



NORTH CAROLINA DEPARTMENT OF TRANSPORTATION  
**GeoTechnical Engineering Unit**



# Shallow Foundation Settlement at U-2525C: Predictions vs. Measured

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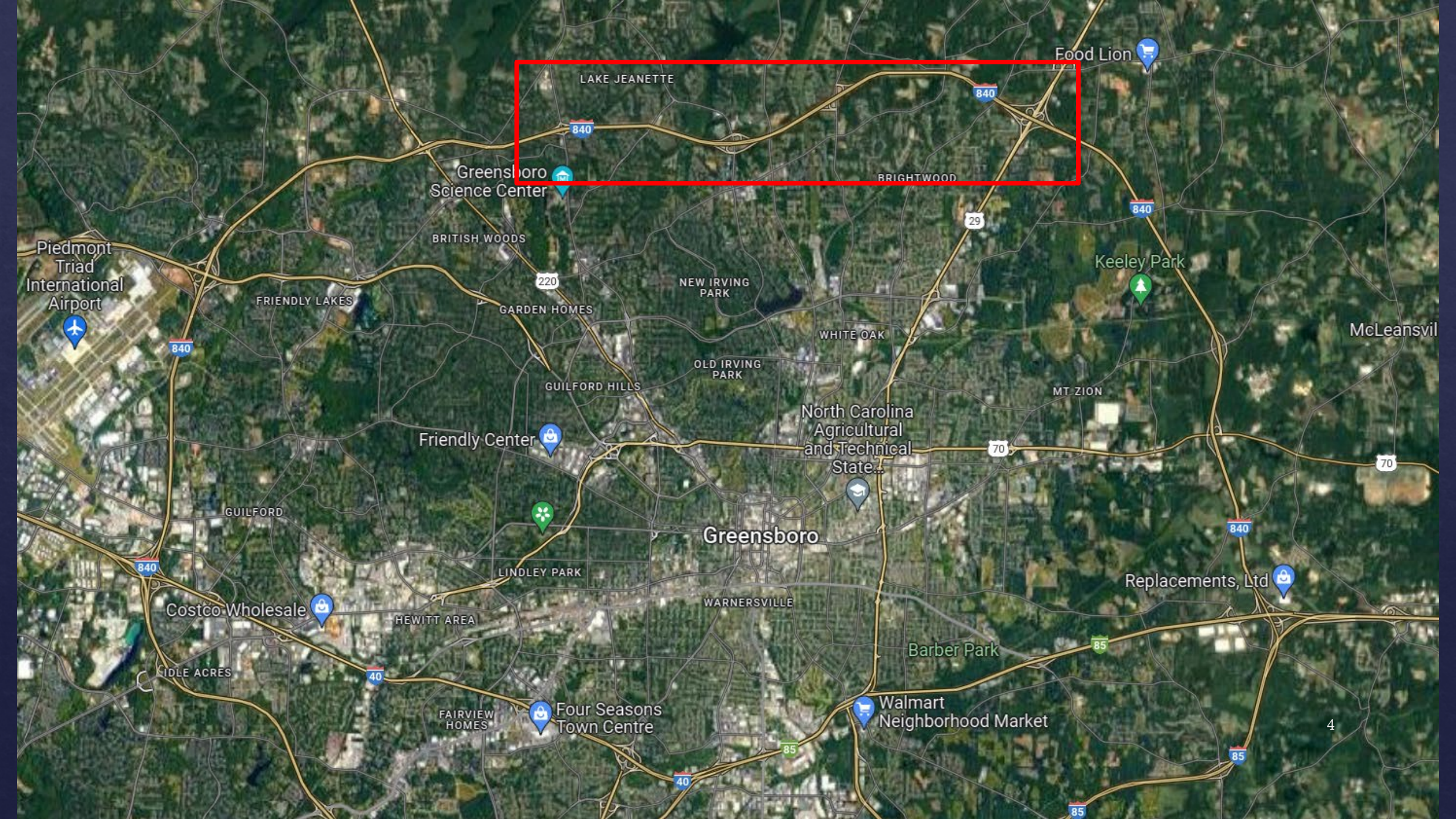
November 1<sup>st</sup>, 2023

# Project Overview









LAKE JEANETTE

Food Lion

840

840

Greensboro Science Center

BRIGHTWOOD

840

Piedmont Triad International Airport

BRITISH WOODS

Keeley Park

FRIENDLY LAKES

220

NEW IRVING PARK

McLeansvil

GARDEN HOMES

WHITE OAK

OLD IRVING PARK

MT ZION

North Carolina Agricultural and Technical State University

70

Friendly Center

GUILFORD HILLS

Greensboro

GUILFORD

Replacements, Ltd

LINDLEY PARK

WARNERSVILLE

Barber Park

Costco Wholesale

HEWITT AREA

IDLE ACRES

FAIRVIEW HOMES

Four Seasons Town Centre

Walmart Neighborhood Market

4

40

85

85

85



# Structures

◇ 7 structures on shallow foundations

◇ Spread footings at end bents

◇ 4 in fill, 3 in cut

INDEX			
STR	STATION	DESCRIPTION	SHEETS
S1	17+37.28 -Y16-	BRIDGE ON SR 2526 (SUMMIT AVE.) OVER I-85 BY-PASS	S1-1 THRU S1-29
S2	329+95.42 -L- (LEFT LANE)	BRIDGE ON I-85 BYPASS OVER SR 2359 (LEES CHAPEL RD) (LEFT LANE)	S2-1 THRU S2-28
S3	329+95.42 -L- (RIGHT LANE)	BRIDGE ON I-85 BYPASS OVER SR 2359 (LEES CHAPEL RD) (RIGHT LANE)	S3-1 THRU S3-28
S4	337+20.09 -L- (LEFT LANE)	BRIDGE ON I-85 BY-PASS OVER NORFOLK SOUTHERN RR (LEFT LANE)	S4-1 THRU S4-39
S5	337+20.09 -L- (RIGHT LANE)	BRIDGE ON I-85 BY-PASS OVER NORFOLK SOUTHERN RR (RIGHT LANE)	S5-1 THRU S5-38
S6	28+98.81 -Y4-	BRIDGE ON SR 2523 (YANCEYVILLE RD.) OVER I-85 BYPASS	S6-1 THRU S6-34
S7	22+29.98 -Y5-	BRIDGE ON SR 1001 (NORTH CHURCH ST.) OVER I-85 BY-PASS	S7-1 THRU S7-28
S8	470+43.12 -L- (LEFT LANE)	BRIDGE ON US I-85 BY-PASS OVER NORTH ELM STREET (LEFT LANE)	S8-1 THRU S8-32
S9	470+43.12 -L- (RIGHT LANE)	BRIDGE ON US I-85 BY-PASS OVER NORTH ELM STREET (RIGHT LANE)	S9-1 THRU S9-32
S10	25+52.71 -Y7-	BRIDGE ON LAKE JEANETTE RD. OVER I-85 BY-PASS	S10-1 THRU S10-36



# Concerns with Shallow Foundations in NC

- ◆ Not often used, low comfort level with designers and construction personnel
- ◆ Settlement unknowns
  - ◆ Total and differential
  - ◆ Wait times
- ◆ Bearing pressure
- ◆ Footings above MSE walls
  - ◆ Added pressure to wall
  - ◆ Extra reinforcement



# Settlement Monitoring

- ◆ Required by contract special provision
- ◆ Survey points
  - ◆ Sites 1, 2, 4, 5, and 6
- ◆ Horizontal inclinometers
  - ◆ Sites 2 and 5
  - ◆ 2 per end bent

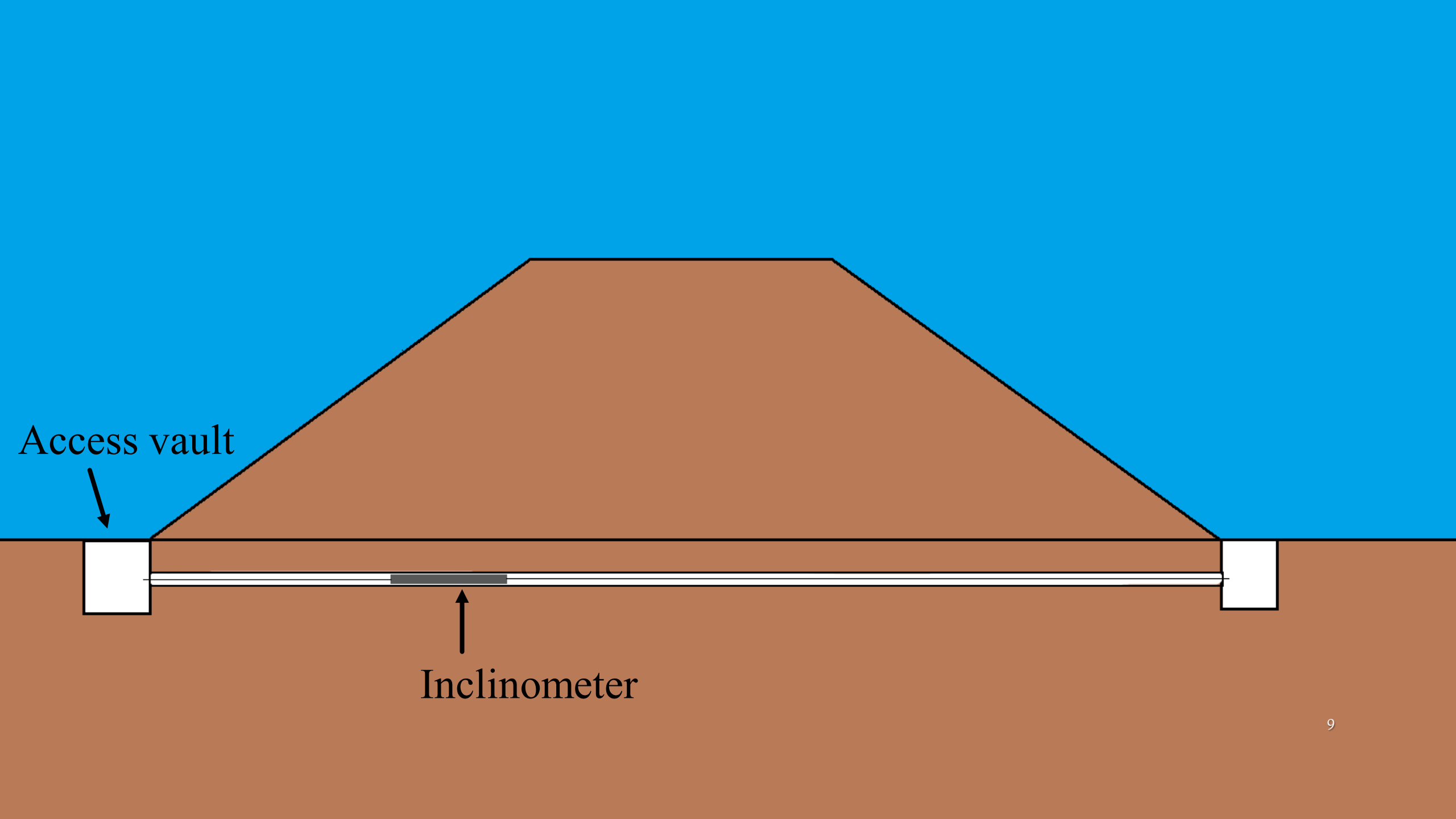


# Horizontal Inclinometers

- ◆ Installed and monitored by Kleinfelder
  - ◆ Durham Geo Slope Indicator (DGSI)
  - ◆ Access vaults and casings
  - ◆ Accelerometer inside probe measures tilt
  - ◆ 2' intervals
- ◆ Monitored from May 2019 to June 2022







Access vault



Inclinometer



















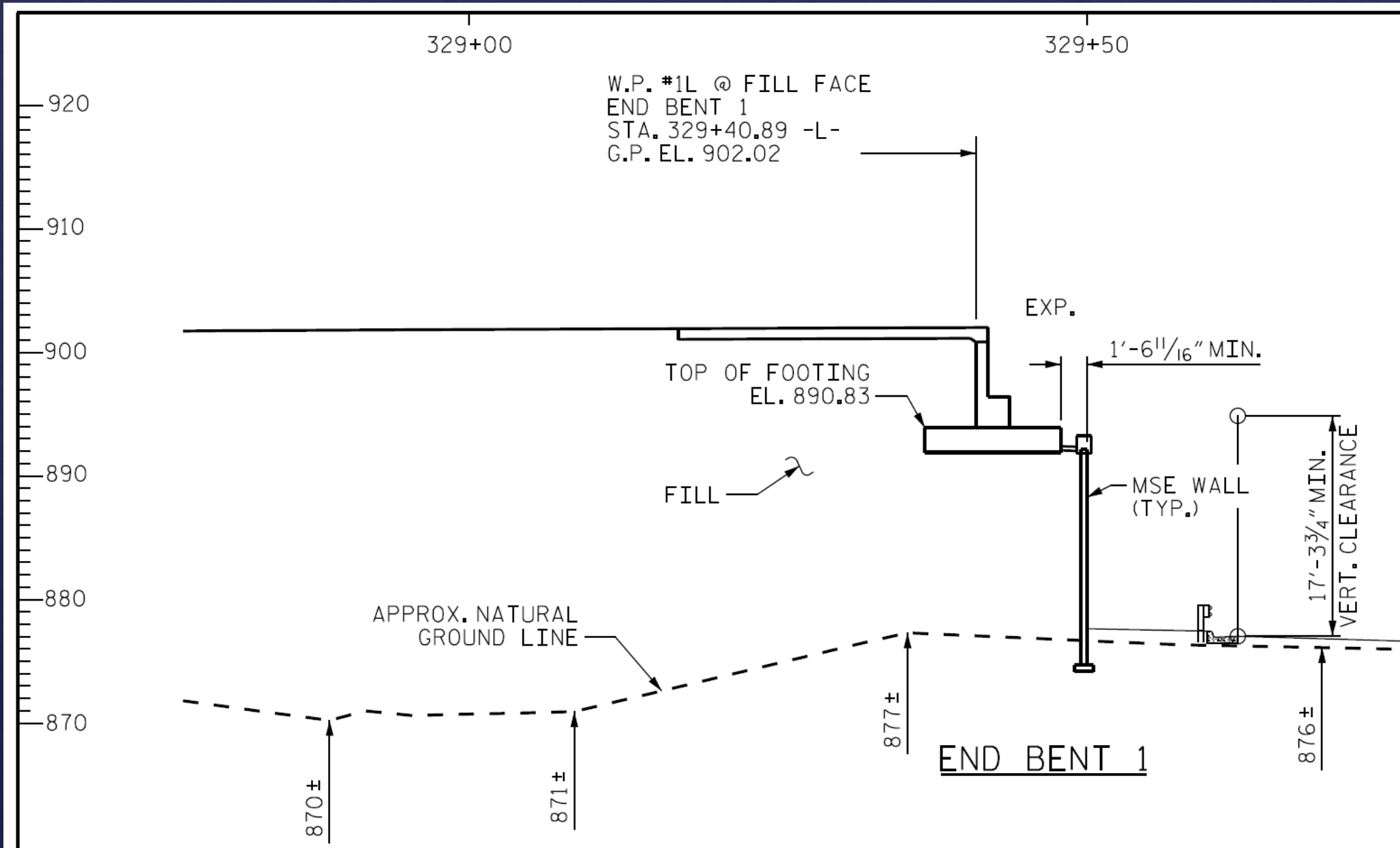


## Site 2: Structures 2 and 3

- ◇ Dual Bridges
- ◇ Fill Section
- ◇ Spread footing Specs
  - ◇ 70'-3" x 12'-5" x 2' EB1 & EB2 both bridges
- ◇ Surcharge walls
  - ◇ 20' above spread footing elevation
  - ◇ 2 month wait

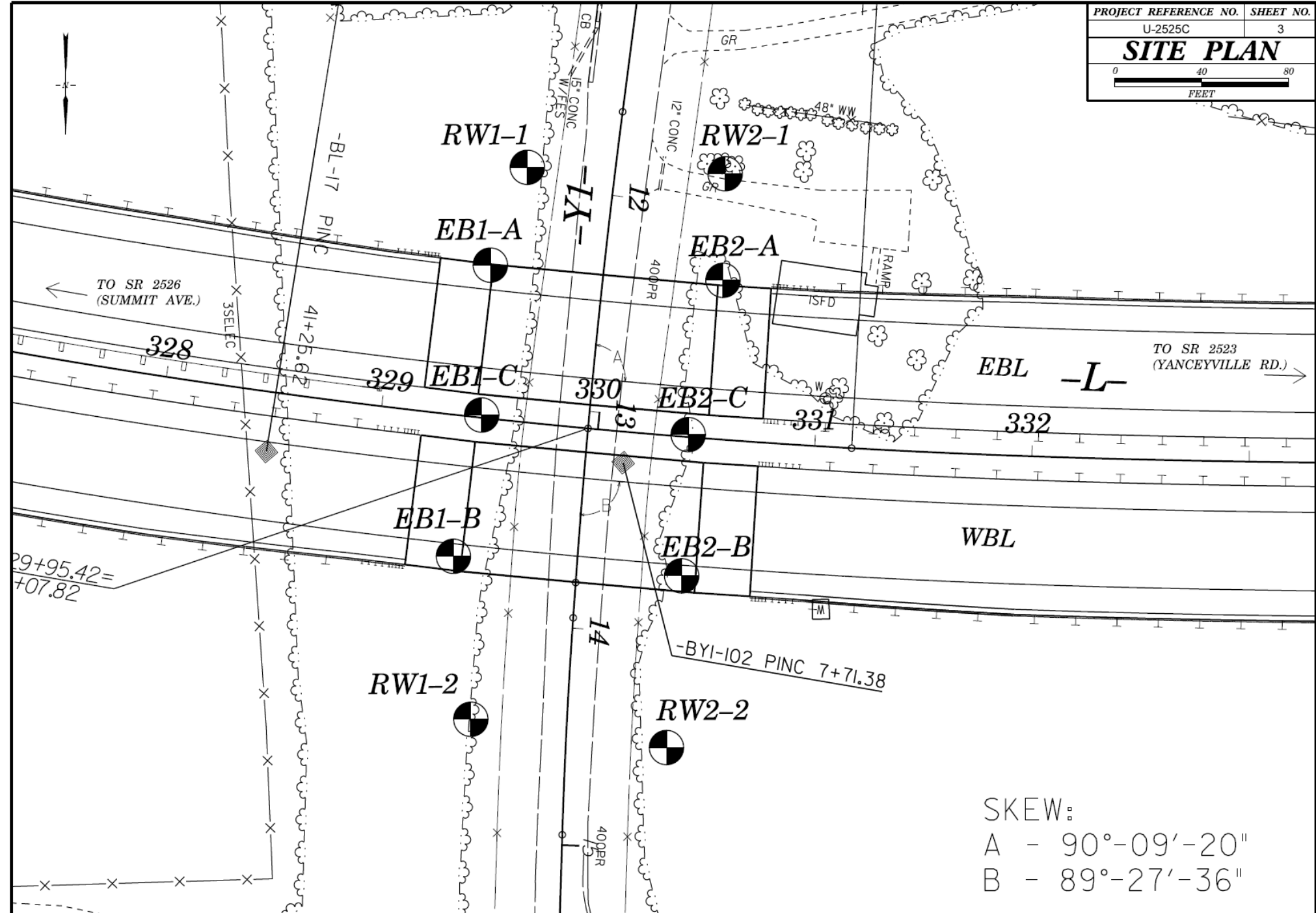


# Structure 2





PROJECT REFERENCE NO.	SHEET NO.
U-2525C	3
<b>SITE PLAN</b>	

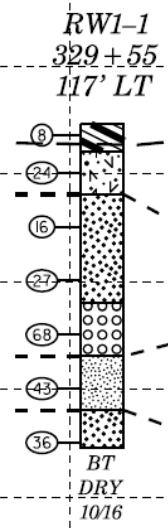


SKEW:  
 A - 90°-09'-20"  
 B - 89°-27'-36"

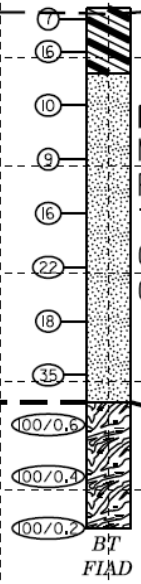


900  
890  
880  
870  
860  
850  
840  
830  
820  
810  
800

**(A) RESIDUAL:**  
MOIST, MEDIUM DENSE TO VERY DENSE,  
YELLOW TO WHITE TO GRAY TO BROWN,  
SILTY, FINE TO COARSE SAND WITH ROCK  
FRAGMENTS



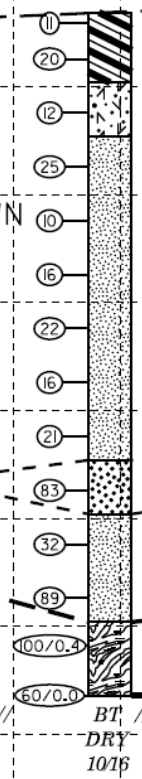
**EB1-A**  
329+43  
70' LT



**RESIDUAL:**  
MOIST, MEDIUM STIFF TO HARD,  
REDDISH BROWN TO YELLOWISH BROWN  
TO RED TO YELLOW, FINE TO  
COARSE SANDY CLAY AND FINE TO  
COARSE SANDY SILT

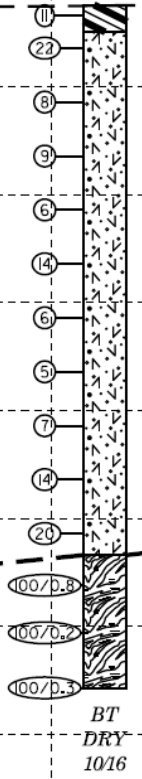
**WEATHERED ROCK:**  
LIGHT BROWNISH GRAY TO  
YELLOW AND WHITE,  
METAMORPHOSED GRANITE

**EB1-C**  
329+46  
1' LT

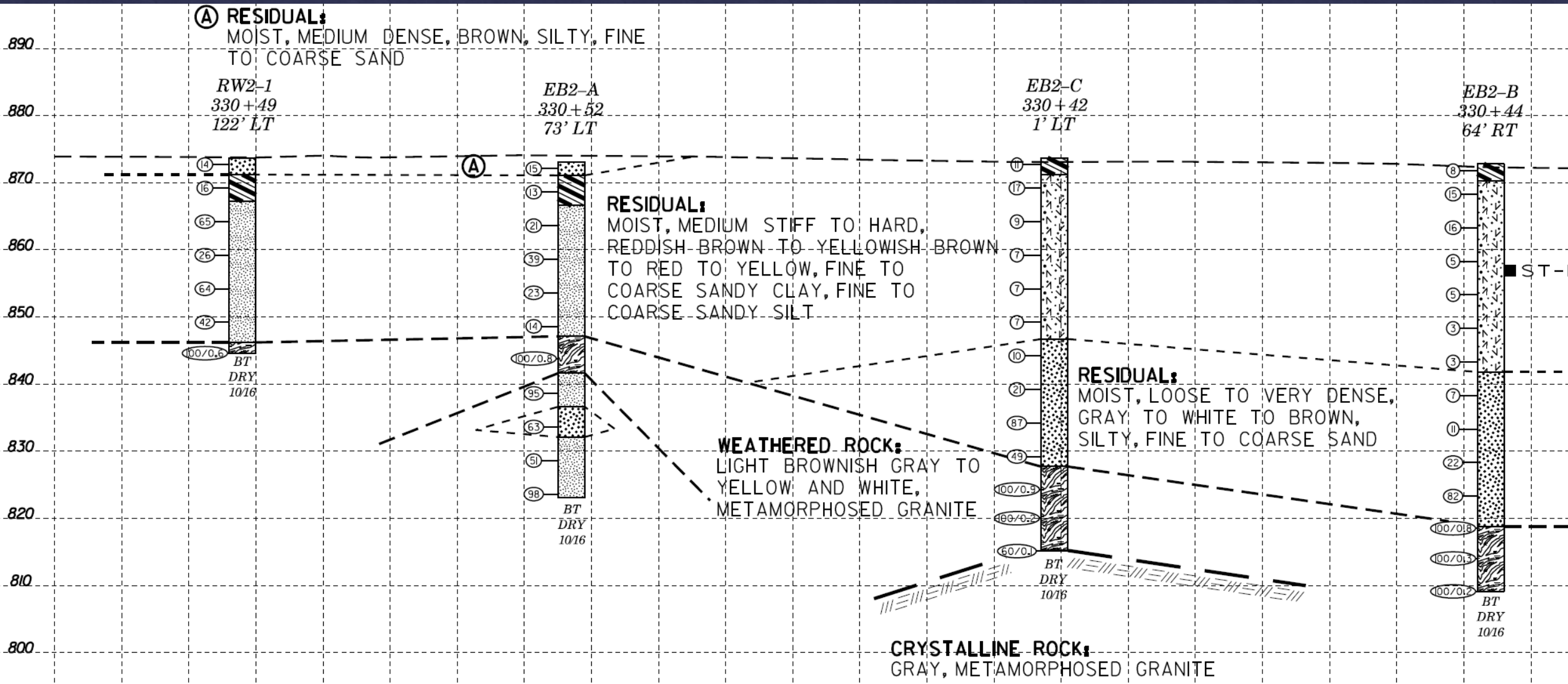


**CRYSTALLINE ROCK:**  
GRAY, METAMORPHOSED GRANITE

**EB1-B**  
329+40  
65' RT

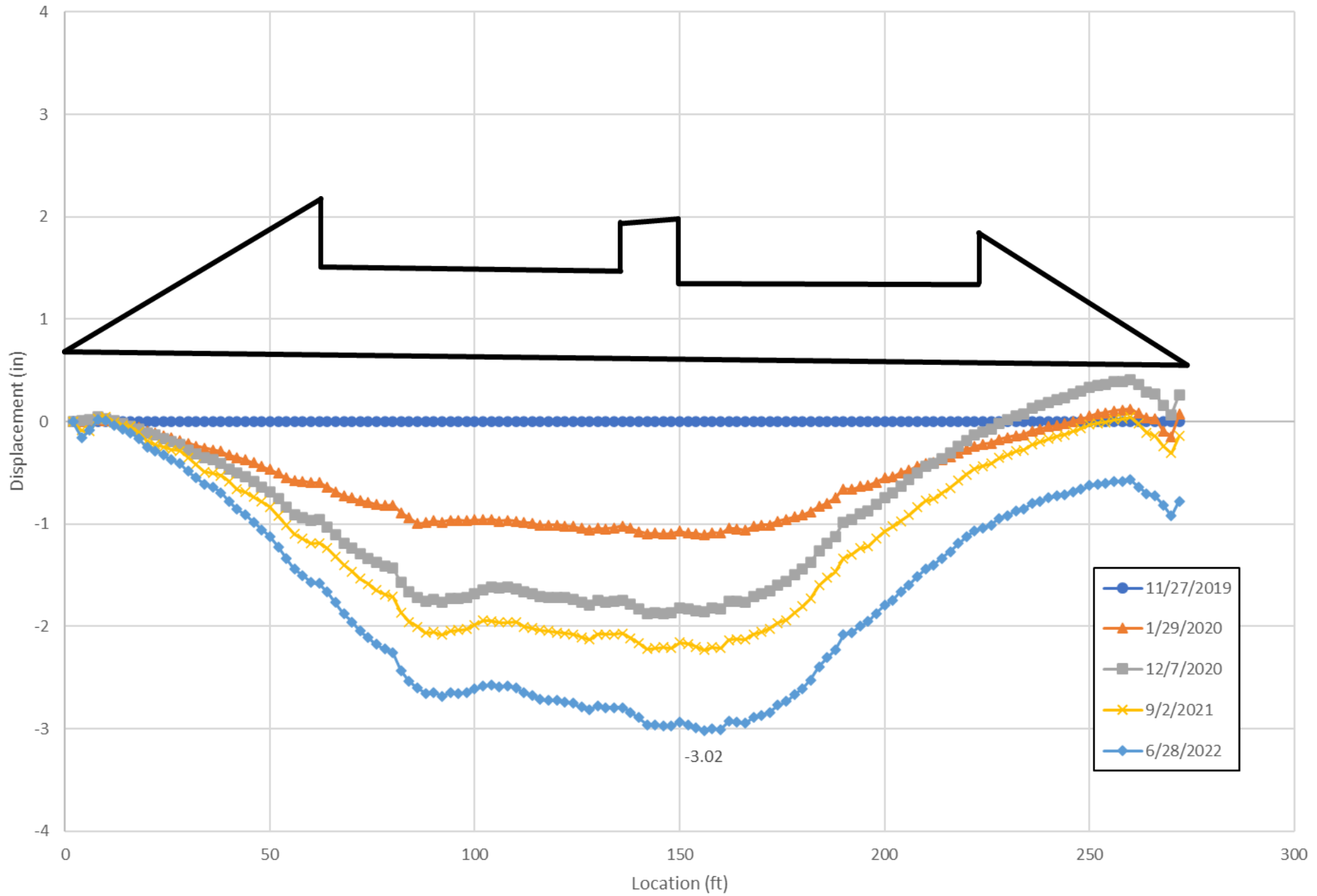






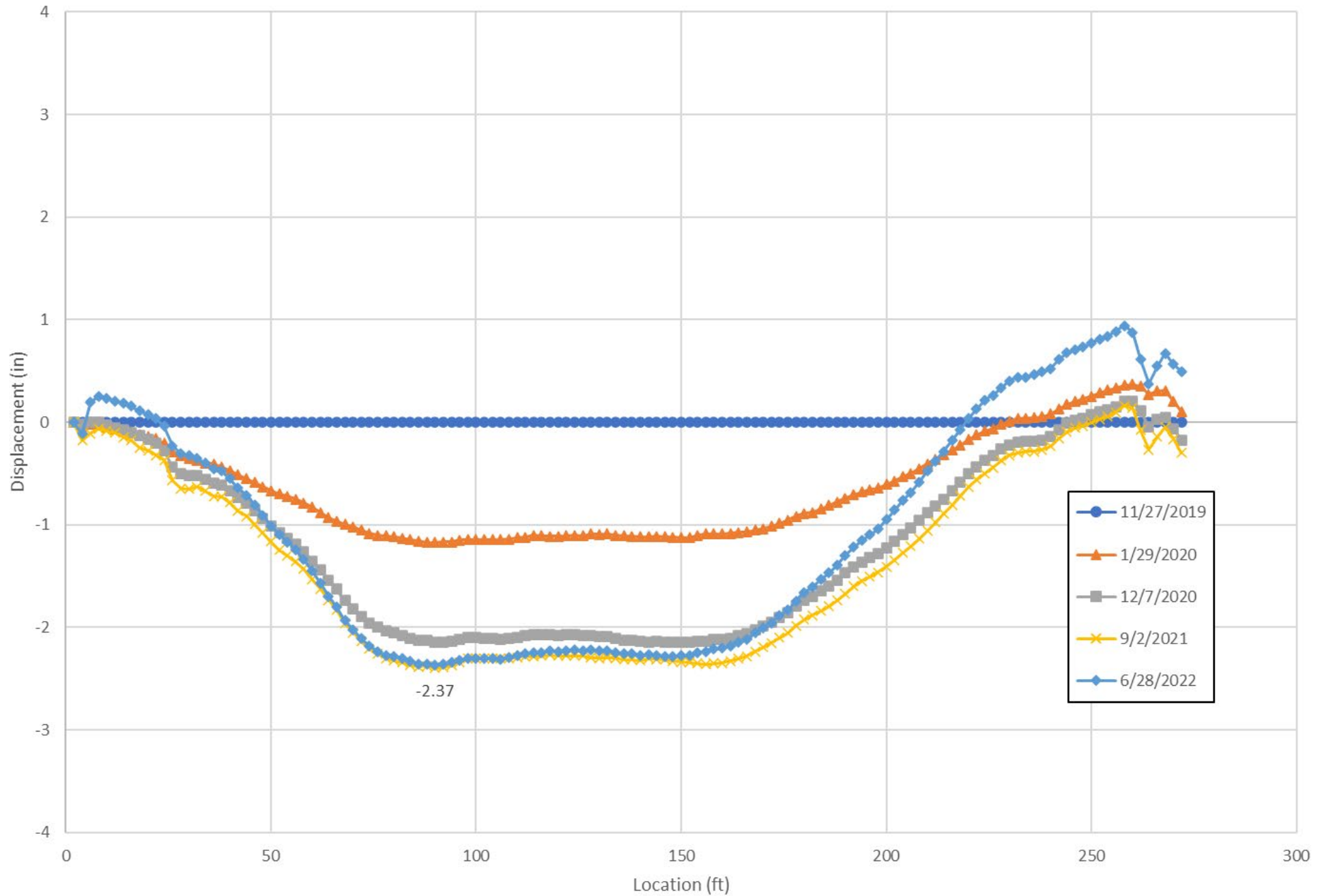


U2525C Site 2A: Front Inclinometer Displacement



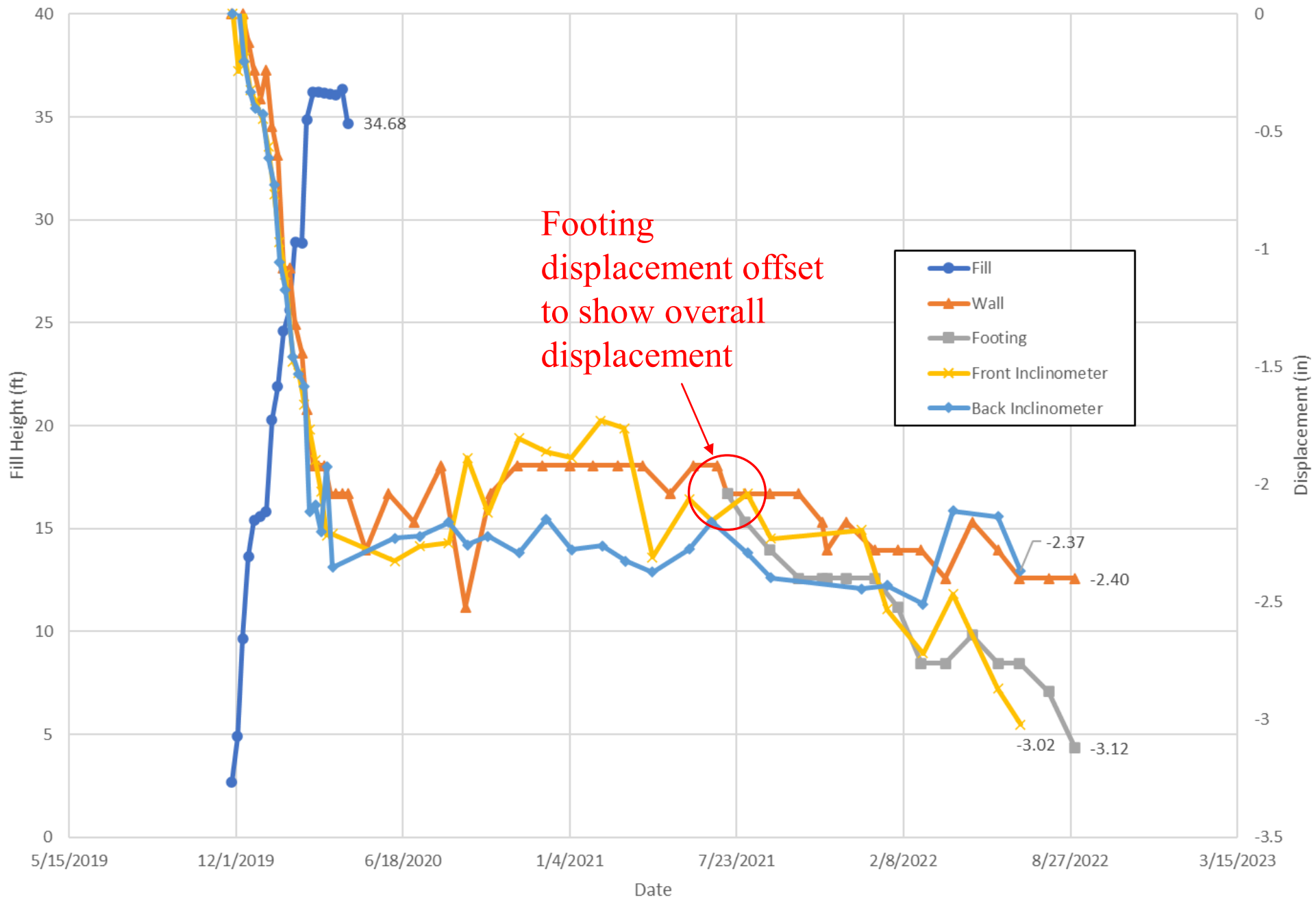


U2525C Site 2A: Back Inclinator Displacement



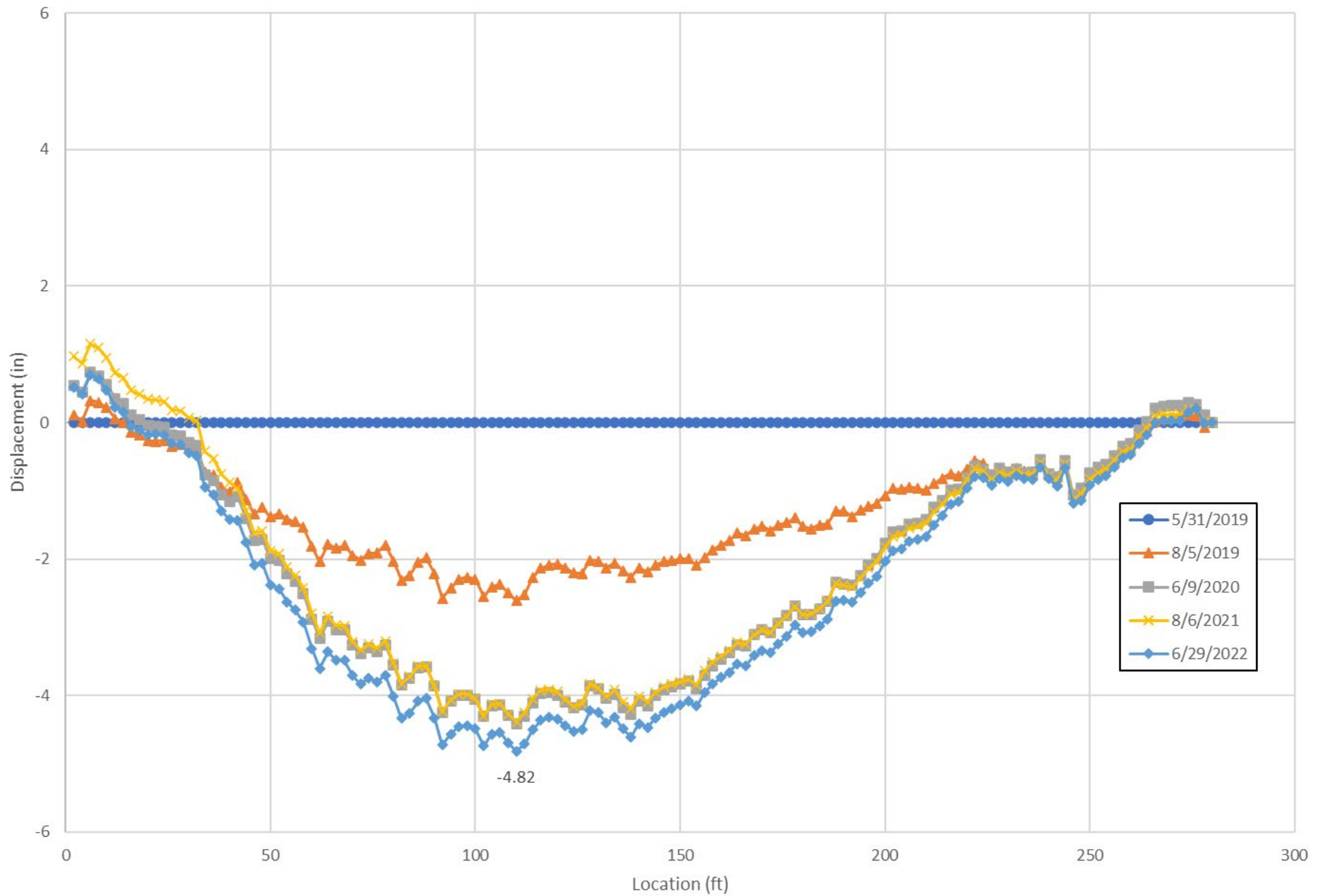


U2525C Site 2A: Footing, Wall, and Incliner Displacement



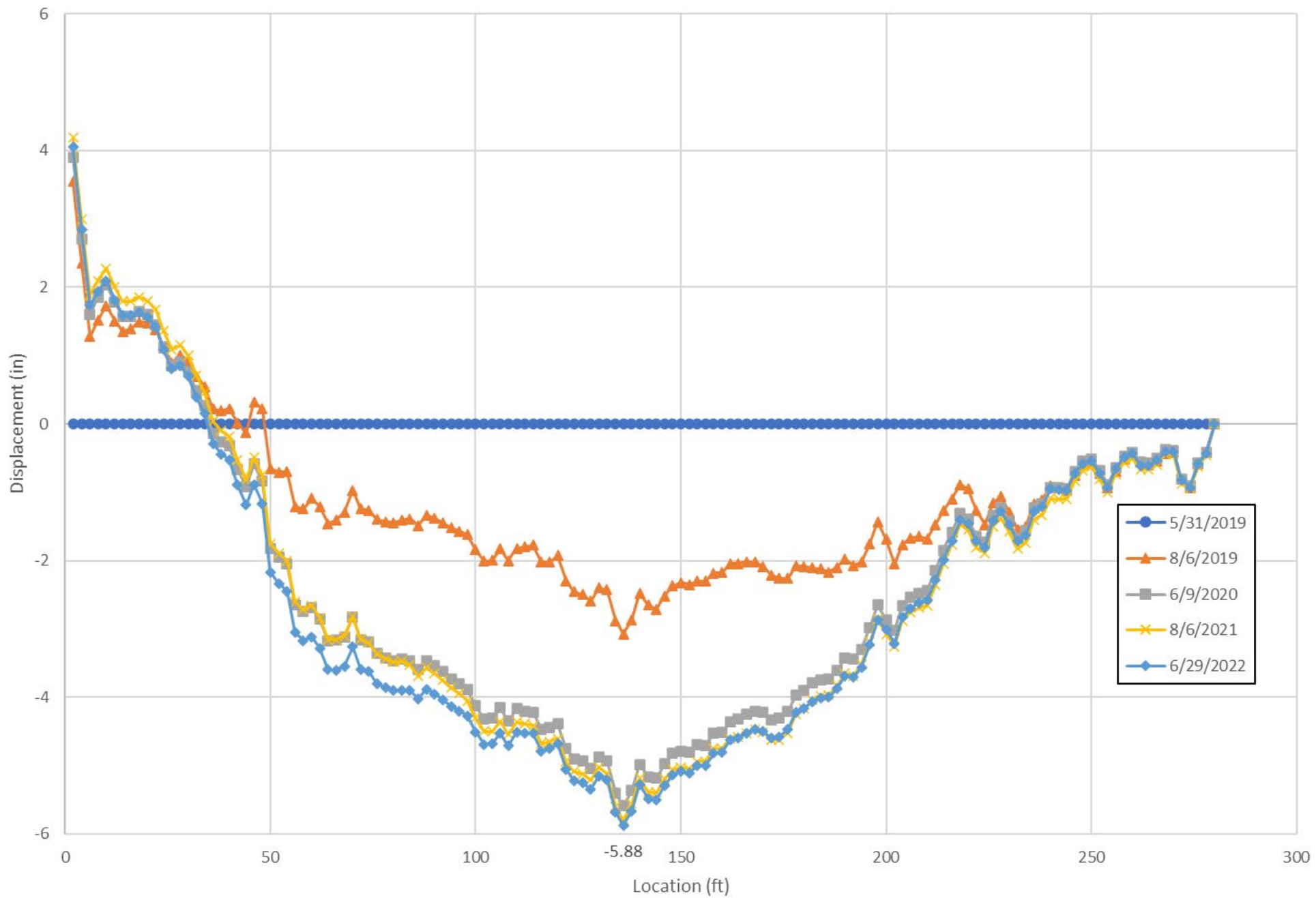


U2525C Site 2B: Front Inclinometer Displacement



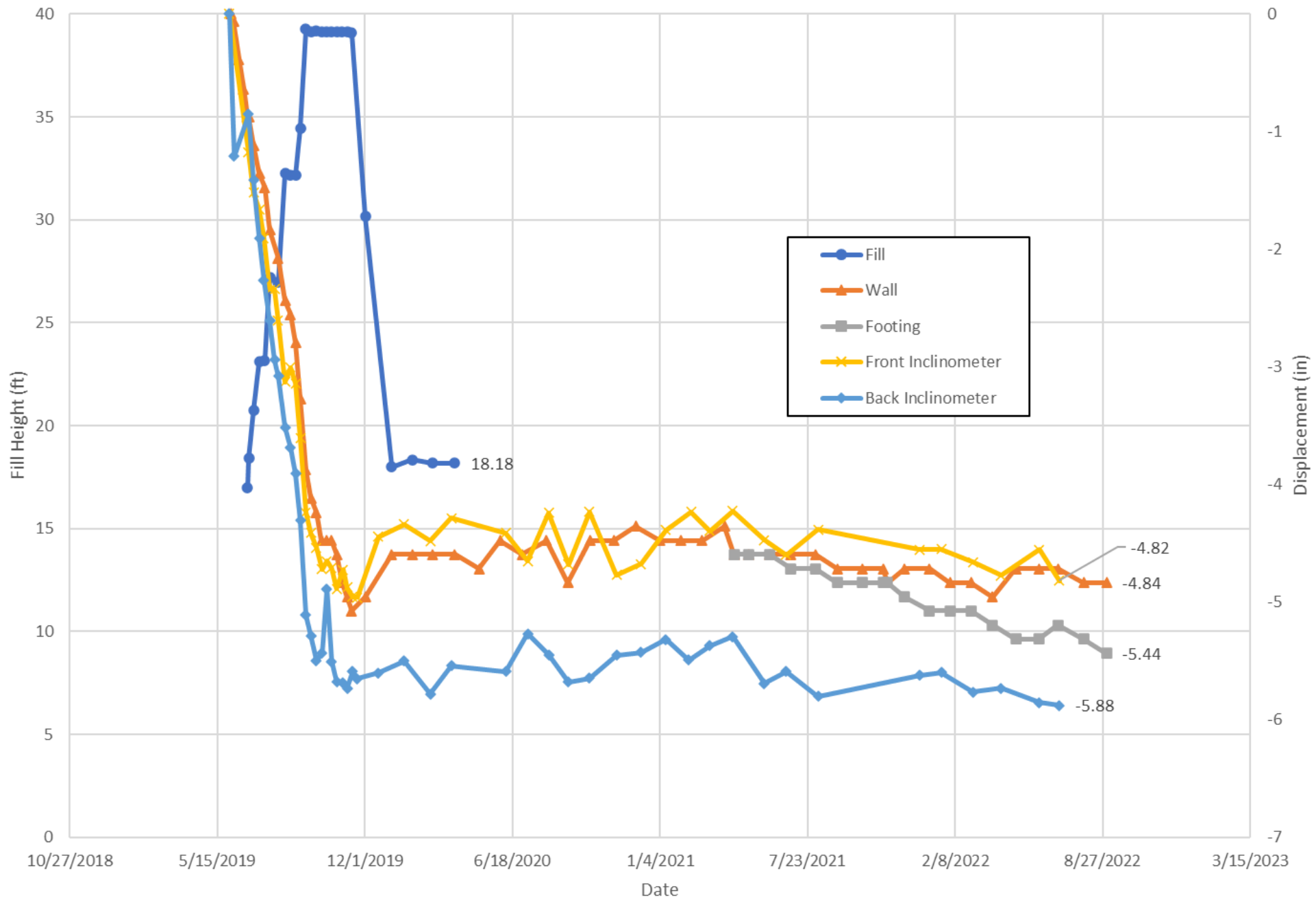


# U2525C Site 2B: Back Inclinometer Displacement





U2525C Site 2B: Footing, Wall, and Inclinometer Displacement



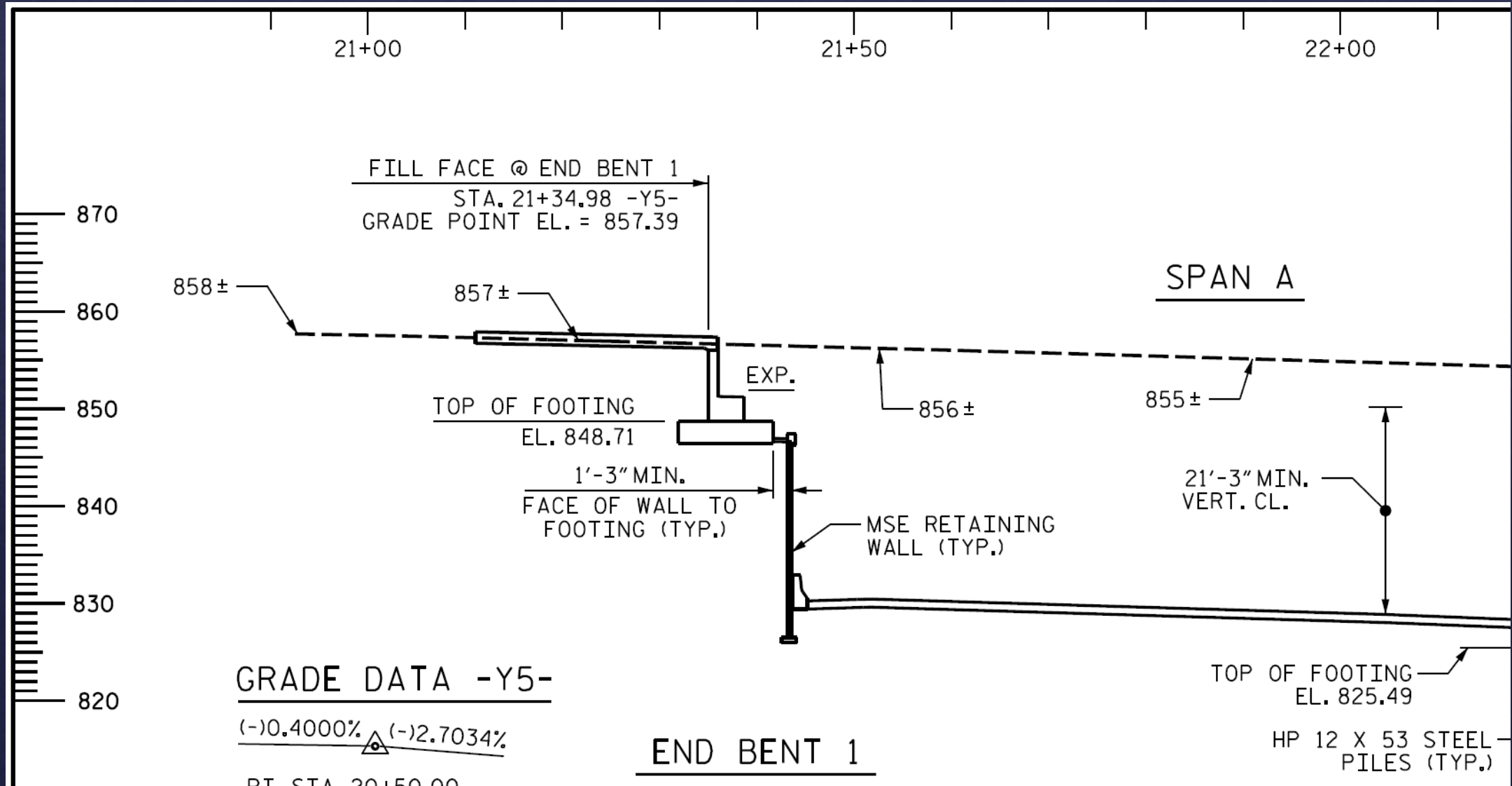


# Site 5: Structure 7

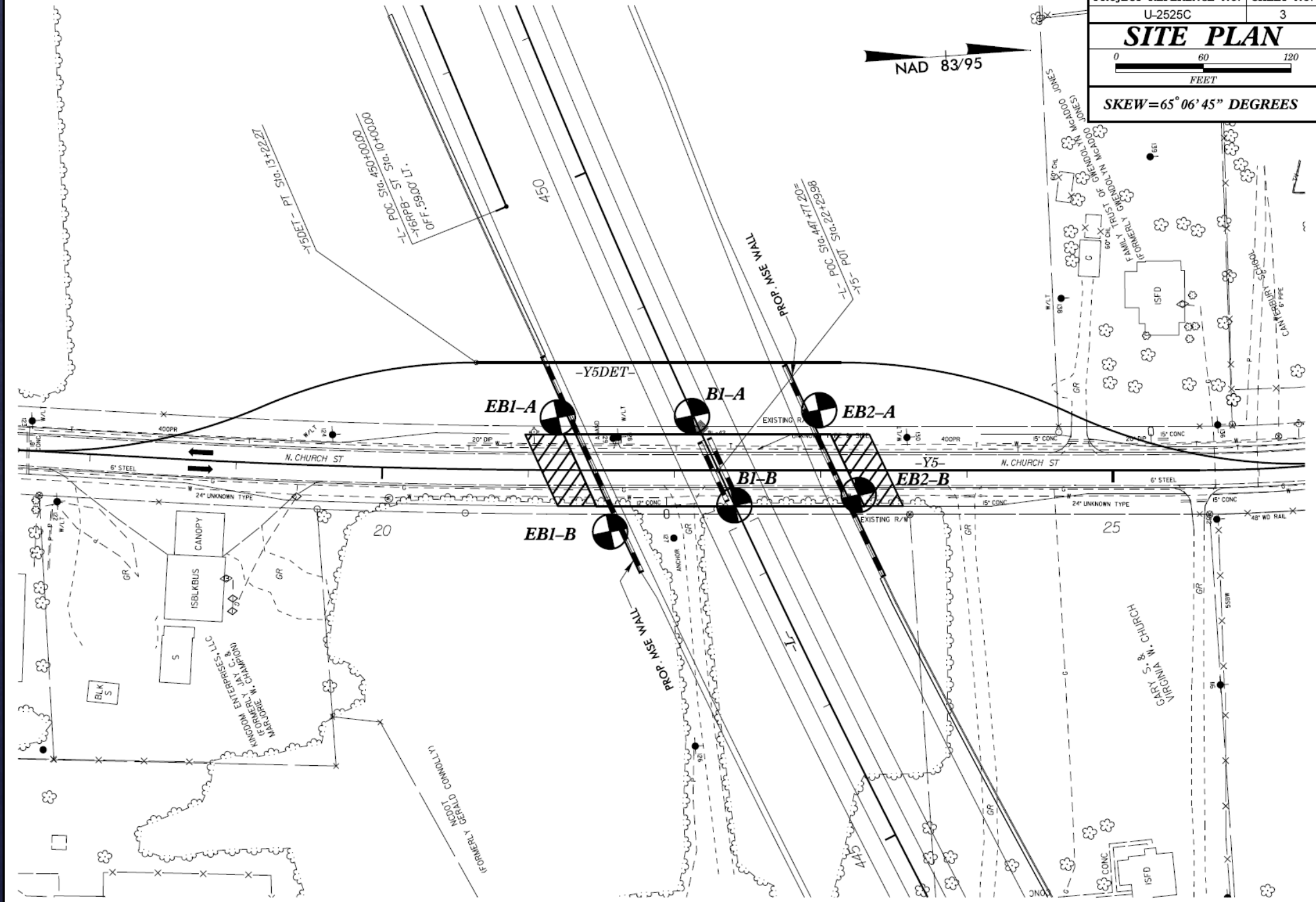
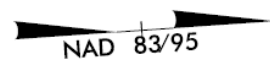
- ◇ Cut section
- ◇ Spread footing specs
  - ◇ 66'-8" x 8' x 2'-3" EB1
  - ◇ 66'-8" x 7'-9" x 2'-3" EB2
- ◇ 1 month wait after bottom of footing elevation reached
- ◇ Undercut at EB2



# Structure 7



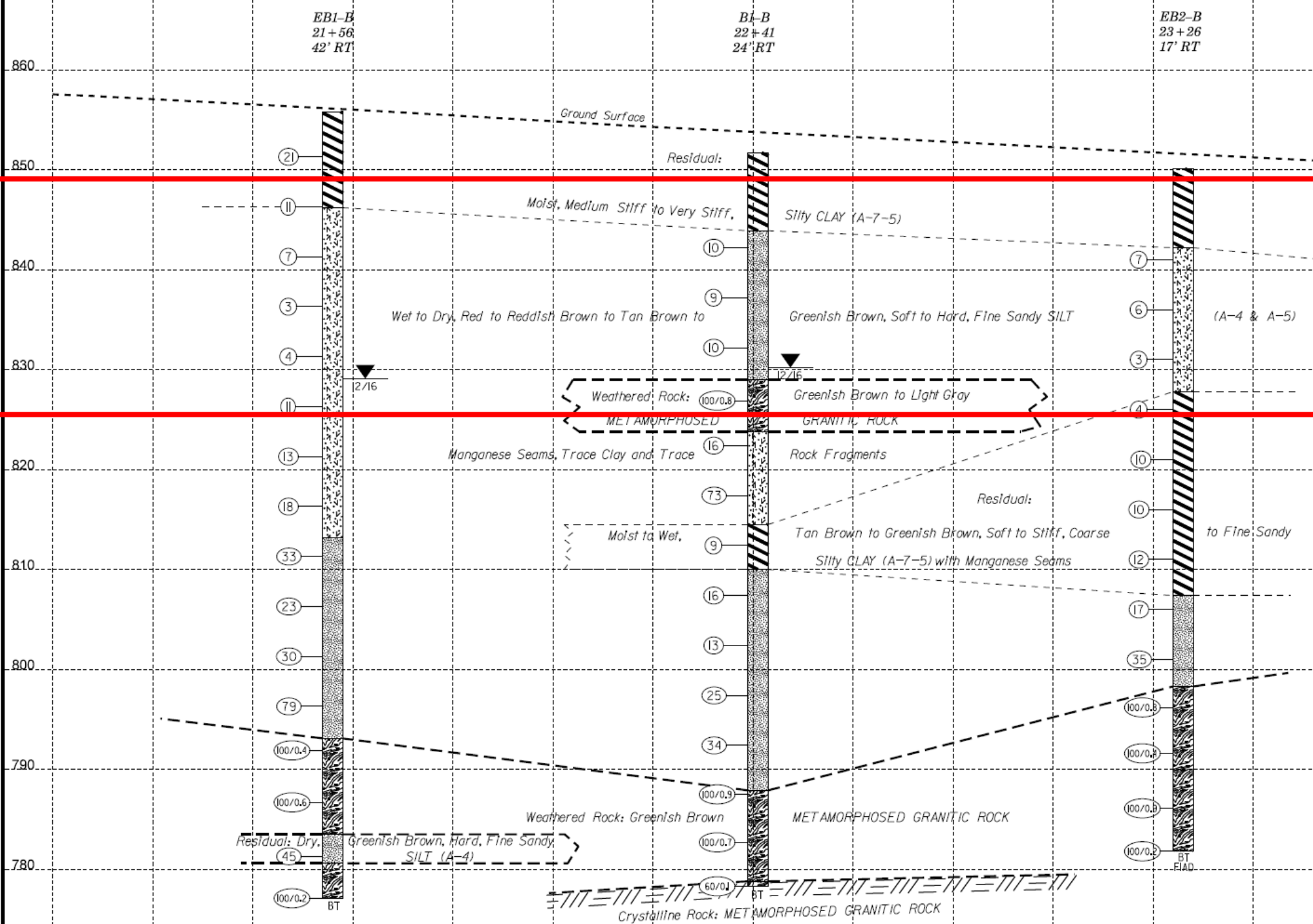






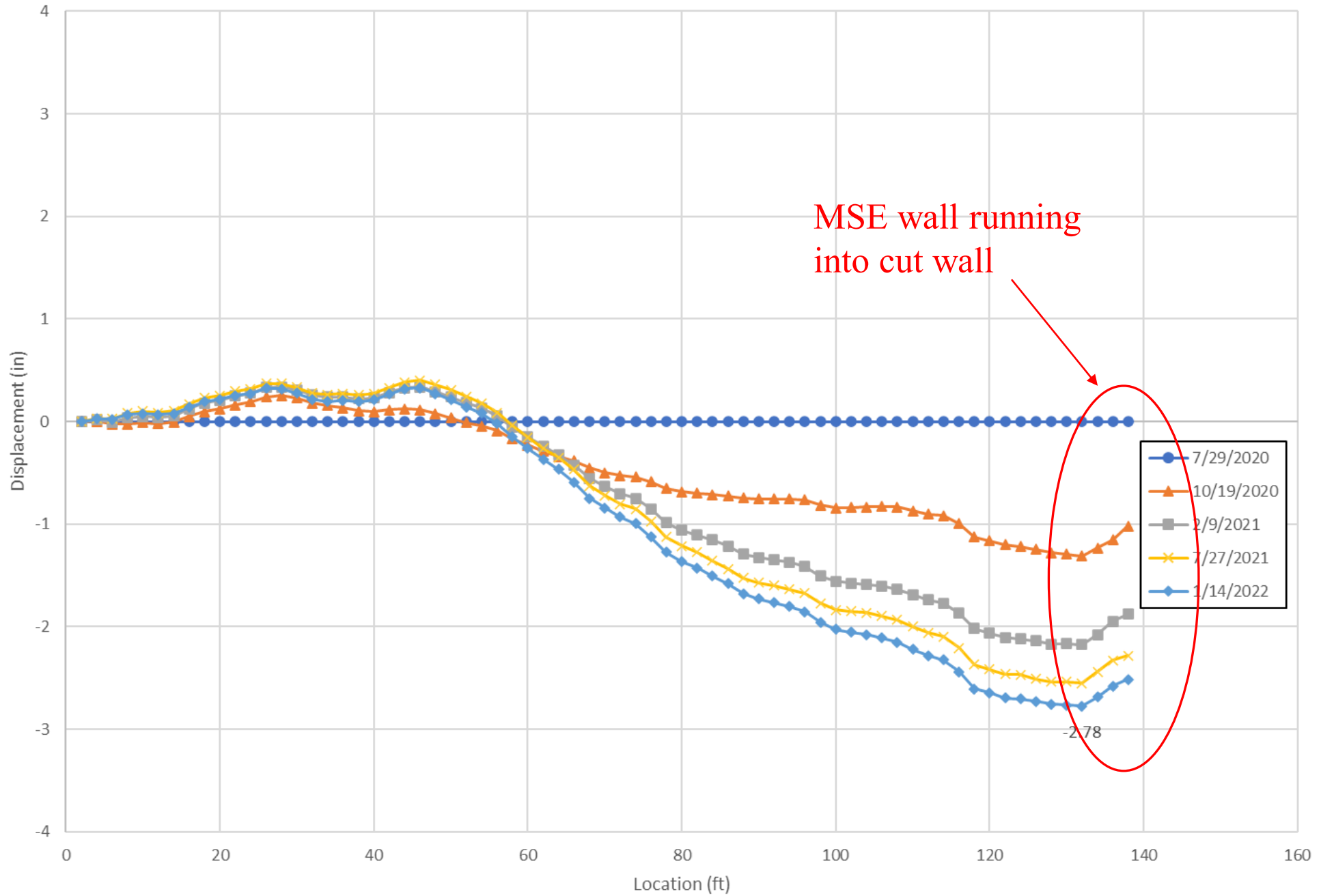
Footing

MSE wall





U2525C 5A: Front Inclinometer Displacement





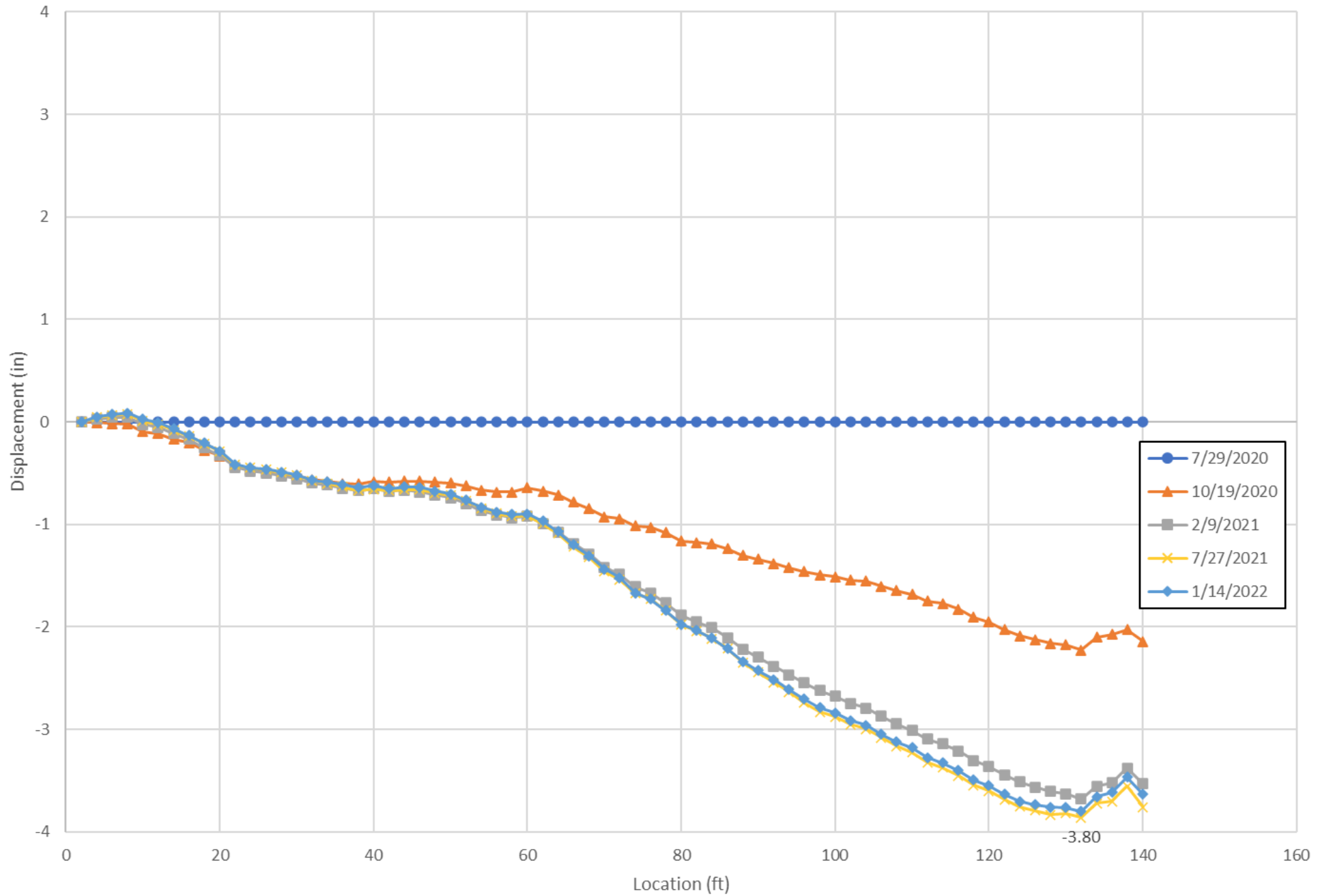


EB1

EB2

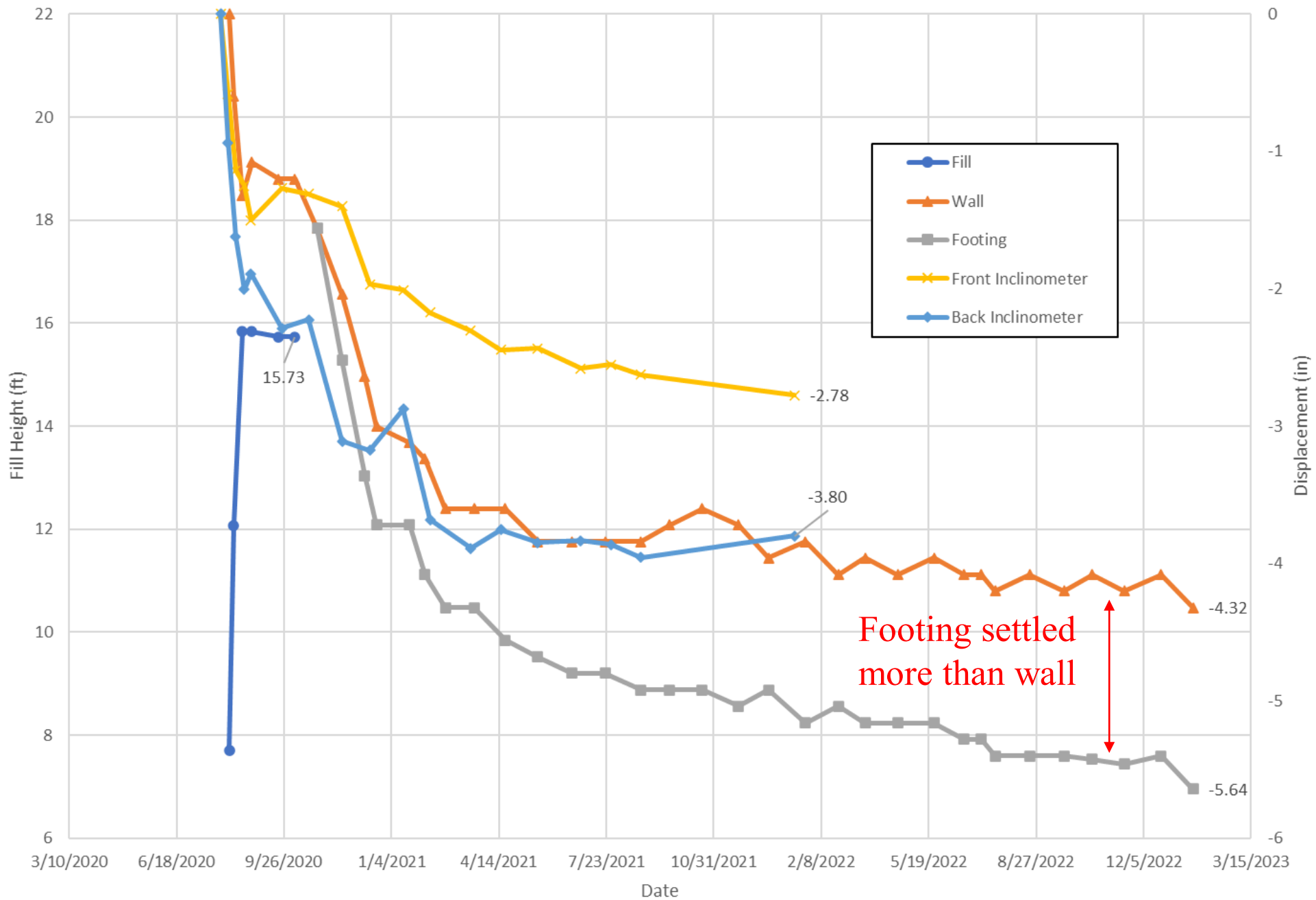


U2525C 5A: Back Inclinator Displacement



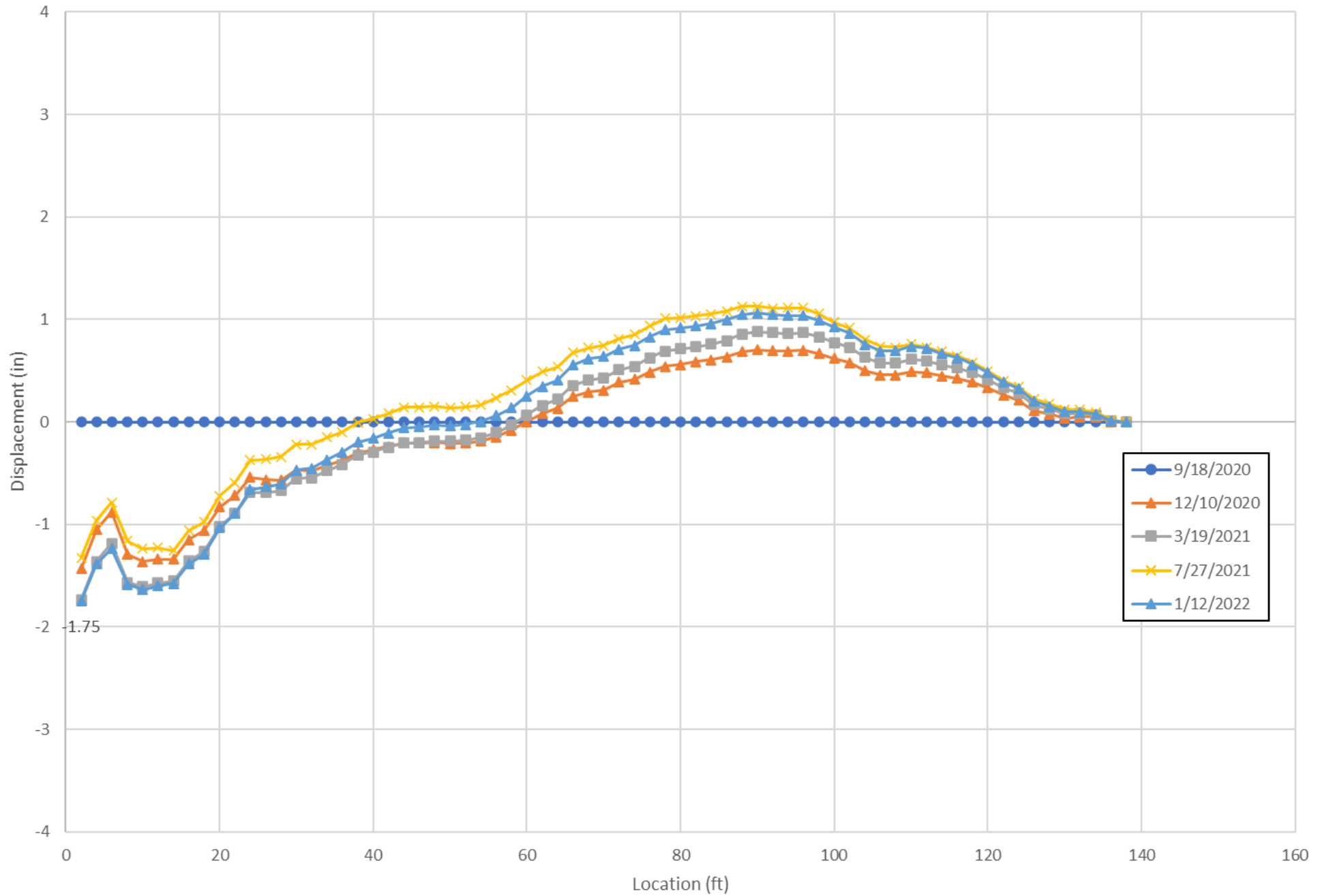


U2525C Site 5A: Footing, Wall, and Inclinometer Displacement



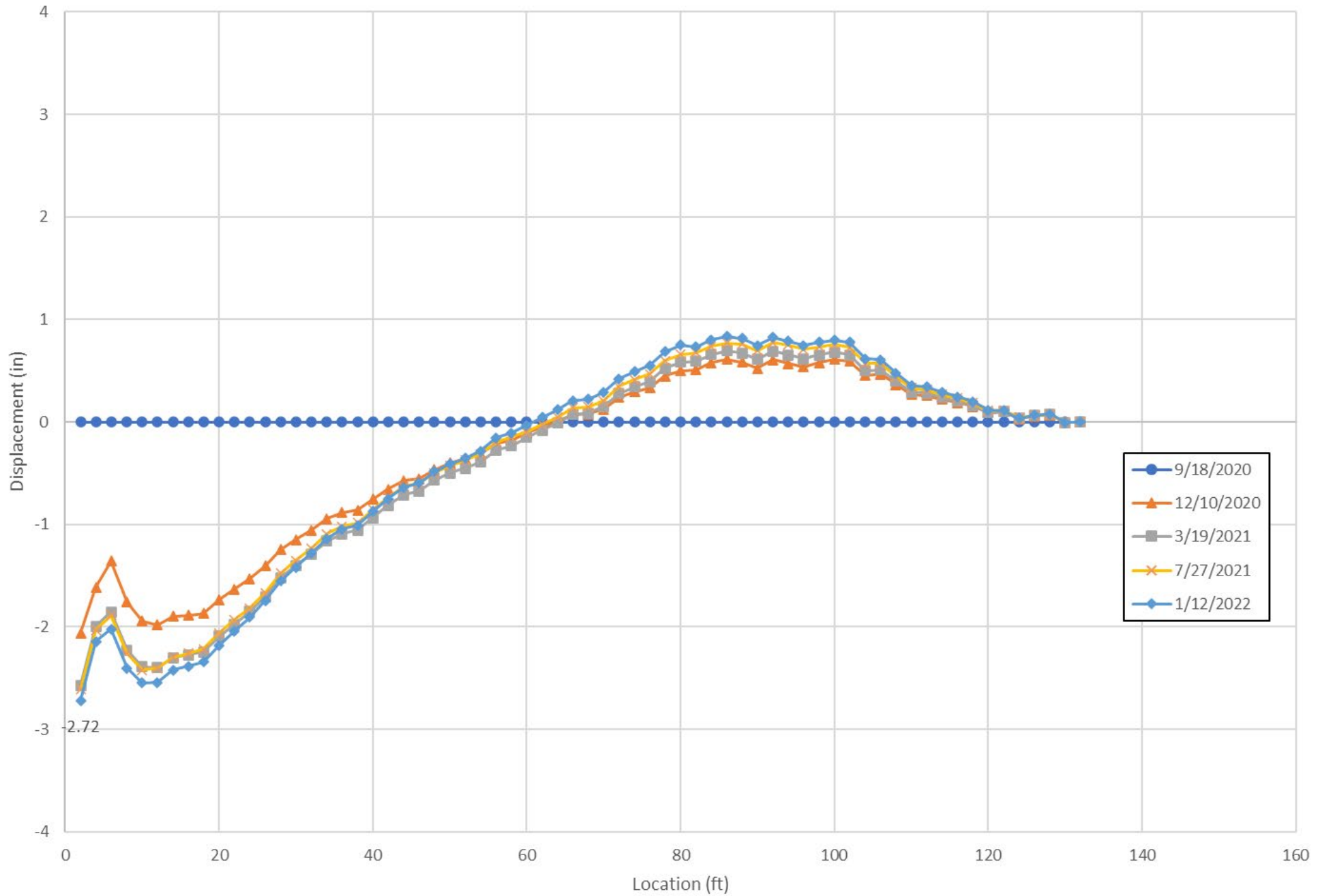


U2525C 5B: Front Inclinometer Displacement



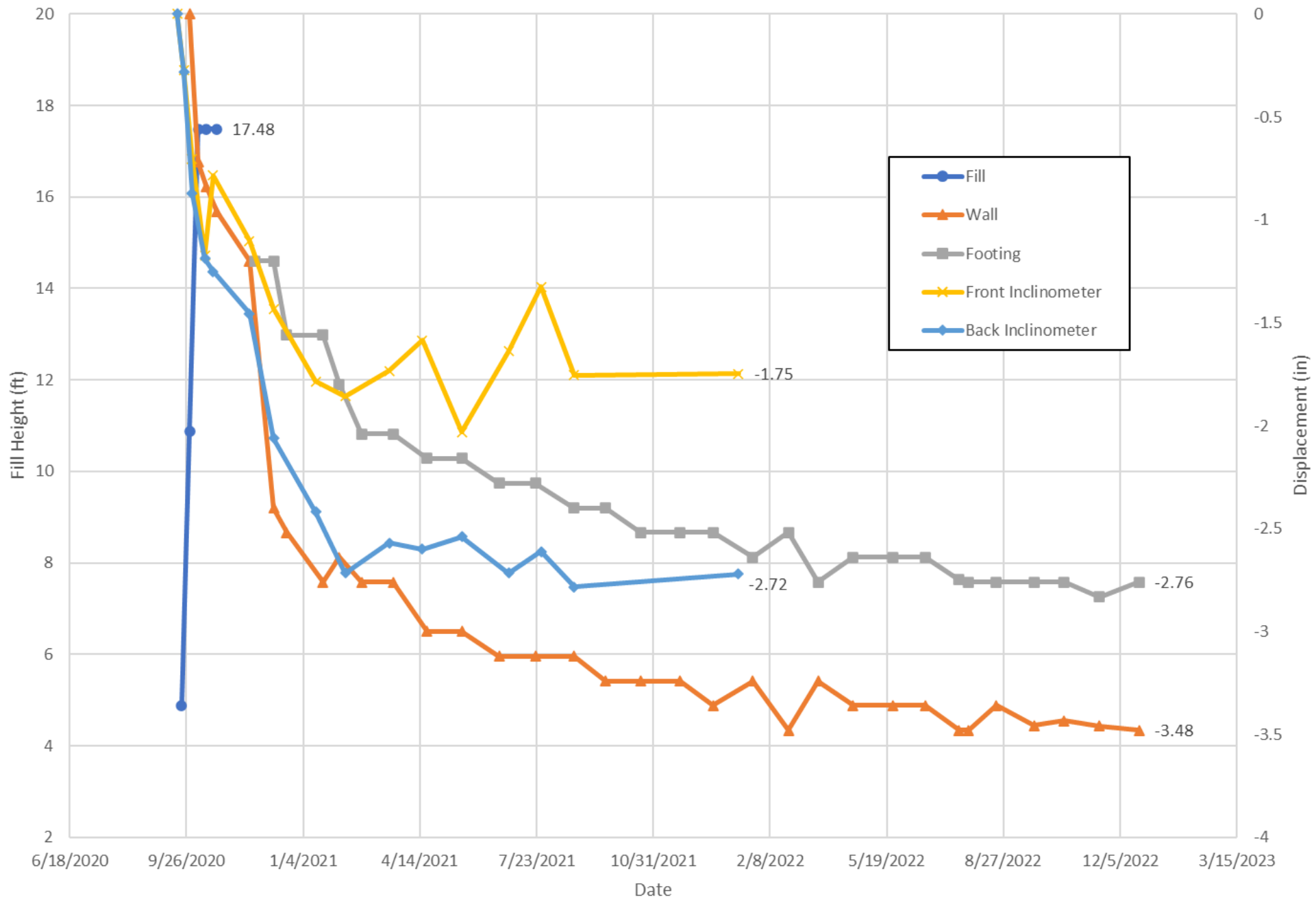


U2525C 5B: Back Inclinometer Displacement





U2525C Site 5B: Footing, Wall, and Inclinometer Displacement





# Settlement Summary

Site	Predicted Settlement (in)	Measured Settlement (in)*	Settlement After Girders Placed (in)
1A	0.50	1.44	0.48
1B	1.00	2.76	0.96
2A	4.00	3.02	0.87
2B	5.25	5.88	0.29
4A	0.50	2.76	1.62
4B	0.25	1.44	1.32
5A	0.25	4.32	2.04
5B	1.50	3.48	2.28
6A	1.00	1.08	0.48
6B	1.00	3.12	0.48

\*Measured maximum settlement at subject Site between inclinometer, wall points, and footing points.

# Differential Settlement

<b>Site</b>	<b>Predicted Differential Footing Settlement (in)</b>	<b>Measured Differential Footing Settlement (in)</b>
1A	0.25	0.12
1B	1.00	0.36
2A	2.00	0.48
2B	2.25	0.48
4A	0.25	0.72
4B	0.25	0.12
5A	0.25	0.72
5B	0.25	0.12
6A	-*	0.12
6B	-*	1.08

\*Settlement analysis not performed.



# Conclusions

- ◇ Most settlement occurred before girder placement
- ◇ Differential not an issue
- ◇ Inclinator and survey point differences
- ◇ Underpredicted total settlement at most sites
- ◇ Cut sites
  - ◇ Soil rebound
  - ◇ Pre-existing load
- ◇ Reinforced fill settlement

# Thoughts on Shallow Foundations

## ◆ Advantages

- ◆ No bridge bump
- ◆ Cost effective
- ◆ Less risk of uncertainties

## ◆ Disadvantages

- ◆ Predicting settlement
- ◆ May require surcharging/pre-loading
- ◆ Requires monitoring
- ◆ Increased investigation
- ◆ Increased engineering analysis



Thank You!