

When a Simple Span Bridge Wasn't so Simple

ROUTE 163 OVER BONNE FEMME CREEK

by

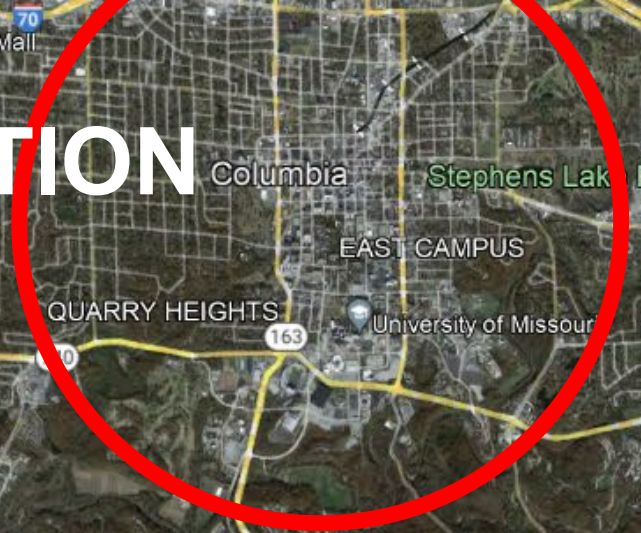
**JON DERNER, PE, SE
ASSISTANT BUSINESS UNIT LEADER, STRUCTURAL**

TEAM CONFERENCE - MARCH 2024

AGENDA

- Background
- Project Criteria
 - Hydraulic Design and Bank Stabilization
 - Geotech Investigation
- Construction
 - Cave Portal Discovery
 - Cave Exploration
 - Additional Considerations
 - Scoped Solutions
 - Final Solution
- Conclusions

PROJECT LOCATION



Devil's Ice Box

Approximate Project Location



BACKGROUND

- Originally constructed in 1960's?
- Single span adjacent channel beam founded on closed abutments
- 26' Roadway
- Span is approximately 36'
- Opening is approximately 34' wide and 12' high

BACKGROUND

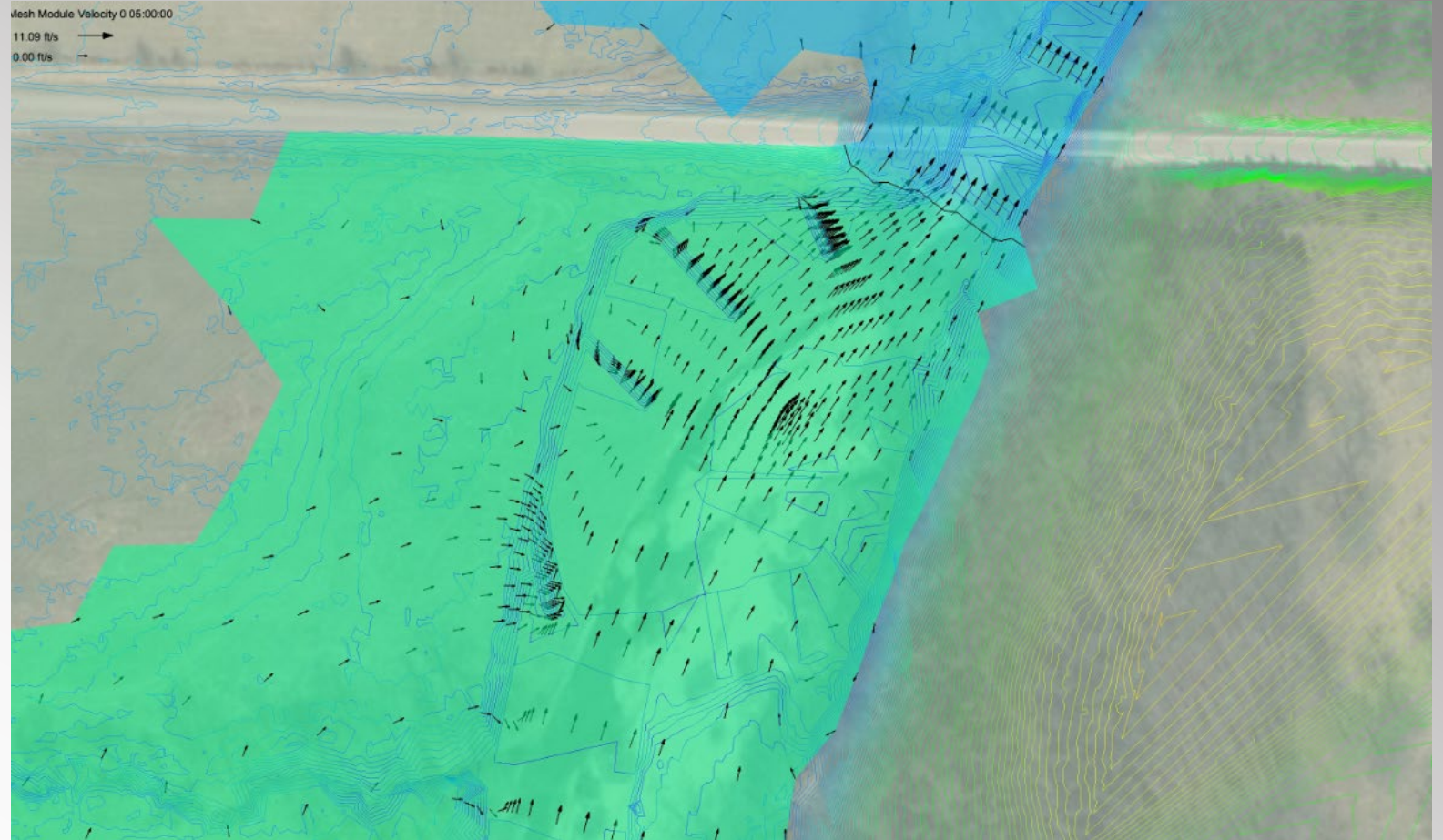


BACKGROUND

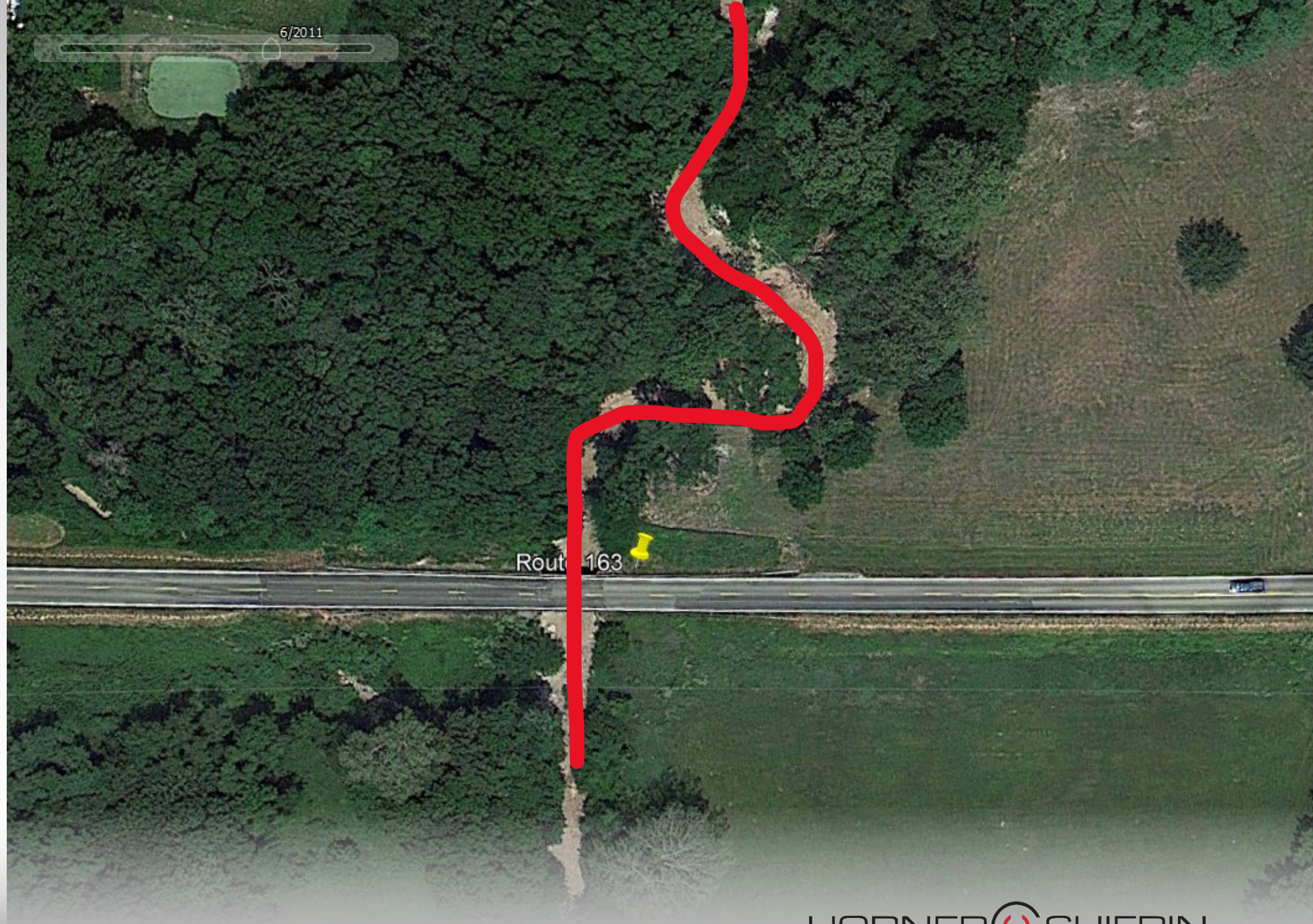


2D HYDRAULICS

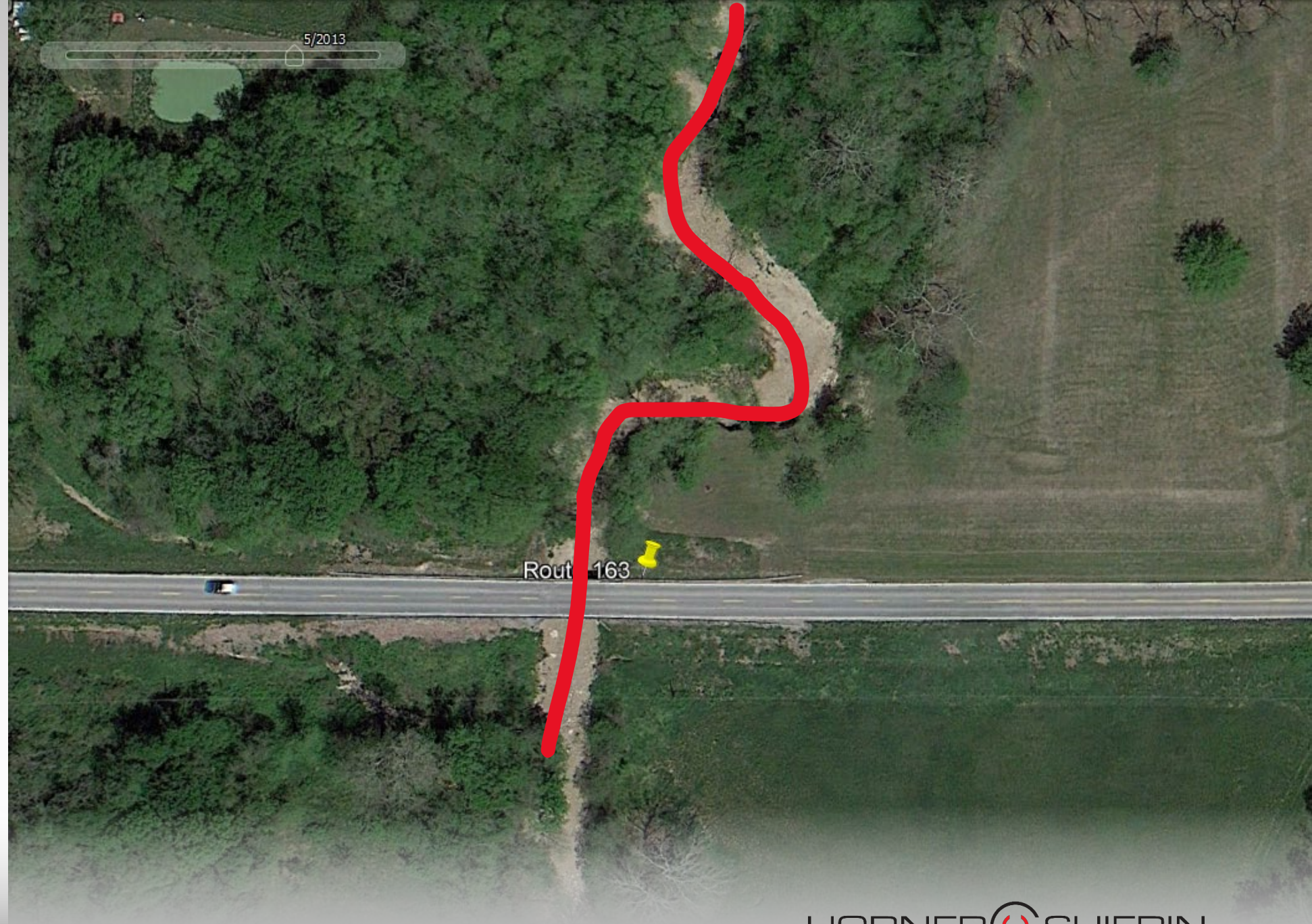
- One of our first 2D hydraulics to evaluate flow patterns and establish stream bank velocities to accurately estimate scour and what is required some bank stabilization recommendations.



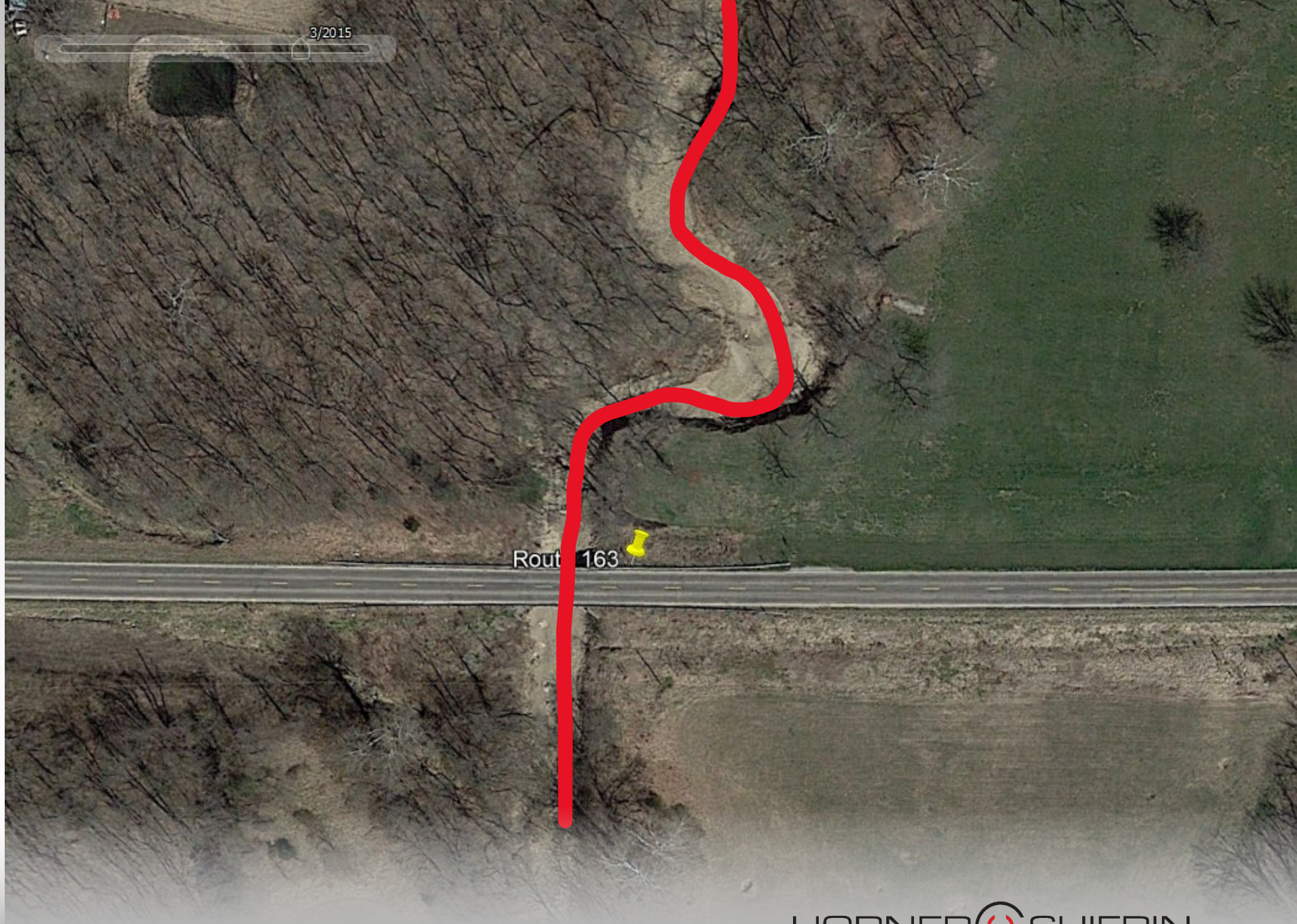
STREAM MIGRATION 2011



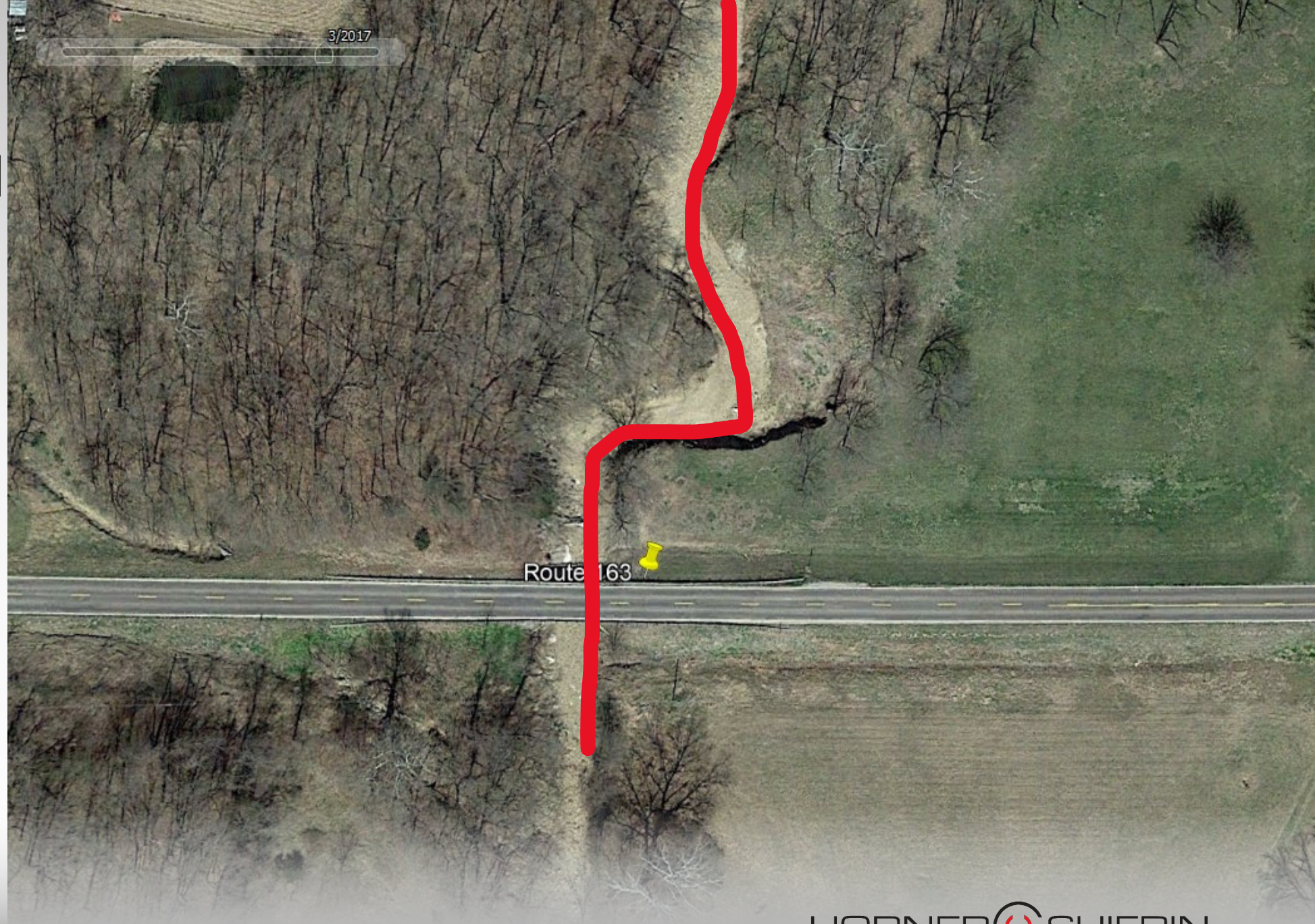
STREAM MIGRATION 2013



STREAM MIGRATION 2015



STREAM MIGRATION 2017



STREAM MIGRATION 2019



STREAM MIGRATION – 2019

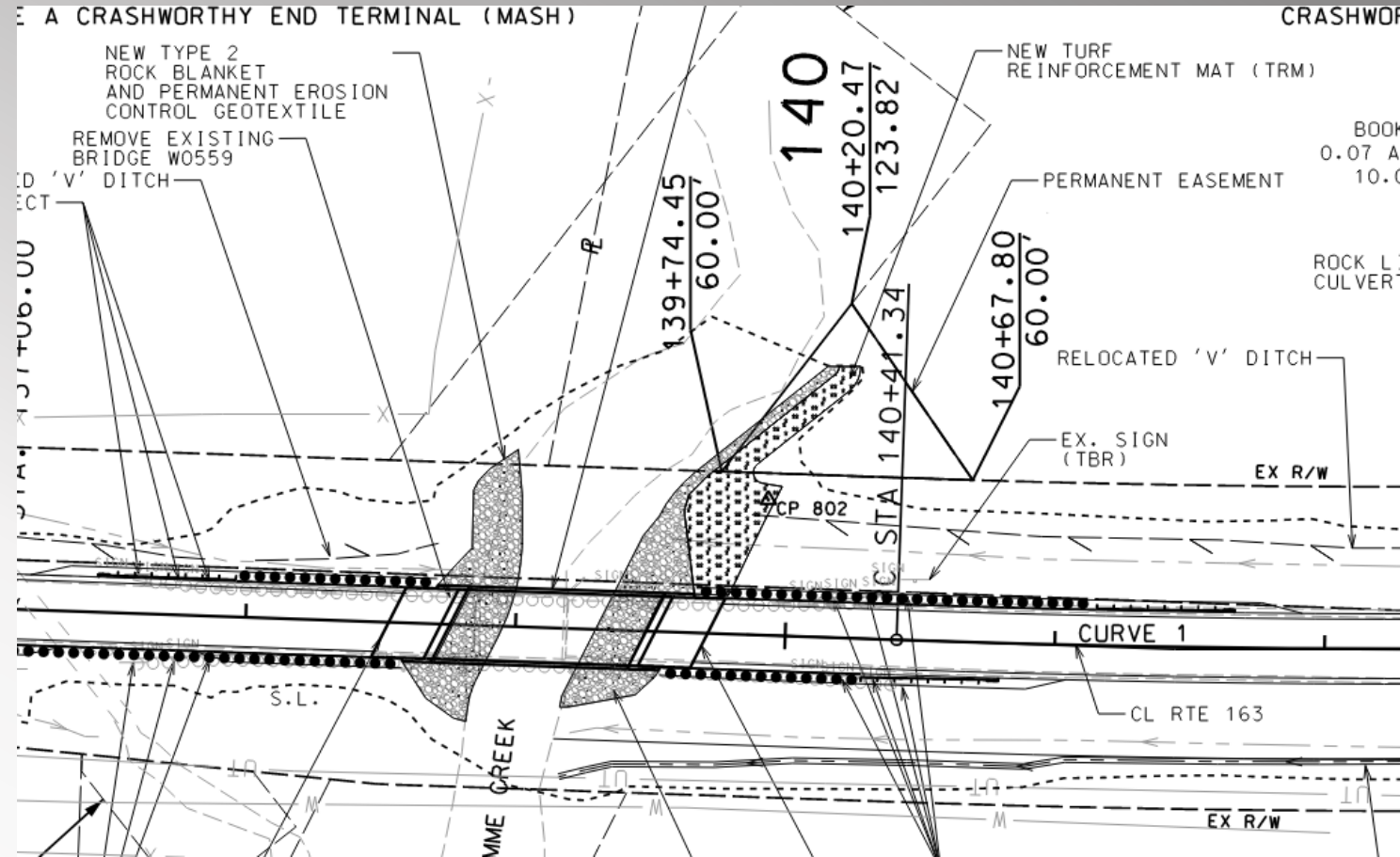


STREAM MIGRATION 2022



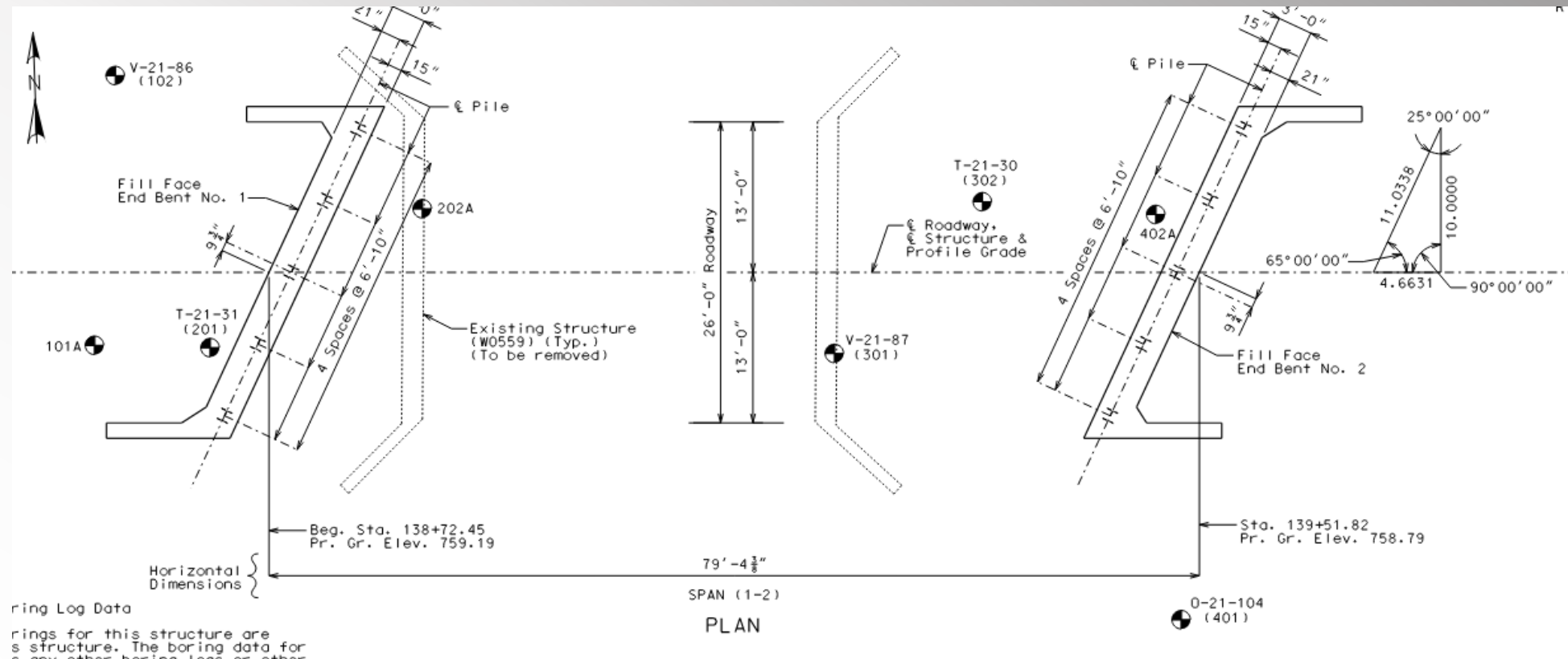
STREAM BANK STABILIZATION

- Use of Turf Reinforcement Mat (TRM)
- Protected End Bents with Type 2 Rock Blankets and extended further upstream than typical



INITIAL GEOTECHNICAL INVESTIGATION

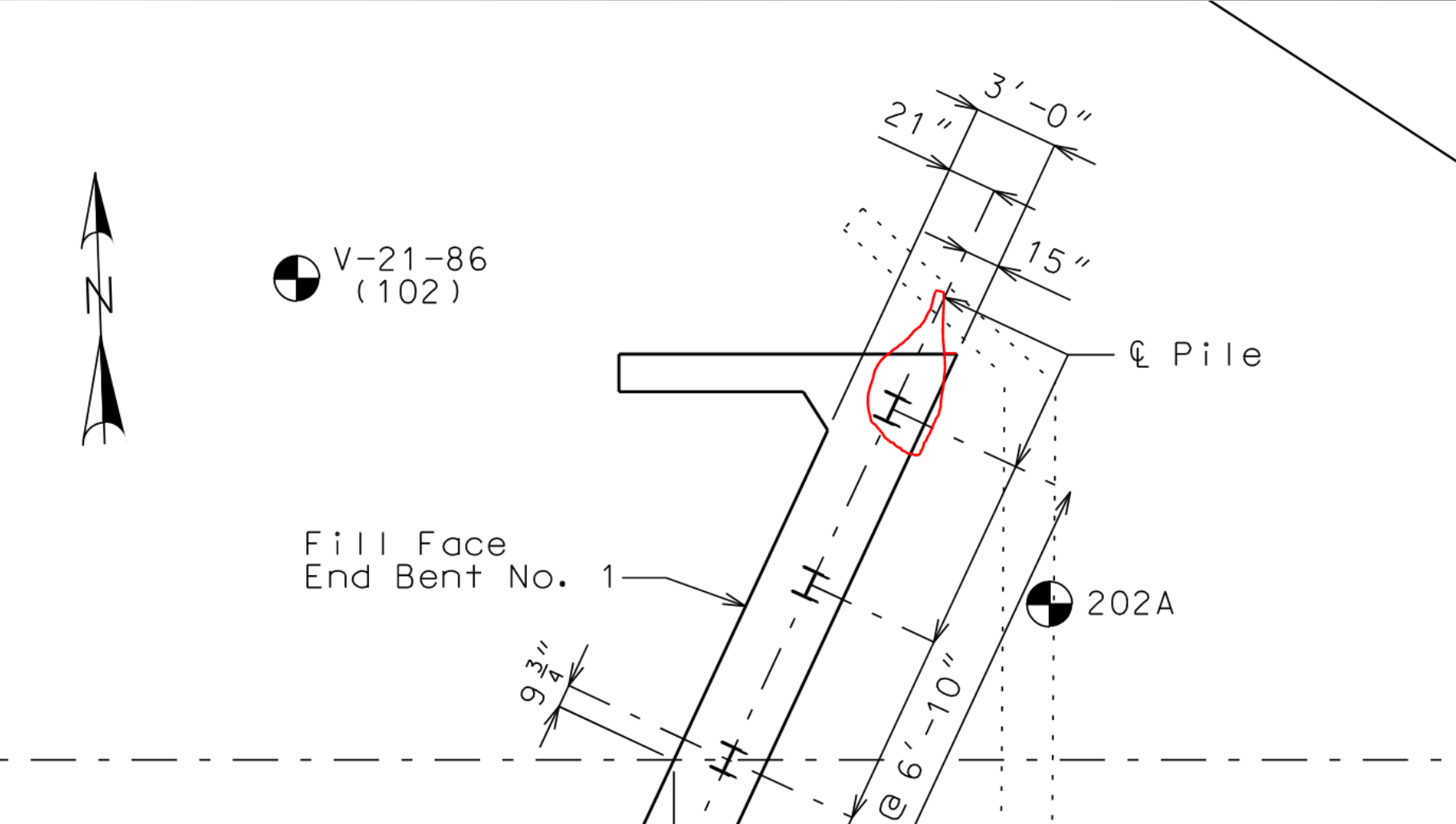
- 8 Initial Borings



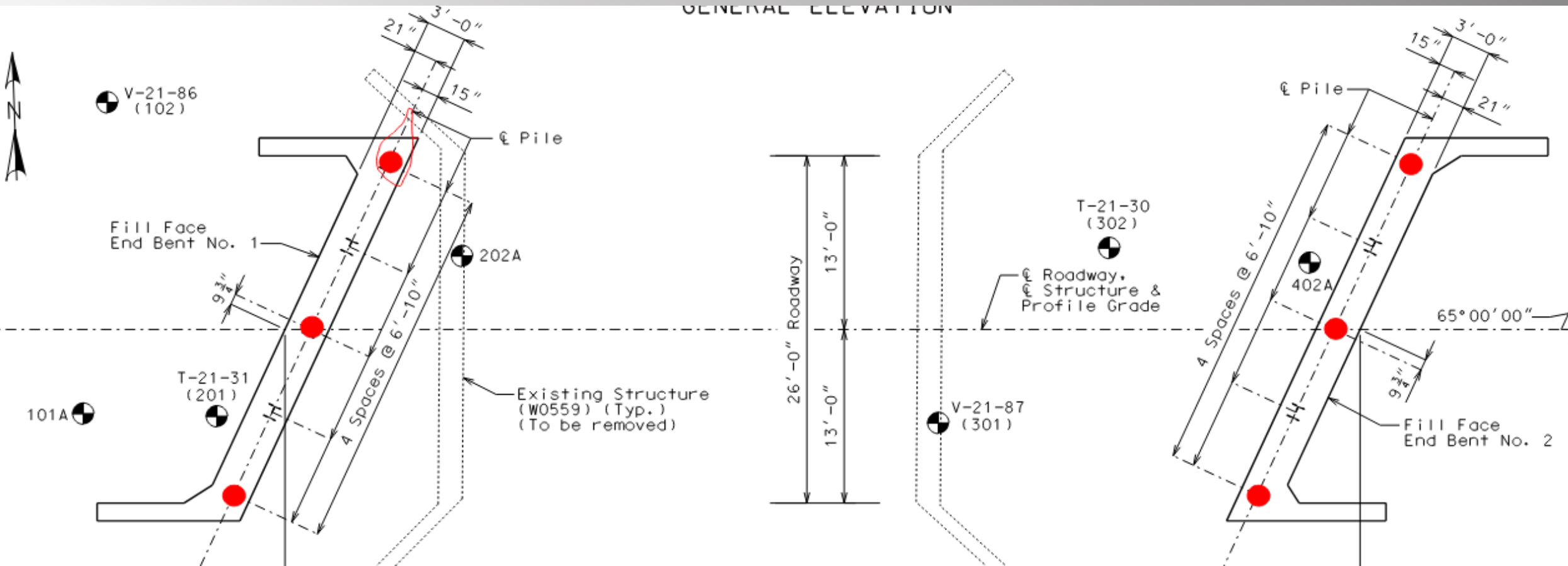
ADDITIONAL GEOTECHNICAL INVESTIGATION



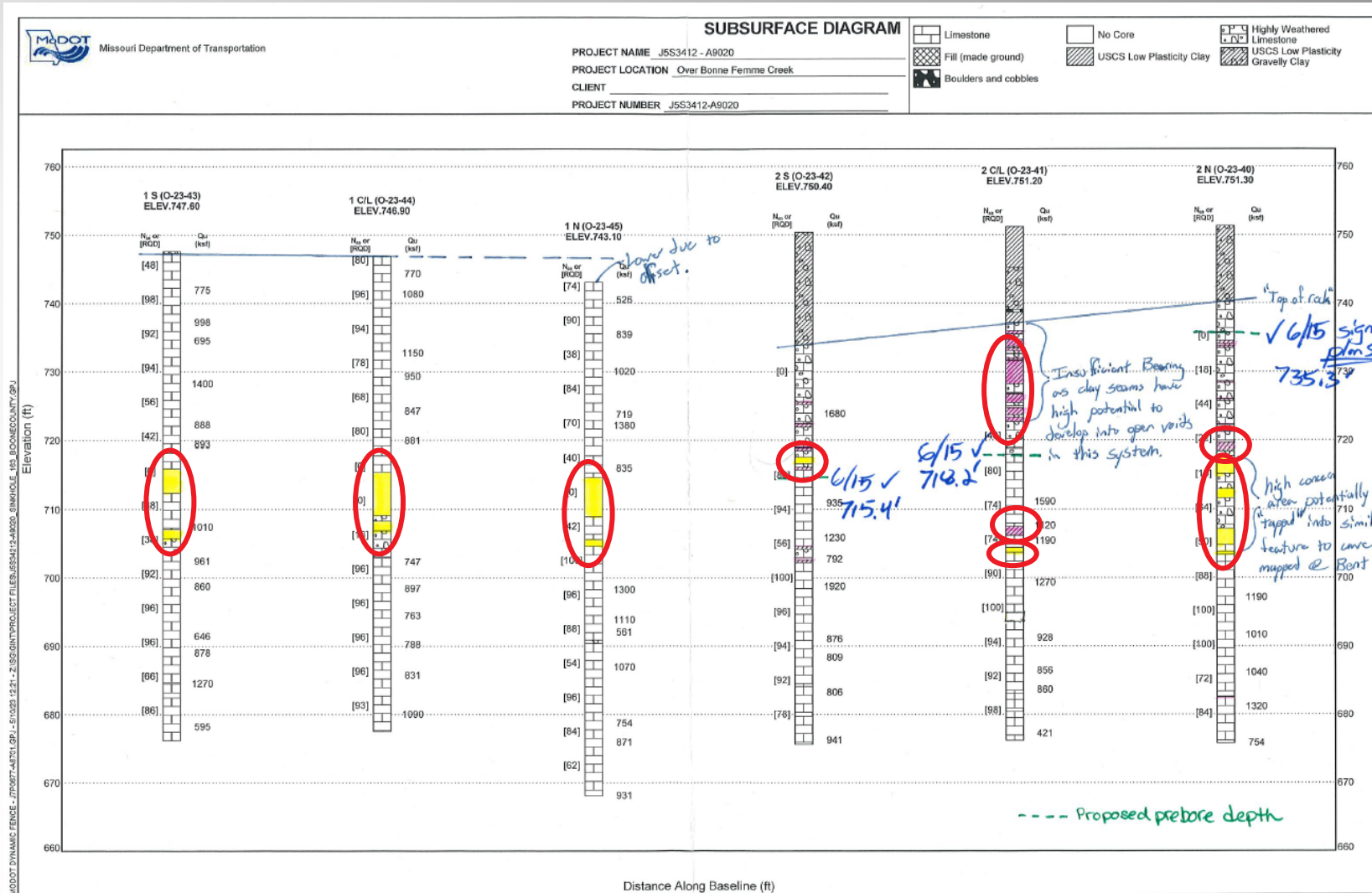
ADDITIONAL GEOTECHNICAL INVESTIGATION



ADDITIONAL GEOTECHNICAL INVESTIGATION



ADDITIONAL GEOTECHNICAL INVESTIGATION



CAVE EXPLORATION



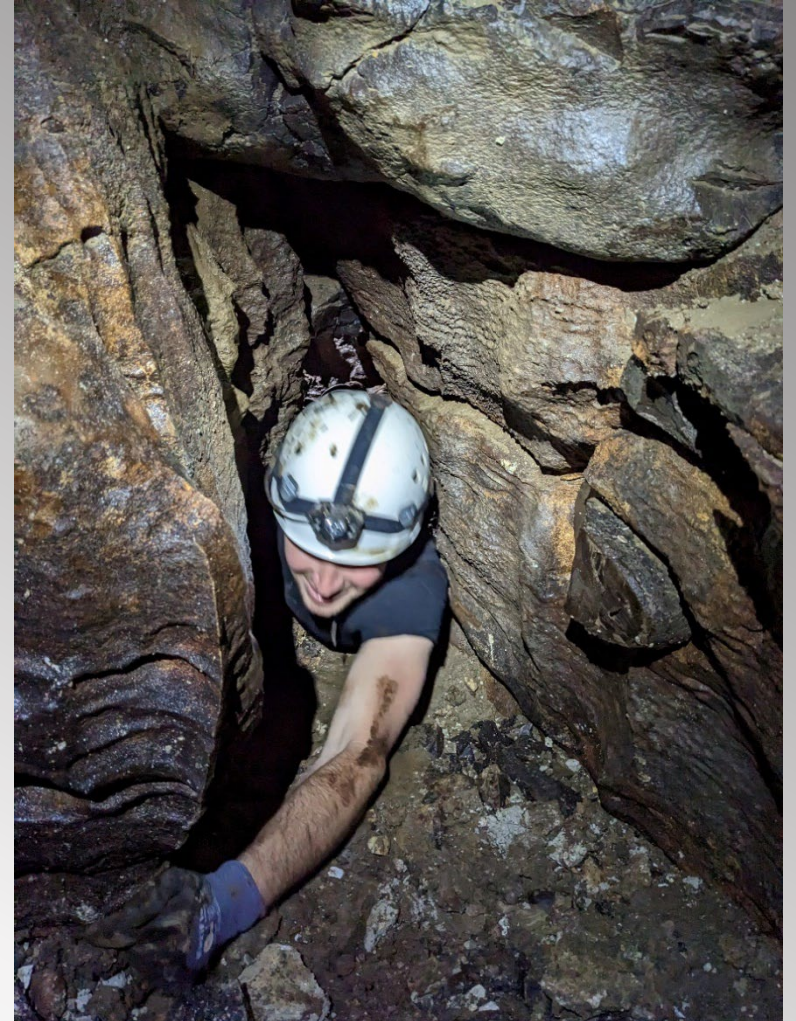
CAVE EXPLORATION



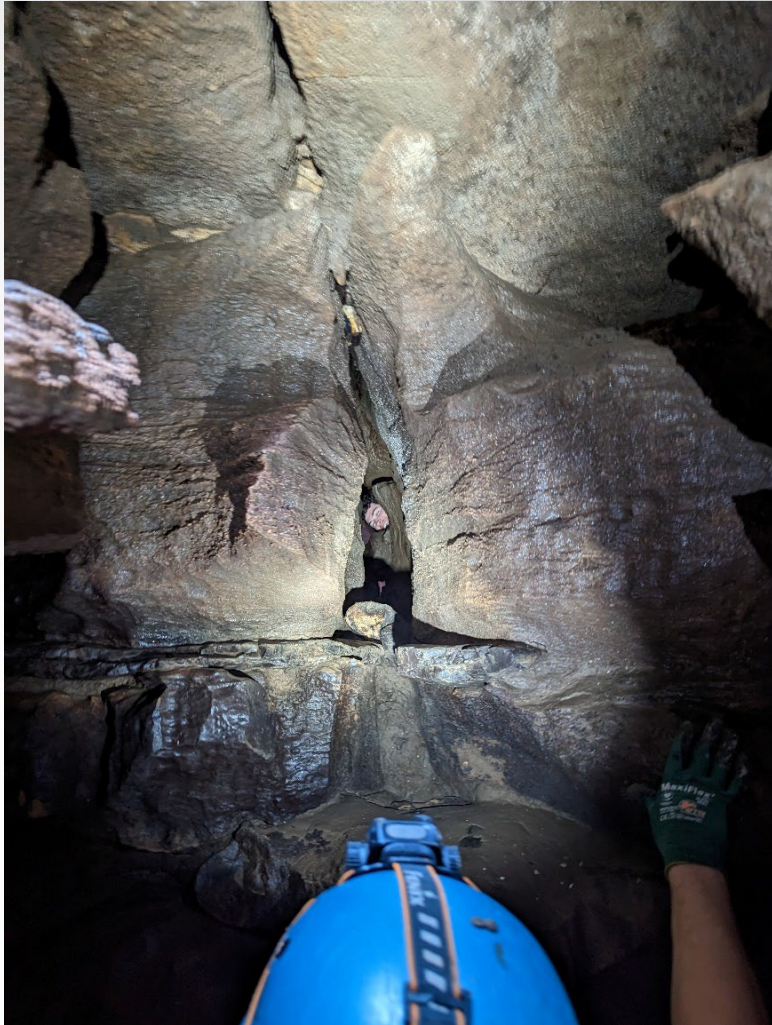
CAVE EXPLORATION



CAVE EXPLORATION



CAVE EXPLORATION



CAVE EXPLORATION

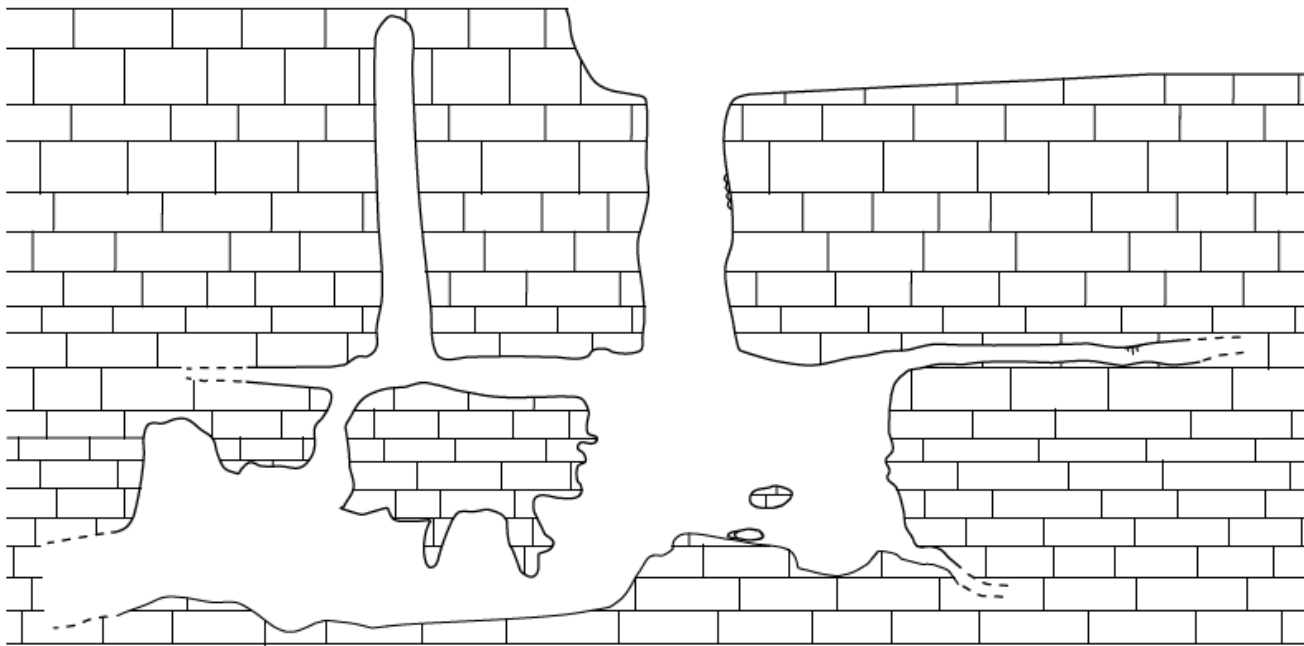


Bonne Femme Bridge Cave

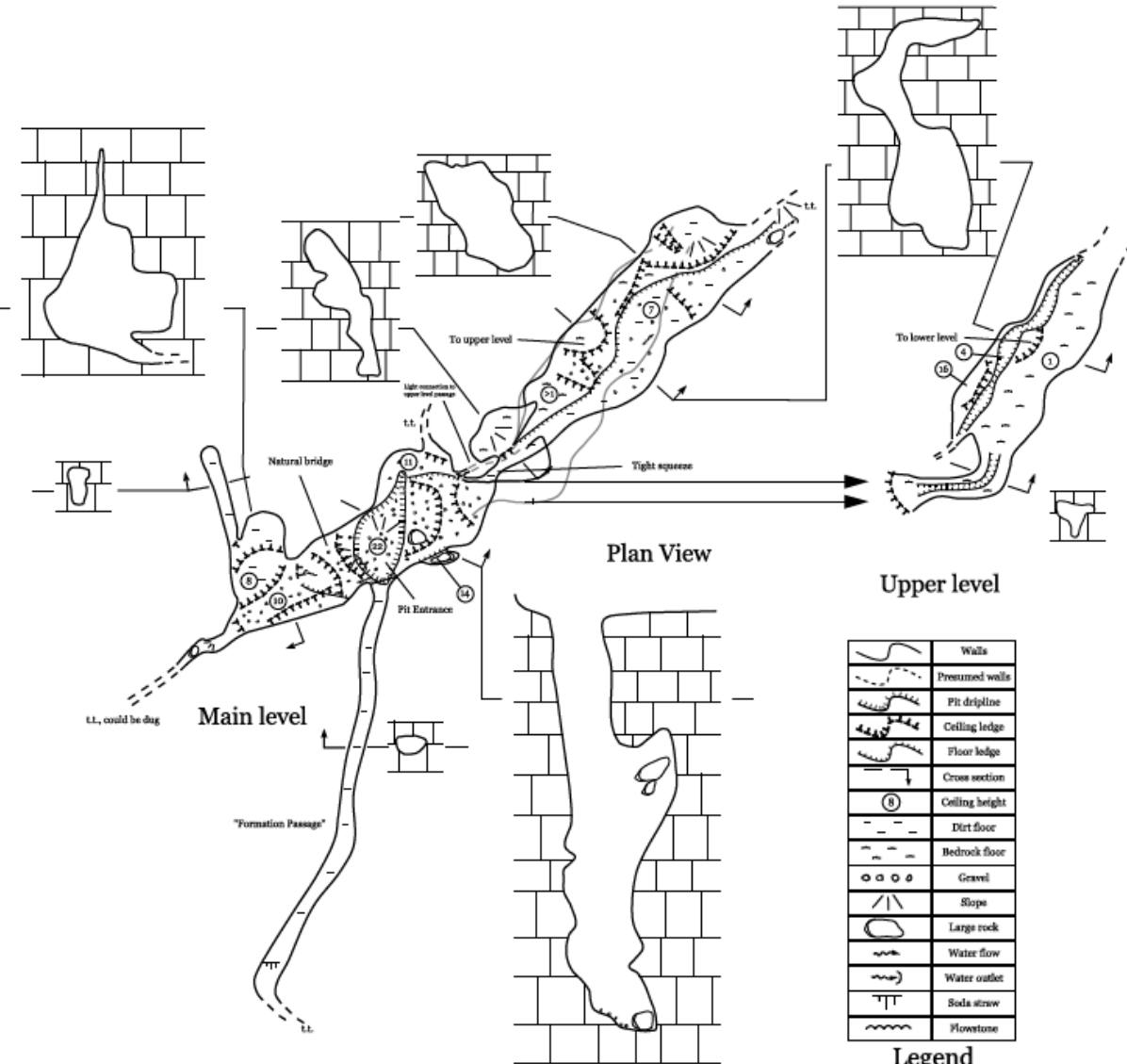
Boone County, Missouri
BNE149

Cave formed in Burlington Limestone

CAVE SURVEY



Profile View



Plan View

Upper level

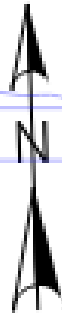
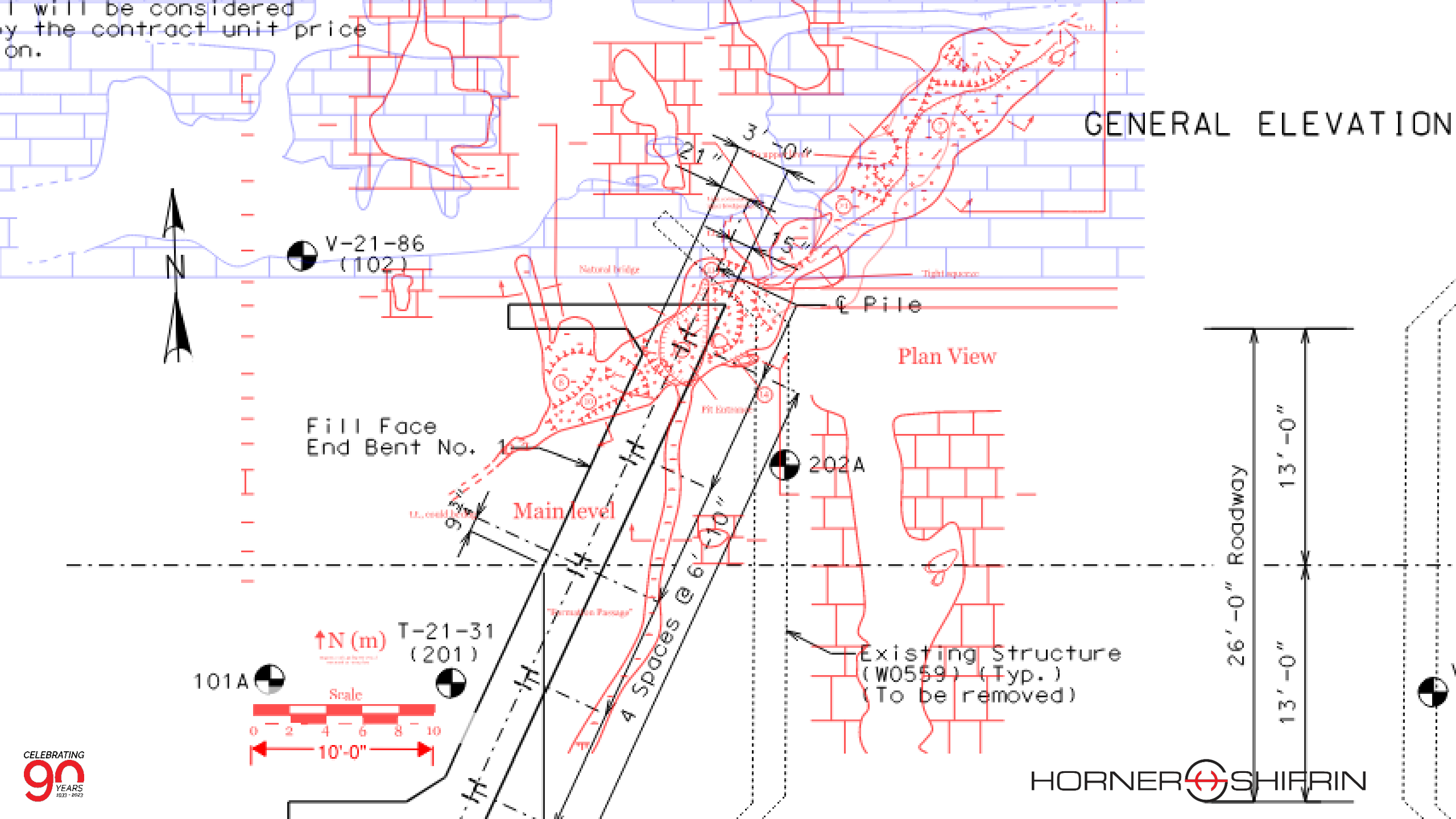
↑N (m)

Scale



It will be considered by the contract unit price on.

GENERAL ELEVATION



V-21-86
(102)

Fill Face
End Bent No. 1

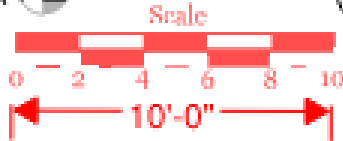
Main level

Plan View

202A

T-21-31
(201)

101A



Existing Structure
(W0559) (Typ.)
(To be removed)

26'-0" Roadway

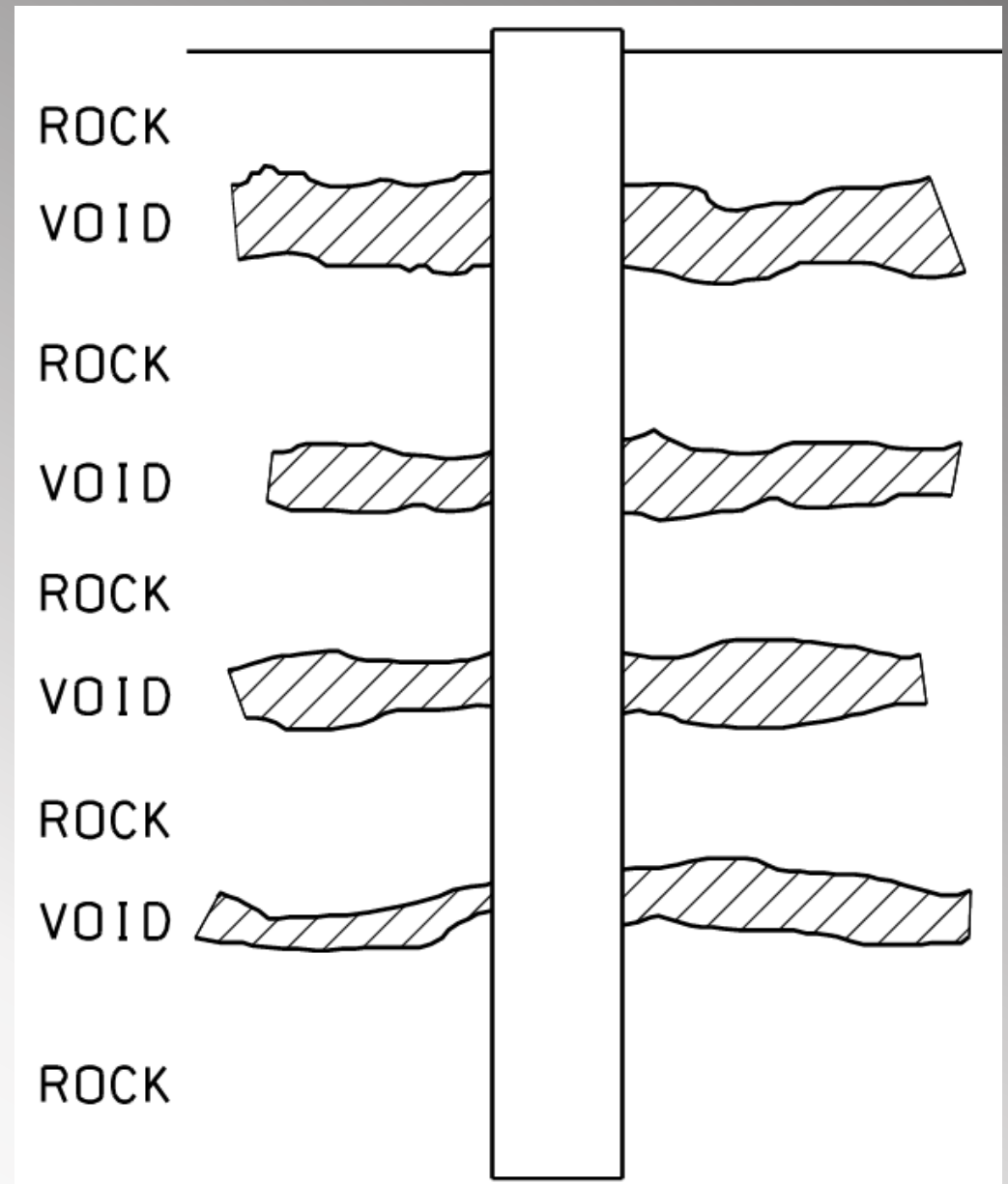
13'-0"

ADDITIONAL CONSIDERATIONS

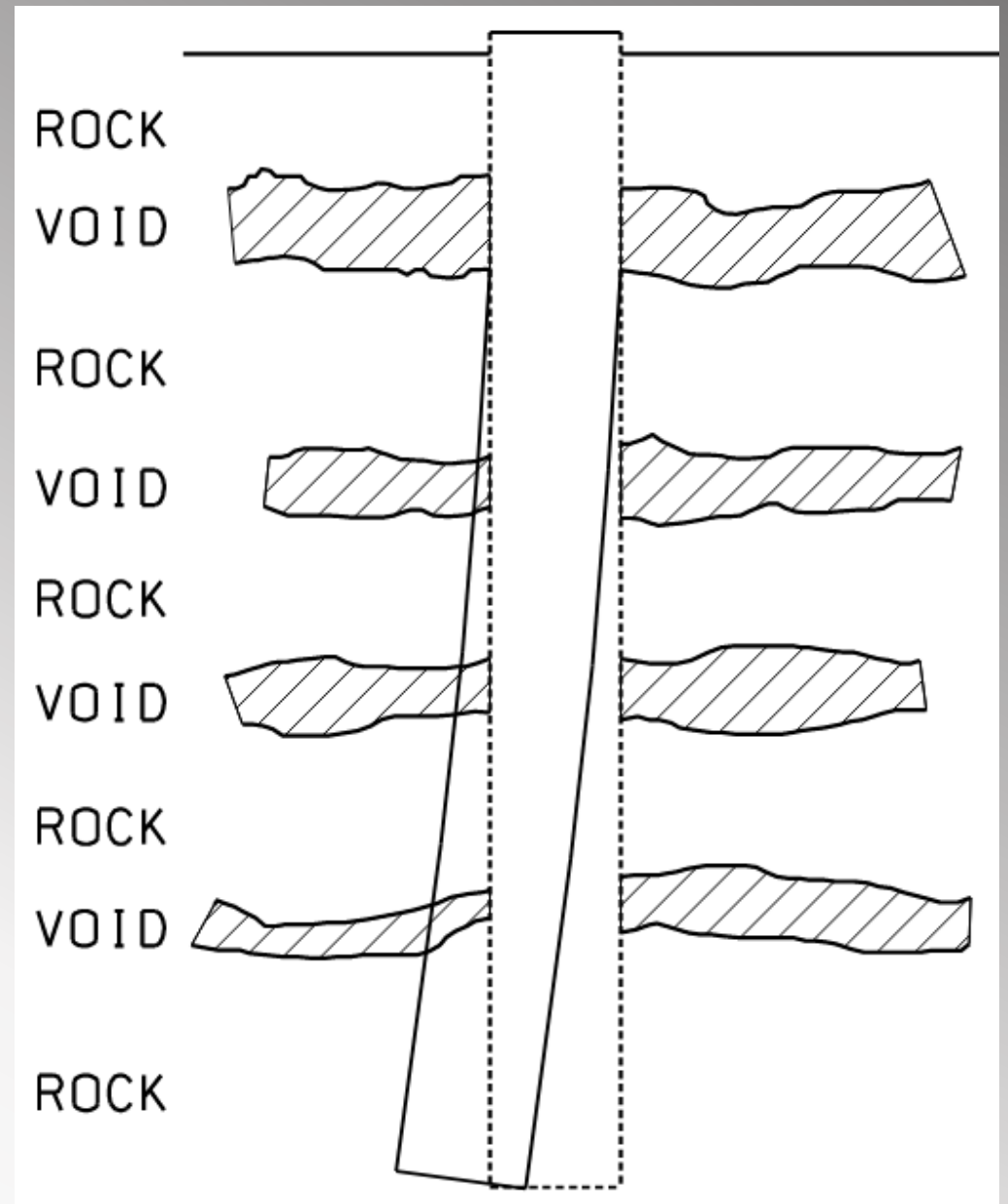
- Don't block water flow in the cave.
- Minimize depositing material in cave.
- Avoid filling the cave with concrete and minimize water from placement of concrete .
- Pink Planarian



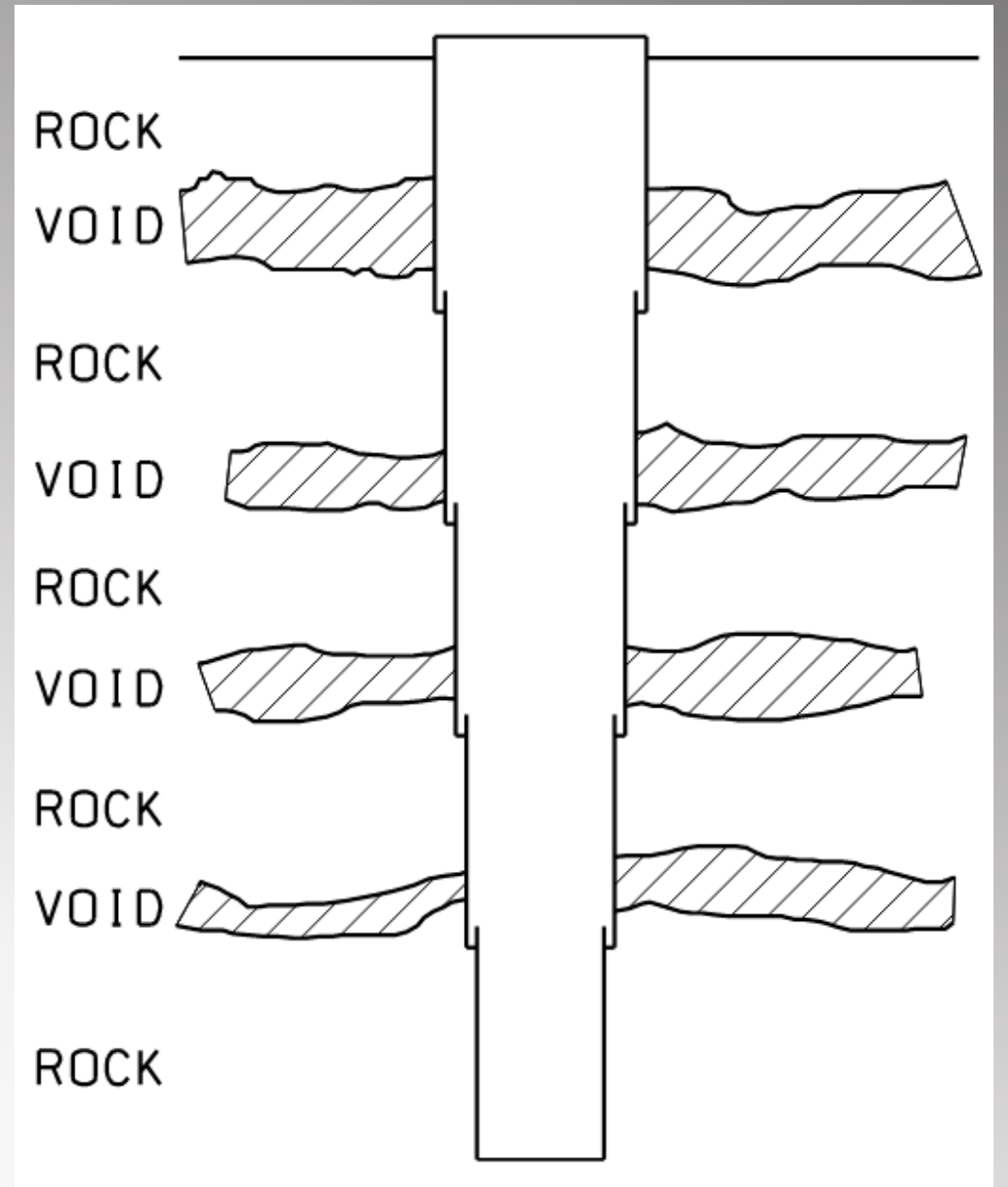
SCOPED SOLUTIONS



SCOPED SOLUTIONS



SCOPED SOLUTIONS



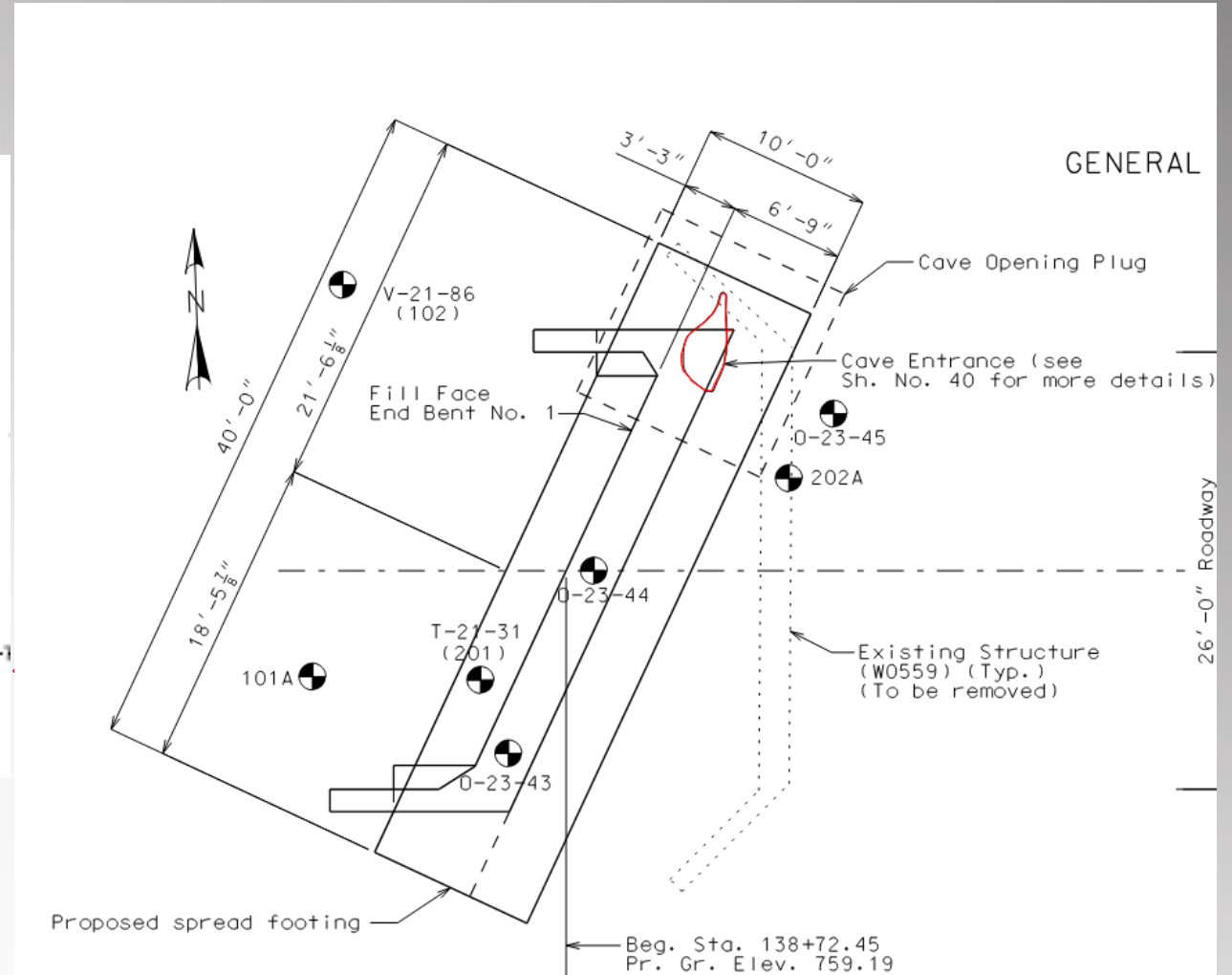
WHAT WE ENDED UP DOING

Foundation Data				
Type	Design Data	Bent Number		
		1	2	
Load Bearing Pile	Pile Type and Size	-	HP 12x53	
	Number	-	7	
	Approximate Length Per Each	ft	-	18 Lt 35 Cnt 38 Rt
	Pile Point Reinforcement	ea	-	All
	Min. Galvanized Penetration (Elev.)	ft	-	Full Length
	Pile Driving Verification Method	-	-	DF
	Resistance Factor	-	-	0.40
Spread Footing	Foundation Material	Rock	-	
	Minimum Nominal Bearing Resistance	ksf	5.7	-

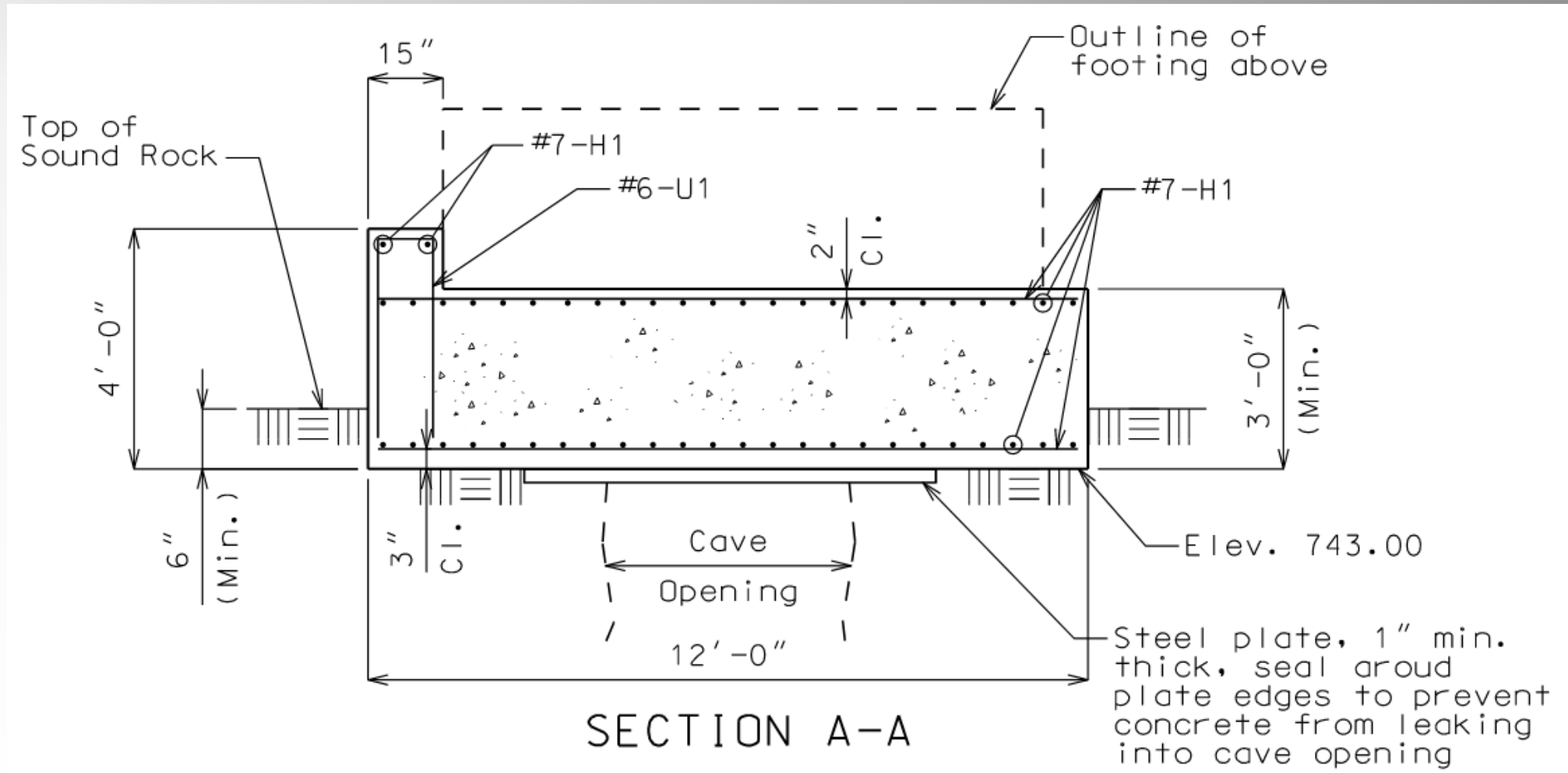
Prepare for piles at Bent No. 2 to elevation 735.3 (north two piles), Elevation 718.2 (middle three piles) and Elevation 715.4 (south two piles).

Beg. Sta. 138+1

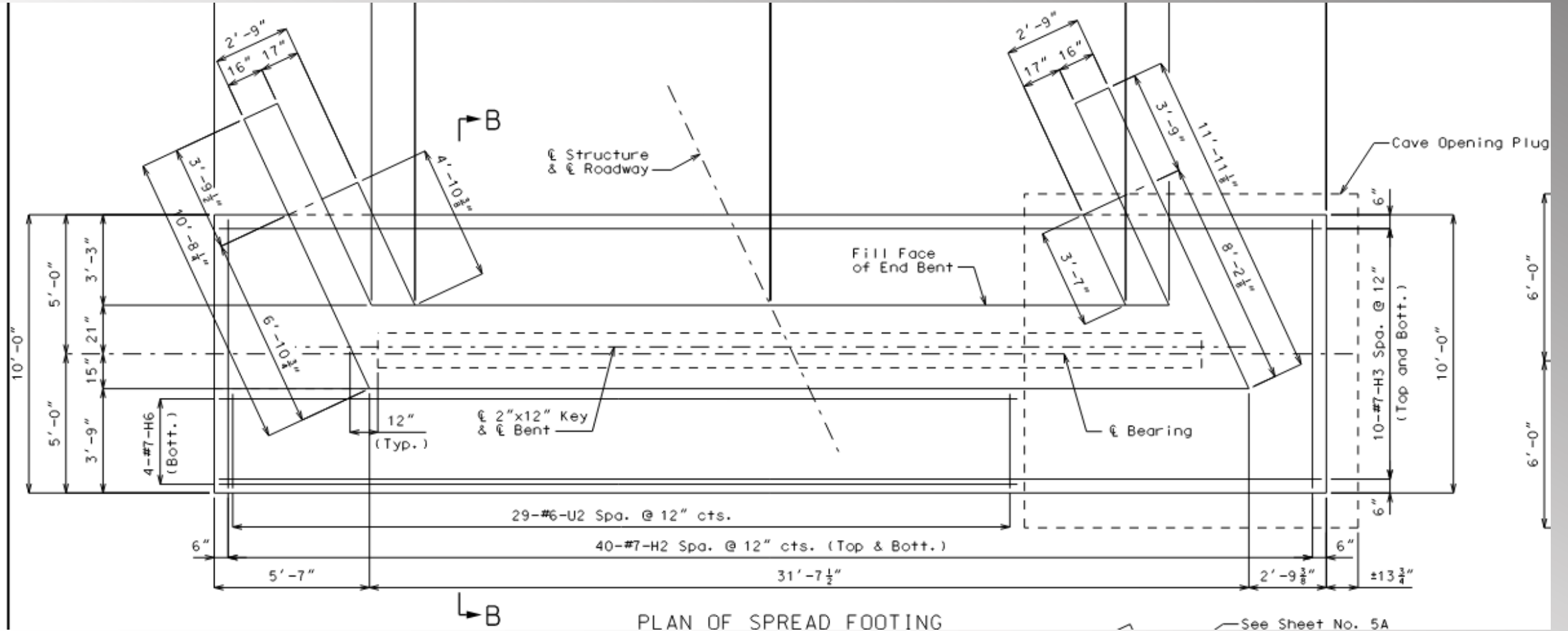
9A. C Added



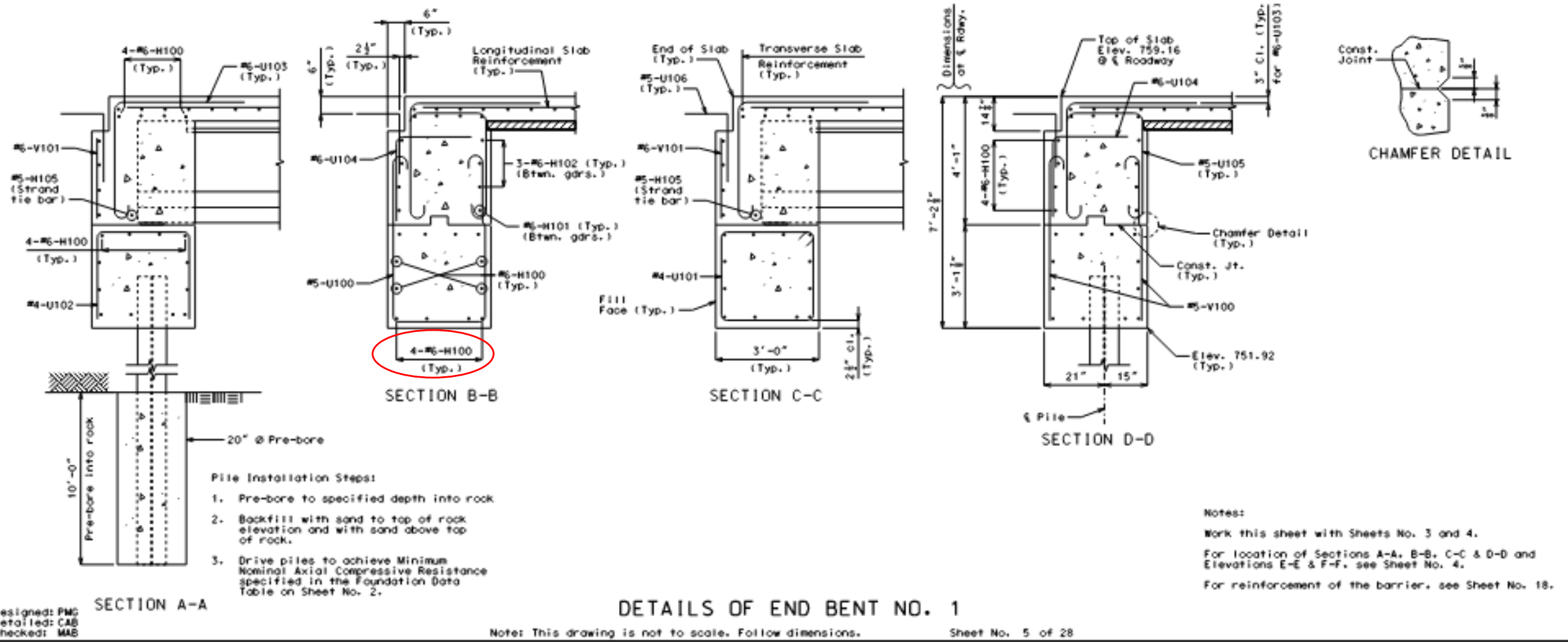
WHAT WE ENDED UP DOING



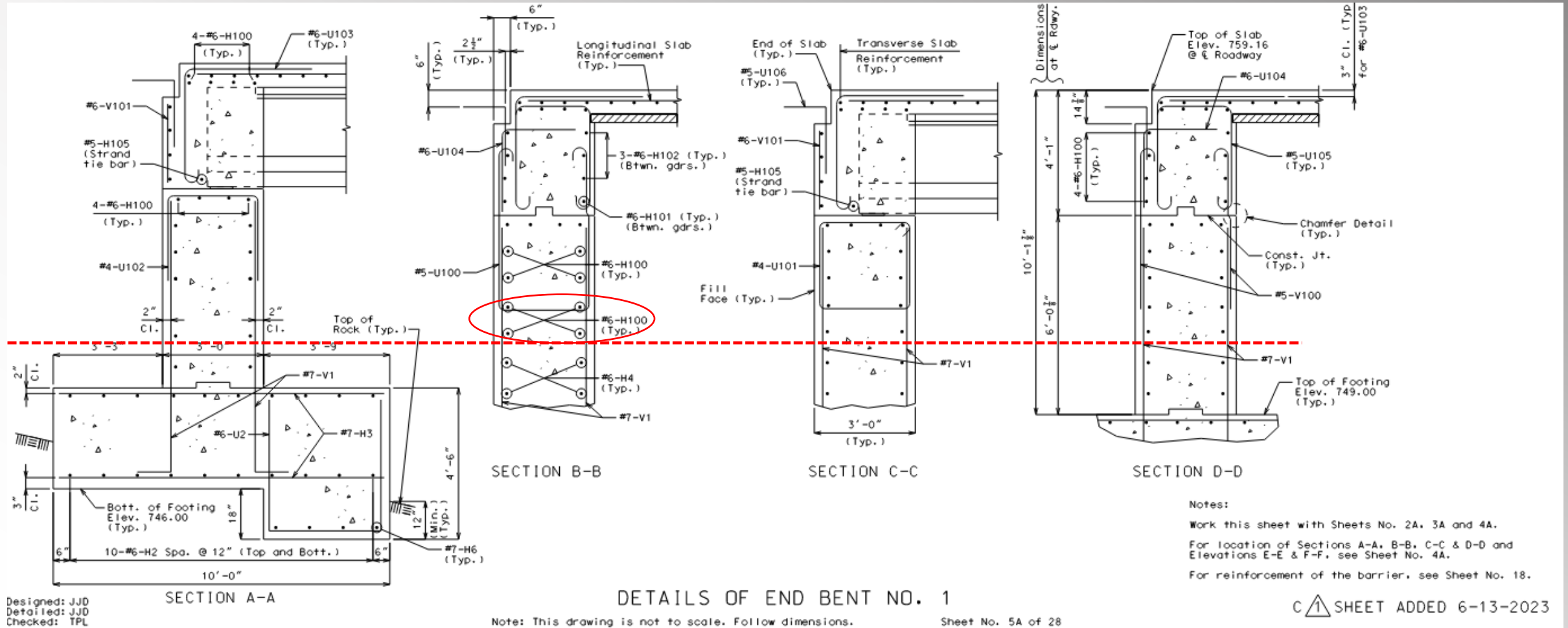
WHAT WE ENDED UP DOING



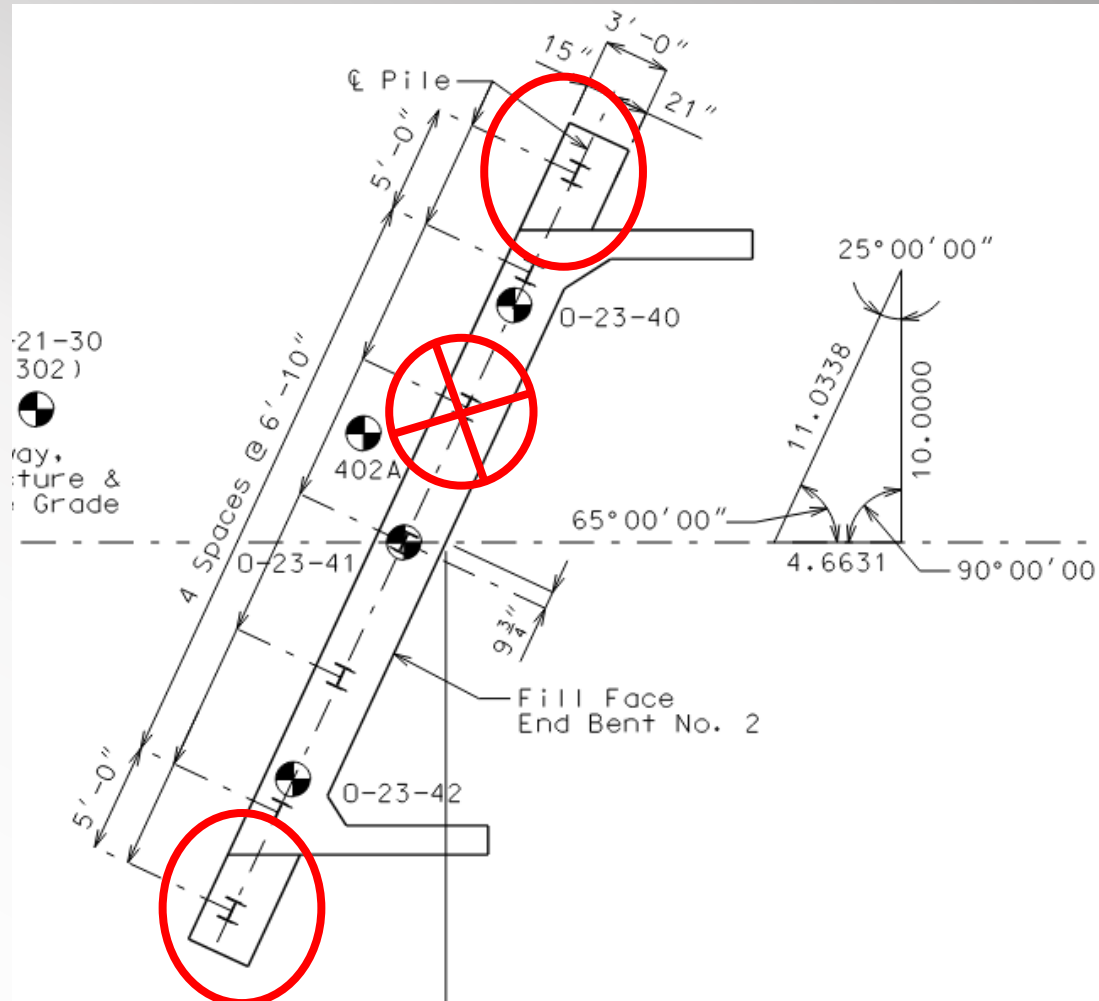
WHAT WE ENDED UP DOING



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WHAT WE ENDED UP DOING

BILL OF REINFORCING STEEL																						
NO. REQ'D.	MARK NO.	LOCATION	EPOXY (E)	SHAPE NO.	STIRRUP (S)	SUBSTR. (X)	VARIES (V)	NO. EACH	DIMENSIONS								NOMINAL LENGTH	ACTUAL LENGTH	WEIGHT			
									B	C	D	E	F	H	K	FT.				IN.	FT.	IN.
									FT.	IN.	FT.	IN.	FT.	IN.	FT.	IN.				FT.	IN.	FT.
		SUBSTRUCTURE																				
		END BENT NO. 1																				
98	7 H1	CAVE PLUG		20					11	8.000					11 8	11 8	2337					
80	7 H2	FOOTING		20					9	8.000					9 8	9 8	1581					
20	7 H3	FOOTING		20					39	8.000					39 8	39 8	1622					
4	6 H4	WALL		20					31	4.000					31 4	31 4	188					
28	6 H5	WALL		20					6	8.000					6 8	6 8	280					
4	7 H6	FOOTING		20					28	8.000					28 8	28 8	234					
24	6 U1	CAVE PLUG		10 S							3	7.000	0	11.000		8 1	7 9	279				
29	6 U2	FOOTING		10 S							4	1.000	3	5.000		11 7	11 3	490				
80	7 V1	WALL		19					8	4.000	1	2.000			9 6	9 4	1526					
		END BENT NO. 2																				
24	6 H10	BEAM	E	20					11	0.000					11 0	11 0	397					
4	6 H11	BEAM	E	20					41	0.000					41 0	41 0	246					
11	4 U10	BEAM	E	13 S					3	0.250	2	8.000	3	0.250	2	8.000	12 2	11 10	87			
6	4 U11	BEAM	E	10 S							2	8.000	3	0.250			8 4	8 2	33			
		TOTALS - C001																				
4			E														120					
6																	1237					
6			E														643					
7																	7300					
		TOTAL															8537					
		TOTAL	E														763					

C  Added

CONCLUSION



QUESTIONS?