

Challenges & Triumphs of a Pile Supported Embankment in the North Carolina Coastal Plain

Mimi Sweitzer, PE
msweitzer@rkk.com
October 31, 2023

STGEC Charlotte 2023



Agenda

- **Project Overview**
- **Geotechnical Highlights**
- **Pile Supported Embankment**
 - **Design**
 - **Construction**
- **Summary**

Perquimans Swing-Span Bridge Design-Build

McLean
CONTRACTING COMPANY

RK&K

HH Hardesty
& Hanover

NCDOT Project R-4467
Perquimans County, NC

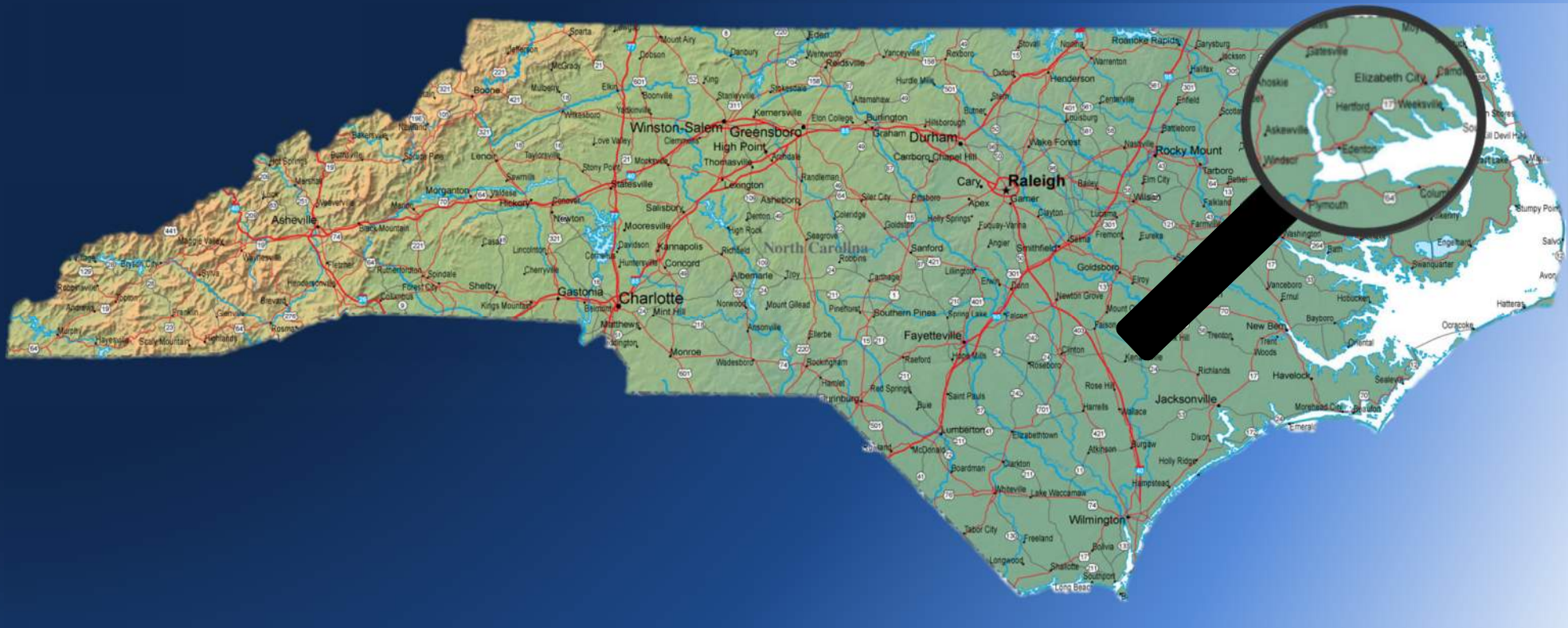


US 17 Bus. / NC 37 from South
of the Perquimans River Bridge
to North of NC 37; Including the
Replacement of Bridge No. 8



STGEC Charlotte 2023

70 years **RK&K**



STGEC Charlotte 2023





STGEC Charlotte 2023





Existing bridge opened in 1929 Swinging “S-bridge” and Causeway Connect towns of Hertford and Winfall



STGEC Charlotte 2023



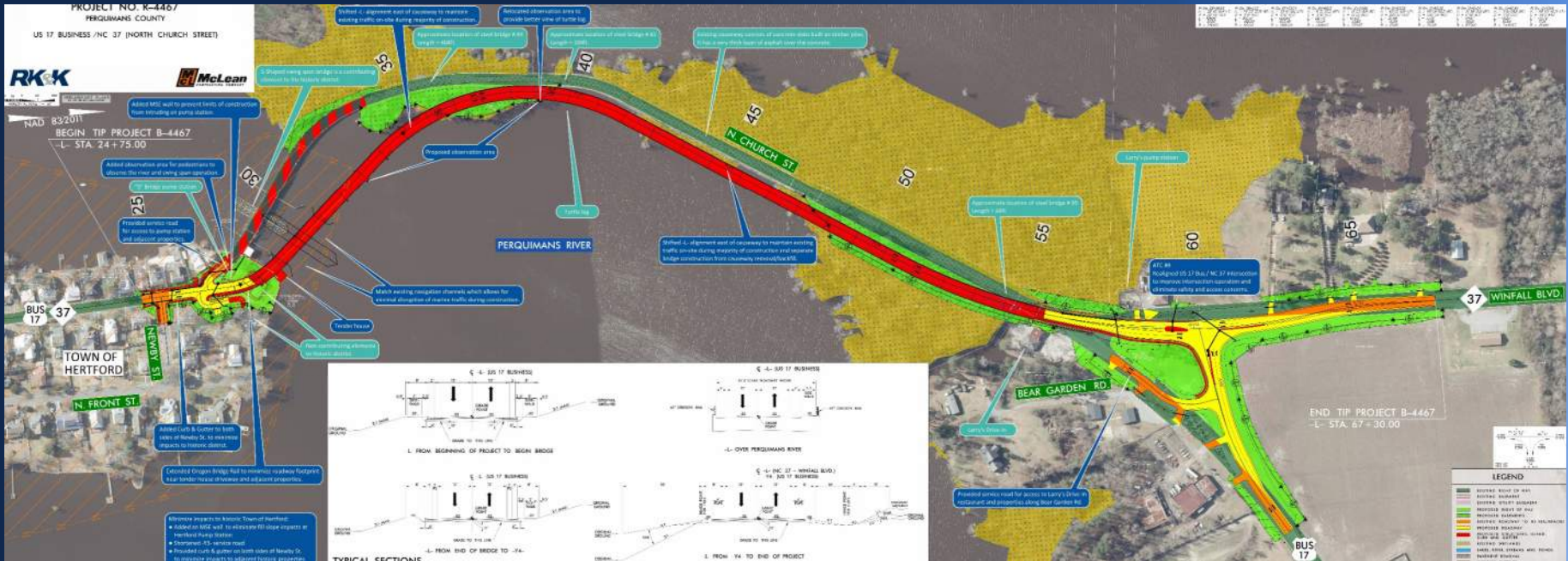
Final Horizontal Alignment

Considerations:

1. Historic Area
2. Existing River Channel
3. Turtle Log
4. Causeway
5. Cypress Trees
6. Larry's
7. Winfall Intersection
8. Sewer Pump Stations



RFP: Alignment must be on the west side of the turtle log and at least 40 feet away from the closest visible portion of the turtle log.



Design Details

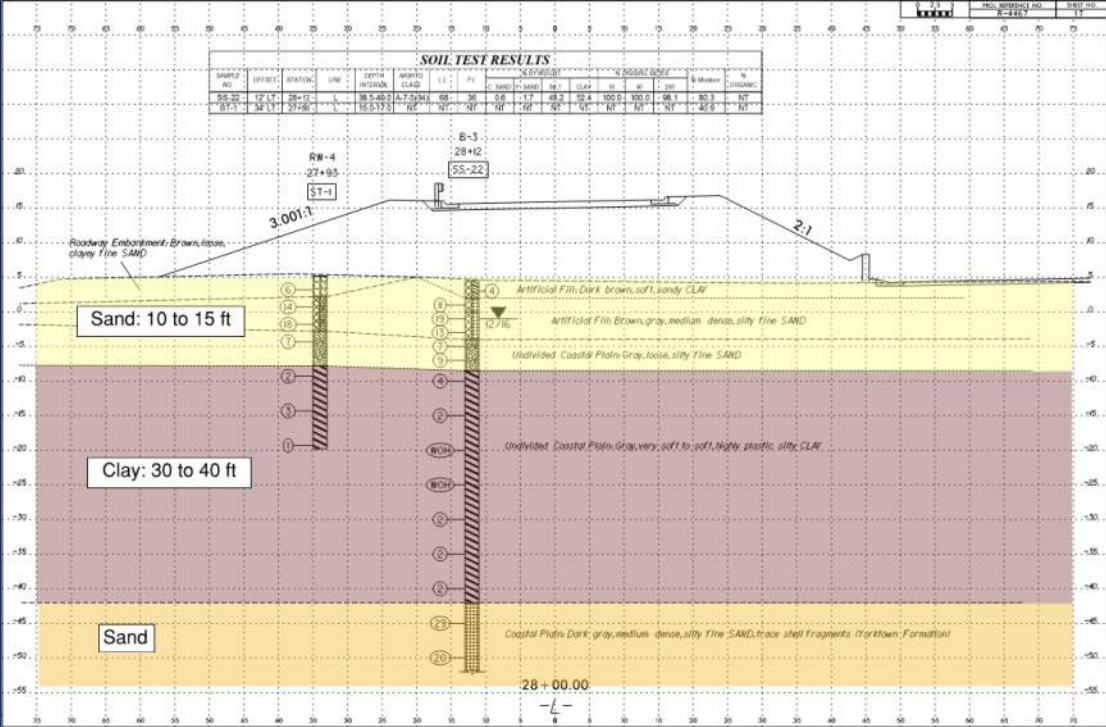
- Shifted Alignment/Raised the grade
- 2,691 feet
- 29 spans

STGEC Charlotte 2023



Geotechnical Highlights

1. Subsurface Investigation



STGEC Charlotte 2023



Geotechnical Highlights

1. Subsurface Investigation
2. Bulkhead Walls



STGEC Charlotte 2023



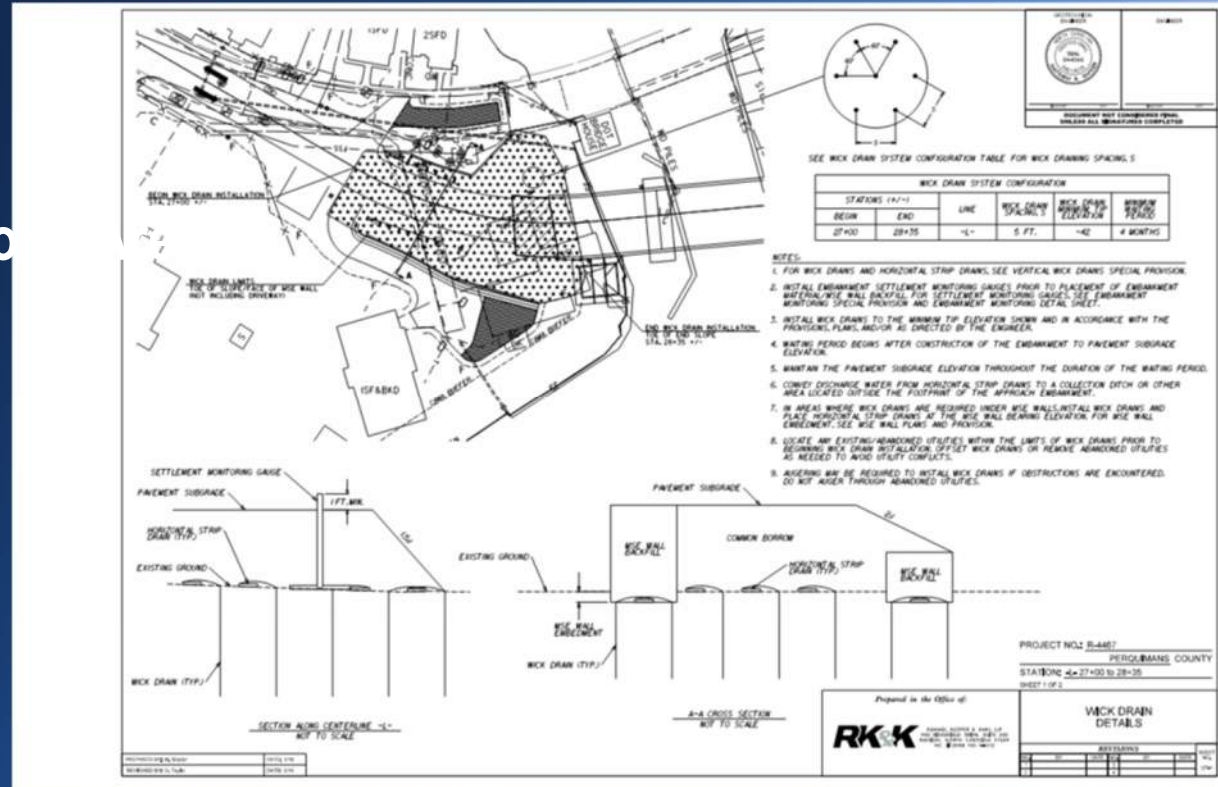
Geotechnical Highlights

1. Subsurface Investigation
2. Bulkhead Walls
3. **Vibration Monitoring (Historic Area)**



Geotechnical Highlights

1. Subsurface Investigation
2. Bulkhead Walls
3. Vibration Monitoring (Historical)
4. Wick Drains at End Bent 1



Geotechnical Highlights

1. Subsurface Investigation
2. Bulkhead Walls
3. Vibration Monitoring (Historic Area)
4. Wick Drains at End Bent 1
5. **RSS over MSE wall**



Geotechnical Highlights

1. Subsurface Investigation
2. Bulkhead Walls
3. Vibration Monitoring (Historic Area)
4. Wick Drains at End Bent 1
5. RSS over MSE wall
6. **Bridge Foundations**
 - **End Bents on HP 14 x73 Steel Piles**
 - **First 3 bents designed by others**
 - **30-inch Prestressed Concrete Piles**



Geotechnical Highlights

1. Subsurface Investigation
2. Bulkhead Walls
3. Vibration Monitoring (Historic Area)
4. Wick Drains at End Bent 1
5. RSS over MSE wall
6. Bridge Foundations
 - End Bents on HP 14 x73 Steel Piles
 - First 3 bents designed by others
 - 30-inch Prestressed Concrete Piles
7. Lateral Load Test



STGEC Charlotte 2023

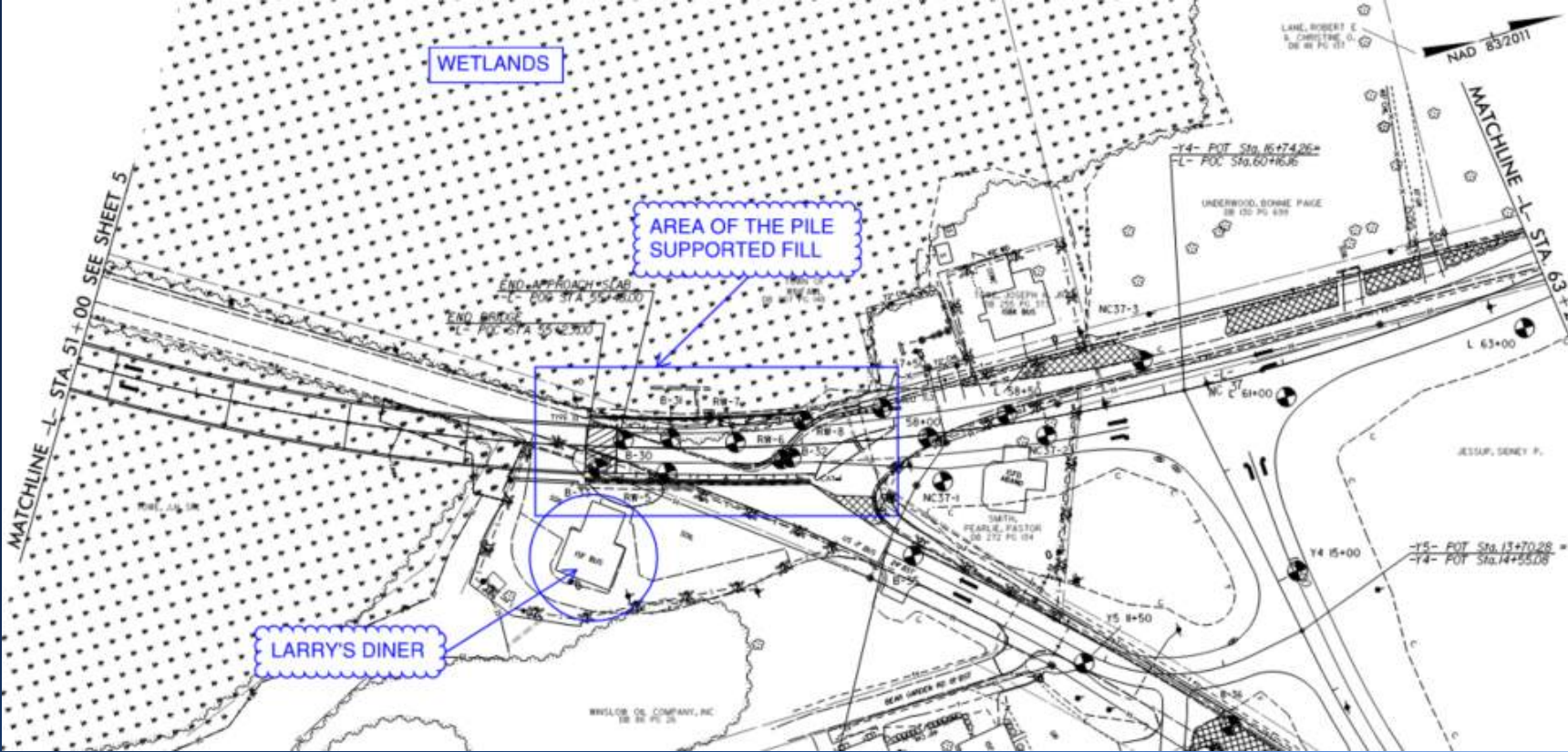
Geotechnical Highlights

1. Subsurface Investigation
2. Bulkhead Walls
3. Vibration Monitoring (Historic Area)
4. Wick Drains at End Bent 1
5. RSS over MSE wall
6. Bridge Foundations
 - End Bents on HP 14 x73 Steel Piles
 - First 3 bents designed by others
 - 30-inch Prestressed Concrete Piles
7. Lateral Load Test
8. **Pile Supported Embankment**

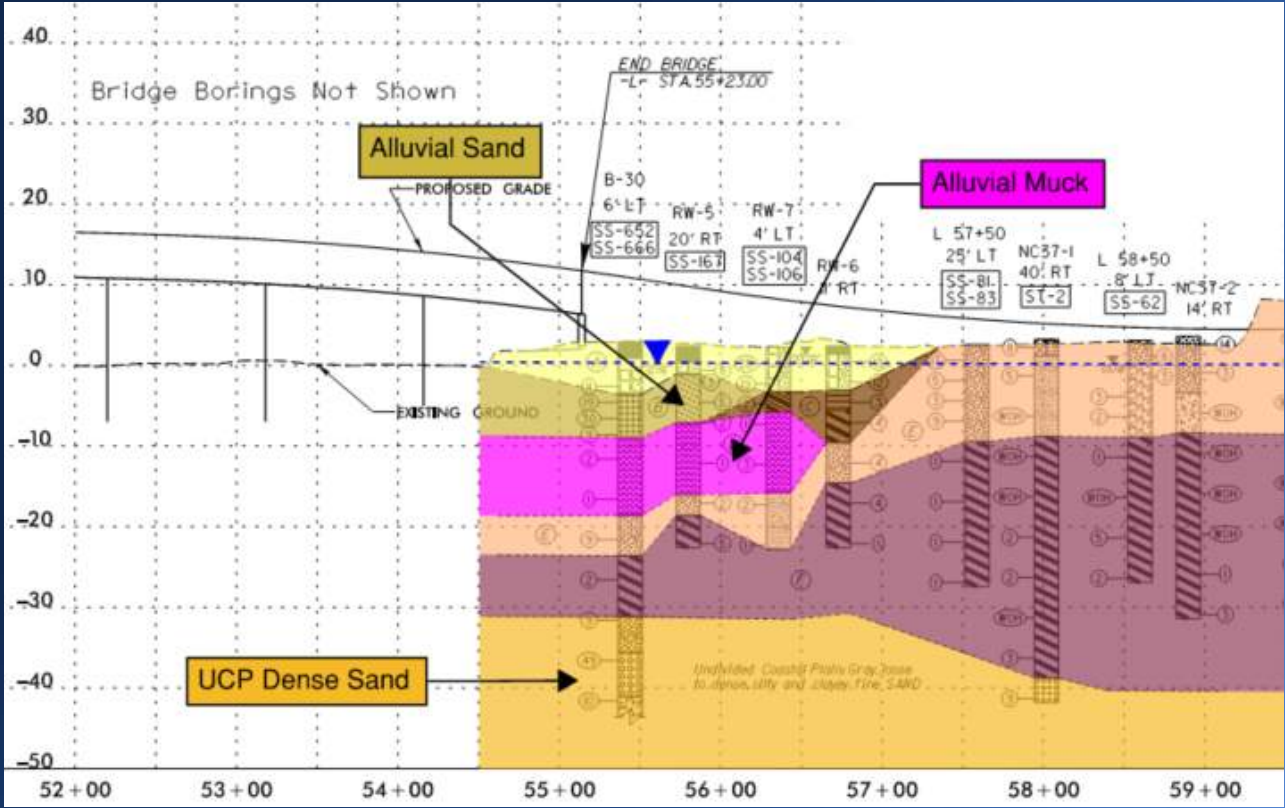
STGEC Charlotte 2023



Pile Supported Embankment - Design

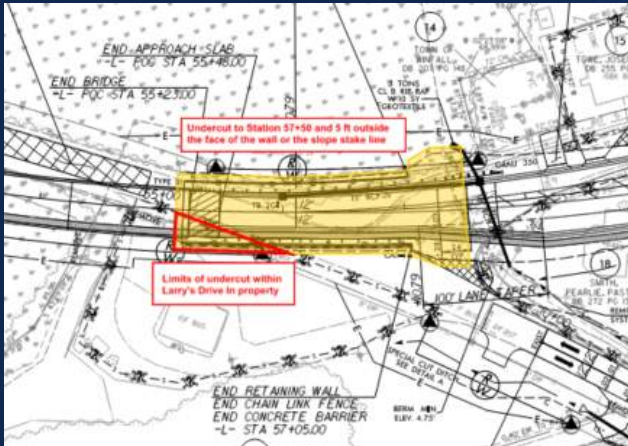


Pile Supported Embankment - Design

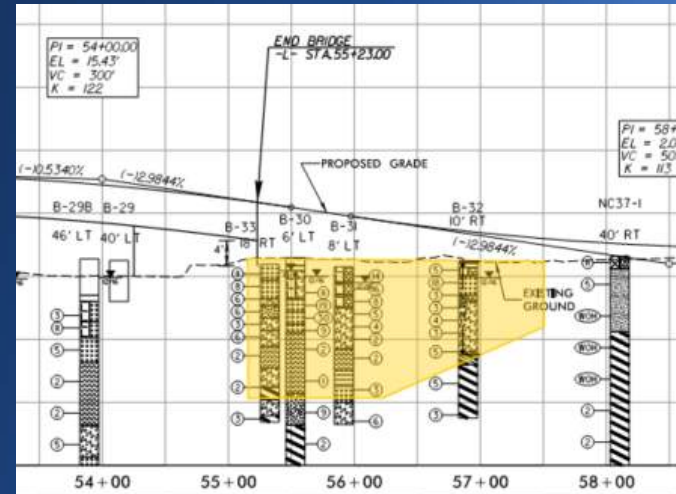


Pile Supported Embankment - Design

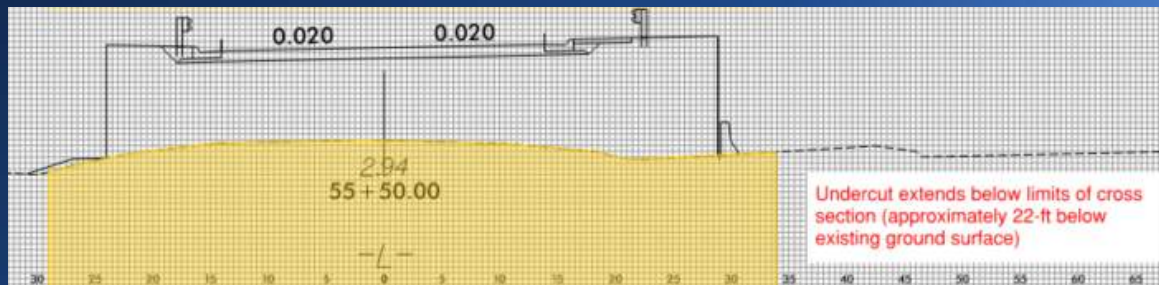
Pursuit Phase – Undercut



Plan



Profile



Cross Section

STGEC Charlotte 2023



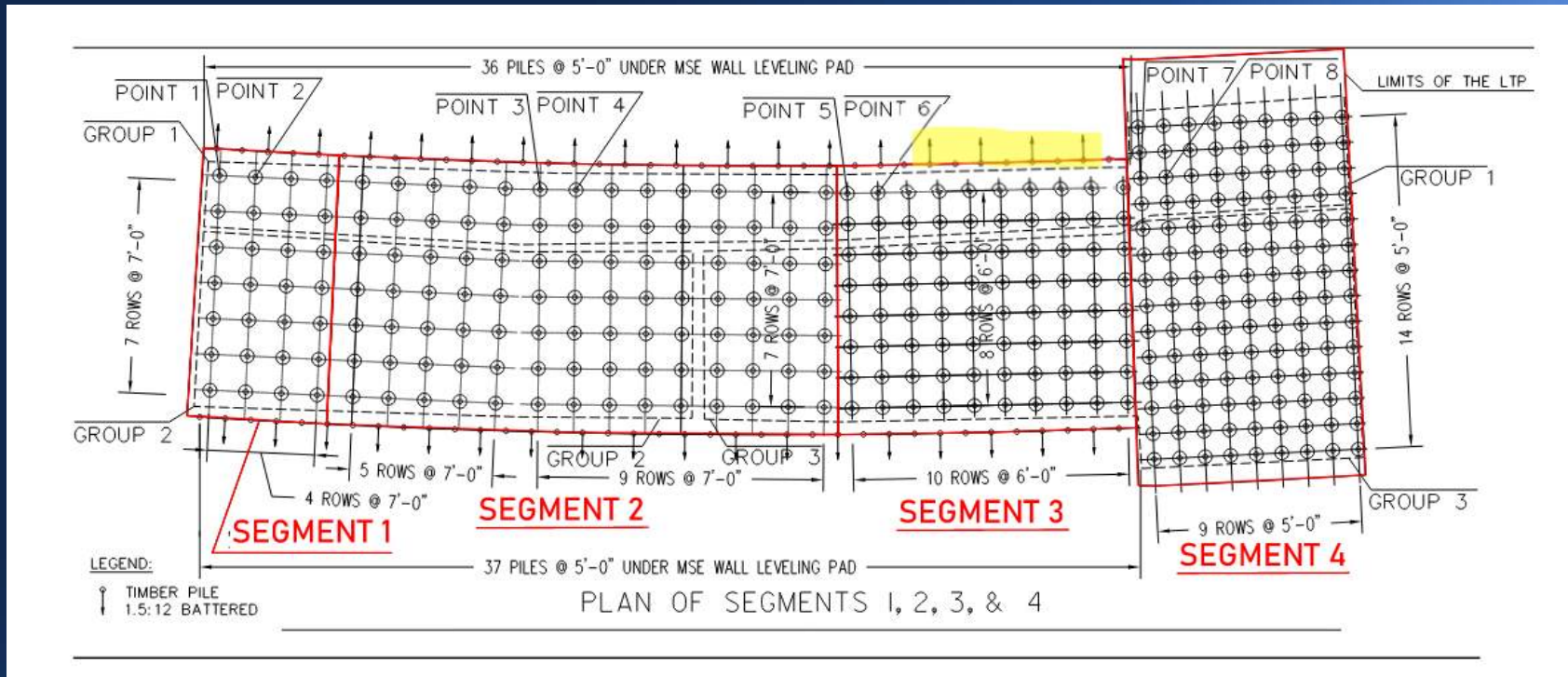
Pile Supported Embankment - Design

Post-Award – PSE

Challenges

1. High Groundwater
2. MSE wall designs/shop drawings complete
3. Pile capacity

Pile Supported Embankment - Design

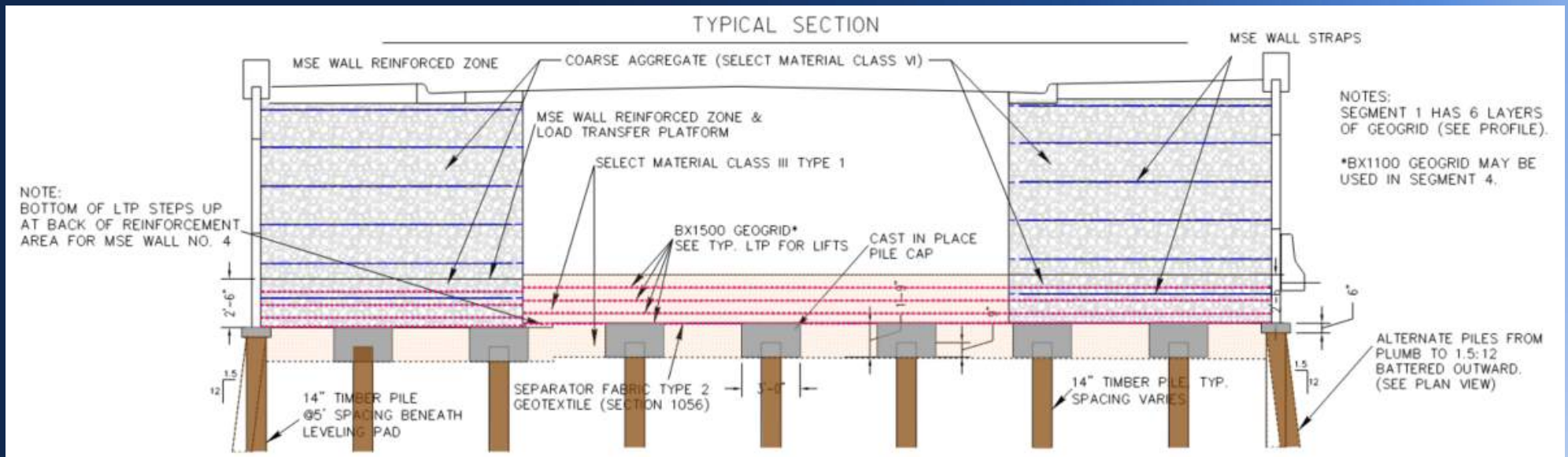


Four Design Segments – based on embankment height

STGEC Charlotte 2023



Pile Supported Embankment - Design

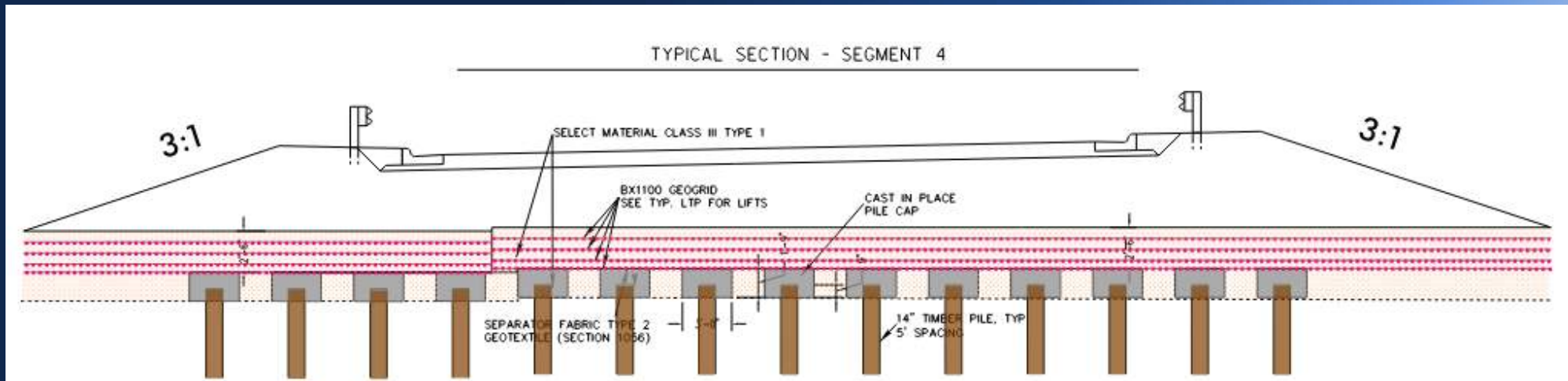


Class A Southern Pine Timber Piles (14-inch butt diameter)

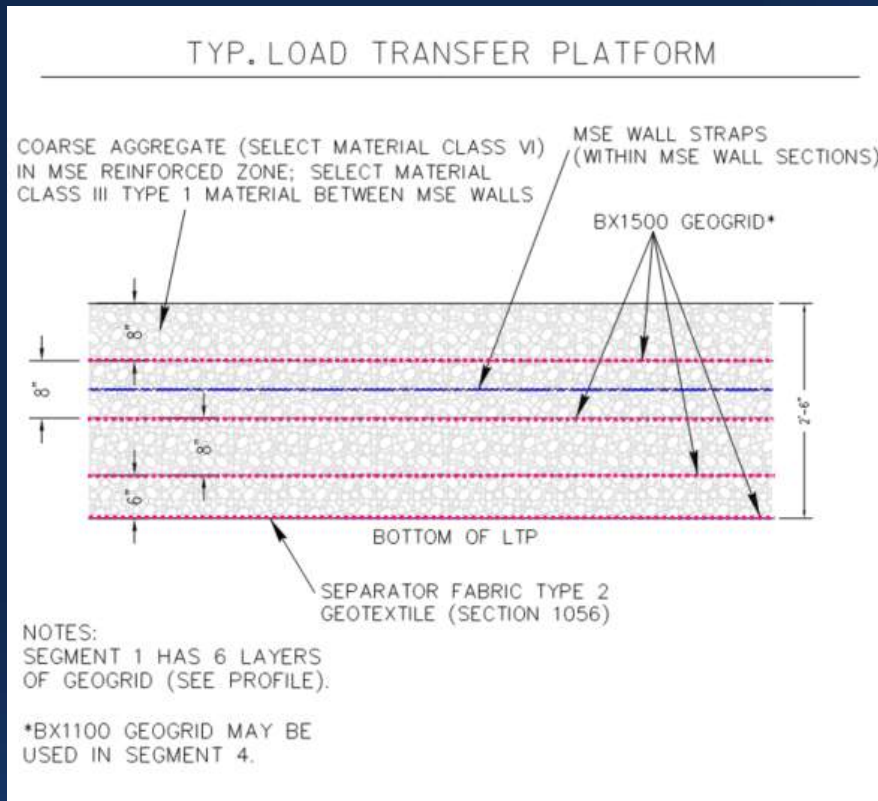
STGEC Charlotte 2023



Pile Supported Embankment - Design



Pile Supported Embankment - Design



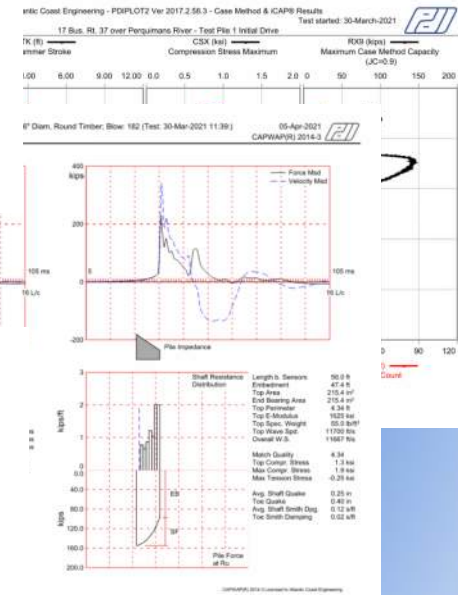
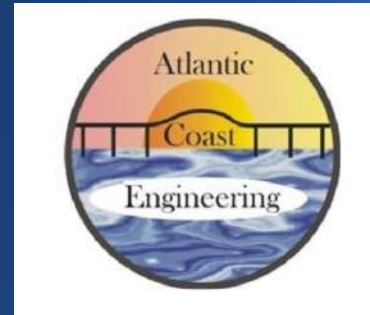
- Select Material between caps
- Separation Geotextile
- Biaxial Geogrid
 - $T_{ult} = 1,850$ lb/ft (MSE Wall)
 - $T_{ult} = 850$ lb/ft (Embankment)
- 4 lifts of Select Material (6 in Segment 1)
 - Coarse in MSE Wall
 - Fine elsewhere

Pile Supported Embankment – Design/Construction

2 TEST PILES

PDA testing by Atlantic Coast Engineering
 March 30, 2021 with restrrike on April 1, 2021

Pile lengths determined
 Driving Criteria Established



Driving Criteria

1. Drive piles on fuel setting 4.
2. Drive piles to a pile tip elevation of -46' and to a minimum end of drive rate of penetration as shown below.
3. Production piles not meeting the minimum end of drive rate of penetration, should be restruck at the direction of the Geotechnical Engineer of record to verify that piles not meeting the minimum end of drive rate of penetration are acceptable.

Driving Criteria for Ground Improvement Piles

Pile Height (ft)	7' of Fill (46 kips)	9' of Fill (80 kips)	11' of Fill (129 kips)	13' of Fill (148 kips)
5.5	11	26	106	191
6.0	10	24	93	156
6.5	10	23	84	133
7.0	9	22	77	118
7.5	9	21	69	105
8.0	9	20	63	96
8.5	8	19	58	90

STGEC Charlotte 2023



Pile Supported Embankment – Construction



NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
ELIZABETH CITY FIELD OFFICE

CJ04003 / B-4467 Perquimans "S" Bridge

Sheet No. _____ of _____
Driving Date: _____
Time: _____ to _____

PILE DRIVING DATA FOR _____

Bent Number: SEGMENT 4	Pile Number: _____	Station: _____
Pile Type: TIGEE	Pile Length: 25'	Head/Casting # _____
Template Elev: _____	Pile Tip @ Start: _____	Ground Elev: _____
Pile Cutoff Elev: _____	Hammer Energy: _____	Embedded Length @ Final: _____
Hammer Type: OED	Stroke: _____	Hammer Cushion: _____
Model: D'E	Min. Bearing Capacity: _____	Min # Strokes: _____
Wave Equation: _____		Max # Strokes: _____

Personnel	Blows Per Ft	Remarks	1 FT Below Batter Board	Blows Per Ft	Remarks
20					
1					
2					
3					
4					
25					
6	5				
7	5				
8	5				
9	5				
30	5				
1	5				
2	5				
3	5				
4	5				
35	5				
6	5				
7	5				
8	5				
9	5				
40	5				
1	5				
2	5				
3	5				
4	5				

STROKE: 5.5R
BPF - REQUIRED: 11 / ACTUAL: 8
RESTRIKE REQUIRED

Penetration Last 10 Blows: _____ FT
Bearing Capacity: _____ TON
Pile Cutoff: _____ FT
Pile Length: _____ FT



STGEC Charlotte 2023



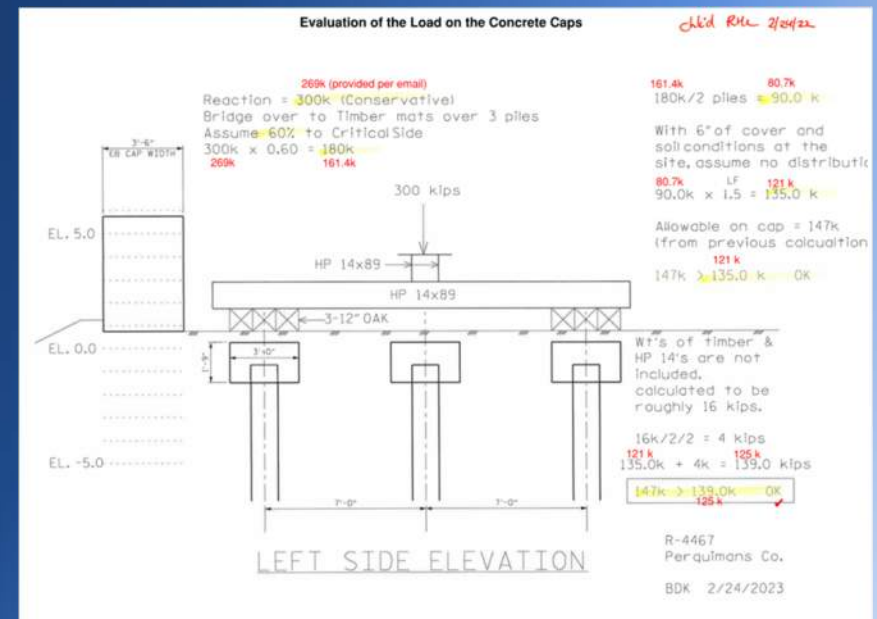
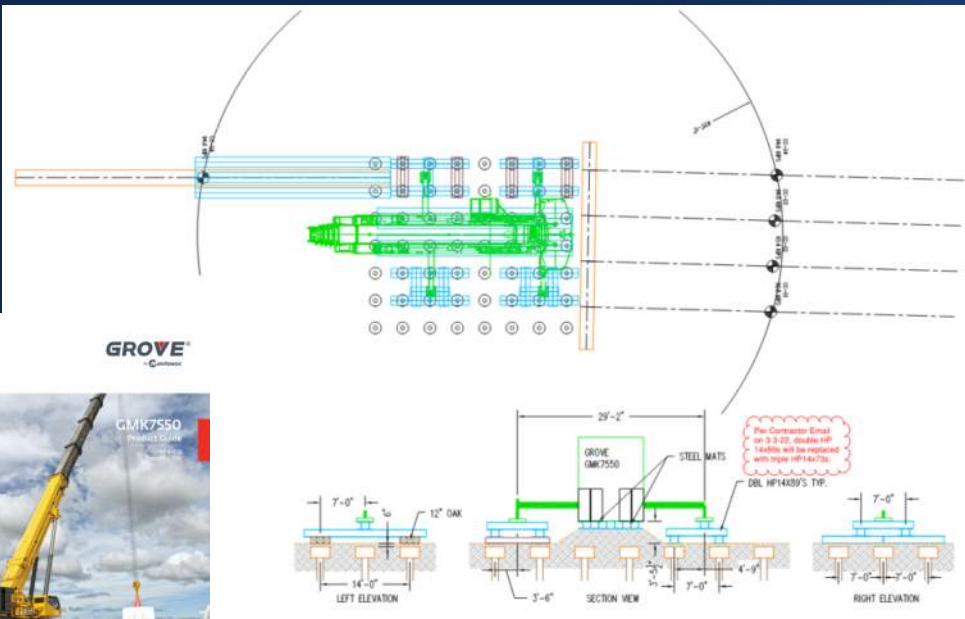
Pile Supported Embankment – Construction



STGEC Charlotte 2023



Pile Supported Embankment – Construction Crane Loading



STGEC Charlotte 2023



Pile Supported Embankment – Construction Crane Loading



STGEC Charlotte 2023



Pile Supported Embankment – Construction Crane Loading



STGEC Charlotte 2023



Pile Supported Embankment – Construction

SUMMARY OF QUANTITIES	
14" X 50' TIMBER PILES	177
14" X 45' TIMBER PILES	228
CIP CAPS	332
SELECT MATERIAL CLASS III TYPE I	1700 CY
GEOGRID (SEG. 4)	1700 SY
GEOGRID (SEG. 1,2,3)	4800 SY
TYPE 2 GEOTEXTILE FOR LTP BOTTOM	1600 SY
NOTE: GEOGRID QUANTITY DOES NOT INCLUDE OVERLAP OR WASTE	



STGEC Charlotte 2023



Pile Supported Embankment – Construction



STGEC Charlotte 2023



Ribbon Cutting – August 27, 2022



STGEC Charlotte 2023





STGEC Charlotte 2023





STGEC Charlotte 2023





STGEC Charlotte 2023





Thank you
Questions?



STGEC Charlotte 2023



References

FHWA GEC 013 - Ground Modification Methods Reference Manual –
Chapter 6

Design of Bridging Layers in Geosynthetic-Reinforced, Column-
Supported Embankments (M. Filz and E. Smith, 2006)

AASHTO LRFD (8th Ed.)

Geosynthetic-Reinforced Column-Support Embankment Design
Guidelines (J. Collin, J. Han and J. Huang, 2005)