Bridge 72016 Drilled Shafts for Hwy 93 Grade Raise Project

Joe Nietfeld

Midwest Geotechnical Conference, Indianapolis, IN

September 23, 2025

DEPARTMENT OF TRANSPORTATION

mndot.gov

Agenda

- Project Details
- Engineering Challenges
- Construction Progress and Challenges
- Project Outlook

Project Details

- Structural EOR: MnDOT
- Geotechnical EOR: MnDOT
- Geotech Peer reviewer: Barr Engineering
- Drilled shaft construction oversight: DBA
- Civil Roadway EOR: Bolten and Menk
- Prime Contractor: S.M. Hentges & Sons, Inc.
- Drilled Shaft Contractor: Veit

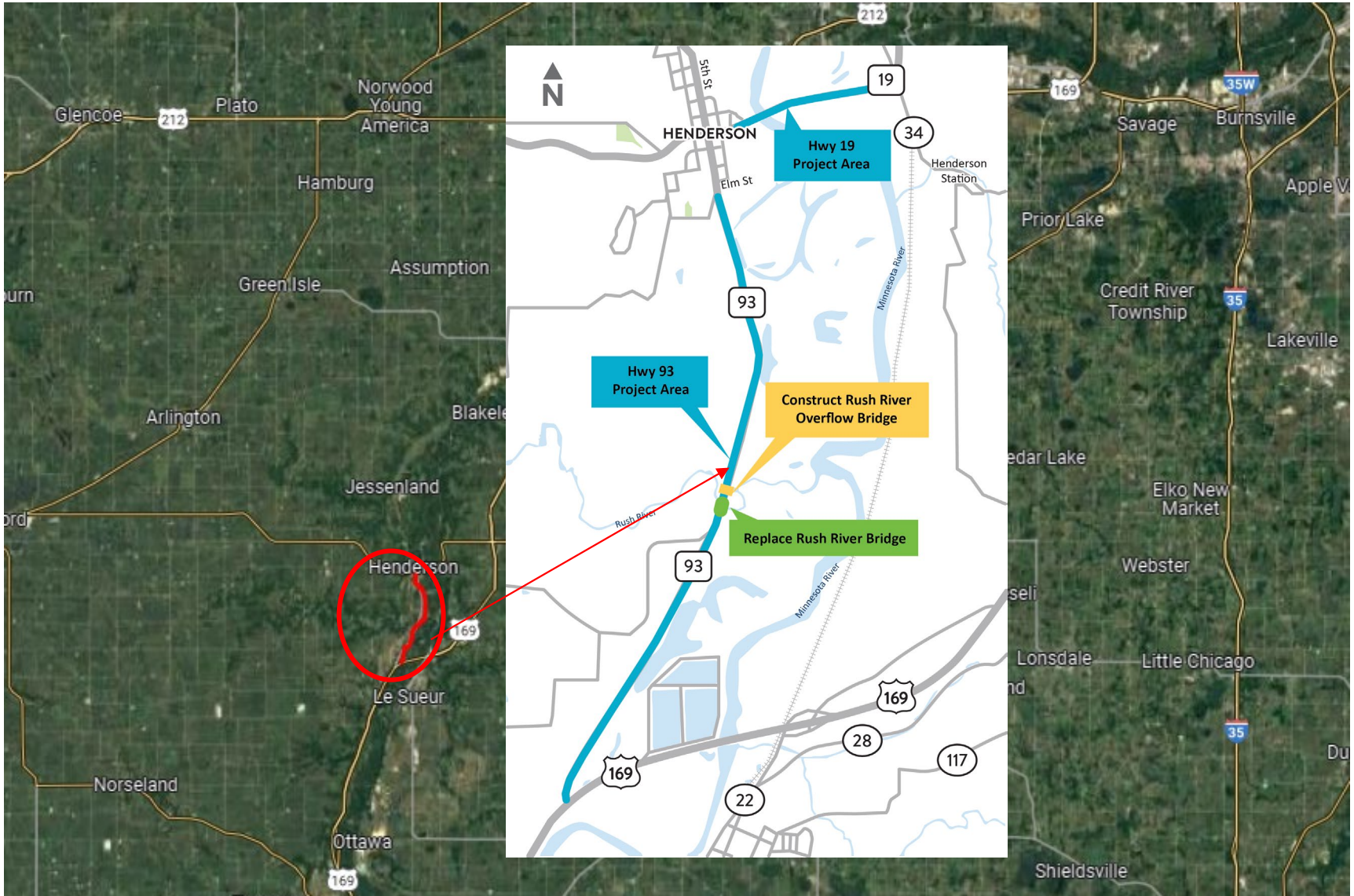
Schedule:

- Project Award: February 27th, 2024
- Clearing: March 2024
- Construction Began: April 15th, 2024
- Anticipated Completion: *Fall 2026*

Awarded Contract Amount:

$30,606,833

Project Location- Henderson, MN



The 1965 Flood


and That

your Henderson Independen

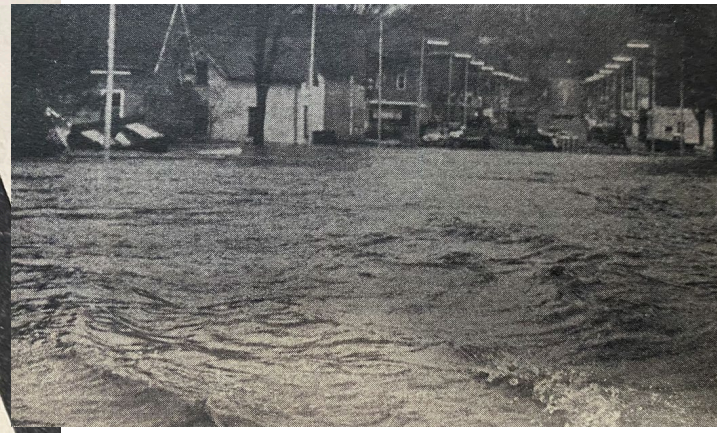
SIBLEY COUNTY'S OLDEST NEWSPAPER

HENDERSON, MINNESOTA THURSDAY, APRIL 15, 1965

Lower main street as viewed by hundreds of persons during height of flood. Note the bridge. Small building floats acr

Photo by Allan Mueller


VOLUME NINTY-THREE 1965 HENDERSON, MINN



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Hwy 93 during March 2019 Flood

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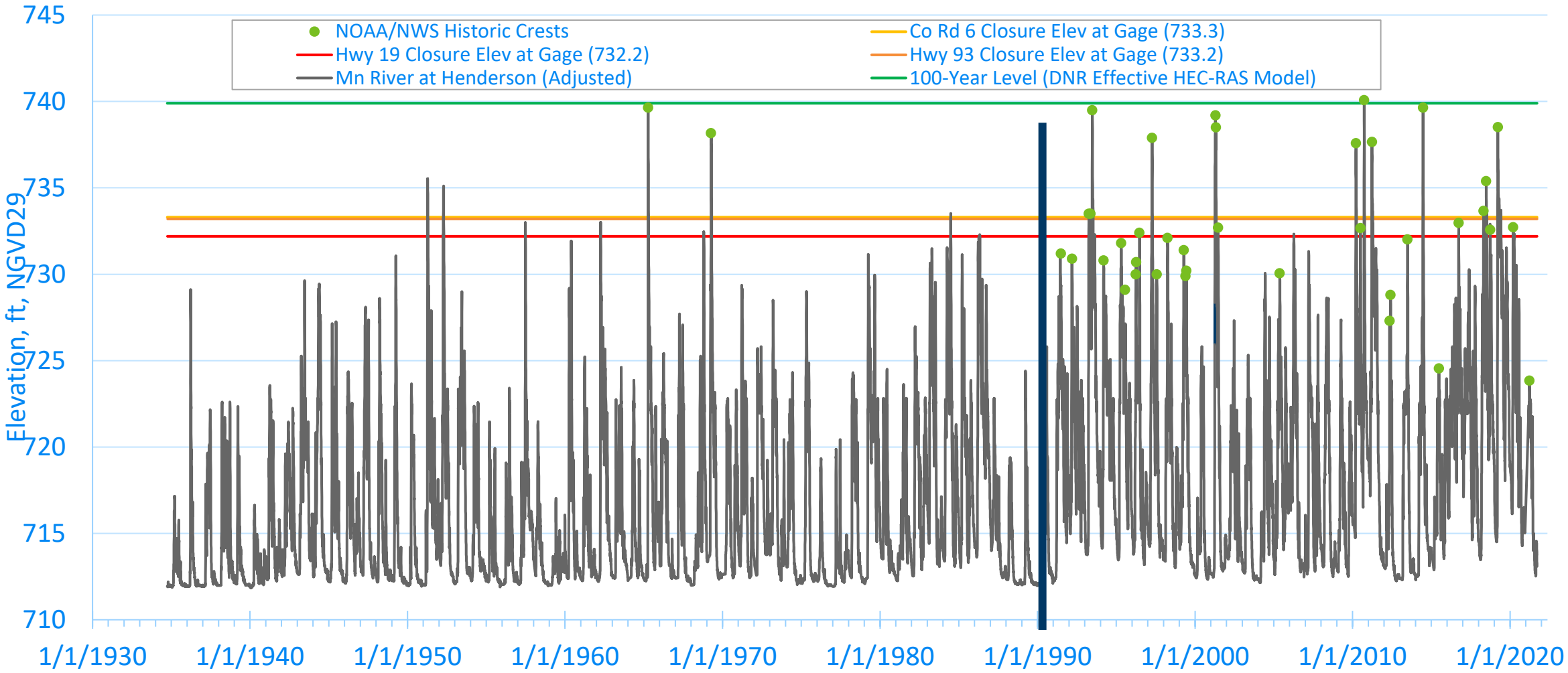
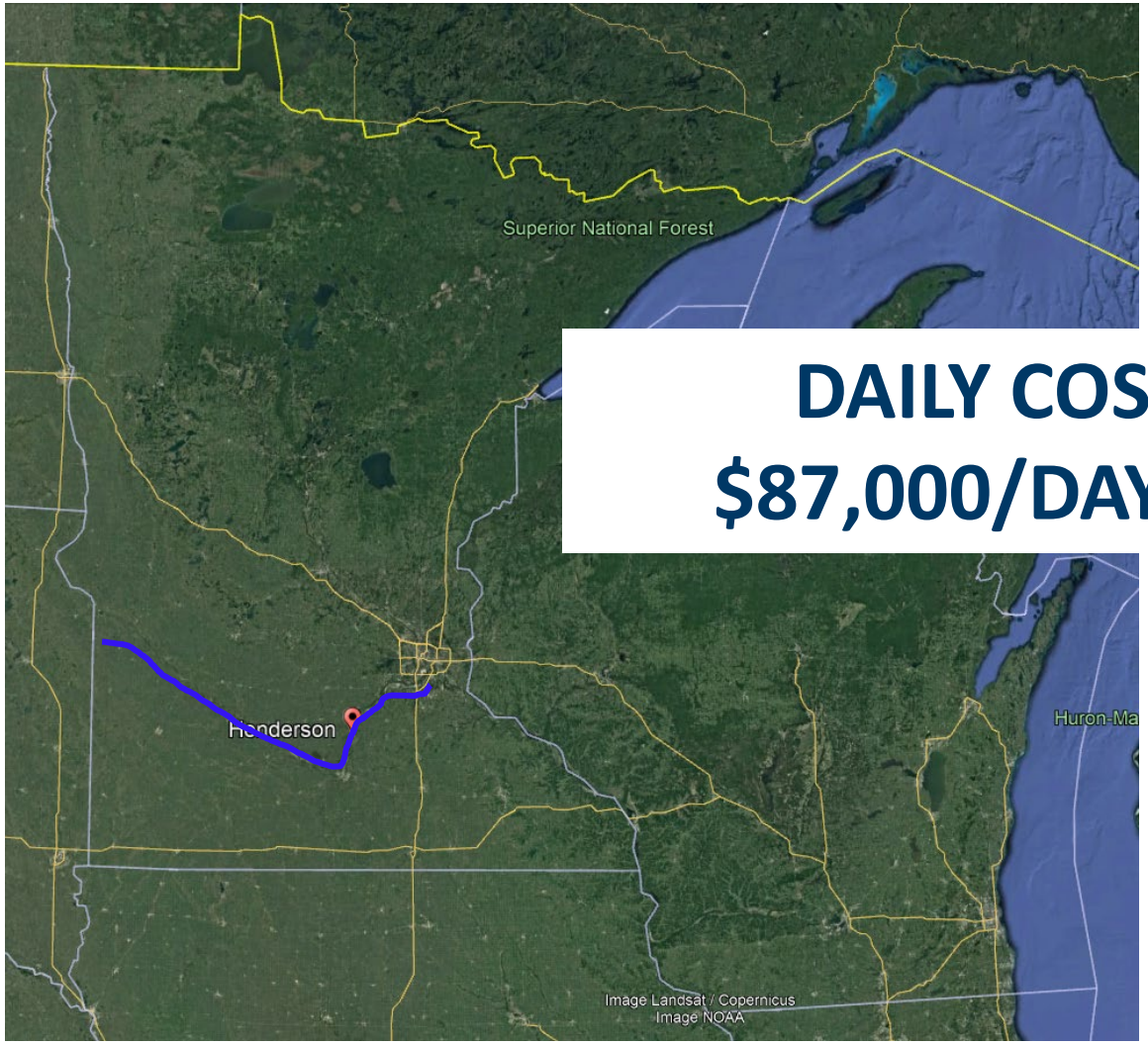
Minnesota River at Henderson

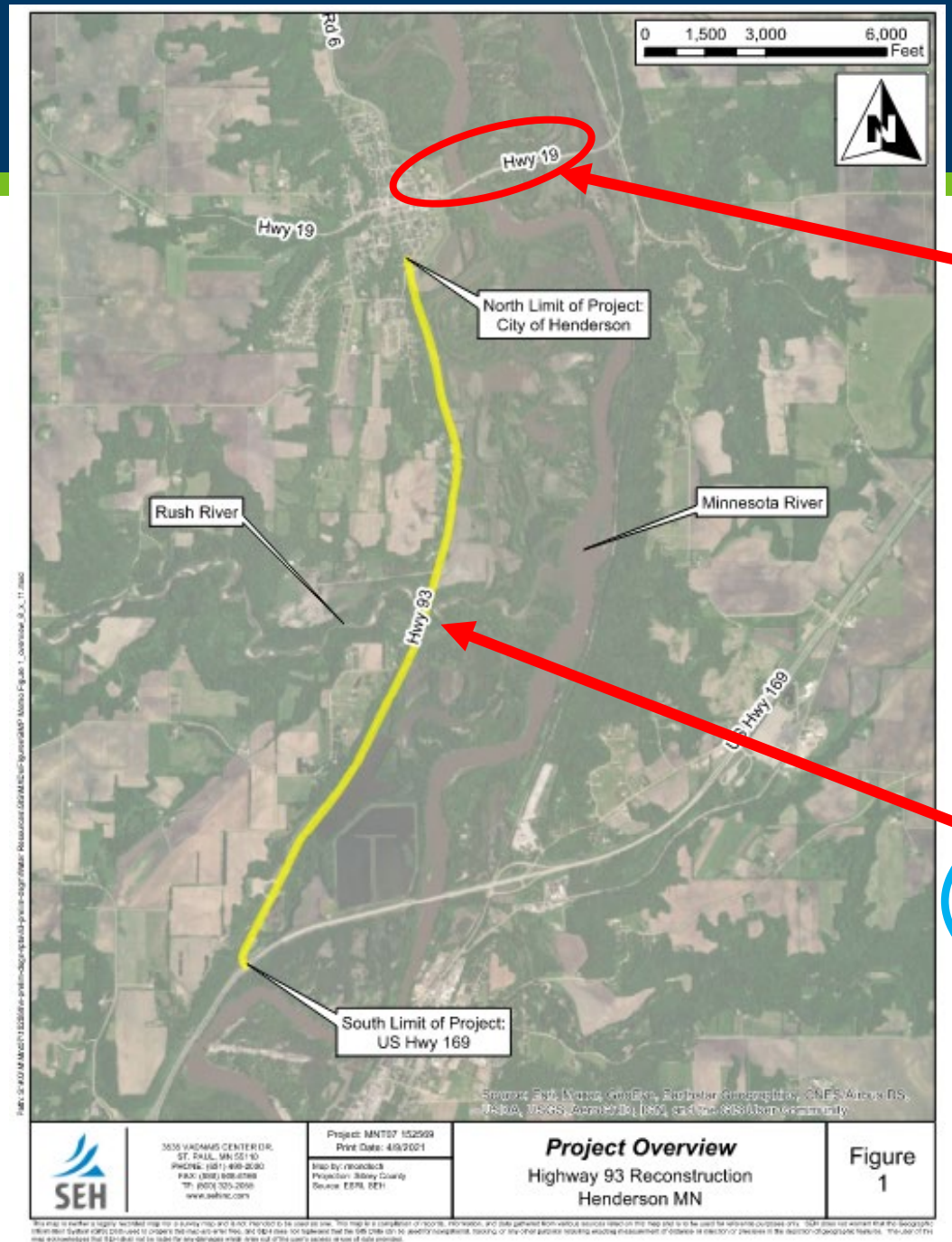


Minnesota River at Henderson



DAILY COST OF CLOSURE:
$87,000/DAY (2017 DOLLARS)

Minnesota River at Henderson



Lower Hwy 19 to act as outlet during flood

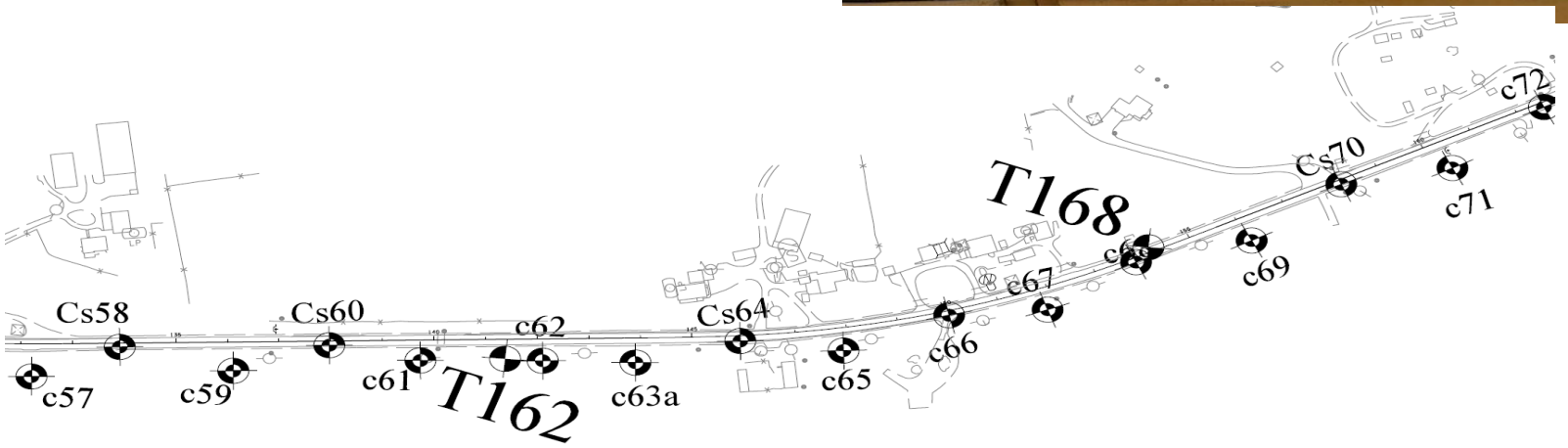
- Raise Hwy 93 8 to 14 ft.
- 1 ft. above 2010 Flood Elevations

TH 93 grade raise

- 3-mile grade raise between 8 and 14 ft. over organic soils between Henderson, MN and US 169
  - 2 bridges
  - 2 pile supported culverts
  - 4 column supported embankments
  - 2.5 miles of wick drains and surcharging

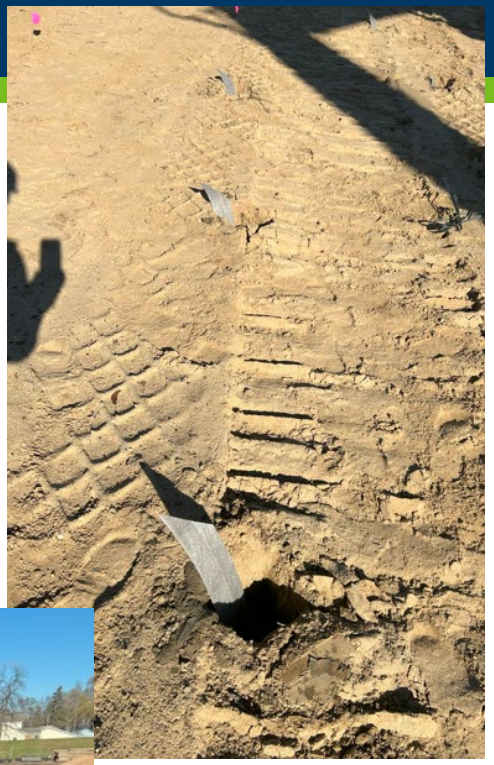
Laboratory Testing

- 100 CPT’s and SCPT’s
- 20 SPT borings
- 13 consolidation tests
- 5 direct shear tests
- Many Atterberg limit and MC tests

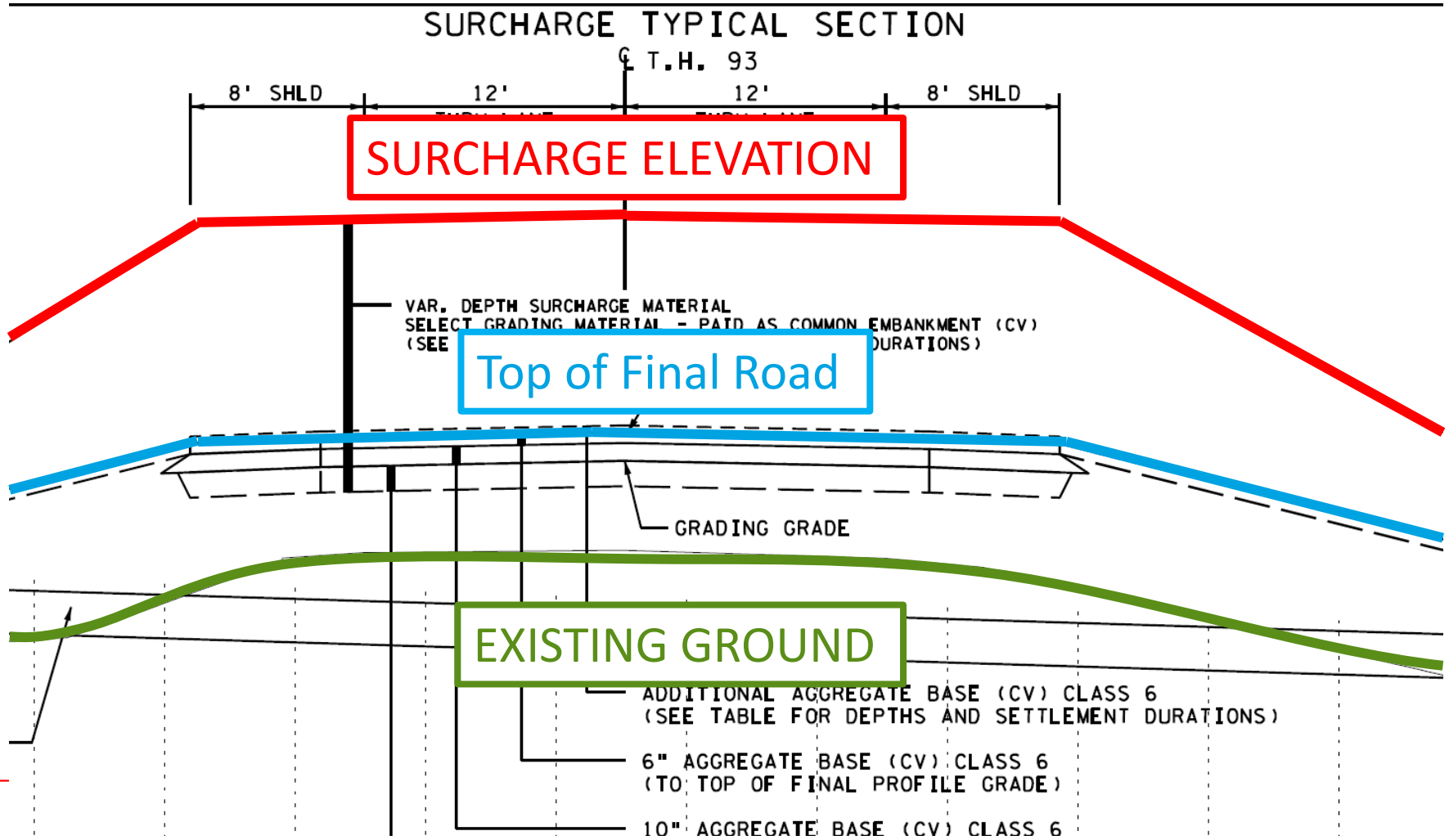


Settlement Mitigation: Surcharge and Wick Drains

- Design: Surcharge and wick drain
  - Split project into 19 sections
  - Predicted settlement
  - Surcharge and wick drain program
    - For primary and secondary consolidation
  - Staged construction for strength
    - Max fill height (strength)
    - PWP increase



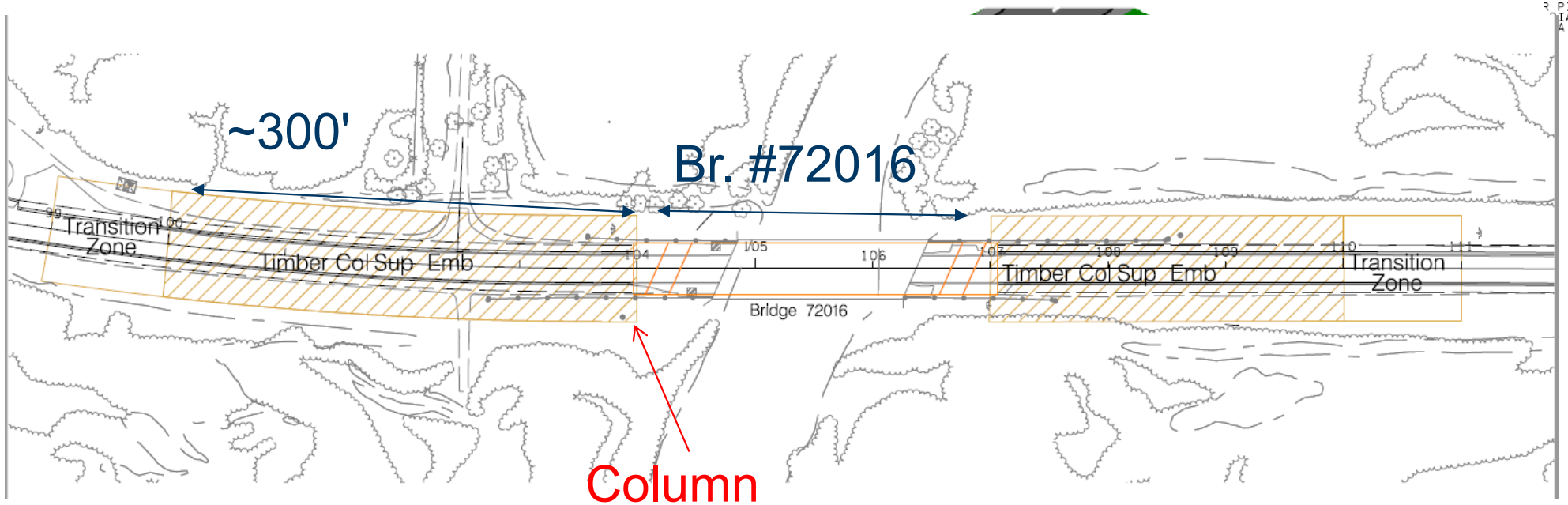
Settlement Mitigation: Surcharge and Wick Drains

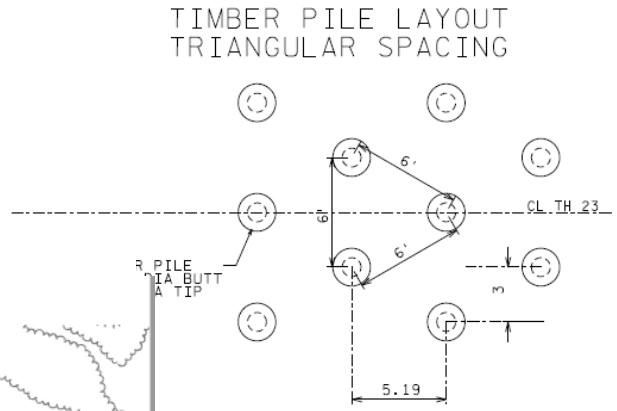


PVD (Wick drains)

Settlement Mitigation: Column Supported Embankments

- Design: Column Supported Embankments
  - 4000 CIP pipe piles- 8 in. and 10 in.

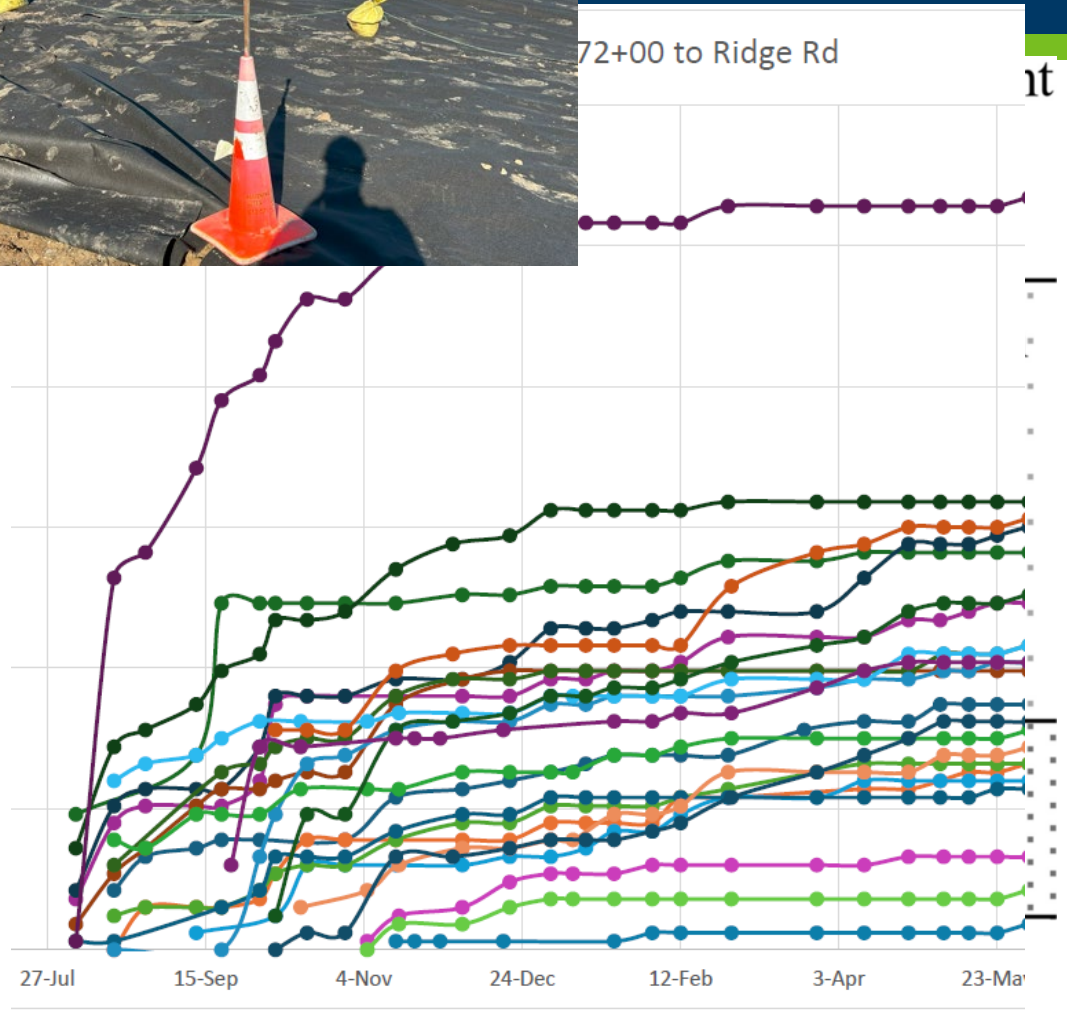




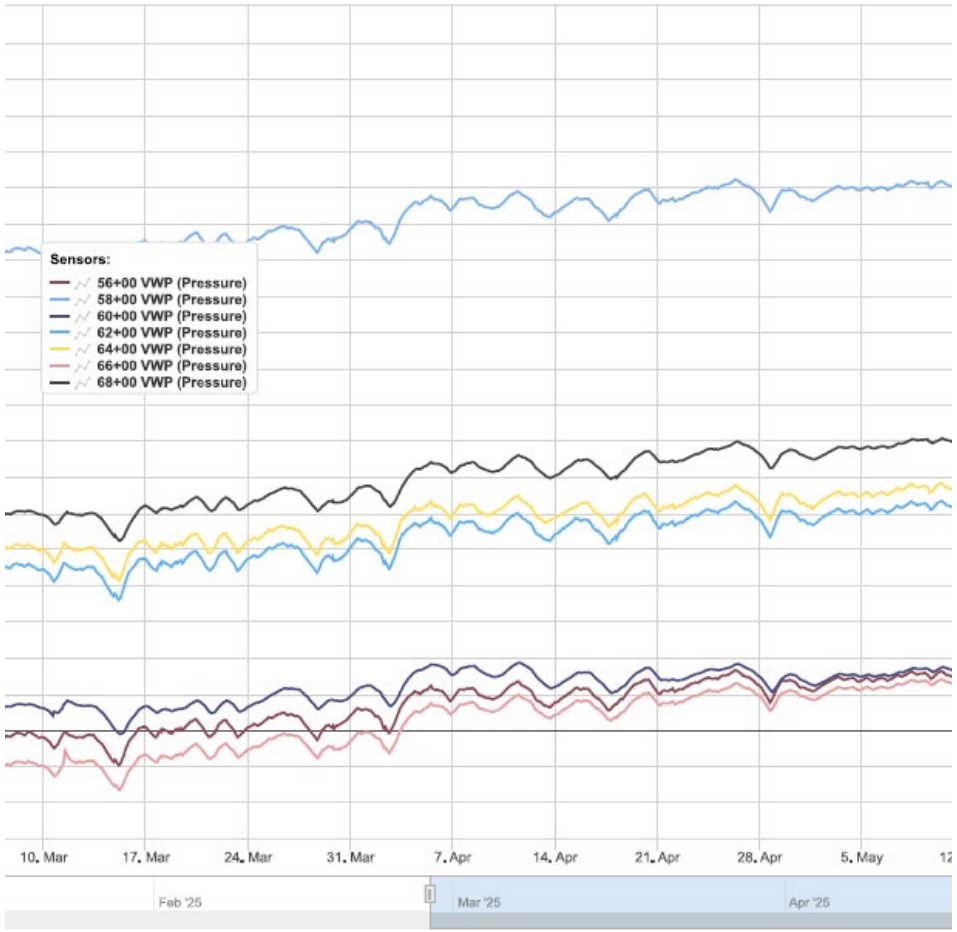
Settlement Mitigation: Column Supported Embankments

- Design: Column Supported Embankments
  - 4000 piles!

Instrumentation

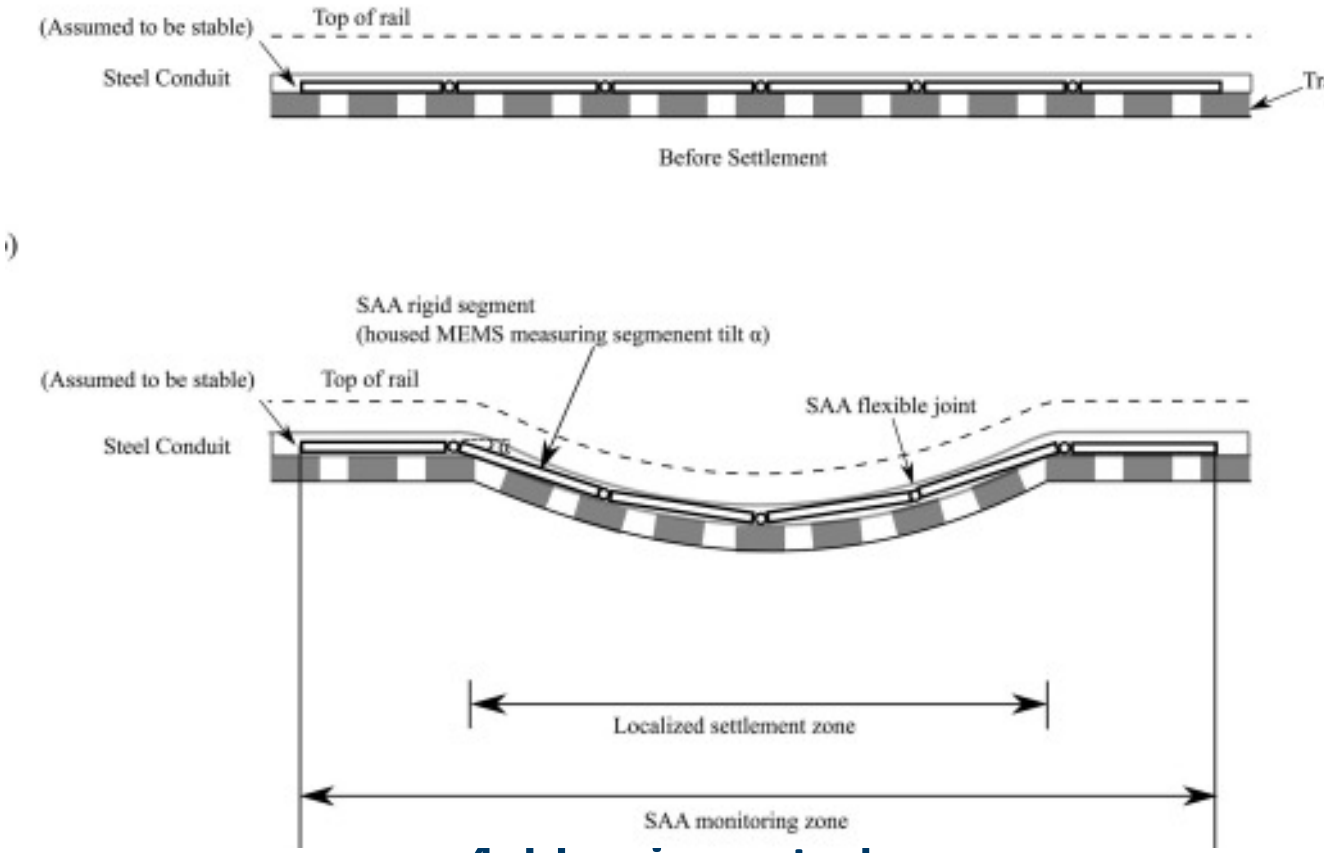


151 Settlement plates

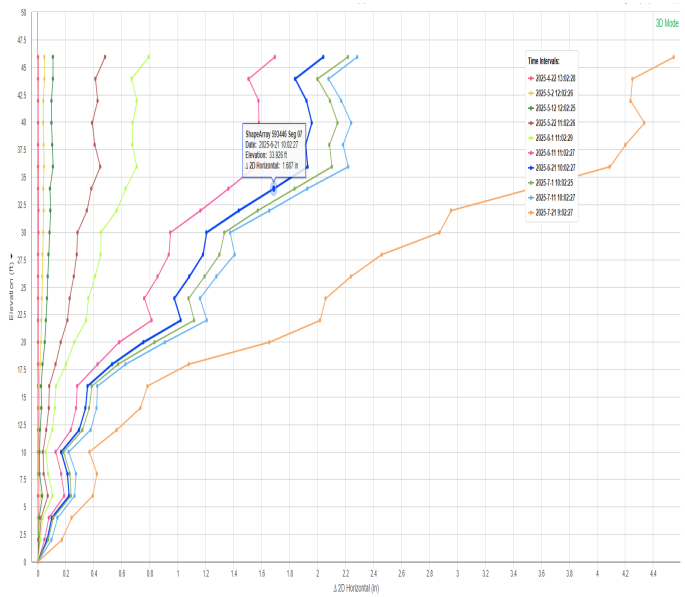


60 Piezometers

Instrumentation



4 Horizontal Shape Arrays



1 Vertical Shape Array

Bridge 72016

Bridge #72016 Scour

100-year scour 29 ft.

500-year scour 39 ft.

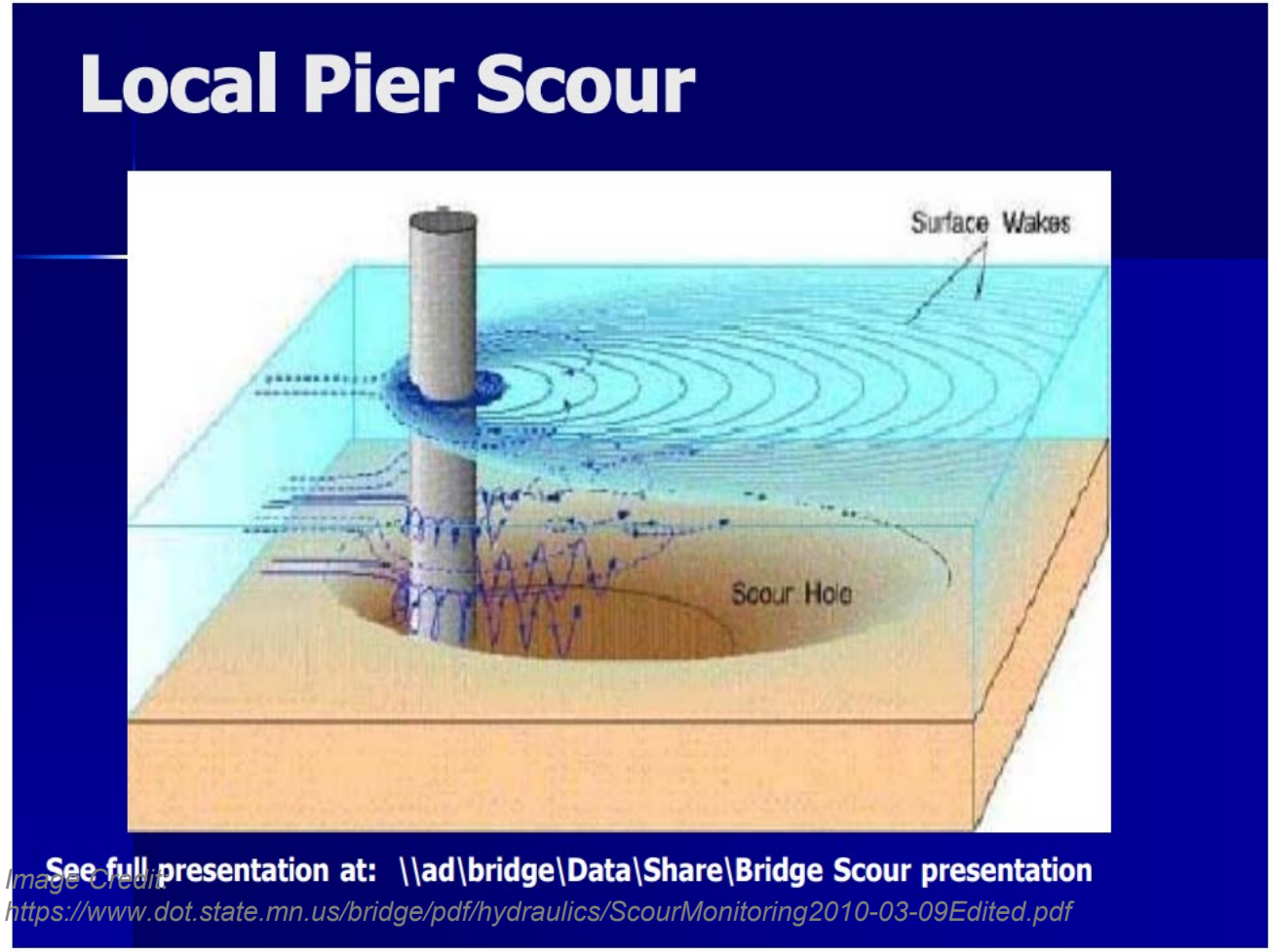
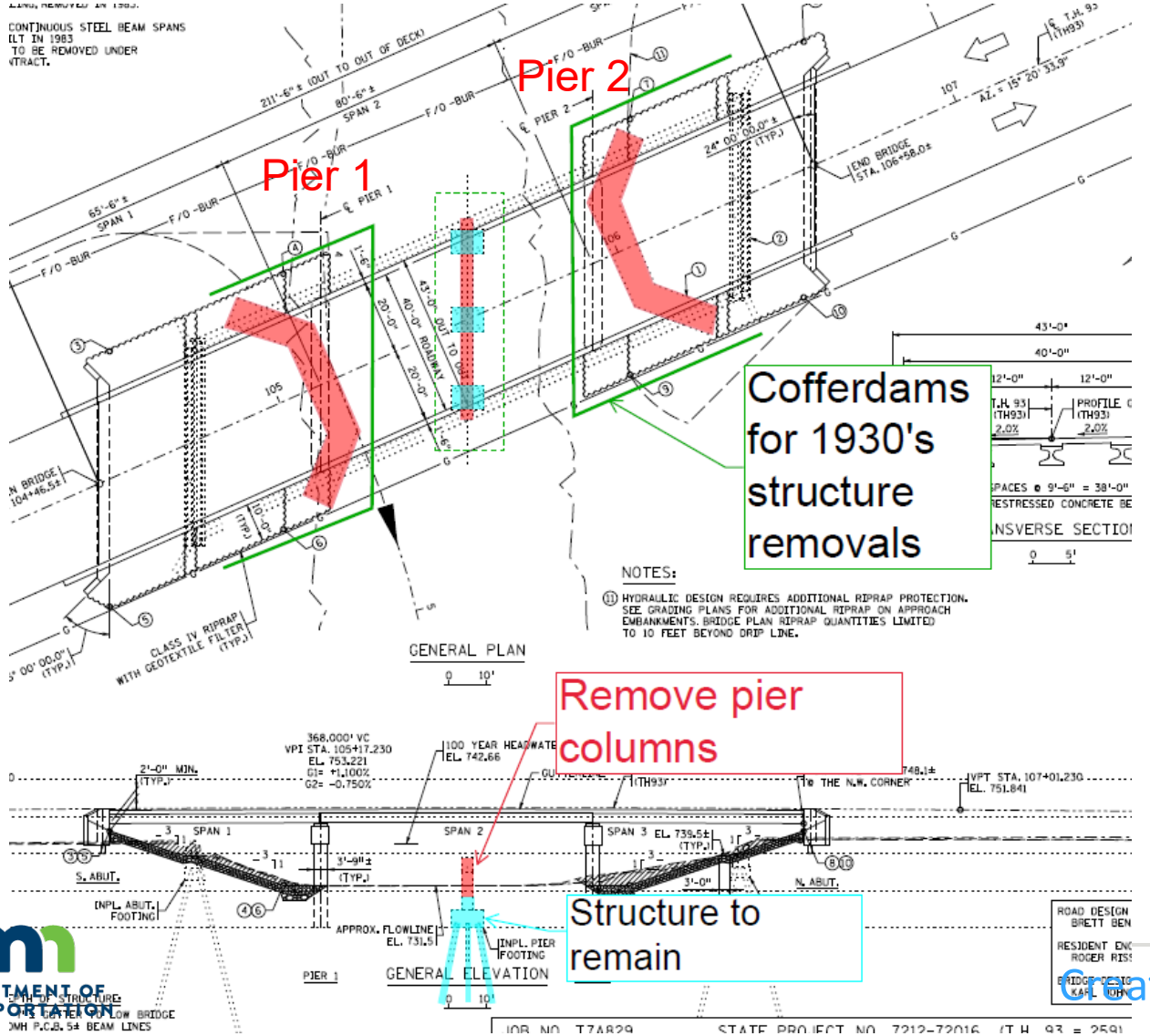
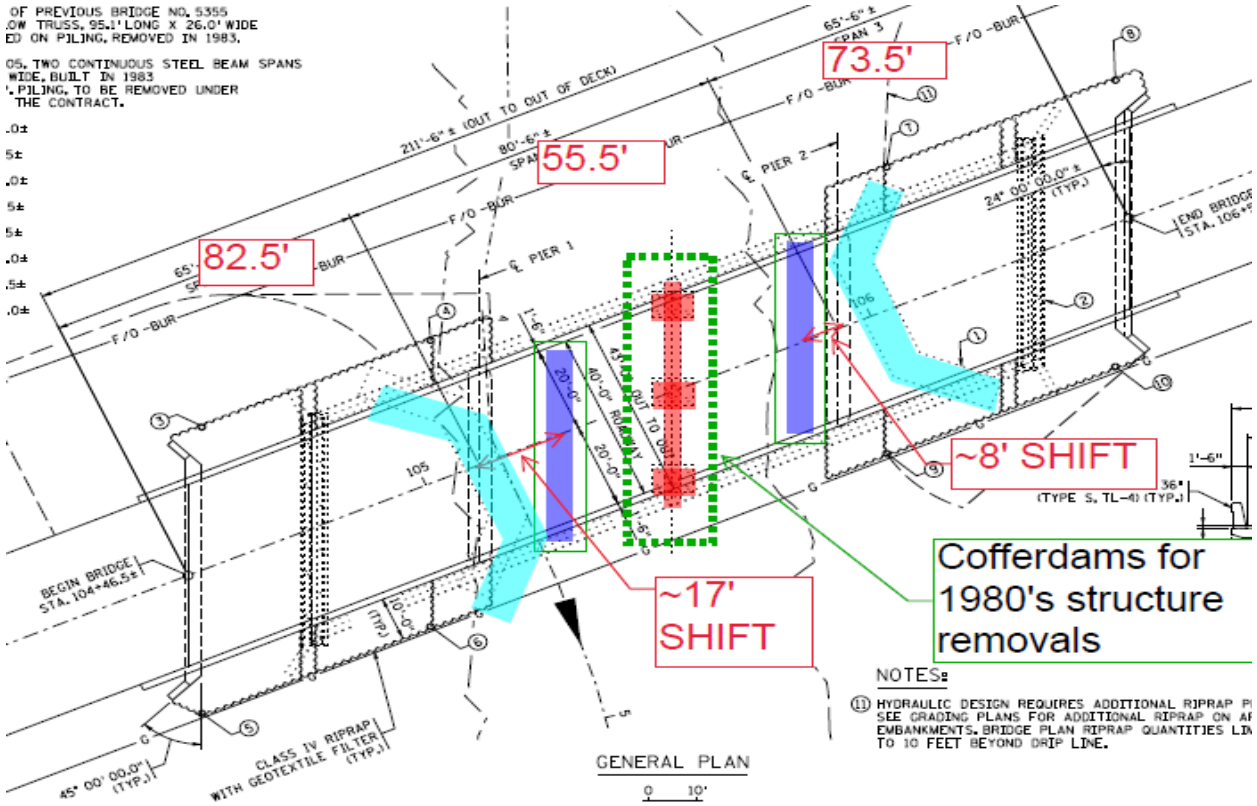


Image Credit: https://www.dot.state.mn.us/bridge/pdf/hydraulics/ScourMonitoring2010-03-09Edited.pdf

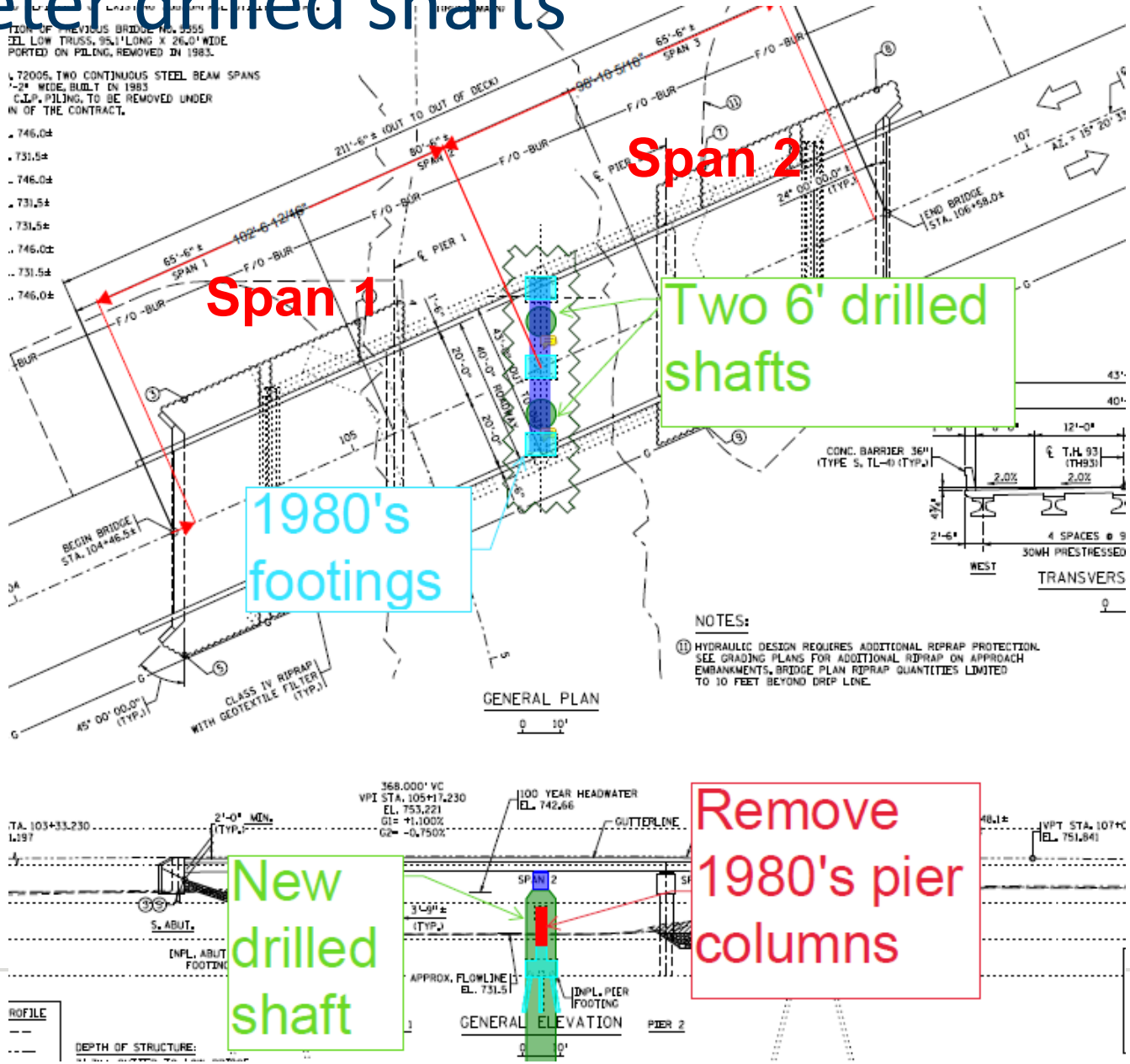
Option 1: 3 span bridge, hammerhead piers with 16" or 20" CIP pipe pile



Option 2: 3 span bridge, pile bent piers with 24" CIP pipe pile (maximum diameter with encasement wall)



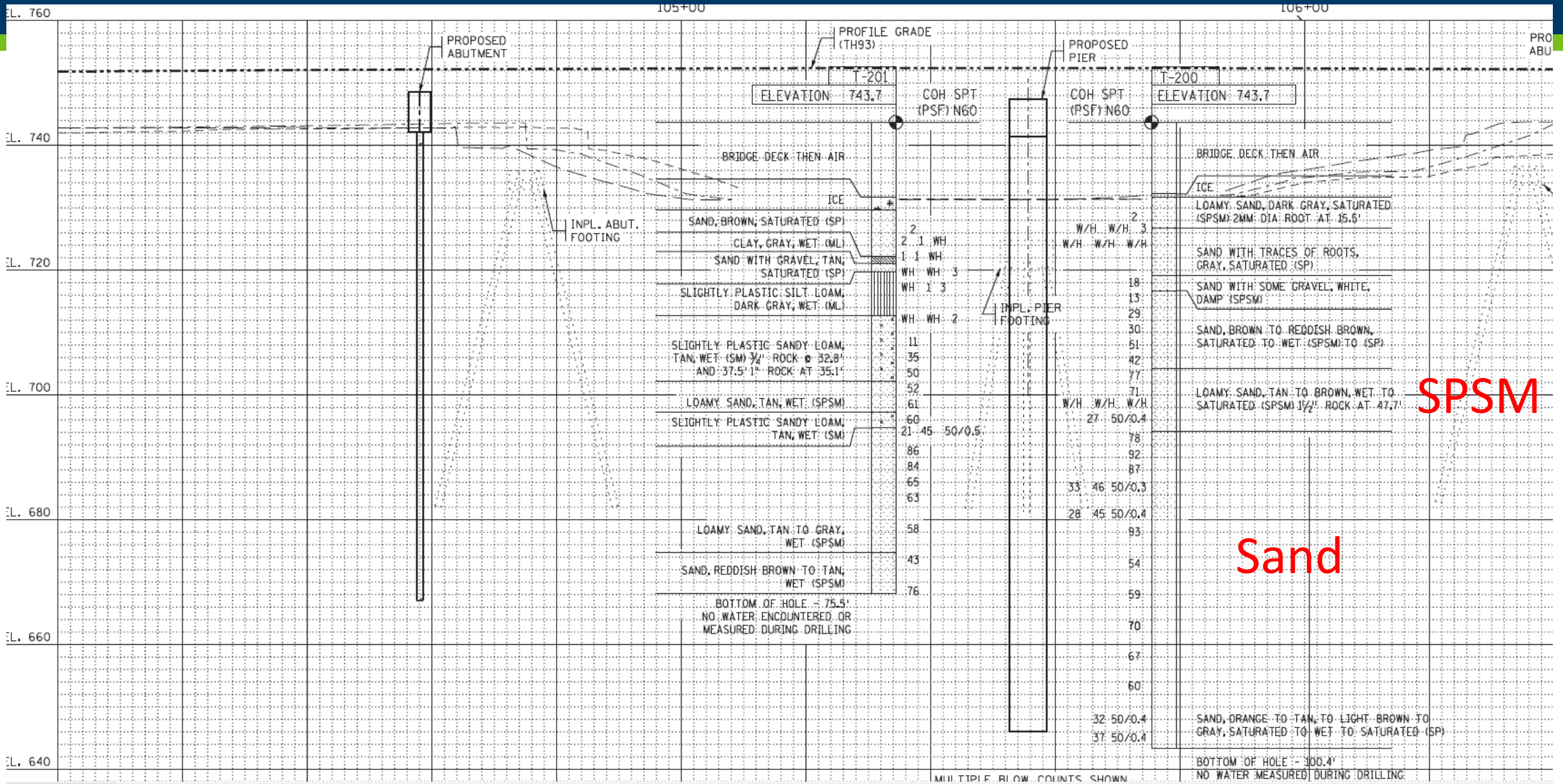
Option 3: 2 span bridge, pile bent piers with two 6' diameter drilled shafts



Bridge 72016 drilled shafts

- Bridge #72016 will be the first known highway bridge with a drilled shaft bent in MN.
- 6' diameter drilled shafts for a 200' bridge!
- For comparison, the St. Anthony falls I-35W bridge at 1216' used 8' diameters drilled shafts
- Takeaway- unique engineering challenges (large grade raise and associated 39' scour) create unique solutions

Bridge 72016 drilled shafts

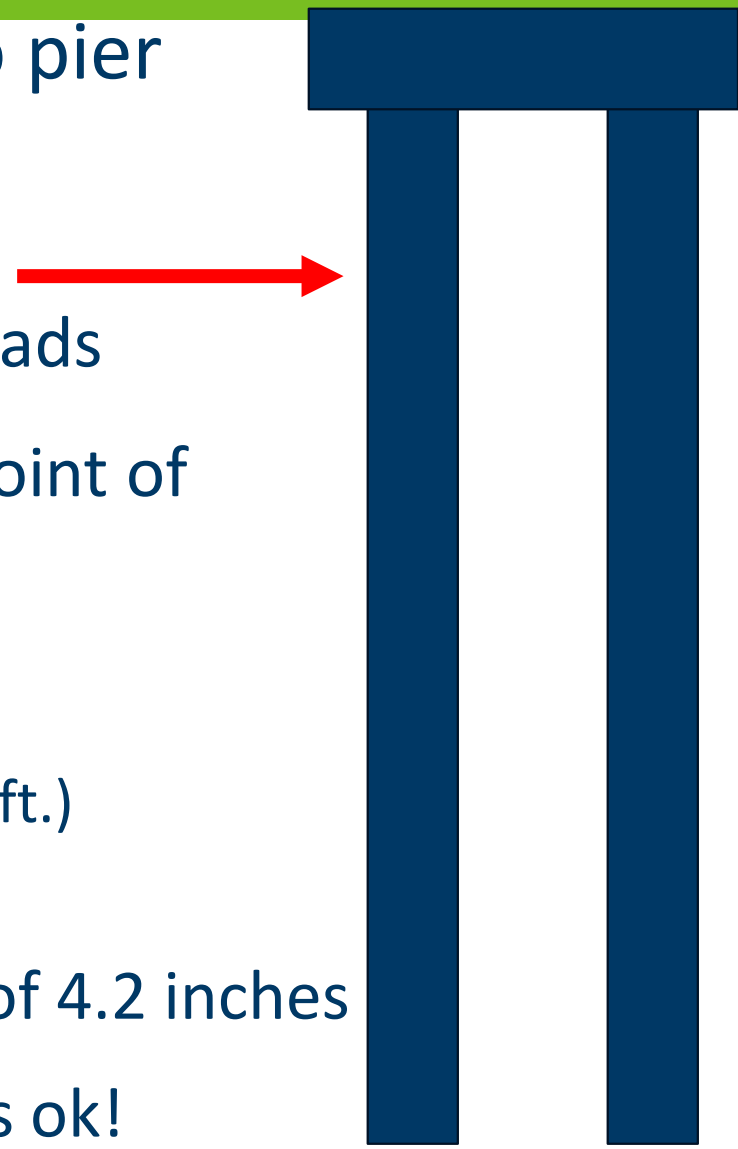


Bridge 72016 drilled shafts

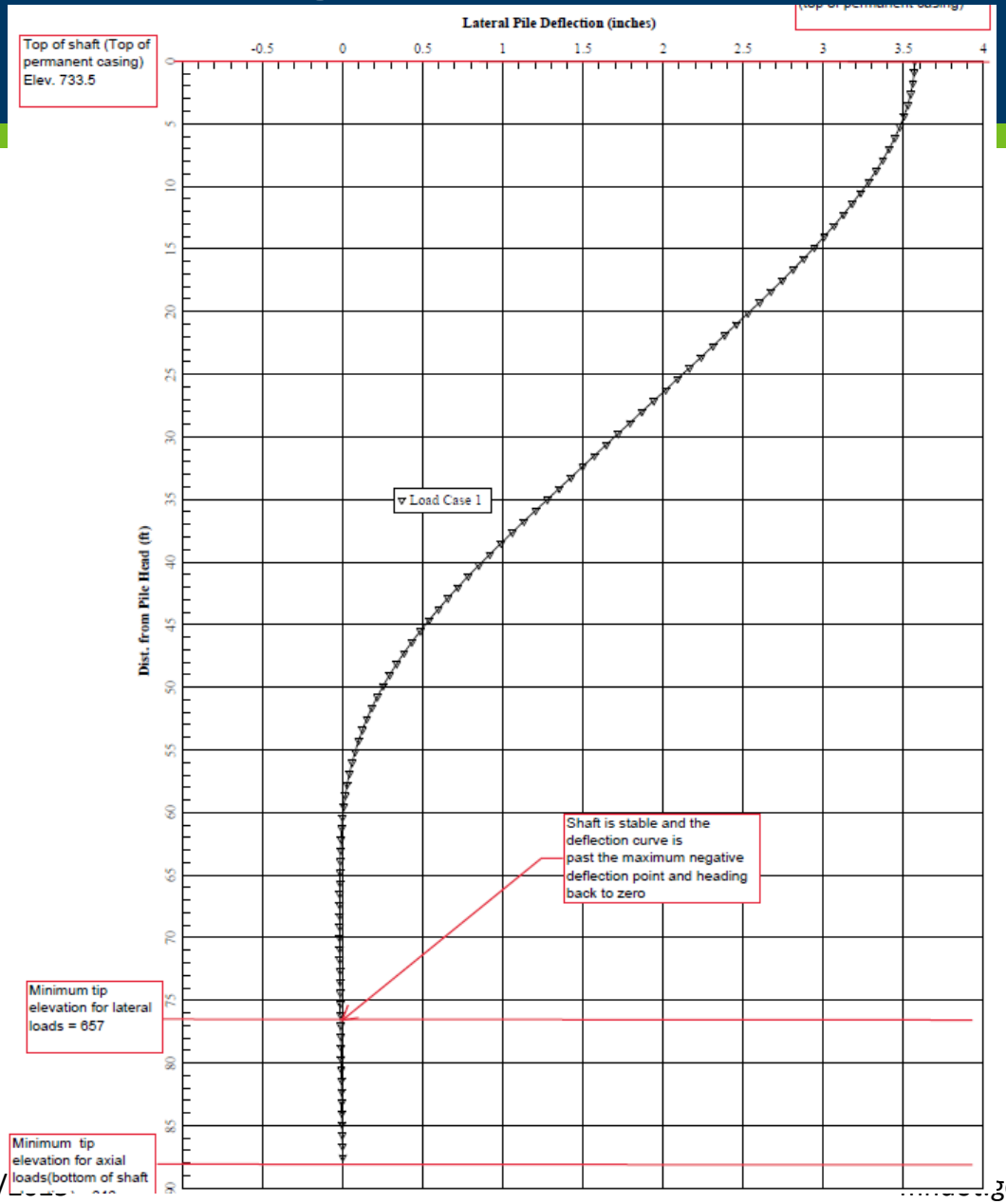
Limit State	Axial Force (k)	Shear (k)	Moment (k-ft)
Strength 1	2124	32	909
Service	1514	140	372
Extreme Event 2	551	204	3317

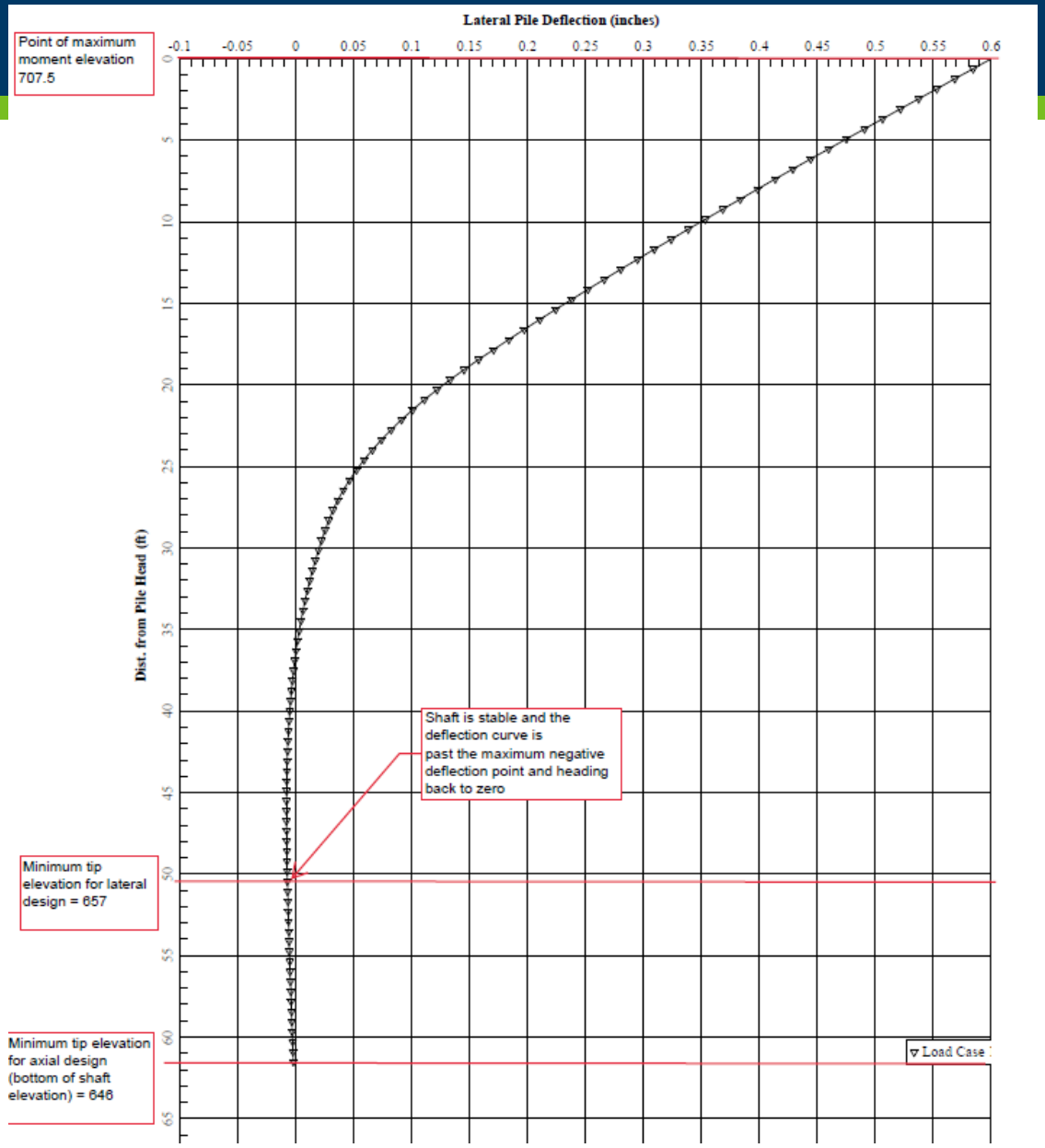
Bridge 72016 drilled shafts- Lateral Analysis

- **Worst case:** Extreme Event 2 limit state parallel to pier
- **Structural Fixity:**
  - Bridge engineer assumed point of fixity –generated loads
  - Geotech ran loads/deflections in LPILE- determined point of fixity
    - Horizontal load at the top of the pile (204 kips)
    - Deflection of shaft at point of max moment (2.3 in. at 35.5 ft.)
- **Stability:**
  - Extreme Event 2 limit state stability check- deflection of 4.2 inches
  - GEC 10 Section 9.3.3.3.1- 10% of diameter ~7.2 inches ok!



Bridge 72016 drilled shafts- lateral





L: 657

A: 646

Bridge 72016 drilled shafts- Axial Analysis

	Unit (ksf)	Shaft length below scour elevation (feet)	Shaft area (sf)	Nominal Resistance (kips)	Resistance Factor	Resistance factor 20% reduction (AASHTO LRFD 10.5.5.2.4)	Factored Resistance (kips)
Side	3.4	51.5	970.75	3301	0.55	0.8	1452
Tip	60		28.27	1696	0.5	0.8	678
Total							**2130**

AASHTO 10.8.3.5.2

Min shaft depth for axial: 646 ft. elev.

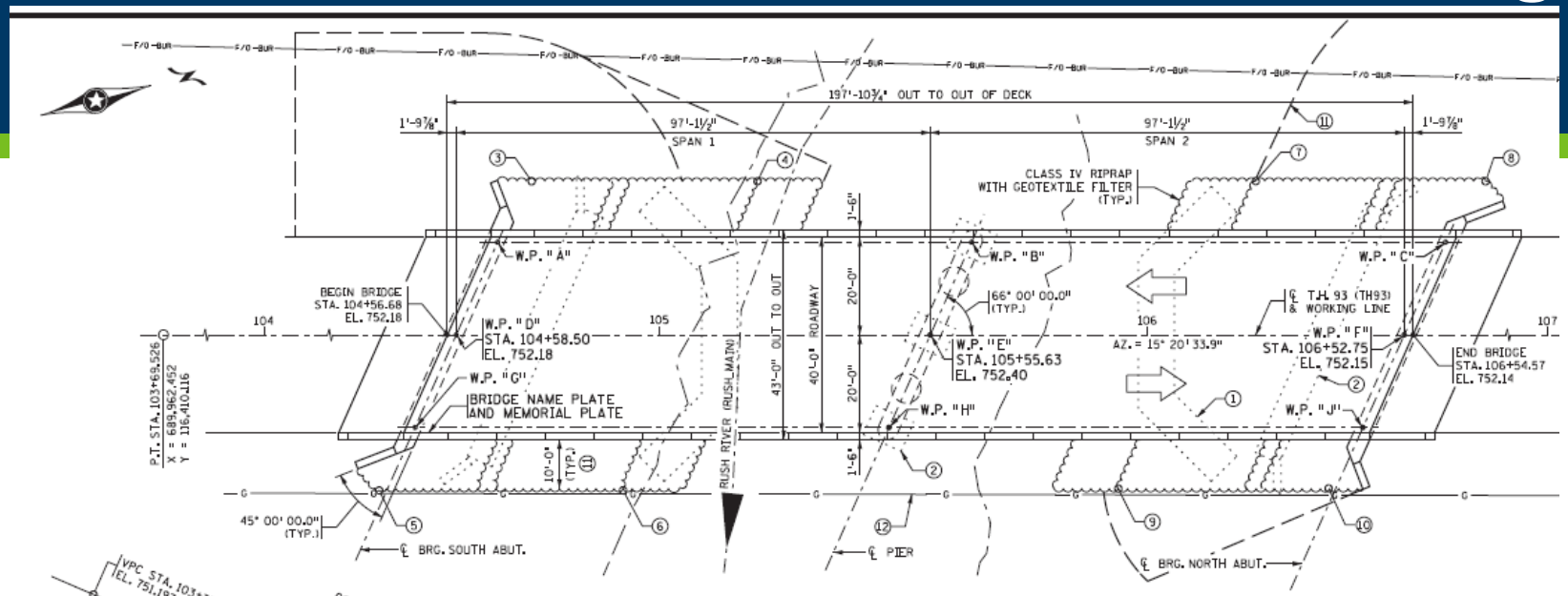
If $N_{60} \le 50$, then $q_p = 1.2N_{60}$ (10.8.3.5.2c-1)

where:

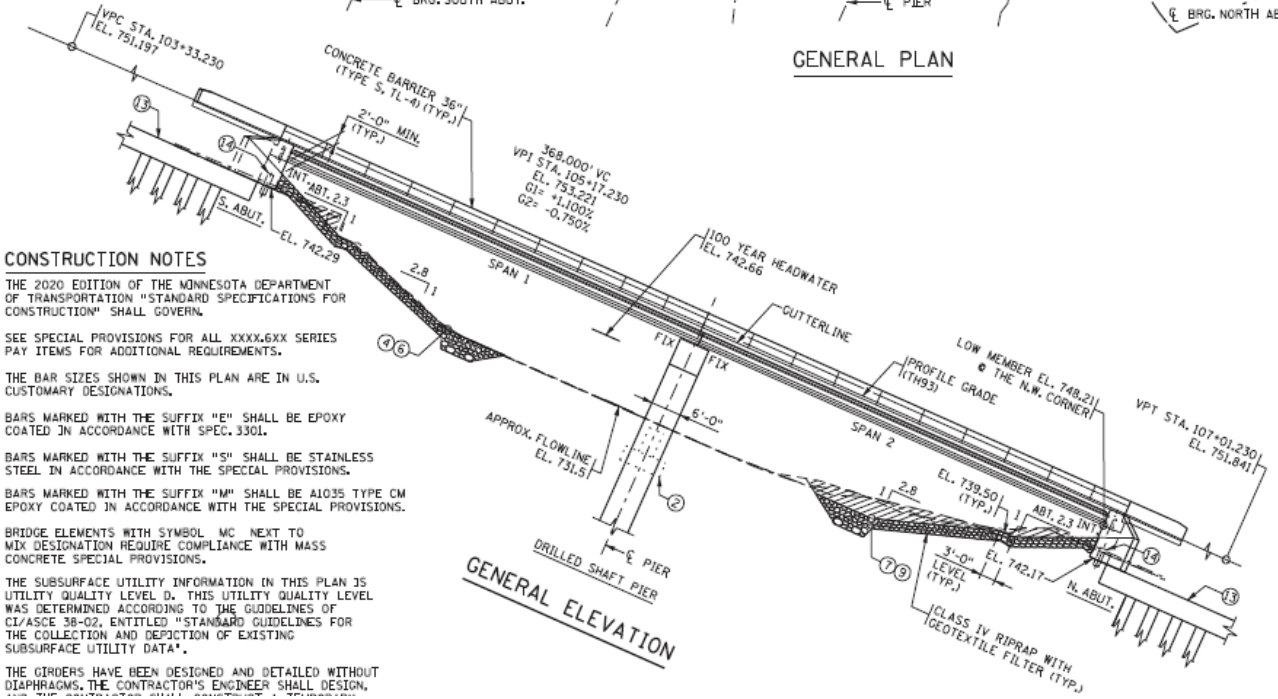
N_{60} = average *SPT* blow count (corrected only for hammer efficiency) in the design zone under consideration (blows/ft)

The value of q_p in Eq. 10.8.3.5.2c-1 should be limited to 60 ksf, unless greater values can be justified though load test data.

Bridge 72016 drilled shafts



GENERAL PLAN



GENERAL ELEVATION

CONSTRUCTION NOTES

THE 2020 EDITION OF THE MINNESOTA DEPARTMENT OF TRANSPORTATION "STANDARD SPECIFICATIONS FOR CONSTRUCTION" SHALL GOVERN.

SEE SPECIAL PROVISIONS FOR ALL XXXX.6XX SERIES PAY ITEMS FOR ADDITIONAL REQUIREMENTS.

THE BAR SIZES SHOWN IN THIS PLAN ARE IN U.S. CUSTOMARY DESIGNATIONS.

BARS MARKED WITH THE SUFFIX "E" SHALL BE EPOXY COATED IN ACCORDANCE WITH SPEC. 3301.

BARS MARKED WITH THE SUFFIX "S" SHALL BE STAINLESS STEEL IN ACCORDANCE WITH THE SPECIAL PROVISIONS.

BARS MARKED WITH THE SUFFIX "M" SHALL BE A1035 TYPE CM EPOXY COATED IN ACCORDANCE WITH THE SPECIAL PROVISIONS.

BRIDGE ELEMENTS WITH SYMBOL MC NEXT TO MIX DESIGNATION REQUIRE COMPLIANCE WITH MASS CONCRETE SPECIAL PROVISIONS.

THE SUBSURFACE UTILITY INFORMATION IN THIS PLAN IS UTILITY QUALITY LEVEL D. THIS UTILITY QUALITY LEVEL WAS DETERMINED ACCORDING TO THE GUIDELINES OF CI/ASCE 38-02, ENTITLED "STANDARD GUIDELINES FOR THE COLLECTION AND DEPICTION OF EXISTING SUBSURFACE UTILITY DATA".

THE GIRDERS HAVE BEEN DESIGNED AND DETAILED WITHOUT DIAPHRAGMS. THE CONTRACTOR'S ENGINEER SHALL DESIGN,

NOTES:

HATCHED AREA TO BE REMOVED

(1) APPROXIMATE LOCATION OF PREV A SINGLE SPAN STEEL LOW TRUS BUILT IN 1935, SUPPORTED ON P WITH ABUTMENT FOOTINGS PRESU BR. 5355 ABUTMENT CONCRETE T

(2) INPLACE BRIDGE NO. 72005, TWO 165'-6" LONG X 50'-2" WIDE, BU SUPPORTED ON 12" C.I.P. PILING. THE BRIDGE PORTION OF THE CO FOOTINGS TO REMAIN UNDER EL.

(3) STA. 104+73.89 ; EL. 746.0

(4) STA. 105+18.02 ; EL. 731.5

(5) STA. 104+39.83 ; EL. 746.0

(6) STA. 104+89.98 ; EL. 731.5

(7) STA. 106+20.95 ; EL. 731.5

(8) STA. 106+68.19 ; EL. 746.0

(9) STA. 105+92.90 ; EL. 731.5

72016

PIER DRILLED SHAFTS: DESIGN DATA							
	FACTORED DESIGN LOAD (KIPS)	ϕ_s	ϕ_p	fs NOMINAL (KSF)	f_p NOMINAL (KSF)	Rn PROV'D (KIPS)*	LOAD CASE
PIER	2,124	0.40	0.44	3.40	60	2,130	STRENGTH
	1,540	1.00	1.00			4997	EXTREME

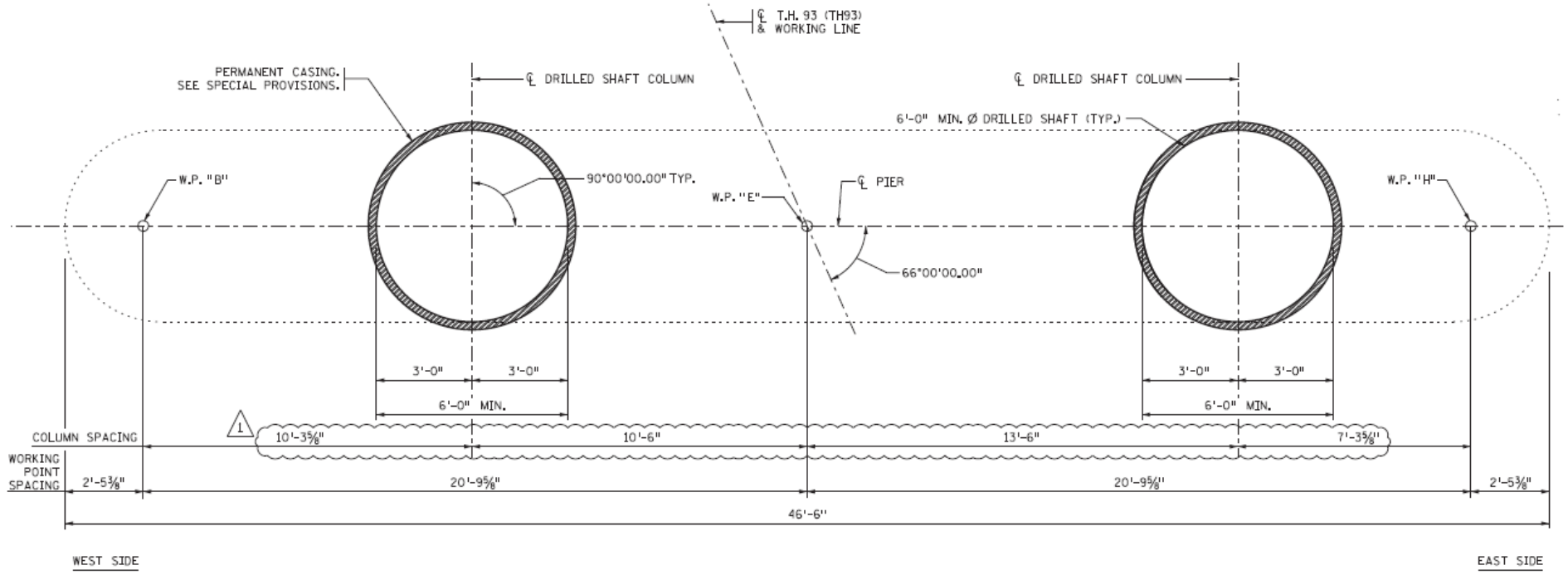
* BASED ON 100 YEAR SCOUR CONDITION

PIER COMPUTED PILE LOAD - TONS/SHAFT	
FACTORED DEAD LOAD	733.6
FACTORED LIVE LOAD	321.7
FACTORED OVERTURNING	6.7
✳ FACTORED DESIGN LOAD	1062.0

✳ BASED ON STRENGTH I LOAD COMBINATION

PIER COMPUTED PILE LOAD - TONS/SHAFT	
FACTORED DEAD LOAD	586.8
FACTORED LIVE LOAD	91.9
FACTORED OVERTURNING	91.7
✳ FACTORED DESIGN LOAD	770.4

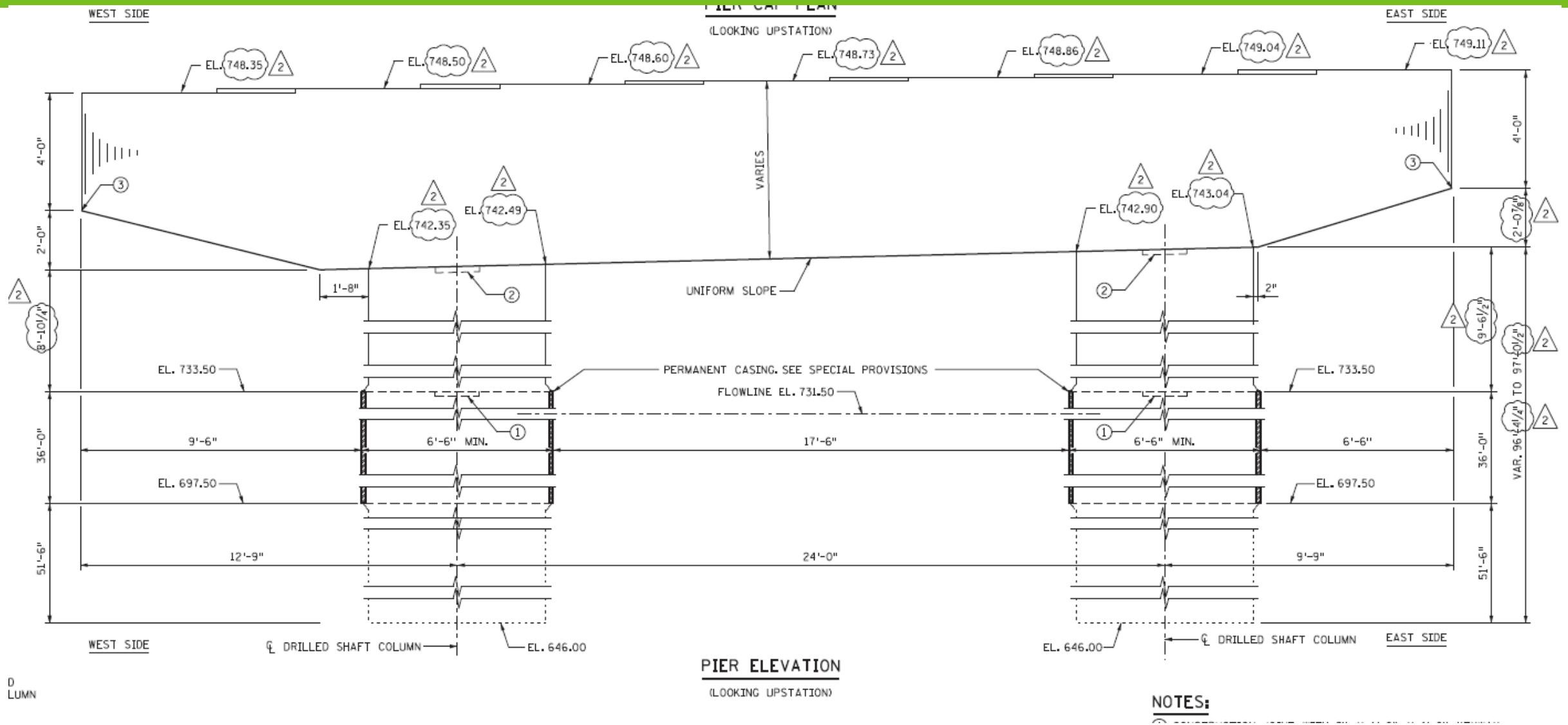
✳ BASED ON EXTREME EVENT II LOAD COMBINATION



DRILLED SHAFT COLUMN LAYOUT

(LOOKING UPSTATION)

Bridge 72016



PIER ELEVATION

(LOOKING UPSTATION)

NOTES:

East Shaft

- 6 ft. diameter soil socket
- Shaft length- 87.5 ft. mostly into sand
- ~40 ft. permanent casing an a ~ 50 ft. soil socket. Perm casing 7’ diameter. 8’ temp casing.

Installation

Installation

- 1st Hole collapsed on 02-12-2025- (mixing slurry in hole)

Notes:

- Veit has slurry tank not running due to cold weather, during today's drilling, the slurry was not mixed in tank, but in buckets and in the hole. Veit needs to provide slurry test results.

2/13/2025, Thursday, sunny, -8 to 10 degrees

- I arrived site at 10 am and checked the water level inside casing after auger broke the ice. The water was tape measured 99 inch from the top of temporary casing, which was at elevation 732.75' similar to river level. I took a sounding and got a measurement of 45.3', which indicated the soil inside hole collapsed into the hole.

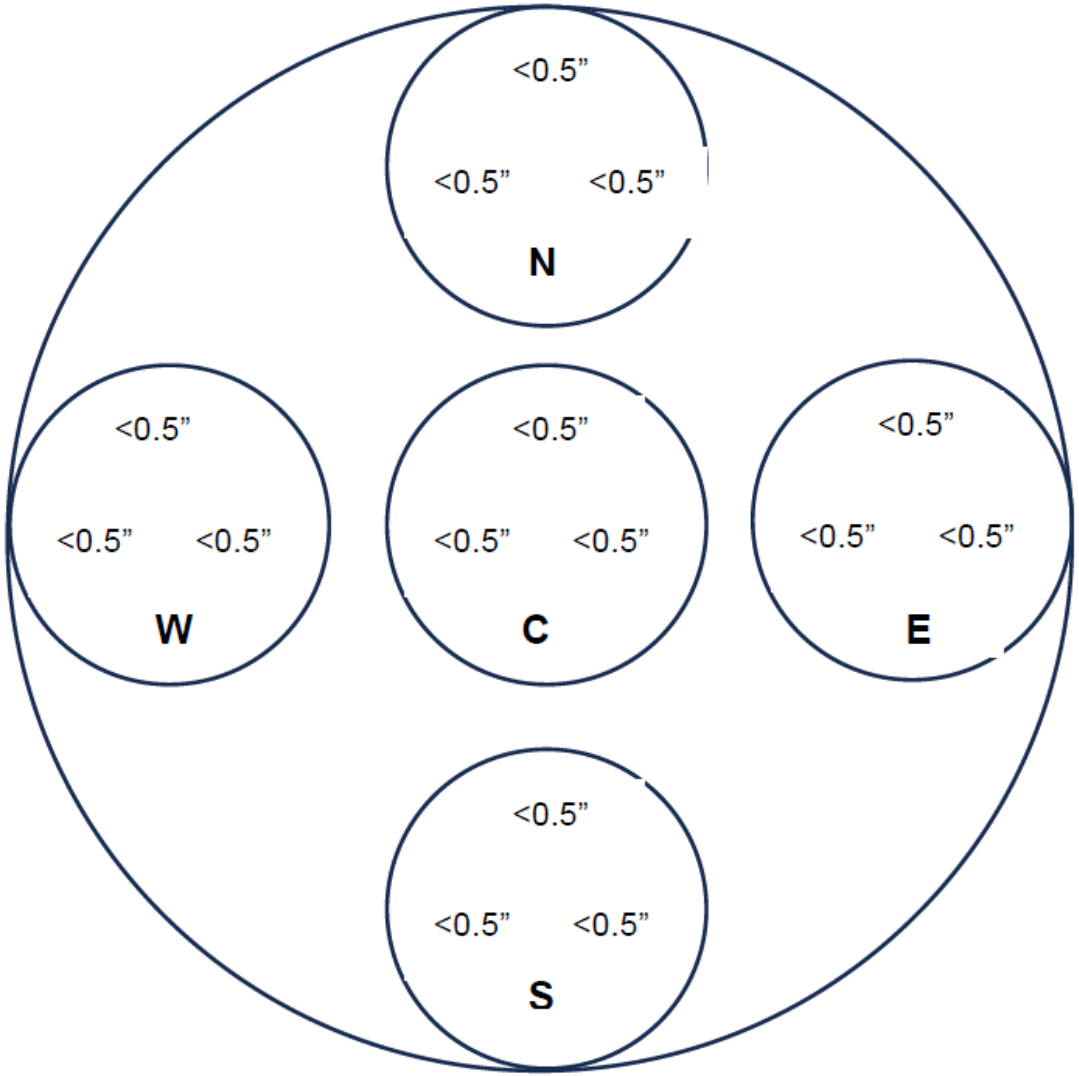
Installation

Installation

Installation

- Successfully drilled and poured the week of 02-24-2025
- Used slurry additive to keep the hole open and periodically topped off the slurry over 2 days
- For sediment removal on 02-27-2025:
  - Tried an airlift, but were concerned with hole sloughing
  - Used a cleanout bucket instead- waited 1/2 hour tested, waited 1 hour
  - the slurry had significantly less than 1% sand after cleanout
  - Bottom met spec- with SID- more than 50% of test locations with < ½” of sediment

SID results



Installation

Installation

Installation

Installation

Installation

Installation

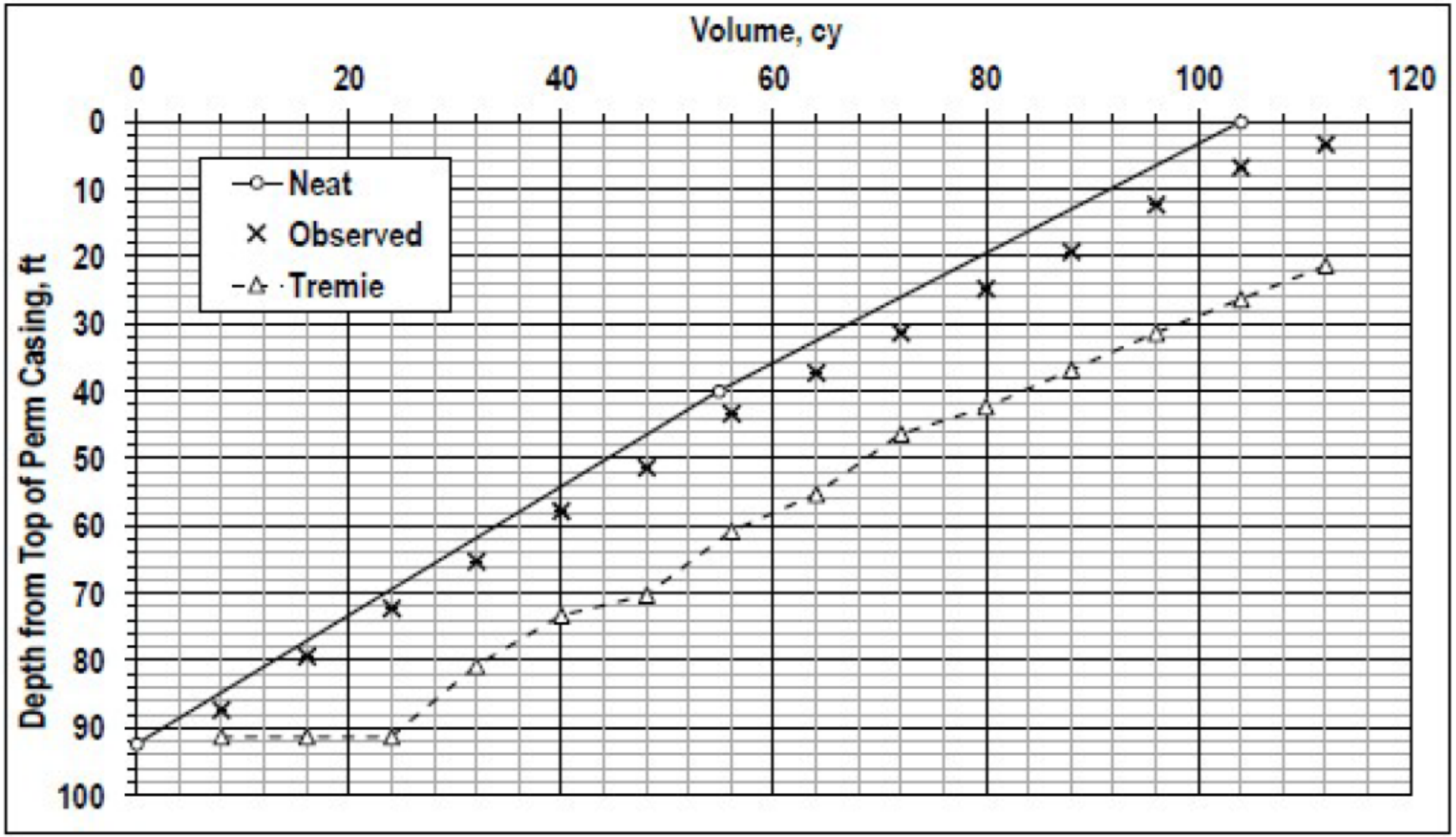
- 2 crane pick to pick the rebar cage
- Tremie took 1 hour to install.
- Pour took 2.5 hours
- The concrete was placed via. pump truck to a tremie pipe. Veit had to constantly pump out slurry as the concrete was placed, but still maintain the 5’ of head.

Picking and moving the cage

Picking and moving the cage

Installation

Installation



Post- Installation

Mass Concrete Temperature sensor

Post- Installation: CSL Testing

Results

Based on our analysis and review of the collected data for the center pier East and West Drilled Shafts at Bridge 27016, no records exhibited velocity reductions greater than ten percent. Therefore, we assign these shafts a “Good” rating and conclude these shafts are of sound integrity, in accordance with the criteria presented in Table 4.

Completed Pier

Construction Progress

Historic Flooding

- Heavy rains in May of 2025 led to historic flooding throughout southern Minnesota
- Highway 93 project mostly underwater, with exception of portions of the Rush River Bridge
- 2025 Flood broke the previous flood elevation record at Henderson by over a foot
- Flood waters were within 1.5’ of the top of the levee
- Projected floodwaters on final product showed that 2 sections would have been under an inch or two of water.

Construction Progress

Thank you!