I-69 Finish Line

EPS Fill under the Interstate

March 15, 2023

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What is EPS fill?

Expanded Polystyrene Foam –
Also commonly referred to as
"EPS", "Geofoam", “Styrofoam”

Why use EPS fill?

- Accelerates project schedules
- Easy to handle – light weight
- Unaffected by weather
- Easily shaped on site to suit the needs of the project

Project Background:

I-69 and SR 252 Interchange
South-Central Morgan County, IN

- SR 252 interchange is located on a steep incline leading into Martinsville, Indiana
- Soil conditions are highly variable
  - Geologic deposition transitions from southern edge of glaciation to White River outwash valley

PROJECT LOCATION SHOWN BY —

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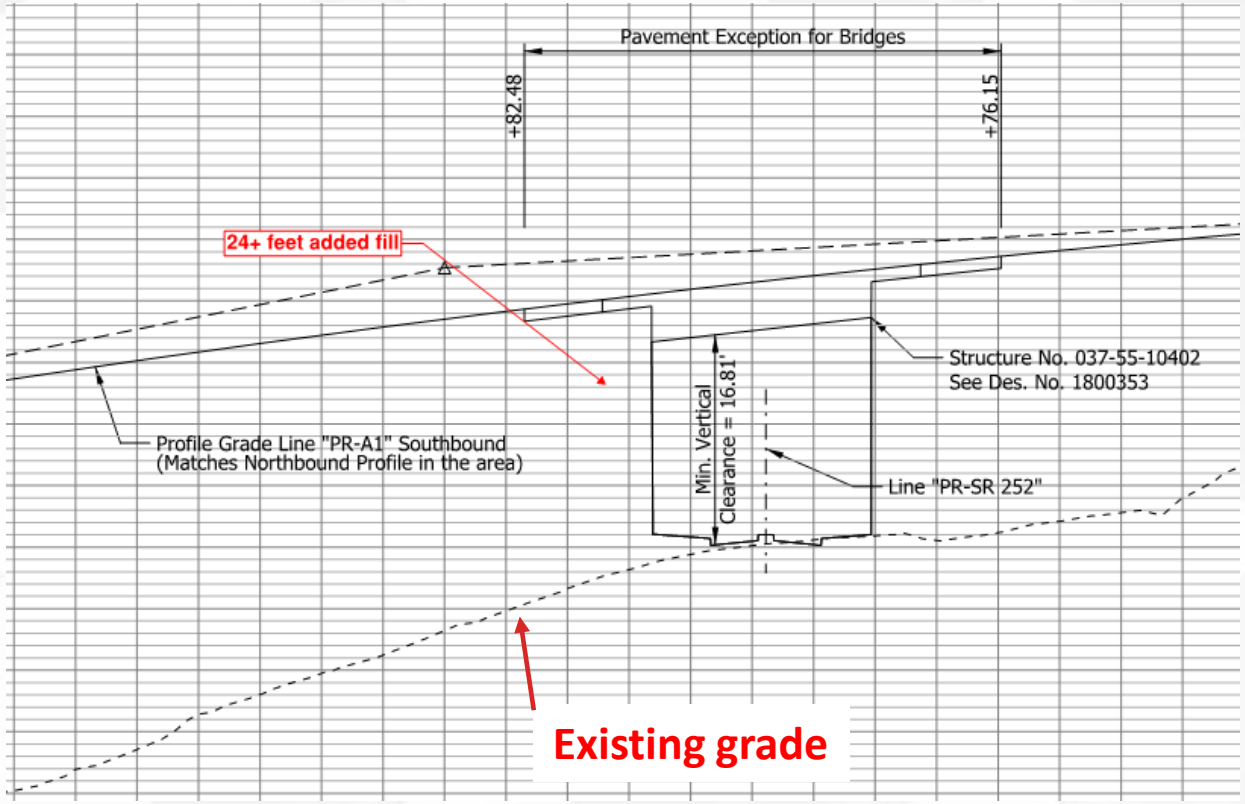
Design Considerations and Constraints (cont'd)

Roadway

a. Flattening and lengthening of proposed profile was required
b. Mainline I-69 profile grade was raised 24 to 40 feet at SR 252
    - Allowed SR 252 to remain at grade, simplifying construction
c. Narrow right-of-way due to existing development – retaining walls were needed



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Construction Schedule

- Let late 2019
- Off-line work 2020
- Full closure 2021

- Settlement
  - 8”-12” over 6-12 months
- But… After built the SR 252 bridge can’t settle due to vertical clearance

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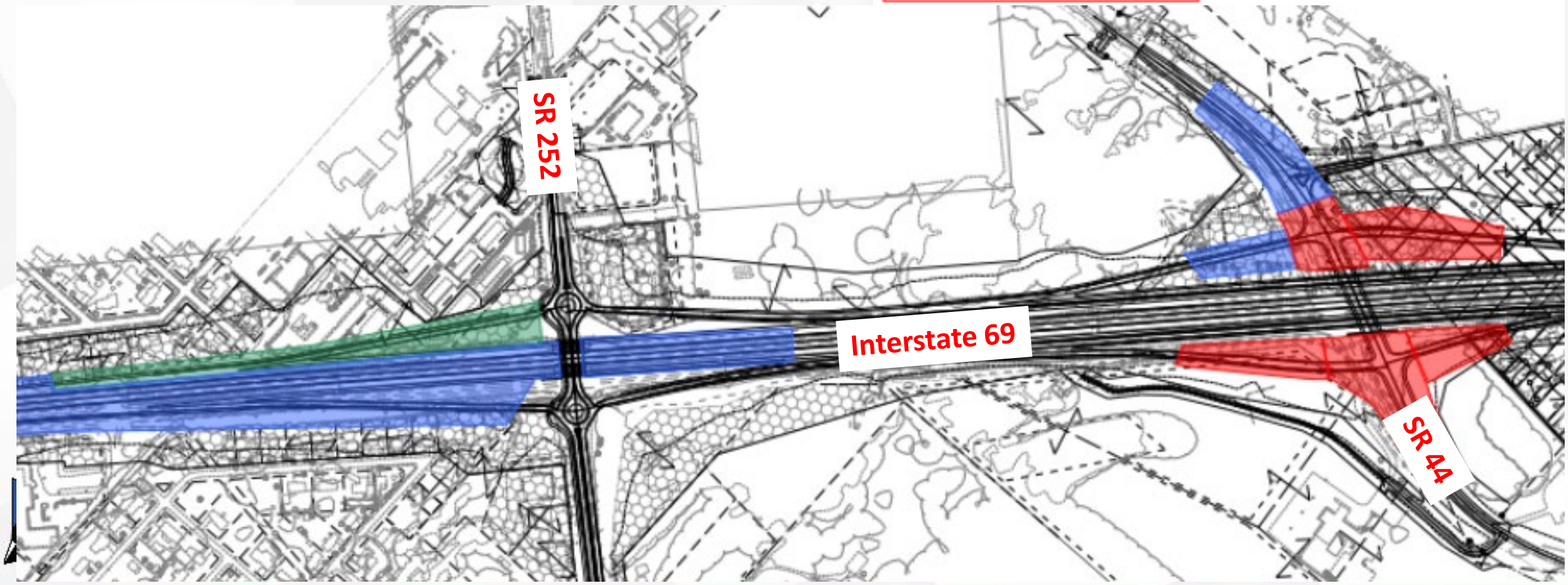
Design Considerations and Constraints (cont'd)

Construction Schedule Requirements



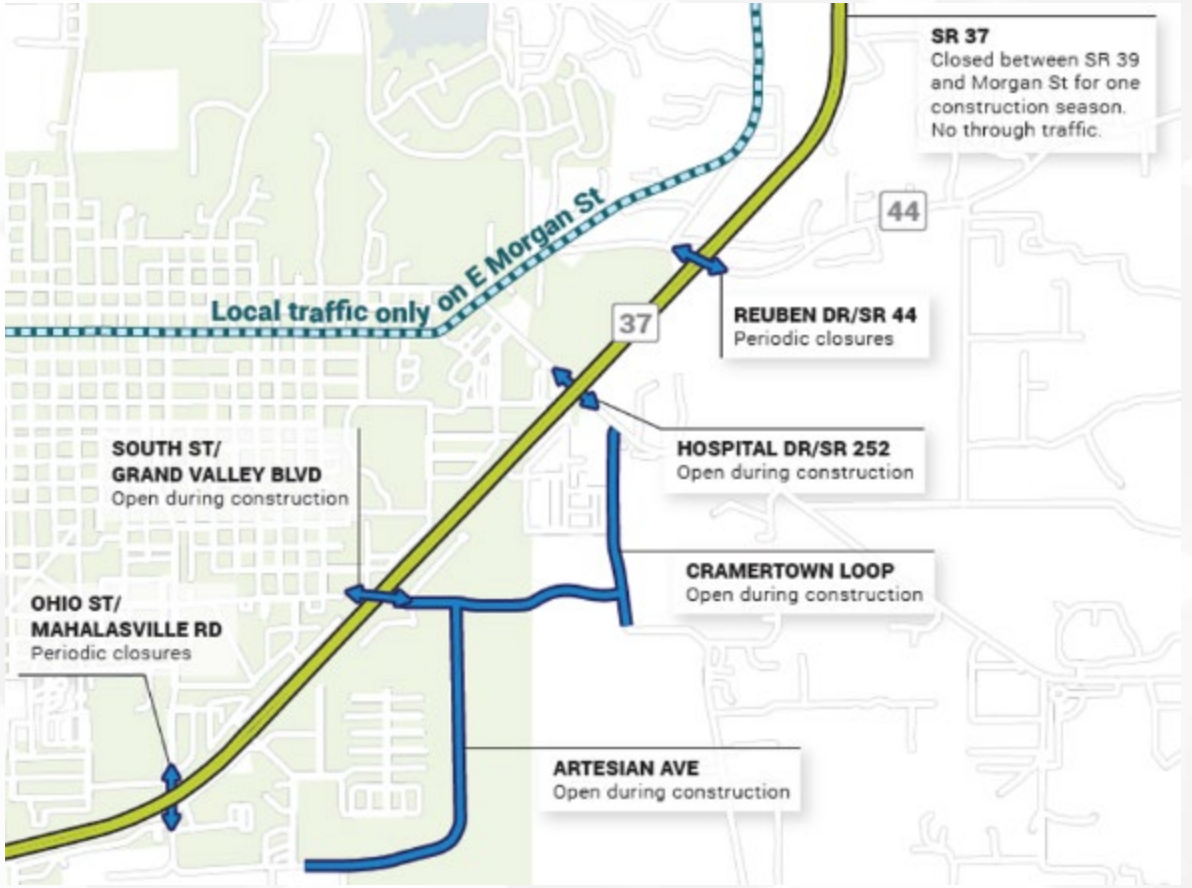
Design Considerations and Constraints (cont'd)

Maintenance of Traffic

a. Accelerated construction schedule while SR 37 is closed for construction for 1 year
   - Imperative this is met – construction of entire Section 6 corridor was contingent on this timeline

b. SR 252 must remain open at all times to maintain access to IU Hospital

c. SR 44 can experience periodic closures



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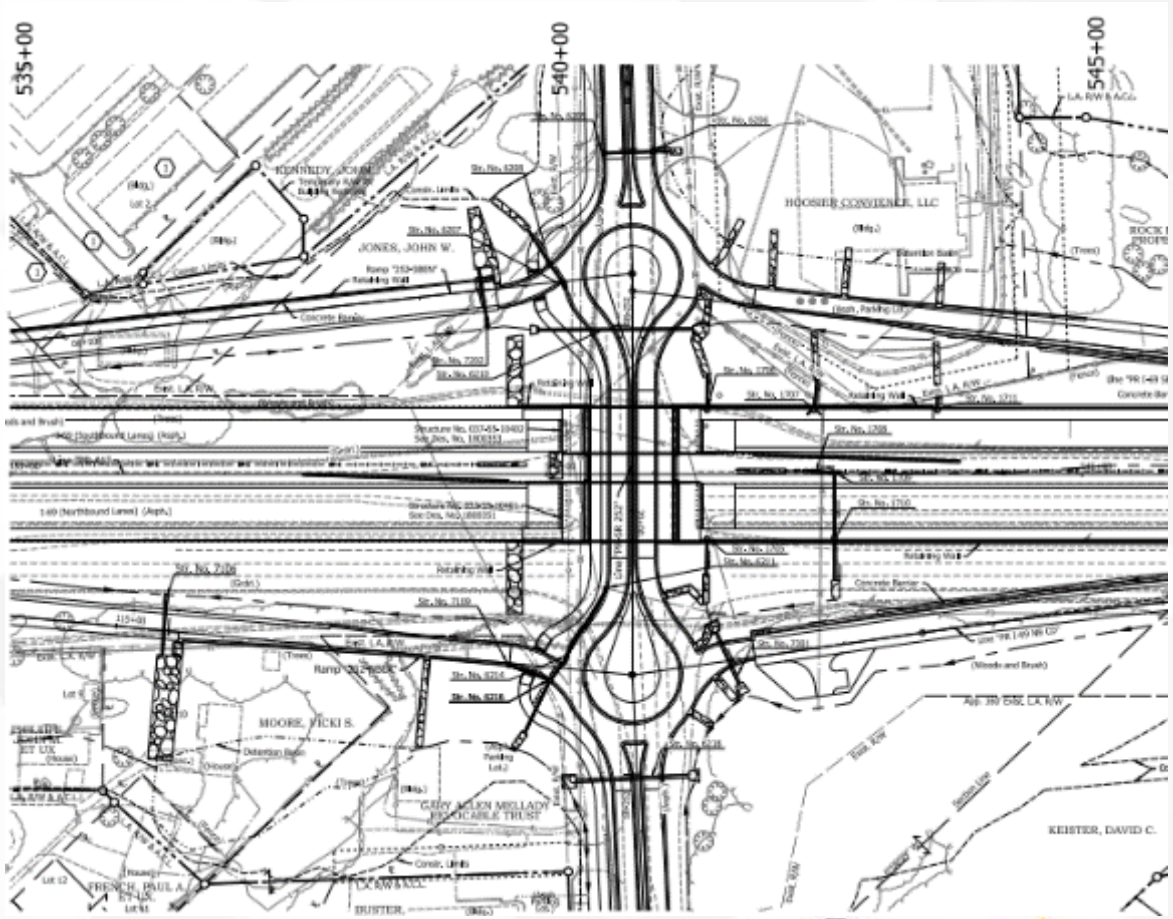
Design Considerations and Constraints (cont'd)

Structural

a. Retaining walls for grade separation
b. Tallest MSE Wall heights from approximately 25 feet at the bridge end bents to 40 feet at the SR 252 interchange ramps
c. Preventing downdrag on piles and potential settlement of bridge
    a. Limited tolerance between SR 252 and bottom of bridge
d. Aesthetics



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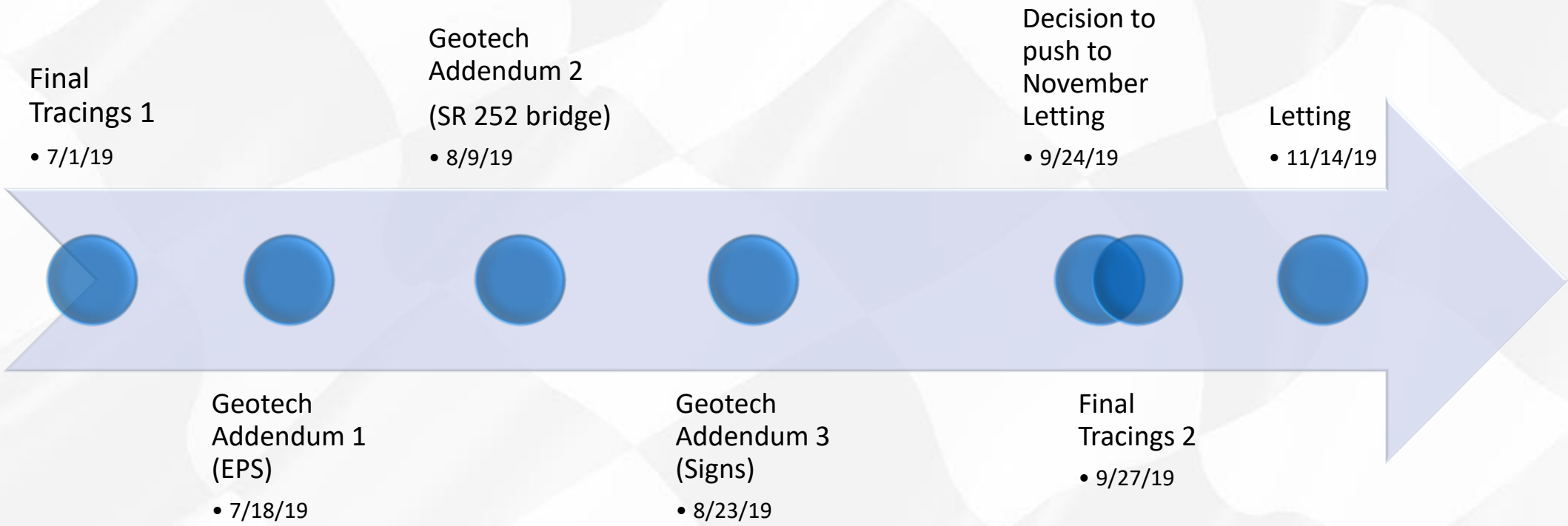
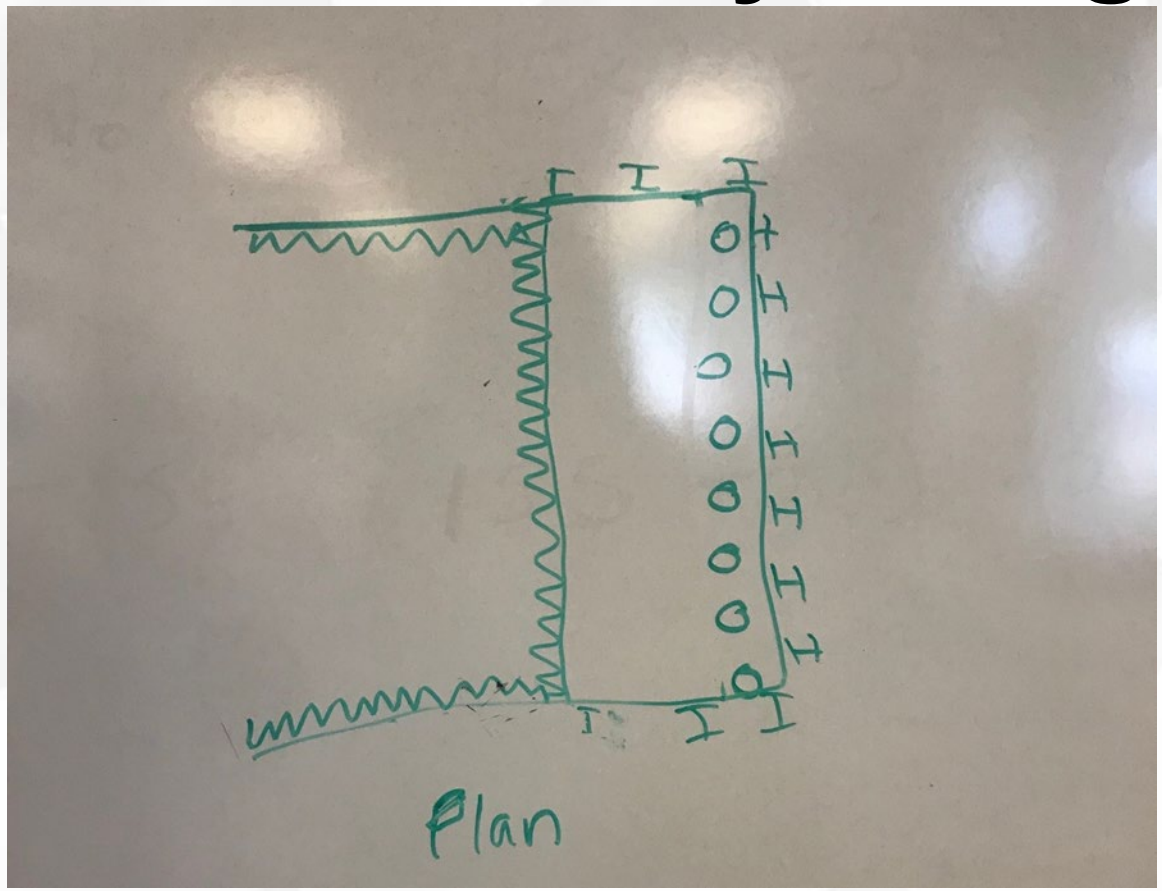
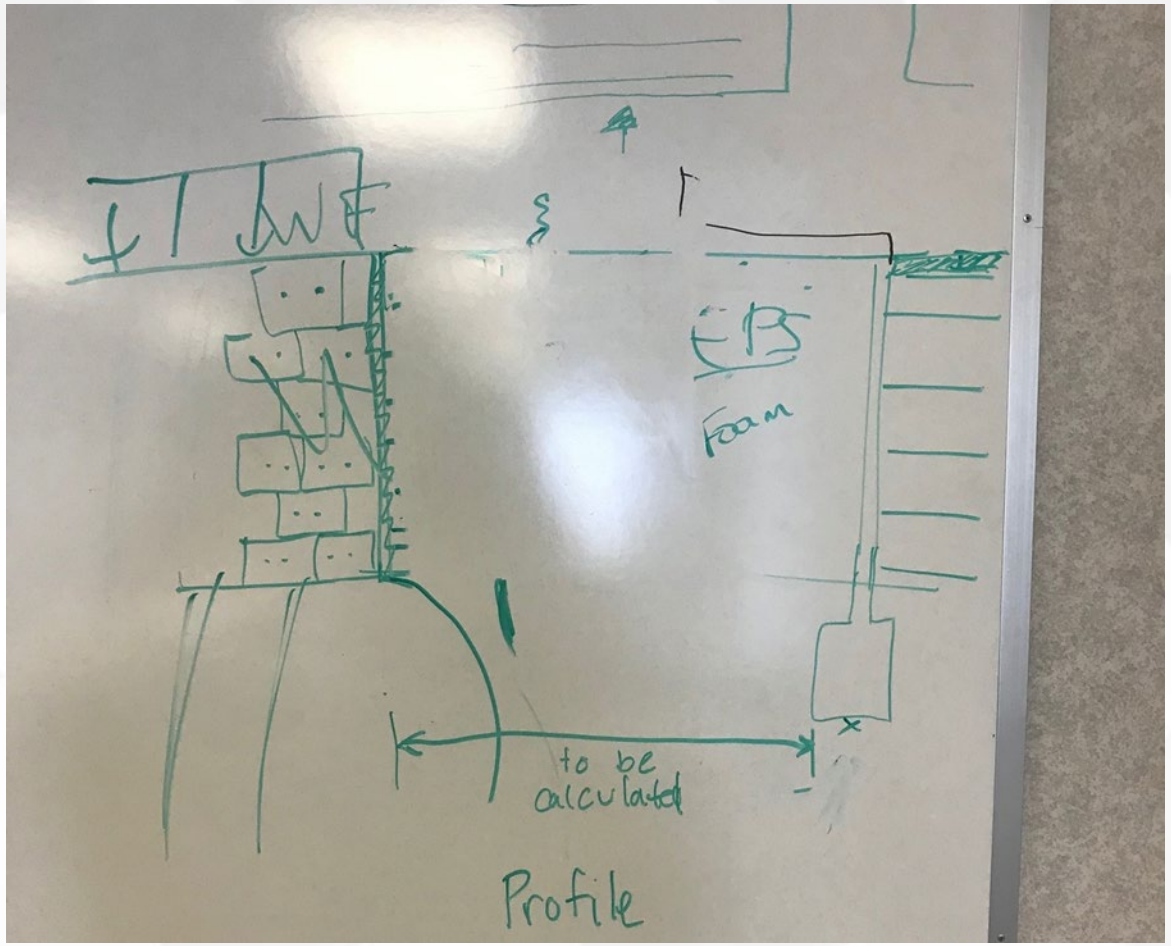
Finale of Design Schedule



Preliminary Design





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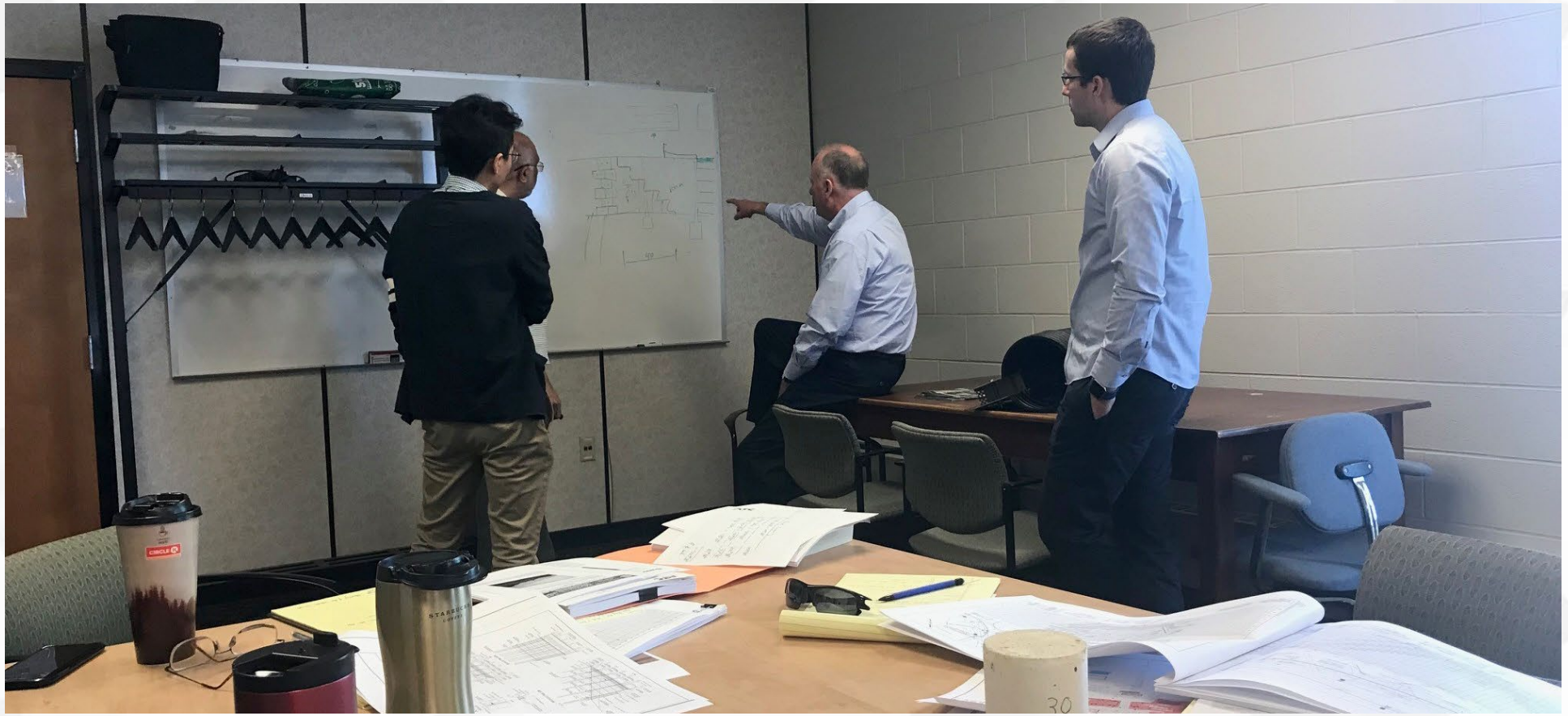
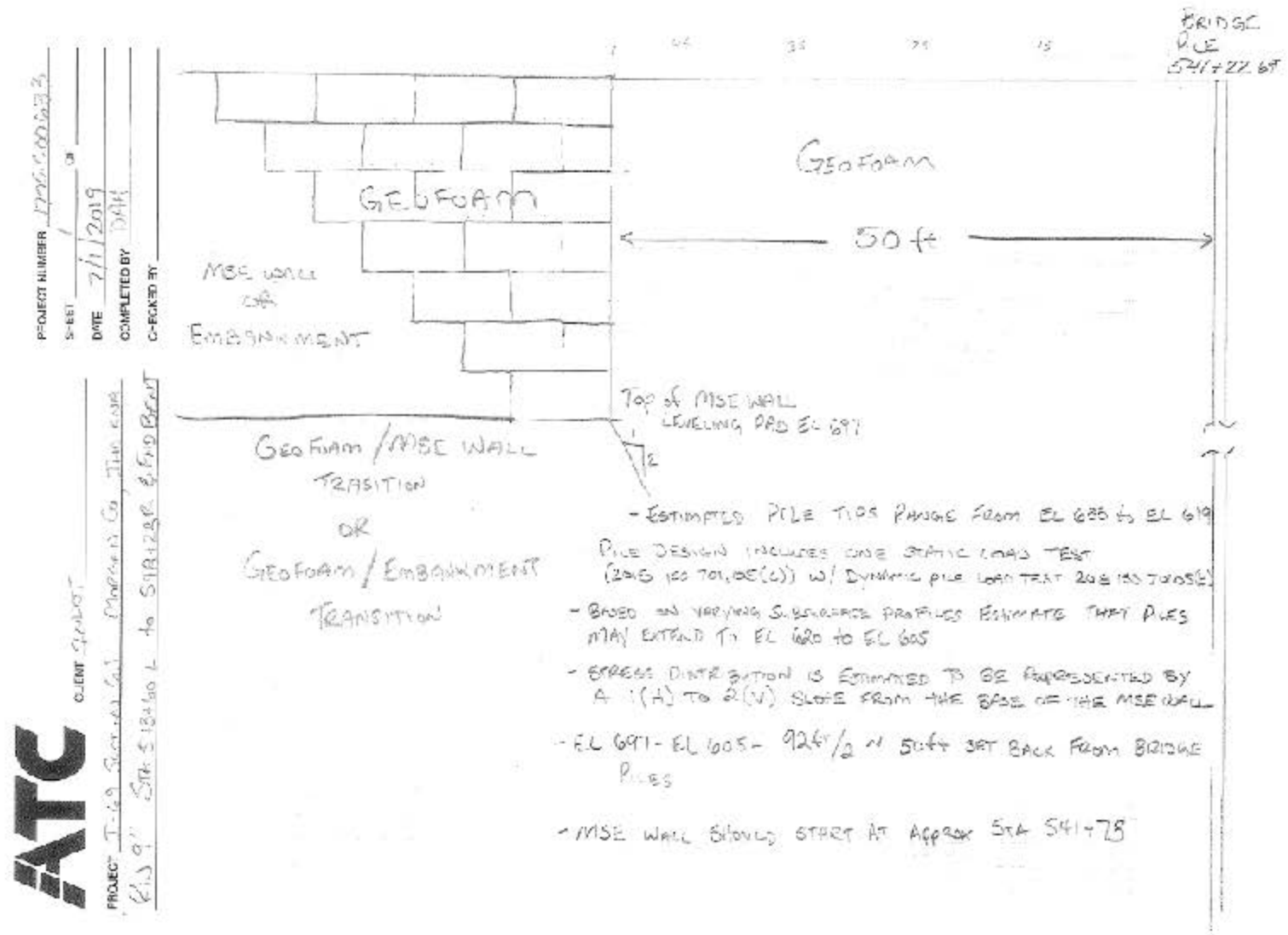
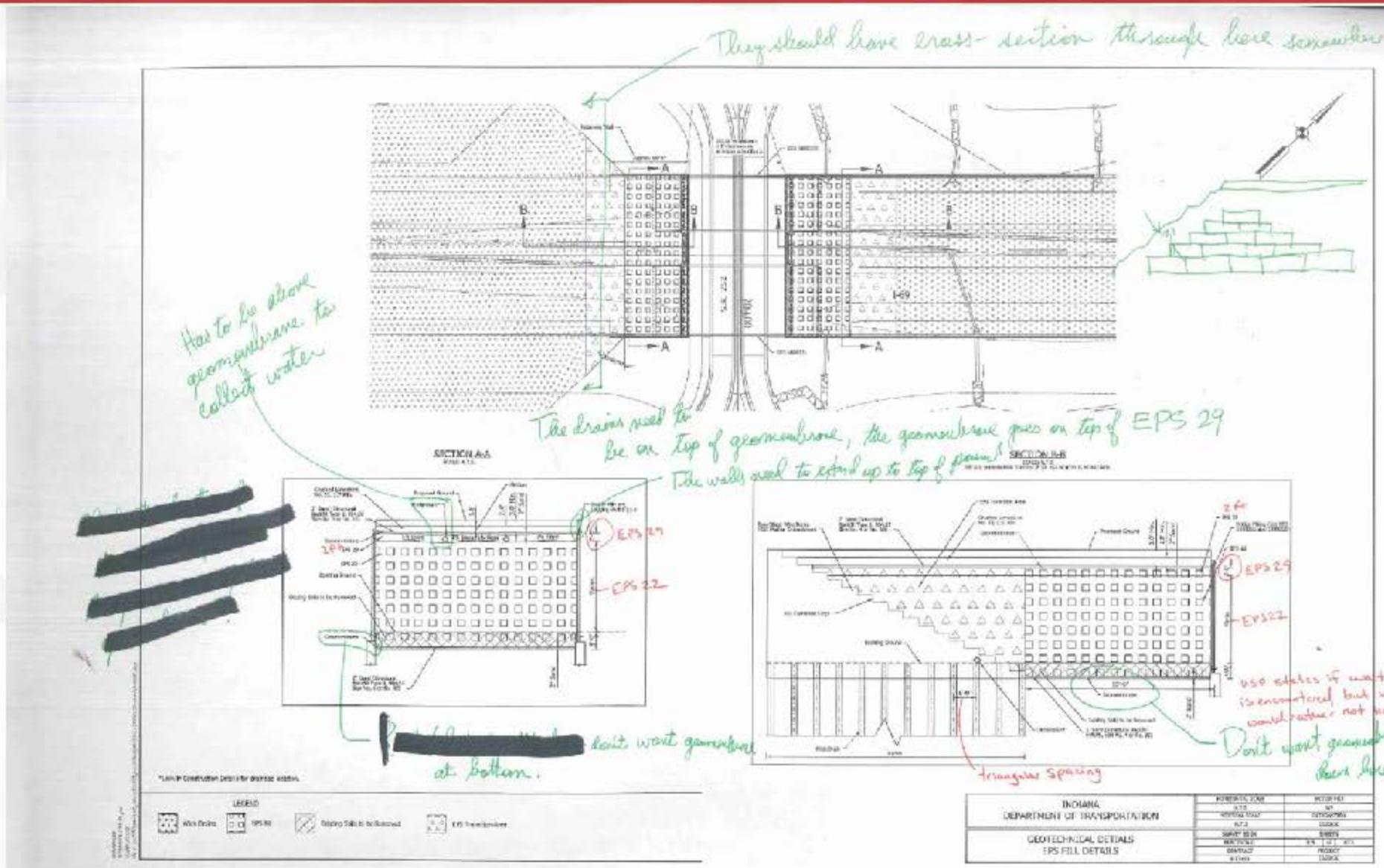
Preliminary Design




PROJECT NUMBER
SHEET
DATE 7/1/2019
COMPLETED BY
CHECKED BY
CLIENT
PROJECT
ATC
BRIDGE @ E STA 541+22.67
GEOFOAM
50 ft
MSE WALL OR EMBANKMENT
Top of MSE WALL LEVELING PAD EL 697
GEOFOAM / MSE WALL TRASITION OR GEOFOAM / EMBANKMENT TRANSITION
- ESTIMATED PILE TIPS RANGE FROM EL 635 to EL 619
PILE DESIGN INCLUDES ONE STATIC LOAD TEST (ASTM D1143/D1143M) W/ DYNAMIC PILE LOAD TEST (ASTM D4945)
- BASED ON VARYING SUBSURFACE PROFILES ESTIMATE THAT PILES MAY EXTEND TO EL 620 TO EL 605
- STRESS DISTRIBUTION IS ESTIMATED TO BE REPRESENTED BY A 1(H) TO 2(V) SLOPE FROM THE BASE OF THE MSE WALL
- EL 697 - EL 605 = 92ft / 2 = 51ft SET BACK FROM BRIDGE PILES
- MSE WALL SHOULD START AT Approx STA 541+78



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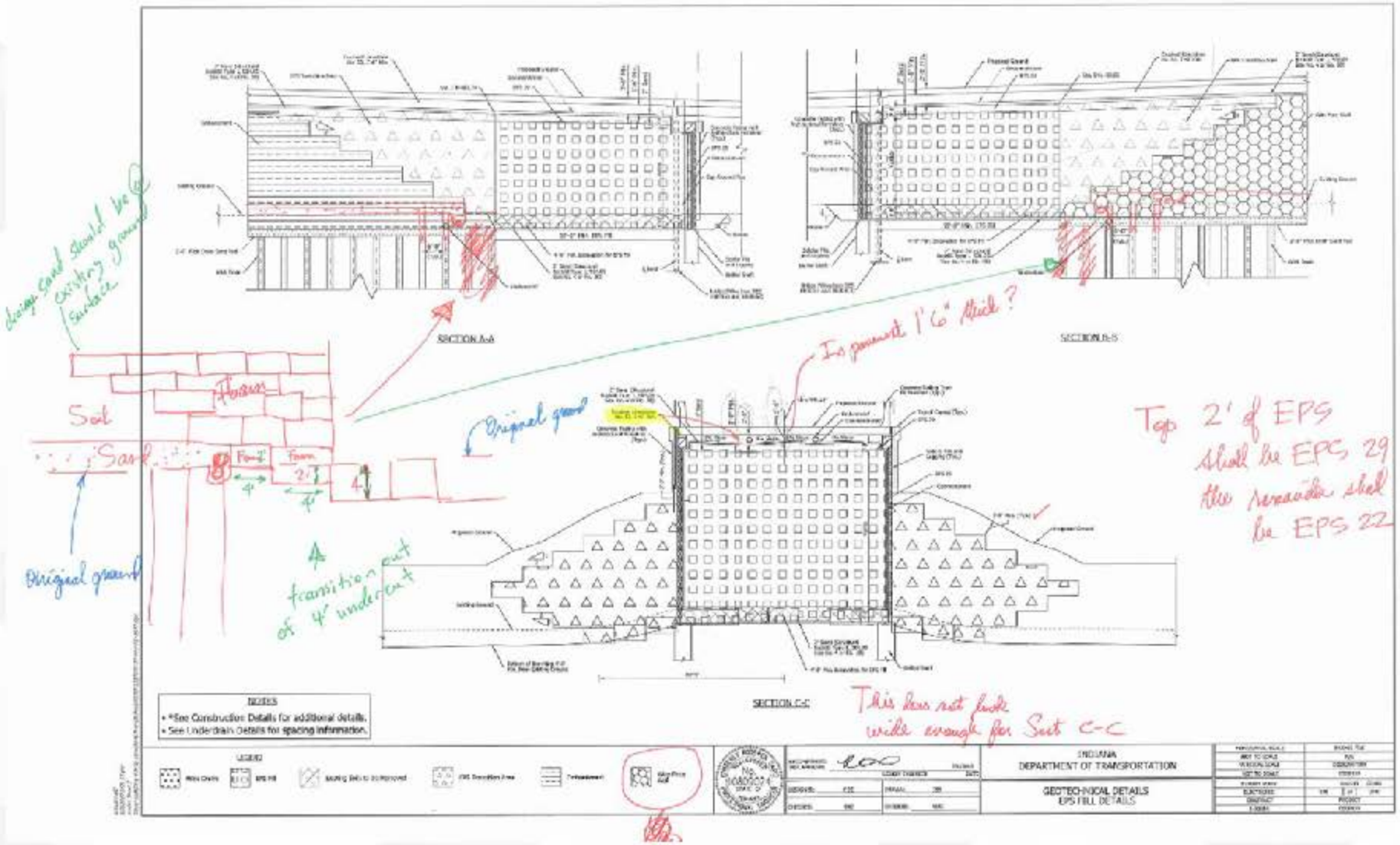
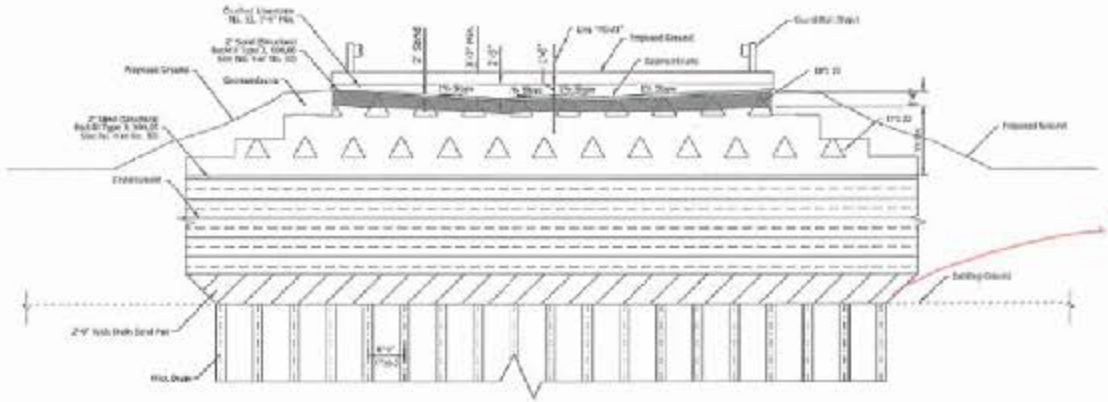
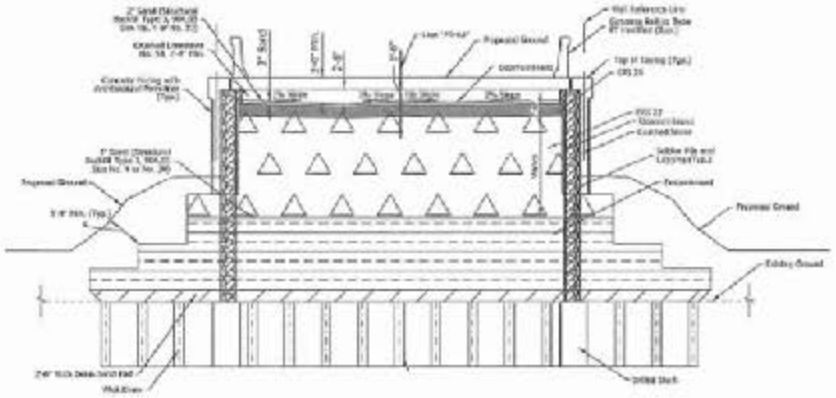

design sand should be at existing ground surface
Sand
Original ground
Original ground
Is pavement 1'6" thick?
Top 2' of EPS shall be EPS 29 the remainder shall be EPS 22
transition cut of 4' undercut
This does not look wide enough for Sect C-C
SECTION A-A
SECTION B-B
SECTION C-C
NOTES
• *See Construction Details for additional details.
• See Underdrain Details for spacing information.
INDIANA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL DETAILS
EPS FILL DETAILS

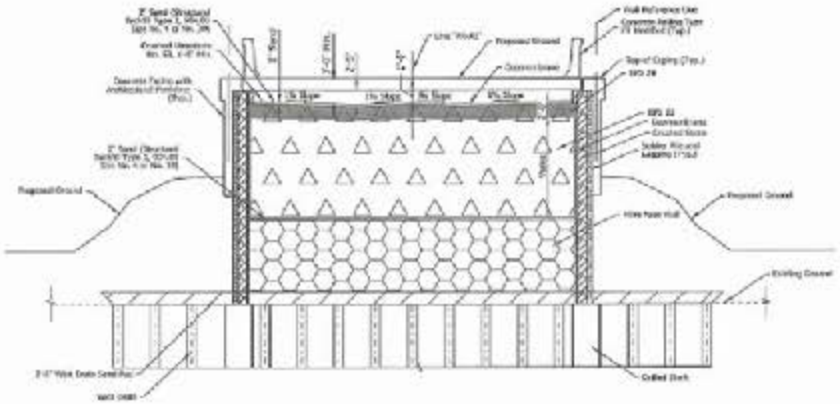


SECTION D-D

This has to daylight at the sides. Is this clear based on cross-sections?

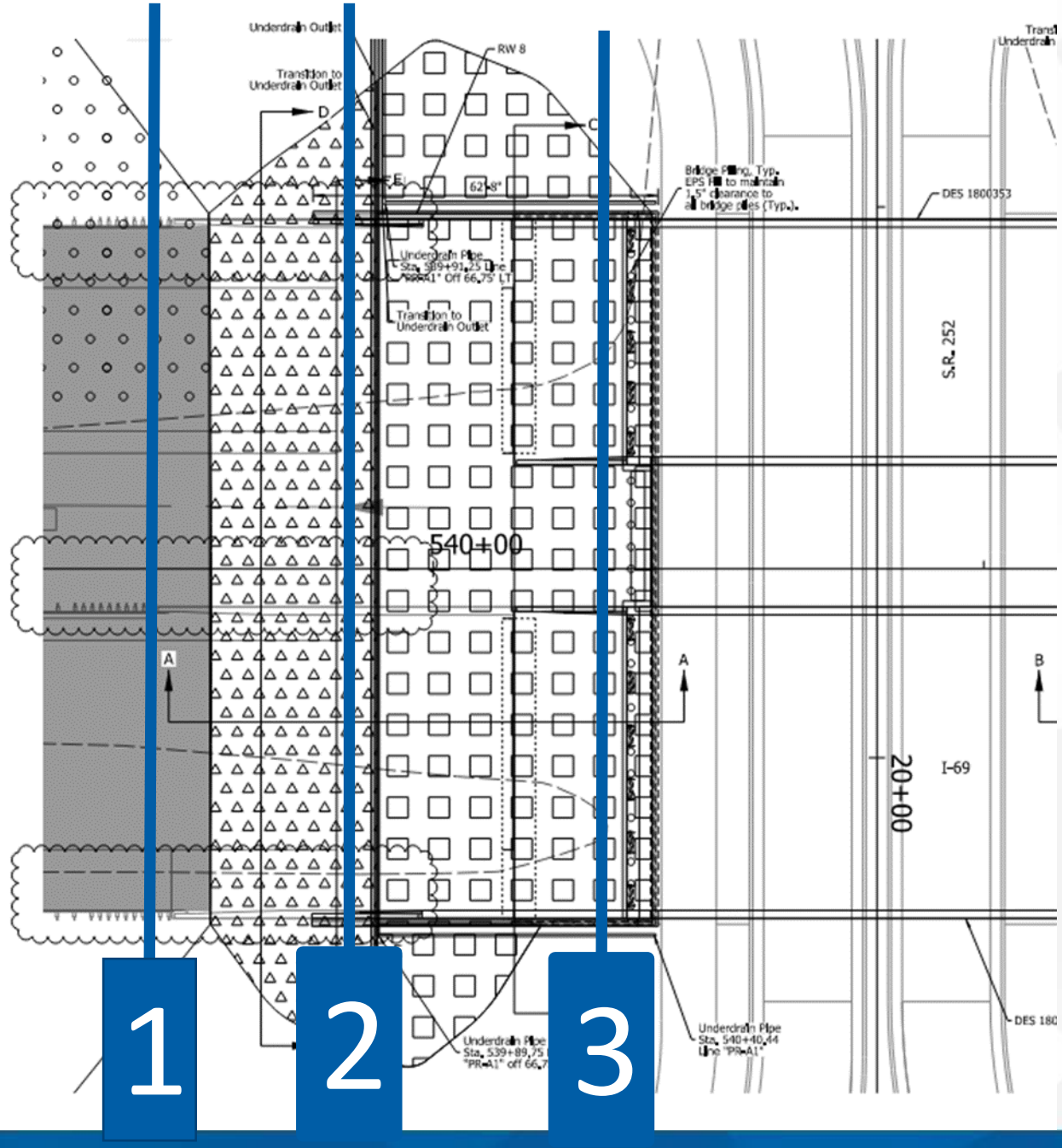


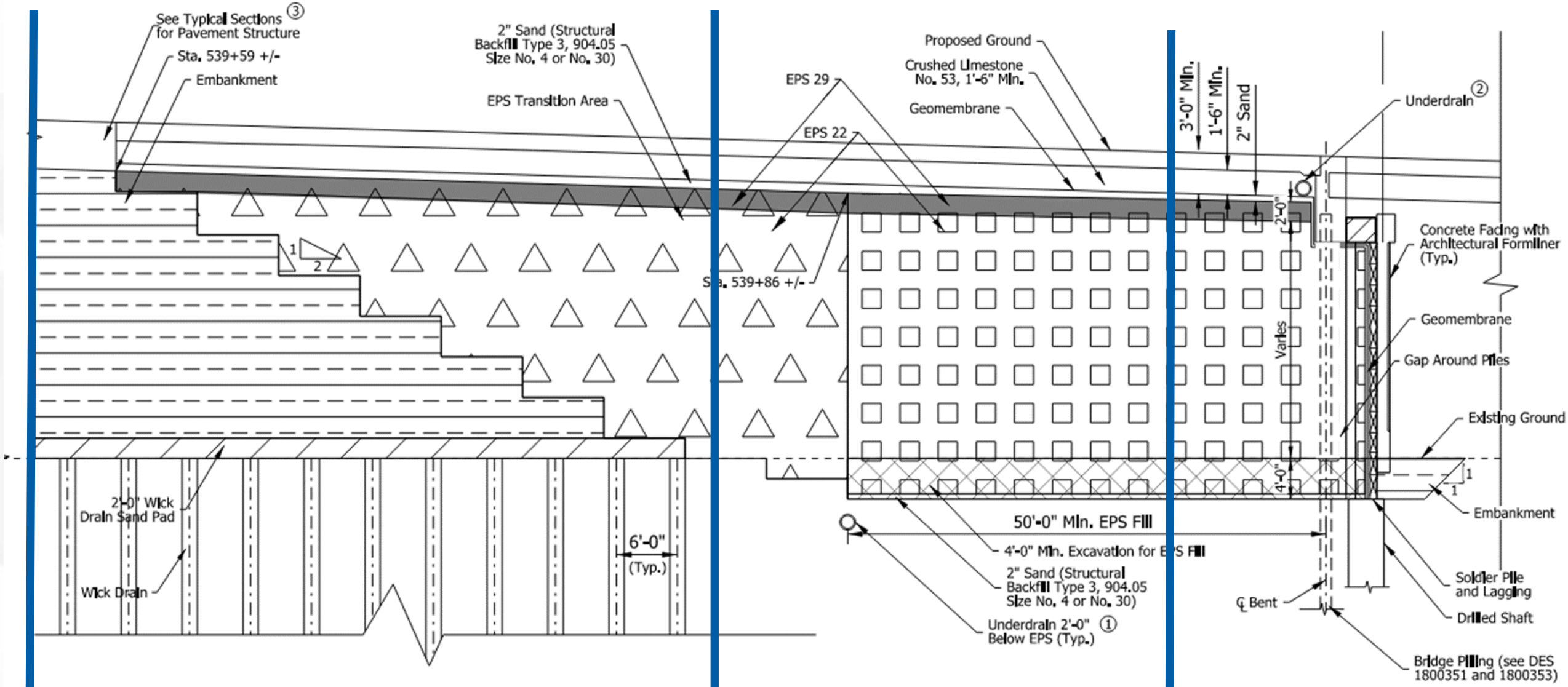
SECTION E-E



SECTION F-F

Plan


Underdrain Outlet
Transition to Underdrain Outlet
RW 8
Bridge Piling, Typ.
EPS Fill to maintain 1.5' clearance to all bridge piles (Typ.).
DES 1800353
Underdrain Pipe
Transition to Underdrain Outlet
S.R. 252
540+00
A
A
B
I-69
20+00
Underdrain Pipe
Underdrain Pipe
Sta. 540+40.44
Line "PR-A1"
DES 180
1
2
3



1

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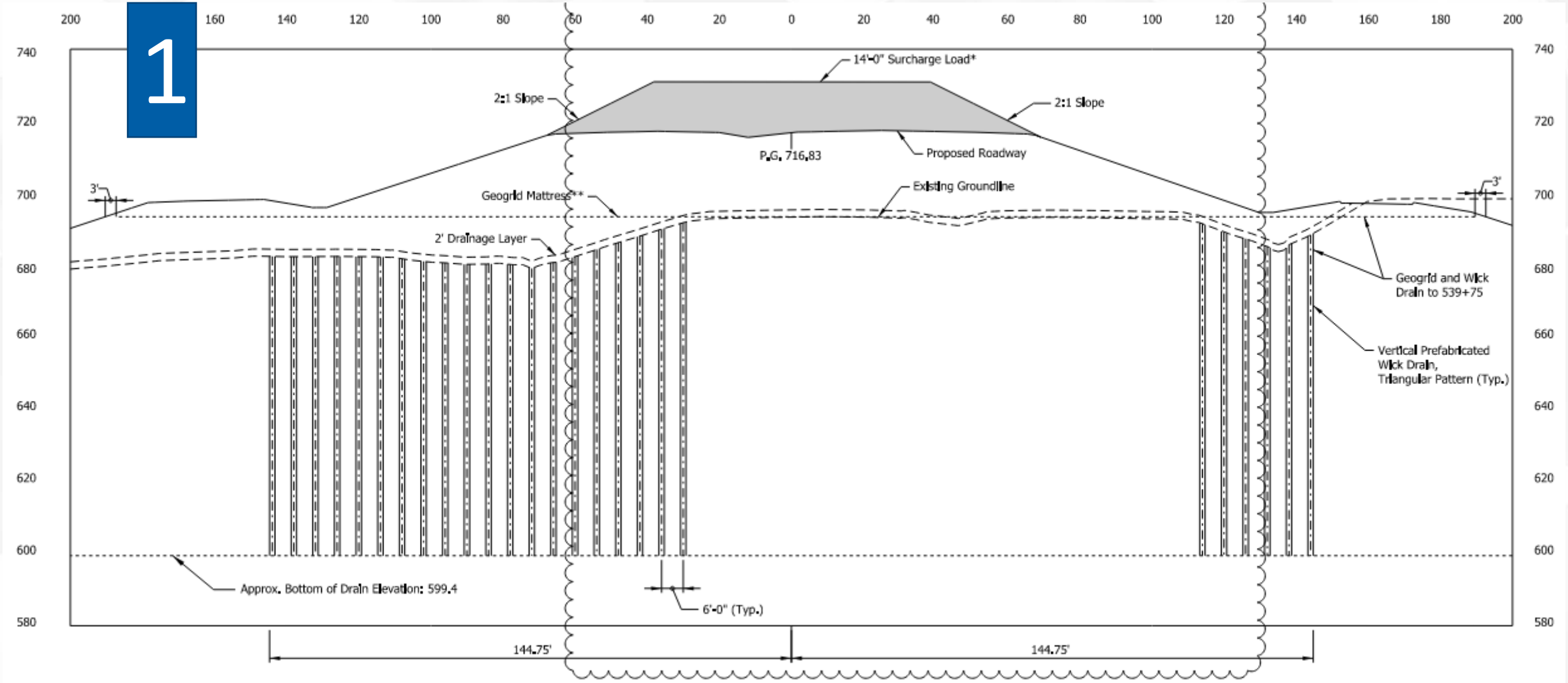
Profile

2

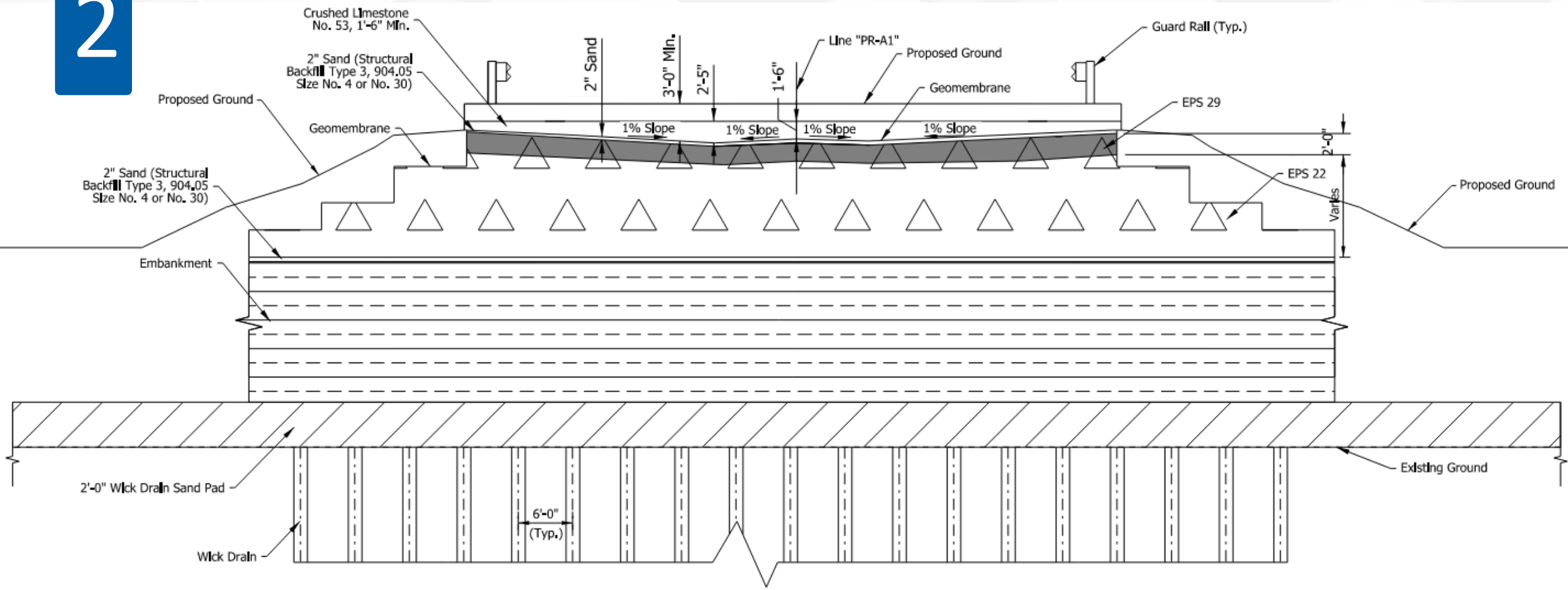
3

NextLevel



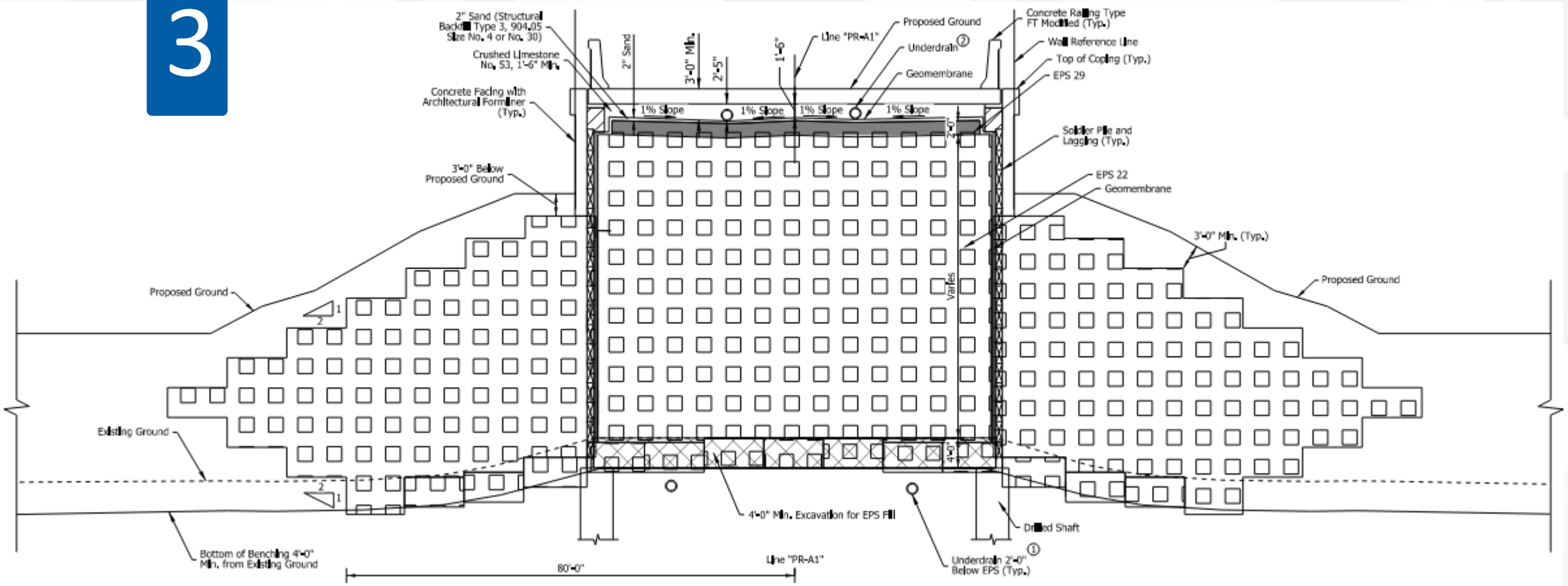
Cross Section – beyond EPS

2



Cross Section – begin EPS

3



Cross Section – full EPS

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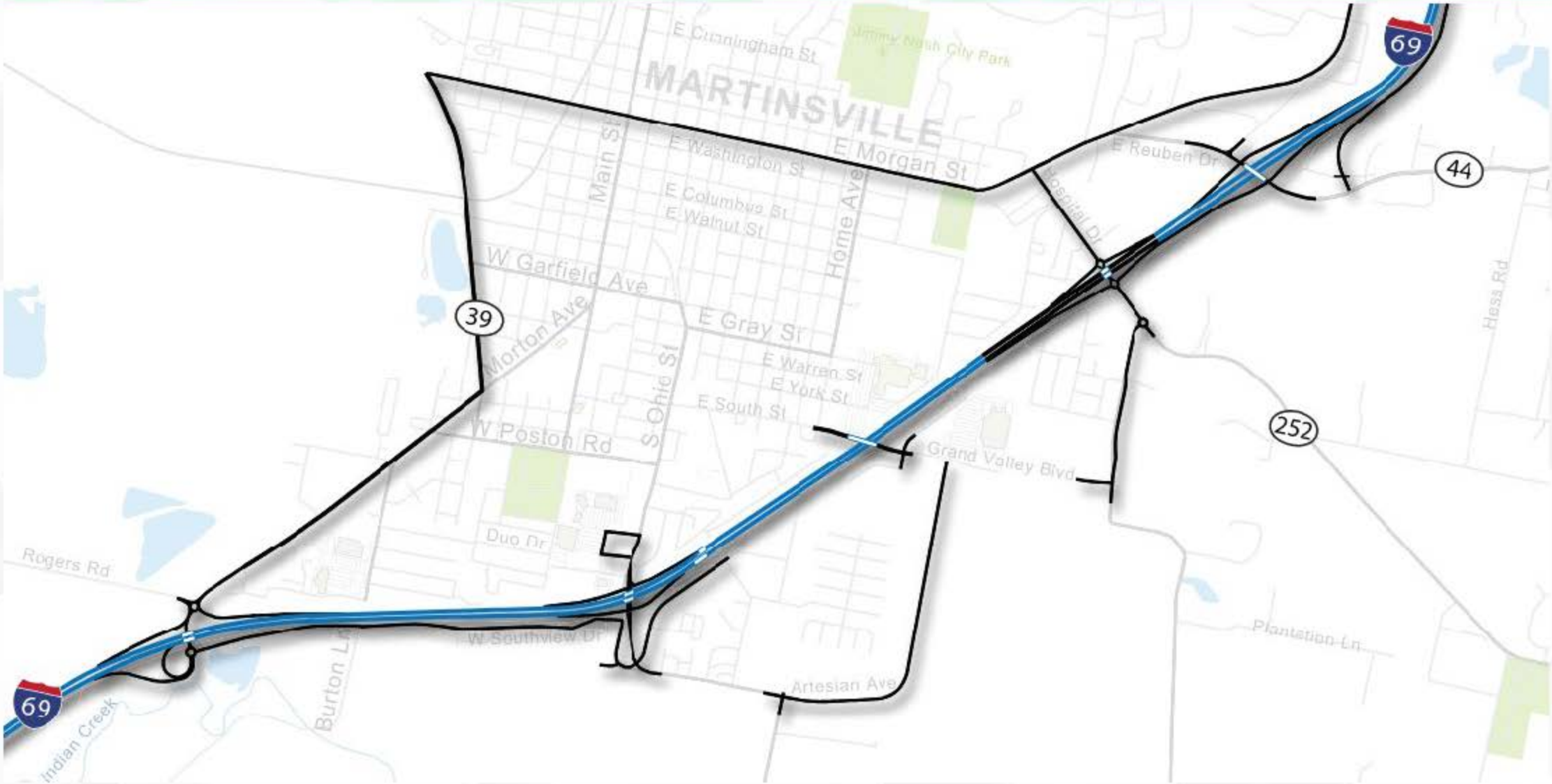

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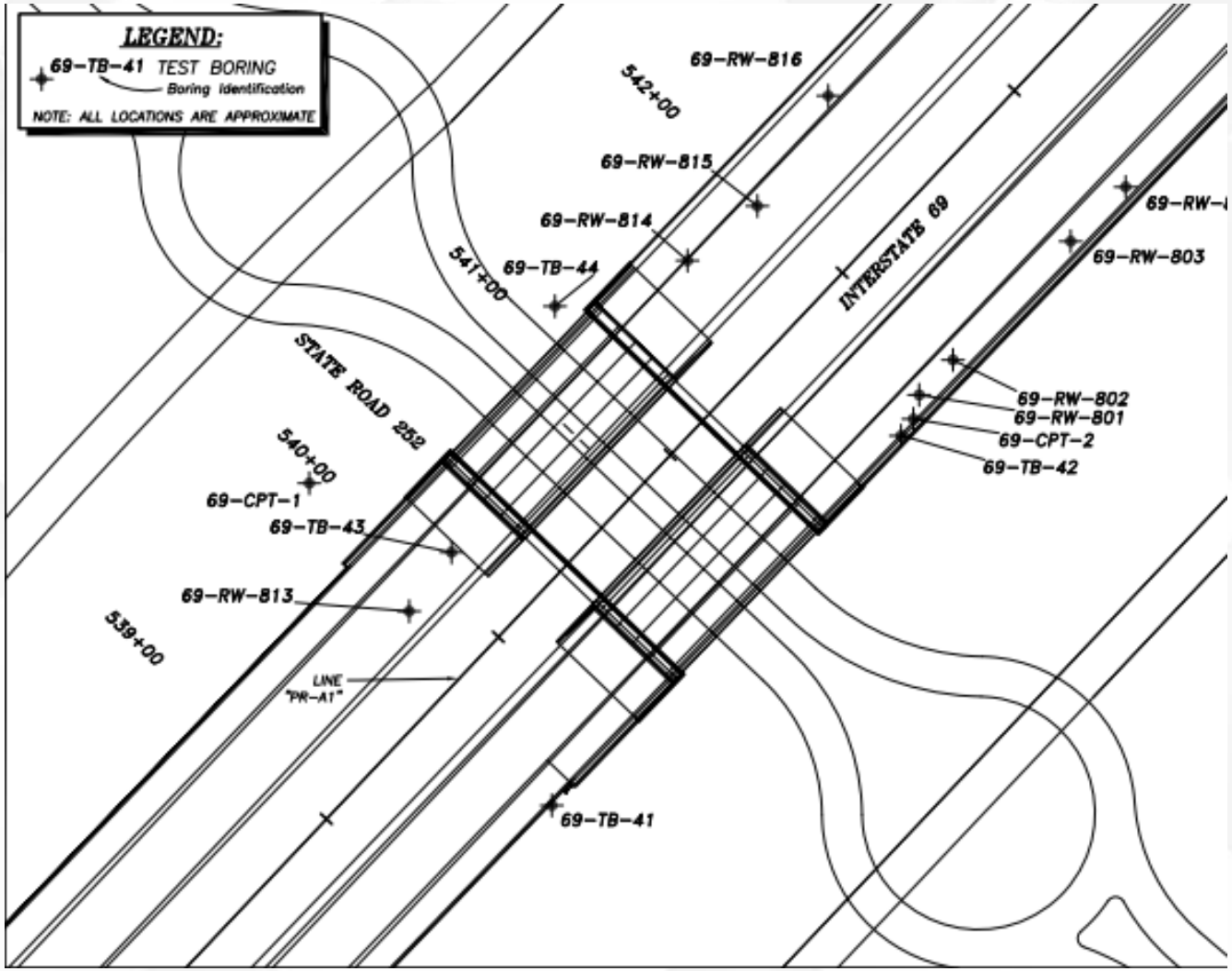
Geotechnical Investigation at SR 252

a. SPT Test Borings to 110 ft for the bridges
b. Borings from 25 ft to 65 ft for MSE Walls
c. CPT probes near SR 252 bridge end bents
d. Lab testing of soil samples:
    a. Classification Tests
    b. Consolidation Tests
    c. Strength Tests



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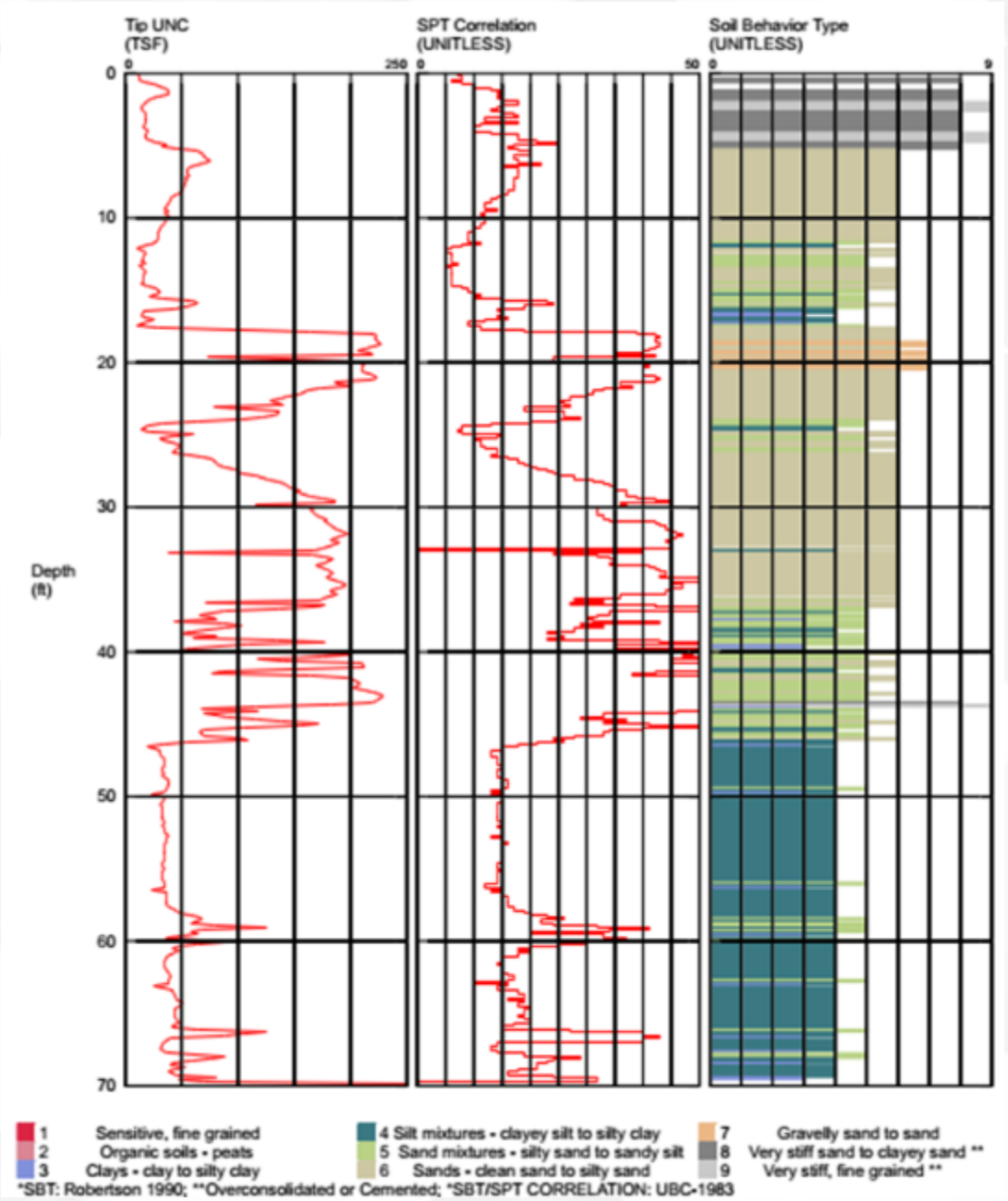
Boring and CPT Logs

- Highly Variable Soil Conditions
  - Borings with 110 feet of silty clay at NE corner of Bridges
  - Loose sands/gravels over deeper compressible cohesive soils
  - Layers of softer, more compressible, cohesive soils with layers of very loose sand to dense sand and gravel



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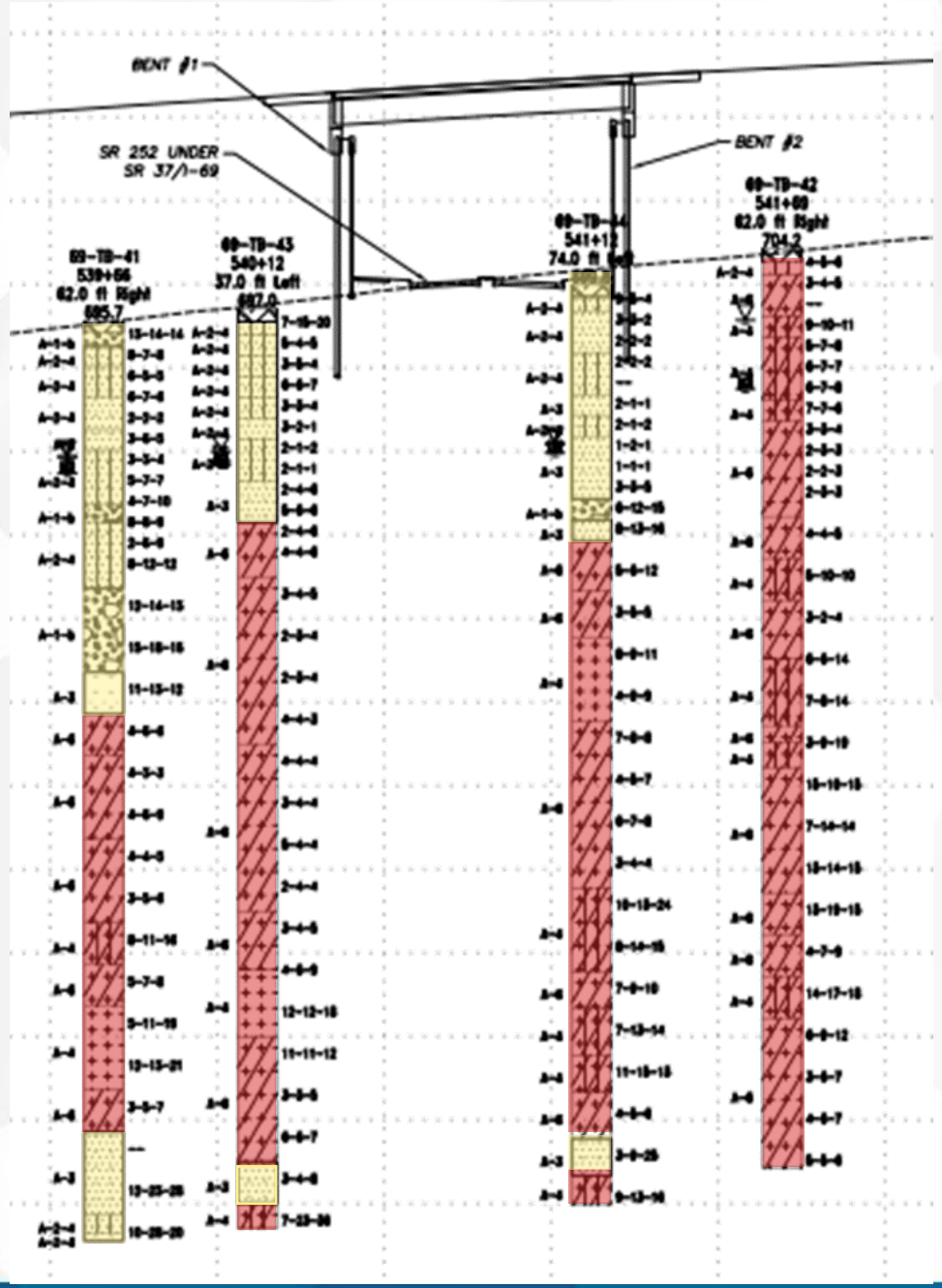
Subsurface Bridge Profile

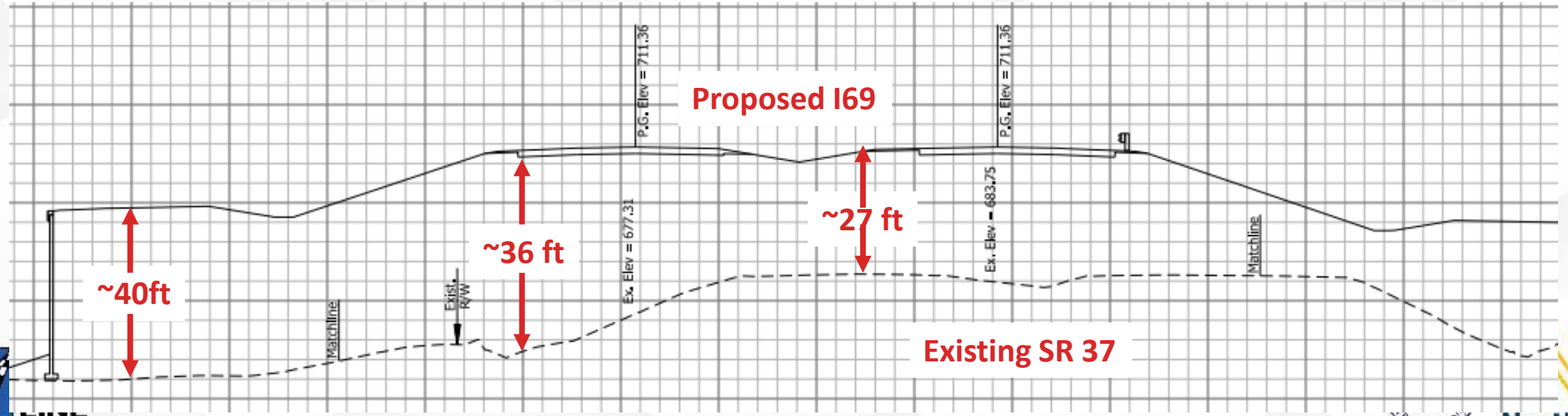
- Layers of softer, more compressible, cohesive soils with layers of very loose to dense sand and gravel
  a. Compressible layers of clay, silty clay at the bridge location
  b. Cohesive soils have higher natural moisture contents in many cases (up to 35%)

a. Ground water generally below 8 feet



Findings and Conclusions

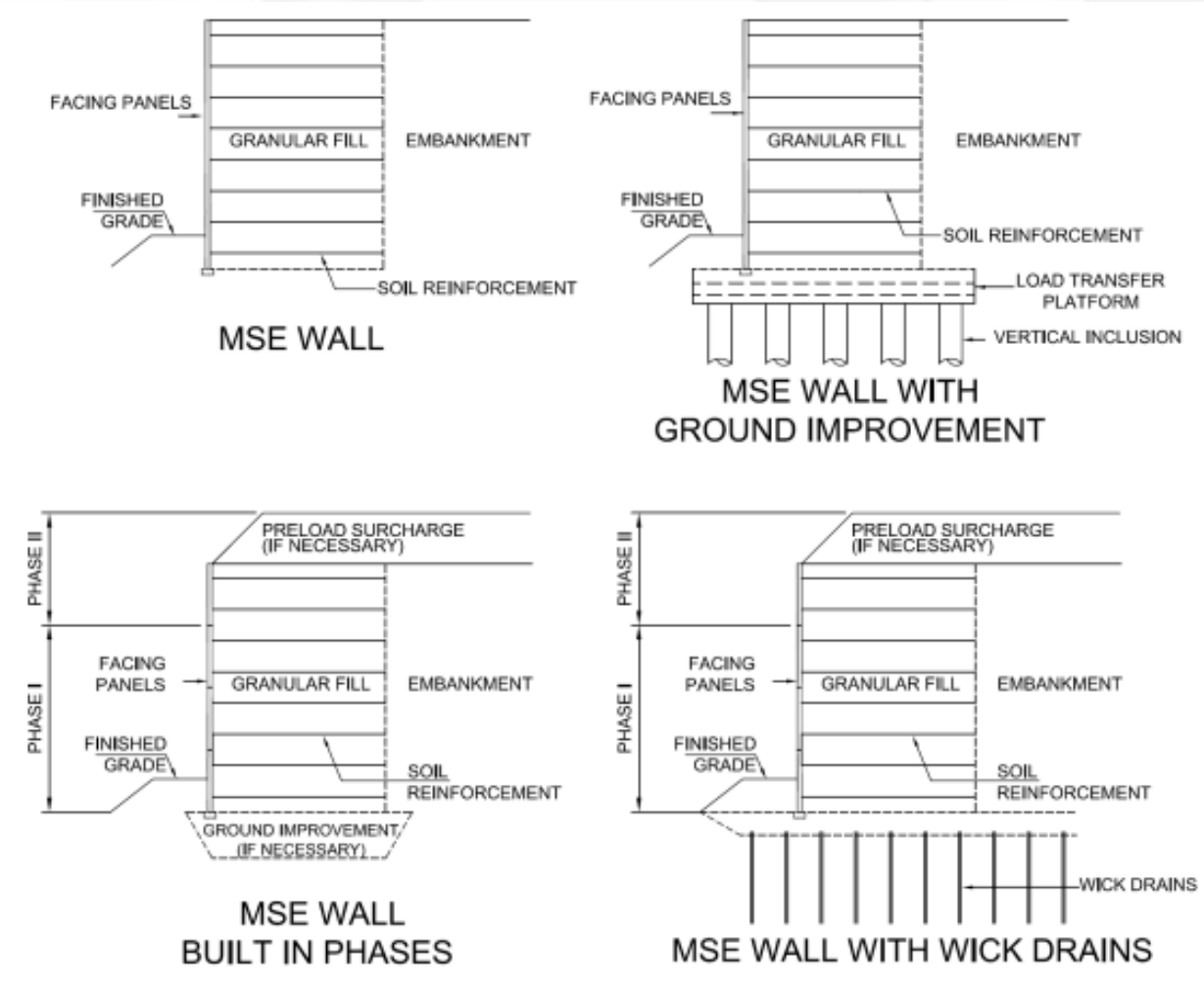
a. Estimated settlement ~8 to 12 inches for MSE Walls
b. Estimated 8 inches settlement at bridge end bents
c. Anticipate high downdrag on bridge piles due to depth of compressible cohesive soils



Conclusions

a. Ground improvement methods considered for the MSE walls:

   i. Aggregate columns and rigid inclusions
   ii. Staged Construction
   iii. Wick drains and surcharge
   iv. Deep soil mixing
   v. Lightweight fills, such as cellular concrete or geofoam



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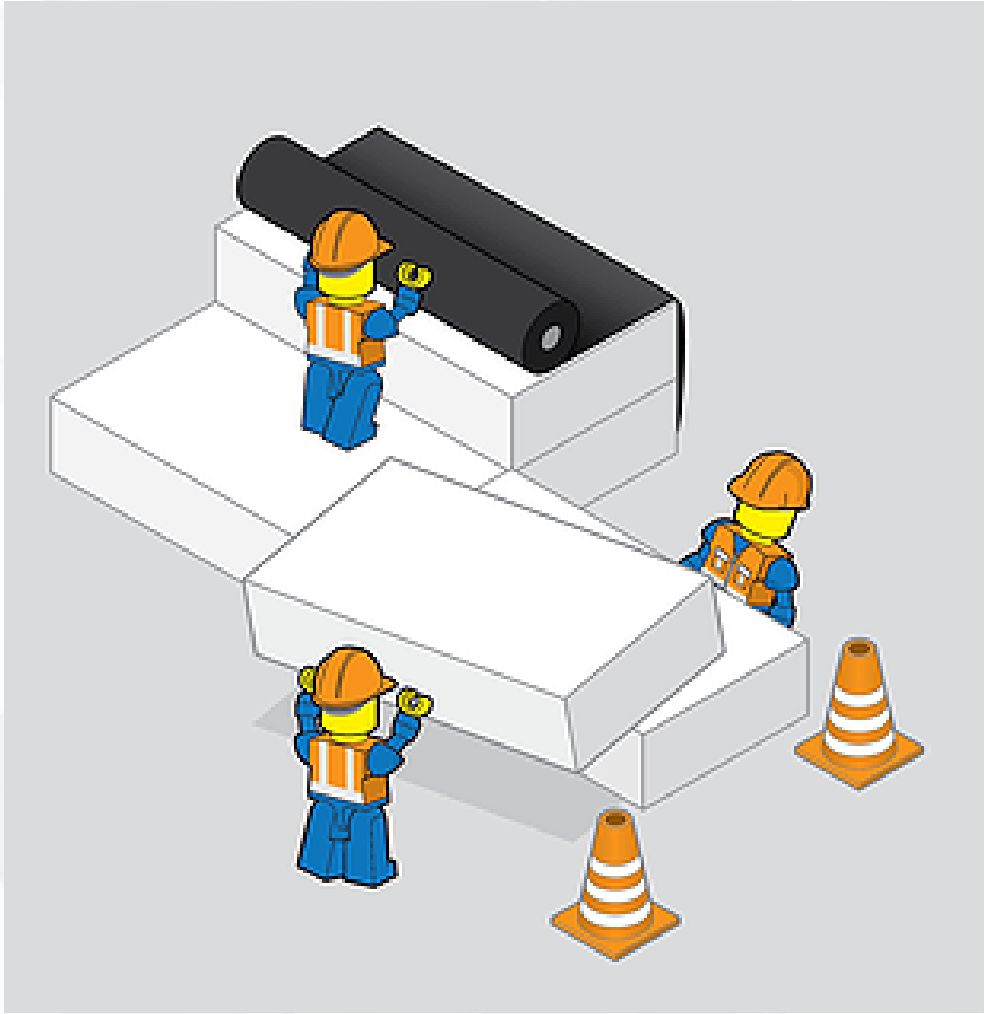
Solution:

- Combination of Wick Drains with Surcharge Loading in areas away from bridge abutments
- Expanded Polystyrene (EPS) at the bridge abutments
- Rigid Inclusions for other structures



Approach to Embankment and Bridge Construction

a. Increase the number of pipe piles
b. Revised design load =160 kips/pile
c. 16 inch pipe piles
d. Perform a static load test

PILE LOADING FOR GEOTECHNICAL TESTING				
LOCATION	NORTHBOUND		SOUTHBOUND	
	BENT 1	BENT 2	BENT 1	BENT 2
PILE SIZE, TYPE & GRADE	16" PP x 0.312" GRADE 3	16" PP x 0.312" GRADE 3	16" PP x 0.312" GRADE 3	16" PP x 0.312" GRADE 3
FACTORED DESIGN LOAD, Q (kips)	160	160	160	160
FACTORED DESIGN SOIL RESISTANCE, R, (kips)	160	160	160	160
RESISTANCE FACTOR, $\emptyset_{dyn}$	0.80	0.80	0.80	0.80
DOWNDRAG LOADS, DD (kips)	0	0	0	0
NOMINAL SOIL RESISTANCE, R_n (kips)*	200	200	200	200
DOWNDRAG FRICTION, R_{sdd} (kips)	0	0	0	0
SCOUR ZONE FRICTION, R_{scour} (kips)	0	0	0	0
RELAXATION OF TIP IN SHALE, R_{relax} (kips)	0	0	0	0
NOMINAL DRIVING RESISTANCE, R_{ndr} (kips)	200	200	200	200
ESTIMATED PILE TIP ELEVATION	653	645	653	645
UPLIFT RESISTANCE FACTOR, Ø	-	-	-	-
NOMINAL UPLIFT RESISTANCE (kips)	-	-	-	-
FACTORED UPLIFT RESISTANCE (kips)	-	-	-	-
TESTING METHOD	STATIC LOAD TEST IN ACCORDANCE WITH STANDARD SPECIFICATION 701.05(c) AND PDA IN ACCORDANCE WITH STANDARD SPECIFICATION 701.05(b).			

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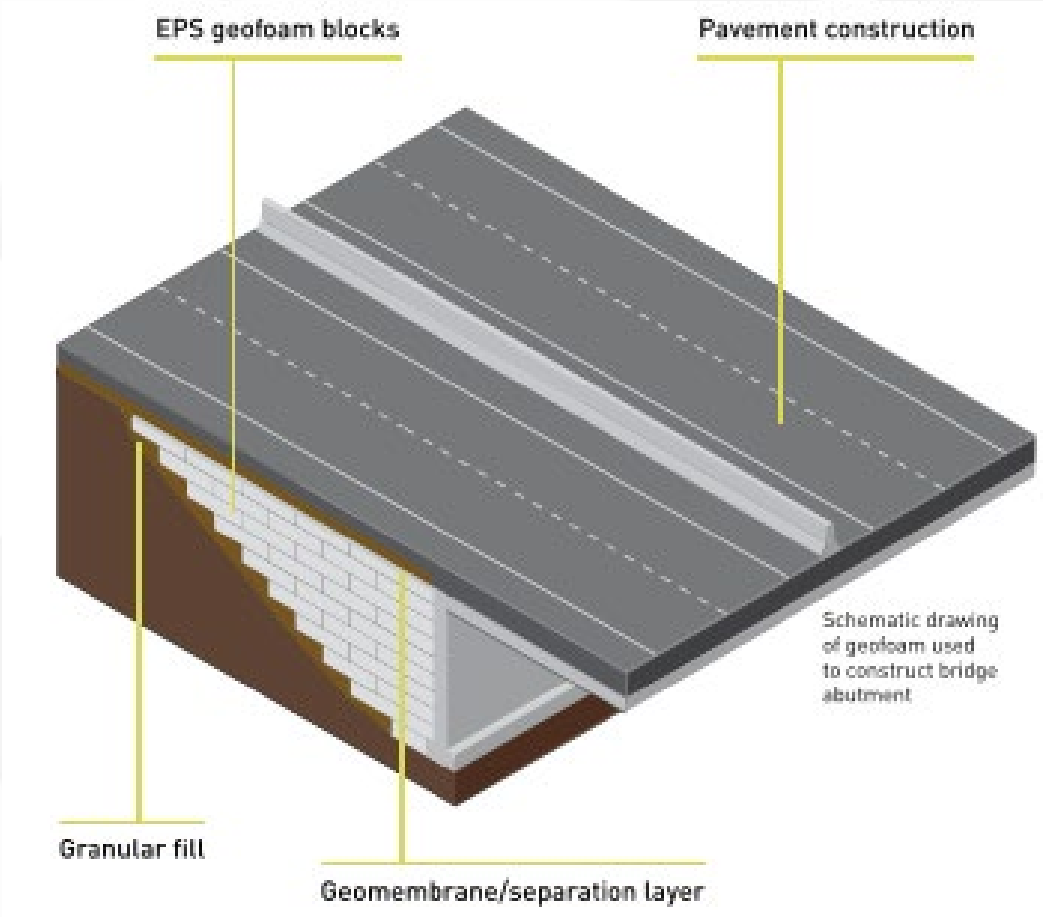
NextLevel

Approach to Embankment and Bridge Construction (cont'd)

Use geofoam at the bridge abutments and wick drains for general roadway embankments/walls

a. Due to risk of settlement

b. Deeper cohesive soils may create significant downdrag on piles at bridge that cannot be reliably accommodated by the piles



Schematic drawing of geofoam used to construct bridge abutment

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NextLevel

Approach to Embankment and Bridge Construction (cont'd)

a. Install geofoam (EPS) within 50 feet of piles and transition to full embankment height
b. Net zero load applied to the underlying soil from the approach embankment and pavement.
    a. Piles can be driven first
    b. No downdrag load on piles

ASTM D6817 Physical Property Requirements of EPS Geofoam

Type	EPS12	EPS15	EPS19	EPS22	EPS29	EPS39	EPS46
Density, min., kg/m³(lb/ft³)	11.2 (0.70)	14.4 (0.90)	18.4 (1.15)	21.6 (1.35)	28.8 (1.80)	38.4 (2.40)	45.7 (2.85)
Compressive Resistance, min., kPa (psi) at 1 %	15 (2.2)	25 (3.6)	40 (5.8)	50 (7.3)	75 (10.9)	103 (15.0)	128 (18.6)
Compressive Resistance, min., kPa (psi) at 5 %	35 (5.1)	55 (8.0)	90 (13.1)	115 (16.7)	170 (24.7)	241 (35.0)	300 (43.5)
Compressive Resistance, min., kPa (psi) at 10 % ^	40 (5.8)	70 (10.2)	110 (16.0)	135 (19.6)	200 (29.0)	276 (40.0)	345 (50.0)
Flexural Strength, min., kPa (psi)	69 (10.0)	172 (25.0)	207 (30.0)	240 (35.0)	345 (50.0)	414 (60.0)	517 (75.0)
Oxygen index, min., volume %	24.0	24.0	24.0	24.0	24.0	24.0	24.0

The typical design load limit for EPS Geofoam is the compressive resistance at 1%. Please refer to section 4.2 for additional information.

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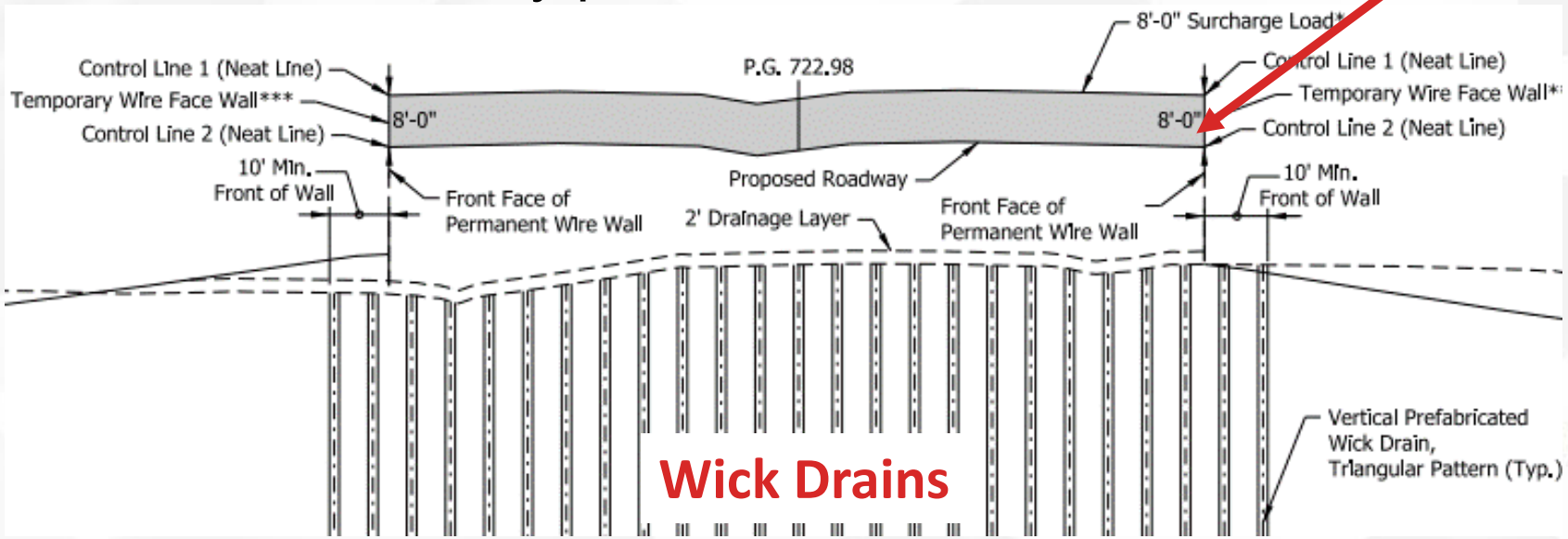
Approach to Embankment and Bridge Construction (cont'd)

a. Geofoam to be encased in soldier pile and concrete lagging walls

b. Concrete Panels to match MSE wall panels

Approach to Embankment and Bridge Construction (cont'd)

a. Wick drains installed for general MSE walls and embankments (away from bridge)
   a. 6 feet triangular pattern
   b. installed to depths of up to 80 feet, or as deep as possible
b. 8 ft surcharge load planned
c. 6 week minimum delay period for settlement



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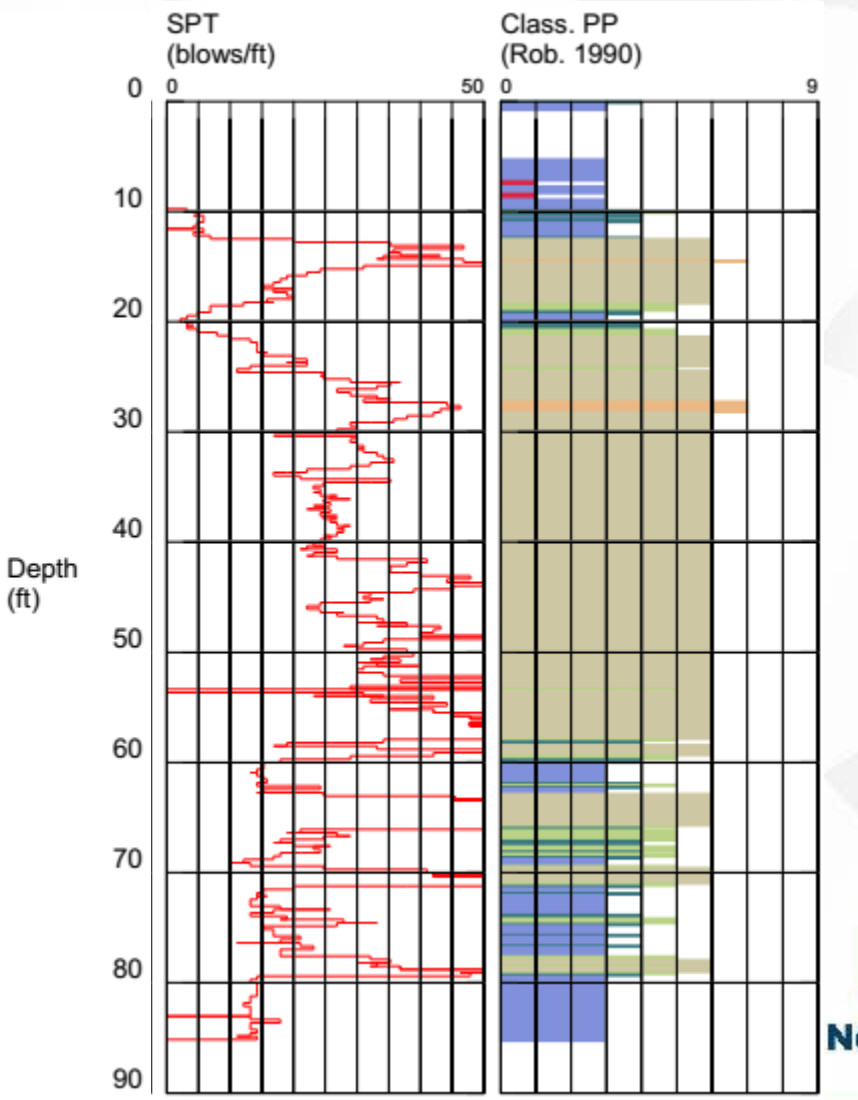
Construction Challenges

- Difficulty installing wick drains in previous SR 37 embankment
- Additional SPT borings and CPT probes performed in wick drain zone between Station 534+00 to Station 539+00

Construction Challenges

- Encountered an upper stratum of stiff and/or dense embankment soil overlying deeper soft cohesive soils
- Wick drains were incapable of penetrating through the stiff existing embankment soils in certain areas



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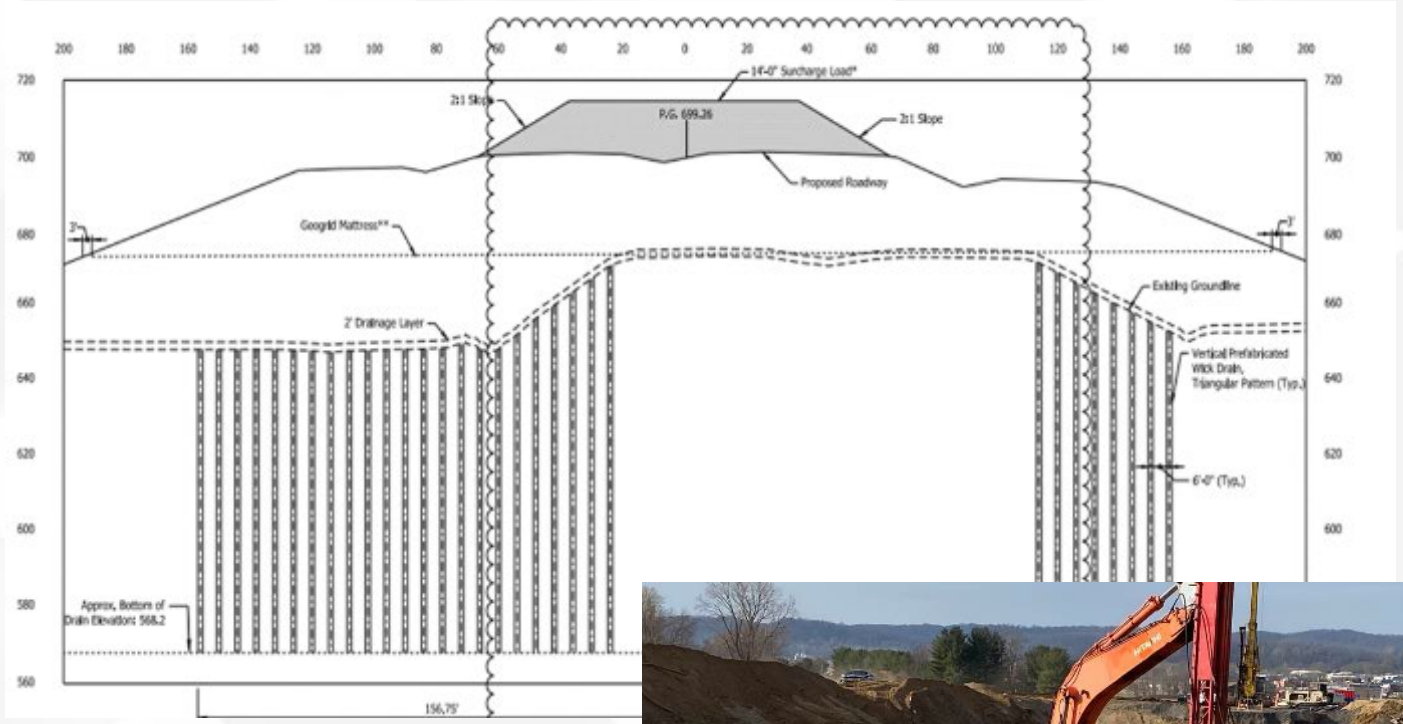
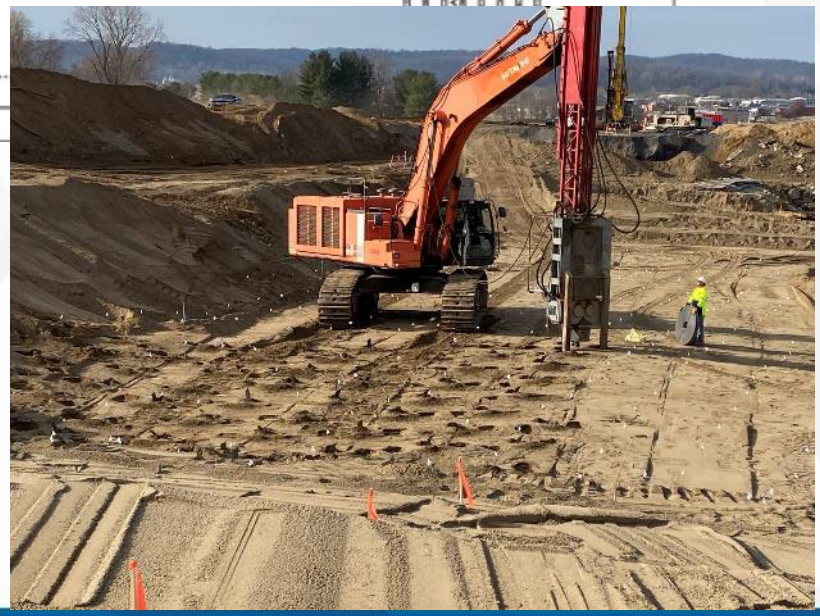
Considerations for Post-Construction Settlement

- Eliminate wick drains in the existing SR 37 Embankment
- Increase the surcharge from 8 ft to 12 ft
- Monitor settlement plates
- Maintain wick drains in all areas where possible to install





Settlement Monitoring

- Settlement plates to be installed during construction
- Estimated settlement amounts on the magnitude of approximately 8 to 12 in.

Locations of Settlement Plates

Station, Line	Offset
523+00, PR-A1	50 ft Left and 40 ft Right
526+50, PR-A1	70 ft Left and 50 ft Right
529+00, PR-A1	70 ft Left and 50 ft Right
532+00, PR-A1	80 ft Left and 50 ft Right
533+50, PR-A1	80 ft Left and 30 ft Right
535+00, PR-A1	60 ft Left and 30 ft Right
538+00, PR-A1	50 ft Left and 30 ft Right
539+00, PR-A1	40 ft Left and 40 ft Right

Locations of Settlement Plates

Station, Line	Offset
535+00, PR-A1	120 ft Left
536+00, PR-A1	130 ft Left
537+00, PR-A1	145 ft Left
538+00, PR-A1	150 ft Left

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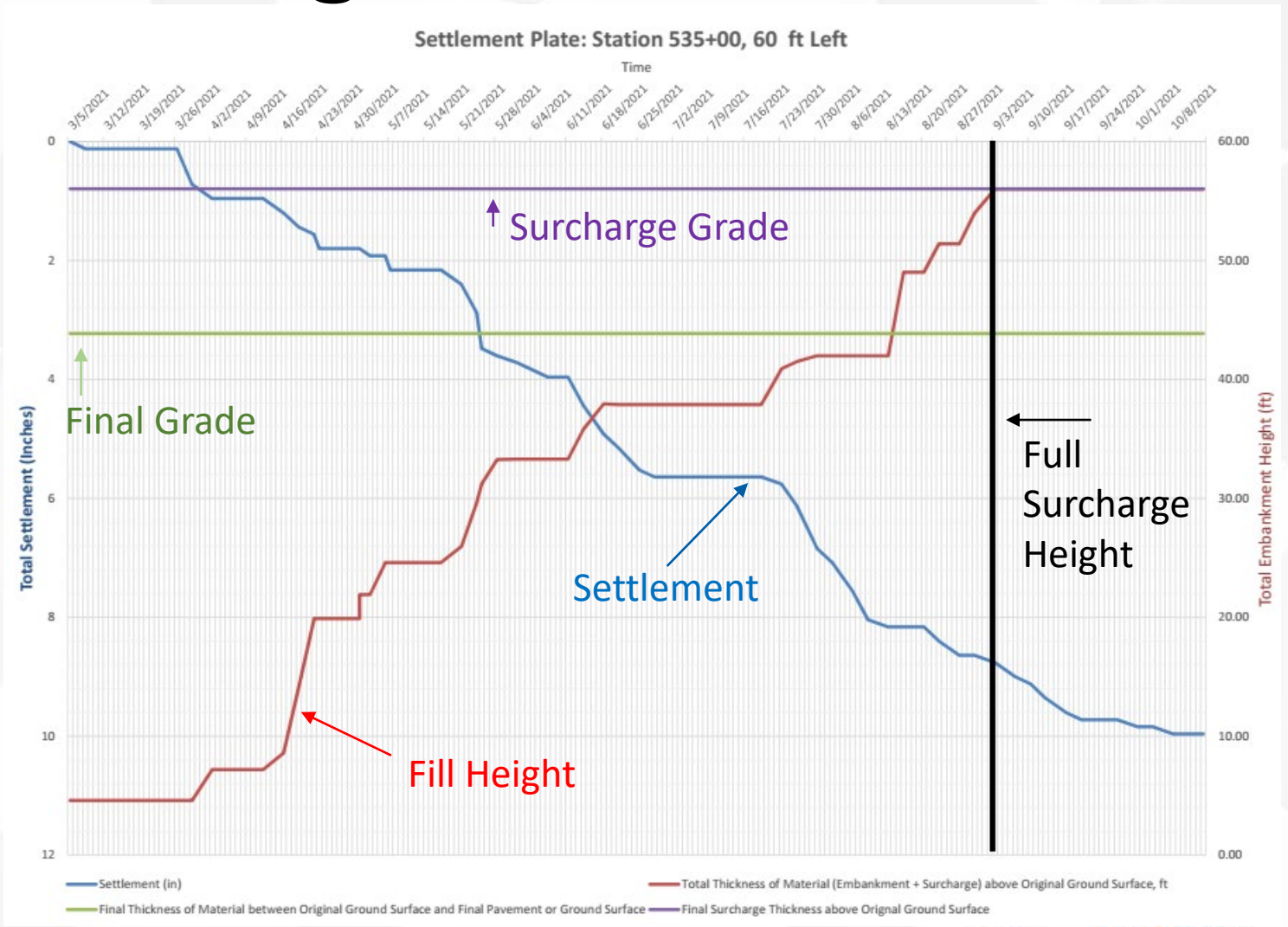
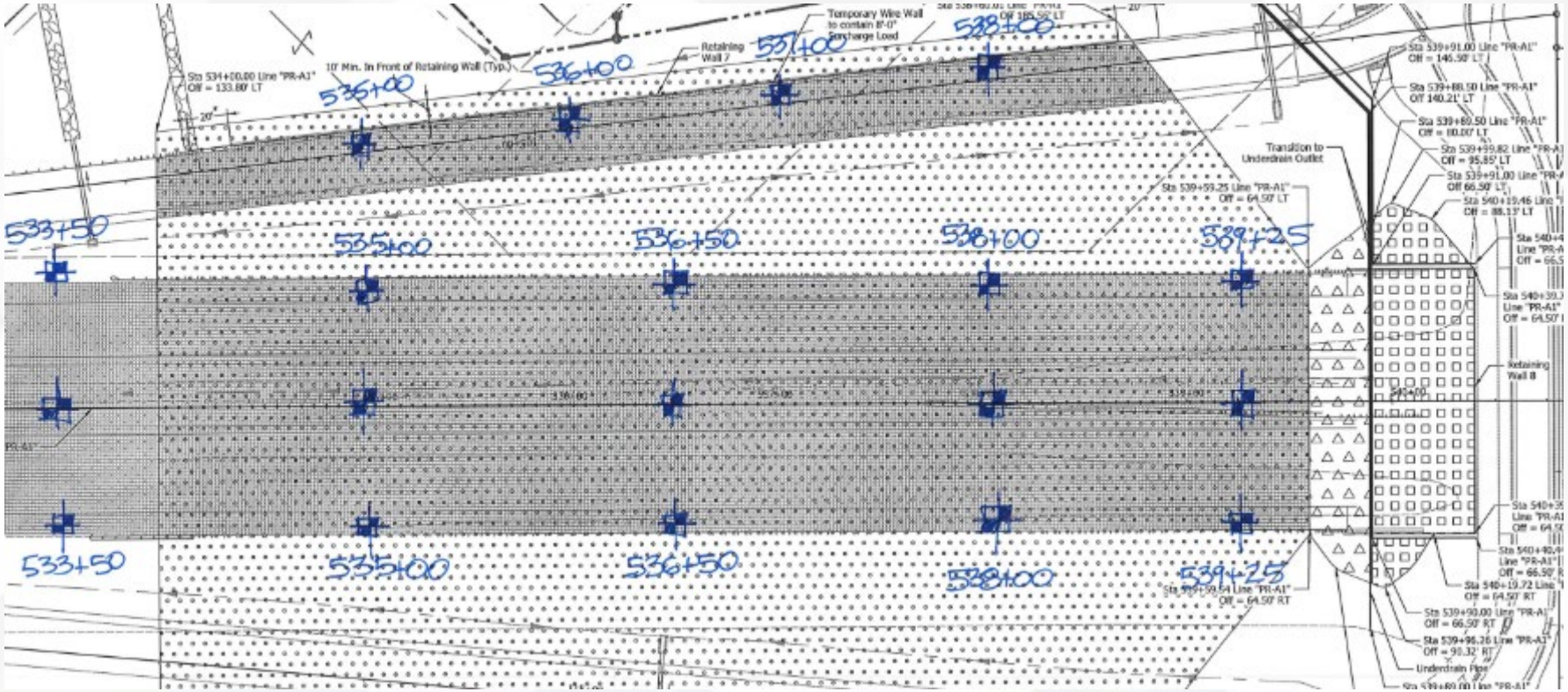
Settlement Monitoring

- Settlement Monitoring From ~March to Oct. 2021
- Total observed settlements ranged from approximately 2 to 11 inches
  - Post-surcharge delay period of approximately 5 to 6 weeks



Post Pavement Settlement Monitoring

- Roadway paved late 2021 to maintain construction schedule
- Additional settlement stakes installed and monitored post paving – prior to final surface



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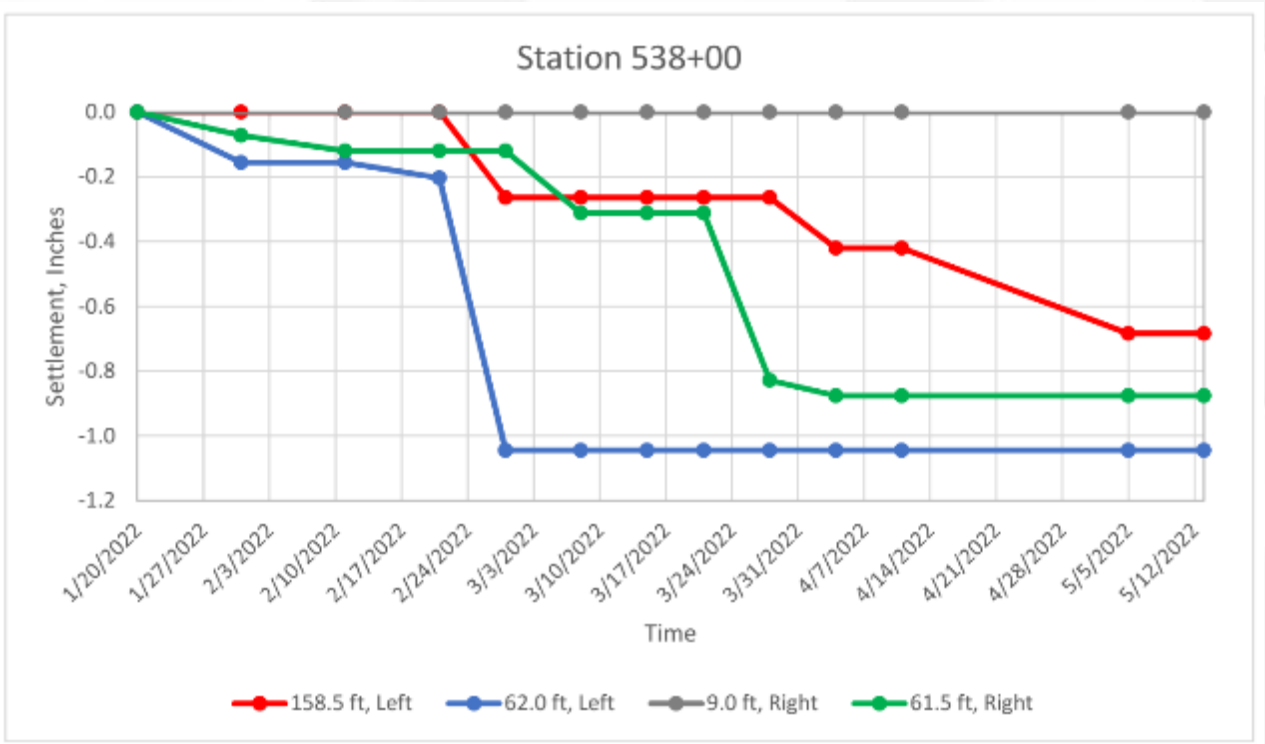
Post Pavement Settlement Monitoring

- Settlement stakes monitored from January to May 2022
- Post paving settlement of
  - ~ ½ inch to 2 inches
- Final surface paved in June 2022
  - Paved to design profile grade to account for additional settlement

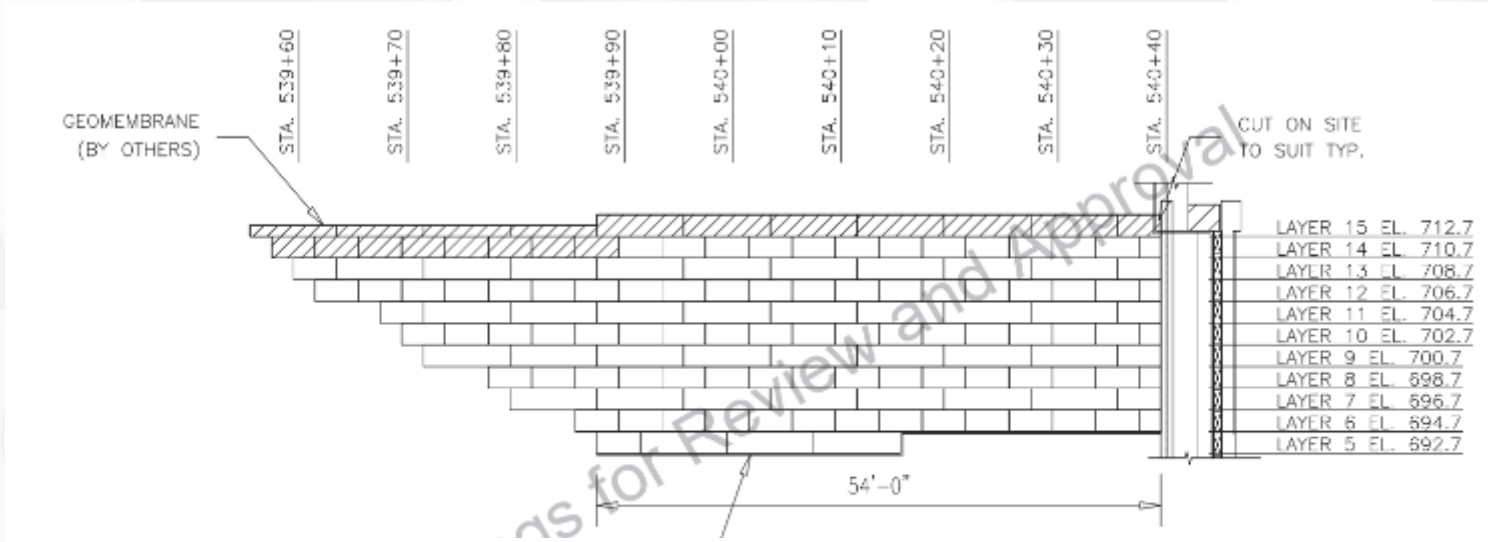


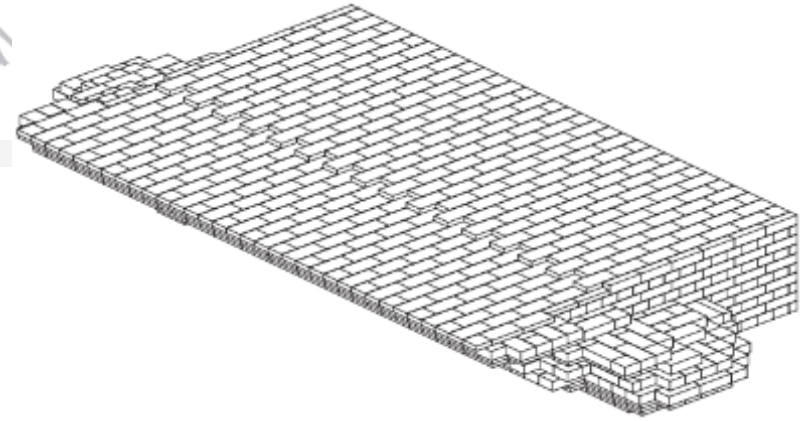
I-69 FINISH LINE

NextLevel

EPS Fill

- Retaining Wall 8:
  - ~210,000 ft³ EPS 22 and EPS 29





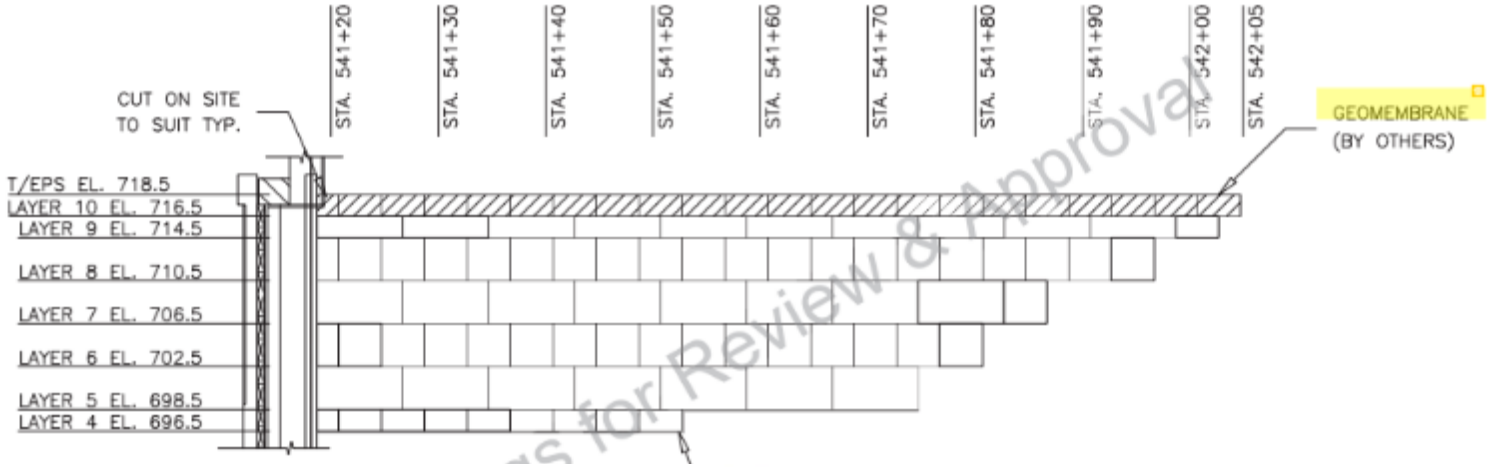
BLOCK QUANTITY SUMMARY						
BLOCK TYPE		L x W x D	QUANTITY	VOLUME (yd³)	VOLUME (ft³)	
A1	EPS22	96x48x24	2,660	6,305	170,240	
A2	EPS22	48x48x24	303	359	9,696	
A3	EPS22	96x24x24	122	145	3,904	
A4	EPS22	48x24x24	23	14	368	
C1	EPS29	96x48x24	321	761	20,544	
C2	EPS29	48x48x24	21	25	672	
C3	EPS29	96x24x24	12	14	384	
C5	EPS29	96x48x12	128	152	4,096	
C6	EPS29	48x48x12	17	10	272	
C7	EPS29	96x24x12	4	2	64	
		EPS22	3,108	6,823	184,208	APPROXIMATE No. OF CONNECTOR PLATES
		EPS29	503	964	26,032	
		TOTAL	3,611	7,787	210,240	6,178

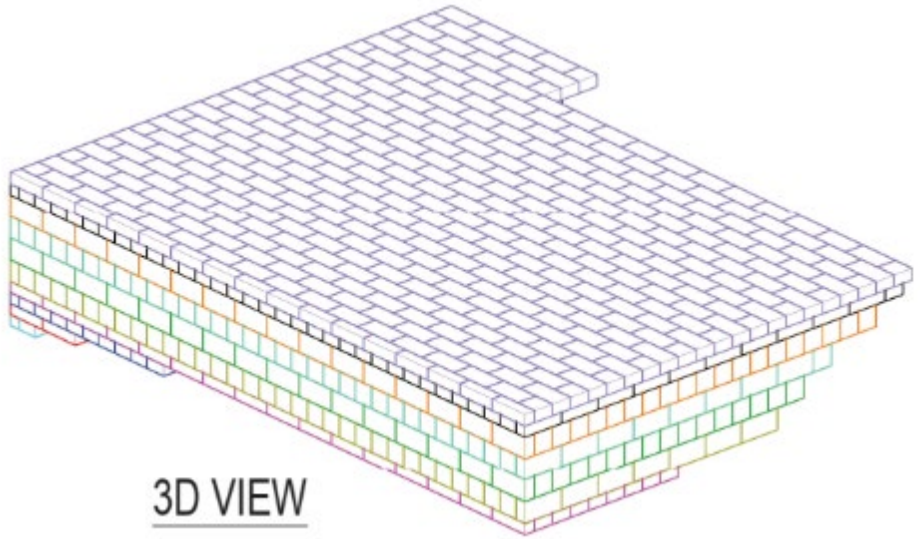
I-69 FINISH LINE

NextLevel

EPS Fill

- Retaining Wall 9:
  - ~201,000 ft^3 EPS 22 and EPS 29





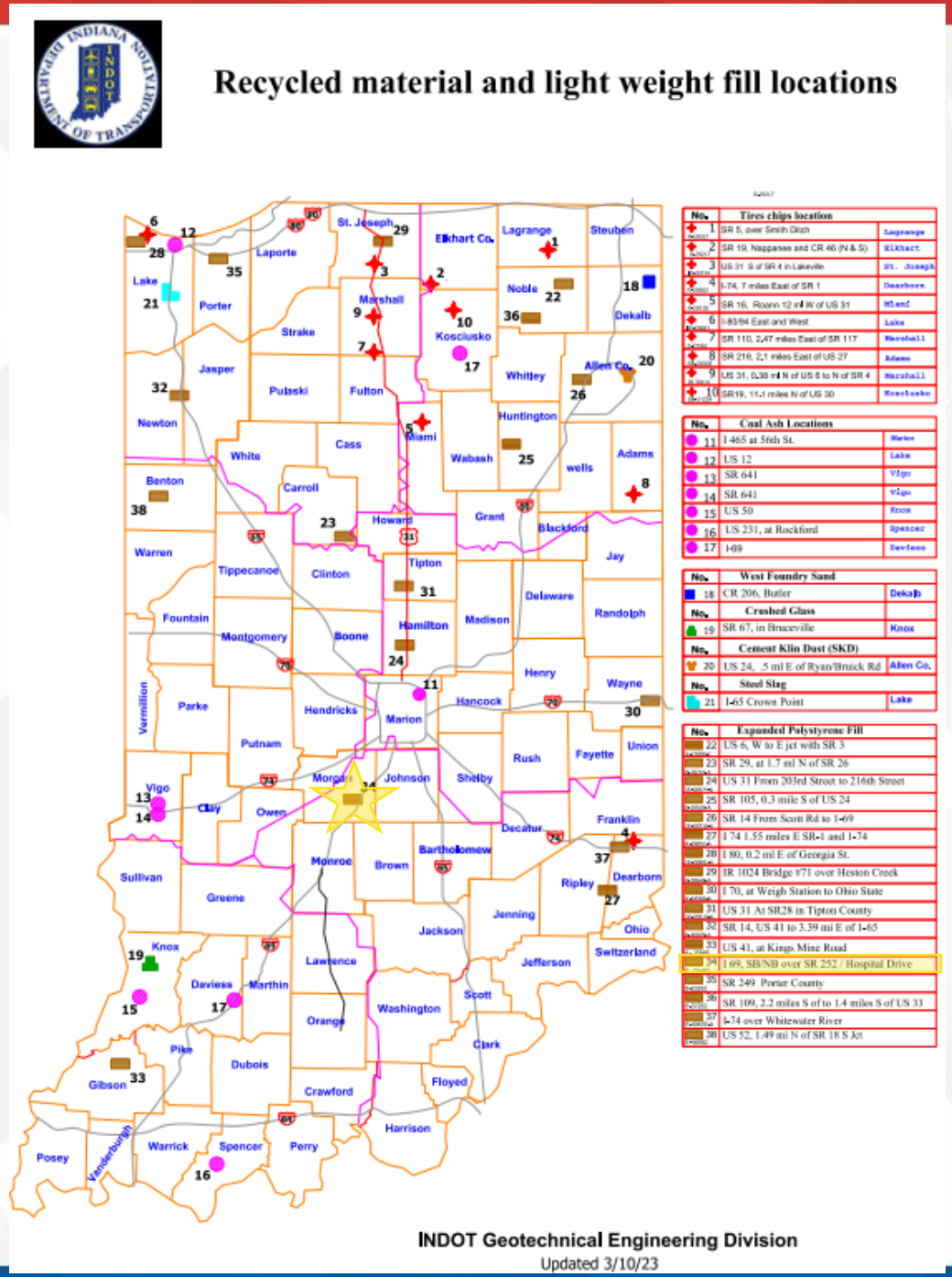
BLOCK QUANTITY SUMMARY						
BLOCK TYPE		L x W x D	QUANTITY	VOLUME (yd³)	VOLUME (ft³)	
A1	EPS22	96x48x24	544	1,289	34,816	
A2	EPS22	48x48x24	67	84	2,272	
A3	EPS22	96x24x24	49	58	1,568	
A4	EPS22	48x24x24	3	2	48	
A5	EPS22	96x48x48	1,007	4,774	128,896	
A6	EPS22	48x48x48	98	232	6,272	
A7	EPS22	96x24x48	64	152	4,096	
A8	EPS22	48x24x48	1	1	32	
C1	EPS29	96x48x24	337	799	21,568	
C2	EPS29	48x48x24	25	30	800	
C3	EPS29	96x24x24	16	19	512	
		EPS22	1,837	6,593	178,000	APPROXIMATE No. OF CONNECTOR PLATES
		EPS29	378	847	22,880	
		TOTAL	2,215	7,440	200,880	3,388

I-69 FINISH LINE

NextLevel

EPS Fill

- Becoming more common on large scale projects
  - Recently used on I-74 over White River in Dearborn Co.
- As execution becomes more common it is expected that cost may reduce – or less of an obstacle in selecting EPS as a viable option



Lessons Learned?

- Weather can affect these EPS units
  - Windy conditions make it difficult to work EPS blocks
  - Extreme rain events can float the blocks if not properly backfilled
- Extreme care is needed to not damage the EPS blocks or the geomembrane that protects the EPS product
- Specialty tools are needs to properly cut the blocks

I-69 FINISH LINE

NextLevel

I-69 Finish Line Video

Construction Photos

I-69 FINISH LINE

NextLevel

I-69 FINISH LINE

INDIANA DEPARTMENT OF TRANSPORTATION

NextLevel

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Questions?