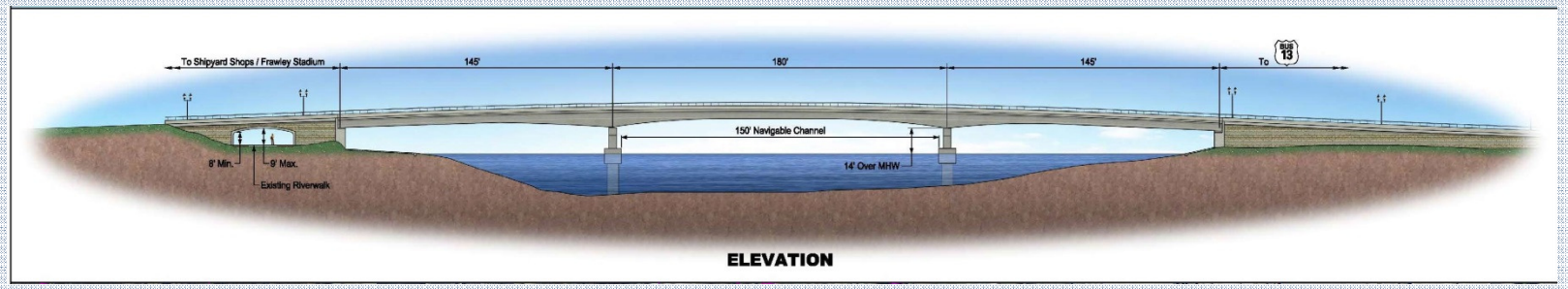
CHRISTINA RIVER BRIDGE & APPROACHES

Wilmington, Delaware



ELEVATION

2018 Mid-Atlantic Quality Assurance Workshop February 2018

Eric M. Klein, P.E., D.GE., F.ASCE
Bibek B. Shrestha, P.E.

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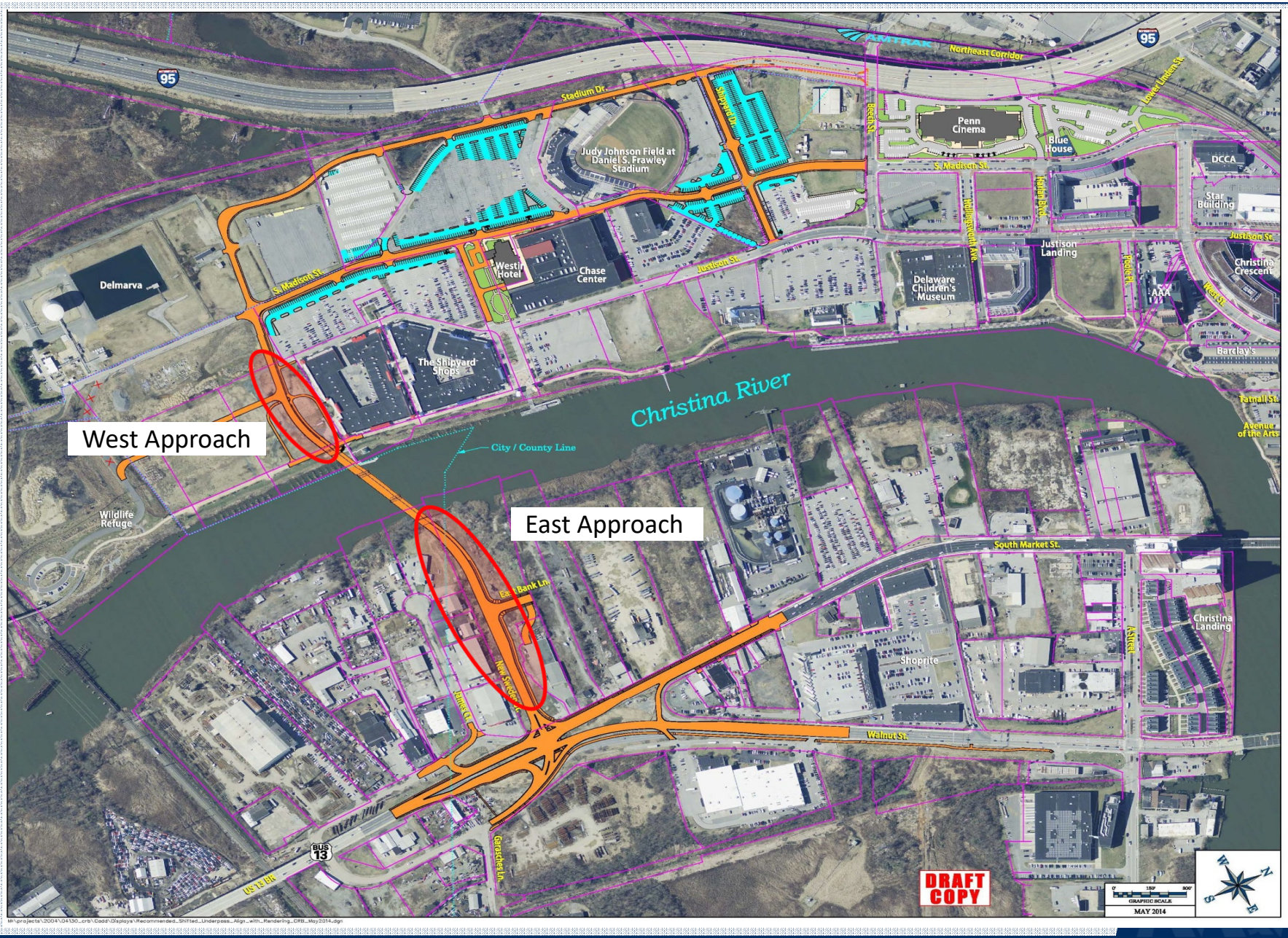
- City of Wilmington Population: 71,525
- Currently 4 bridge connections over the Christina River in Wilmington



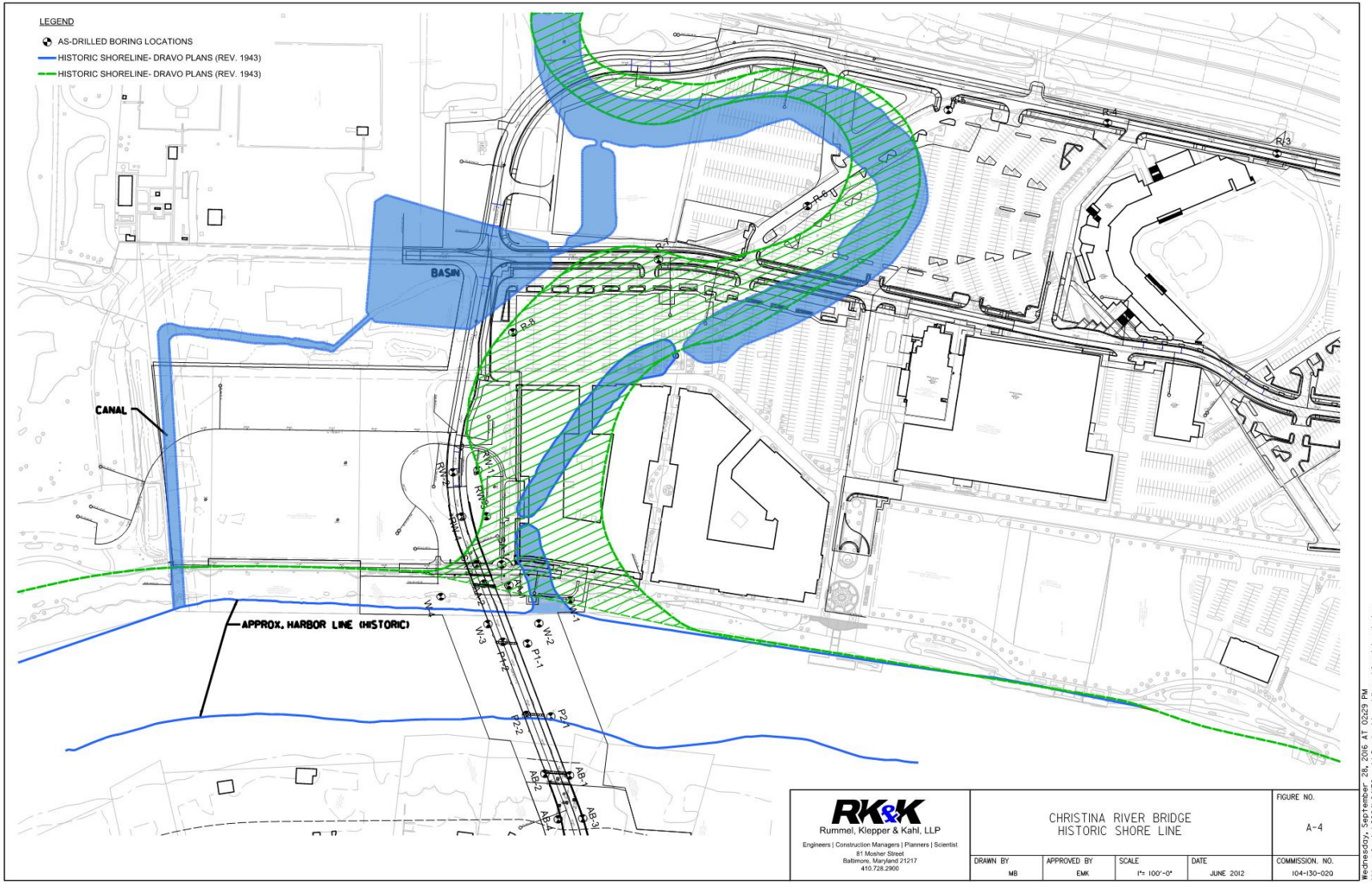
PROJECT SITE

Site History

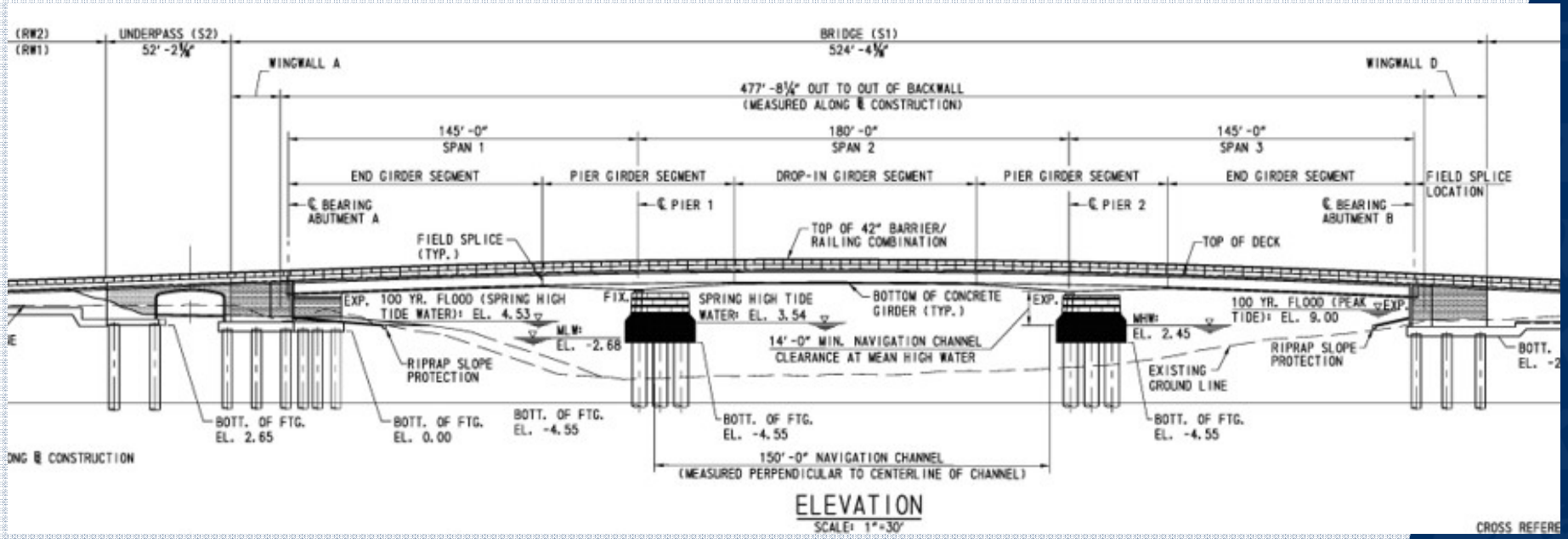
- Leather Tannery – Leather Tanning industry was established in early 1800s. By 1910, leather was Delaware's most valuable produced product. There were 12 tanneries along the Christina River. A beef slaughterhouse occupied the eastside of the project site during the 1930s to 1960s
- Ship Building – The Christina River was used extensively for ship building during the World Wars. During WWII, the area accounted for 5 Landing Ship Tanks, 15 Destroyer Escorts, and 18 C1-A Passenger Cargo Vessels. Dravo shipyard was located on the Westside of the project site.
- Wilmington Coal and Gas – also occupied the Westside of the project site.

Contamination

- Shallow soil contains lead, arsenic, polychlorinated biphenyls (PCBs) and polynuclear aromatic hydrocarbons (PAHs) above the DNREC screening level criteria.
- The subsurface contains arsenic, lead, PCBs, benzene, toluene, ethylbenzene, xylenes (BTEX), cyanide, petroleum hydrocarbons, and PAHs above the DNREC screening criteria.
- Groundwater contains arsenic, lead, vanadium and methyl tertiary butyl ether (MTBE).



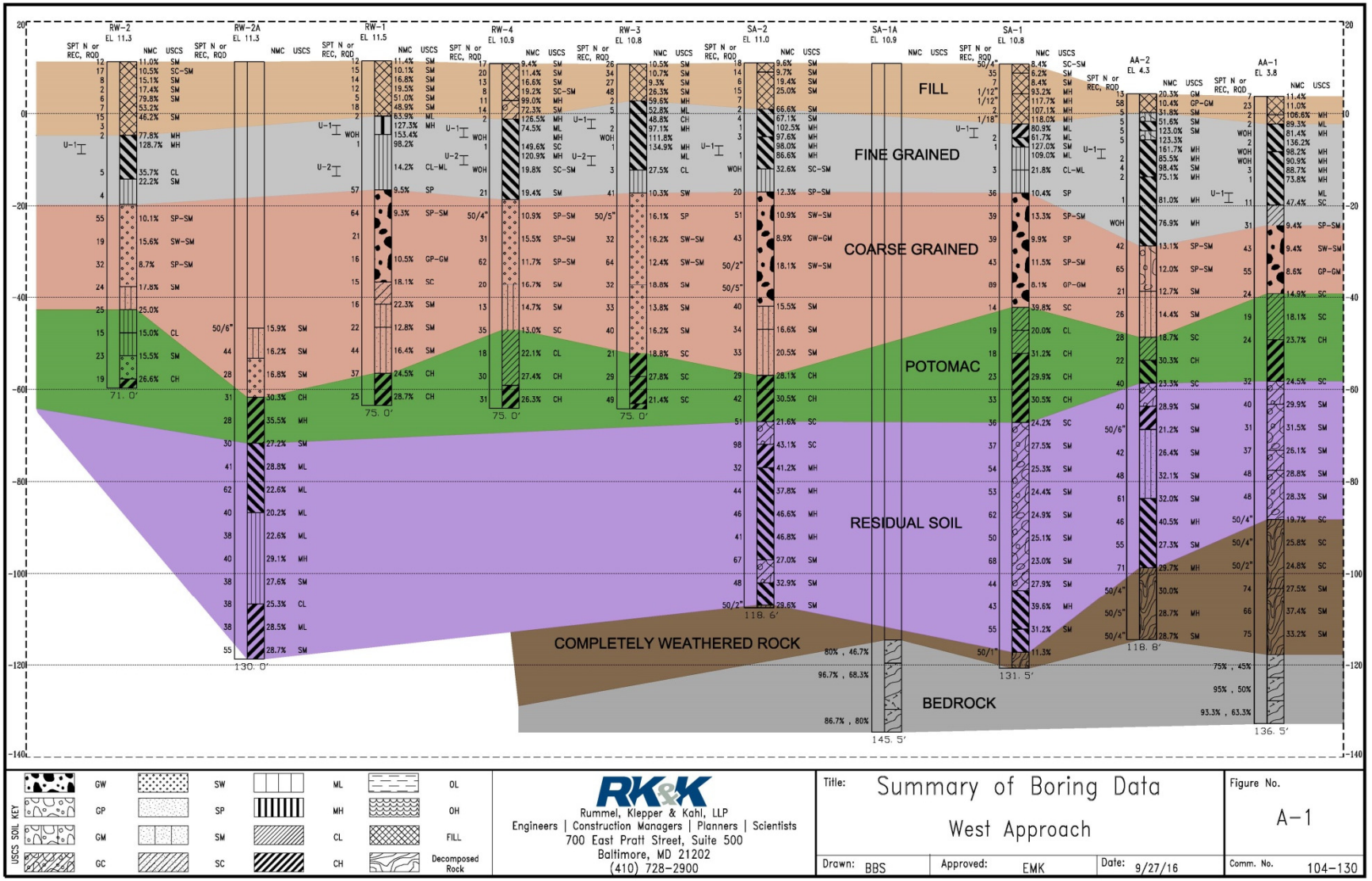
HISTORIC SHORE LINE



- 470-ft long bridge
- 180-ft mid-span
- Two 145-ft approach spans
- 52-ft wide underpass

- 100-year Flood Elevation
  - Spring High Tide EL +4.53
  - Peak Tide EL +9.00
- Navigation Channel
  - 150-ft Wide
  - 14-ft Min. clearance at MHW

BRIDGE PLAN – 100-YR. FLOOD



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Engineers | Construction Managers | Planners | Scientists
700 East Pratt Street, Suite 500
Baltimore, MD 21202
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Title: Summary of Boring Data
West Approach

Figure No. A-1

Drawn: BBS | Approved: EMK | Date: 9/27/16 | Comm. No. 104-130

RKK FENCE - USCS (DEFAULT) CRISTINA RIVER BRIDGE.GPJ RKK_CURRENT.GDT 9/27/16

WEST APPROACH SOIL PROFILE

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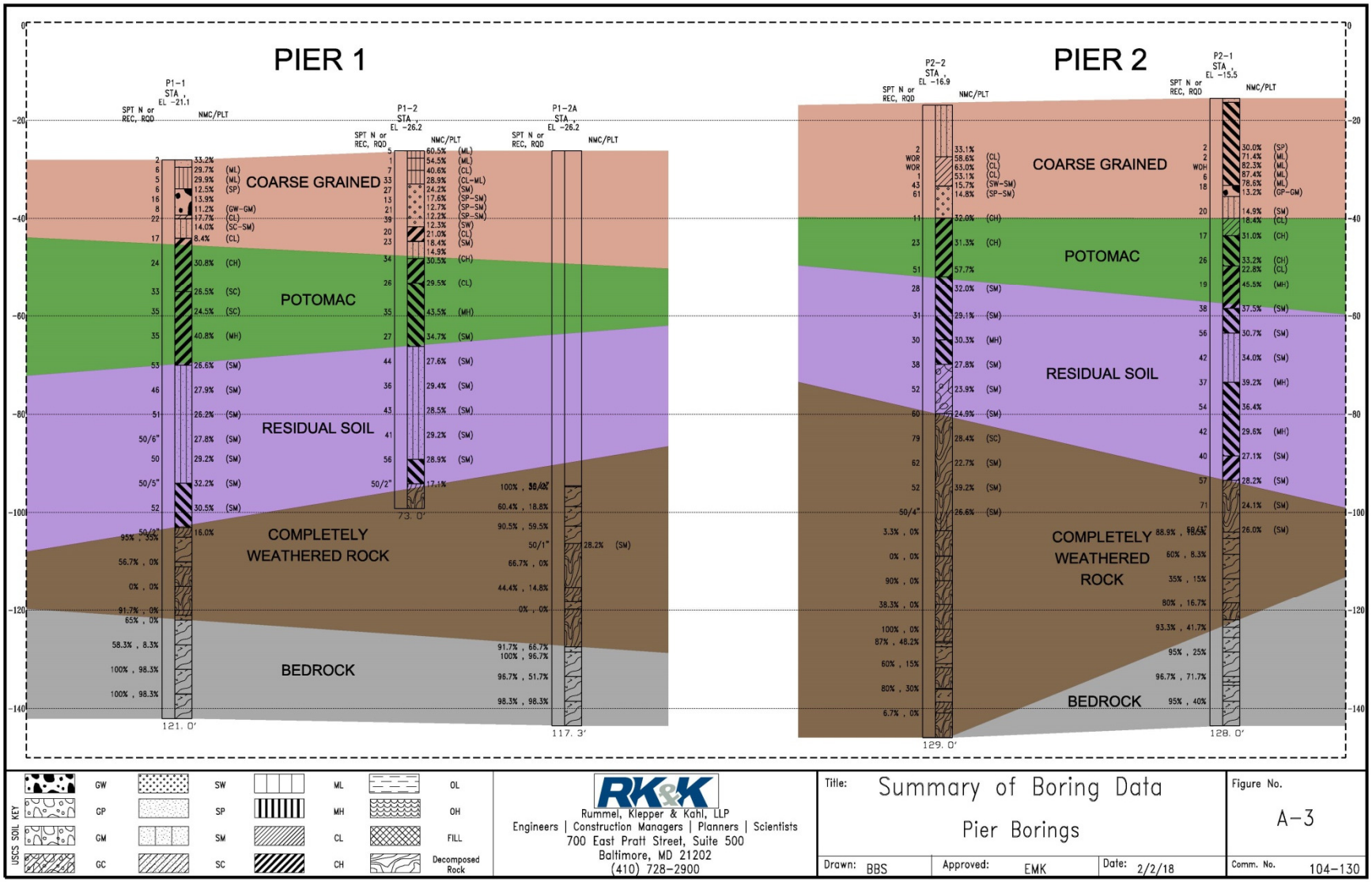
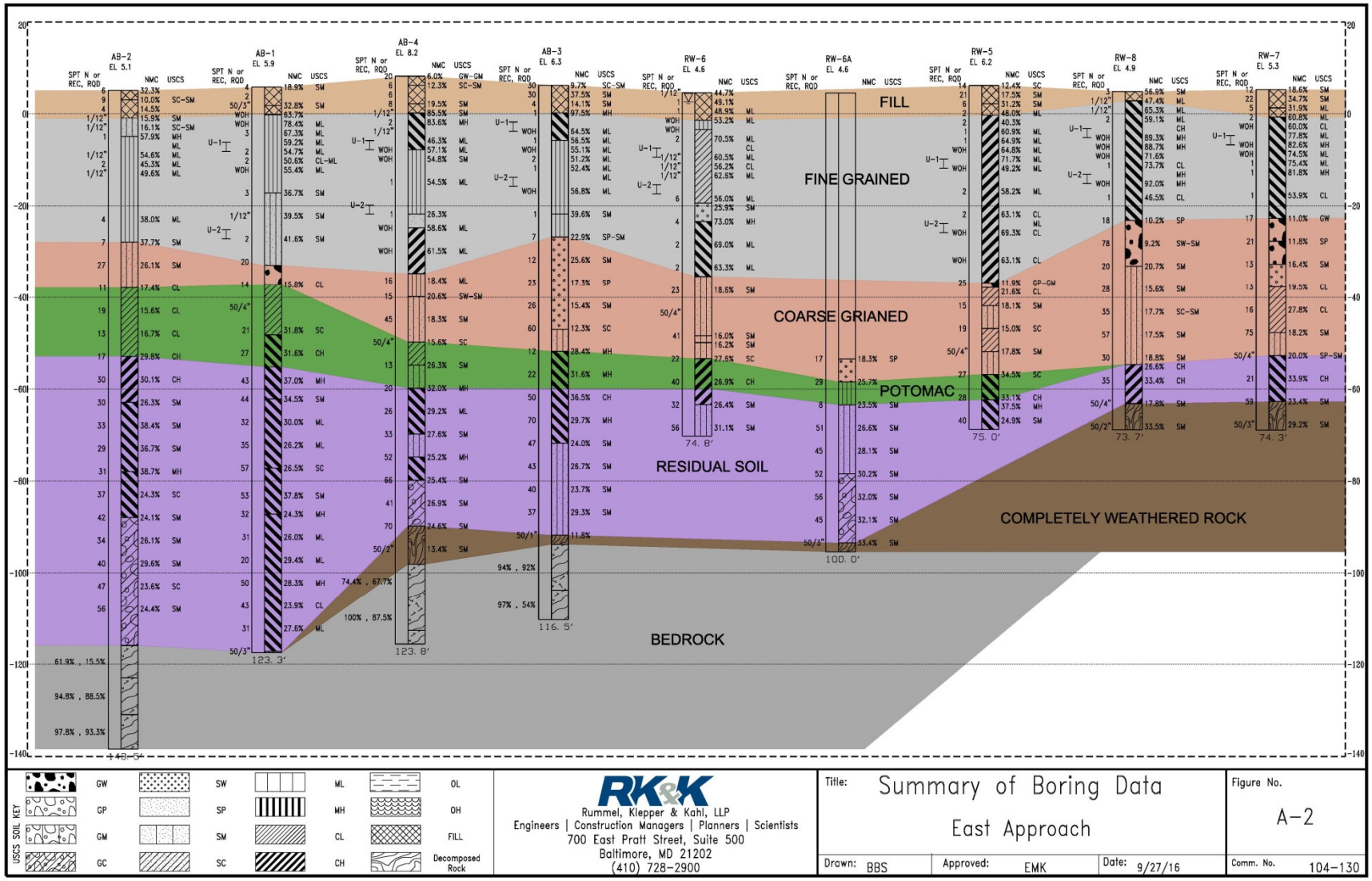


PIER 1 and PIER 2 SOIL PROFILE



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Title: Summary of Boring Data
East Approach

Figure No. A-2

Drawn: BBS | Approved: EMK | Date: 9/27/16

Comm. No. 104-130

RKK FENCE - USCS (DEFAULT) CRISTINA RIVER BRIDGE.GPJ RKK_CURRENT.GDT 9/27/16

EAST APPROACH SOIL PROFILE

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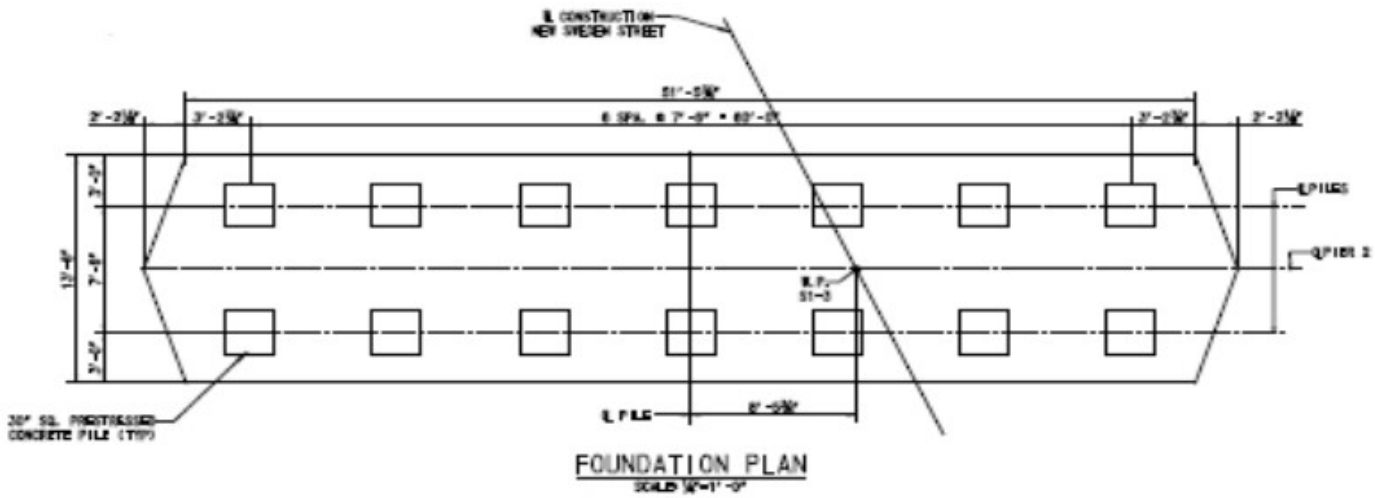
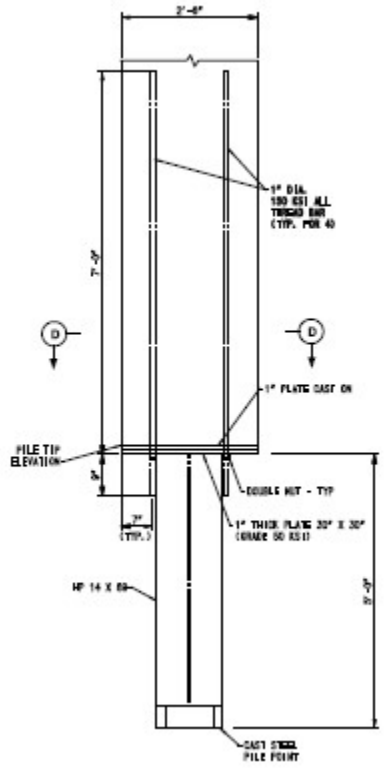
Bridge Foundation Alternative Analysis

- Drilled Shaft
  - 4-ft Diameter for Abutments
  - 6-ft Diameter for Piers with Rock Socket

- Driven Precast Concrete Piles
  - 24-inch Square Piles for East Abutment
  - 30-inch Square Piles for Piers and West Abutment
  - High Strain Dynamic Testing with Signal Matching
    - Two sacrificial test piles in the water
    - One Test pile at each Substructure

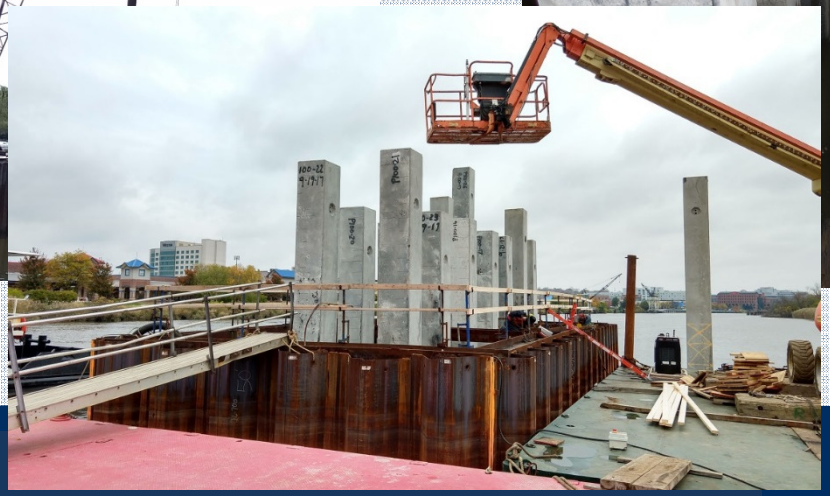
Driven Precast Concrete Pile Foundation





Pier Foundation Plan

Driven Precast Concrete Pile Foundation



Bridge Approach Alternative Analysis

- Conventional Abutment with Extended CIP Wingwalls on Deep Foundation
- U-Shaped CIP Concrete Wall supported on Deep Foundation
- Bridge Back Spans
- Preloading Embankment and MSE Wall Approach
- Total Load Balance with Expanded Polystyrene (EPS)
- Deep Mixing Method (DMM) with MSE Walls
- Stone Columns/Densified Aggregate Piers

Preloading Embankment – Staged Construction

Staged Construction for Shear Strength Gain

- 5-Stage Construction for 17-ft high embankment
- PVD's with Quarantine Period - 90% Consolidation
- 90-days between Stages for Strength Gain

General Equation: $S_u = 0.25\ (OCR)^{0.8}\sigma_v'$

Upper Range: $S_u = 0.4\ \sigma_v'$

Calibrated Equation: $S_u = 0.31\ (OCR)^{0.8}\sigma_v'$

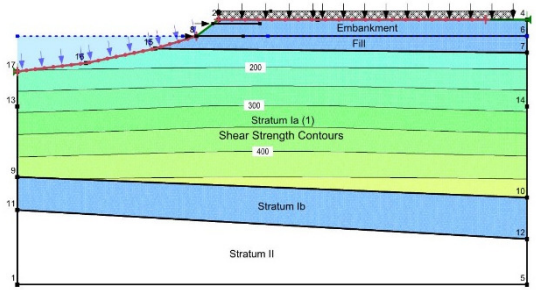
Power Curve: $S_u = 0.4099(\sigma_v')^{1.3207}$

WSDOT Method based on Ladd (1991)

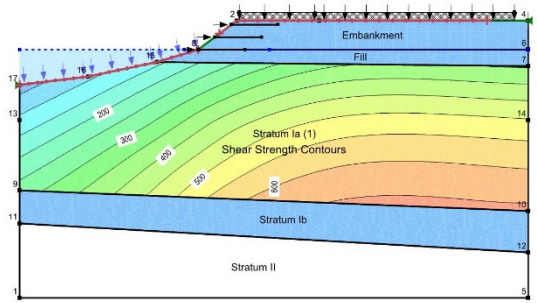
Shear Strength Gain: $\Delta\ S_u = \Delta\sigma_v \tan\varphi_{consol.}$

where : $\tan\varphi_{consol.} = \frac{\sin\varphi_{cu}}{1-\sin\varphi_{cu}}$

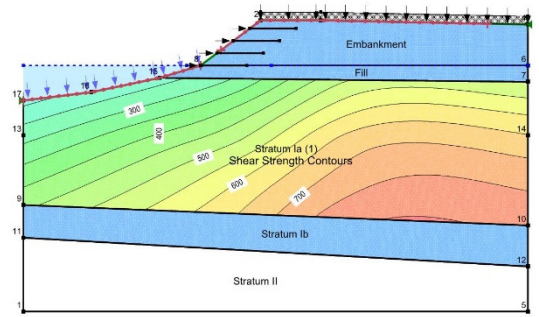
Preloading Embankment – Staged Construction



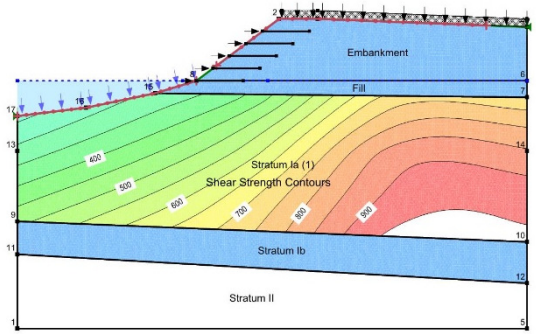
4-ft High Embankment
Stage I Preloading Embankment



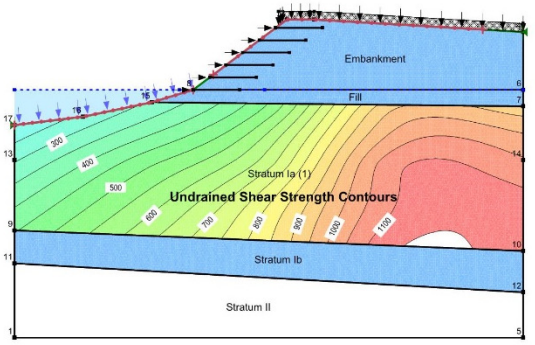
7-ft High Embankment
Stage II Preloading Embankment



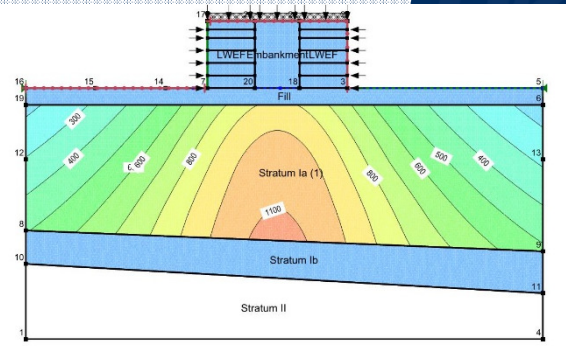
11-ft High Embankment
Stage III Preloading Embankment



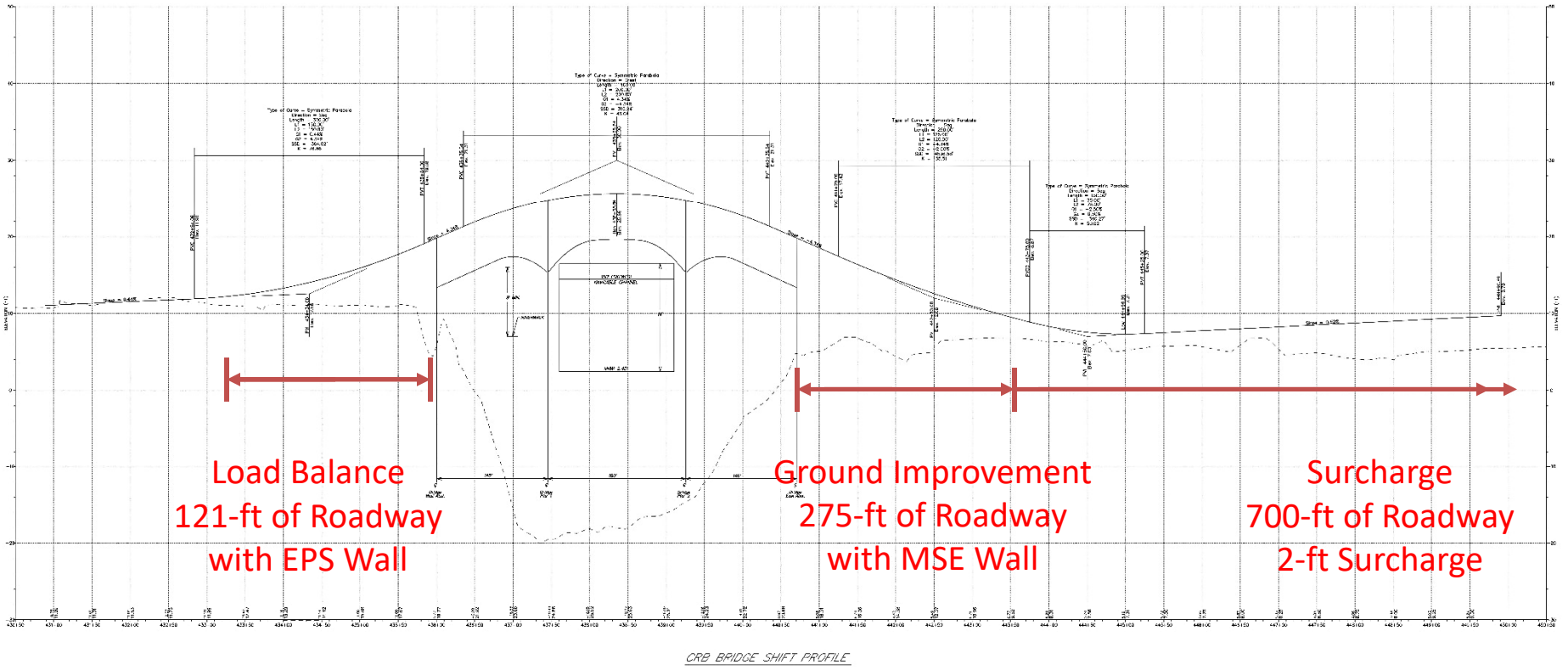
15-ft High Embankment
Stage IV Preloading Embankment



17-ft High Embankment
Stage V Preloading Embankment



Permanent MSE Wall Configuration
Stratum Ia Undrained Shear Strength Contours
STA 441+05 Back to Back MSE Walls

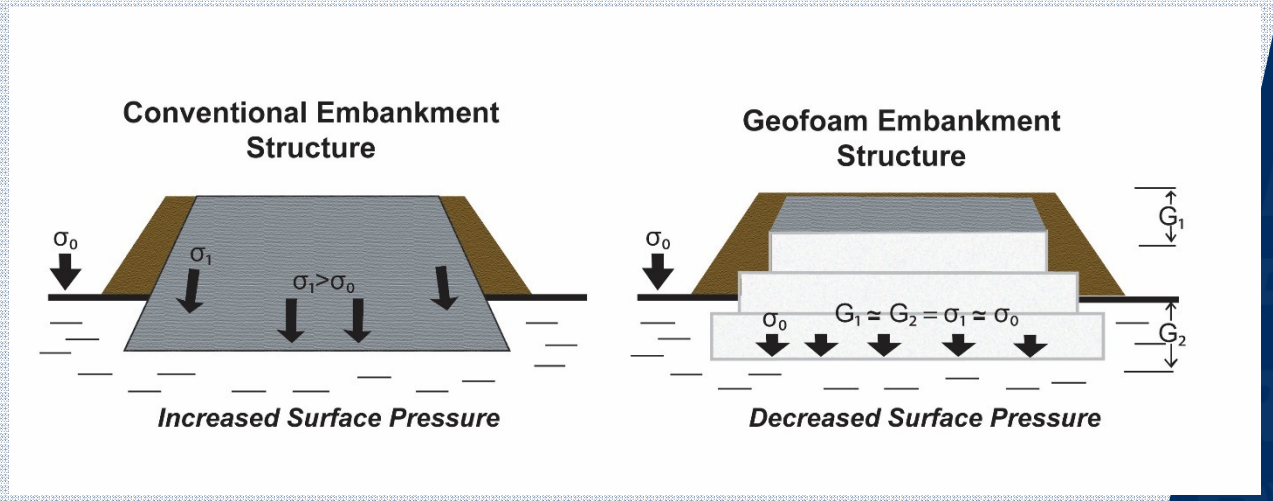


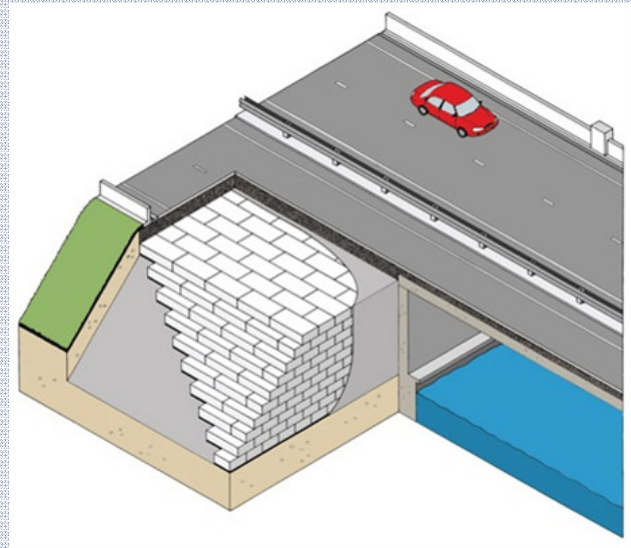
CRB BRIDGE SHIFT PROFILE

ROADWAY PROFILE

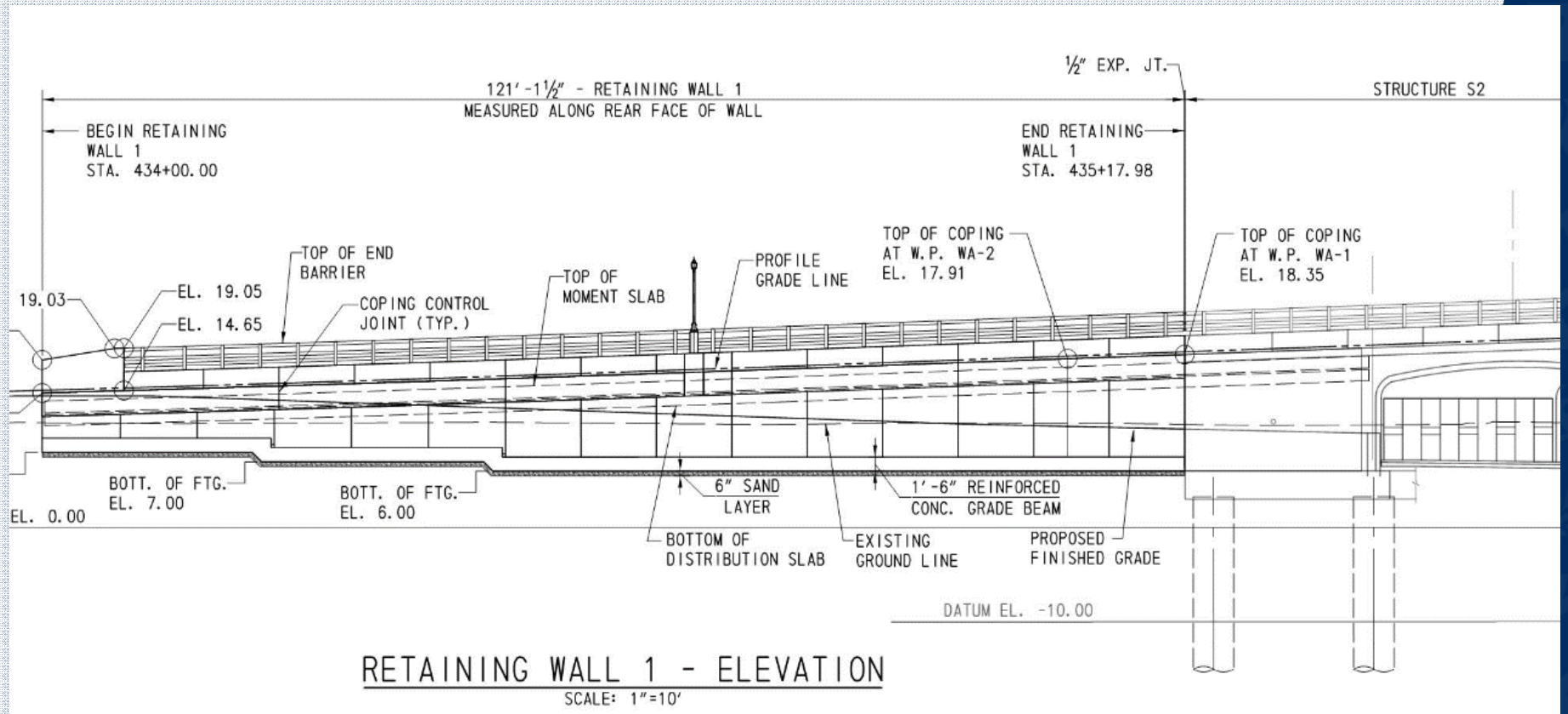
Bridge West Approach Ramp

Expanded Polystyrene (EPS) Embankment





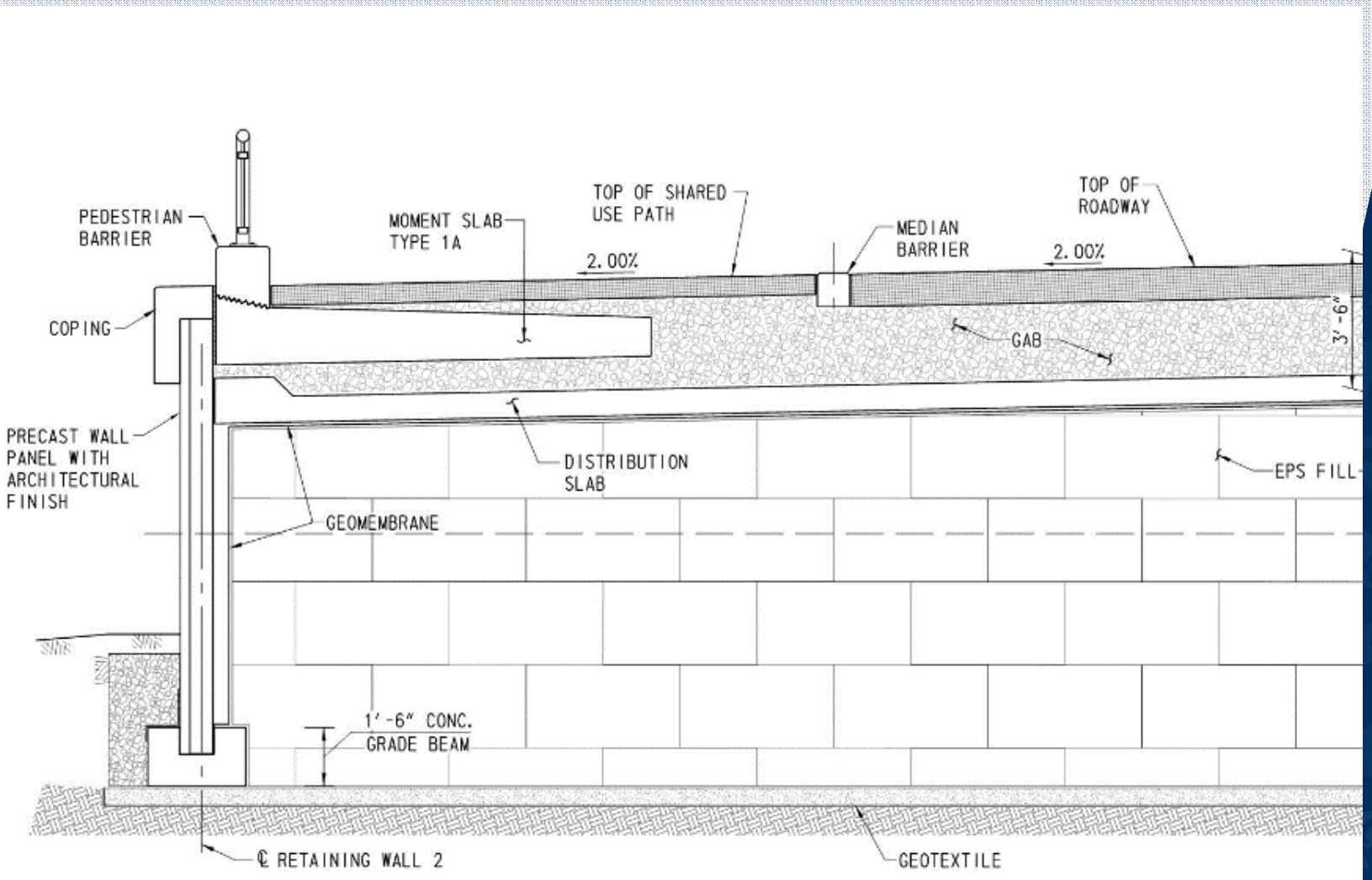
Bridge West Approach Ramp



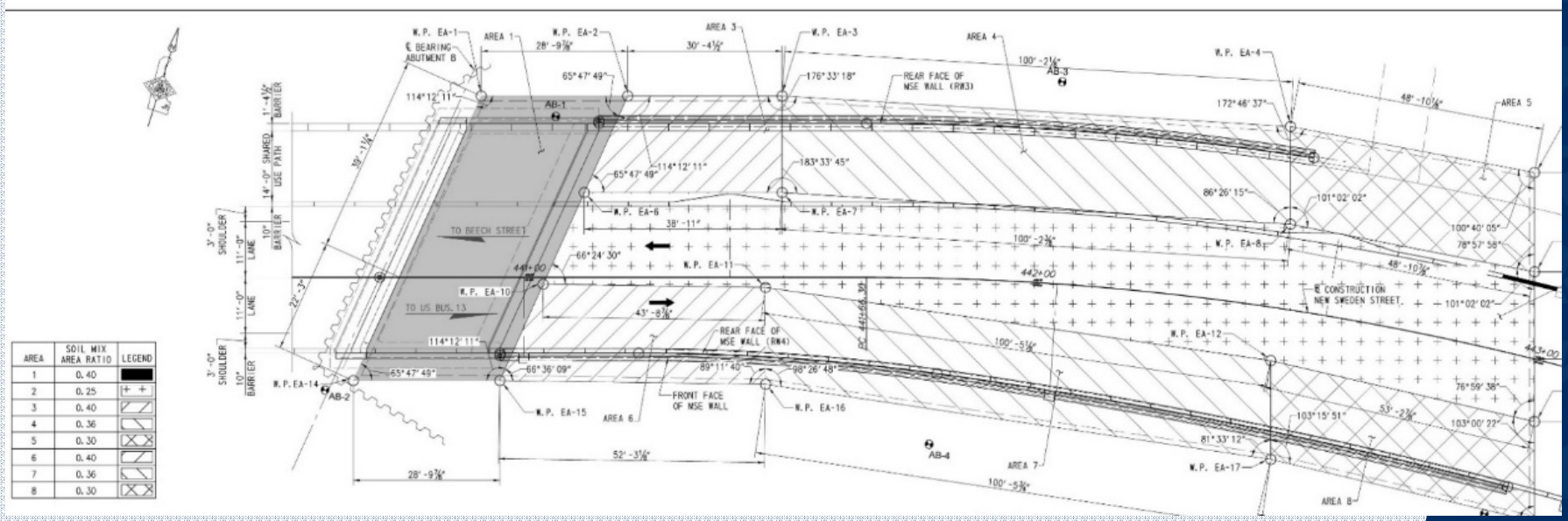
RETAINING WALL 1 - ELEVATION

SCALE: 1"=10'

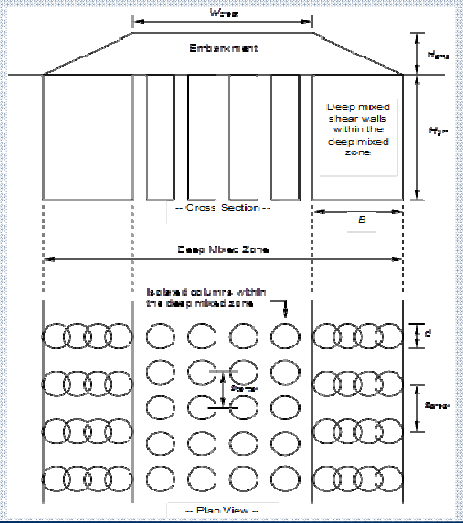
Bridge West Approach Ramp



Bridge East Approach Ramp



AREA	SOIL MIX AREA RATIO	LEGEND
1	0.40	
2	0.25	
3	0.40	
4	0.36	
5	0.30	
6	0.40	
7	0.36	
8	0.30	



Preliminary Design of DMM

- Bench Scale Testing
- Unconfined Compressive Strength: 120-psi
- Diameter of DMM: 3-ft Min and 5-ft Max
- Length of DMM: 40-ft to 50-ft
- Area Ratio: 25% to 40%

Deep Mixing Method (DMM)

Bridge East Approach Ramp

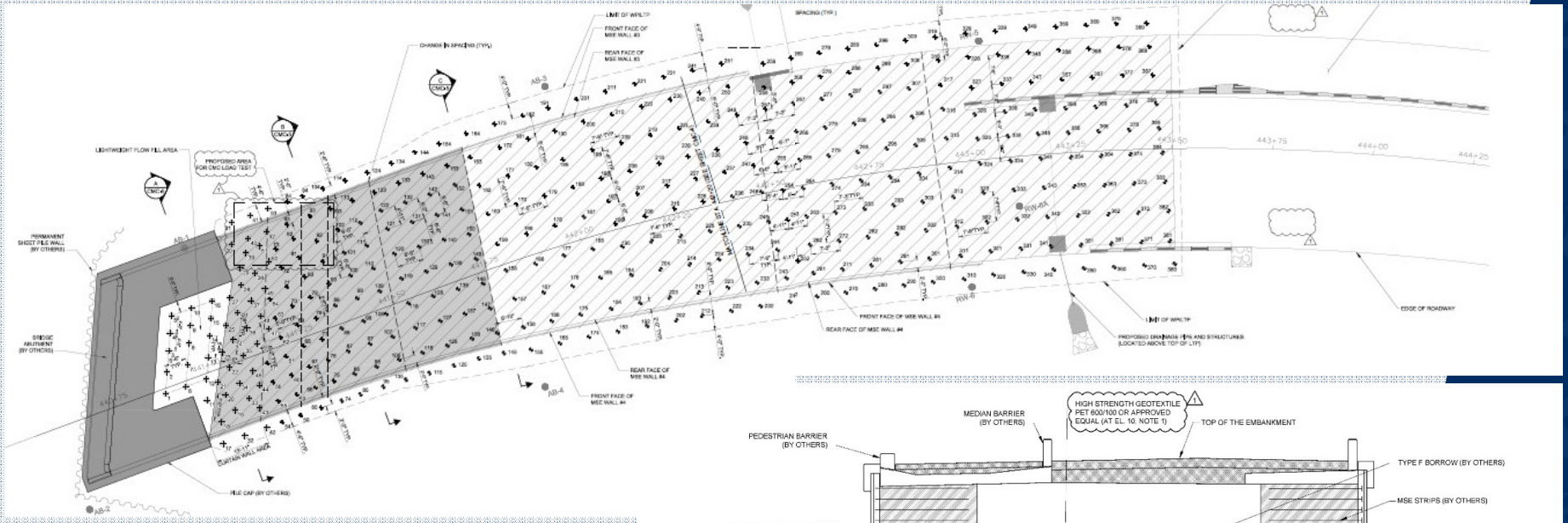
Deep Mixing Method (DMM)

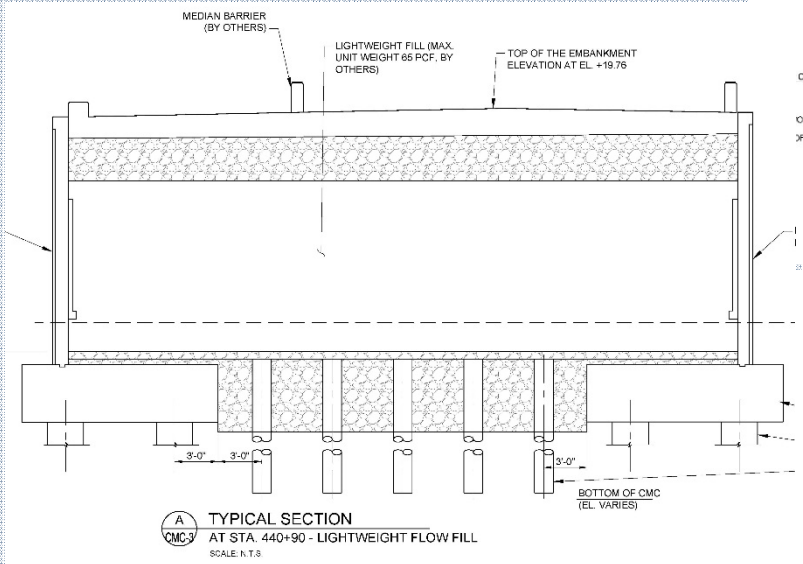
- Bench Scale Testing
- Performance Specification
- Contractor's Design
  - Bench Scale Testing (Optional)
  - Final Design
  - Preproduction DMM Test Program
  - Production DMM
  - DMM QA/QC Program

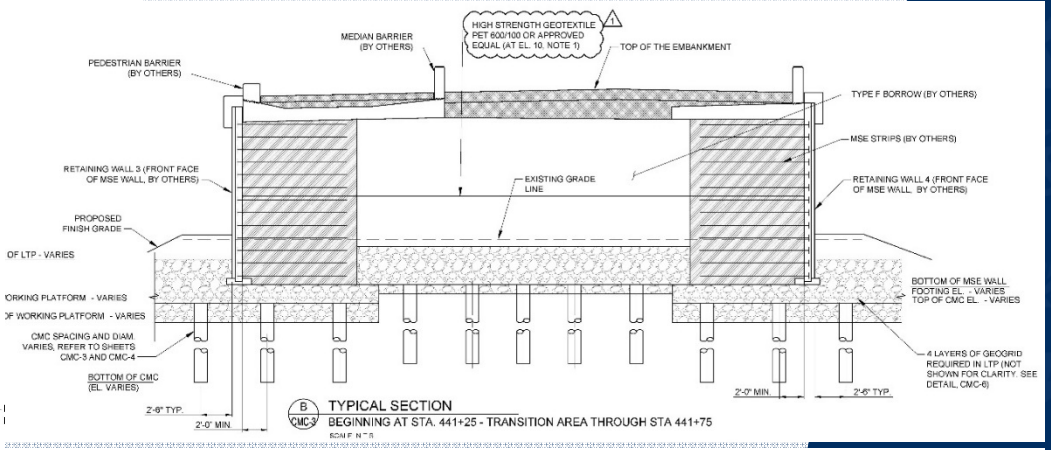
Controlled Modulus Column (CMC)

- Performance Specification
- Contractor's Design
  - Final Design
  - Static Load Test
  - Production DMM
  - CMC Installation Logs for QA/QC
- Minimum Amount of Spoils

Bridge East Approach Ramp







- Diameter of CMC: 15.6-inch and 12.5-inch
- 388 CMCs installed
- CMC Spacing: 5-ft to 7.5-ft
- CMC Length: 40-ft to 70-ft, Avg. 54-ft
- LTP Thickness: 3.5-ft and 2.5-ft

Controlled Modulus Column

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Bridge East Approach Ramp

Controlled Modulus Column

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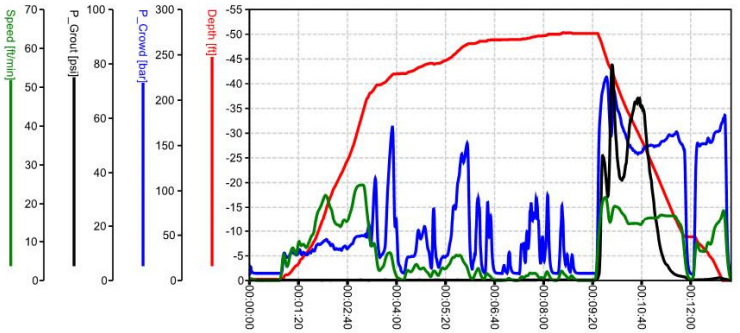
Bridge East Approach Ramp

DGI-Menard
CMC Installation Log

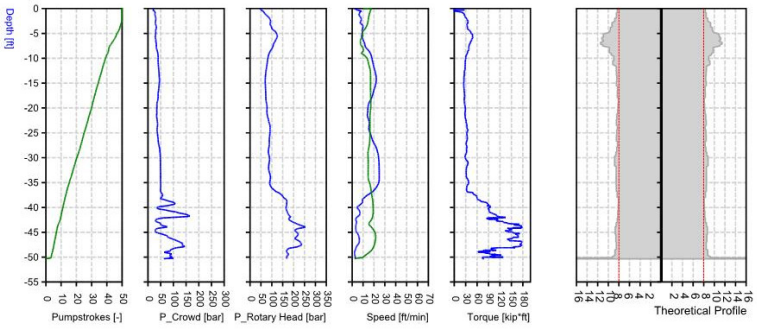
menard

Job Site Data:		Data for Pile No:	r2		
Project name:	Christina River	Date:	10/19/2017	CMC length:	50.34 ft
Area:	Wilmington, DE	Starttime:	9:10:51 AM	CMC diameter:	16 inch
Client:	DelDOT	Endtime:	9:23:55 AM	Theo. Volume:	70.3 ft³
Contractor:	R.E. Pierson	Totaltime:	00:13:04	Act. Volume:	88.1 ft³
Machine:	BG-22	Pausetime:	00:00:00	Overbreak:	25.3 %

Timediagram



Depthdiagram downwards upwards



Controlled Modulus Column

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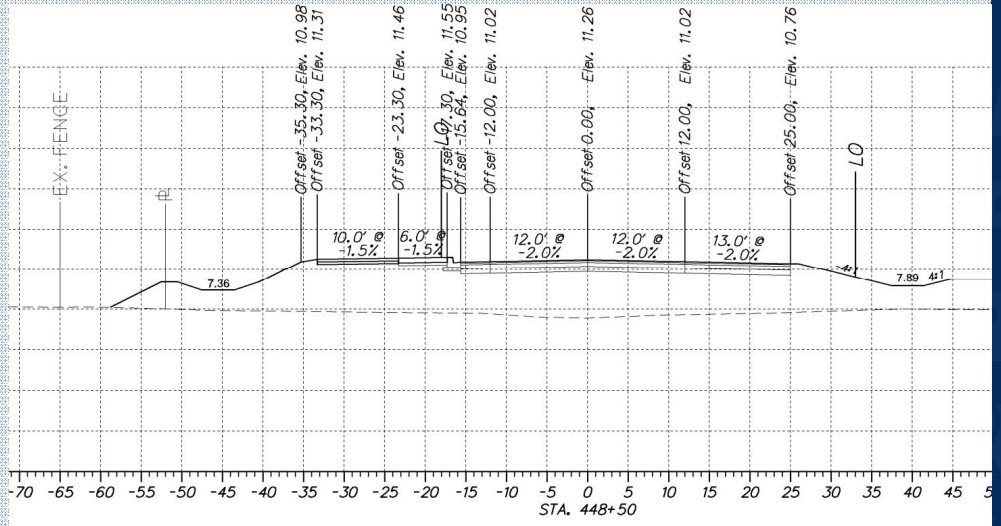
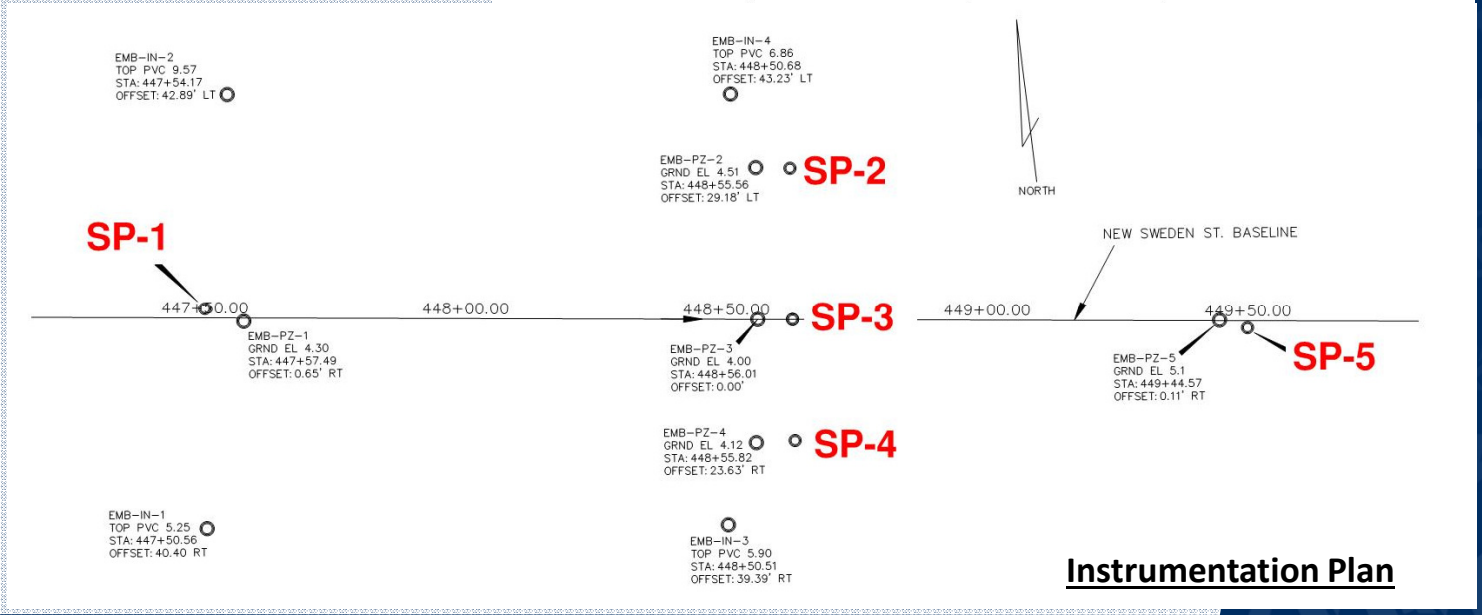
East Approach Surchage

Embankment Surcharge

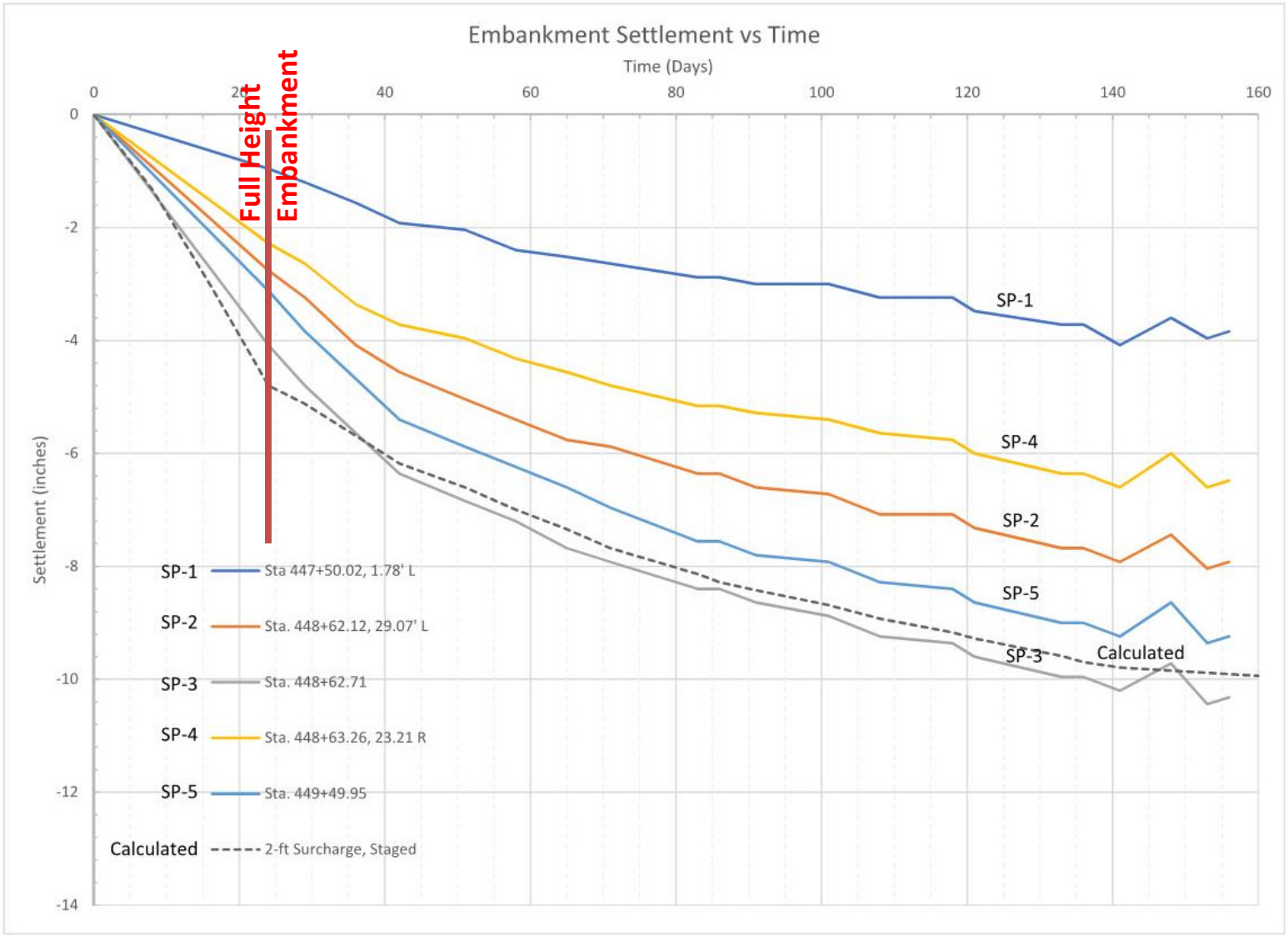
- Height of Embankment: 7-ft
- Additional Surcharge: 2-ft
- Quarantine Period: 5-months
- Total Est. Settlement: 10-inches





Instrumentation Plan

East Approach Surchage Settlement



References

Expanded Polystyrene (EPS)

- NCHRP Web Document 65 (Project 24-11), Geofoam Applications in the Design of Highway Embankments (July 2004)
- NCHRP Report 529, Guideline and Recommended Standard for Geofoam Applications in Highway Embankments

Ground Improvement

- Publication No: FHWA-NHI-16-027, FHWA GEC 013, Ground Modification Methods (April 2017)
- Publication No: FHWA-HRT-13-046, FHWA Design Manual: Deep Mixing for Embankment and Foundation Support (October 2013)
- Collin, J.G., Han, J., and Huang, J., "Geosynthetic-Reinforced Column-Support Embankment Design Guidelines".

Existing Conditions

Conceptual Rendering

Thank You