MemFix 4:
A CMGC Project
LESSONS LEARNED

By

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:

The 55th Annual KU Geotechnical Engineering Conference
Lawrence, KS
November 9, 2023

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OUTLINE

- What is CM-GC?
- Background (Previous Widening Project)
- Project Objectives
- Subsurface Exploration
- Design / Construction Challenges
- Lessons Learned / Benefits
- Questions

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WHAT IS CM-GC?

- It is a contracting method that involves a Contractor in the design and construction phases of the project.
- The intent is to form a partnership with TDOT, the Designer, and the Contractor.
- The goals of this partnership are to mitigate risk, improve the construction schedule, streamline the design process, and develop a project that adheres to the budget.

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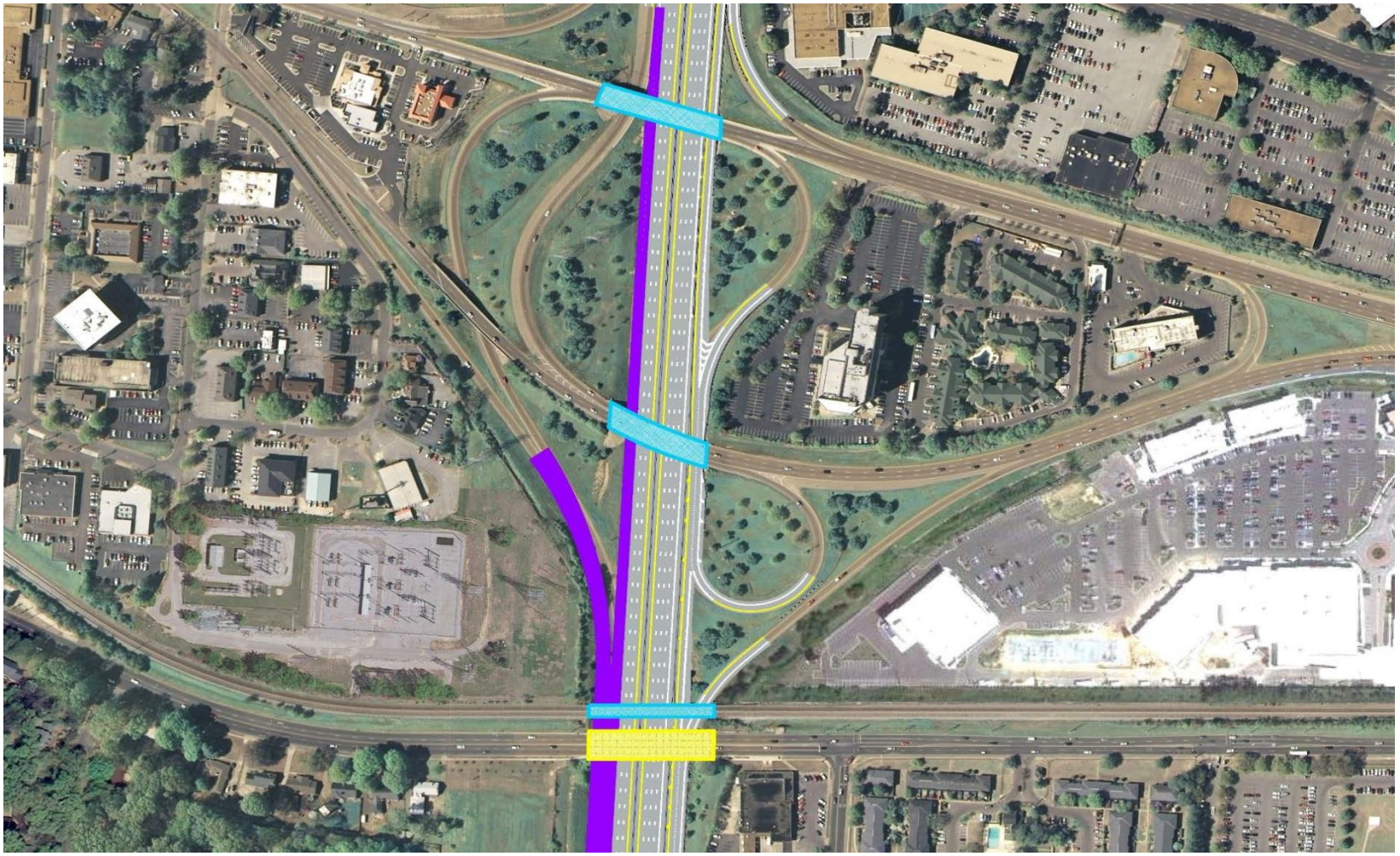
PROJECT LOCATION



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PREVIOUS I-240 WIDENING

- Project extended from north of Highway 385 to north of Walnut Grove Road.
- A total of four lanes in each direction.
- A total of 15 retaining walls on both NB and SB of I-240.
- Combined soil nail/anchor walls under bridges:
  - EB Poplar
  - WB Poplar
  - Shady Grove
  - Park Avenue
  - NS

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PREVIOUS I-240 WIDENING

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PREVIOUS I-240 WIDENING CHALLENGES

- Soil Nail/anchor walls required “top-down” construction and excavation under five bridge abutments to allow for the planned widening.

- Existing records showed the piles supporting the bridges extended a sufficient distance below the toe elevations of the proposed walls.

- Design of walls under bridges was completed with the nails/anchors were to be located around existing piles.

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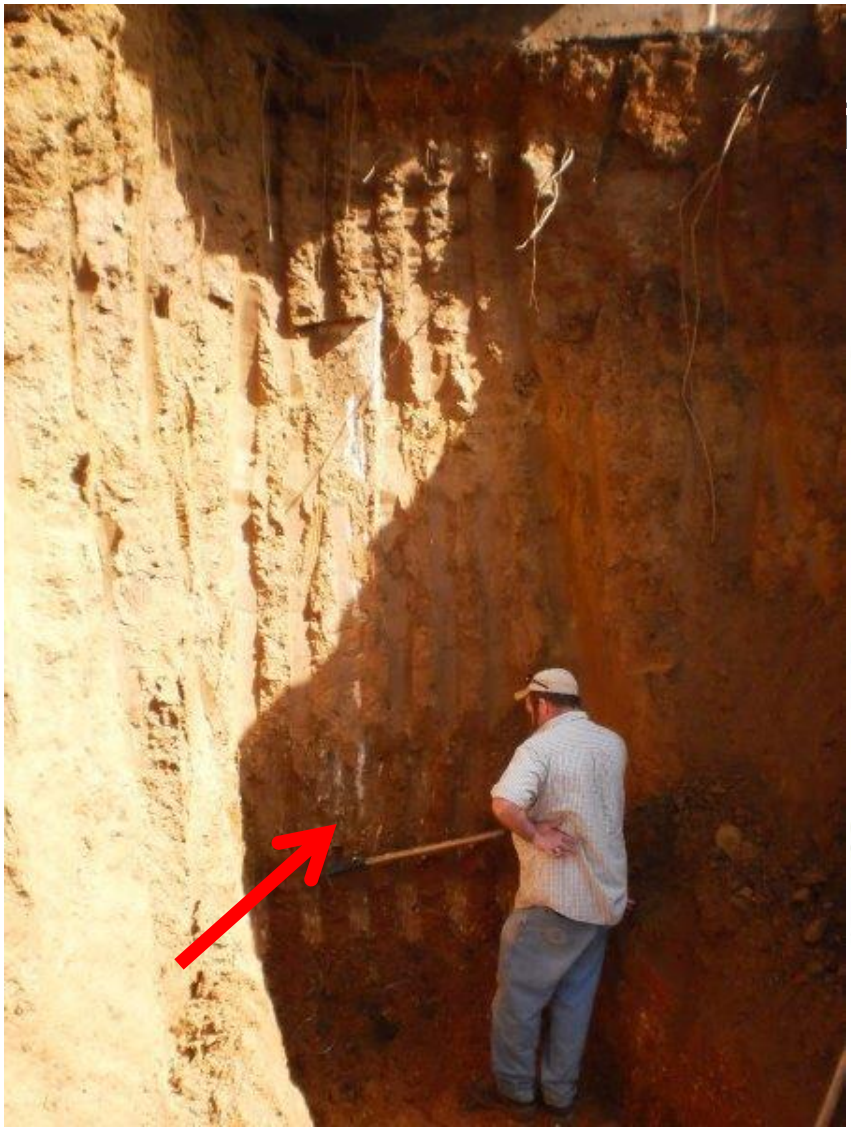
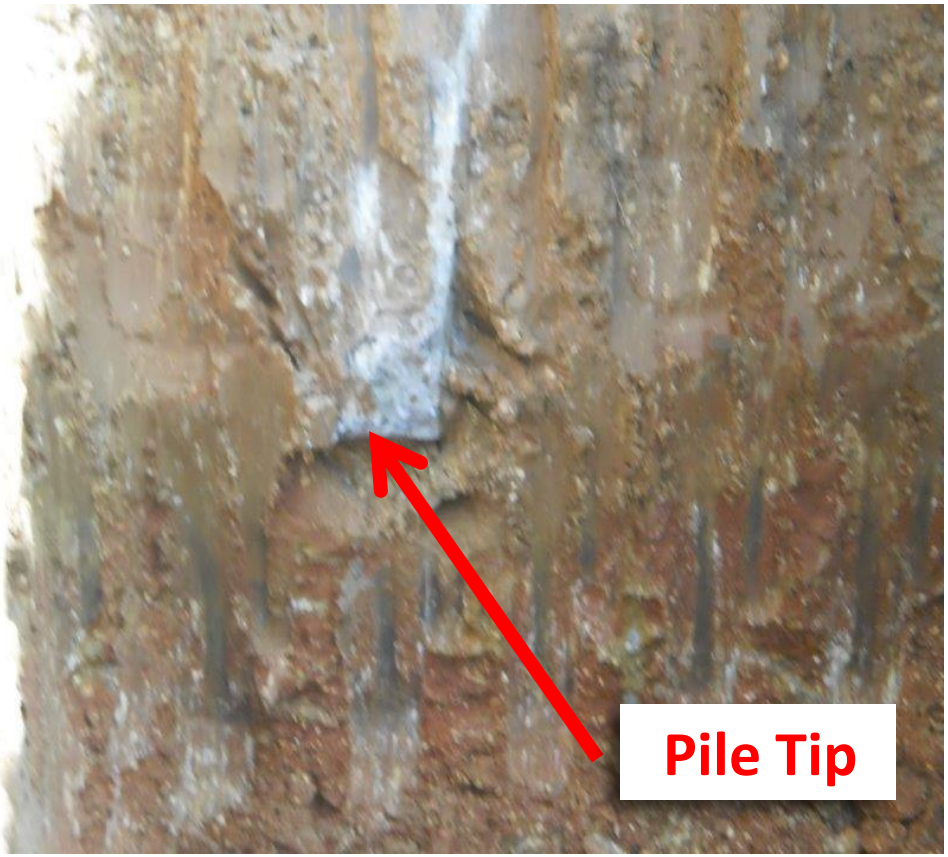
PREVIOUS I-240 WIDENING CHALLENGES





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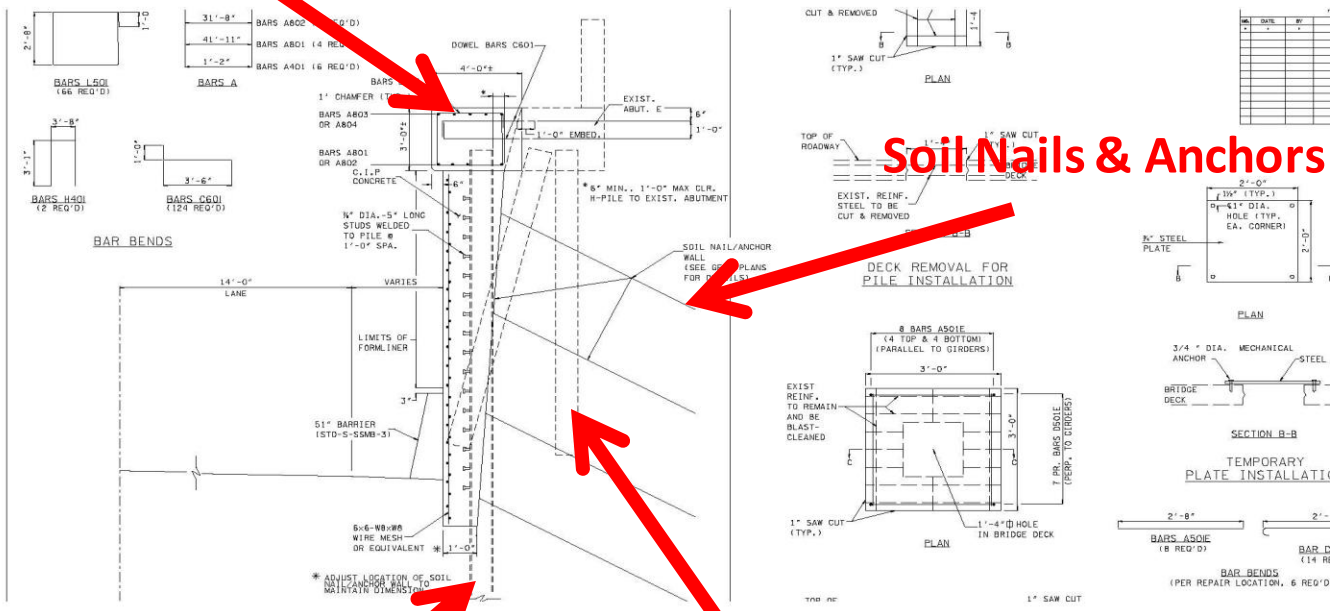
AUXILIARY ABUTMENTS

Auxiliary Abutment



Soil Nails & Anchors

Existing Concrete Piles

New H Piles, Design Capacity = 50 tons

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AUXILIARY ABUTMENT CONSTRUCTION

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CURRENT WB/EB POPLAR EASTERN ABUTMENTS

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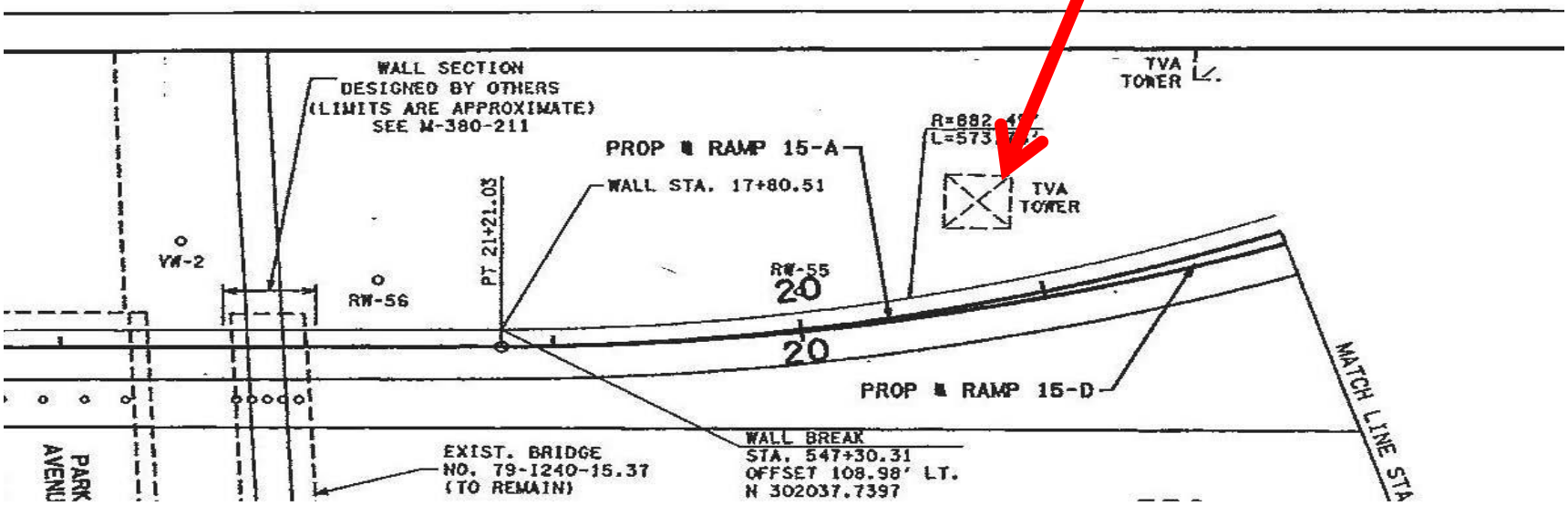
MORE CHALLENGES – WALL 13

Conventional MSE or soil nail wall was not allowed.



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PROJECT OBJECTIVES

- Provide an eight-lane I-240 mainline (complete the planned widening of I-240).
- Improve four deficient bridges over I-240:
  - Replace WB & EB Poplar Avenue.
  - Replace NS Railroad bridge (owned by TDOT).
  - Rehab or replace Park Avenue.
- Improve horizontal and vertical clearances.
- Satisfy the public project requirements of NS Railroad.
- Minimize construction time and impacts by using Accelerated Bridge Construction (ABC).

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PROJECT TEAM

Company	Involvement
Alfred Benesch & Company	Project Lead – Roadway, Rail, Structural & Public Coordination
Gresham Smith & Partners	CM/GC Process, ITS, Utility Coordination, Roadway & Structures Peer Review
Barge Design	Roadway Structures, Traffic Control Design & Field Survey
Geotechnology	Geotechnical Exploration & Engineering
Kiewit Infrastructure South Co	Contractor

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EXISTING WEST BOUND POPLAR AVENUE

- 295’ – Five-Span
- Tangent
- Concrete beam
- 54’ Ex. Width
- 3 travel lanes w/ sidewalks
- Min. Vert. Clearance 16.21’

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EXISTING EAST BOUND POPLAR AVENUE

- 246’ – 4 Span
- Curved
- Concrete Beam
- 60’ Ex. Width

- 3 Travel Lanes - No Sidewalks
- Min. Vert. Clearance 16.34’
- No Utility Conflicts

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EXISTING PARK AVENUE

- 292’ – 5 Span
- Tangent
- Concrete Beam
- 70’ Ex. Width
- 4 Travel Lanes w/ Sidewalks
- Fair Condition
- Min. Vert. Clearance 16.49

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EXISTING NORFOLK SOUTHERN RAILROAD

- 320’ – 6 Span
- Tangent
- Steel Beam

- 2 Track Ballast Deck
- Min. Vert. Clearance 15.61’
- 100’ Railroad ROW

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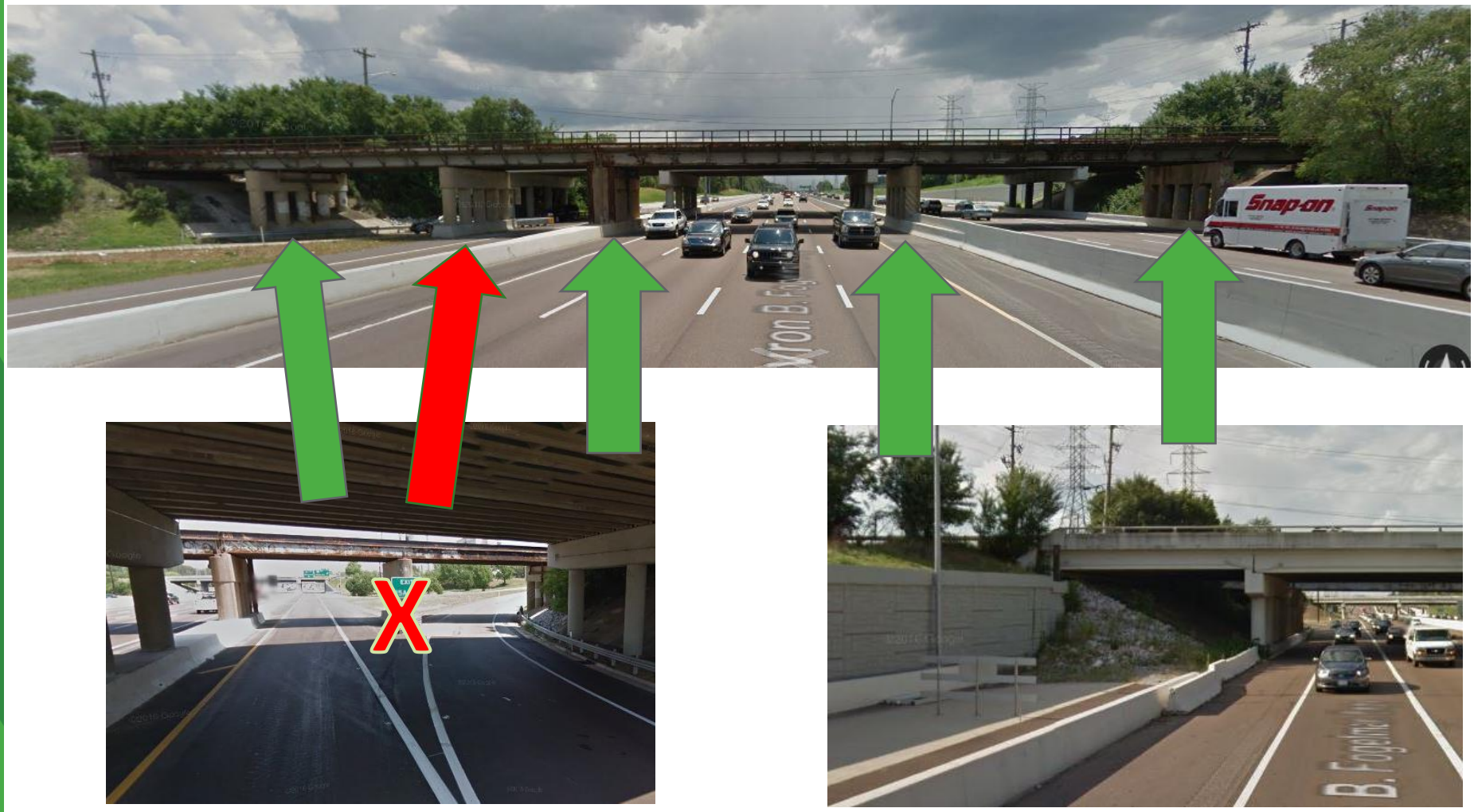
NORFOLK SOUTHERN RAILROAD (cont.)



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SUBSURFACE EXPLORATION (cont.)

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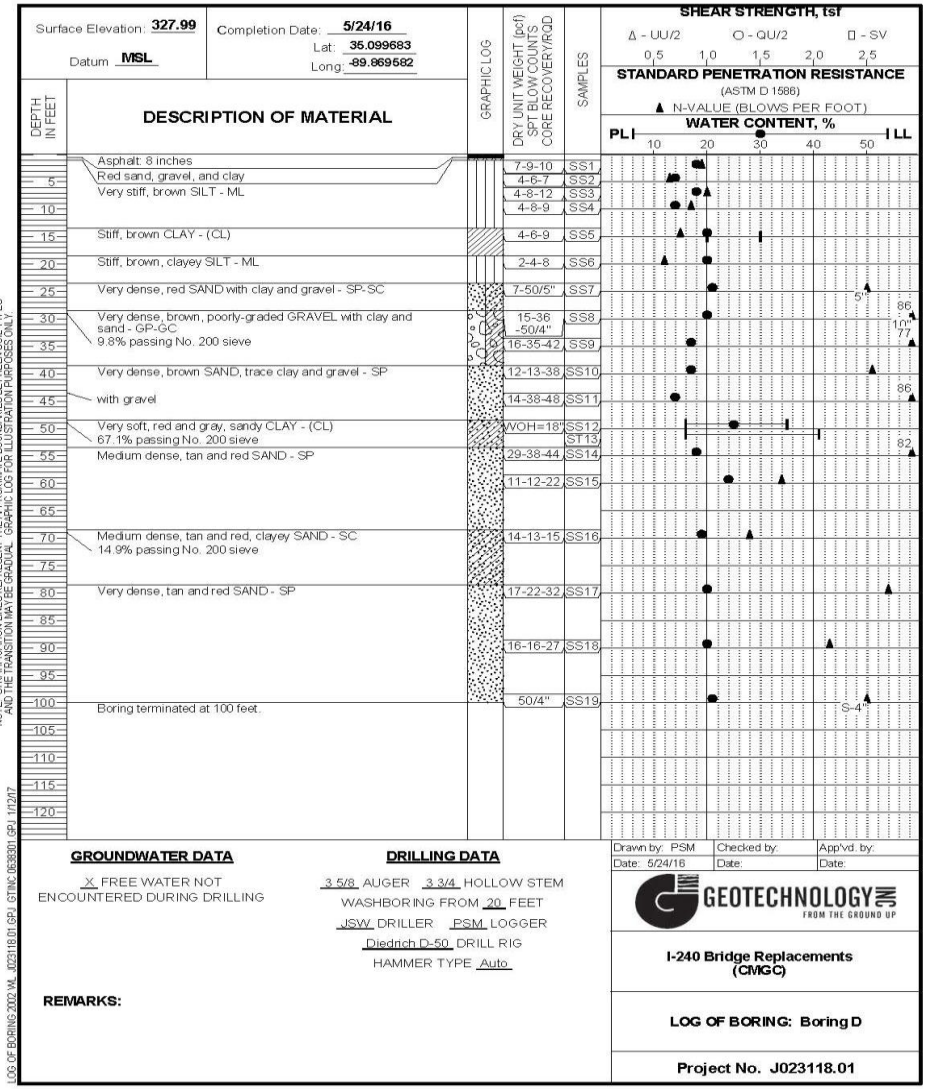
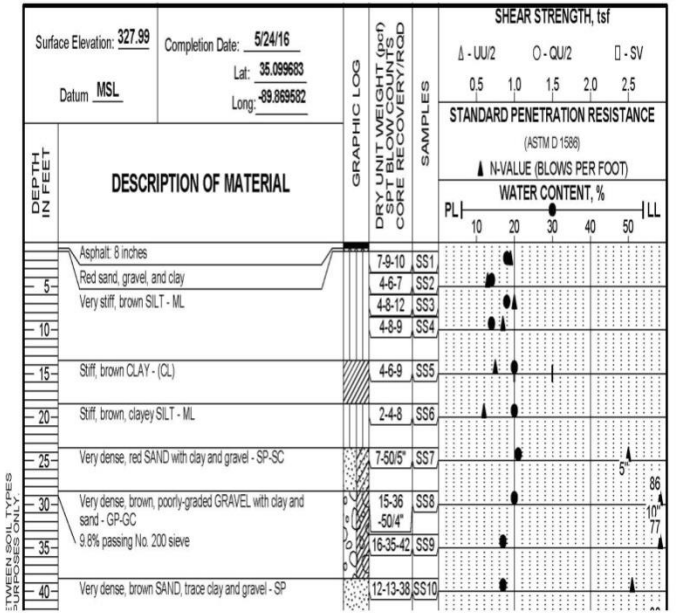
SUBSURFACE CONDITIONS





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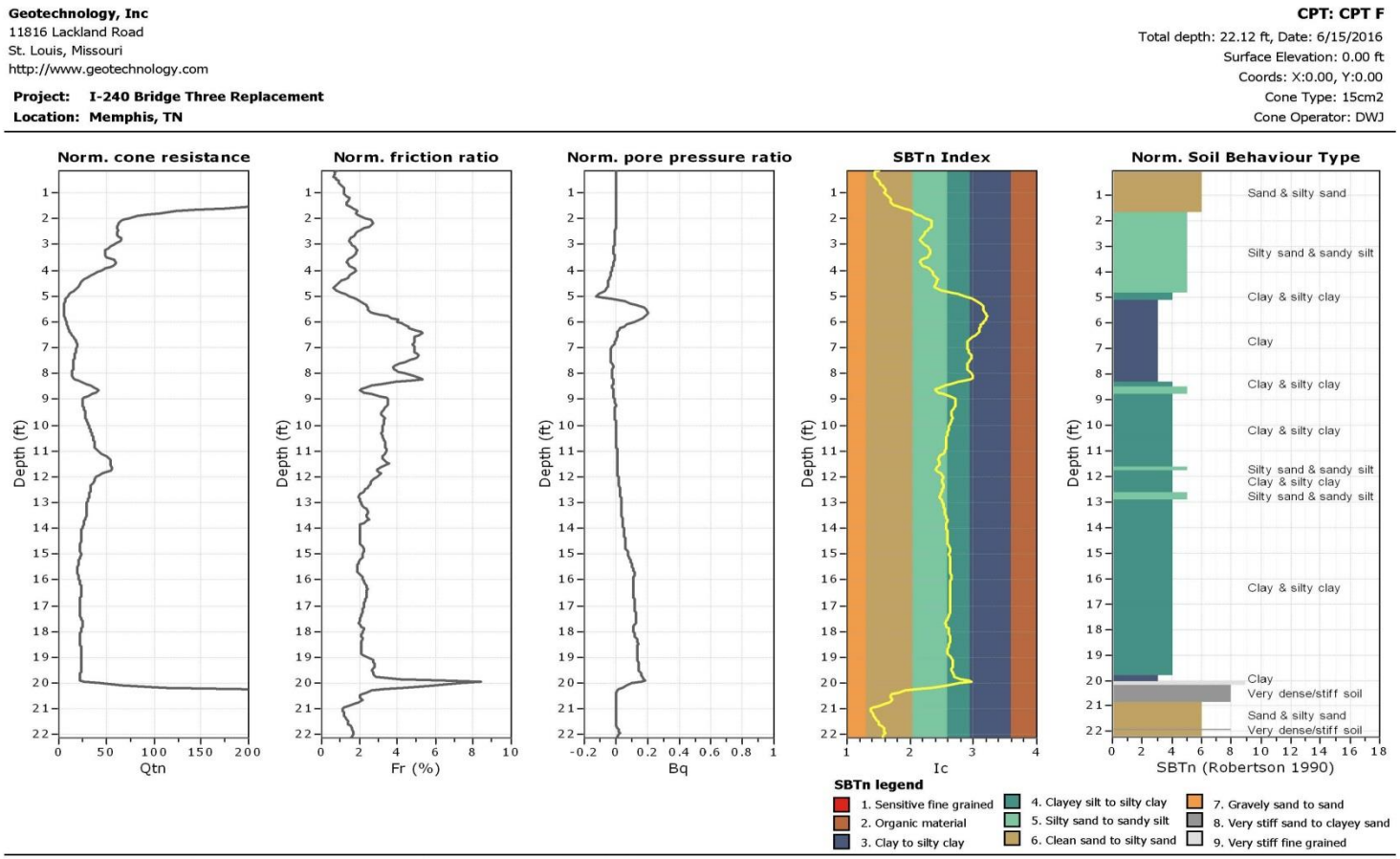
SUBSURFACE CONDITIONS (cont.)



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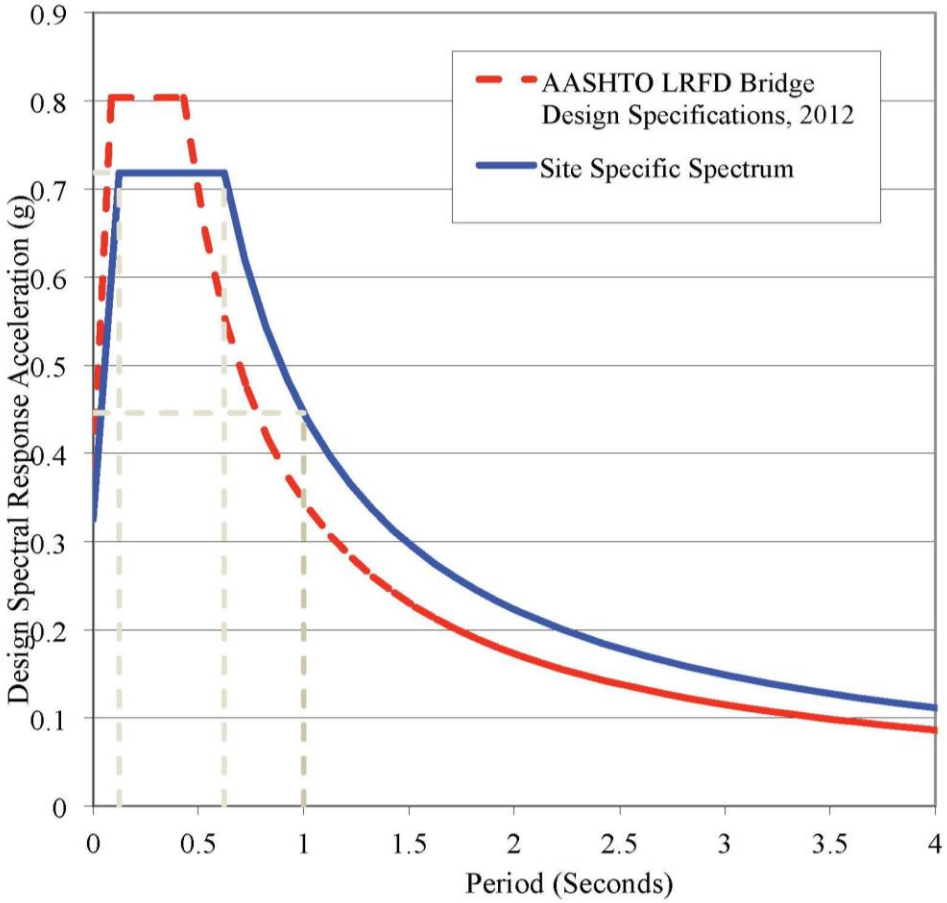
SITE-SPECIFIC SEISMIC STUDY



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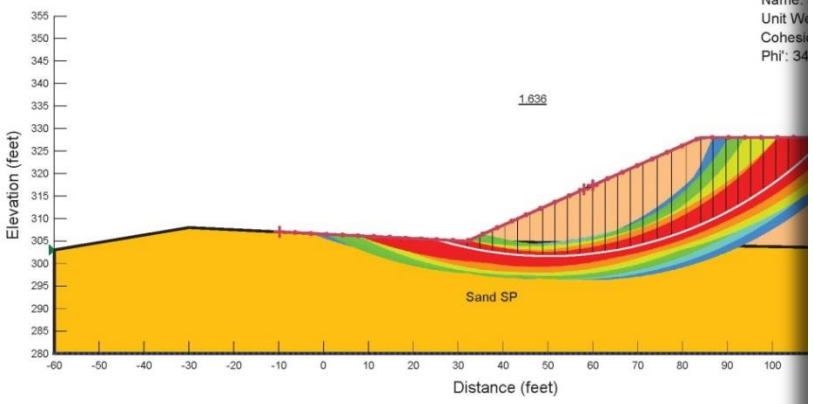
GEOTECHNICAL ANALYSES & RECOMMENDATIONS

I-240 CM/GC - MEMFIX 4
POPLAR AVENUE, NORFOLK SOUTHERN AND PARK AVENUE BRIDGES OVER I-240
MEMPHIS, SHELBY COUNTY, TENNESSEE
GEOTECHNOLOGY PROJECT NUMBER Number J023118.01

Slope at Station: Ramp 15D: 24+50
Seismic Condition (Undrained); Kh = 0.1523g
Spencers Method

Name: Existing Slope
Unit Weight: 120 pcf
Cohesion': 1,000 psf
Phi': 0 °

Name: Existing Slope
Unit Weight: 120 pcf
Cohesion': 1,000 psf
Phi': 0 °



I-240 CM/GC - MEMFIX 4
POPLAR AVENUE, NORFOLK SOUTHERN AND PARK AVENUE BRIDGES OVER I-240
MEMPHIS, SHELBY COUNTY, TENNESSEE
GEOTECHNOLOGY PROJECT NUMBER Number J023118.01

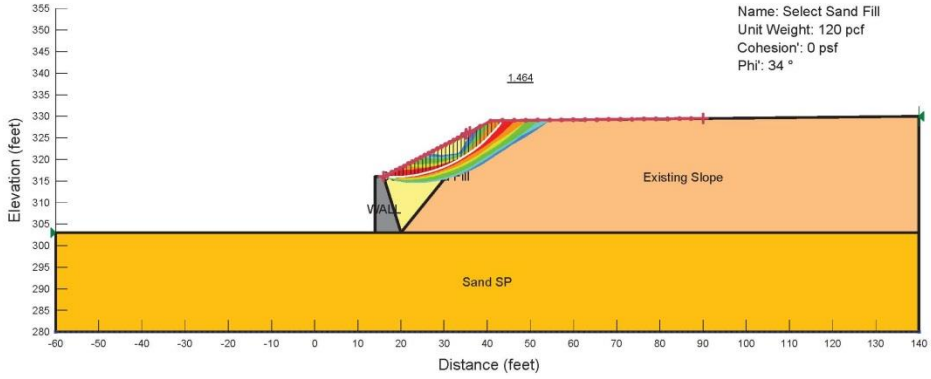
Slope at Station: Ramp 15D: 27+00
Long Term Condition (Drained)
Spencers Method

Name: Existing Slope
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 29 °

Name: WALL
Unit Weight: 125 pcf

Name: Sand SP
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °

Name: Select Sand Fill
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °



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GEOTECHNICAL ANALYSES & RECOMMENDATIONS (cont.)

East Bound Poplar Avenue, East Abutment; North; Boring VW-4				
HP-14x73	Pile Cutoff Elevation: 319.82 ft			
	Nominal Axial Resistance			
	Compression			Uplift
Pile Penetration	Skin Friction	End Bearing	Total	
ft	Tons	Tons	Tons	Tons
30	84	11	95	63
35	115	11	127	87
40	152	11	163	114
45	193	10	203	145
50	228	8	236	171
55	259	2	261	195
60	286	8	293	214
65	330	8	338	247
70	377	8	385	283

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CONSTRUCTION SCHEDULE

- Official Start: 01/01/2018
- Actual Start: December, 2017

- Expected Completion: 6/30/2019
- Actual Completion: 6/25/2019

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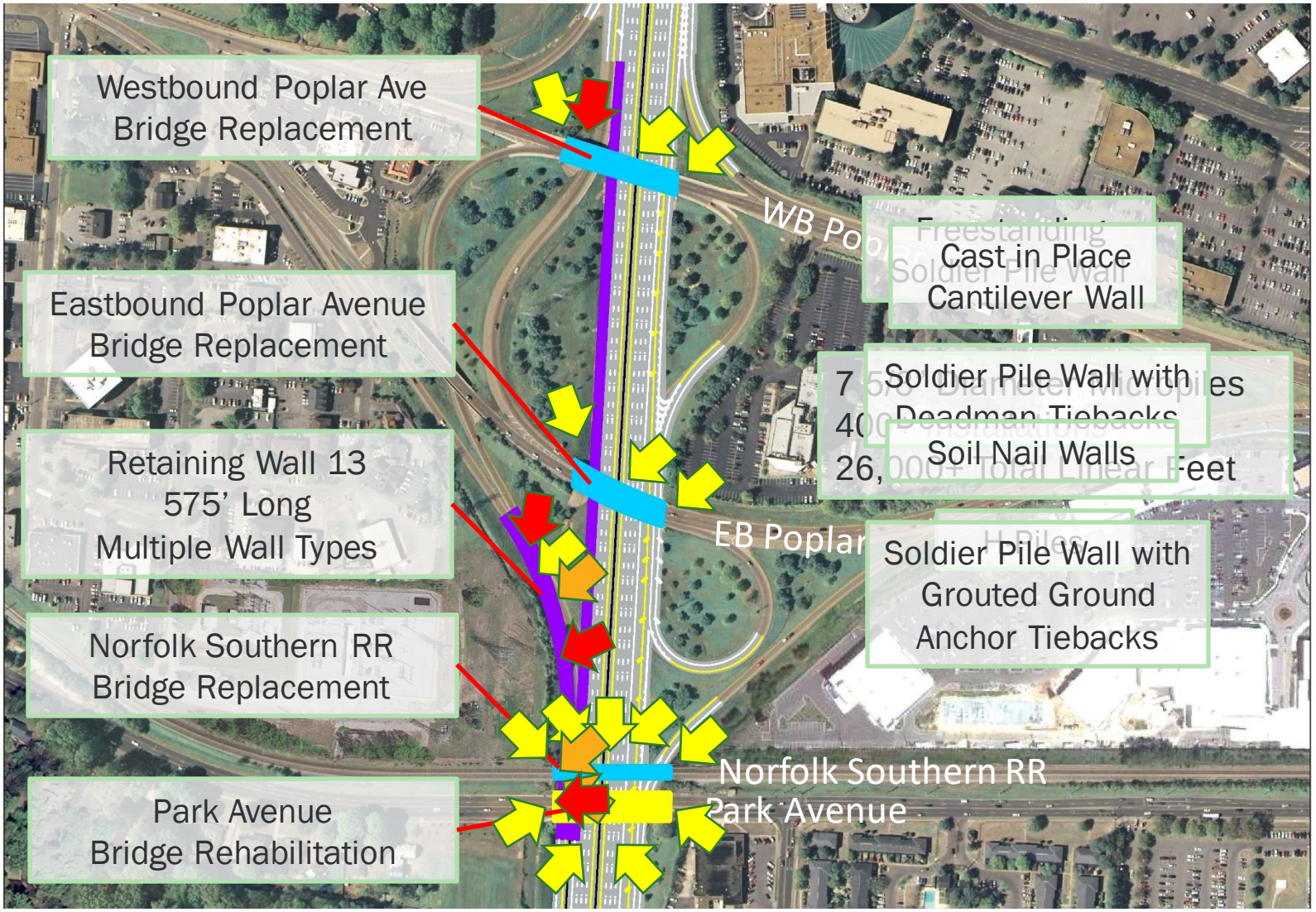
STRUCTURE PROJECT OVERVIEW



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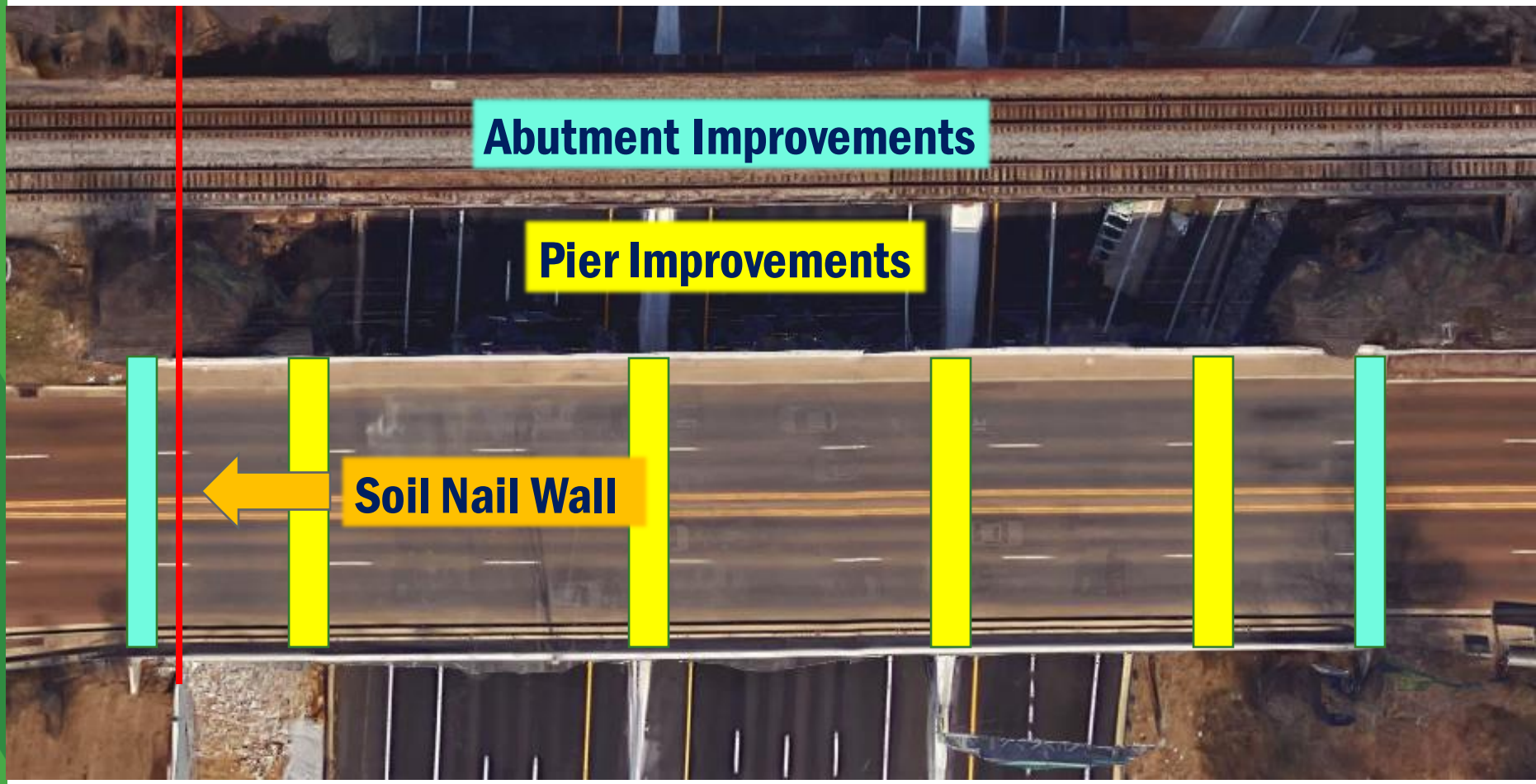
PARK AVENUE REHABILITATION



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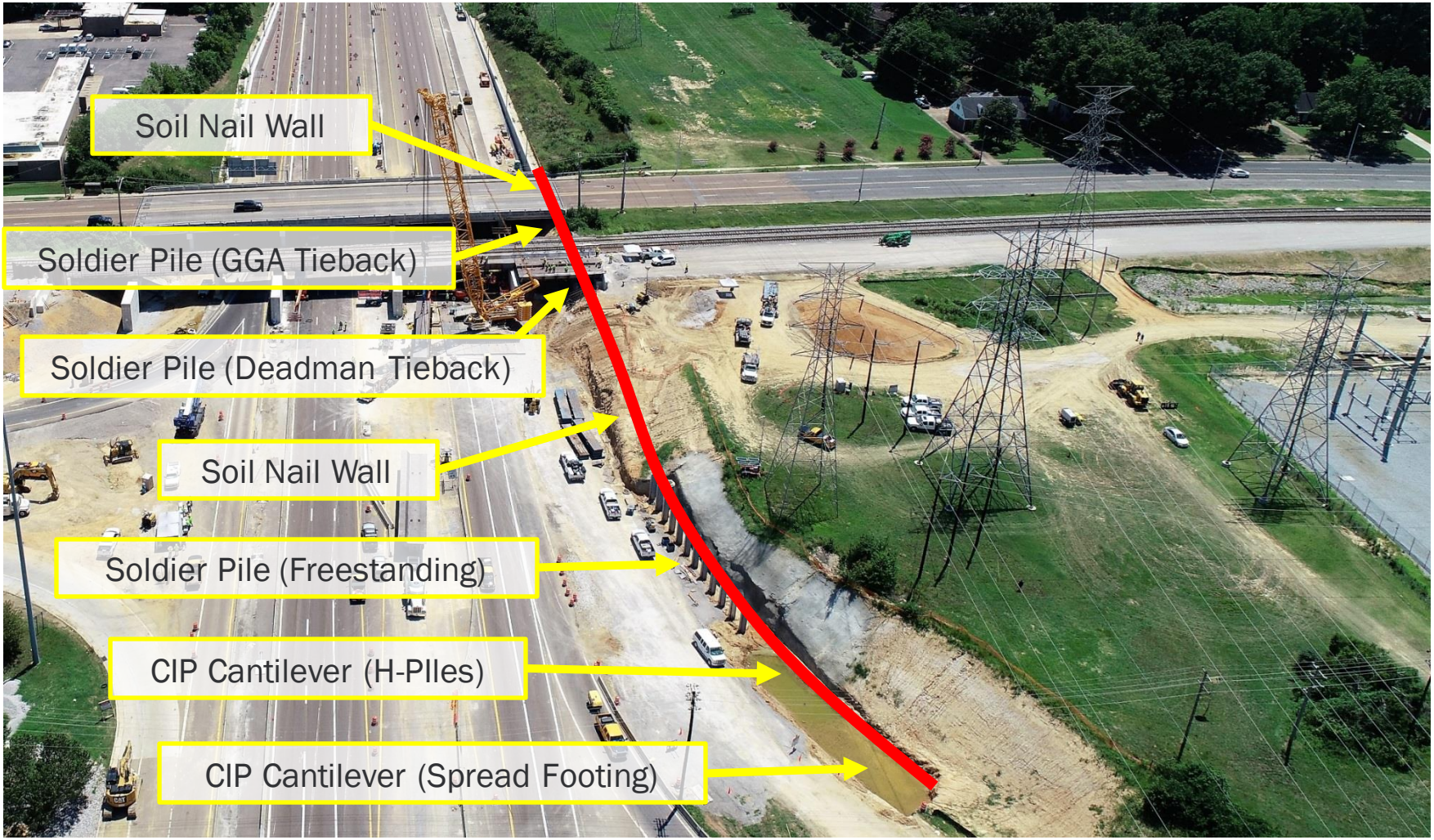
RETAINING WALL 13



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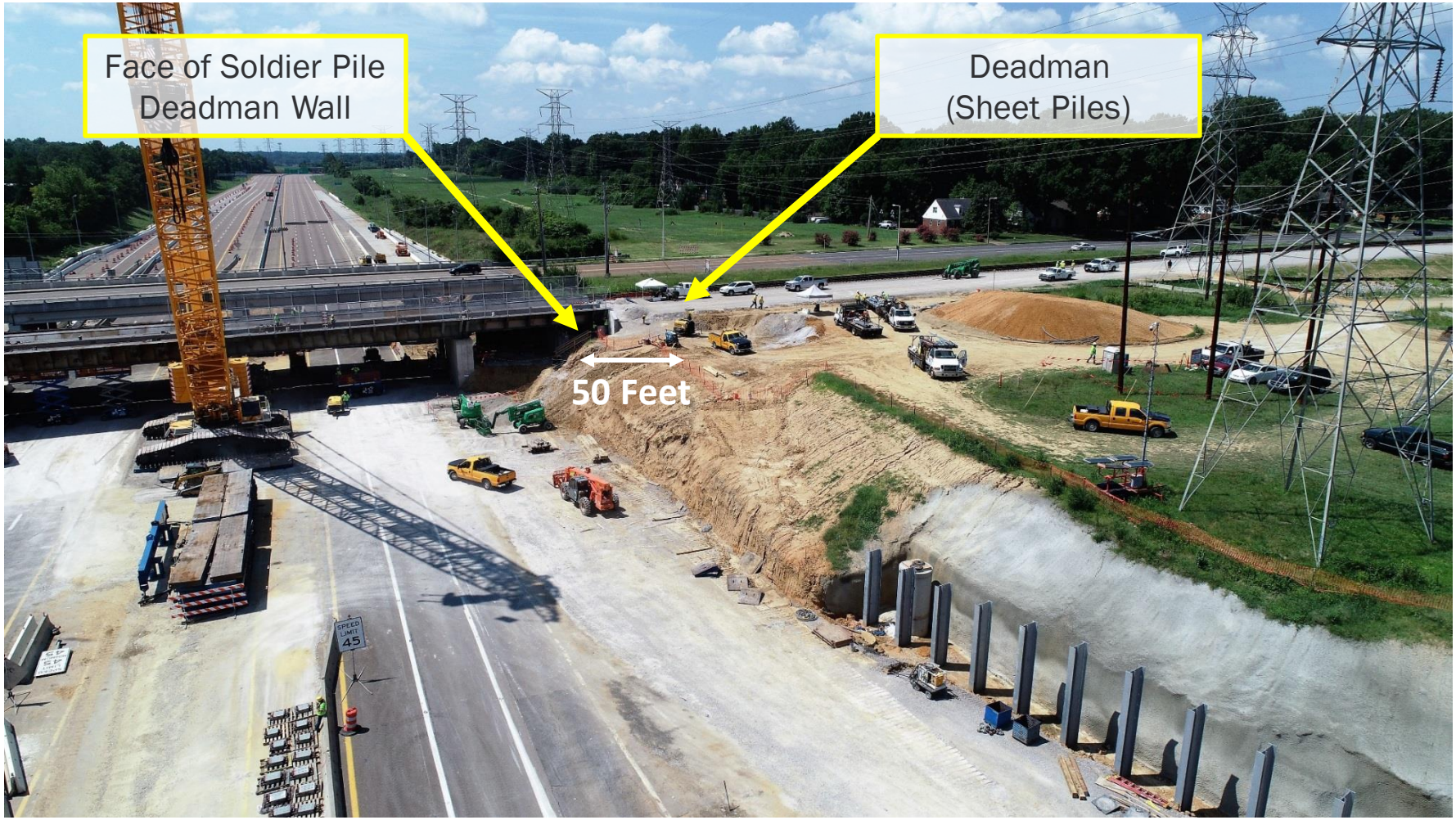
RETAINING WALL 13



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SOLDIER PILE DEADMAN TIEBACK WALL

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SHORING BETWEEN NS EXISTING BRIDGE AND SHOO FLY

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NORFOLK SOUTHERN BRIDGE

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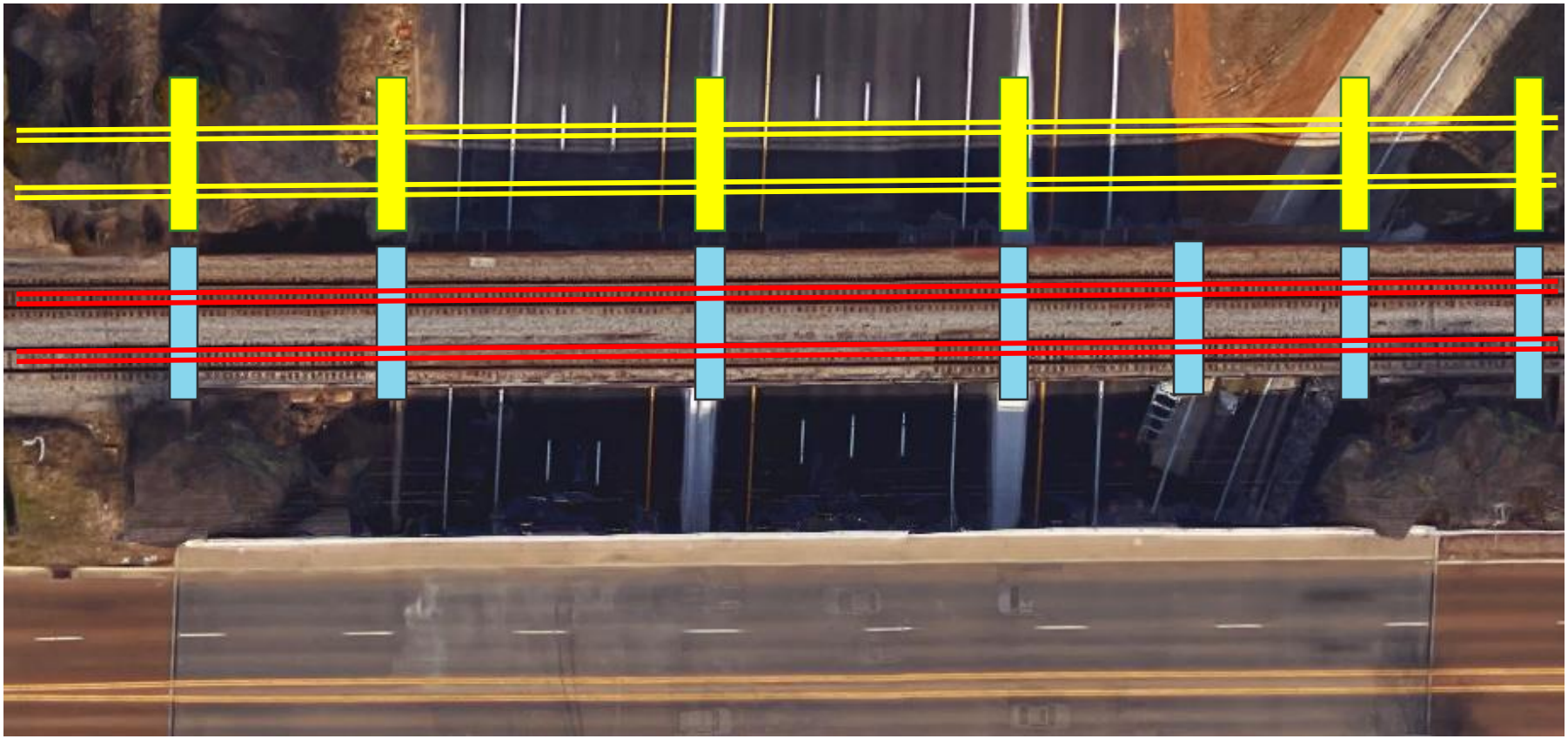
NORFOLK SOUTHERN BRIDGE



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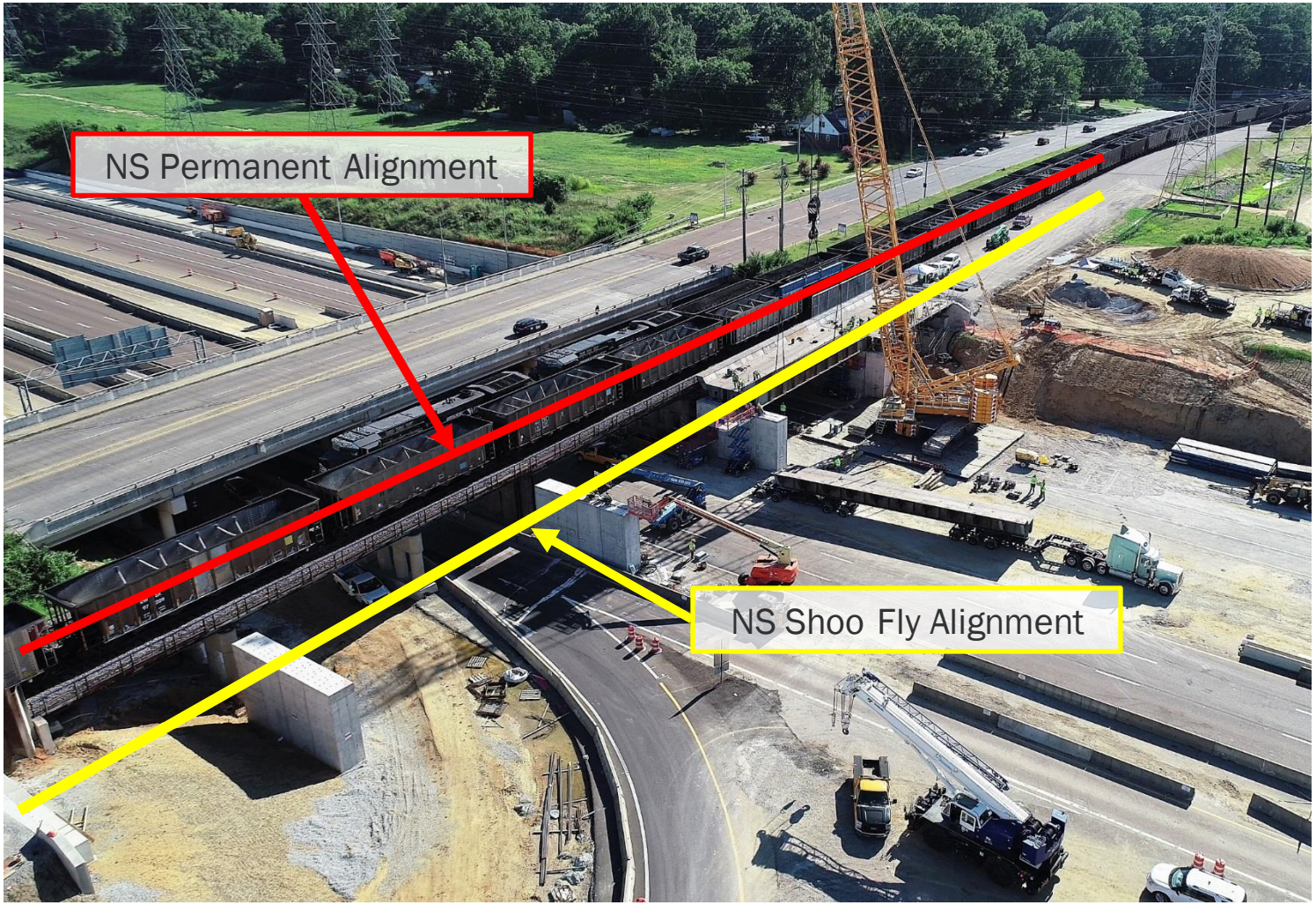
NORFOLK SOUTHERN BRIDGE



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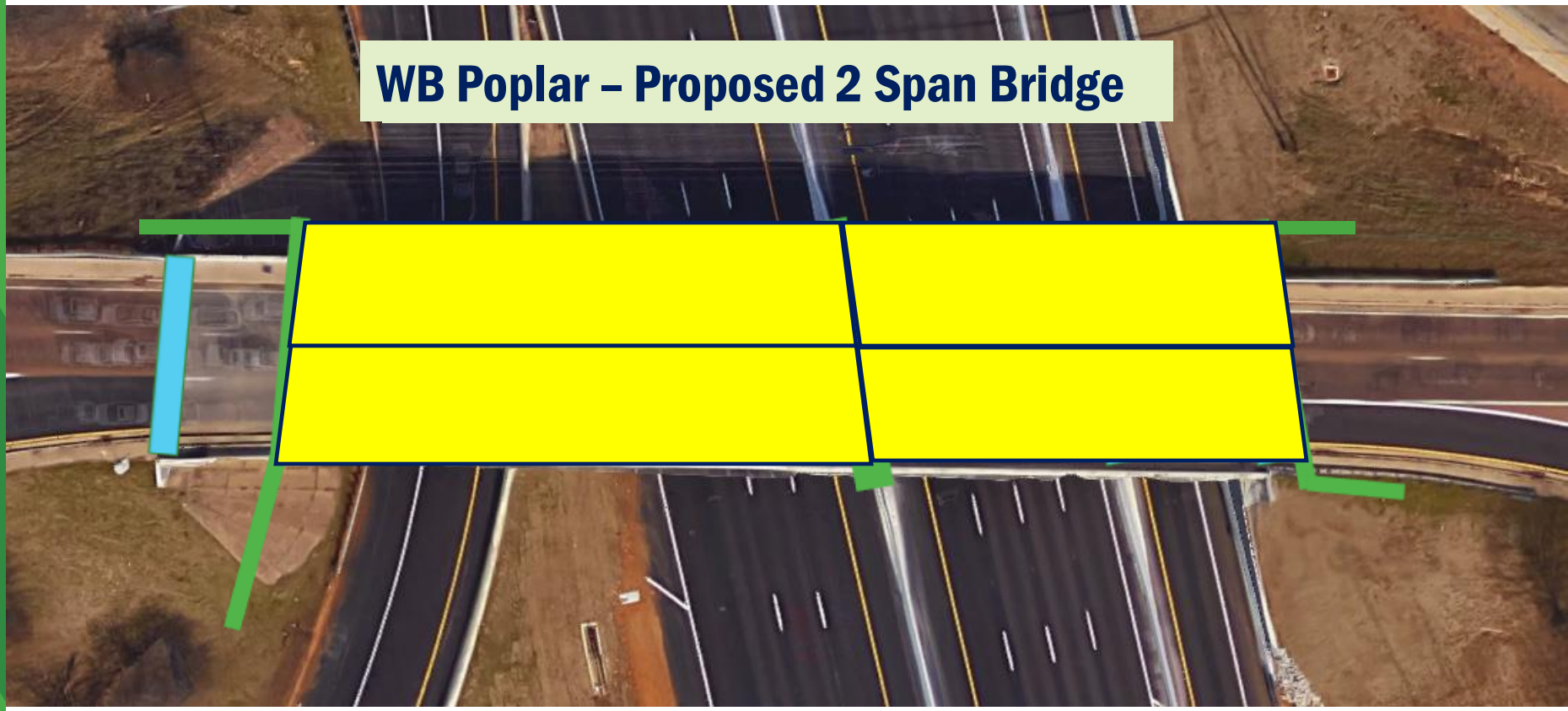
WB/EB POPLAR BRIDGE REPLACEMENTS



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WB/EB POPLAR WESTERN ABUTMENTS

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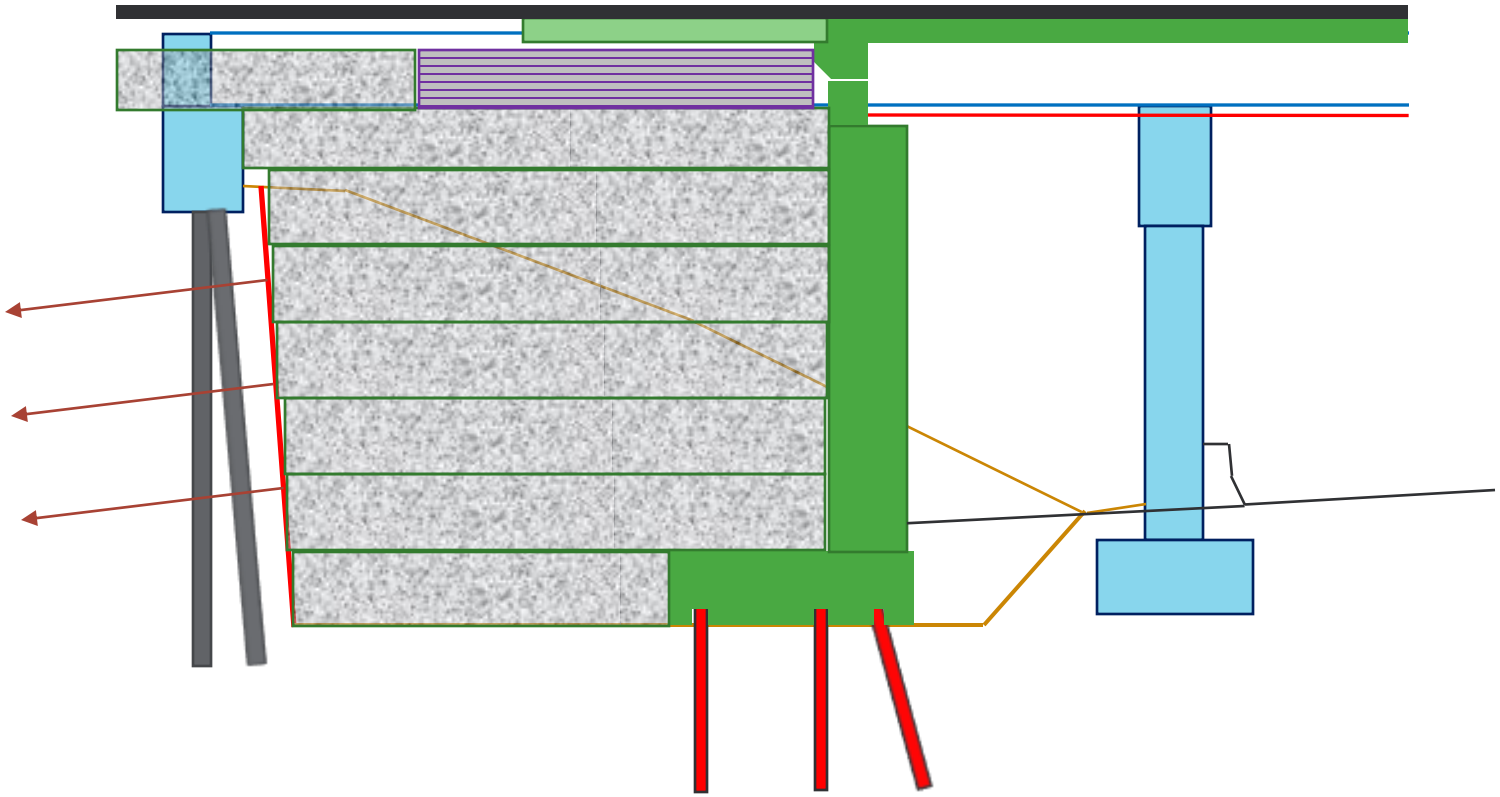
WB/EB POPLAR WEST ABUTMENTS



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WEST ABUTMENT CONSTRUCTION

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GEOGRID UNDER APPROACH SLAB

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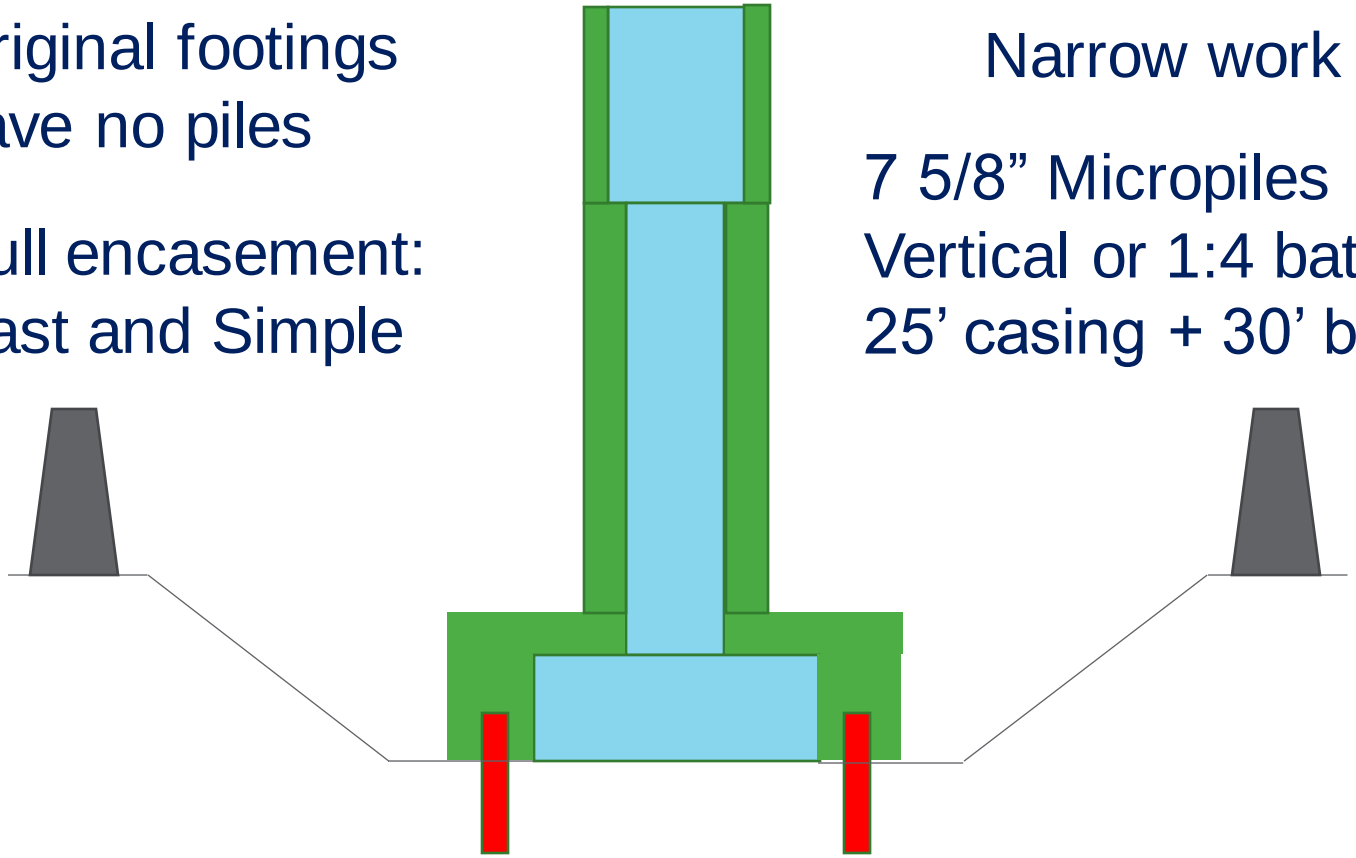
WB/EB POPLAR PIERS

Original footings have no piles

Full encasement:
Fast and Simple



Narrow work zone

7 5/8” Micropiles
Vertical or 1:4 batter
25’ casing + 30’ bond zone

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WB/EB POPLAR PIERS

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WB/EB EASTERN ABUTMENTS

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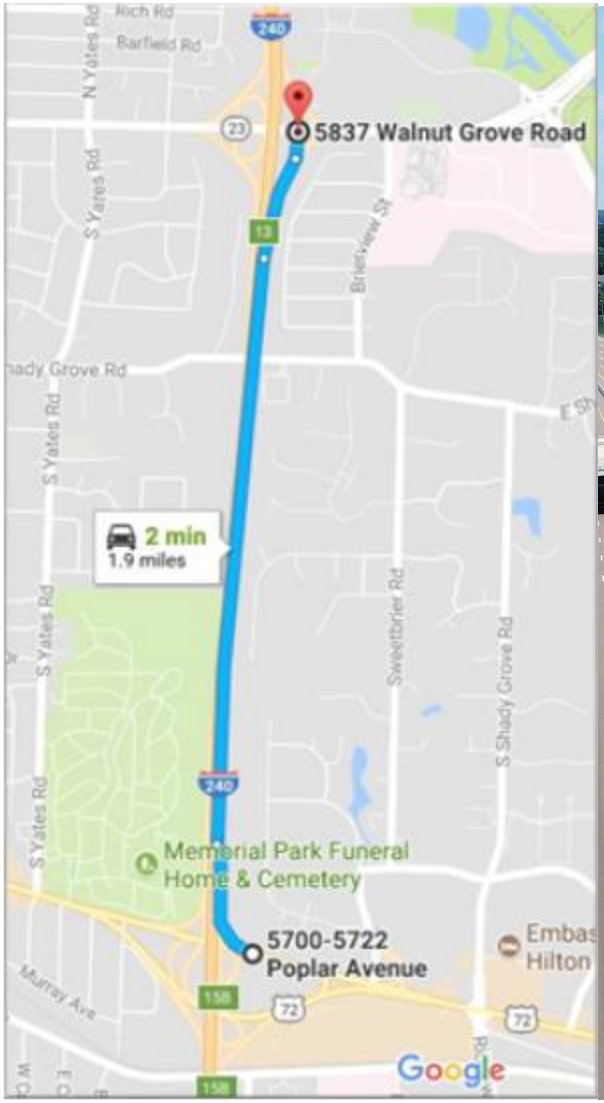
WALNUT GROVE BRIDGE FARM



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BRIDGE FARM

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BRIDGE FARM

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SELF PROPELLED MOBILE TRANSPORT
(SPMT)

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SPMT

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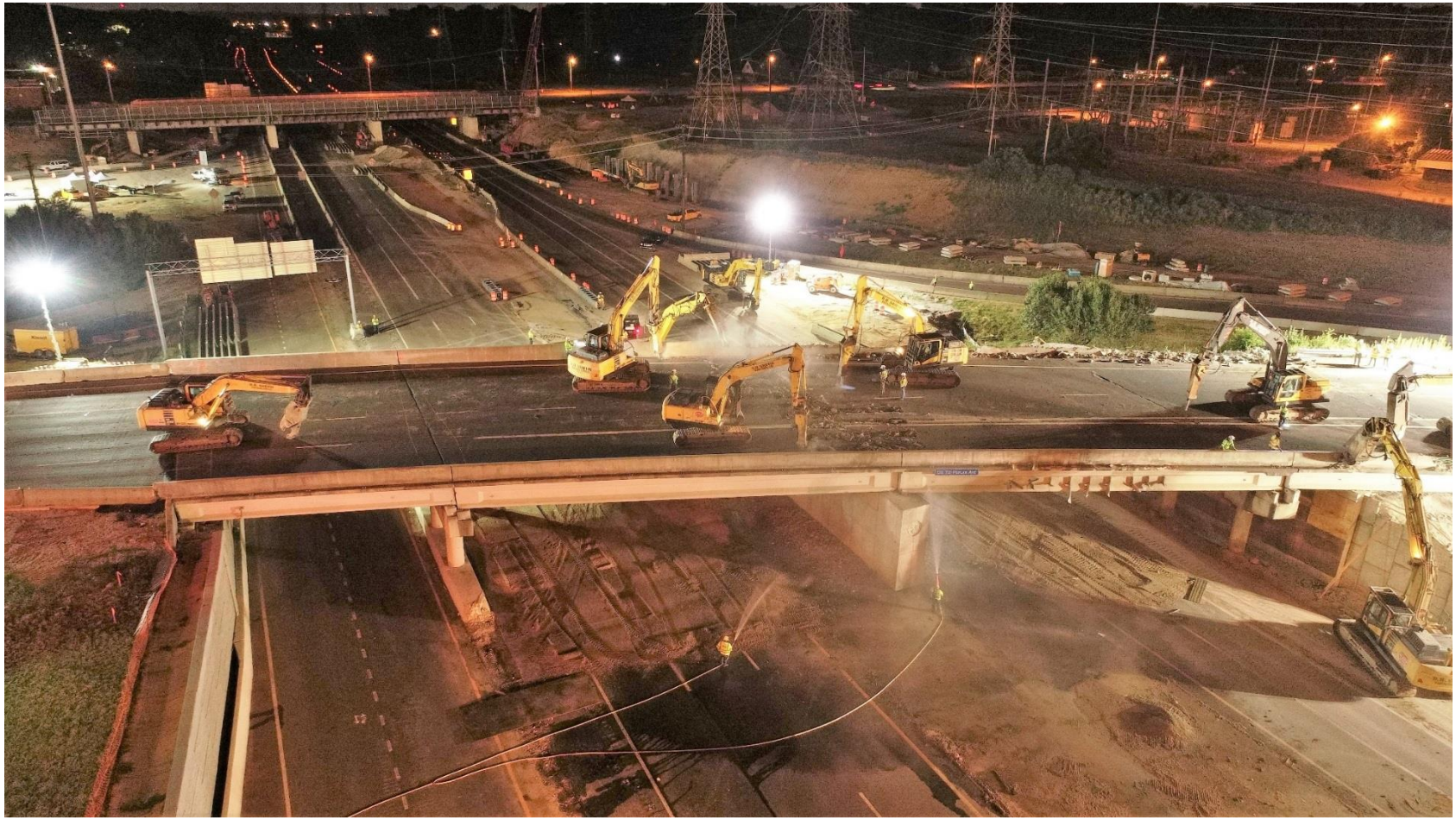
DEMOLITION



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DEMOLITION

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SUPERSTRUCTURE UNIT INSTALLATION

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SUPERSTRUCTURE CLOSURE POUR

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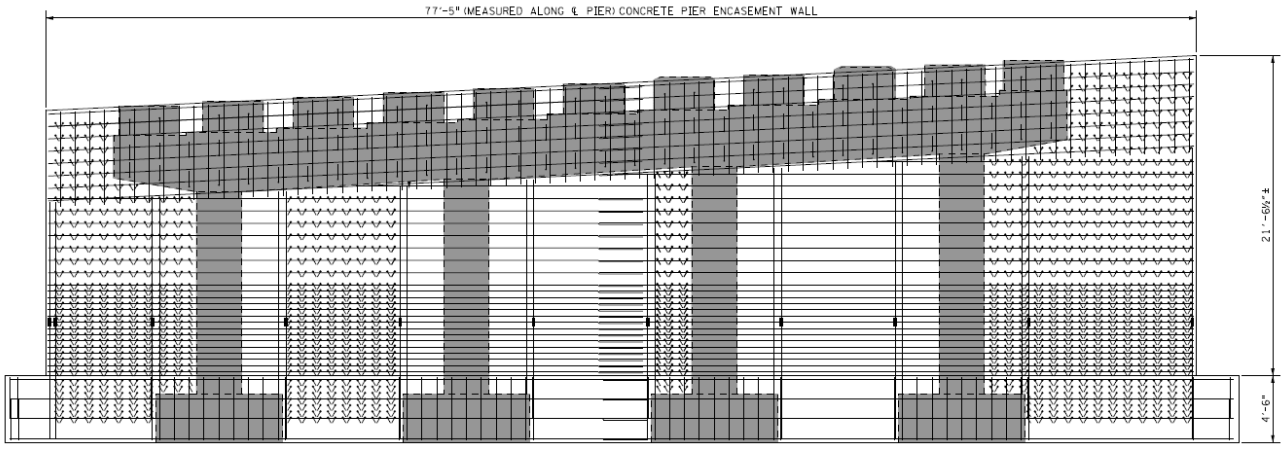
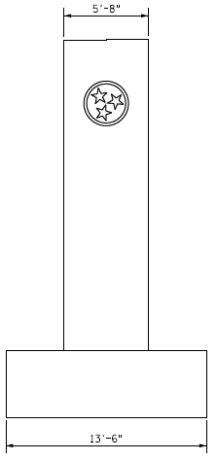
WB/EB POPLAR PIERS





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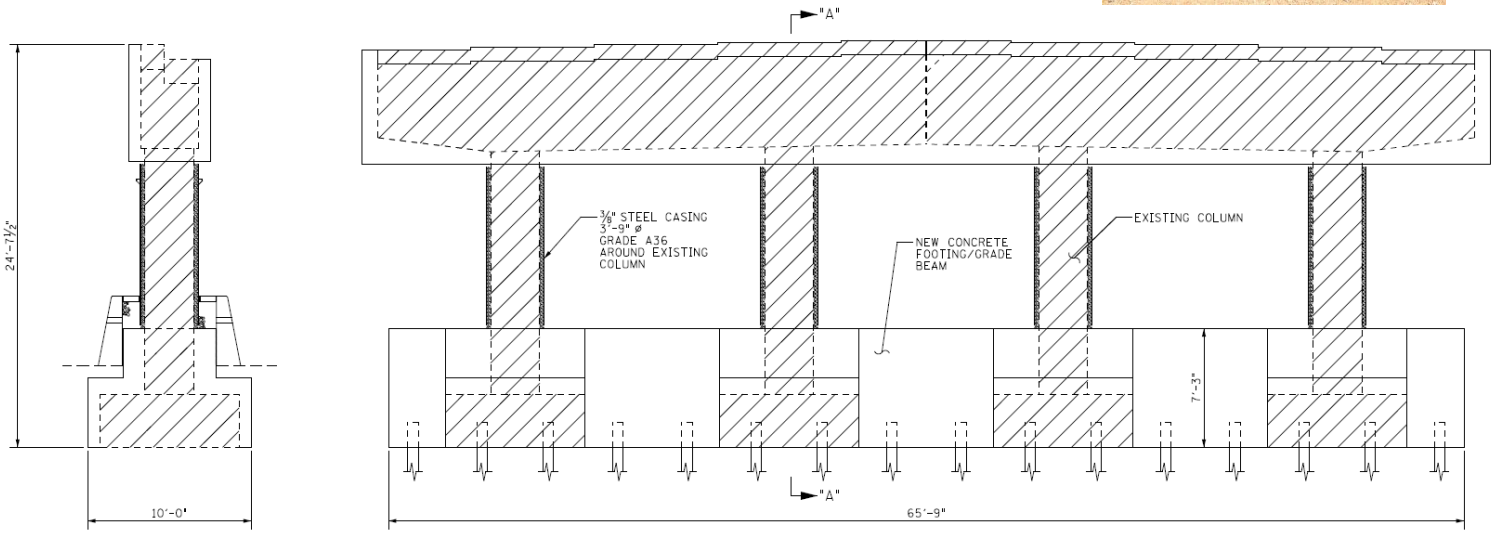
PARK AVENUE PIERS

- Cap strengthened
- Conventional steel jacket retrofit
- Existing footings incorporated
- Piles designed for full superstructure load



SECTION "A"-"A"

PIER ELEVATION VIEW

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CONSTRUCTION PROGRESS

CONSTRUCTION PROGRESS

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H-PILE DRIVING

- Variation
  - Six different HP sizes on project
  - Design Loads ranging from 40 tons to 140 tons
  - Site Conditions
  - Tips vs. No Tips
- Schedule
  - Driving and Testing Results Review
  - Acceptance Criteria?

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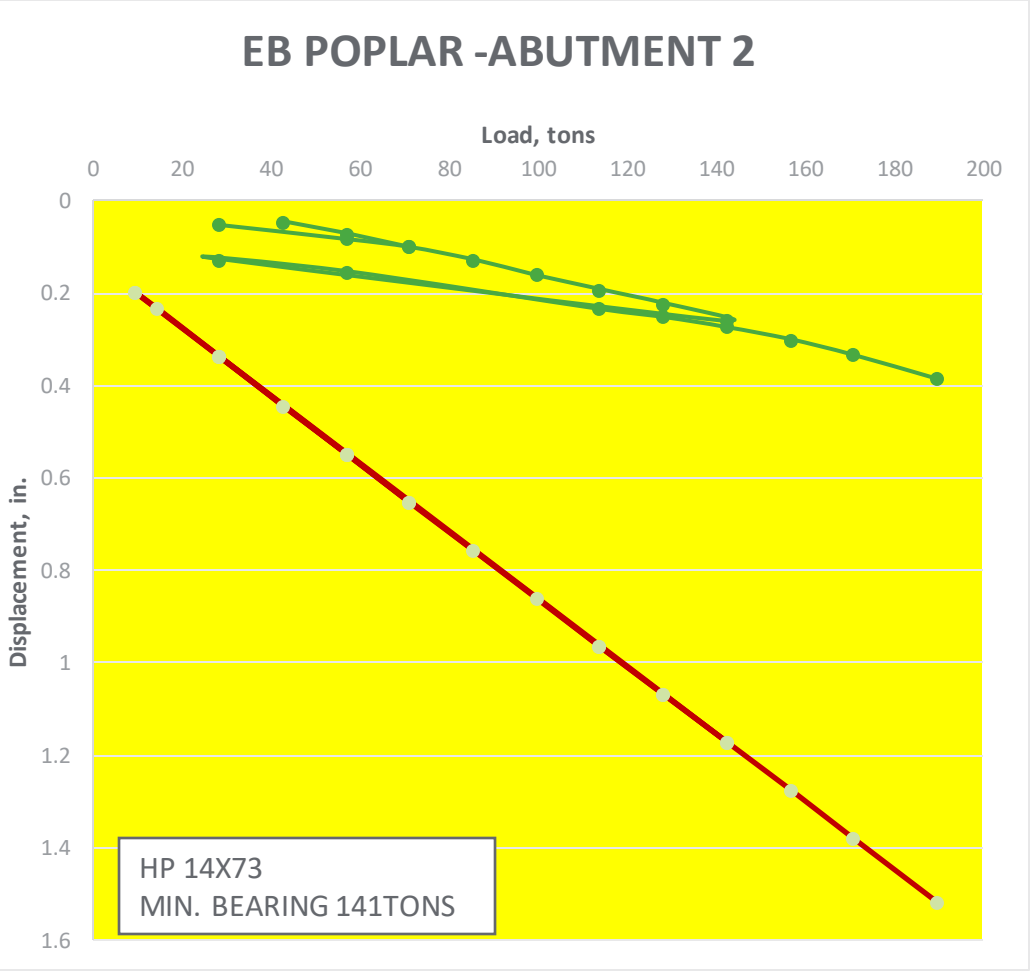
GEOTECHNICAL CHALLENGES
PILE DRIVING

Pen below p.c.o	Drop	Blows per foot	Bearing in tons	Pen below p.c.o	Drop	Blows per foot	Bearing in tons
				36	6.6	13	25.9
14	6.8	36	63.0	37	6.2	12	22.6
15	7.2	31	59.3	38	5.8	9	16.2
16	7.0	29	54.7	39	5.5	8	13.8
17	7.1	30	57.0	40	5.5	6	10.5
18	6.8	30	54.6	41	6.6	15	29.4
19	7.1	25	49.1	42	6.6	13	25.9
20	6.9	25	47.8	43	6.4	10	19.8
21	6.8	21	40.7	44	6.4	11	21.6
22	6.7	21	40.1	45	6.4	13	25.1
23	6.8	20	39.0	46	6.4	11	21.6
24	6.6	16	31.2	47	6.4	11	21.6
25	7.0	23	45.2	48	6.2	12	22.6
26	7.3	19	40.1	49	6.4	13	25.1
27	7.5	24	50.2	50	6.5	13	25.5
28	7.2	28	54.7	51	6.6	12	24.1
29	7.5	27	55.3	52	6.7	13	26.3
30	7.4	22	46.0	53	6.8	15	30.3
31	7.3	20	41.9	54	6.8	14	28.5
32	7.0	18	36.7	55	6.7	14	28.1
33	7.1	20	40.7	57	7.1	16	33.5
34	7.2	17	35.9	58	7.1	19	39.0
35	6.8	17	33.9	59	7.0	19	38.4



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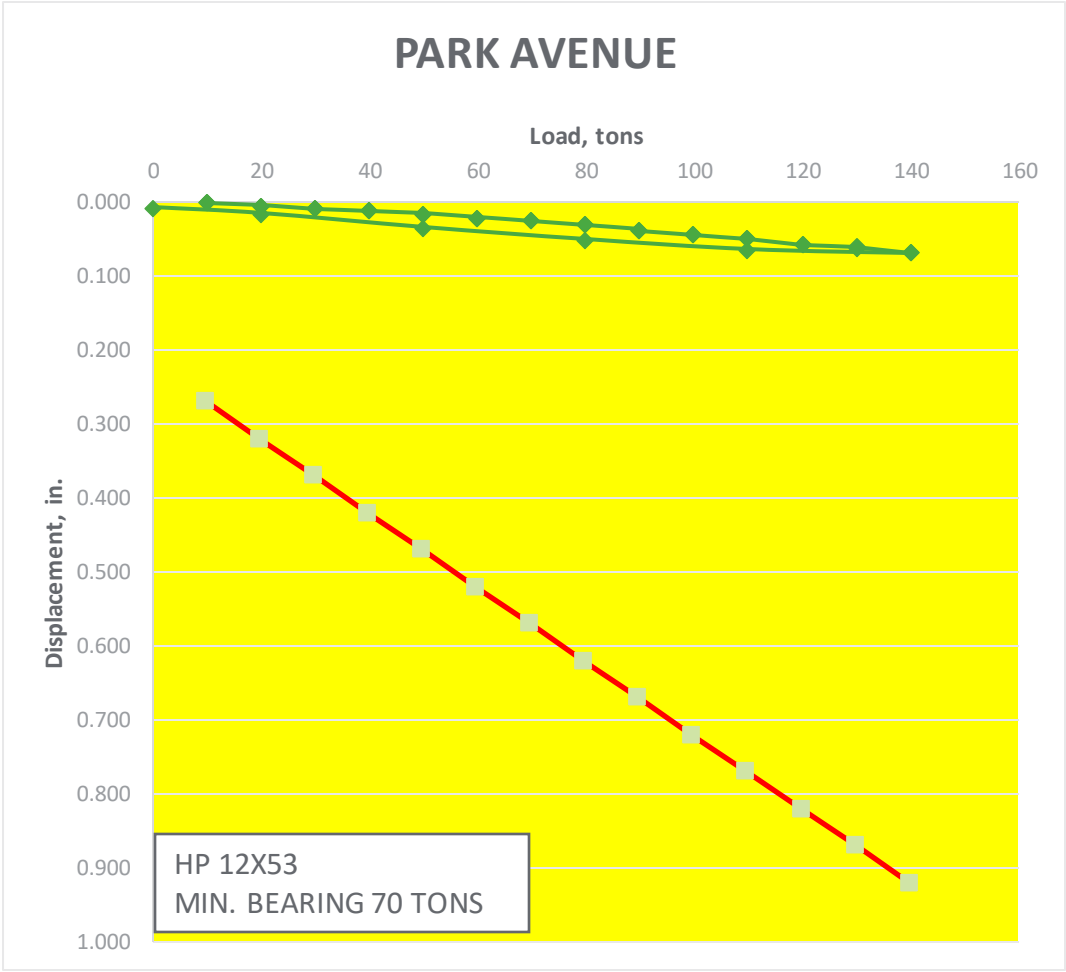
GEOTECHNICAL CHALLENGES
PILE DRIVING

Pen. below PCO	Drop (H) ft.	Blows per Foot	Bearing (tons)	Pen. below PCO	Drop (H) ft.	Blows per Foot	Bearing (tons)
26	6.3	**19**	**34**	51	6.2	**14**	
27	6.2	**22**		52	6.4	**17**	
28	5.9	**23**		53	6.5	**15**	
29	6.0	**19**		54	6.5	**16**	
30	6.0	**22**	**37**	55	6.7	**17**	**33**
31	6.0	**20**		56	6.8	**13**	
32	6.2	**18**		57	6.9	**17**	
33	6.2	**19**		58	6.9	**17**	
34	6.5	**30**		59	6.8	**16**	
35	6.6	**25**	**45**	60	6.7	**18**	**35**
36	6.7	**21**		61	6.8	**18**	
37	6.7	**31**		62	6.7	**19**	
38	6.7	**22**		63	6.8	**18**	
39	6.4	**23**		64	6.9	**18**	
40	6.3	**23**	**40**	65	6.8	**21**	**39**
41	6.4	**24**		66	7.0	**19**	
42	6.5	**22**		67	7.1	**17**	
43	7.1	**19**		68	7.1	**20**	
44	6.8	**26**		69	7.1	**20**	
45	6.7	**27**	**49**	70	6.9	**19**	**37**
46	7.0	**24**		71	7.1	**18**	
47	6.8	**21**		72	7.2	**20**	
48	6.6	**18**		73	7.2	**19**	
49	6.4	**14**		74	7.0	**20**	
50	6.3	**15**	**28**	75	7.2	**20**	**41**



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FORMULA ACCURACY

LOCATION	STATIC TEST FAILURE RESISTANCE, TONS	ESTIMATED TEST PILE RESISTANCE AT TERMINATION, TONS		
		ENGINEERING NEWS (EN)	WSDOT	MODIFIED GATES
EB POPLAR ABUTMENT 2	>200	38	93	102
PARK AVENUE	>140	41	98	107

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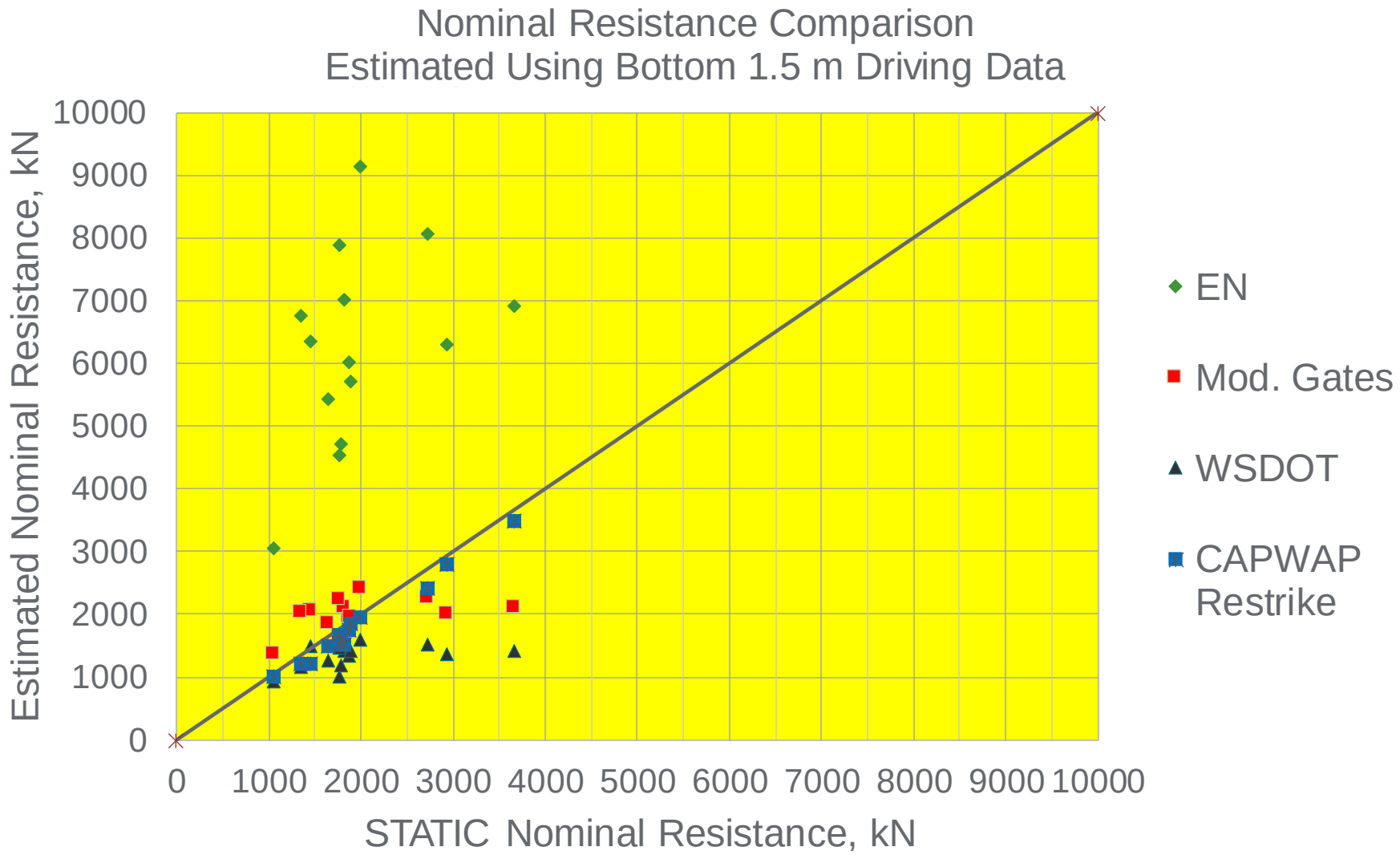
FORMULA ACCURACY – I 40/240 INTERCHANGE



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RECOMMENDATIONS

- Perform a dynamic load test with Signal Matching (RF=0.65), a static load test (RF=0.75), OR both (RF = 0.85).
- Establish a pile length and a termination blow count using the load test result (maintain hammer type and fuel setting, same as used for driving the test pile).
- Use WSDOT or Modified Gates Formulae.
- EN Formula should no longer be used.

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EB POPLAR BRIDGE REPLACEMENT
WEEKEND OF 8/24/18 – 8/27/18

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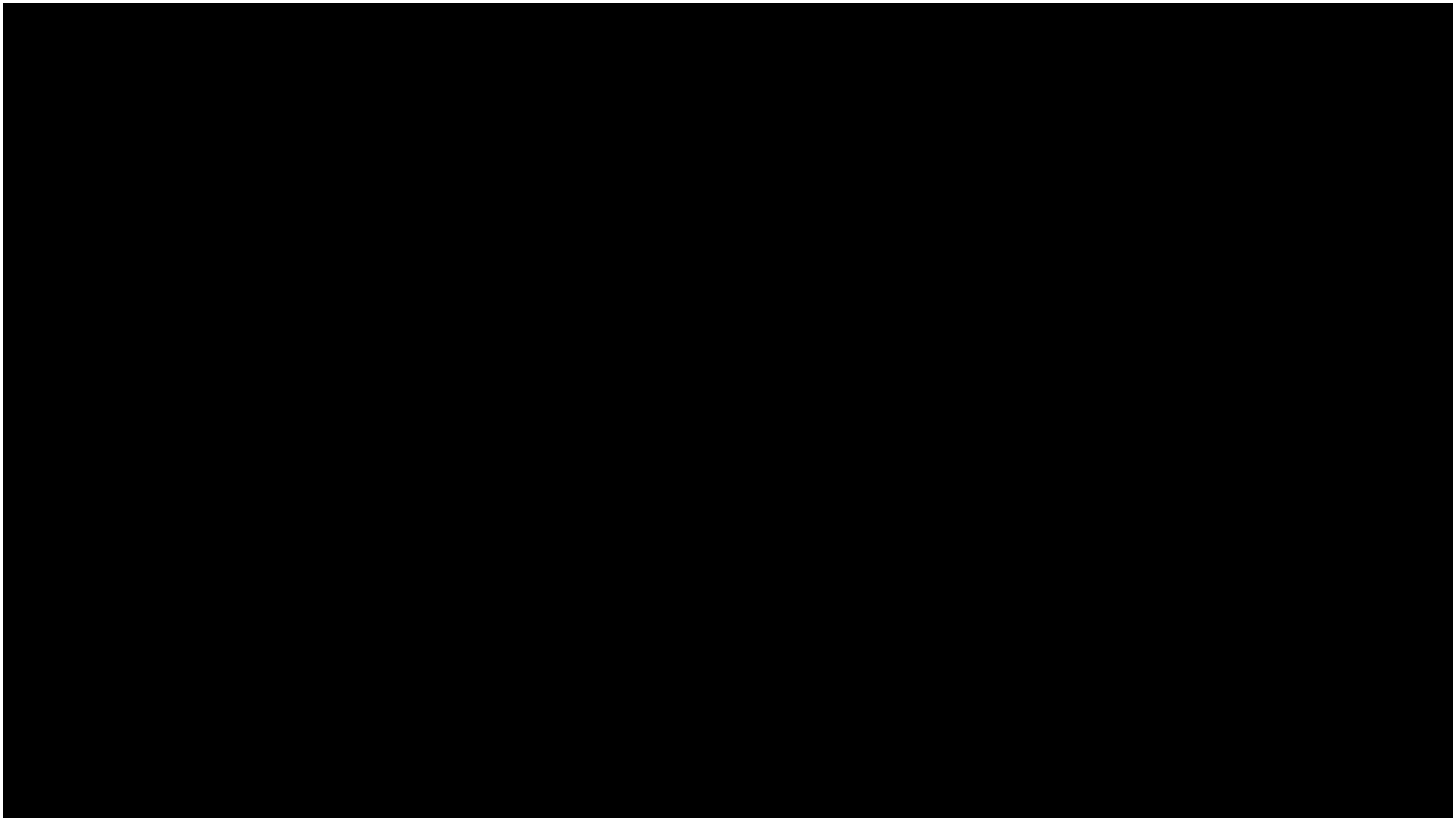
NORFOLK SOUTHERN BRIDGE SLIDE 1 WEEKEND OF 2/1/19 – 2/4/19



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NORFOLK SOUTHERN BRIDGE SLIDE 2
WEEKEND OF 2/8/19 – 2/11/19

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BENEFITS / LESSONS LEARNED
General

- Contractor under contract to provide input during design.
- Owner able to review and approve innovative design and construction methods.
- Design work incorporates understanding of constructability.
- Pre-identify and mitigate risks.
- Allows for early procurement.
- ABC is not the cheapest option, but if you consider user cost, then it is a competitive alternative.

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BENEFITS / LESSONS LEARNED
Designer Perspective

- Implementation of ABC resulted in less than one year of lane closures.
- Design developed to expedite construction.
- Micropiles: maximized efficiency.
- Designed for tight working conditions with contractor input.
- Minimized utility relocations.
- Efficient issue identification & timely responses.
- Contractor aware of design intent when developing bid.
- Efficient RR coordination conveying design, construction, and owner concerns simultaneously – allowed the team to get an approved plan to slide the bridge.

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BENEFITS / LESSONS LEARNED
TDOT Perspective

- CMGC process was a great fit/approach for the project given the history of this portion of I-240.
- With the high ADT and complexity of work, no other method would have been as successful.
- Involvement of all partners from inception was an advantage that resolved issues early on.
- The submittal process (pre-established and closely monitored with a tracker) helped keep reviews moving.

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BENEFITS / LESSONS LEARNED TDOT Perspective – cont.

- With the high number of micro-piles required; earlier or a more thorough investigation for pile data would have been valuable.
- Traffic conditions made it difficult to drive sacrificial piles for additional/earlier data.

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BENEFITS / LESSONS LEARNED CONTRACTOR PERSPECTIVE

- The biggest benefit was the CMGC process.
- The project was highly technical work with a lot of third party coordination.
- NSRR & MLGW played a key role in the project.
- Without the CMGC process and the focus the entire team had during reconstruction/design, the project would not have seen the same success and meet the schedule and goals.

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BENEFITS / LESSONS LEARNED CONTRACTOR PERSPECTIVE-cont.

- Another attribute of the CMGC process is the continuity of the team between design and construction, this streamlined communication and relationships and when issues did arise, they were resolved timely between all parties being engaged.
- The monthly team partnering meetings to discuss project status and potential challenges, this engaged the off project management and leadership and really became an avenue of problem solving where all three parties, TDOT, Benesch, and Kiewit could get on the same page and attack any project issues before they impacted the project or schedule.

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BENEFITS / LESSONS LEARNED
A Memphian Perspective

- Glad you did it the way you did; with the exception of interstate closure, there is a little construction impact.

- You built two bridges to replace one, why?
  - It was the only way to do it to minimize the impact on the NS operation.
  - We actually built one superstructure; approving the slide approach allowed us to do so.

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