.75	.15	74.5	777	76.5	777
11.	.75	.75	.15	76.5	777	81.5	780.5
12.	2	.65	.15	81.5	780.5	84.5	781
13.	0	1	1	84.5	781	93.5	781
14.	0	1	1	93.5	781	116.5	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1.5 ft  
Thickness: 0.5 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Analysis Point 1: X = 74.5, Y = 777

Total Rocks Passing Analysis Point: 696

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	28.28	2293
75%	32.3	2853
90%	35.92	3358
95%	38.1	3660
98%	40.54	4000

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 41.99	Maximum: 10.16	Maximum: 4597
Average: 28.28	Average: 3.28	Average: 2293
Minimum: 11.03	G. Mean: 1.95	Std. Dev.: 830
Std. Dev.: 5.96	Std. Dev.: 4.92	

Remarks: Sta. 395+50 Proposed (Short Term)

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Analysis Point 2: X = 84.5, Y = 781

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	10.89	423
75%	10.89	423
90%	10.89	423
95%	10.89	423
98%	10.89	423

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 10.89	Maximum: 0	Maximum: 423
Average: 10.89	Average: -.09	Average: 423
Minimum: 10.89	G. Mean: 0	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 395+50 Proposed (Short Term)

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Analysis Point 3: X = 93.5, Y = 781

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	11.27	421
75%	11.27	421
90%	11.27	421
95%	11.27	421
98%	11.27	421

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 11.27	Maximum: .04	Maximum: 421
Average: 11.27	Average: .04	Average: 421
Minimum: 11.27	G. Mean: .04	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	



Remarks: Sta. 395+50 Proposed (Short Term)

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1. 23	14		4.29	1	0
2. 29	18		5.78	2	0
3. 19	10		3.35	0	0
4. 27	19		2.96	7	2
5. 33	19		4.43	5	0
6. 26	19		2.98	2	0
7. 37	27		6.05	8	2
8. 39	21		6.05	6	1
9. 42	28		5.96	10	3
10. 41	22		10.52	9	1
11. 30	12		0	0	0
12. 11	11		0	0	-1
13. 11	11		0	0	0
14. 12	12		0	0	0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

X Interval	Rocks Stopped
0 To 10 ft	0
15. To 20 ft	0
20 To 30 ft	290
30 To 40 ft	14
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	660
80 To 90 ft	35
90 To 100 ft	0
100 To 110 ft	0
110 To 116.5 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP  
Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP  
Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 74.5  
Analysis Point 2 X-Coordinate: 84.5  
Analysis Point 3 X-Coordinate: 93.5  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 818.5

Remarks: Sta. 395+50 Proposed (Short Term)

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.25	.75	.15	0	839	11.5	827
2.	.25	.9	.25	11.5	827	20.5	818.5
3.	.15	.75	.15	20.5	818.5	30.5	818.5
4.	.5	.75	.15	30.5	818.5	36.5	811
5.	.5	.75	.15	36.5	811	43.5	806
6.	.5	.75	.15	43.5	806	50.5	802
7.	1	.9	.25	50.5	802	61	790
8.	.75	.75	.15	61	790	66.5	787
9.	.75	.75	.15	66.5	787	74.5	777
10.	.75	.75	.15	74.5	777	76.5	777
11.	.75	.75	.15	76.5	777	81.5	780.5
12.	2	.65	.15	81.5	780.5	84.5	781
13.	0	1	1	84.5	781	93.5	781
14.	0	1	1	93.5	781	116.5	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task  
10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of  
Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1  
839\_Proposed ST.dat

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal
Diameter: 1 ft
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Analysis Point 1: X = 74.5, Y = 777

Total Rocks Passing Analysis Point: 540

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	24.6	1595
75%	29.3	2123
90%	33.53	2597
95%	36.07	2882
98%	38.92	3202

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 42.86</b>	<b>Maximum: 8.06</b>	<b>Maximum: 4102</b>
Average: 24.6	Average: 2.44	Average: 1595
Minimum: 6.49	G. Mean: 1.27	Std. Dev.: 781
Std. Dev.: 6.97	Std. Dev.: 6.32	

Remarks: Sta. 395+50 Proposed (Short Term)

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Analysis Point 2: X = 84.5, Y = 781

**NO ROCKS PAST ANALYSIS POINT 2**

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Analysis Point 3: X = 93.5, Y = 781

NO ROCKS PAST ANALYSIS POINT 3

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1. 22	13		4.35	1	0
2. 28	17		5.81	3	0
3. 17	9		3.12	0	0
4. 24	18		3.88	7	1
5. 33	16		4.38	4	0
6. 27	15		4.32	3	0
7. 39	22		6.78	8	2
8. 37	18		7.12	5	0
9. 43	25		6.97	8	2
10. 39	19		10.44	6	1
11. No rocks		past end of cell			
12. No rocks		past end of cell			
13. No rocks		past end of cell			
14. No rocks		past end of cell			

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed ST.dat

X Interval	Rocks Stopped
0 To 10 ft	0

15. To 20 ft	0
20 To 30 ft	406
30 To 40 ft	29
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	25
70 To 80 ft	538
80 To 90 ft	2
90 To 100 ft	0
100 To 110 ft	0
110 To 116.5 ft	0

# Long Term - 1.25H:1V Slope, Reduced Lithologic Bench Width

Slope and Station: STA 395+50  
After Construction - Long Term Conditions

CALCULATED: DCM  
CHECKED: AKB  
DATE: 5/13/2024  
DATE: 5/21/2024

Total Rocks: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Description	Location	Description
Analysis Point 1 =	74.5	Toe of Slope @ Catchment
Analysis Point 2 =	84.5	Edge of Pavement
Analysis Point 3 =	93.5	Edge of Travel Lane

4' Dia x 1' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane					
	Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing				
	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	Analysis Point			
	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)			
4' x 1' Discoidal Rock (2073 lb)	46.19	7.85	77919	105.64	653	65.3	9.60	0.44	5419	7.35	14	1.4	10.49	0.51	4924	6.68	13	1.3
4' x 1' Discoidal Rock (2073 lb)	46.47	7.62	78237	106.08	655	65.5	9.13	0.38	4914	6.66	7	0.7	9.63	0.45	4461	6.05	7	0.7
4' x 1' Discoidal Rock (2073 lb)	43.18	7.70	72716	98.59	660	66.0	9.46	0.32	4836	6.56	13	1.3	10.33	0.48	4617	6.26	13	1.3
4' x 1' Discoidal Rock (2073 lb)	46.55	7.78	78551	106.50	664	66.4	9.46	0.37	4932	6.69	9	0.9	10.97	0.47	5102	6.92	8	0.8
4' x 1' Discoidal Rock (2073 lb)	45.96	7.56	76354	103.52	638	63.8	9.44	0.24	4750	6.44	8	0.8	10.37	0.39	4591	6.22	7	0.7
<b>AVERAGE:</b>	<b>45.67</b>	<b>7.70</b>	<b>76755</b>	<b>104.07</b>	<b>654.0</b>	<b>65.4</b>	<b>9.42</b>	<b>0.35</b>	<b>4970</b>	<b>6.74</b>	<b>10.2</b>	<b>1.0</b>	<b>10.36</b>	<b>0.46</b>	<b>4739</b>	<b>6.43</b>	<b>9.6</b>	<b>1.0</b>
<b>MAXIMUM:</b>	<b>46.55</b>	<b>7.85</b>	<b>78551</b>	<b>106.50</b>	<b>664.0</b>	<b>66.4</b>	<b>9.60</b>	<b>0.44</b>	<b>5419</b>	<b>7.35</b>	<b>14.0</b>	<b>1.4</b>	<b>10.97</b>	<b>0.51</b>	<b>5102</b>	<b>6.92</b>	<b>13.0</b>	<b>1.3</b>
<b>MINIMUM:</b>	<b>43.18</b>	<b>7.56</b>	<b>72716</b>	<b>98.59</b>	<b>638.0</b>	<b>63.8</b>	<b>9.13</b>	<b>0.24</b>	<b>4750</b>	<b>6.44</b>	<b>7.0</b>	<b>0.7</b>	<b>9.63</b>	<b>0.39</b>	<b>4461</b>	<b>6.05</b>	<b>7.0</b>	<b>0.7</b>

meets 95%

2' Dia x 1' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane					
	Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing				
	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	Analysis Point			
	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)			
2' x 1' Discoidal Rock (518 lb)	46.86	9.35	20003	27.12	303	30.3	7.77	0.22	865	1.17	1	0.1	7.72	0.39	716	0.97	1	0.1
2' x 1' Discoidal Rock (518 lb)	43.16	8.61	16966	23.00	337	33.7	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0	0.0
2' x 1' Discoidal Rock (518 lb)	45.26	8.58	18465	25.04	315	31.5	5.54	0.07	384	0.52	1	0.1	4.80	0.14	278	0.38	1	0.1
2' x 1' Discoidal Rock (518 lb)	41.32	9.62	16173	21.93	318	31.8	15.36	0.48	2849	3.86	3	0.3	14.52	0.60	2539	3.44	3	0.3
2' x 1' Discoidal Rock (518 lb)	42.25	9.37	17099	23.18	319	31.9	8.77	0.21	1067	1.45	1	0.1	9.07	0.26	991	1.34	1	0.1
<b>AVERAGE:</b>	<b>43.77</b>	<b>9.11</b>	<b>17741</b>	<b>24.05</b>	<b>318.4</b>	<b>31.8</b>	<b>7.49</b>	<b>0.20</b>	<b>1033</b>	<b>1.40</b>	<b>1.2</b>	<b>0.1</b>	<b>7.22</b>	<b>0.28</b>	<b>905</b>	<b>1.23</b>	<b>1.2</b>	<b>0.1</b>
<b>MAXIMUM:</b>	<b>46.86</b>	<b>9.62</b>	<b>20003</b>	<b>27.12</b>	<b>337.0</b>	<b>33.7</b>	<b>15.36</b>	<b>0.48</b>	<b>2849</b>	<b>3.86</b>	<b>3.0</b>	<b>0.3</b>	<b>14.52</b>	<b>0.60</b>	<b>2539</b>	<b>3.44</b>	<b>3.0</b>	<b>0.3</b>
<b>MINIMUM:</b>	<b>41.32</b>	<b>8.58</b>	<b>16173</b>	<b>21.93</b>	<b>303.0</b>	<b>30.3</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>

meets 95%

1.5' Dia x 0.5' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane					
	Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing				
	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	Analysis Point			
	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)			
1.5' x 0.5' Discoidal Rock (146 lb)	40.33	8.77	4277	5.80	182.0	18.2	0.00	0.00	0	0.00	0.0	0.0	0.00	0.00	0	0.00	0.0	0.0
1.5' x 0.5' Discoidal Rock (146 lb)	40.70	9.71	4320	5.86	181.0	18.1	0.00	0.00	0	0.00	0.0	0.0	0.00	0.00	0	0.00	0.0	0.0
1.5' x 0.5' Discoidal Rock (146 lb)	41.22	8.99	4488	6.08	181.0	18.1	0.00	0.00	0	0.00	0.0	0.0	0.00	0.00	0	0.00	0.0	0.0
1.5' x 0.5' Discoidal Rock (146 lb)	39.35	8.50	4032	5.47	172.0	17.2	0.50	0.00	0	0.00	0.0	0.0	0.00	0.00	0	0.00	0.0	0.0
1.5' x 0.5' Discoidal Rock (146 lb)	40.68	8.29	4290	5.82	171.0	17.1	0.00	0.00	0	0.00	0.0	0.0	0.00	0.00	0	0.00	0.0	0.0
<b>AVERAGE:</b>	<b>40.46</b>	<b>8.85</b>	<b>4281</b>	<b>5.80</b>	<b>177.4</b>	<b>17.7</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>
<b>MAXIMUM:</b>	<b>41.22</b>	<b>9.71</b>	<b>4488</b>	<b>6.08</b>	<b>182.0</b>	<b>18.2</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>
<b>MINIMUM:</b>	<b>39.35</b>	<b>8.29</b>	<b>4032</b>	<b>5.47</b>	<b>171.0</b>	<b>17.1</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>

meets 95%

1' Dia x 1' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane					
	Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing		Velocity	Bounce	Kinetic	Rocks Passing				
	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	Analysis Point	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	Analysis Point			
	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)	Max.	Max.	Max.	(count)	(%)			
1' x 1' Discoidal Rock (130 lb)	39.13	7.64	3367	4.57	47.0	4.7	0.00	0.00	0	0.00	0.0	0.0	0.00	0.00	0	0.00	0.0	0.0
1' x 1' Discoidal Rock (130 lb)	40.30	7.24	3809	5.16	46.0	4.6	0.00	0.00	0	0.00	0.0	0.0	0.00	0.00	0	0.00	0.0	0.0
1' x 1' Discoidal Rock (130 lb)	41.18	7.84	3752	5.09	57.0	5.7	0.00	0.00	0	0.00	0.0	0.0	0.00	0.00	0	0.00	0.0	0.0
1' x 1' Discoidal Rock (130 lb)	38.90	6.11	3379	4.58	41.0	4.1	0.00	0.00	0	0.00	0.0	0.0	0.00	0.00	0	0.00	0.0	0.0
1' x 1' Discoidal Rock (130 lb)	40	8.04	3688	5.00	49.0	4.9	0.00	0.00	0	0.00	0.0	0.0	0.00	0.00	0	0.00	0.0	0.0
<b>AVERAGE:</b>	<b>39.90</b>	<b>7.37</b>	<b>3599</b>	<b>4.88</b>	<b>48.0</b>	<b>4.8</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>MAXIMUM:</b>	<b>41.18</b>	<b>8.04</b>	<b>3809</b>	<b>5.16</b>	<b>57.0</b>	<b>5.7</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>MINIMUM:</b>	<b>38.90</b>	<b>6.11</b>	<b>3367</b>	<b>4.57</b>	<b>41.0</b>	<b>4.1</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>

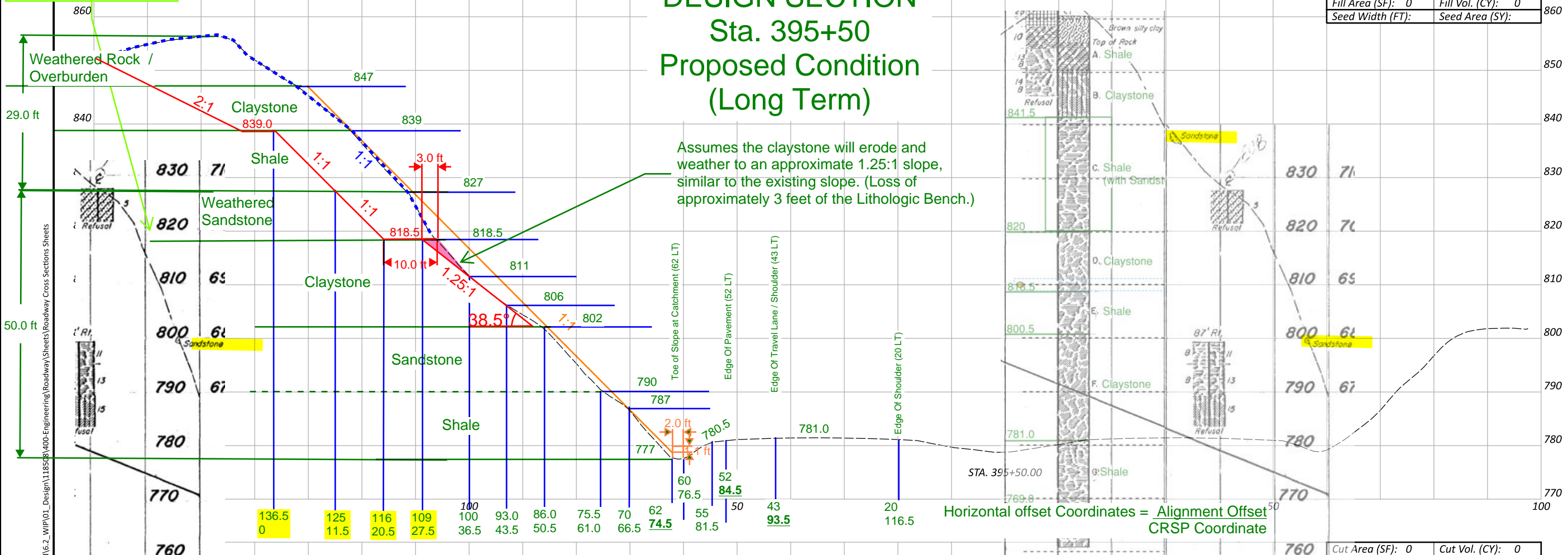
meets 95%

NOTE: CRSP Input/Output values provided for final analysis for each respective boulder size

Bottom of Sandstone based on Site Reconnaissance El. 817.8 - 820.5

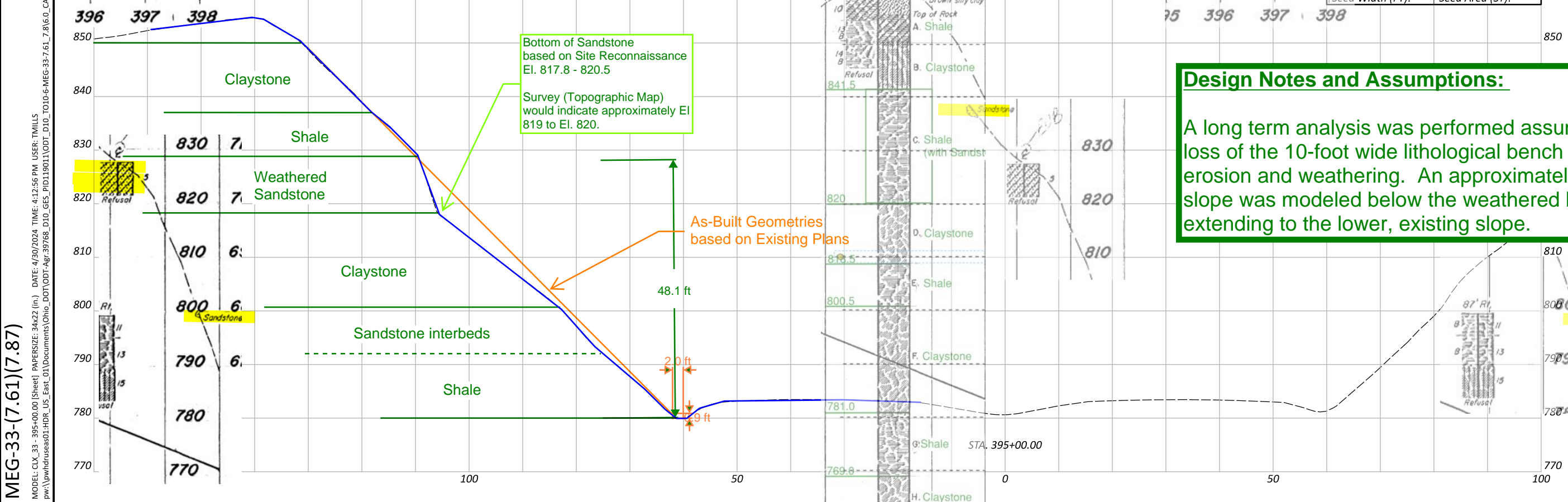
# DESIGN SECTION Sta. 395+50 Proposed Condition (Long Term)

Cut Area (SF):	0	Cut Vol. (CY):	0
Fill Area (SF):	0	Fill Vol. (CY):	0
Seed Width (FT):		Seed Area (SY):	



Horizontal offset Coordinates = Alignment Offset  
CRSP Coordinate

Cut Area (SF):	0	Cut Vol. (CY):	0
Fill Area (SF):	0	Fill Vol. (CY):	0
Seed Width (FT):		Seed Area (SY):	



**Design Notes and Assumptions:**

A long term analysis was performed assuming a 30% loss of the 10-foot wide lithological bench due to erosion and weathering. An approximately 1.25H:1V slope was modeled below the weathered bench and extending to the lower, existing slope.

MEG-33-(7.61)(7.87)

MODEL: CLK\_33 - 395+00.00 [Sheet] PAPER SIZE: 34x22 (in.) DATE: 4/30/2024 TIME: 4:12:56 PM USER: TMMILLS  
 P:\pwhdruseas01\HDR\_US\_East\_01\Documents\Ohio\_DOT\ODT-Agr-39768\_D10\_GES\_PID19011\ODT\_D10\_TO10-6-MEG-33-7.61\_7.816.0\_CAD\_BIM\6.2\_wip\01\_Design\118508\400-Engineering\Roadway\Sheets\Roadway Cross Sections Sheets

CROSS SECTIONS US 33  
STA. 395+00 TO STA. 395+50

DESIGN AGENCY	
DESIGNER	TDM
REVIEWER	
PROJECT ID	MM-DD-YY
SHEET TOTAL	118508
P.O.	0

Sheet Totals		
Seeding	Cut	Fill

Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Proposed - Long Term (1.25H:1V)**  
 Subject: **Sta. 395+50**

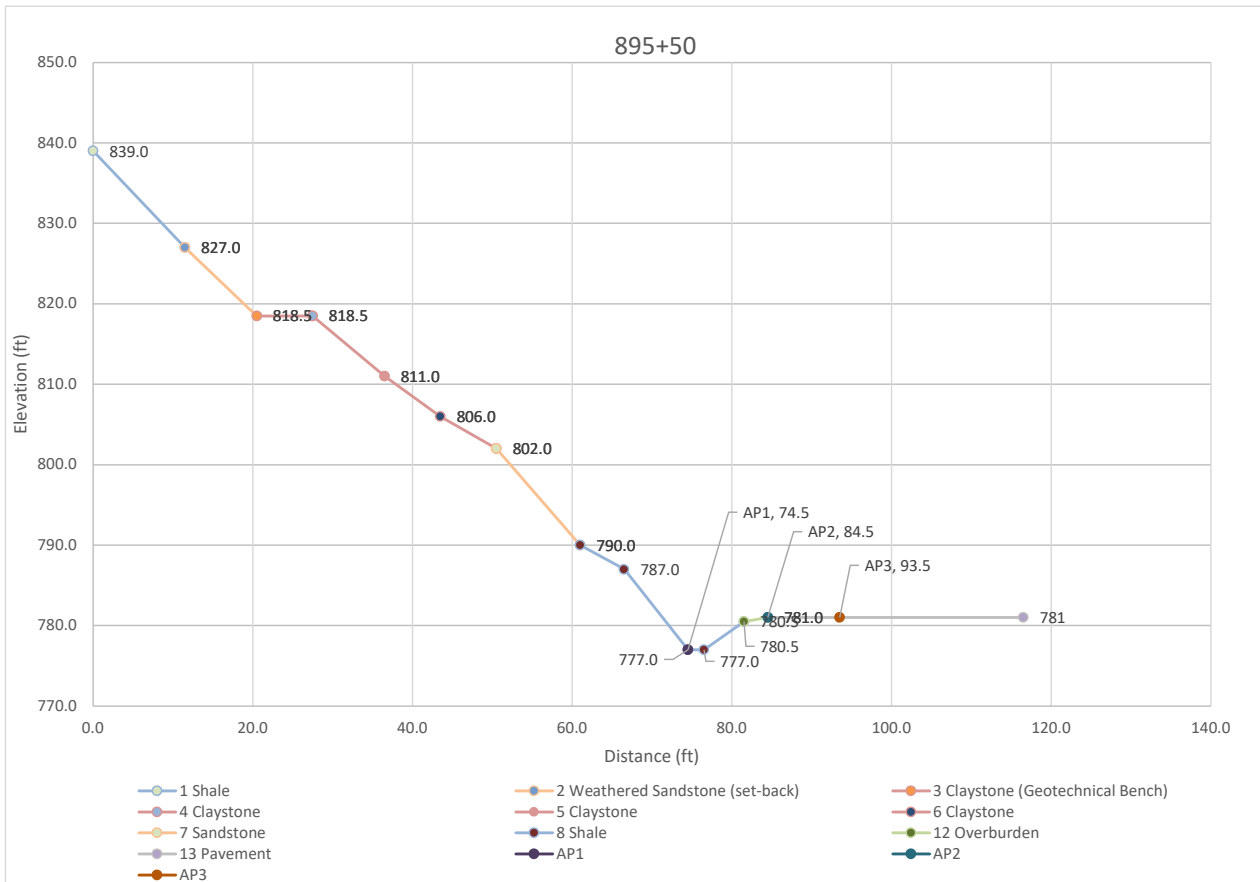
Computed: **DCM** Date: **05/13/24**  
 Checked: **AKB** Date: **05/21/24**  
 Page: **1** of **2**

	<b>X</b>	<b>Y</b>	<b>Description</b>
Analysis Pt 1 =	AP1	74.5	Toe of Slope @ Catchment
Analysis Pt 2 =	AP2	84.5	Edge of Pavement
Analysis Pt 3 =	AP3	93.5	Edge of Travel Lane

**CRSP Assumptions:** Analysis using Long Term Conditions  
 ≥95% rockfall retained at Analysis Pt 2 design criteria  
 Roughness based on field measurements and experience with bedrock of the Monongahela Group  
 Rock shape is discoidal, 1 feet to 4 feet

Upper Zone Ymax: 839 Δ Elev.  
 Upper Zone Ymin: 818.5 20.5

	Cell	Surface R	Tangent C	Normal C	Begin X	Begin Y	End X	End Y
1 Shale	1	0.75	0.75	0.15	0.0	839.0	11.5	827.0
2 Weathered Sandstone (set-back)	2	1.5	0.9	0.25	11.5	827.0	20.5	818.5
3 Claystone (Geotechnical Bench)	3	0.5	0.75	0.15	20.5	818.5	27.5	818.5
4 Claystone	4	0.5	0.75	0.15	27.5	818.5	36.5	811.0
5 Claystone	5	0.5	0.75	0.15	36.5	811.0	43.5	806.0
6 Claystone	6	0.5	0.75	0.15	43.5	806.0	50.5	802.0
7 Sandstone	7	1.0	0.9	0.25	50.5	802.0	61.0	790.0
8 Shale	8	0.75	0.75	0.15	61.0	790.0	66.5	787.0
9 Shale	9	0.75	0.75	0.15	66.5	787.0	74.5	777.0
10 Shale	10	0.75	0.75	0.15	74.5	777.0	76.5	777.0
11 Shale	11	0.75	0.75	0.15	76.5	777.0	81.5	780.5
12 Overburden	12	2.0	0.65	0.15	81.5	780.5	84.5	781.0
13 Pavement	13	0	1	1	84.5	781.0	93.5	781
14 Pavement	14	0	1	1	93.5	781.0	116.5	781





Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Proposed - Long Term (1.25H:1V)**  
 Subject: **Sta. 395+50**

Computed: **DCM** Date: **5/13/24**  
 Checked: **AKB** Date: **5/21/24**  
 Page: **2** of **2**

Overburden  
Claystone and Shale  
Sandstone

**Table 503-2. Hardness reference guide with CRSP coefficient values (Modified from Woodard, 2004)**

Hardness Input Code	Consistency	Field Identification	Normal Coefficient Values (Rn)	Tangential Coefficient Values (Rt)
1	Very soft	Easily penetrated several inches by fist	0.10	0.50
2	Soft	Easily penetrated several inches by thumb	0.10	0.55
3	Firm	Can be penetrated several inches by thumb with moderate effort	0.15	0.65
4	Stiff	Readily indented by thumb but penetrated only with great effort	0.15	0.70
5	Very stiff	Readily indented by thumbnail	0.20	0.75
6	Hard	Indented with difficulty by thumbnail	0.20	0.80-0.85
7	Very weak rock	Can be carved with a knife. Can be excavated readily with a point of a pick. Pieces 1 inch (25 mm) or more in thickness can be broken by finger pressure. Can be scratched by fingernail.	0.15	0.75
8	Weak rock	Can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure.	0.15	0.75
9	Slightly strong rock	Can be grooved or gouged 0.05 inch (2 mm) deep by firm pressure of a knife or pick point. Can be excavated in small chips to pieces about 1-inch (25 mm) maximum size by hard blows of the point of a geologist's pick.	0.20	0.80
10	Moderately strong rock	Can be scratched with a knife or pick. Grooves or gouges to 1/4" (6mm) deep can be excavated by hand blows of a geologist's pick. Requires moderate hammer blows to detach hand specimen.	0.25	0.85
11	Strong rock	Can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach hand specimen. Sharp and resistant edges are present on hand specimen.	0.25-0.30	0.9
12	Very strong rock	Cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0
13	Extremely strong rock	Cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0

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OHIO DEPARTMENT OF TRANSPORTATION  
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**Table 503-1. CRSP Coefficient Guide for Normal and Tangential Coefficient (from Jones, et al., 2000)**

Description of Slope	Normal Coefficient (Rn)	Remarks
Smooth hard surfaces and paving	0.60-1.0	For short slopes try lower values in applicable range
Most bedrock and boulder fields	0.15-0.30	
Talus and firm soil slopes	0.12-0.20	-If max. velocity/KE* are design criteria, use lower values in range; if avg. velocity/KE* are design criteria, use higher values in range
Soft soil slopes**	0.10-0.20	

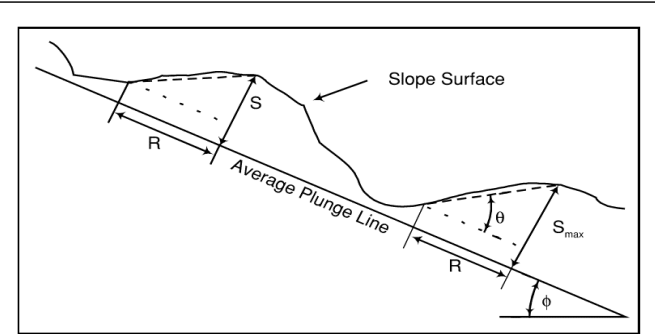
\*KE = kinetic energy  
 \*\*Soft soil slope coefficients were extrapolated from other slope types due to lack of data

Description of Slope	Tangential Coefficient (Rt)	Remarks
Smooth hard surfaces and paving	0.90-1.0	Rt is not very sensitive compared to Rn, but may be important for hard or significantly vegetated slopes
Most bedrock and boulder fields	0.75-0.95	
Talus and firm soil slopes	0.65-0.95	
Soft soil slopes*	0.50-0.80	-Use lower Rt as the density of vegetation on the slope increases

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For Pavement Use 1.0 for Rn and Rt



**Figure 2. Surface roughness (S) established as the perpendicular variation from an average plunge line (defined by slope angle  $\phi$ ) over a distance equal to the radius of the rock (R). Maximum slope variation ( $\theta_{max}$ ) is defined by S and R (Pfeiffer, 1989; Pfeiffer et al., 1991; 1995).**

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_7\_Sta39550\_Proposed LT\_4x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 74.5  
Analysis Point 2 X-Coordinate: 84.5  
Analysis Point 3 X-Coordinate: 93.5  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 818.5

Remarks: Sta. 395+50 Proposed (Longt Term)

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.75	.75	.15	0	839	11.5	827
2.	1.5	.9	.25	11.5	827	20.5	818.5
3.	.5	.75	.15	20.5	818.5	27.5	818.5
4.	.5	.75	.15	27.5	818.5	36.5	811
5.	.5	.75	.15	36.5	811	43.5	806
6.	.5	.75	.15	43.5	806	50.5	802
7.	1	.9	.25	50.5	802	61	790
8.	.75	.75	.15	61	790	66.5	787
9.	.75	.75	.15	66.5	787	74.5	777
10.	.75	.75	.15	74.5	777	76.5	777
11.	.75	.75	.15	76.5	777	81.5	780.5
12.	2	.65	.15	81.5	780.5	84.5	781
13.	0	1	1	84.5	781	93.5	781
14.	0	1	1	93.5	781	116.5	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_7\_Sta39550\_Proposed LT\_4x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2

Ending Cell Number: 14  
 Rock Density: 165 lb/ft<sup>3</sup>  
 Rock Shape: Discoidal  
 Diameter: 4 ft  
 Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Analysis Point 1: X = 74.5, Y = 777

Total Rocks Passing Analysis Point: 638

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	32.28	43226
75%	34.7	49664
90%	36.88	55456
95%	38.19	58933
98%	39.65	62835

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 45.96	Maximum: 7.56	Maximum: 76354
Average: 32.28	Average: 4.34	Average: 43226
Minimum: 24.45	G. Mean: 3.65	Std. Dev.: 9536
Std. Dev.: 3.58	Std. Dev.: 2.52	

Remarks: Sta. 395+50 Proposed (Longt Term)

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Analysis Point 2: X = 84.5, Y = 781

Total Rocks Passing Analysis Point: 8

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
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50%	5.97	2179	0.02
75%	7.66	3316	5.33
90%	9.18	4340	10.12
95%	10.09	4954	12.99
98%	11.12	5644	16.21

Velocity (ft/sec)                      Bounce Height (ft)                      Kinetic Energy (ft-lb)

Maximum: 9.44                      Maximum: .24                      Maximum: 4750  
Average: 5.97                      Average: .05                      Average: 2179  
Minimum: 2.35                      G. Mean: .02                      Std. Dev.: 1685  
Std. Dev.: 2.5                      Std. Dev.: 7.87

Remarks: Sta. 395+50 Proposed (Longt Term)

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Analysis Point 3: X = 93.5, Y = 781

Total Rocks Passing Analysis Point: 7

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	7.06	2415
75%	8.47	3366
90%	9.74	4222
95%	10.51	4736
98%	11.36	5313

Velocity (ft/sec)                      Bounce Height (ft)                      Kinetic Energy (ft-lb)

Maximum: 10.37                      Maximum: .39                      Maximum: 4591  
Average: 7.06                      Average: .11                      Average: 2415  
Minimum: 4.41                      G. Mean: .05                      Std. Dev.: 1409  
Std. Dev.: 2.09                      Std. Dev.: 6.77

Remarks: Sta. 395+50 Proposed (Longt Term)

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Velocity Units: ft/sec            Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1. 24	15		4.09	2	0
2. 30	17		5.92	4	0
3. 19	10		3.58	0	0
4. 28	19		2.96	4	0
5. 33	22		2.05	1	0
6. 27	23		1.76	1	0
7. 38	32		3.13	6	1
8. 40	26		4.56	3	0
9. 46	32		3.58	8	4
10. 42	32		6.35	6	2
11. 11	6		2.35	1	0
12. 9	6		2.5	0	0
13. 10	7		2.09	0	0
14. 9	7		1.84	0	0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	0
15. To 20 ft	0
20 To 30 ft	362
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	502
80 To 90 ft	129
90 To 100 ft	0
100 To 110 ft	0
110 To 116.5 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61 7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 74.5  
Analysis Point 2 X-Coordinate: 84.5  
Analysis Point 3 X-Coordinate: 93.5  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 818.5

Remarks: Sta. 395+50 Proposed (Longt Term)

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.75	.75	.15	0	839	11.5	827
2.	1.5	.9	.25	11.5	827	20.5	818.5
3.	.5	.75	.15	20.5	818.5	27.5	818.5
4.	.5	.75	.15	27.5	818.5	36.5	811
5.	.5	.75	.15	36.5	811	43.5	806
6.	.5	.75	.15	43.5	806	50.5	802
7.	1	.9	.25	50.5	802	61	790
8.	.75	.75	.15	61	790	66.5	787
9.	.75	.75	.15	66.5	787	74.5	777
10.	.75	.75	.15	74.5	777	76.5	777
11.	.75	.75	.15	76.5	777	81.5	780.5
12.	2	.65	.15	81.5	780.5	84.5	781
13.	0	1	1	84.5	781	93.5	781
14.	0	1	1	93.5	781	116.5	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2

Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 2 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Analysis Point 1: X = 74.5, Y = 777

Total Rocks Passing Analysis Point: 319

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	30.18	9138
75%	33.32	10904
90%	36.15	12493
95%	37.85	13447
98%	39.76	14518

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 42.25	Maximum: 9.37	Maximum: 17099
Average: 30.18	Average: 3.8	Average: 9138
Minimum: 16.58	G. Mean: 2.8	Std. Dev.: 2616
Std. Dev.: 4.66	Std. Dev.: 3.29	

Remarks: Sta. 395+50 Proposed (Longt Term)

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Analysis Point 2: X = 84.5, Y = 781

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
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50%	8.77	1067	0.21
75%	8.77	1067	0.88
90%	8.77	1067	1.49
95%	8.77	1067	1.85
98%	8.77	1067	2.26

Velocity (ft/sec)                      Bounce Height (ft)                      Kinetic Energy (ft-lb)

Maximum: 8.77                      Maximum: .21                      Maximum: 1067  
Average: 8.77                      Average: .21                      Average: 1067  
Minimum: 8.77                      G. Mean: .21                      Std. Dev.: 0  
Std. Dev.: 0                      Std. Dev.: 1

Remarks: Sta. 395+50 Proposed (Longt Term)

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Analysis Point 3: X = 93.5, Y = 781

Total Rocks Passing Analysis Point: 1

Cumulative Probability	Velocity (ft/sec)	Bounce Ht. (ft)	Energy (ft-lb)
50%	9.07	992	0.26
75%	9.07	992	0.94
90%	9.07	992	1.55
95%	9.07	992	1.91
98%	9.07	992	2.32

Velocity (ft/sec)                      Bounce Height (ft)                      Kinetic Energy (ft-lb)

Maximum: 9.07                      Maximum: .26                      Maximum: 991  
Average: 9.07                      Average: .26                      Average: 991  
Minimum: 9.07                      G. Mean: .26                      Std. Dev.: 0  
Std. Dev.: 0                      Std. Dev.: 1

Remarks: Sta. 395+50 Proposed (Longt Term)



CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1. 22	13		4.03	2	0
2. 30	14		5.91	4	0
3. 16	8		3.09	1	0
4. 27	17		2.46	3	0
5. 25	19		2.36	2	0
6. 26	20		2.34	2	0
7. 36	28		5.07	7	2
8. 38	23		5.61	5	1
9. 42	30		4.66	9	3
10. 41	26		10.19	8	1
11. 29	29		0	0	0
12. 9	9		0	0	0
13. 9	9		0	0	0
14. 9	9		0	0	0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	0
15. To 20 ft	88
20 To 30 ft	593
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	302
80 To 90 ft	16
90 To 100 ft	0
100 To 110 ft	0
110 To 116.5 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 74.5  
Analysis Point 2 X-Coordinate: 84.5  
Analysis Point 3 X-Coordinate: 93.5  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 818.5

Remarks: Sta. 395+50 Proposed (Longt Term)

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.75	.75	.15	0	839	11.5	827
2.	1.5	.9	.25	11.5	827	20.5	818.5
3.	.5	.75	.15	20.5	818.5	27.5	818.5
4.	.5	.75	.15	27.5	818.5	36.5	811
5.	.5	.75	.15	36.5	811	43.5	806
6.	.5	.75	.15	43.5	806	50.5	802
7.	1	.9	.25	50.5	802	61	790
8.	.75	.75	.15	61	790	66.5	787
9.	.75	.75	.15	66.5	787	74.5	777
10.	.75	.75	.15	74.5	777	76.5	777
11.	.75	.75	.15	76.5	777	81.5	780.5
12.	2	.65	.15	81.5	780.5	84.5	781
13.	0	1	1	84.5	781	93.5	781
14.	0	1	1	93.5	781	116.5	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2

Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal
Diameter: 1.5 ft
Thickness: 0.5 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Analysis Point 1: X = 74.5, Y = 777

Total Rocks Passing Analysis Point: 171

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	27.96	2254
75%	31.96	2809
90%	35.55	3307
95%	37.71	3607
98%	40.13	3943

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 40.68</b>	<b>Maximum: 8.29</b>	<b>Maximum: 4290</b>
Average: 27.96	Average: 3.25	Average: 2254
Minimum: 13.23	G. Mean: 2.27	Std. Dev.: 821
Std. Dev.: 5.92	Std. Dev.: 3.18	

Remarks: Sta. 395+50 Proposed (Longt Term)

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Analysis Point 2: X = 84.5, Y = 781

**NO ROCKS PAST ANALYSIS POINT 2**

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Analysis Point 3: X = 93.5, Y = 781

**NO ROCKS PAST ANALYSIS POINT 3**

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1. 21		12	3.98	2	0
2. 27		13	5.9	4	0
3. 15		8	2.99	1	0
4. 26		16	2.9	3	0
5. 25		18	3.13	2	0
6. 28		18	3.24	2	0
7. 37		25	6.13	6	2
8. 36		21	6.01	5	1
9. 41		28	5.92	8	3
10. 39		22	10.08	7	1
11. 6		6	0	0	0
12. No rocks		past end of cell			
13. No rocks		past end of cell			
14. No rocks		past end of cell			

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	2
15. To 20 ft	147
20 To 30 ft	680

30 To	40 ft	0
40 To	50 ft	0
50 To	60 ft	0
60 To	70 ft	0
70 To	80 ft	165
80 To	90 ft	6
90 To	100 ft	0
100 To	110 ft	0
110 To	116.5 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61 7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 74.5  
Analysis Point 2 X-Coordinate: 84.5  
Analysis Point 3 X-Coordinate: 93.5  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 818.5

Remarks: Sta. 395+50 Proposed (Longt Term)

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.75	.75	.15	0	839	11.5	827
2.	1.5	.9	.25	11.5	827	20.5	818.5
3.	.5	.75	.15	20.5	818.5	27.5	818.5
4.	.5	.75	.15	27.5	818.5	36.5	811
5.	.5	.75	.15	36.5	811	43.5	806
6.	.5	.75	.15	43.5	806	50.5	802
7.	1	.9	.25	50.5	802	61	790
8.	.75	.75	.15	61	790	66.5	787
9.	.75	.75	.15	66.5	787	74.5	777
10.	.75	.75	.15	74.5	777	76.5	777
11.	.75	.75	.15	76.5	777	81.5	780.5
12.	2	.65	.15	81.5	780.5	84.5	781
13.	0	1	1	84.5	781	93.5	781
14.	0	1	1	93.5	781	116.5	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61 7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec  
Starting Cell Number: 2

Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Analysis Point 1: X = 74.5, Y = 777

Total Rocks Passing Analysis Point: 49

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	24.32	1555
75%	29.37	2136
90%	33.91	2659
95%	36.64	2973
98%	39.7	3326

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 40	Maximum: 8.04	Maximum: 3688
Average: 24.32	Average: 2.89	Average: 1555
Minimum: 9.09	G. Mean: 1.71	Std. Dev.: 861
Std. Dev.: 7.48	Std. Dev.: 4.67	

Remarks: Sta. 395+50 Proposed (Longt Term)

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Analysis Point 2: X = 84.5, Y = 781

NO ROCKS PAST ANALYSIS POINT 2

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Analysis Point 3: X = 93.5, Y = 781

**NO ROCKS PAST ANALYSIS POINT 3**

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1. 22	10		3.91	2	0
2. 27	12		5.57	4	0
3. 13	7		3.12	1	0
4. 21	14		3.23	2	0
5. 25	16		3.36	2	0
6. 23	15		4.25	2	0
7. 34	22		5.67	5	1
8. 30	16		6.96	4	0
9. 40	24		7.48	8	2
10. 39	22		10	6	1
11. No rocks		past end of cell			
12. No rocks		past end of cell			
13. No rocks		past end of cell			
14. No rocks		past end of cell			

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Results\Sta 395+50\20240515\_MEG-33-7.61-7.87\_Sta39550\_Proposed LT\_4x1 Disc.doc

X Interval	Rocks Stopped
0 To 10 ft	123
15. To 20 ft	326
20 To 30 ft	502



30 To	40 ft	0
40 To	50 ft	0
50 To	60 ft	0
60 To	70 ft	0
70 To	80 ft	49
80 To	90 ft	0
90 To	100 ft	0
100 To	110 ft	0
110 To	116.5 ft	0

# Long Term - 1.25H:1V Slope, Reduced Lithologic Bench Width with Talus Build-up on the Bench

Slope and Station: STA 395+50  
 After Construction - Long Term Conditions (with Talus Build-Up)  
 Total Rocks: 1000  
 Starting Velocity in X-Direction: 1 ft/sec  
 Starting Velocity in Y-Direction: -1 ft/sec  
 Starting Cell Number: 2  
 Ending Cell Number: 14  
 Rock Density: 165 lb/ft<sup>3</sup>

CALCULATED: DCM  
 CHECKED: AKB  
 DATE: 5/13/2024  
 DATE: 5/21/2024

Description	Location	Description
Analysis Point 1 =	74.5	Toe of Slope @ Catchment
Analysis Point 2 =	84.5	Edge of Pavement
Analysis Point 3 =	93.5	Edge of Travel Lane

4' Dia x 1' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane								
	Velocity		Bounce	Kinetic		Rocks Passing		Velocity		Bounce	Kinetic		Rocks Passing		Velocity		Bounce	Kinetic		Rocks Passing	
	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	(count)	(%)	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	(count)	(%)	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	(count)	(%)	(count)	(%)	
	Max.	Max.	Max.			Max.	Max.	Max.			Max.	Max.	Max.			Max.	Max.	Max.			
4' x 1' Discoidal Rock (2073 lb)	48.70	7.76	87797	119.04	827	82.7	9.36	0.49	5115	6.94	19	1.9	10.56	0.60	5183	7.03	19	1.9	19	1.9	
4' x 1' Discoidal Rock (2073 lb)	49.22	7.81	88947	120.60	826	82.6	9.77	0.58	5058	6.86	12	1.2	11.58	0.38	5672	7.69	12	1.2	12	1.2	
4' x 1' Discoidal Rock (2073 lb)	47.92	7.60	85435	115.83	837	83.7	9.70	0.41	5293	7.18	20	2.0	9.98	0.61	4700	6.37	19	1.9	19	1.9	
4' x 1' Discoidal Rock (2073 lb)	48.77	7.88	87877	119.15	815	81.5	9.39	0.46	5134	6.96	19	1.9	10.53	0.54	4942	6.70	19	1.9	19	1.9	
4' x 1' Discoidal Rock (2073 lb)	47.86	7.78	85051	115.31	817	81.7	9.56	0.28	5105	6.92	21	2.1	10.74	0.47	5005	6.79	21	2.1	21	2.1	
<b>AVERAGE:</b>	<b>48.49</b>	<b>7.77</b>	<b>87021</b>	<b>117.99</b>	<b>824.4</b>	<b>82.4</b>	<b>9.56</b>	<b>0.44</b>	<b>5141</b>	<b>6.97</b>	<b>18.2</b>	<b>1.8</b>	<b>10.68</b>	<b>0.52</b>	<b>5100</b>	<b>6.92</b>	<b>18.0</b>	<b>1.8</b>	<b>18.0</b>	<b>1.8</b>	
<b>MAXIMUM:</b>	<b>49.22</b>	<b>7.88</b>	<b>88947</b>	<b>120.60</b>	<b>837.0</b>	<b>83.7</b>	<b>9.77</b>	<b>0.58</b>	<b>5293</b>	<b>7.18</b>	<b>21.0</b>	<b>2.1</b>	<b>11.58</b>	<b>0.61</b>	<b>5672</b>	<b>7.69</b>	<b>21.0</b>	<b>2.1</b>	<b>21.0</b>	<b>2.1</b>	
<b>MINIMUM:</b>	<b>47.86</b>	<b>7.60</b>	<b>85051</b>	<b>115.31</b>	<b>815.0</b>	<b>81.5</b>	<b>9.36</b>	<b>0.28</b>	<b>5058</b>	<b>6.86</b>	<b>12.0</b>	<b>1.2</b>	<b>9.98</b>	<b>0.38</b>	<b>4700</b>	<b>6.37</b>	<b>12.0</b>	<b>1.2</b>	<b>12.0</b>	<b>1.2</b>	

meets 95%

2' Dia x 1' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane								
	Velocity		Bounce	Kinetic		Rocks Passing		Velocity		Bounce	Kinetic		Rocks Passing		Velocity		Bounce	Kinetic		Rocks Passing	
	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	(count)	(%)	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	(count)	(%)	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	(count)	(%)	(count)	(%)	
	Max.	Max.	Max.			Max.	Max.	Max.			Max.	Max.	Max.			Max.	Max.	Max.			
2' x 1' Discoidal Rock (518 lb)	46.57	9.69	19626	26.61	262	26.2	8.76	0.02	1027	1.39	2	0.2	8.03	0.38	777	1.05	1	0.1	1	0.1	
2' x 1' Discoidal Rock (518 lb)	45.65	8.22	18917	25.65	285	28.5	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0	0.0	0	0.0	
2' x 1' Discoidal Rock (518 lb)	47.10	9.45	20457	27.74	268	26.8	3.79	0.03	190	0.26	1	0.1	4.08	0.01	197	0.27	1	0.1	1	0.1	
2' x 1' Discoidal Rock (518 lb)	46.62	8.65	19770	26.80	263	26.3	6.88	0.03	574	0.78	1	0.1	6.95	0.05	564	0.76	1	0.1	1	0.1	
2' x 1' Discoidal Rock (518 lb)	46.15	8.62	19558	26.52	291	29.1	3.41	0.05	170	0.23	1	0.1	3.57	0.10	150	0.20	1	0.1	1	0.1	
<b>AVERAGE:</b>	<b>46.42</b>	<b>8.93</b>	<b>19666</b>	<b>26.66</b>	<b>273.8</b>	<b>27.4</b>	<b>4.57</b>	<b>0.03</b>	<b>392</b>	<b>0.53</b>	<b>1.0</b>	<b>0.1</b>	<b>4.53</b>	<b>0.11</b>	<b>338</b>	<b>0.46</b>	<b>0.8</b>	<b>0.1</b>	<b>0.8</b>	<b>0.1</b>	
<b>MAXIMUM:</b>	<b>47.10</b>	<b>9.69</b>	<b>20457</b>	<b>27.74</b>	<b>291.0</b>	<b>29.1</b>	<b>8.76</b>	<b>0.05</b>	<b>1027</b>	<b>1.39</b>	<b>2.0</b>	<b>0.2</b>	<b>8.03</b>	<b>0.38</b>	<b>777</b>	<b>1.05</b>	<b>1.0</b>	<b>0.1</b>	<b>1.0</b>	<b>0.1</b>	
<b>MINIMUM:</b>	<b>45.65</b>	<b>8.22</b>	<b>18917</b>	<b>25.65</b>	<b>262.0</b>	<b>26.2</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	

meets 95%

1.5' Dia x 0.5' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane								
	Velocity		Bounce	Kinetic		Rocks Passing		Velocity		Bounce	Kinetic		Rocks Passing		Velocity		Bounce	Kinetic		Rocks Passing	
	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	(count)	(%)	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	(count)	(%)	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	(count)	(%)	(count)	(%)	
	Max.	Max.	Max.			Max.	Max.	Max.			Max.	Max.	Max.			Max.	Max.	Max.			
1.5' x 0.5' Discoidal Rock (146 lb)	45.04	8.71	5017	6.80	135	13.5	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0.00	0	0.00	0	0.0
1.5' x 0.5' Discoidal Rock (146 lb)	40.96	7.73	4353	5.90	145	14.5	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0.00	0	0.00	0	0.0
1.5' x 0.5' Discoidal Rock (146 lb)	44.68	7.66	5047	6.84	133	13.3	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0.00	0	0.00	0	0.0
1.5' x 0.5' Discoidal Rock (146 lb)	40.33	9.22	4186	5.68	144	14.4	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0.00	0	0.00	0	0.0
1.5' x 0.5' Discoidal Rock (146 lb)	40.65	8.82	4363	5.92	142	14.2	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0.00	0	0.00	0	0.0
<b>AVERAGE:</b>	<b>42.33</b>	<b>8.43</b>	<b>4593</b>	<b>6.23</b>	<b>139.8</b>	<b>14.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>
<b>MAXIMUM:</b>	<b>45.04</b>	<b>9.22</b>	<b>5047</b>	<b>6.84</b>	<b>145.0</b>	<b>14.5</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>
<b>MINIMUM:</b>	<b>40.33</b>	<b>7.66</b>	<b>4186</b>	<b>5.68</b>	<b>133.0</b>	<b>13.3</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>

meets 95%

1' Dia x 1' thick Disc. Rock Launched (1000)	Analysis Point 1 - Toe of Slope (@ Catchment)						Analysis Point 2 - Top of Catchment Berm						Analysis Point 3 - Edge of Travel Lane								
	Velocity		Bounce	Kinetic		Rocks Passing		Velocity		Bounce	Kinetic		Rocks Passing		Velocity		Bounce	Kinetic		Rocks Passing	
	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	(count)	(%)	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	(count)	(%)	(ft/sec)	HT (ft)	Energy (ft-lb)	kJ	(count)	(%)	(count)	(%)	
	Max.	Max.	Max.			Max.	Max.	Max.			Max.	Max.	Max.			Max.	Max.	Max.			
1' x 1' Discoidal Rock (130 lb)	38.94	6.57	3601	4.88	37	3.7	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0.00	0	0.00	0	0.0
1' x 1' Discoidal Rock (130 lb)	37.72	9.77	3265	4.43	53	5.3	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0.00	0	0.00	0	0.0
1' x 1' Discoidal Rock (130 lb)	36.39	6.89	3165	4.29	44	4.4	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0.00	0	0.00	0	0.0
1' x 1' Discoidal Rock (130 lb)	38.27	6.51	3217	4.36	41	4.1	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0.00	0	0.00	0	0.0
1' x 1' Discoidal Rock (130 lb)	38.07	6.98	3308	4.49	50	5.0	0.00	0.00	0	0.00	0	0.0	0.00	0.00	0	0.00	0.00	0	0.00	0	0.0
<b>AVERAGE:</b>	<b>37.88</b>	<b>7.34</b>	<b>3311</b>	<b>4.49</b>	<b>45.0</b>	<b>4.5</b>	<b>0.0</b>	<b>0.0</b>	<b>0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>
<b>MAXIMUM:</b>	<b>38.94</b>	<b>9.77</b>	<b>3601</b>	<b>4.88</b>	<b>53.0</b>	<b>5.3</b>	<b>0.0</b>	<b>0.0</b>	<b>0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>
<b>MINIMUM:</b>	<b>36.39</b>	<b>6.51</b>	<b>3165</b>	<b>4.29</b>	<b>37.0</b>	<b>3.7</b>	<b>0.0</b>	<b>0.0</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>	<b>0.00</b>	<b>0.0</b>	<b>0.0</b>

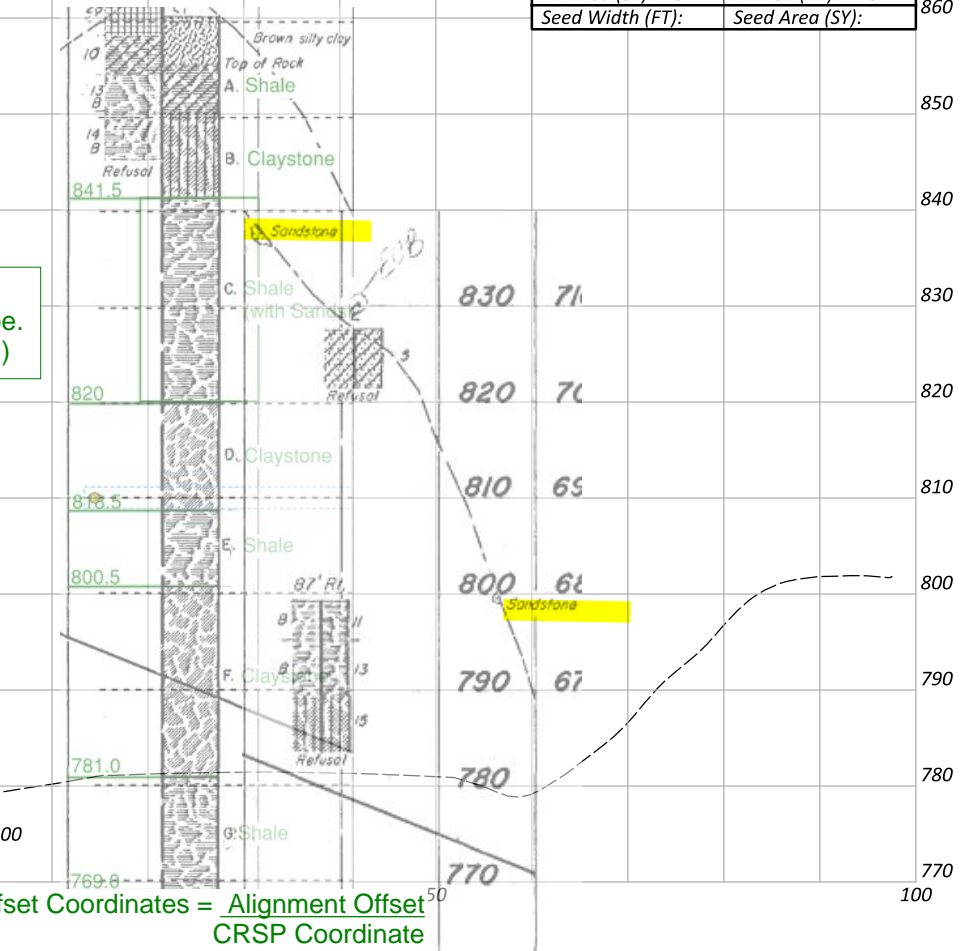
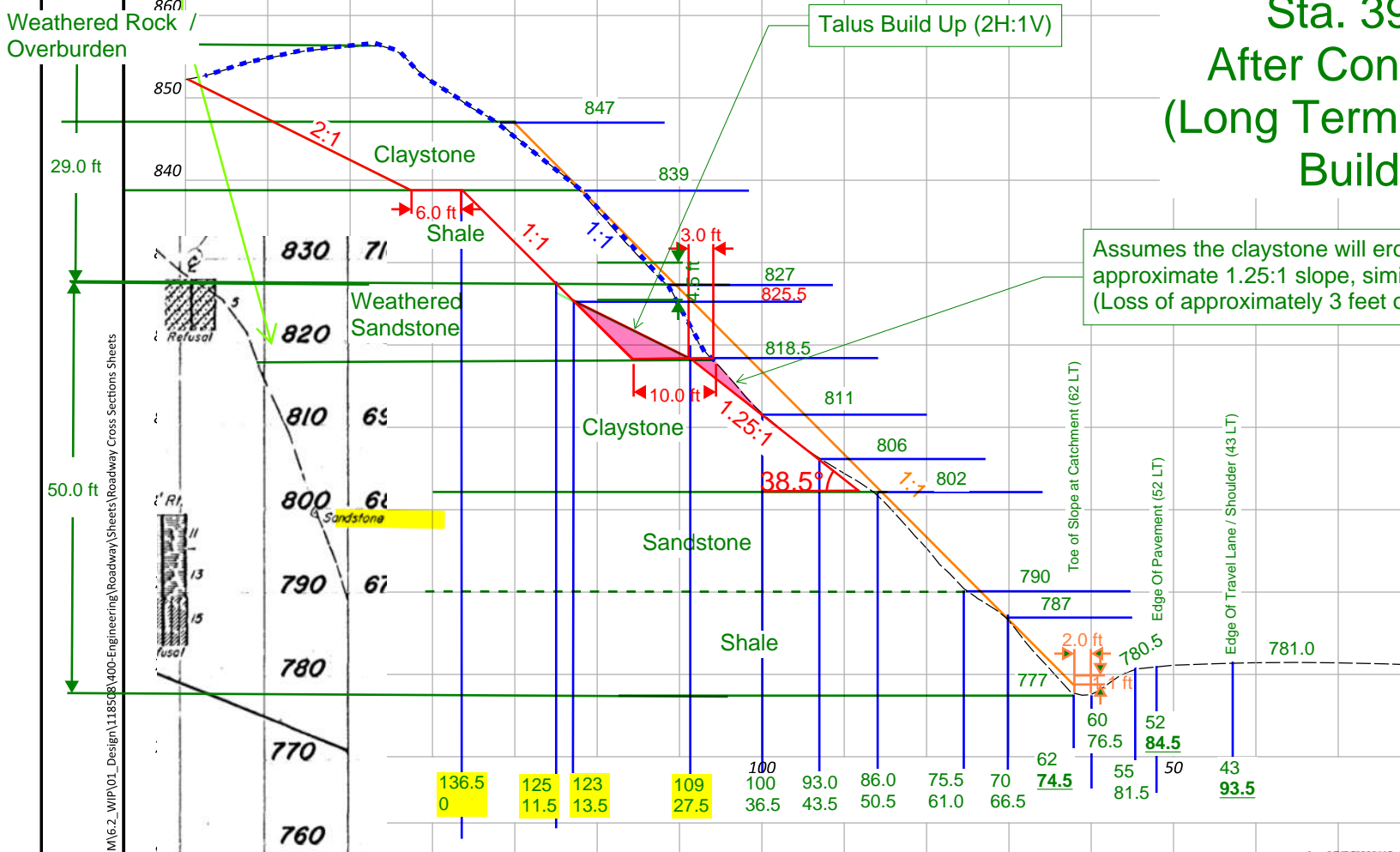
meets 95%

NOTE: CRSP Input/Output values provided for final analysis for each respective boulder size

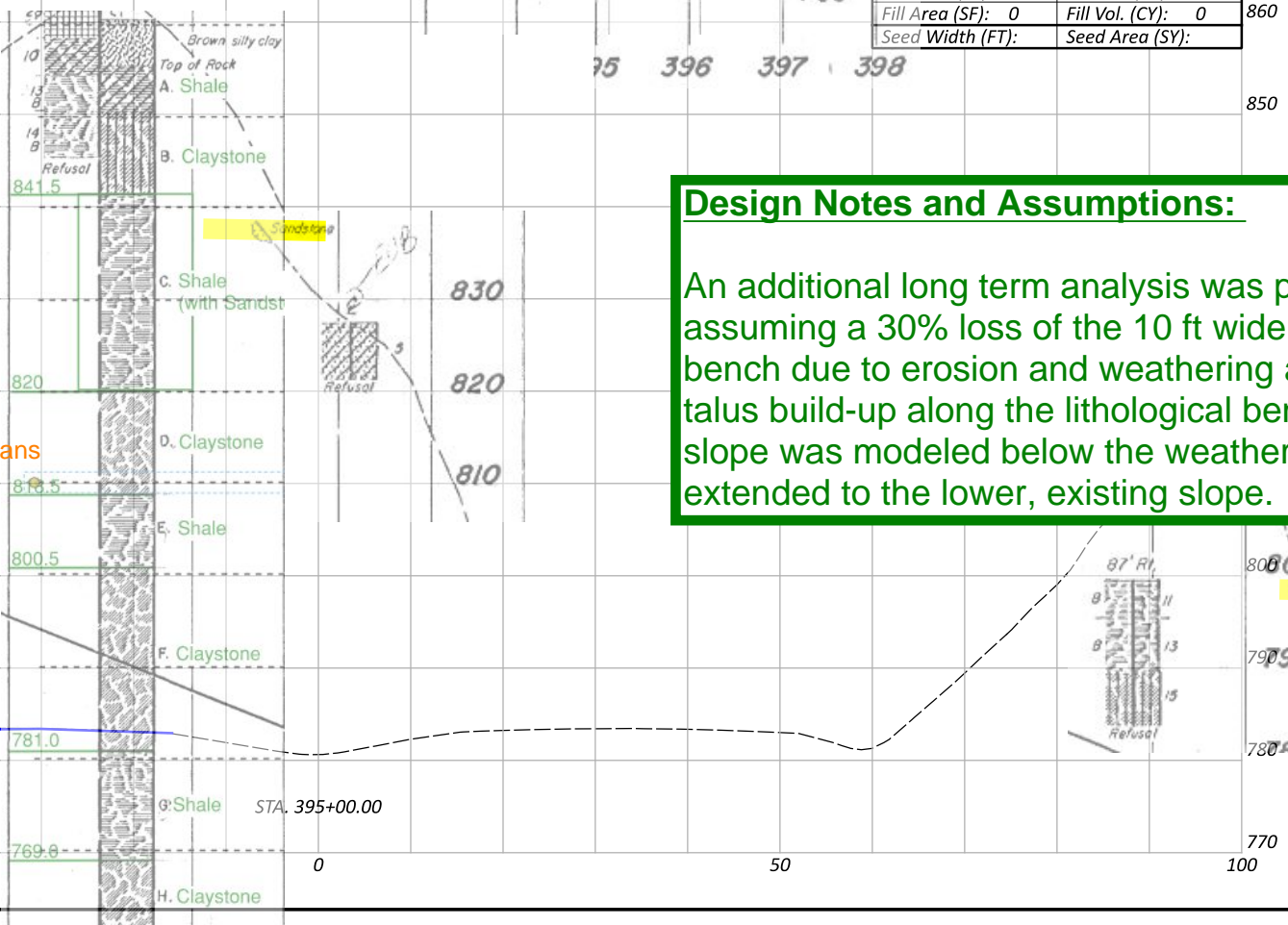
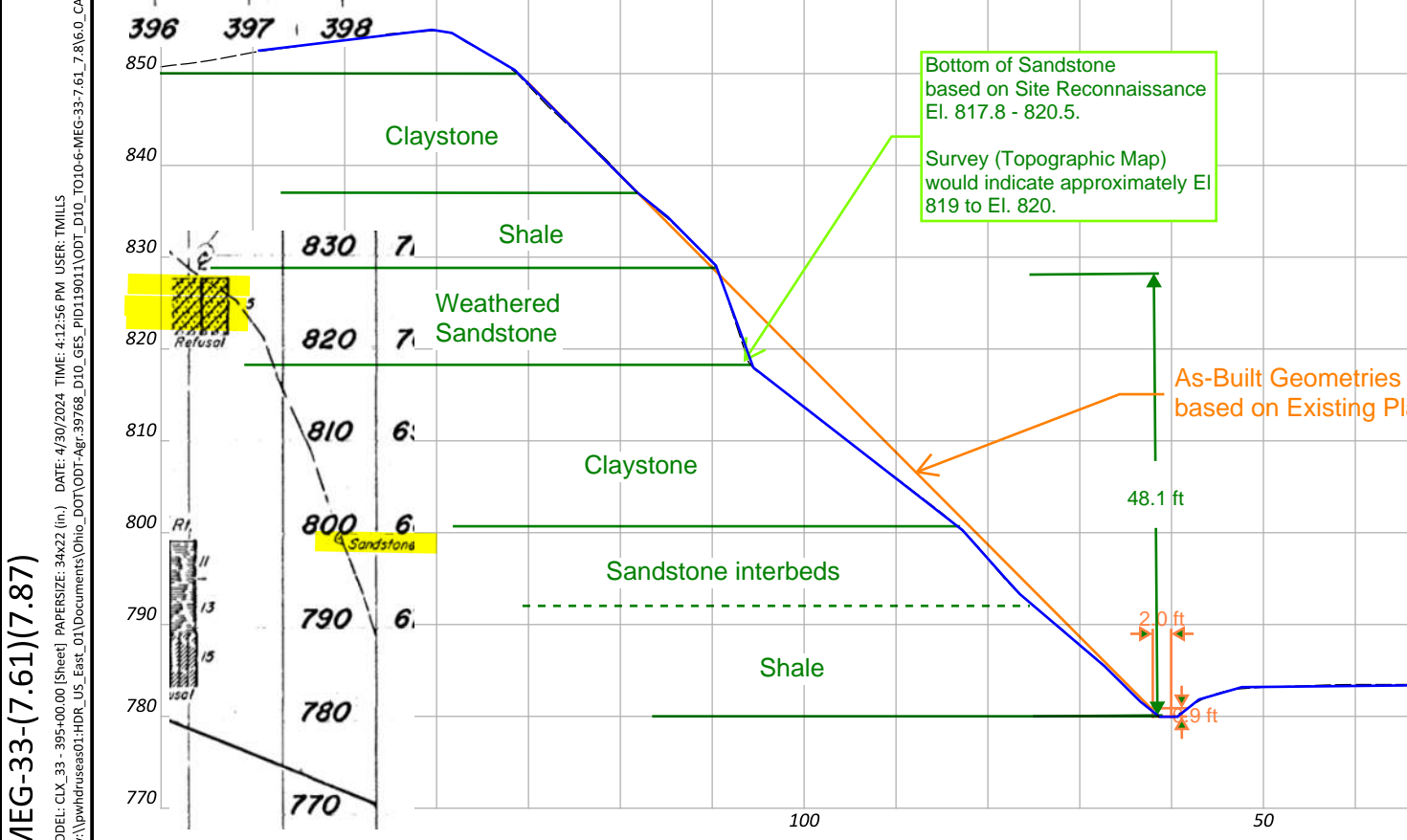
Bottom of Sandstone based on Site Reconnaissance El. 817.8 - 820.5

# DESIGN SECTION Sta. 395+50 After Construction (Long Term with Talus Build-up)

Cut Area (SF):	0	Cut Vol. (CY):	0
Fill Area (SF):	0	Fill Vol. (CY):	0
Seed Width (FT):		Seed Area (SY):	



Cut Area (SF):	0	Cut Vol. (CY):	0
Fill Area (SF):	0	Fill Vol. (CY):	0
Seed Width (FT):		Seed Area (SY):	



**Design Notes and Assumptions:**

An additional long term analysis was performed assuming a 30% loss of the 10 ft wide lithological bench due to erosion and weathering as well as with talus build-up along the lithological bench. A 1.25H:1V slope was modeled below the weathered bench and extended to the lower, existing slope.

MEG-33-(7.61)(7.87)

MODEL: CLK\_33 - 395+00.00 [Sheet] PAPER SIZE: 34x22 (in.) DATE: 4/30/2024 TIME: 4:12:56 PM USER: TMMILLS  
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CROSS SECTIONS US 33  
STA. 395+00 TO STA. 395+50

DESIGN AGENCY	HR
DESIGNER	TDM
REVIEWER	PJD MM-DD-YY
PROJECT ID	118508
SHEET TOTAL	P.0 0

Sheet Totals	Seeding	Cut	Fill

Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Proposed - Long Term (1.25H:1V) with Talus Build-up**  
 Subject: **Sta. 395+50**

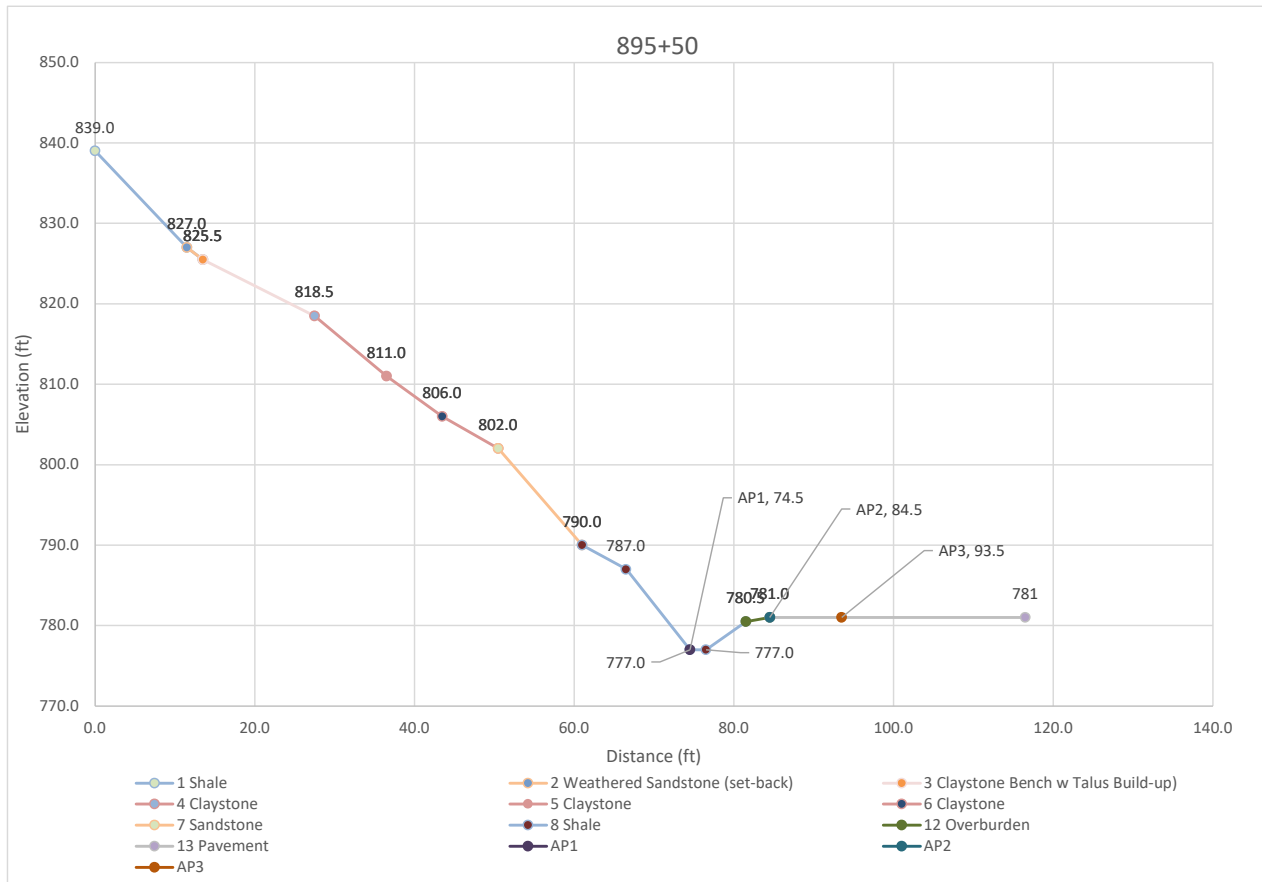
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 Checked: **AKB** Date: **05/21/24**  
 Page: **1** of **2**

	<b>X</b>	<b>Y</b>	<b>Description</b>	
Analysis Pt 1 =	AP1	74.5	777	Toe of Slope @ Catchment
Analysis Pt 2 =	AP2	84.5	781	Edge of Pavement
Analysis Pt 3 =	AP3	93.5	781	Edge of Travel Lane

**CRSP Assumptions:** Analysis using Long Term Conditions  
 ≥95% rockfall retained at Analysis Pt 2 design criteria  
 Roughness based on field measurements and experience with bedrock of the Monongahela Group  
 Rock shape is discoidal, 1 feet to 4 feet

Upper Zone Ymax: 839 Δ Elev.  
 Upper Zone Ymin: 825.5 13.5

	Cell	Surface R	Tangent C	Normal C	Begin X	Begin Y	End X	End Y
1 Shale	1	0.75	0.75	0.15	0.0	839.0	11.5	827.0
2 Weathered Sandstone (set-back)	2	1.5	0.9	0.25	11.5	827.0	13.5	825.5
3 Claystone Bench w Talus Build-up)	3	2	0.65	0.15	13.5	825.5	27.5	818.5
4 Claystone	4	0.5	0.75	0.15	27.5	818.5	36.5	811.0
5 Claystone	5	0.5	0.75	0.15	36.5	811.0	43.5	806.0
6 Claystone	6	0.5	0.75	0.15	43.5	806.0	50.5	802.0
7 Sandstone	7	1.0	0.9	0.25	50.5	802.0	61.0	790.0
8 Shale	8	0.75	0.75	0.15	61.0	790.0	66.5	787.0
9 Shale	9	0.75	0.75	0.15	66.5	787.0	74.5	777.0
10 Shale	10	0.75	0.75	0.15	74.5	777.0	76.5	777.0
11 Shale	11	0.75	0.75	0.15	76.5	777.0	81.5	780.5
12 Overburden	12	2.0	0.65	0.15	81.5	780.5	84.5	781.0
13 Pavement	13	0	1	1	84.5	781.0	93.5	781
14 Pavement	14	0	1	1	93.5	781.0	116.5	781



Project: **MEG-33-7.61/7.8 Rockfall**  
 County: **Meigs**  
 Option: **Proposed - Long Term (1.25H:1V) with Talus Build-**  
 Subject: **Sta. 395+50**

Computed: **DCM** Date: **5/13/24**  
 Checked: **AKB** Date: **5/21/24**  
 Page: **2** of **2**

Overburden  
Claystone and Shale  
Sandstone

**Table 503-2. Hardness reference guide with CRSP coefficient values (Modified from Woodard, 2004)**

Hardness Input Code	Consistency	Field Identification	Normal Coefficient Values (Rn)	Tangential Coefficient Values (Rt)
1	Very soft	Easily penetrated several inches by fist	0.10	0.50
2	Soft	Easily penetrated several inches by thumb	0.10	0.55
3	Firm	Can be penetrated several inches by thumb with moderate effort	0.15	0.65
4	Stiff	Readily indented by thumb but penetrated only with great effort	0.15	0.70
5	Very stiff	Readily indented by thumbnail	0.20	0.75
6	Hard	Indented with difficulty by thumbnail	0.20	0.80-0.85
7	Very weak rock	Can be carved with a knife. Can be excavated readily with a point of a pick. Pieces 1 inch (25 mm) or more in thickness can be broken by finger pressure. Can be scratched by fingernail.	0.15	0.75
8	Weak rock	Can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure.	0.15	0.75
9	Slightly strong rock	Can be grooved or gouged 0.05 inch (2 mm) deep by firm pressure of a knife or pick point. Can be excavated in small chips to pieces about 1-inch (25 mm) maximum size by hard blows of the point of a geologist's pick.	0.20	0.80
10	Moderately strong rock	Can be scratched with a knife or pick. Grooves or gouges to 1/4" (6mm) deep can be excavated by hand blows of a geologist's pick. Requires moderate hammer blows to detach hand specimens.	0.25	0.85
11	Strong rock	Can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach hand specimen. Sharp and resistant edges are present on hand specimens.	0.25-0.30	0.9
12	Very strong rock	Cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0
13	Extremely strong rock	Cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires hard repeated blows of the geologist hammer.	0.25-0.30	0.95-1.0

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**Table 503-1. CRSP Coefficient Guide for Normal and Tangential Coefficient (from Jones, et al., 2000)**

Description of Slope	Normal Coefficient (Rn)	Remarks
Smooth hard surfaces and paving	0.60-1.0	For short slopes try lower values in applicable range
Most bedrock and boulder fields	0.15-0.30	
Talus and firm soil slopes	0.12-0.20	-If max. velocity/KE* are design criteria, use lower values in range; if avg. velocity/KE* are design criteria, use higher values in range
Soft soil slopes**	0.10-0.20	

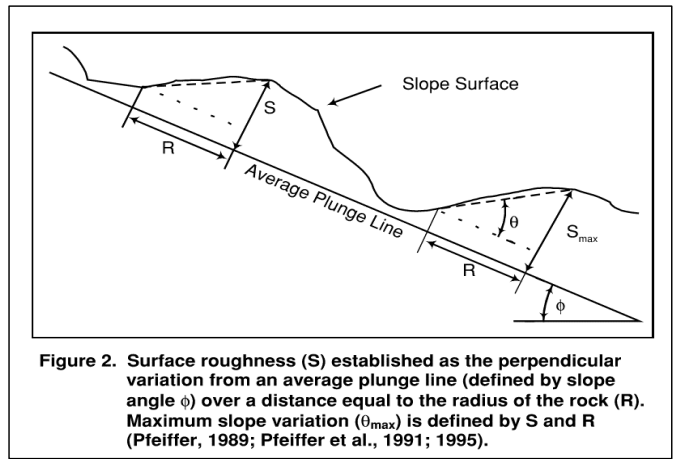
\*KE = kinetic energy  
 \*\*Soft soil slope coefficients were extrapolated from other slope types due to lack of data

Description of Slope	Tangential Coefficient (Rt)	Remarks
Smooth hard surfaces and paving	0.90-1.0	Rt is not very sensitive compared to Rn, but may be important for hard or significantly vegetated slopes
Most bedrock and boulder fields	0.75-0.95	
Talus and firm soil slopes	0.65-0.95	
Soft soil slopes*	0.50-0.80	-Use lower Rt as the density of vegetation on the slope increases

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For Pavement Use 1.0 for Rn and Rt



CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP  
Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP  
Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 74.5  
Analysis Point 2 X-Coordinate: 84.5  
Analysis Point 3 X-Coordinate: 93.5  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 825.5

Remarks: Sta. 395+50 Proposed (Longt Term with Talus Build Up)

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.75	.75	.15	0	839	11.5	827
2.	1.5	.9	.25	11.5	827	13.5	825.5
3.	2	.65	.15	13.5	825.5	27.5	818.5
4.	.5	.75	.15	27.5	818.5	36.5	811
5.	.5	.75	.15	36.5	811	43.5	806
6.	.5	.75	.15	43.5	806	50.5	802
7.	1	.9	.25	50.5	802	61	790
8.	.75	.75	.15	61	790	66.5	787
9.	.75	.75	.15	66.5	787	74.5	777
10.	.75	.75	.15	74.5	777	76.5	777
11.	.75	.75	.15	76.5	777	81.5	780.5
12.	2	.65	.15	81.5	780.5	84.5	781
13.	0	1	1	84.5	781	93.5	781
14.	0	1	1	93.5	781	116.5	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task  
10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of  
Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1  
839\_Proposed LT with Talus.dat

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 4 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Analysis Point 1: X = 74.5, Y = 777

Total Rocks Passing Analysis Point: 817

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	32.49	44231
75%	35.02	50994
90%	37.29	57076
95%	38.65	60728
98%	40.18	64827

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 47.86	Maximum: 7.78	Maximum: 85051
Average: 32.49	Average: 4.47	Average: 44231
Minimum: 23.71	G. Mean: 3.78	Std. Dev.:
10016		
Std. Dev.: 3.74	Std. Dev.: 2.41	

Remarks: Sta. 395+50 Proposed (Longt Term with Talus Build Up)

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Analysis Point 2: X = 84.5, Y = 781

Total Rocks Passing Analysis Point: 21

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	6.9	2942
75%	8.58	4227
90%	10.08	5383
95%	10.99	6076
98%	12	6855

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 9.56</b>	<b>Maximum: .28</b>	<b>Maximum: 5105</b>
Average: 6.9	Average: .08	Average: 2942
Minimum: 2.42	G. Mean: .03	Std. Dev.: 1903
Std. Dev.: 2.48	Std. Dev.: 6.9	

Remarks: Sta. 395+50 Proposed (Long Term with Talus Build Up)

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\EI 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_EI 839\_Proposed LT with Talus.dat

Analysis Point 3: X = 93.5, Y = 781

Total Rocks Passing Analysis Point: 21

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	7.17	2663
75%	8.94	3814
90%	10.54	4848
95%	11.5	5469
98%	12.58	6166

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 10.74</b>	<b>Maximum: .47</b>	<b>Maximum: 5005</b>
Average: 7.17	Average: .16	Average: 2663
Minimum: 2.7	G. Mean: .1	Std. Dev.: 1703
Std. Dev.: 2.63	Std. Dev.: 3.93	



Remarks: Sta. 395+50 Proposed (Longt Term with Talus Build Up)

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1. 24	15		4.11	2	0
2. 24	14		4.34	2	0
3. 24	13		4.68	2	0
4. 30	20		3.13	4	0
5. 29	23		2.48	1	0
6. 31	24		2.19	1	0
7. 41	34		3.21	6	2
8. 42	27		4.97	4	0
9. 48	32		3.74	8	4
10. 48	32		6.03	7	2
11. 11	6		2.68	1	0
12. 10	7		2.48	0	0
13. 11	7		2.63	0	0
14. 10	7		2.38	0	0

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

X Interval	Rocks Stopped
0 To 10 ft	0
15. To 20 ft	75
20 To 30 ft	107
30 To 40 ft	1
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	607
80 To 90 ft	189
90 To 100 ft	0
100 To 110 ft	0
110 To 116.5 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP  
Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP  
Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 74.5  
Analysis Point 2 X-Coordinate: 84.5  
Analysis Point 3 X-Coordinate: 93.5  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 825.5

Remarks: Sta. 395+50 Proposed (Longt Term with Talus Build Up)

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.75	.75	.15	0	839	11.5	827
2.	1.5	.9	.25	11.5	827	13.5	825.5
3.	2	.65	.15	13.5	825.5	27.5	818.5
4.	.5	.75	.15	27.5	818.5	36.5	811
5.	.5	.75	.15	36.5	811	43.5	806
6.	.5	.75	.15	43.5	806	50.5	802
7.	1	.9	.25	50.5	802	61	790
8.	.75	.75	.15	61	790	66.5	787
9.	.75	.75	.15	66.5	787	74.5	777
10.	.75	.75	.15	74.5	777	76.5	777
11.	.75	.75	.15	76.5	777	81.5	780.5
12.	2	.65	.15	81.5	780.5	84.5	781
13.	0	1	1	84.5	781	93.5	781
14.	0	1	1	93.5	781	116.5	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task  
10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of  
Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1  
839\_Proposed LT with Talus.dat

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 2 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Analysis Point 1: X = 74.5, Y = 777

Total Rocks Passing Analysis Point: 291

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	30.32	9315
75%	33.85	11329
90%	37.03	13141
95%	38.94	14229
98%	41.08	15450

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 46.15</b>	<b>Maximum: 8.62</b>	<b>Maximum: 19558</b>
Average: 30.32	Average: 3.78	Average: 9315
Minimum: 18.52	G. Mean: 2.61	Std. Dev.: 2983
Std. Dev.: 5.24	Std. Dev.: 4.14	

Remarks: Sta. 395+50 Proposed (Longt Term with Talus Build Up)

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Analysis Point 2: X = 84.5, Y = 781

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	3.41	170	0.05
75%	3.41	170	0.72
90%	3.41	170	1.33
95%	3.41	170	1.69
98%	3.41	170	2.1

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 3.41	Maximum: .05	Maximum: 170
Average: 3.41	Average: .05	Average: 170
Minimum: 3.41	G. Mean: .05	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 395+50 Proposed (Longt Term with Talus Build Up)

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Analysis Point 3: X = 93.5, Y = 781

Total Rocks Passing Analysis Point: 1

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)		Energy (ft-lb)
50%	3.57	150	0.1
75%	3.57	150	0.77
90%	3.57	150	1.38
95%	3.57	150	1.74
98%	3.57	150	2.15

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 3.57	Maximum: .1	Maximum: 150
Average: 3.57	Average: .1	Average: 150
Minimum: 3.57	G. Mean: .1	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: Sta. 395+50 Proposed (Longt Term with Talus Build Up)

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1. 23	13		4.09	2	0
2. 24	12		4.63	2	0
3. 23	10		4.8	2	0
4. 28	18		3.26	2	0
5. 30	20		3.06	2	0
6. 30	21		2.75	2	0
7. 41	29		5.15	7	2
8. 39	23		6.12	5	1
9. 46	30		5.24	9	3
10. 46	26		10.27	7	1
11. 7	5		1.92	0	0
12. 3	3		0	0	0
13. 4	4		0	0	0
14. 5	5		0	0	-1

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

X Interval	Rocks Stopped
0 To 10 ft	0
15. To 20 ft	442
20 To 30 ft	267
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	269
80 To 90 ft	21
90 To 100 ft	0
100 To 110 ft	0
110 To 116.5 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 74.5  
Analysis Point 2 X-Coordinate: 84.5  
Analysis Point 3 X-Coordinate: 93.5  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 825.5

Remarks: Sta. 395+50 Proposed (Longt Term with Talus Build Up)

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.75	.75	.15	0	839	11.5	827
2.	1.5	.9	.25	11.5	827	13.5	825.5
3.	2	.65	.15	13.5	825.5	27.5	818.5
4.	.5	.75	.15	27.5	818.5	36.5	811
5.	.5	.75	.15	36.5	811	43.5	806
6.	.5	.75	.15	43.5	806	50.5	802
7.	1	.9	.25	50.5	802	61	790
8.	.75	.75	.15	61	790	66.5	787
9.	.75	.75	.15	66.5	787	74.5	777
10.	.75	.75	.15	74.5	777	76.5	777
11.	.75	.75	.15	76.5	777	81.5	780.5
12.	2	.65	.15	81.5	780.5	84.5	781
13.	0	1	1	84.5	781	93.5	781
14.	0	1	1	93.5	781	116.5	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1.5 ft  
Thickness: 0.5 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\EI 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_EI 839\_Proposed LT with Talus.dat

Analysis Point 1: X = 74.5, Y = 777

Total Rocks Passing Analysis Point: 142

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	27.61	2207
75%	31.83	2813
90%	35.63	3357
95%	37.91	3684
98%	40.47	4051

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
Maximum: 40.65	Maximum: 8.82	Maximum: 4363
Average: 27.61	Average: 3.28	Average: 2207
Minimum: 12.28	G. Mean: 1.81	Std. Dev.: 896
Std. Dev.: 6.26	Std. Dev.: 6.11	

Remarks: Sta. 395+50 Proposed (Longt Term with Talus Build Up)

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\EI 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_EI 839\_Proposed LT with Talus.dat

Analysis Point 2: X = 84.5, Y = 781

NO ROCKS PAST ANALYSIS POINT 2

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Analysis Point 3: X = 93.5, Y = 781

NO ROCKS PAST ANALYSIS POINT 3

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Velocity Units: ft/sec            Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1.	22	12	4.14	2	0
2.	23	11	4.51	2	0
3.	21	10	3.91	2	0
4.	26	17	3.35	2	0
5.	27	18	3.23	2	0
6.	30	18	3.45	2	0
7.	36	26	5.89	7	2
8.	37	20	6.9	6	1
9.	41	28	6.26	9	3
10.	41	23	10.37	7	1
11.	6	6	0	0	0
12.	No rocks	past end of cell			
13.	No rocks	past end of cell			
14.	No rocks	past end of cell			

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

X Interval	Rocks Stopped
0 To 10 ft	3



15. To 20 ft	603
20 To 30 ft	252
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	135
80 To 90 ft	7
90 To 100 ft	0
100 To 110 ft	0
110 To 116.5 ft	0

CRSP Input File -J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Input File Specifications

Units of Measure: U.S.  
Total Number of Cells: 14  
Analysis Point 1 X-Coordinate: 74.5  
Analysis Point 2 X-Coordinate: 84.5  
Analysis Point 3 X-Coordinate: 93.5  
Initial Y-Top Starting Zone Coordinate: 839  
Initial Y-Base Starting Zone Coordinate: 825.5

Remarks: Sta. 395+50 Proposed (Longt Term with Talus Build Up)

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1.	.75	.75	.15	0	839	11.5	827
2.	1.5	.9	.25	11.5	827	13.5	825.5
3.	2	.65	.15	13.5	825.5	27.5	818.5
4.	.5	.75	.15	27.5	818.5	36.5	811
5.	.5	.75	.15	36.5	811	43.5	806
6.	.5	.75	.15	43.5	806	50.5	802
7.	1	.9	.25	50.5	802	61	790
8.	.75	.75	.15	61	790	66.5	787
9.	.75	.75	.15	66.5	787	74.5	777
10.	.75	.75	.15	74.5	777	76.5	777
11.	.75	.75	.15	76.5	777	81.5	780.5
12.	2	.65	.15	81.5	780.5	84.5	781
13.	0	1	1	84.5	781	93.5	781
14.	0	1	1	93.5	781	116.5	781

CRSP Simulation Specifications: Used with J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Total Number of Rocks Simulated: 1000  
Starting Velocity in X-Direction: 1 ft/sec  
Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2  
Ending Cell Number: 14  
Rock Density: 165 lb/ft<sup>3</sup>

Rock Shape: Discoidal  
Diameter: 1 ft  
Thickness: 1 ft

CRSP Analysis Point 1 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Analysis Point 1: X = 74.5, Y = 777

Total Rocks Passing Analysis Point: 50

Cumulative Probability Bounce Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)
50%	24.6	1551
75%	28.73	2014
90%	32.45	2430
95%	34.68	2679
98%	37.19	2960

Velocity (ft/sec) (ft-lb)	Bounce Height (ft)	Kinetic Energy
<b>Maximum: 38.07</b>	<b>Maximum: 6.98</b>	<b>Maximum: 3308</b>
Average: 24.6	Average: 2.92	Average: 1551
Minimum: 13.56	G. Mean: 1.69	Std. Dev.: 684
Std. Dev.: 6.12	Std. Dev.: 5.18	

Remarks: Sta. 395+50 Proposed (Longt Term with Talus Build Up)

CRSP Analysis Point 2 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Analysis Point 2: X = 84.5, Y = 781

**NO ROCKS PAST ANALYSIS POINT 2**

CRSP Analysis Point 3 Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Analysis Point 3: X = 93.5, Y = 781

NO ROCKS PAST ANALYSIS POINT 3

CRSP Data Collected at End of Each Cell - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

Velocity Units: ft/sec      Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1. 23	10		4.01	2	0
2. 21	10		4.29	2	0
3. 21	11		4.46	2	0
4. 27	16		4.12	3	0
5. 26	17		4.39	3	0
6. 24	16		4.03	2	0
7. 37	23		7.32	6	2
8. 35	17		6.46	2	0
9. 38	25		6.12	7	2
10. 35	21		10.81	5	1
11. No rocks	past end of cell				
12. No rocks	past end of cell				
13. No rocks	past end of cell				
14. No rocks	past end of cell				

CRSP Rocks Stopped Data - J:\ODOT-District 10 GES\Task 10-6 MEG-33-7.61\_7.87\CRSP Analyses\Sta 395+50\E1 839 Top of Generator\20240514\_MEG-33-7.61\_7.87\_CRSP Analysis\_Sta 39550\_E1 839\_Proposed LT with Talus.dat

X Interval	Rocks Stopped
0 To 10 ft	158

15. To 20 ft	659
20 To 30 ft	130
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	3
70 To 80 ft	50
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 116.5 ft	0

MEG-33-7.87  
Proposed Benching

Sta. 393+00 to Sta. 397+00



Bottom of Sandstone Bluff Layer -  
Els. 817.8, 820.5, 817.6, 819.8  
Measured heights of 3 ft to 8ft.

Top Sandstone Out Crop  
El. 797.5

Bottom of Sandstone Out Crop  
El. 792.7

109.0 ft

115.0 ft

117.5 ft

MP 8 (Sign)

Exposed Shale along cut face run-off  
rill extending from Approx. El 768.1 to  
the bottom of the roadway drainage  
ditch.

396

397

398

399

401

Ex LA-R/W

Ex LA-R/W

Ex LA-R/W

Ex LA-R/W

Ex LA-R/W

Ex LA-R/W

Ex LA-R/W

Ex LA-R/W

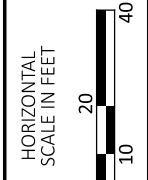
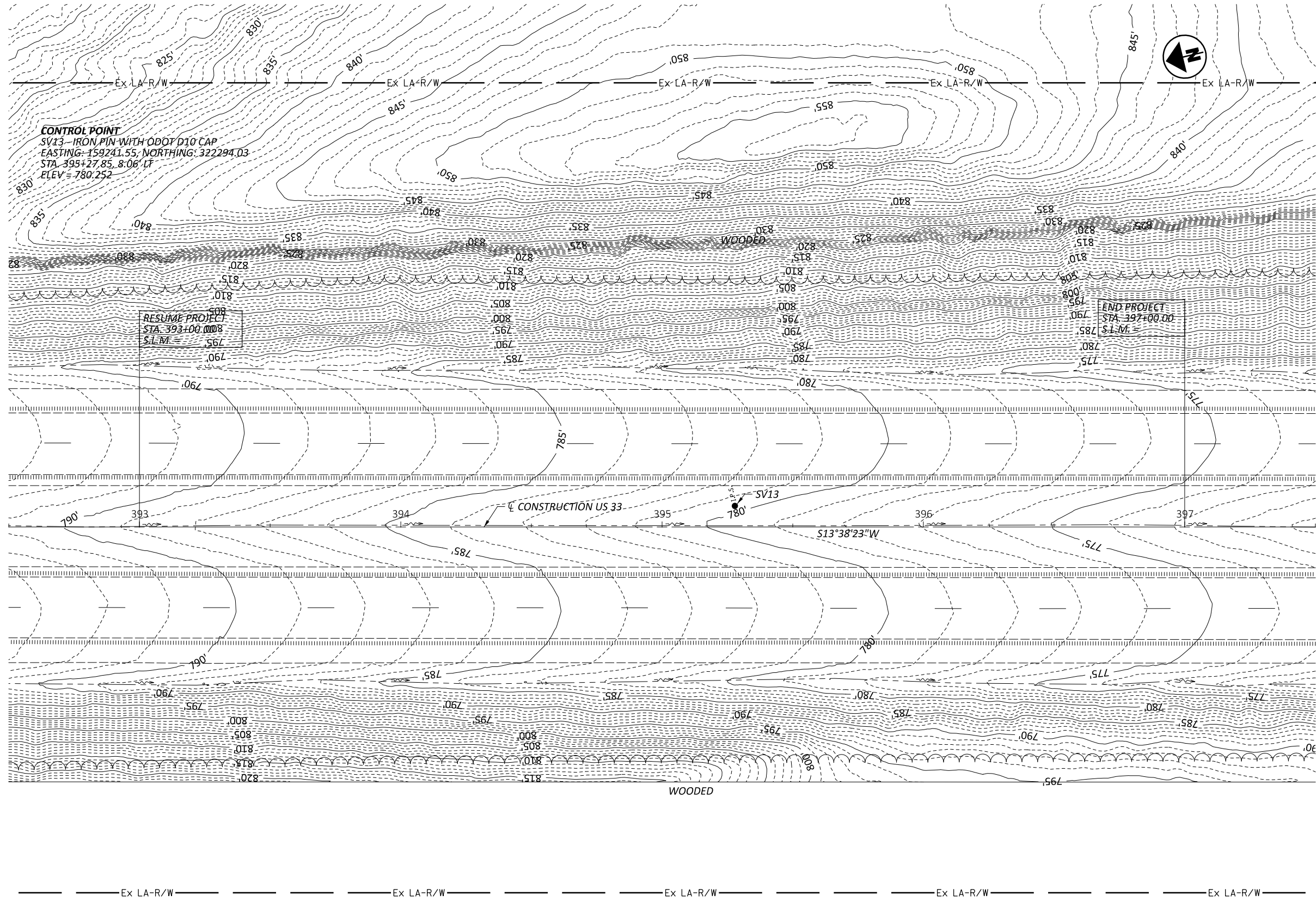
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Ex LA-R/W

Ex LA-R/W

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Ex LA-R/W



PLAN US 33  
STA. 393+00 TO STA. 397+00

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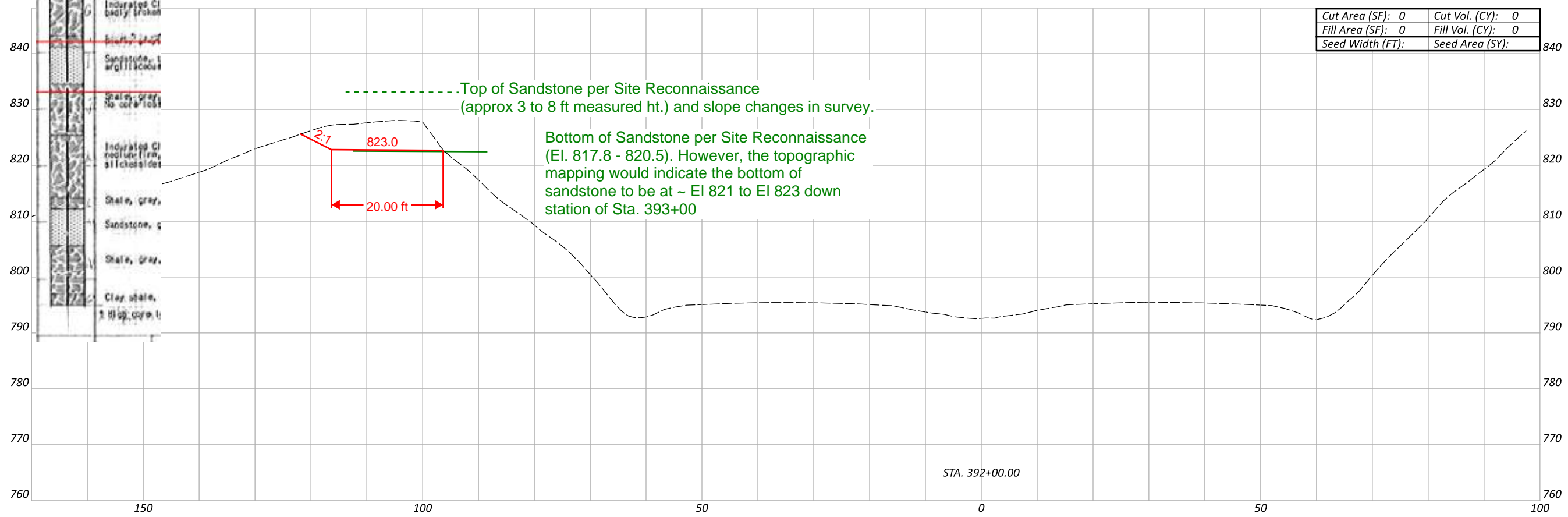
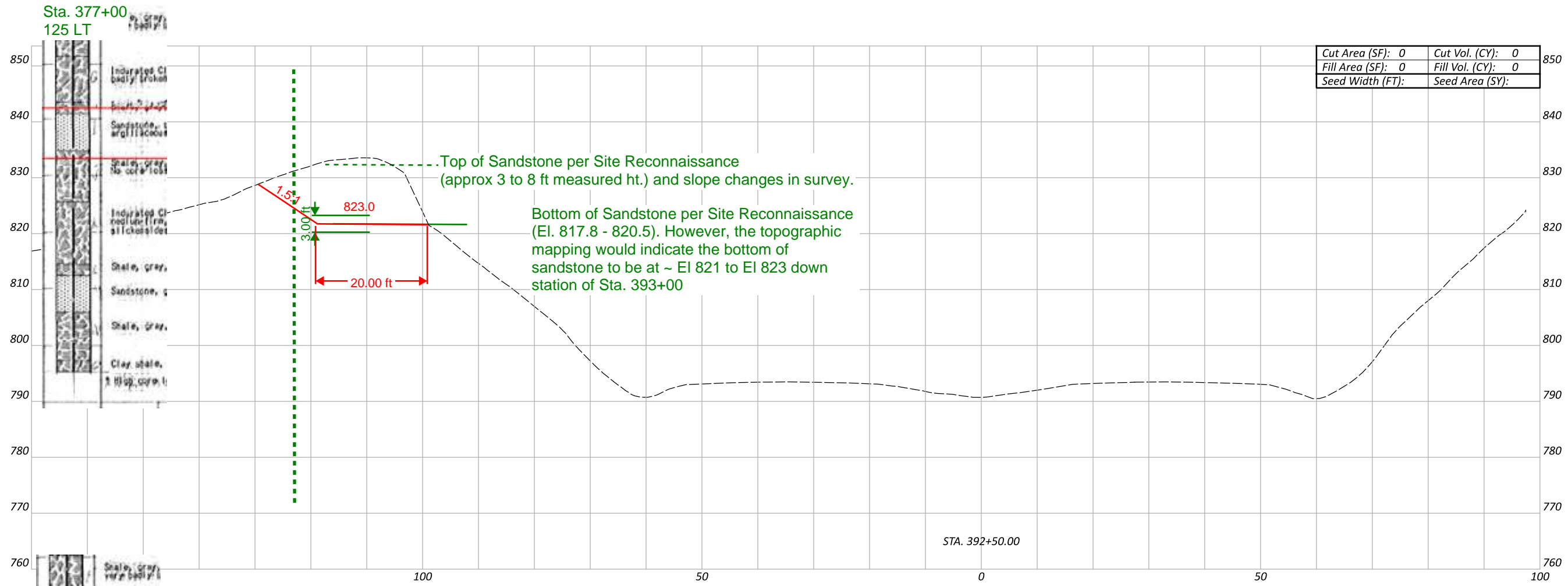
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CROSS SECTIONS US 33  
 STA. 392+00 TO STA. 392+50

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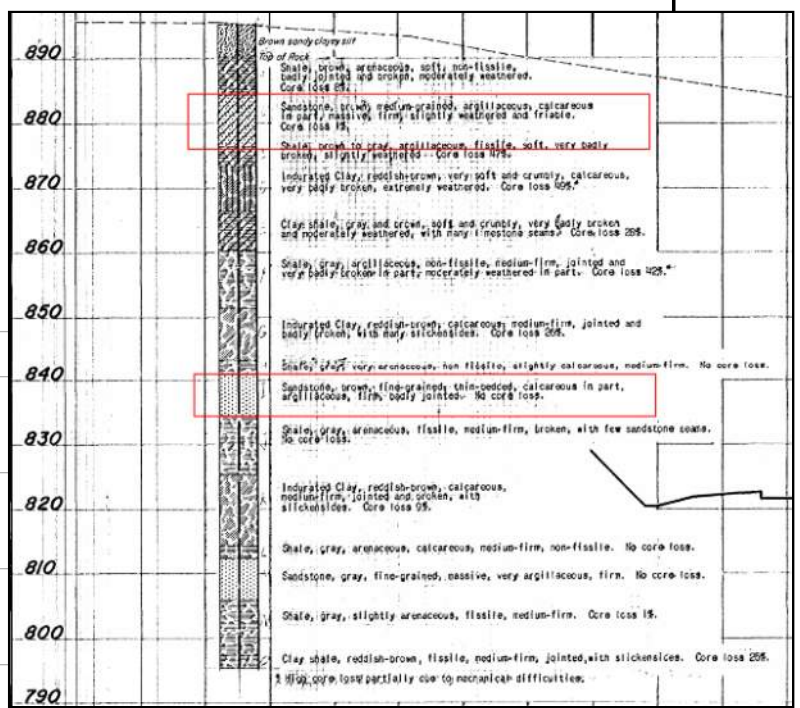
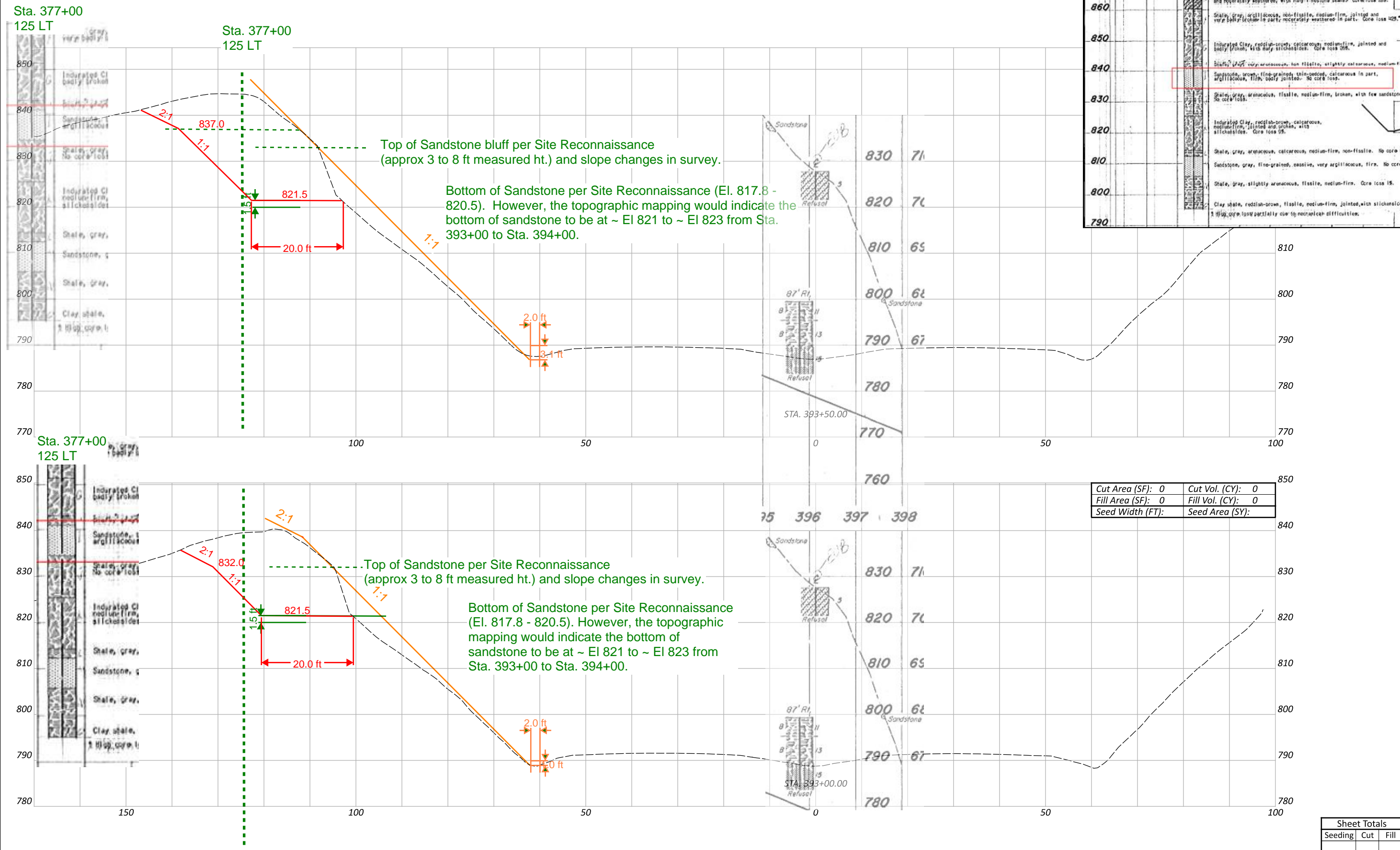


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REVIEWER  
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CROSS SECTIONS  
STA. 393+00 TO STA.

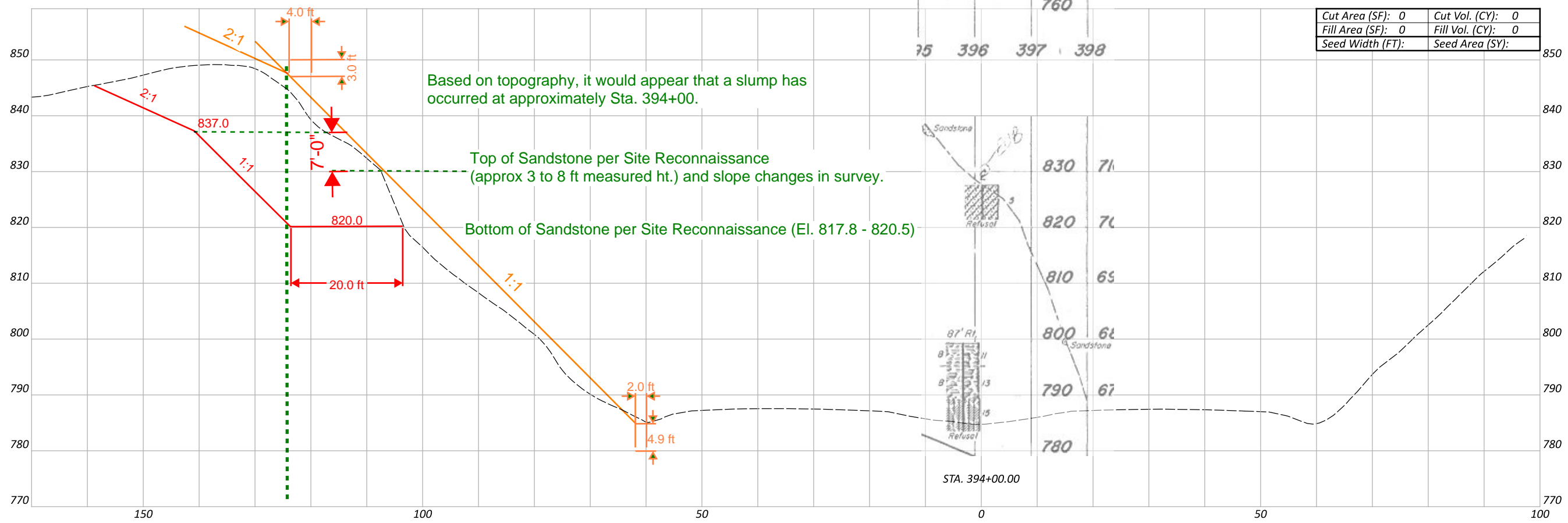
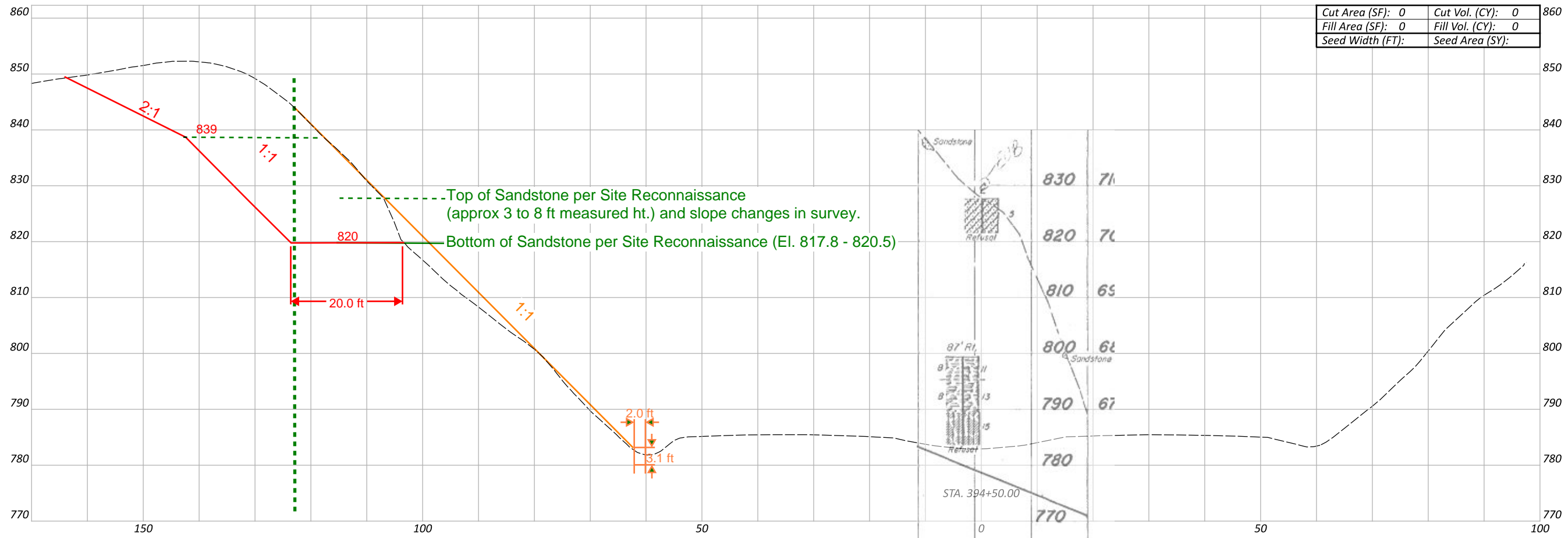
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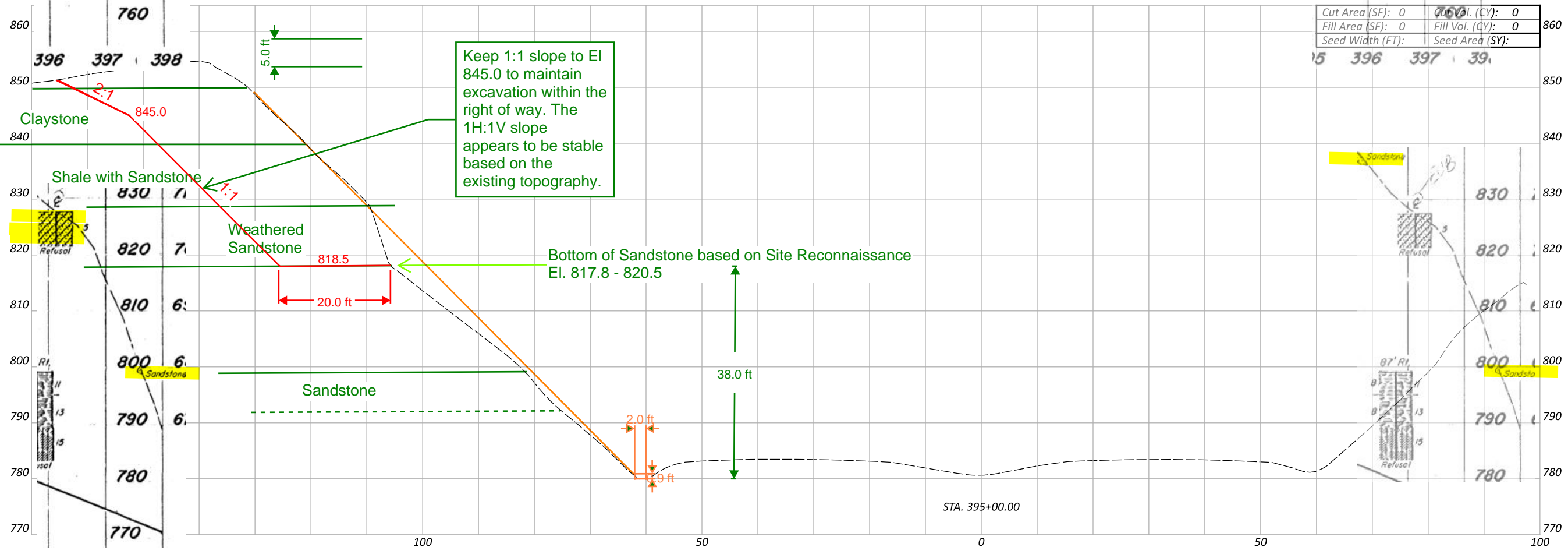
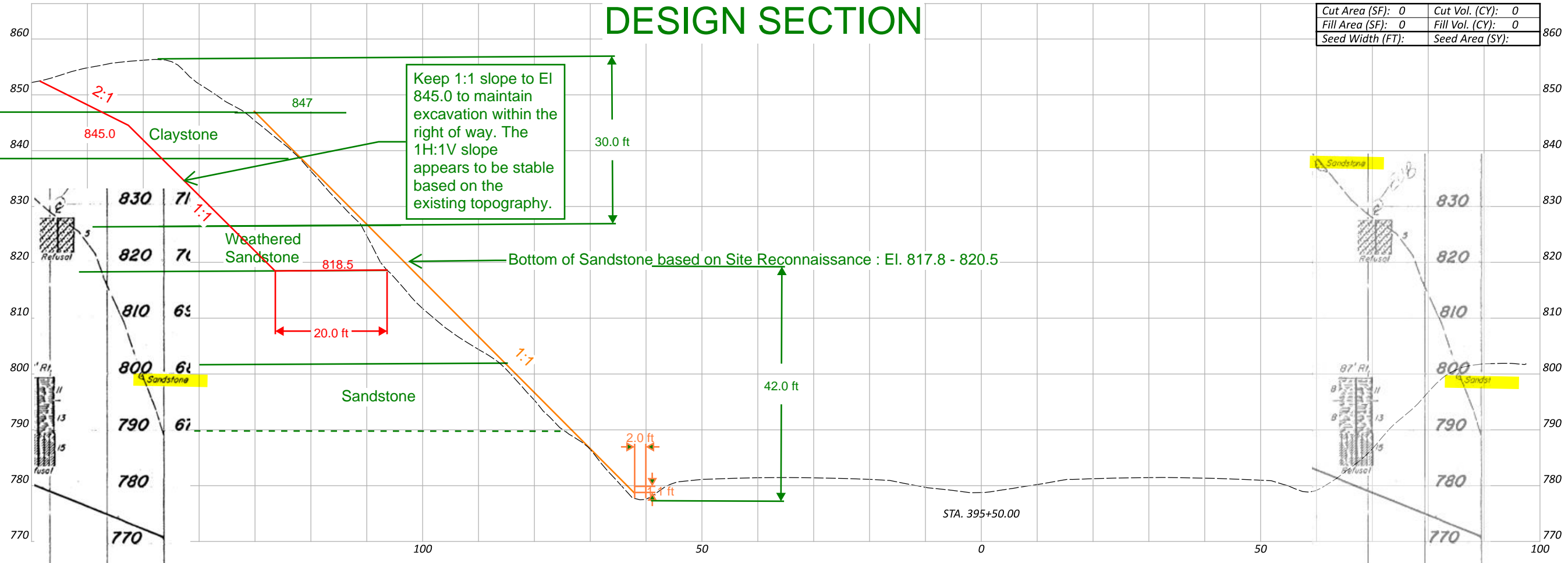


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# DESIGN SECTION



CROSS SECTIONS US 33  
 STA. 395+00 TO STA. 395+50

DESIGN AGENCY



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REVIEWER

PJD MM-DD-YY

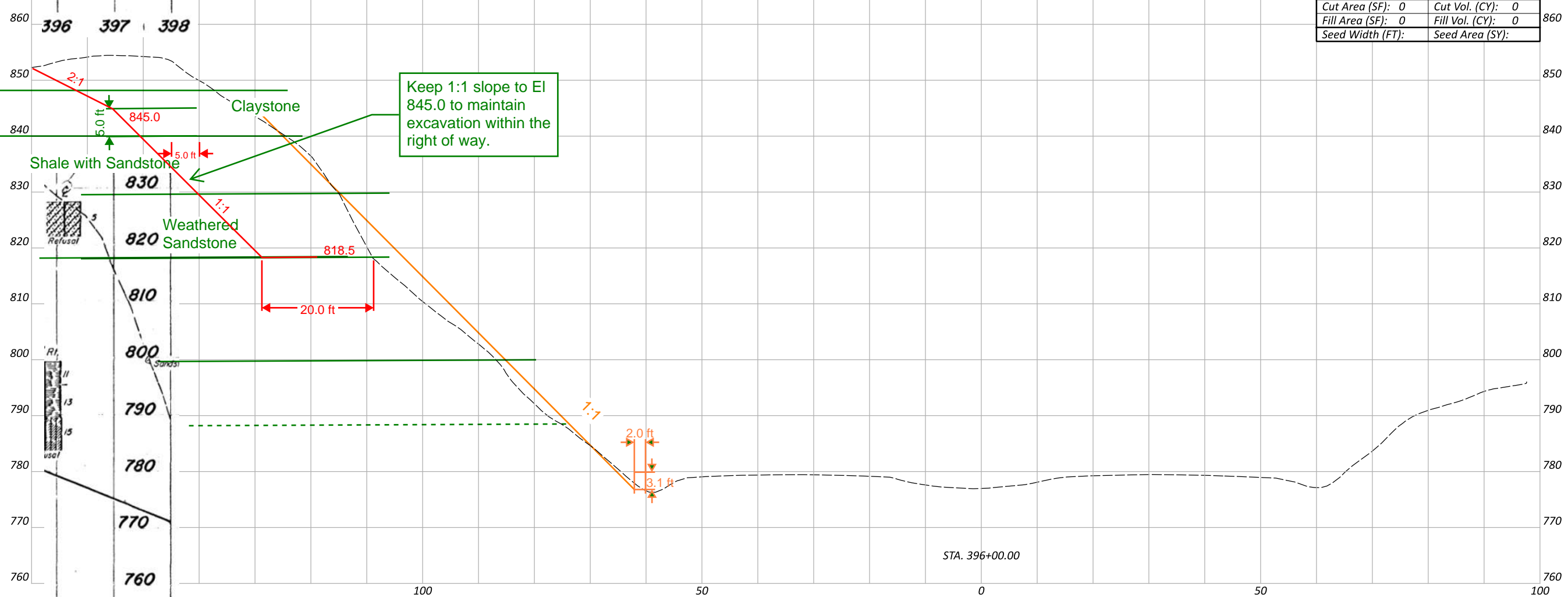
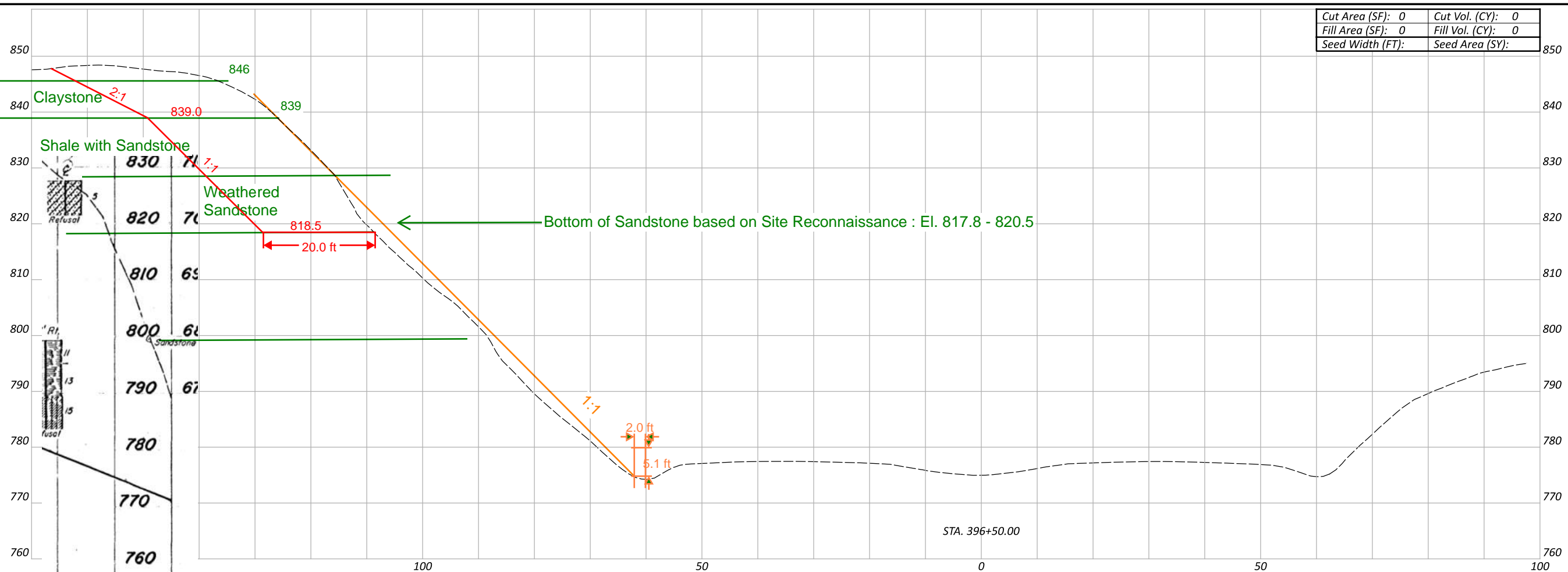
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CROSS SECTIONS US 33  
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DESIGN AGENCY



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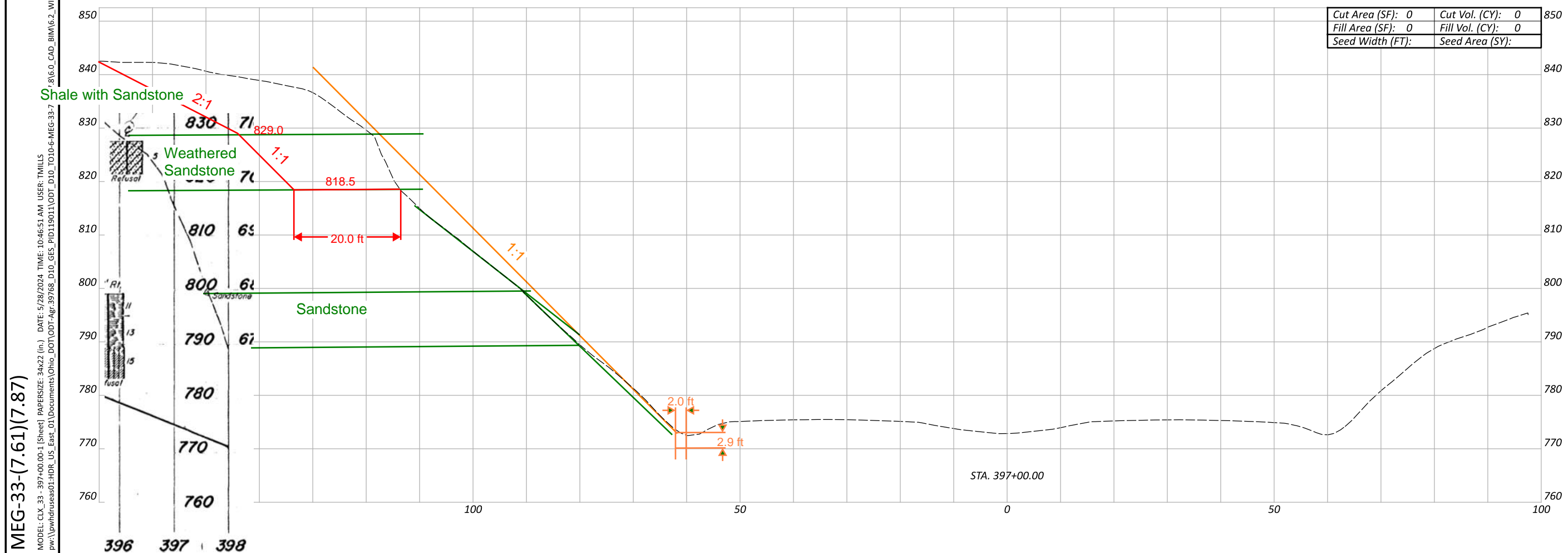
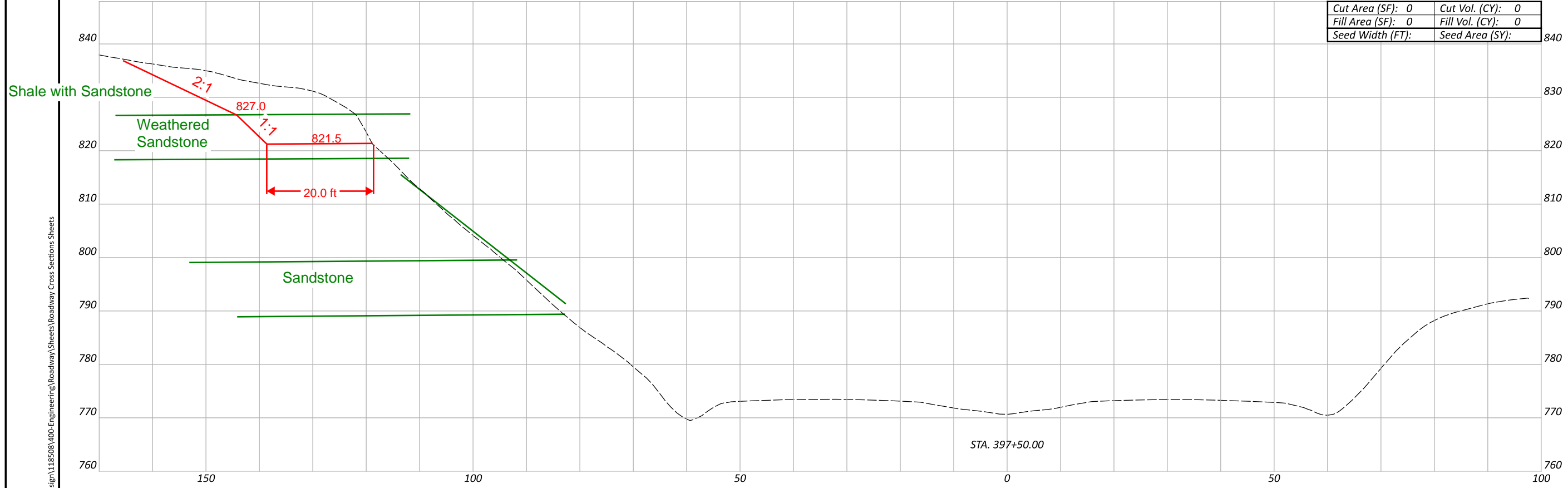
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CROSS SECTIONS US 33  
 STA. 397+00 TO STA. 397+50

DESIGN AGENCY



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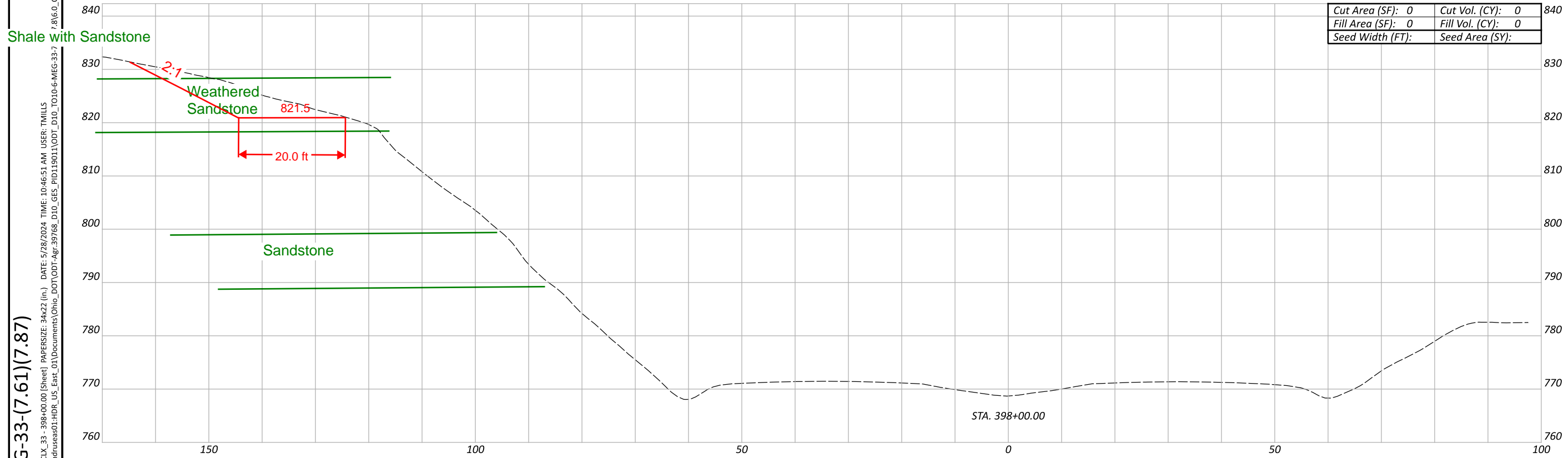
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