INDOT
BRIDGE DESIGN CONFERENCE
Drilled Shaft

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Derek Merida, VP/Bridge Operations,

Milestone Contractors

February 21, 2023

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When contractors like to use Drilled Shafts

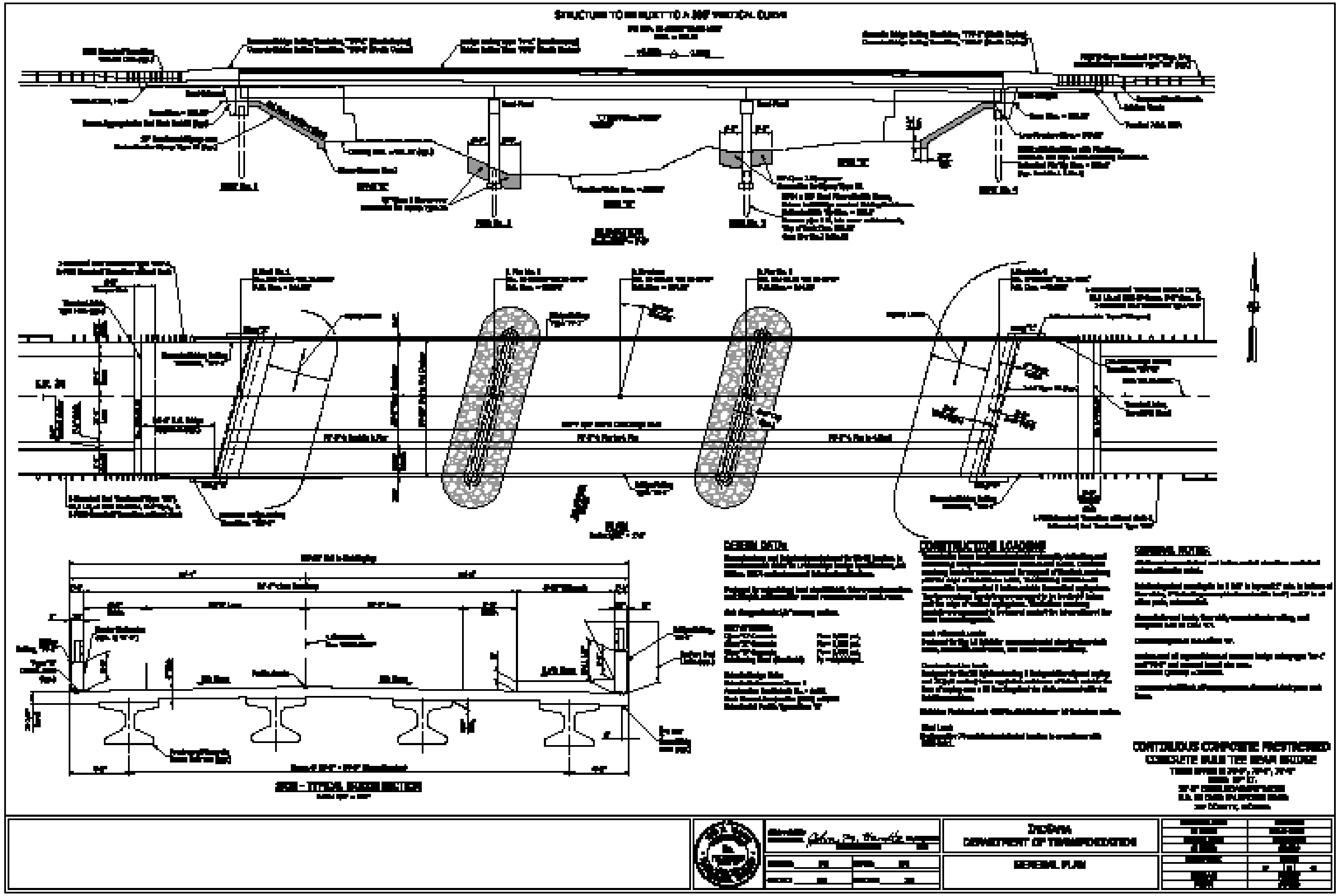
- Cofferdams – To eliminate the requirement of cofferdams that is
- Spread footer with multiple rows of piling
- Foundation seal is required
- Quality rock is reachable – 20' to 50' deep – but could be deeper

Drilled shaft in place of single row of piling?

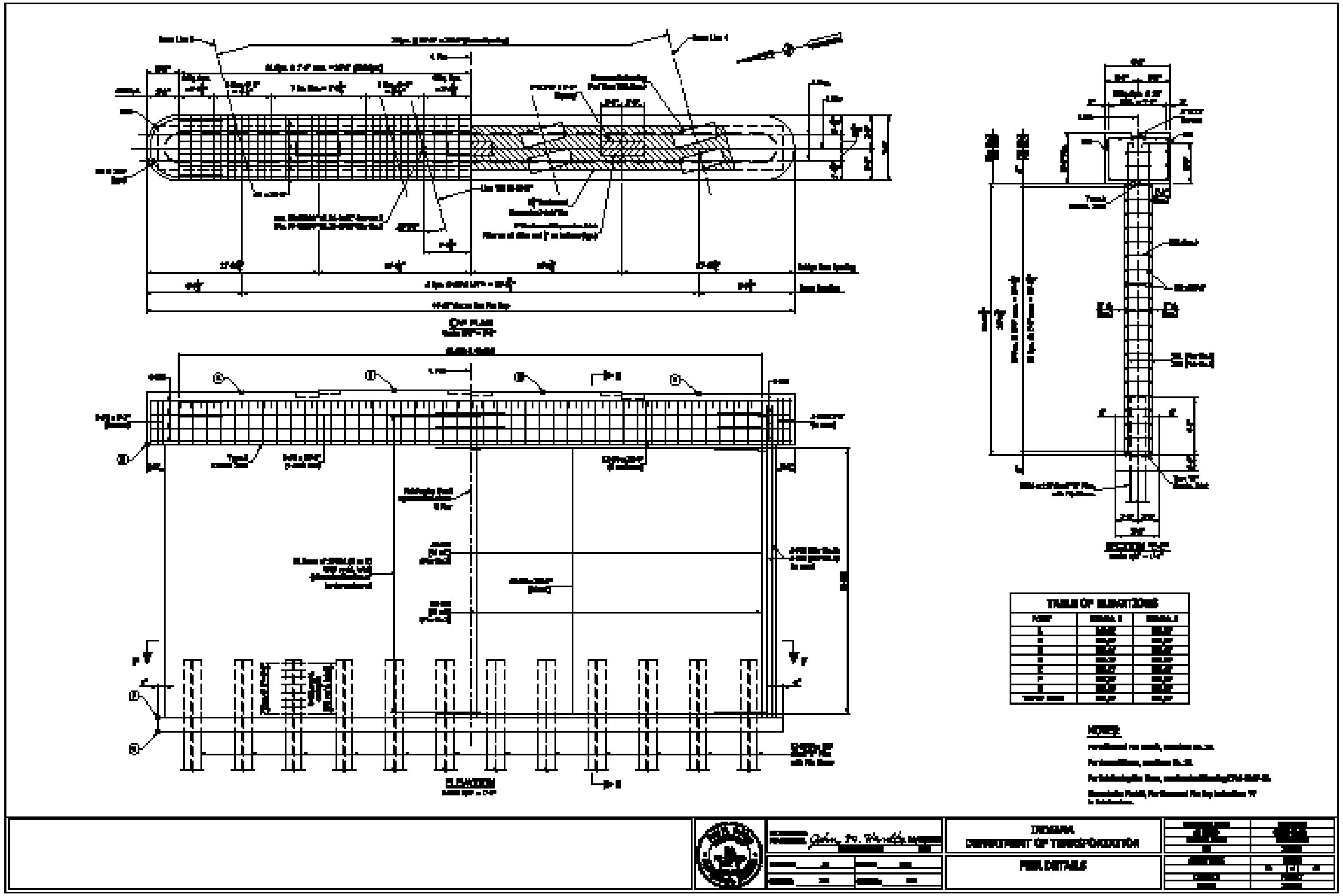
Typically only if a cofferdam is required

And cored holes in rock are required for the piling

SR 26 Jay Co Original



SR 26 Jay Co Original



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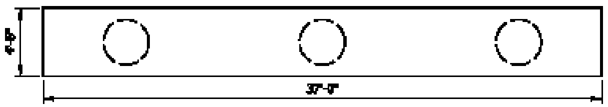
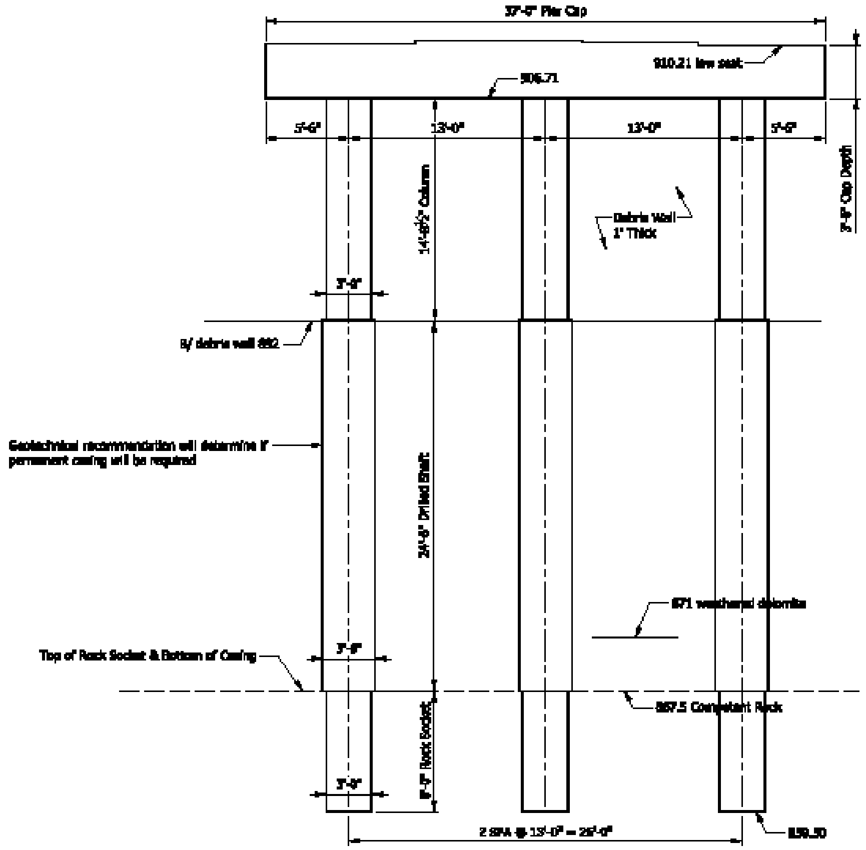
SR 26 Jay Co Drilled Shaft Option

Pier 2

Reinforcing Ratios:
Cap = #200/CYS
Column = #200/CYS
Shaft = #150/CYS
Rock Socket = #200/CYS
Debris Wall = 160 #/CYS

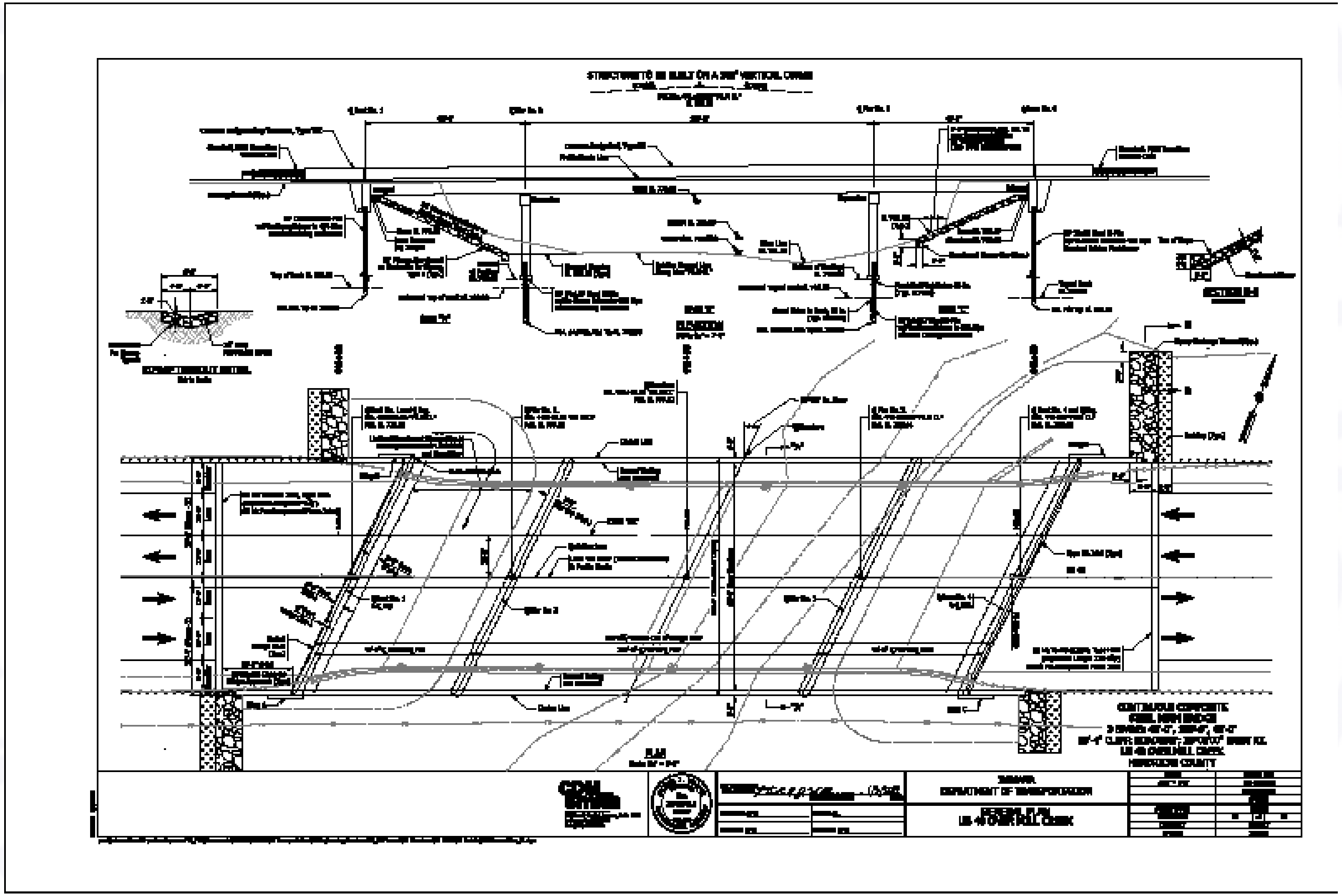


Pier 2 Cap Plan View

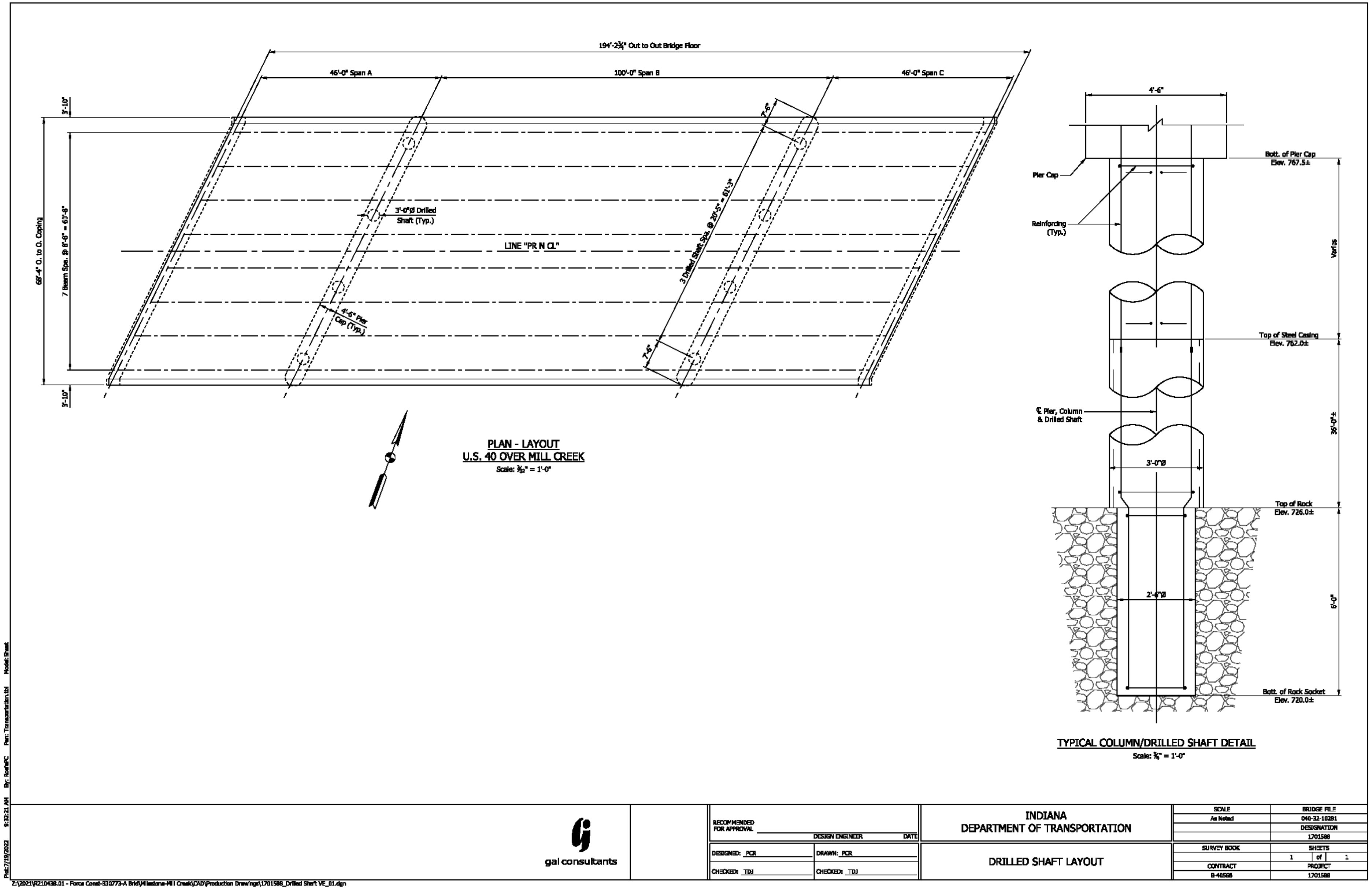


Pier 2 Elevation

US 40 Hendricks Co Single Row Piling



US 40 Hendricks Co Drilled Shaft Option



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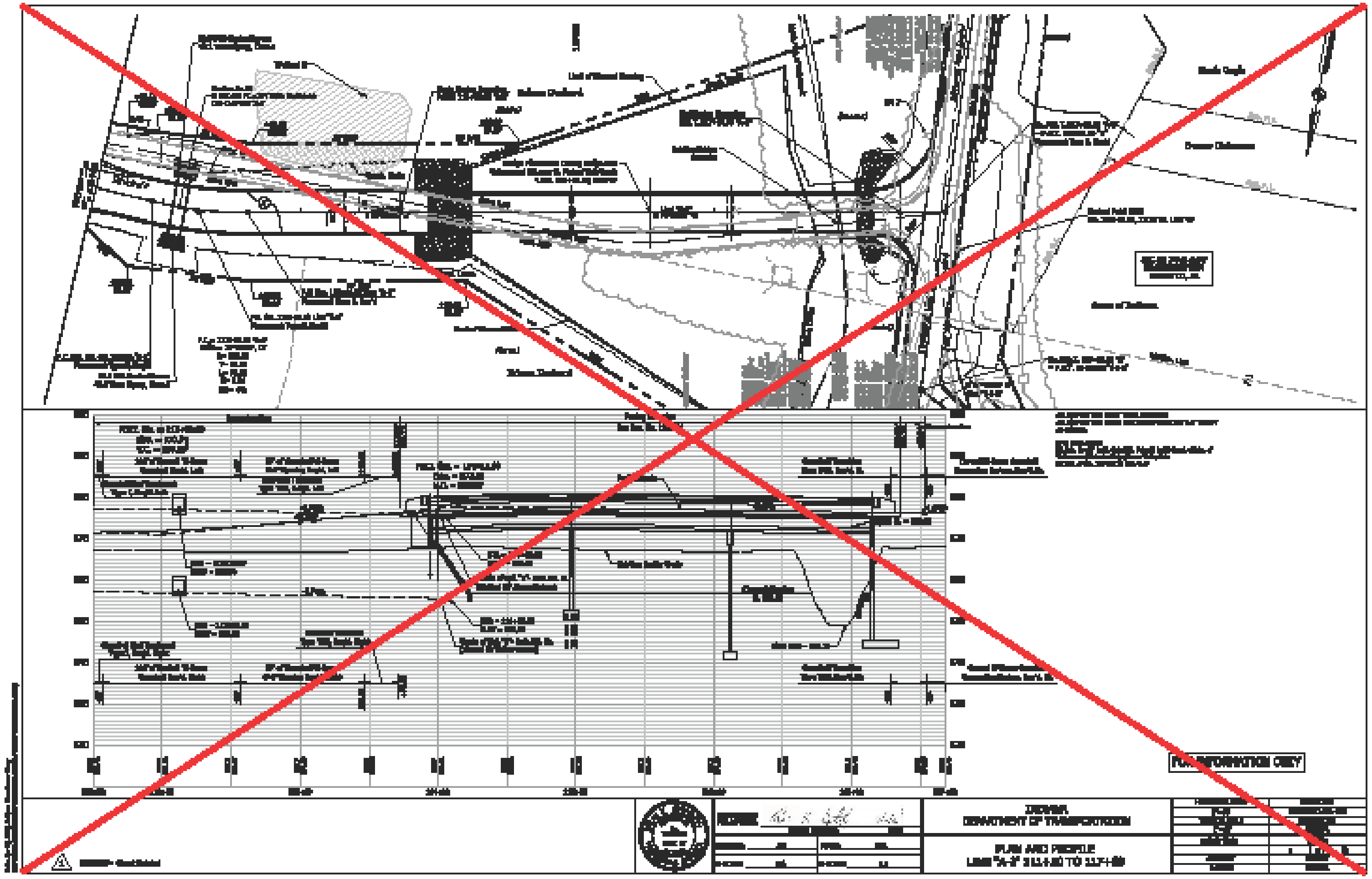
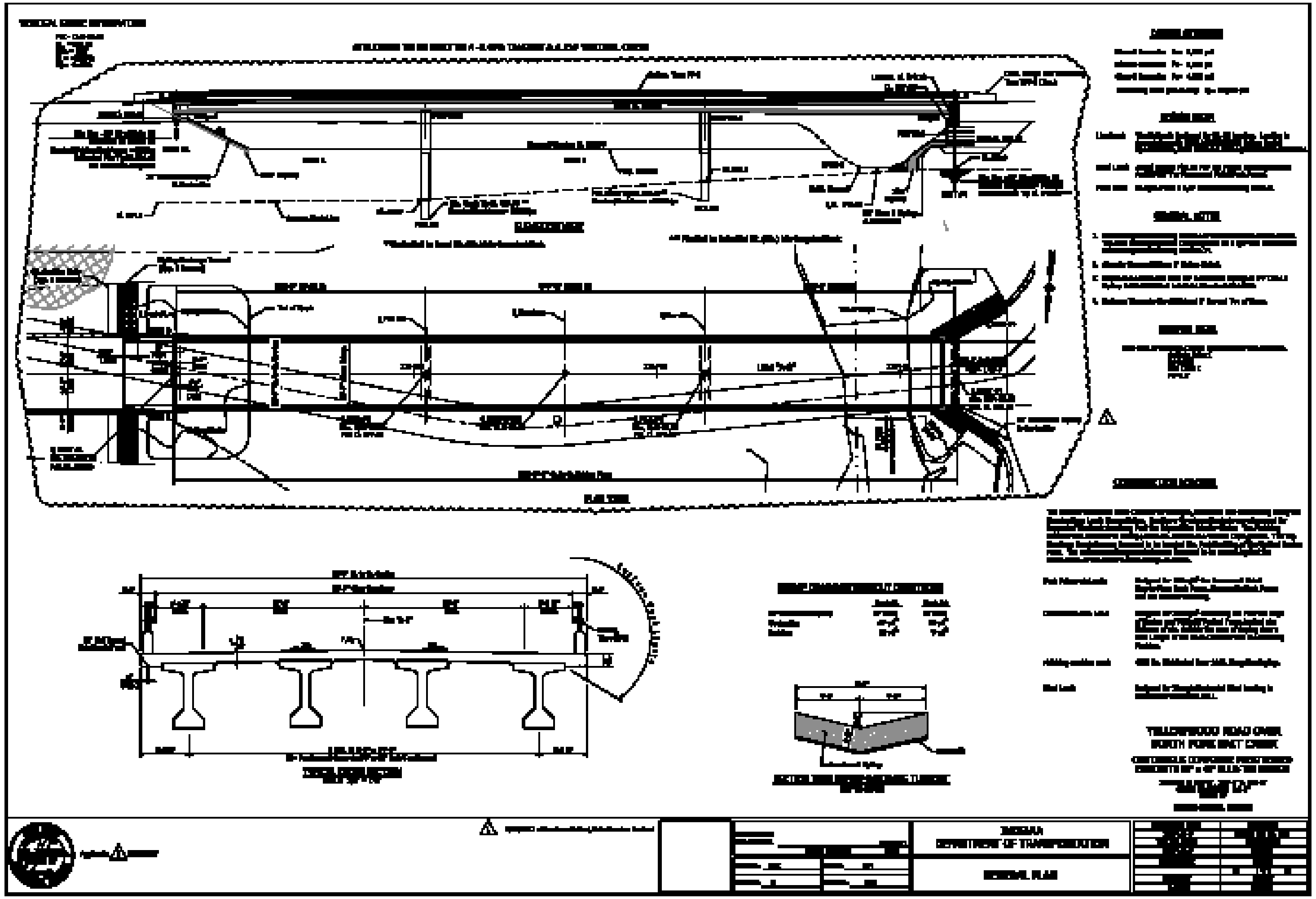
Other Uses for Drilled Shafts

- Spread footer on rock that requires cofferdam or shoring
- Location requires limited vibration

Yellowwood Rd Brown Co Original



Yellowwood Rd Brown Co Drilled Shaft Option



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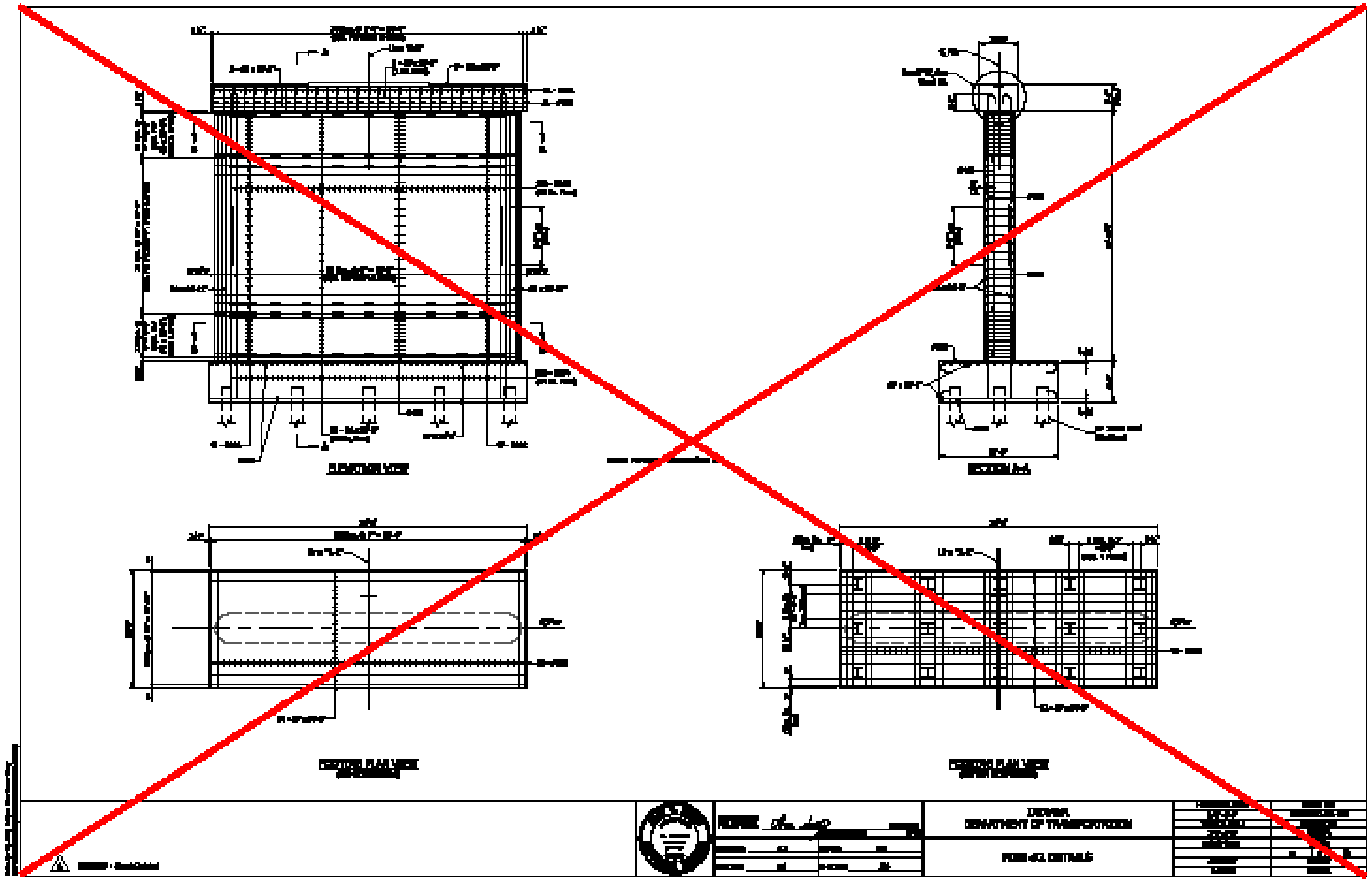
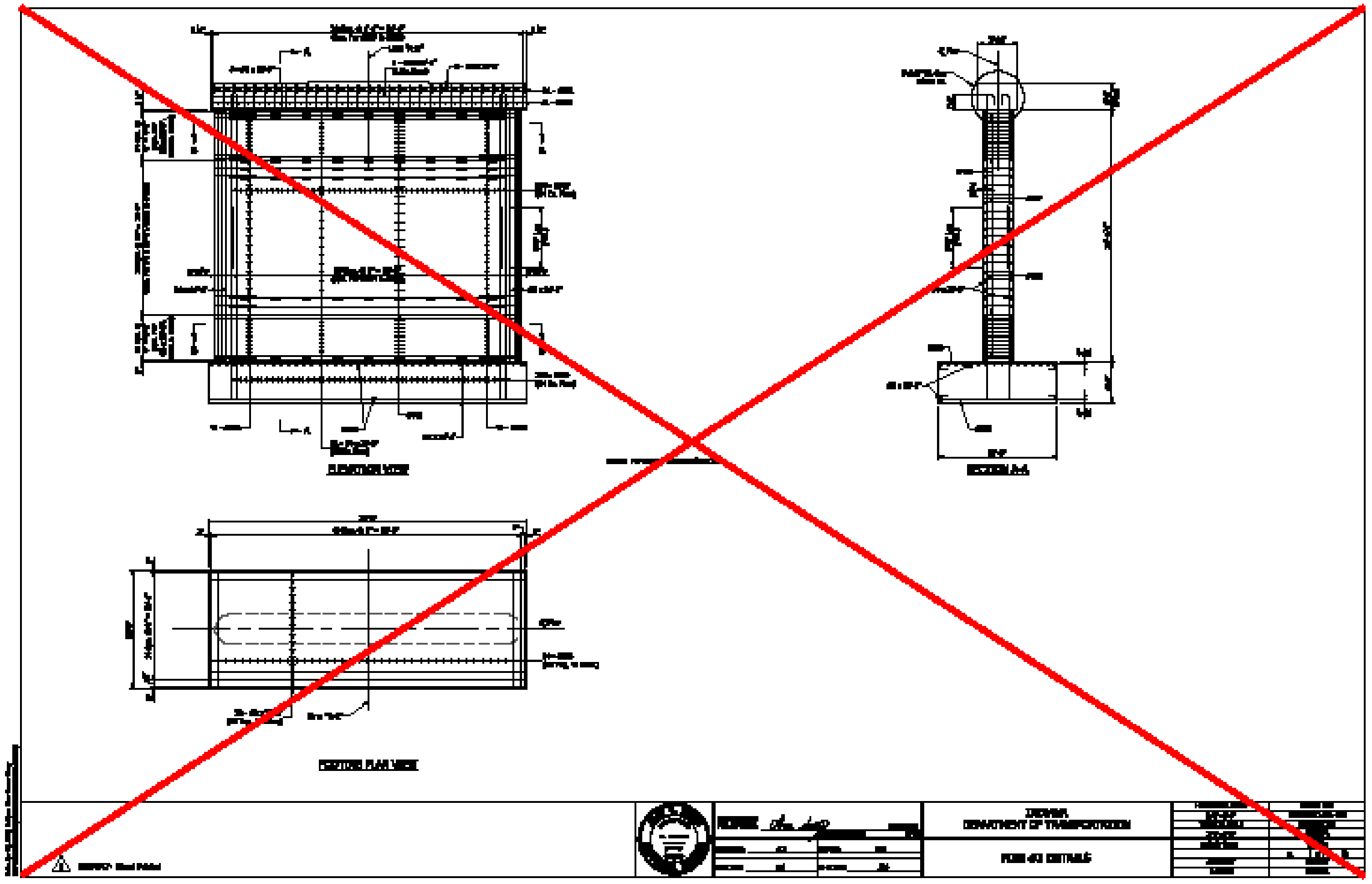
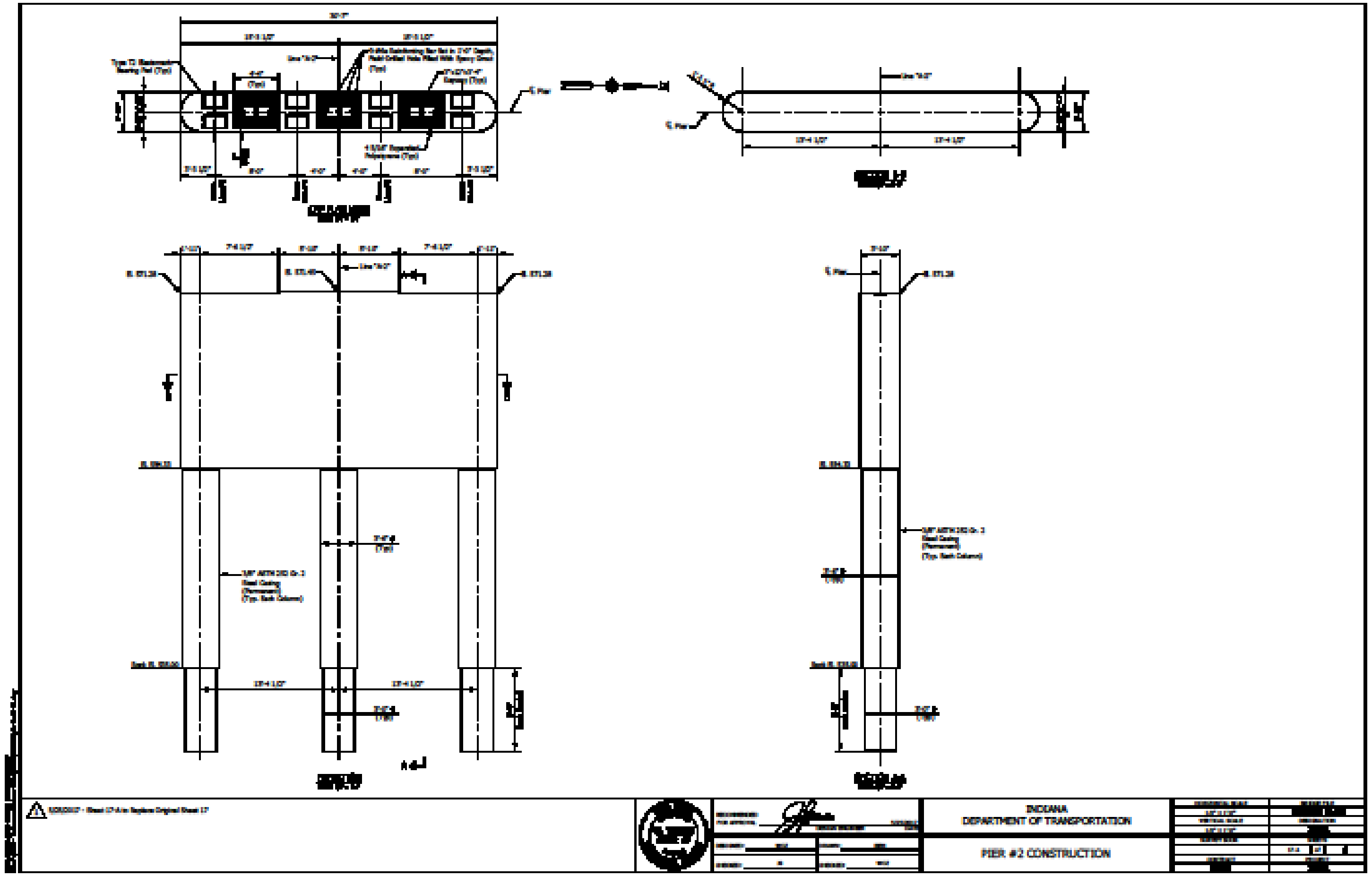
Yellowwood Rd Brown Co Original Pier 2

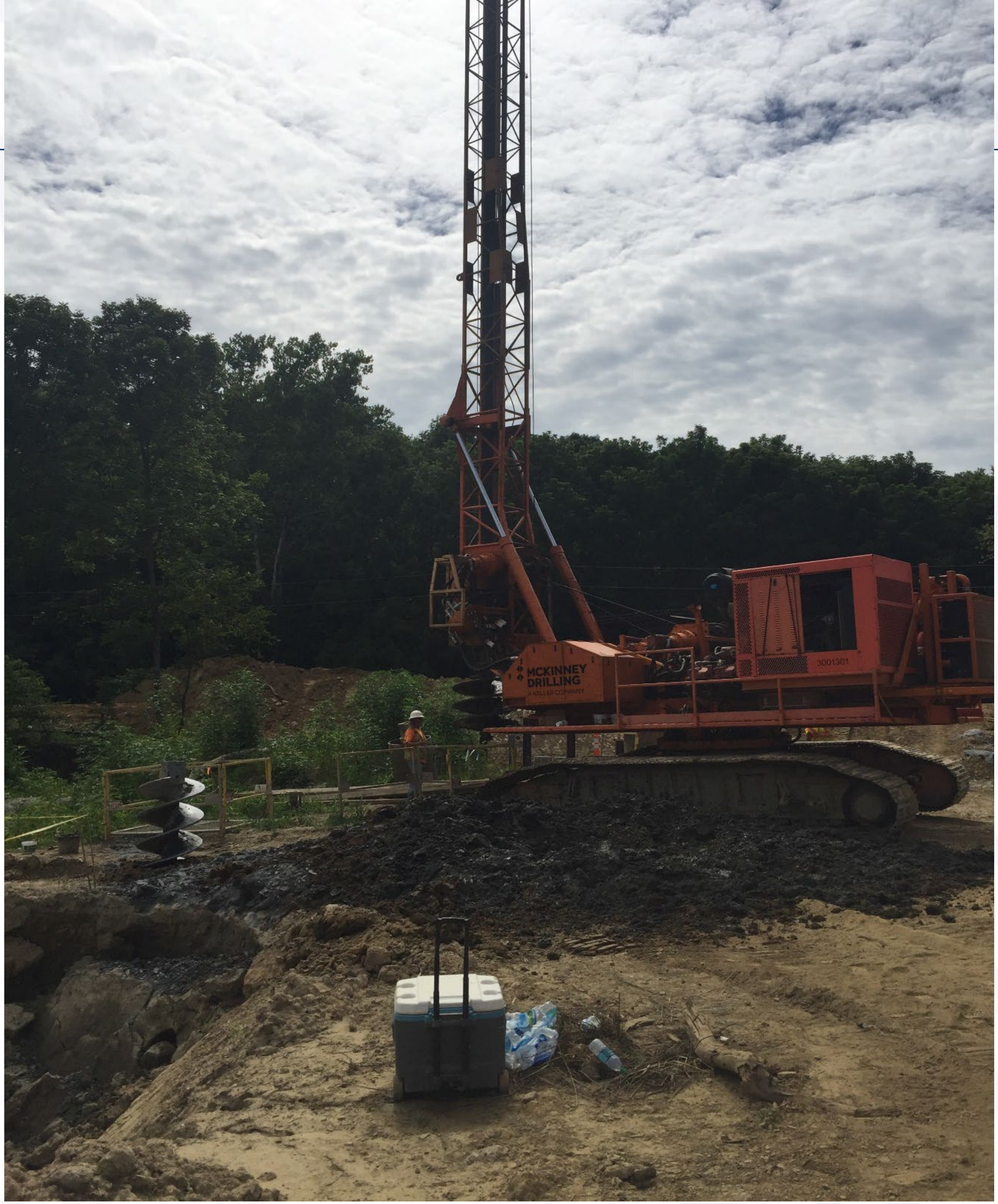


Yellowwood Rd Brown Co Original Pier 3



Yellowwood Rd Brown Co Drilled Shaft Piers





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Yellowwood Rd Brown Co

Yellowwood Rd Brown Co

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Yellowwood Rd Brown Co

Williams Covered Bridge

Huron-Williams Rd over E. Fork White River

Huron-Williams Rd over E. Fork White River

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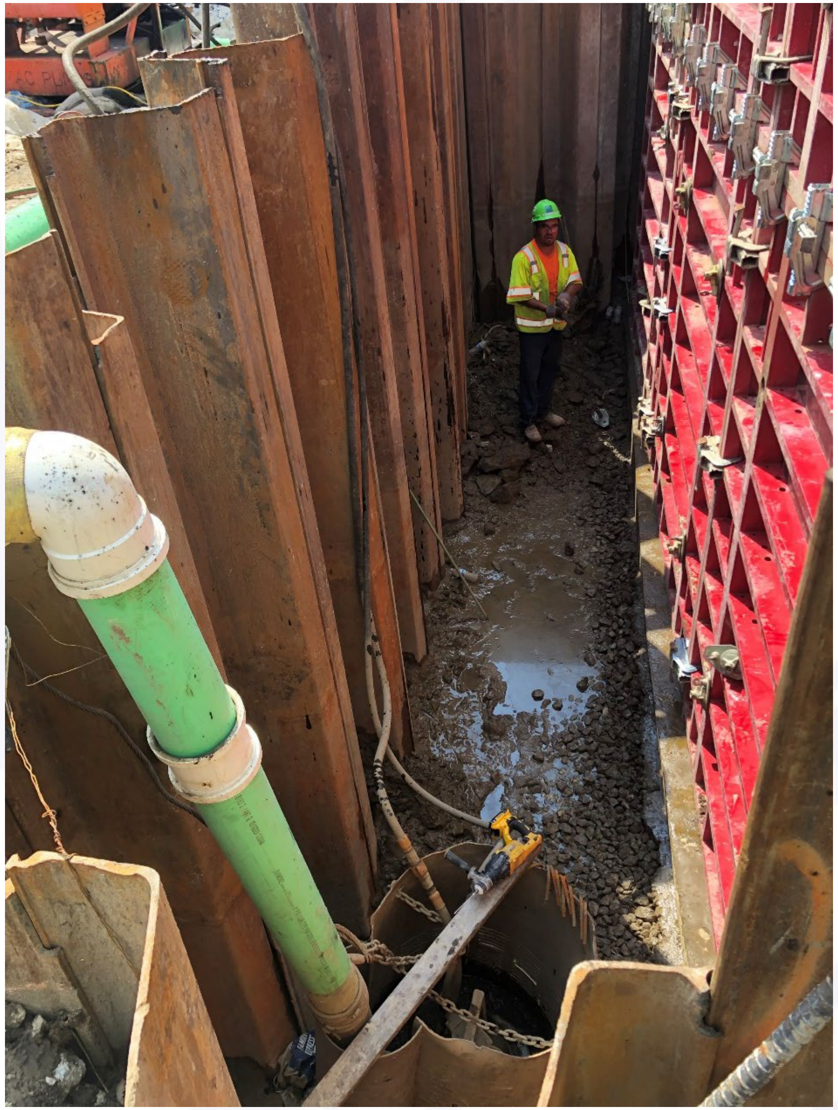
HAYES
DRILLING, INC.
SOILMEC



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Link-Belt
800


4x4

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February 21, 2023

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Few Cost Reduction Incentive (CRI) Projects

Contract No.	Plan Contract Cost ($)	CRI Cost ($)	Total Cost Savings ($)	Redesign Fees ($)	Net Savings ($)
R-33239	1,155,659.76	965,578.54	190,081.22	61,500.00	128,581.22
R-41542	1,895,370.70	1,631,528.57	263,842.13	112,350.00	151,492.13
B-39294	1,512,251.77	1,044,081.70	468,170.07	76,000.00	392,170.07
B-39818	N/A	N/A	132,000.00	47,000.00	85,000.00
B-40568	962,477.43	824,085.64	138,391.79	40,000.00	98,391.79

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Foundation Selection Criteria

- Cost: Material, Labor, Inspection and Time
- Structural Loading Requirements: Compression, Uplift, deformations, cyclic and redundancy
- Design, Construction & Inspection: Standard practice and familiarity; Codes
- Noise, Vibration, clearance
- Rock, Karst, Boulders
- Contaminated Sites
- Availability: Materials, equipment, skilled contractors

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Drilled Shaft Advantages

- Economics
- Minimizes Pile Cap dimensions
- May eliminate Cofferdams
- Integral shaft-column design minimizing costs
- Easy installation through boulders and cobble without deflections
- Use of fewer shafts than piles
- Eliminates vibration and noise issues
- Overcomes deeper scour depths

Drilled Shaft Disadvantages

- Requires construction expertise
- Quality is sensitive to construction procedures
- Requires specialty contractors, cleanout tools, rotators, oscillators, etc.
- Requires specialty inspection and acceptance:
  - integrity and performance testing, concrete samples, volume plots, NDT testing
- Care needed when artesian pressures exist
- Not recommended for contaminated sites
- Fewer foundation support elements, hence, less redundancy
- Requires specialty tests to prove capacity – Osterberg Load Test
- Requires comparatively high deflections to mobilize shaft resistance

Driven Pile Advantages

- Economics
- Common HP and Pipe piles readily available
- Uses contractor's crane and forces
- No specialty contractor needed
- Good bid prices generally
- Pile groups provide design redundancy
- Easy to add additional piles if needed during construction redesign

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Driven Pile Advantages

- Pile lengths relatively easy to extend with welding and splicing
- Inspection is relatively easy
  - Dynamic Formulae
  - It is a tested pile
  - Pipe piles can be visually inspected
  - PDA/CAPWAP can aid in assessing pile damage
- Soil is not removed unless open ended, No spoils, No caving, heave, or loss of support
- Loads are light enough to perform Static Load Tests to failure

Driven Pile Advantages:

- Standard Specifications straightforward
- Greater familiarity since driven piles are regularly installed
- Less complicated than wet/casing drilled shafts
- Greater speed since readily available prefabricated elements
- Work area is neat and clean as no soil spoils
- Practical when artesian pressures exists

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Driven Pile Disadvantages

- Noise and vibration limitations may limit the foundation choice
- Impact hammers may cause distress to nearby older structures and utilities
- Displacement piles may cause heave
- Cannot penetrate Rock
- Cobbles and Boulders may cause damage, misalignment and create drivability issues
- Thicker walls and larger diameter pile may be costly

Driven Pile Disadvantages

- Closed ended large diameter piles difficult to drive
- Sometimes difficulty in meeting uplift and fixity requirements
- Penetrating hard material without damage may require pre-drilling or pre-boring, reducing pile economy
- Greater lateral loads may require many piles or battered piles
- Difficult to install in low headroom conditions

Generalized Comparison

Driven Piles

- Smaller element
- Lower Capacity
- Lower cost
- More elements used
- Highly redundant
- Simple field inspection

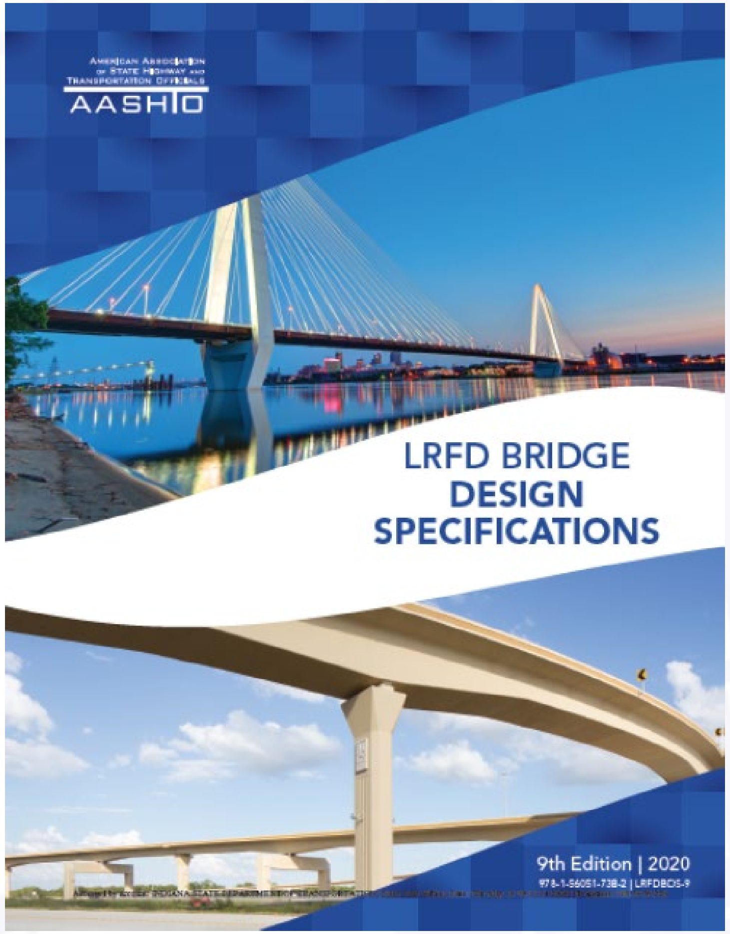
Drilled Shafts

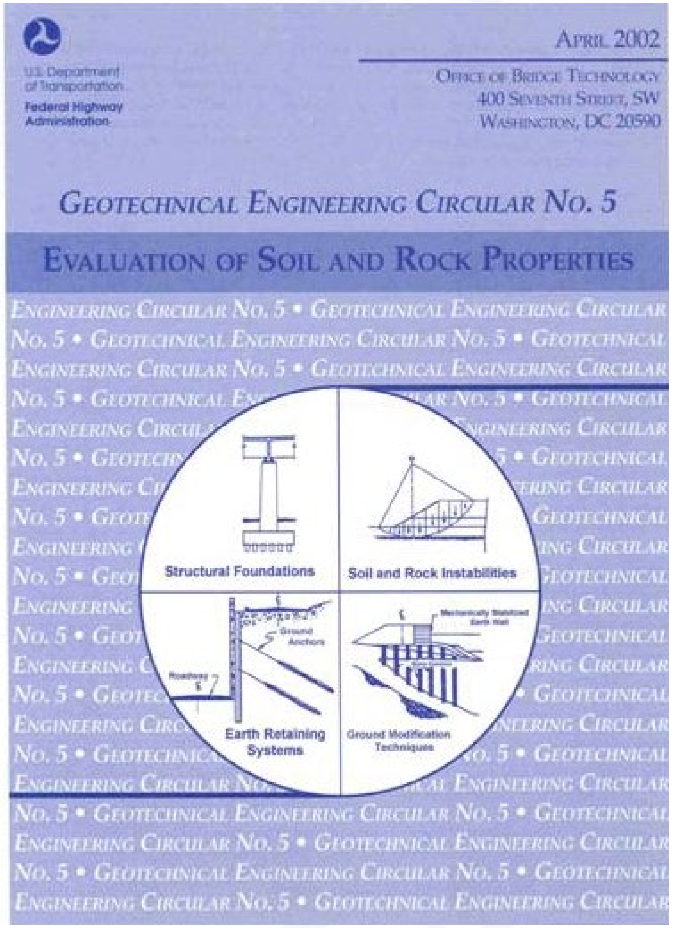
- Bigger elements
- Higher capacity
- Higher cost
- Fewer elements used
- Little to no redundancy
- More complex field inspection

Essentials For Successful Drilled Shaft Design & Construction

- Understand drilled shaft use
- Understand Geotech investigations and site characterization
- Understand design and specifications
- Educate constructors and designers about common issues so that good foundation construction practices are followed
- Achieve quality assurance

Available Resources





Available Resources


U.S. Department of Transportation
Federal Highway Administration

Publication No. FHWA-NHI-10-016
FHWA GEC 010
May 2010

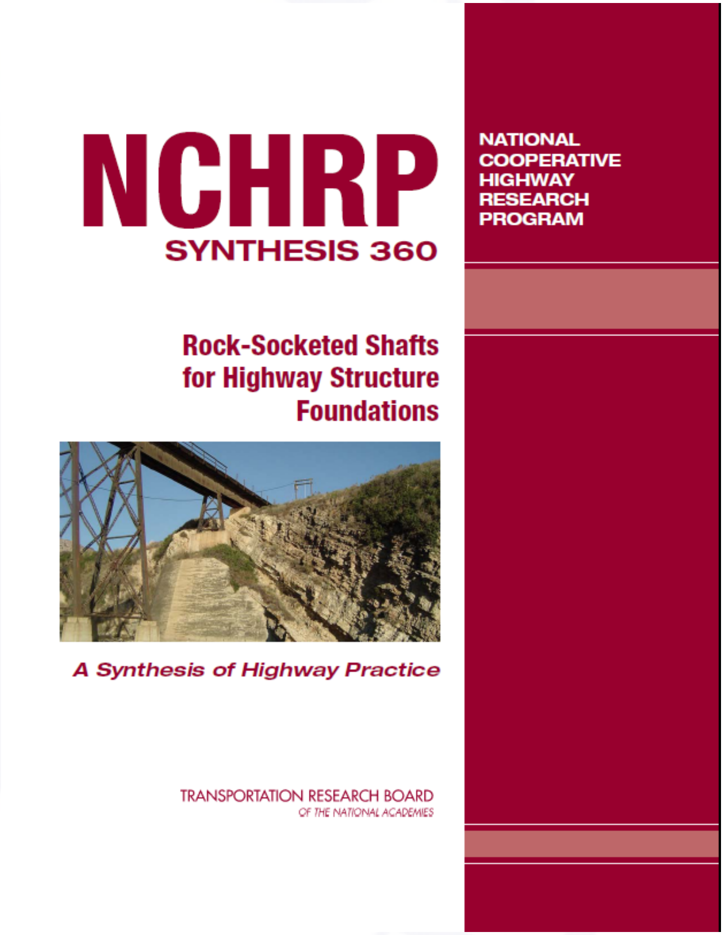
NHI Course No. 132014

Drilled Shafts: Construction Procedures and LRFD Design Methods

Developed following:

AASHTO LRFD Bridge Design Specifications, 4th Edition, 2007, with 2008 and 2009 Interims.

NHI
NATIONAL HIGHWAY INSTITUTE


NCHRP
SYNTHESIS 360

Rock-Socketed Shafts for Highway Structure Foundations

A Synthesis of Highway Practice

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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Available Resources

IN.gov An official website of the Indiana State Government | Accessibility Settings | Language Translation | Governor Eric J. Holcomb

MENU **Indiana Department of Transportation** Search INDOT

Reccuring Special Provisions and Plan Details

INDOT > Doing Business with INDOT > Standards & Specifications > RSP Home > Division 700

Effective for Lettings with the 2022 INDOT Standard Specifications

| RSP Home | Division 100 | Division 200 | Division 300 | Division 400 |

| Division 500 | Division 600 | **Division 700** | Division 800 | Division 900 |

***Revision Date = Date the Recurring Special Provision was Added or Revised (mm/dd/yy)**
****Letting Date = Effective for use on lettings on or after this date (mm/dd/yy) - Be sure to select the RSP or RPD for the correct letting date you need**

Division 700 - Structures

722-B-318	Bridge Deck Overlays	06/16/22	12/01/22
724-B-086	Approved Expansion Joint SS Devices	03/21/06	09/01/13
724-B-147d	Alternate SS Joint Part	01/22/01	01/22/01
725-R-741	Cured-In-Place Pipe Liner, CIPP	09/16/21	03/01/22
725-R-746	Slip Lining of Existing Pipe	10/21/21	03/01/22
728-B-203	Drilled Shaft Foundations	04/25/21	09/01/21
731-R-743	Mechanically Stabilized Earth Retaining Walls	12/17/21	06/01/22
734-R-567	Limiting Movement Criteria For Permanent Earth Retention System For Cut-Wall Application *(edit.)*	08/20/09	09/01/13
738-B-297	Polymeric Concrete Bridge Deck Overlay	03/17/22	09/01/22
738-B-297	Polymeric Concrete Bridge Deck Overlay	12/16/22	03/01/23

https://www.in.gov/dot/div/contracts/standards/rsp/sep21/sep21.htm

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FHWA GEC 10

- LRFD design – Chapter 10
- Design process – Chapter 11
- Lateral loading design – Chapter 12
- Axial loading Design – Chapter 13
- Shaft group design – Chapter 14
- Extreme event design – Chapter 15
- Structural design – Chapter 16
- Specifications – Chapter 18
- Quality Assurance – Chapters 19 & 20

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Why is Geotechnical Investigation Required?

- Determine site geology and groundwater conditions
- Determine appropriate soil and rock strength parameters
- Prepare geotechnical design report
- Perform engineering analyses for design
- Establish appropriate construction methods
- Prepare specifications
- Recommend load testing and QA program
- Make reliable cost estimates

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Role of the Geotechnical Team

- Communicate site conditions and design recommendations to the design and construction teams
- Recommend alternate foundation elements within the geotechnical recommendations:
  - drilled shaft if cofferdam and rock is shallow,
    if difficult soils are present,
    and if scour depths are deep
- Aid in preparation of bid documents
- Aid in planning construction
- Help minimize change orders
- Provide technical support during design and construction

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Recap Foundation Selection Considerations

- Time, risk, reliability
- Design Needs: axial, lateral, moment, extreme event
- Material, labor, construction cost
- Site access, causeway, congested site
- Impact on pile/shaft cap and structural design
- Noise, vibration, spoils, pollution
- Adaptability, ability to change or retrofit
- Sensitivity to construction procedures, site conditions
- Specifications, regulations
- Construction, inspection, acceptance/assurance expertise
- Weather, groundwater, and other impacts

Keys to a successful drilled shaft project

- Minimize construction issues through early recognition of geotechnical problems during design stage and designing accordingly
- Perform adequate subsurface investigation in advance of final design
- Perform Osterberg load test or APPLE Load test at the start of construction or at design stage
- Perform Integrity testing – CSL, PIT/IRS & TIP during construction
- Select appropriate methods and materials for excavation support (dry, casing, slurry, combined)
- Check appropriate drilling equipment and tools for excavation – Quality control plan
- Match field inspection (quality assurance) procedures with construction procedures

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Conclusion

- Drilled shaft has excellent strength in flexure and high axial resistance
- The completed drilled shaft must be a competent structural element that provides sufficient structural strength in compression, tension and flexure to transfer the loads from the structure
- Carefully planned construction methods in conjunction with careful field observation and oversight are critical to a successful drilled shaft
- Non-destructive test methods such as CSL, IRS and TIP are essential for shafts build under wet/slurry methods
- Cost effective design decisions – Good economics and engineering - Good communication between construction, geotech & design

Questions?

Osterberg Load Test SR 57

Construction observation

Pulling
Inner
Casing

Concrete
Not over
flowed

Pulling
Outer
Casing







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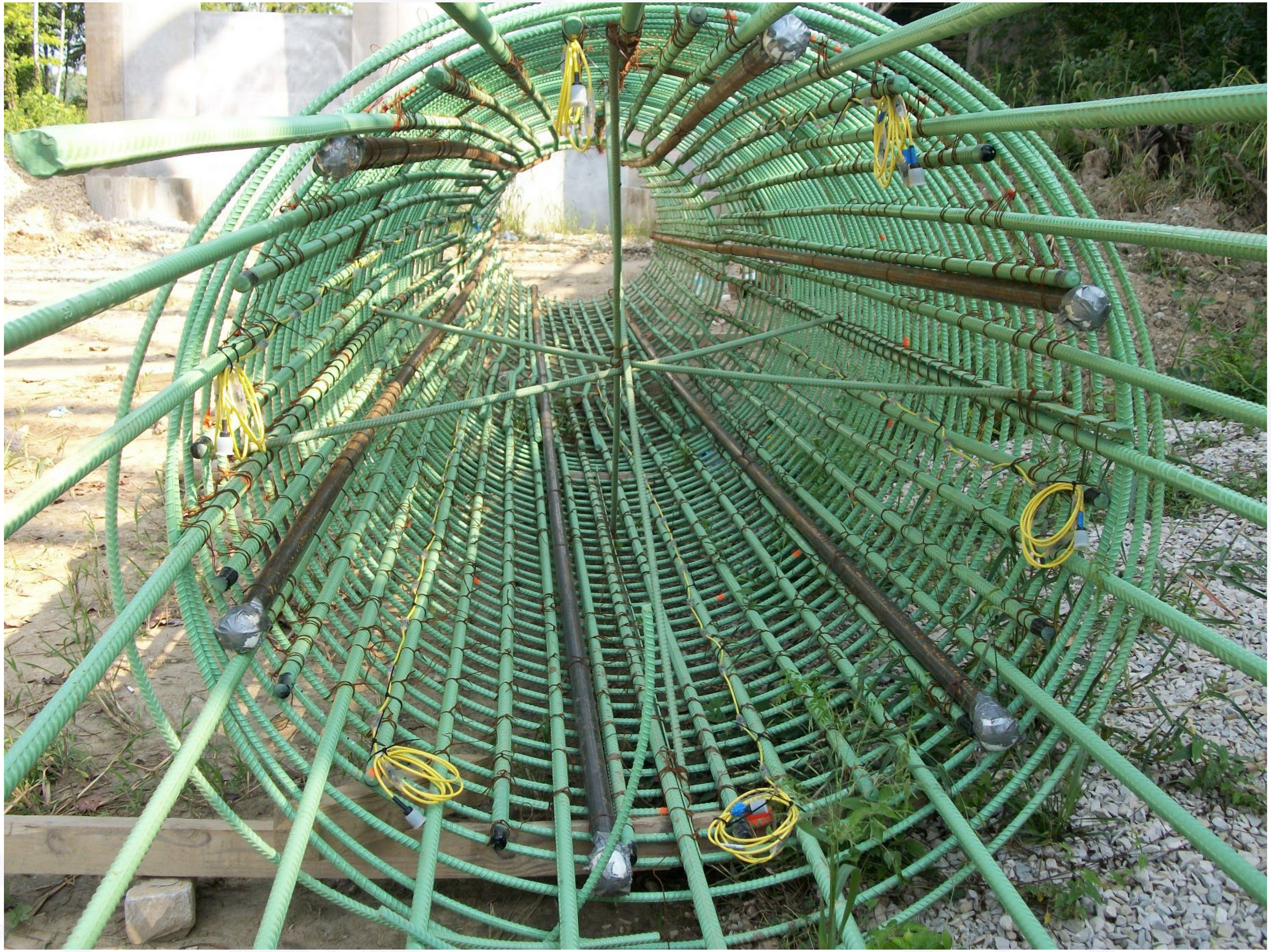
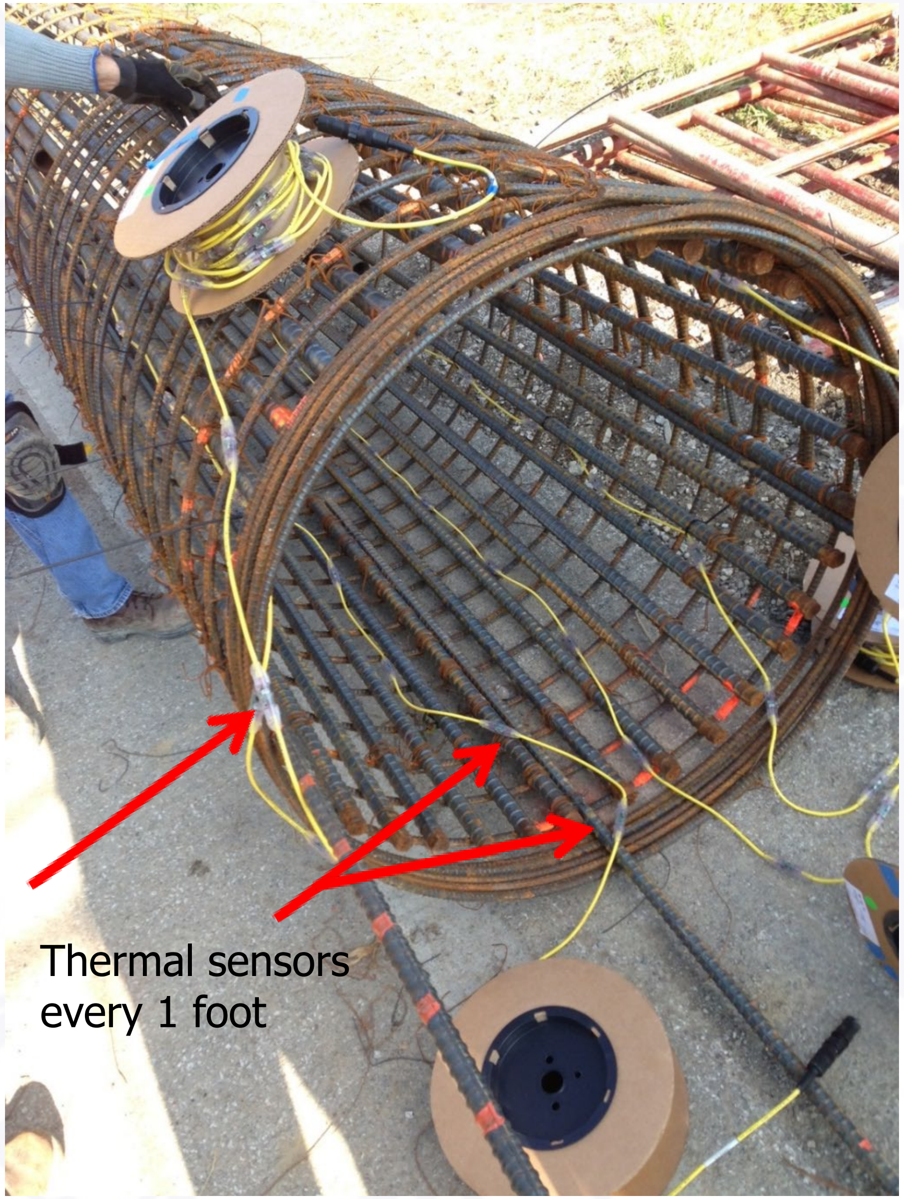
Construction Issues

Parallel CSL Tubes?



Thermal Integrity Profiling



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Centering the Reinforcing Steel

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Drilled Shaft I-465 Near I-74 on west side of Indy

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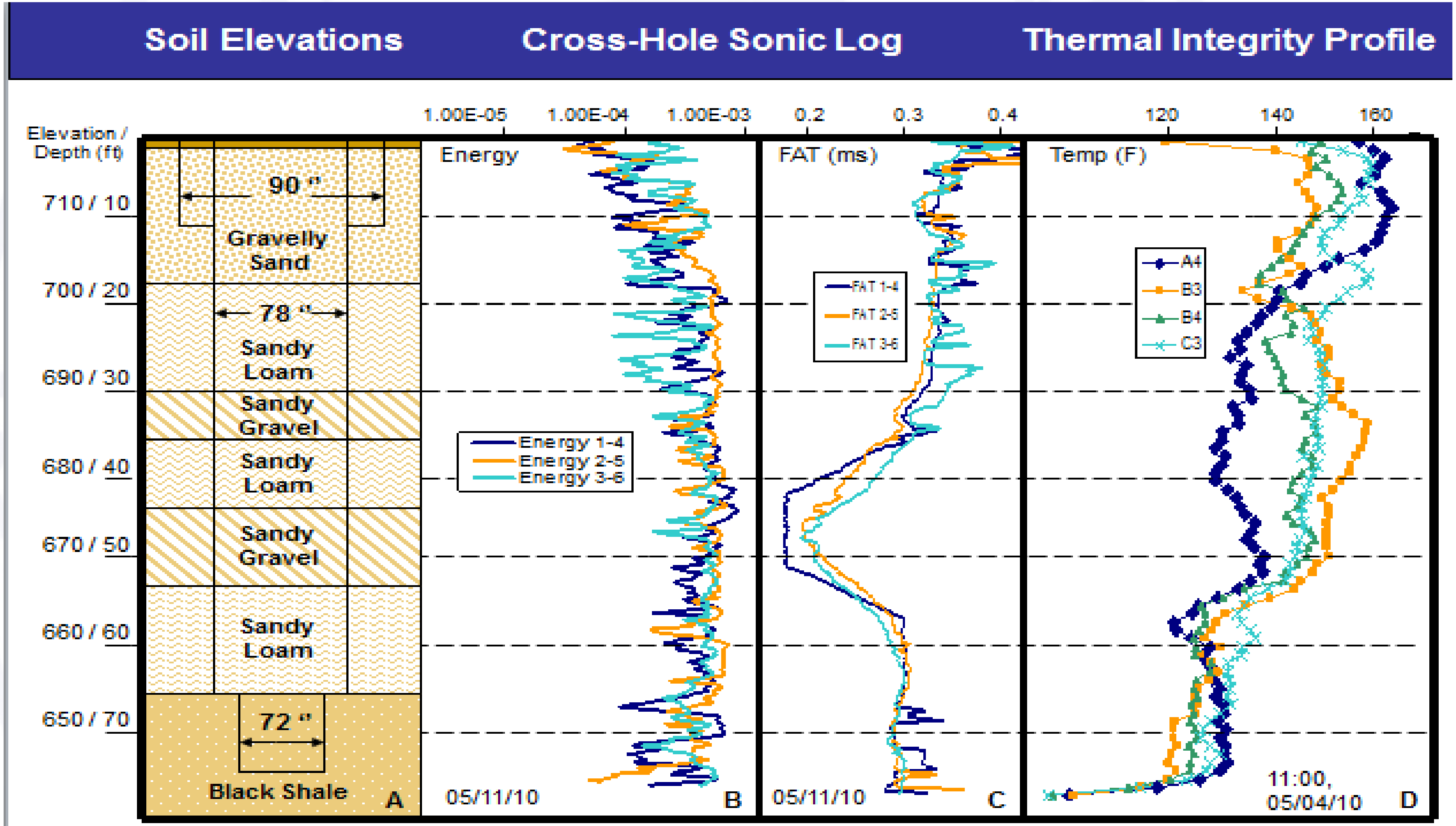

Soil Elevations
Cross-Hole Sonic Log
Thermal Integrity Profile
Elevation / Depth (ft)
710 / 10
700 / 20
690 / 30
680 / 40
670 / 50
660 / 60
650 / 70
90 "
Gravelly Sand
78 "
Sandy Loam
Sandy Gravel
Sandy Loam
Sandy Gravel
Sandy Loam
72 "
Black Shale
A
1.00E-05
1.00E-04
1.00E-03
Energy
Energy 1-4
Energy 2-5
Energy 3-6
05/11/10
B
0.2
0.3
0.4
FAT (ms)
FAT 1-4
FAT 2-5
FAT 3-6
05/11/10
C
120
140
160
Temp (F)
A4
B3
B4
C3
11:00, 05/04/10
D