Unlocking the Potential of Buried Steel Structures

Building Better Bridges in 2025
Short Span Steel Bridge Alliance
April 23, 2025

Joel Hahm, PE

Senior Engineer

Contech Engineered Solutions, LLC

Outline

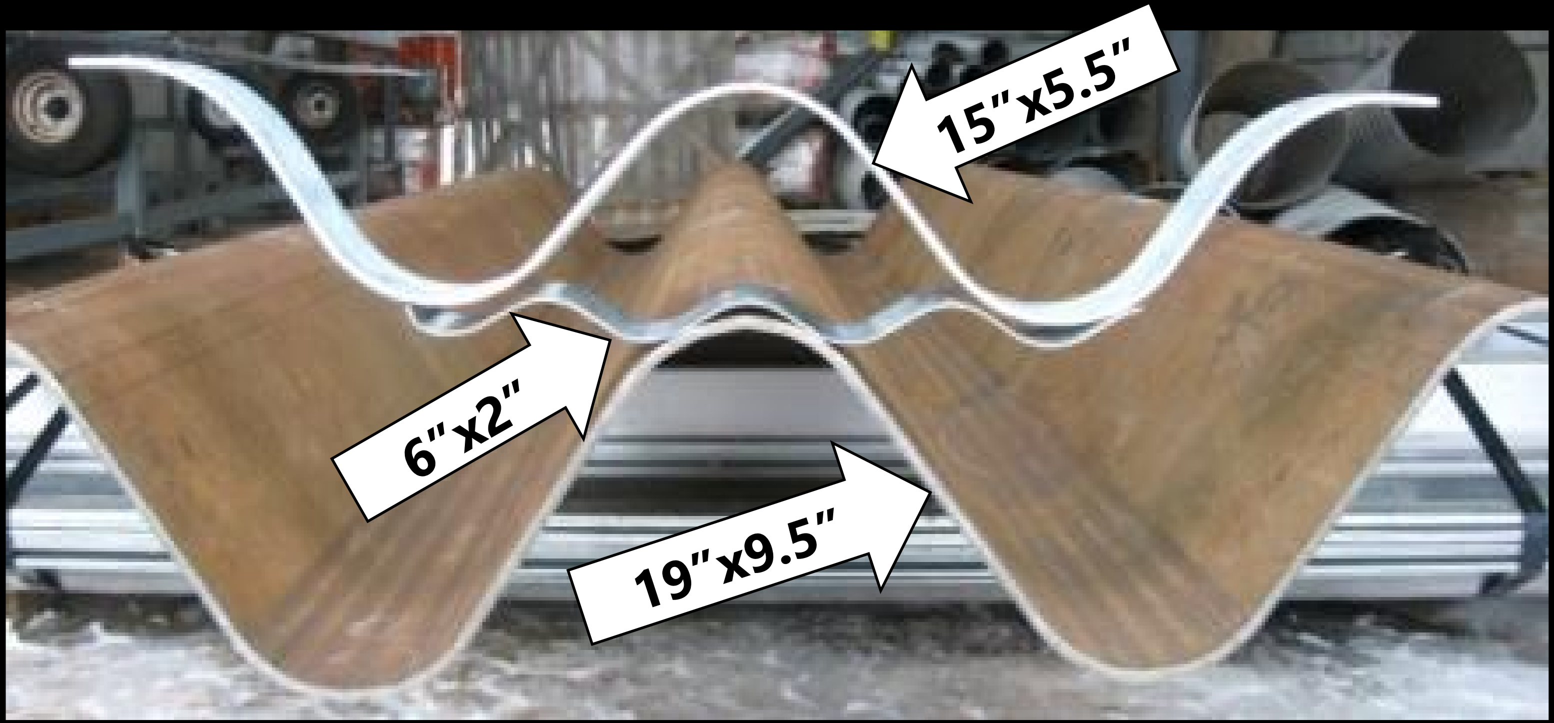
- Introduction to Buried Bridges
- How to Evaluate a Potential Buried Bridge Project
- Case Studies & Example Projects

Definition of Buried Bridges

- >20’ span buried structure that works with granular backfill to support loads through soil-structure interaction
- Made with corrugated metal - Flexible & able to accommodate differential movement
- Subject of numerous webinars, conference sessions, & workshops – design, ABC, resilience, durability / service life, large span applications, load rating, low volume roads, and other topics
- Meet governing agency (e.g. AASHTO, CHBDC, etc.) materials, design, construction, and load rating requirements.

Buried Bridge Materials

- Shallow Corrugated Steel Structural Plate (6” x 2” profile) or aluminum (9” x 2.5” profile)
- Deep Corrugated Steel Structural Plate (> 5” corrugation profile depth)
- Deep Corrugated is ~9x stiffer than shallow corrugated steel & 6.25x stiffer than aluminum
- Deep Corrugated is ~33% stronger than shallow corrugated & ~100% stronger than aluminum.
- Aluminum is ~35% of the weight of steel
- Structures are flexible - differential settlement tolerance of ~6” over 50 ft.



Advantages & Applications

- Wildlife Crossings / AOP
- Value Engineered Solutions
- Grade Separation
- Challenging Geotechnical Conditions
- Bridge Replacement / Rehabilitation
- Single Span Alternative to Multi-Cell Crossings

- Structurally Redundant / Resilient
- Lower Cost Foundations
- Reuse Bridge Foundations
- Emergency / Temp / Detour Bridges
- Staged Construction
- No "Bump at the end of the bridge"
- Low Maintenance Cost & Easy to Inspect
- Able to Carry Heavy Loads

Durability & Service Life

- **Buried bridges typically have no invert**
- **50% more galvanizing than CSP and are available in much higher steel thicknesses**
- **Electrochemical requirements apply for soil & water *in contact with* the structure – not necessarily site soil conditions.**
- **Use same backfill electrochemical requirements as those in AASHTO LRFD Design Section 11.10.6.4.2 for MSE walls:**

  - pH = 5 to 10
  - Resistivity $\geq$3000 ohm-cm
  - Chlorides $\leq$100 ppm
  - Sulfates $\leq$200 ppm
  - Organic Content $\leq$1 percent

- **Added features/detailing like splash walls, secondary coatings, barriers, etc. can limit exposure.**
- **Design considerations (site conditions, foundations, grading, proper hydraulic design, etc.) & quality of construction can have a significant impact on service life.**
- ***Service life primarily depends on proper design & installation, maintenance, and what structure is exposed to. End user (owner) has greatest impact on and control over service life.***

Evaluating a Bridge Project

Basic Steps to Consider Bridge Options:

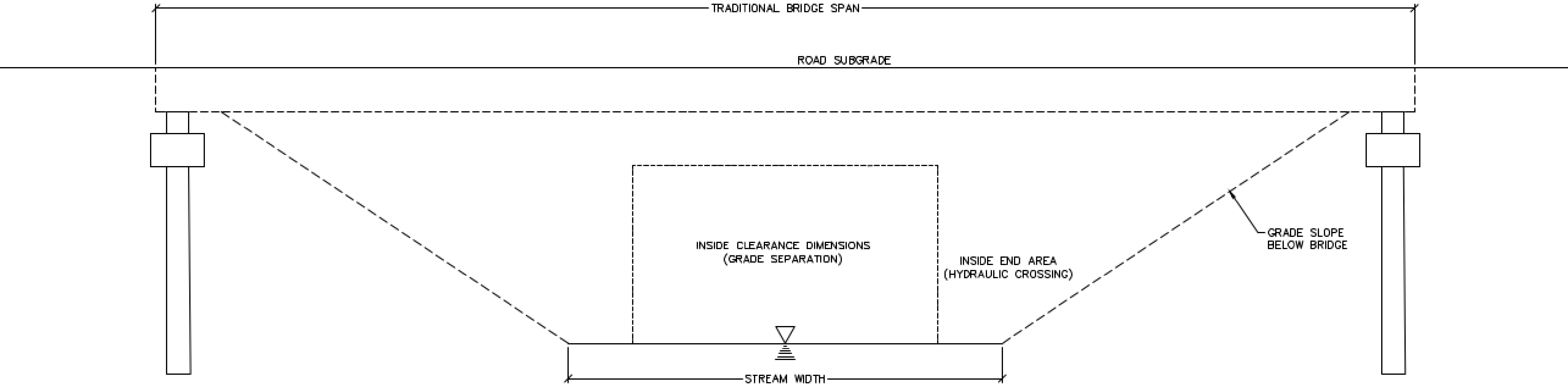
Feasibility

1. Sketch of cross section
2. Define site constraints
3. Define size / clearance requirements below bridge
4. Determine conventional bridge span / buried bridge geometry
5. Compile site information – boring logs, photos, historical data, etc.
6. Preliminary design check

Evaluation

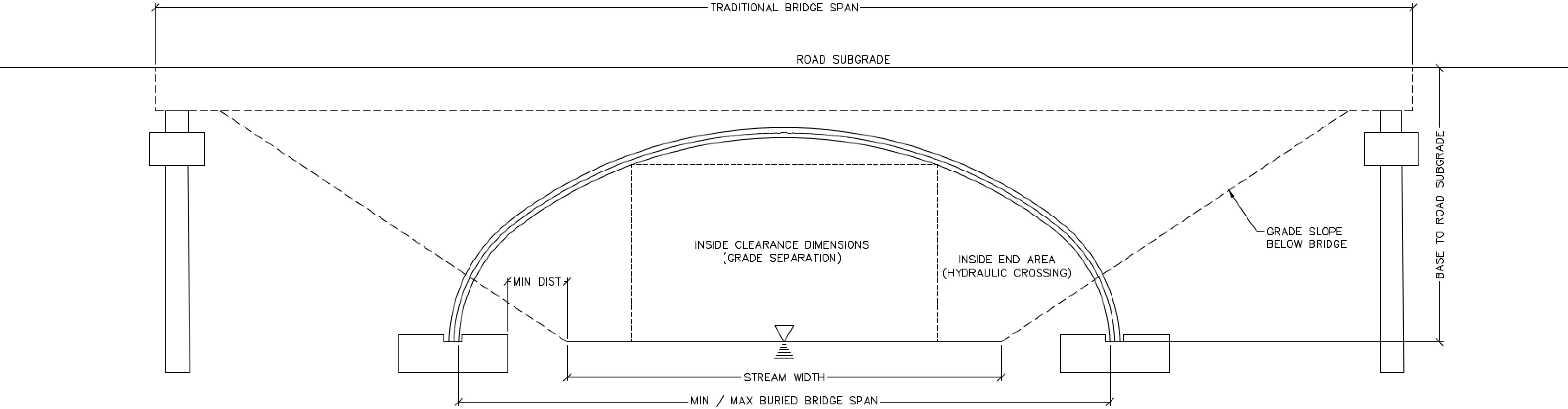
1. Evaluate foundation options
2. Construction considerations & end treatments
3. Evaluate project timeline & cost
4. Compare options

Site Limitations & Geometry Requirements – with Conventional Bridge

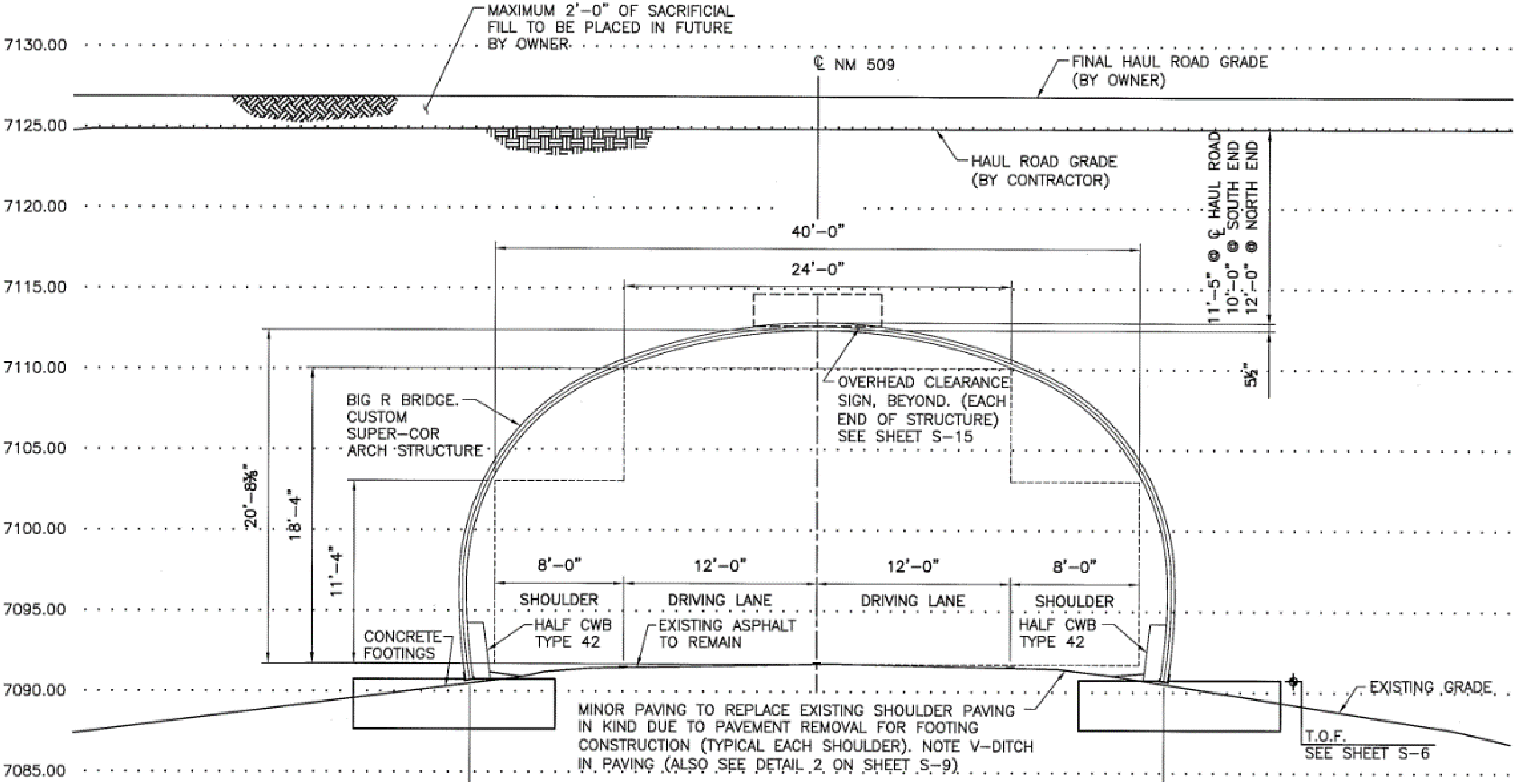


SITE CONDITIONS & CONSTRAINTS

Site Limitations & Geometry Requirements – Consider with Buried Bridge



SITE CONDITIONS & CONSTRAINTS



7130.00
7125.00
7120.00
7115.00
7110.00
7105.00
7100.00
7095.00
7090.00
7085.00
MAXIMUM 2'-0" OF SACRIFICIAL FILL TO BE PLACED IN FUTURE BY OWNER
℄ NM 509
FINAL HAUL ROAD GRADE (BY OWNER)
HAUL ROAD GRADE (BY CONTRACTOR)
11'-5" @ ℄ HAUL ROAD
10'-0" @ SOUTH END
12'-0" @ NORTH END
5½"
40'-0"
24'-0"
OVERHEAD CLEARANCE SIGN, BEYOND. (EACH END OF STRUCTURE) SEE SHEET S-15
BIG R BRIDGE. CUSTOM SUPER-COR ARCH STRUCTURE
20'-8⅜"
18'-4"
11'-4"
8'-0"
12'-0"
12'-0"
8'-0"
SHOULDER
DRIVING LANE
DRIVING LANE
SHOULDER
HALF CWB TYPE 42
EXISTING ASPHALT TO REMAIN
HALF CWB TYPE 42
CONCRETE FOOTINGS
EXISTING GRADE
T.O.F. SEE SHEET S-6
MINOR PAVING TO REPLACE EXISTING SHOULDER PAVING IN KIND DUE TO PAVEMENT REMOVAL FOR FOOTING CONSTRUCTION (TYPICAL EACH SHOULDER). NOTE V-DITCH IN PAVING (ALSO SEE DETAIL 2 ON SHEET S-9)

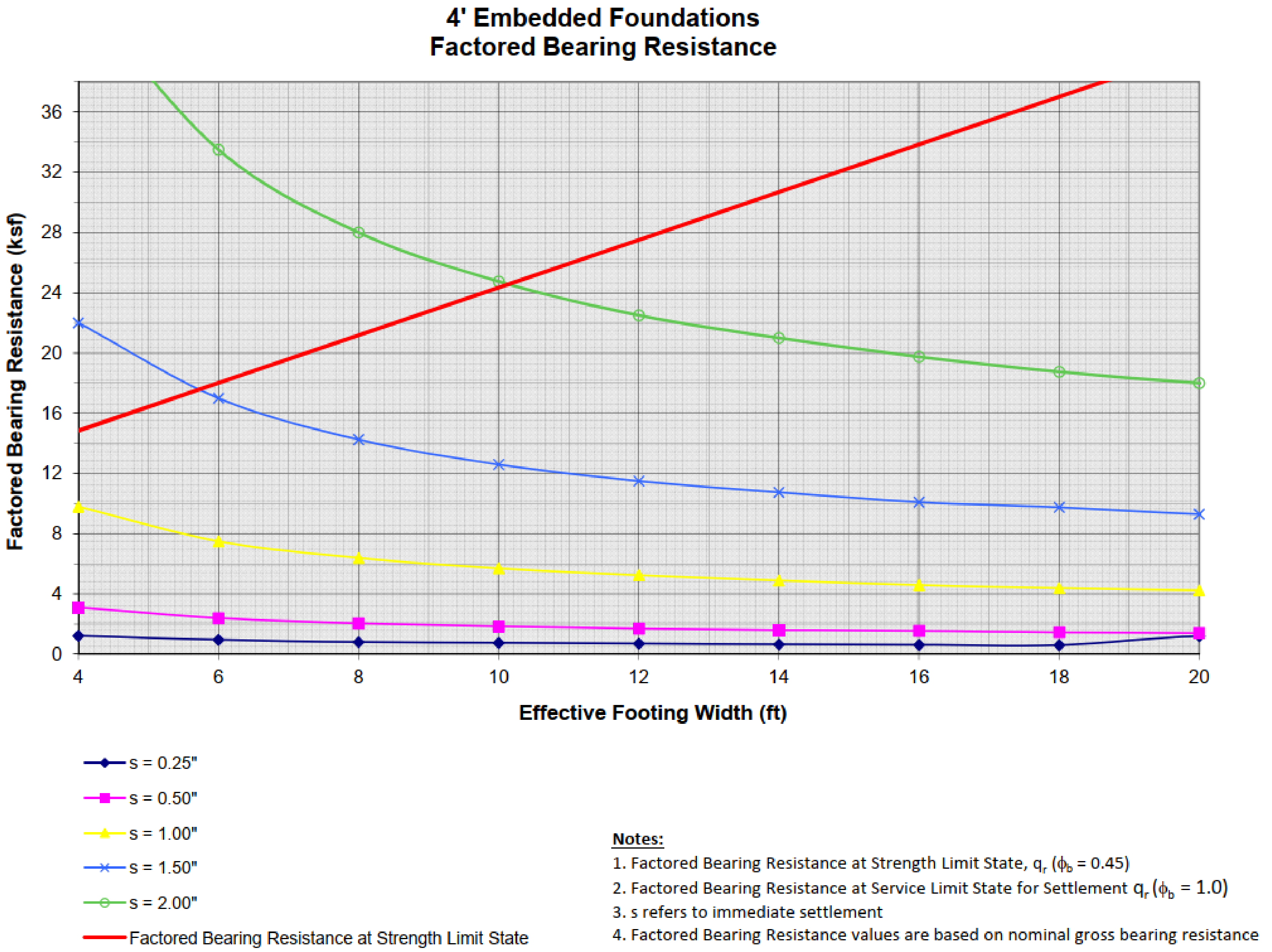

Peabody
18 FT 8 IN

Basic Design Inputs

- Structure geometry – span, rise, shape details
- Site soil conditions – foundation soils & embankments soils (from boring logs, photos, previous work in the area; consider cut vs. fill soil properties)
- Backfill soil properties (unit weight, strength properties – based on code requirements and available materials)
- Soil cover height & engineered backfill zone width
- Foundation type (deep vs. spread foundations)
- Design live load
- Buried Metal Bridge section properties

Foundation Considerations

- Buried bridges can accommodate more differential settlement than conventional bridges & precast structures
- Allowable differential settlement is a function of structure span & rise (AASHTO LRFD Sec 12.8.4.1)
- Considering settlement tolerance of structure will result in a smaller foundation
- Soil improvement can increase allowable bearing pressures
- Buried Bridges can be designed using intermediate & deep foundations when needed
- Consider cost of foundations when evaluating structure options



Notes:
1. Factored Bearing Resistance at Strength Limit State, q_r (ϕ_b = 0.45)
2. Factored Bearing Resistance at Service Limit State for Settlement q_r (ϕ_b = 1.0)
3. s refers to immediate settlement
4. Factored Bearing Resistance values are based on nominal gross bearing resistance

Construction Considerations & End Treatments

- Personnel – earthwork contractor, heavy civil contractor, county forces, etc.
- Equipment needs – cranes are usually not needed
- Modular / staged construction
- Potential detours
- Accelerated construction
- Site access
- Headwalls, step bevels, protruding ends, etc.

Final Evaluation

- Material cost can be provided by a manufacturer
- Foundations, constructability, end treatments have been considered
- Look at big picture – grading, site improvements, project schedule, other factors
- Compare with other options

I-44 over Route 96 Entrance Ramp & CR 1147– Lawrence County, Missouri

Fabricator:	Big R Bridge / Contech Engineered Solutions
Contractor:	Emery Sapp & Sons
Design Engineer:	Lochmueller Group / Parsons Engineering

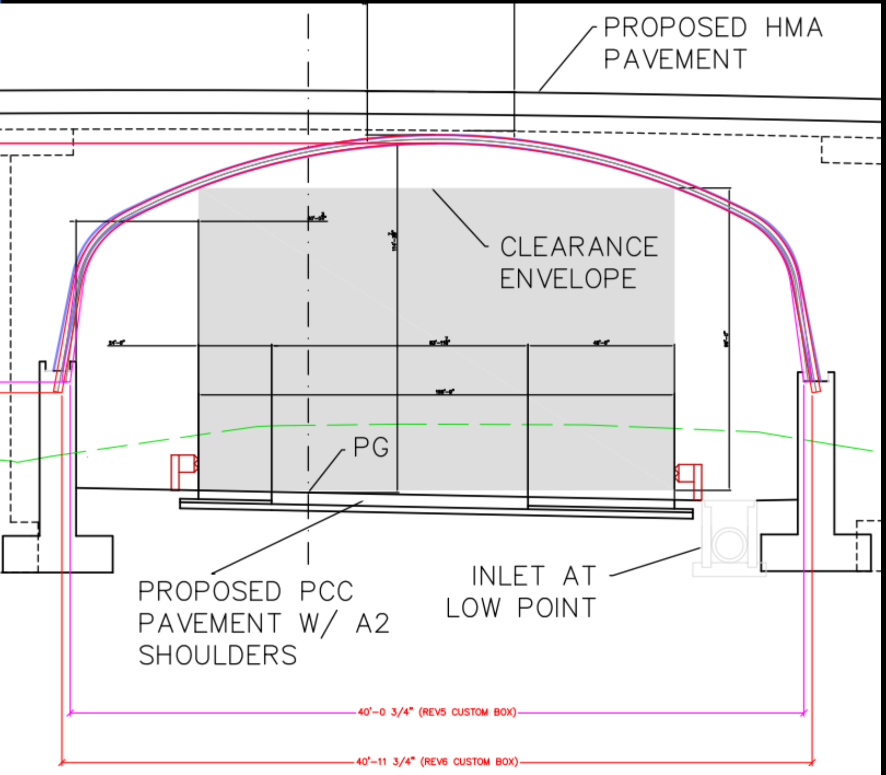
Existing Structures to be replaced – Precast & Steel Beam Bridges

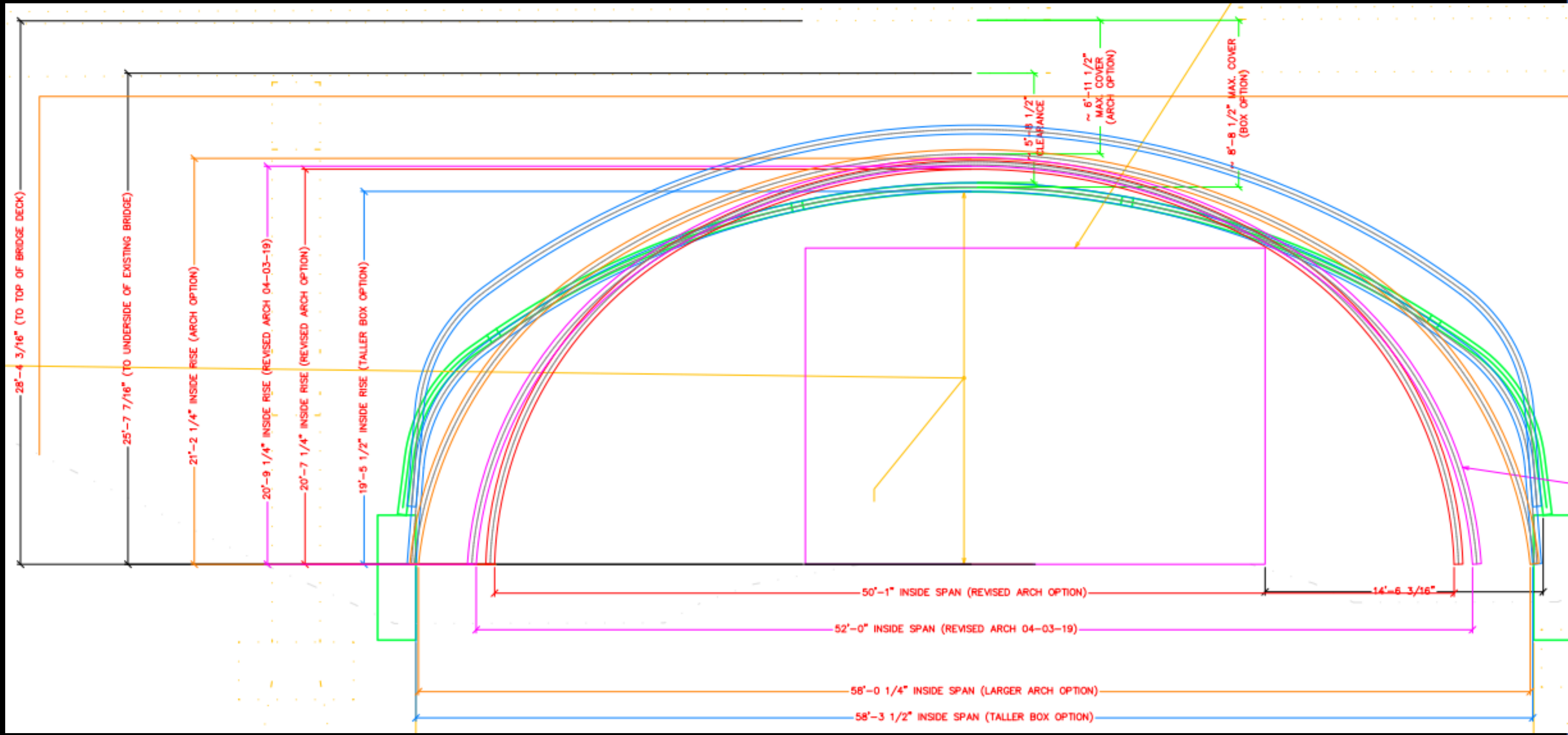

I-44 over Entrance Ramp from Route 96 to EB I44


I-44 over CR 1147

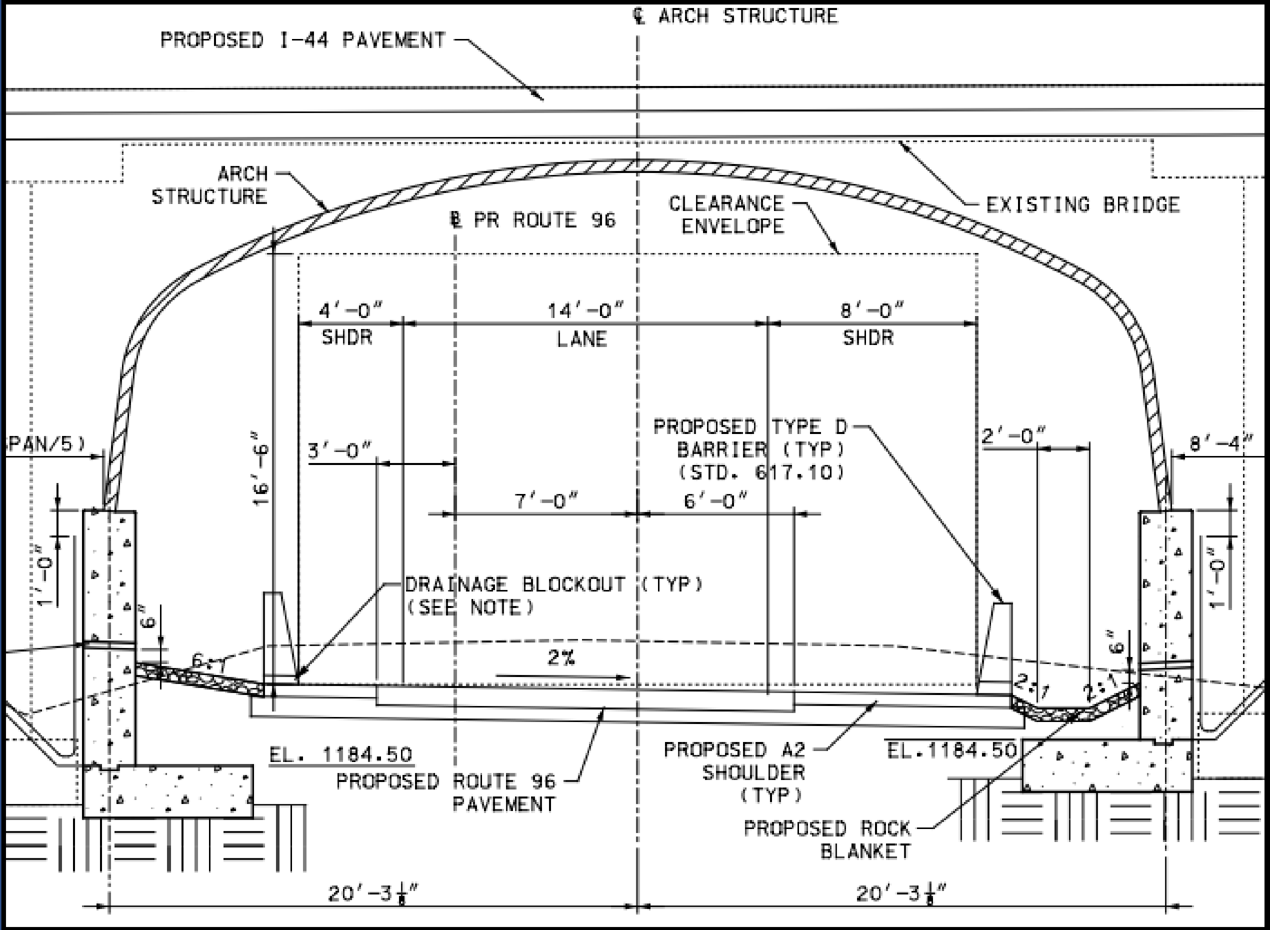
Development of Custom Structure Geometries (iterative process)

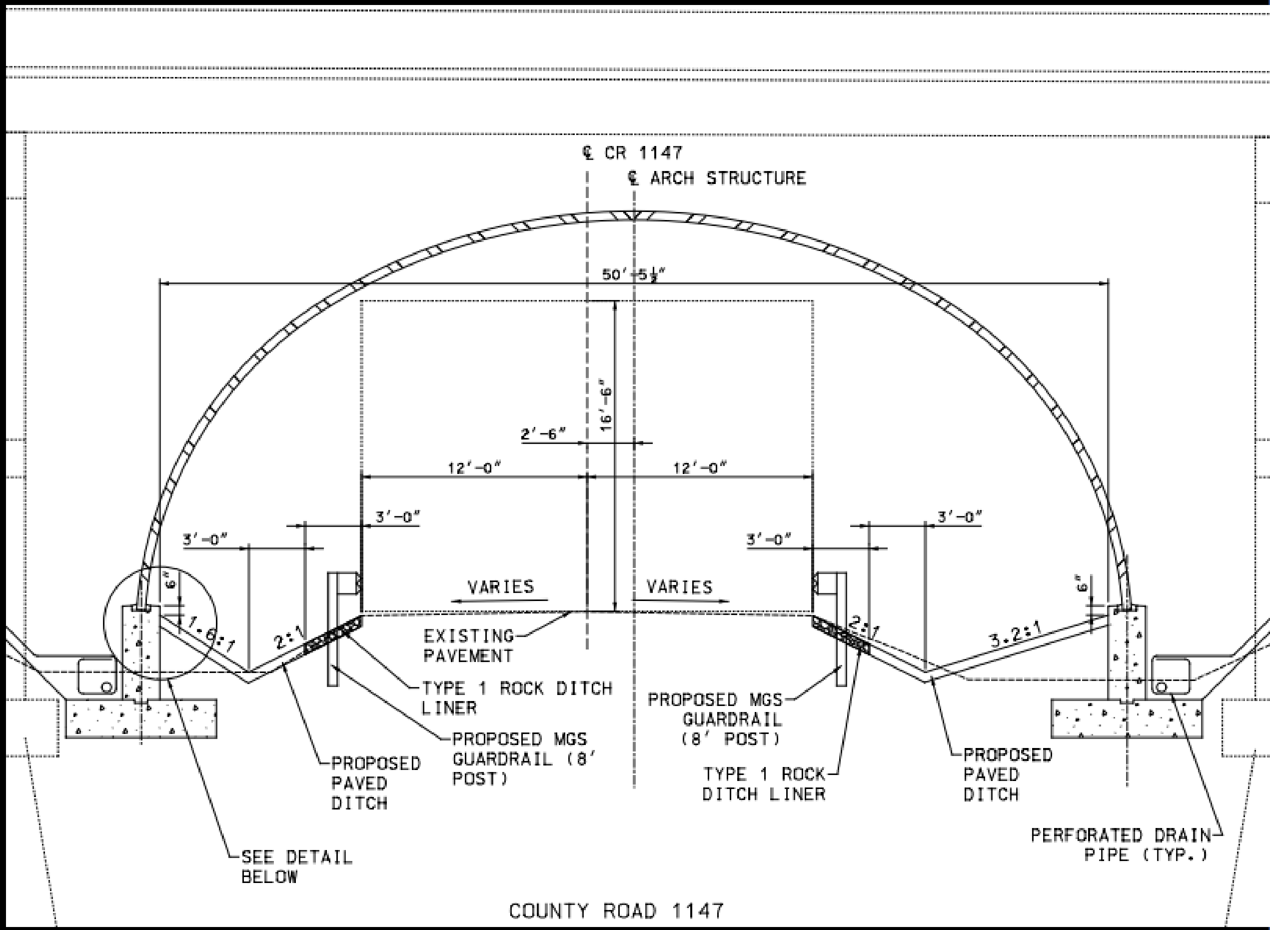
- Minimum inside clearance for vehicles
- Final top of road elevations, AASHTO cover requirements
- Avoid conflicts with existing bridge elements & site features





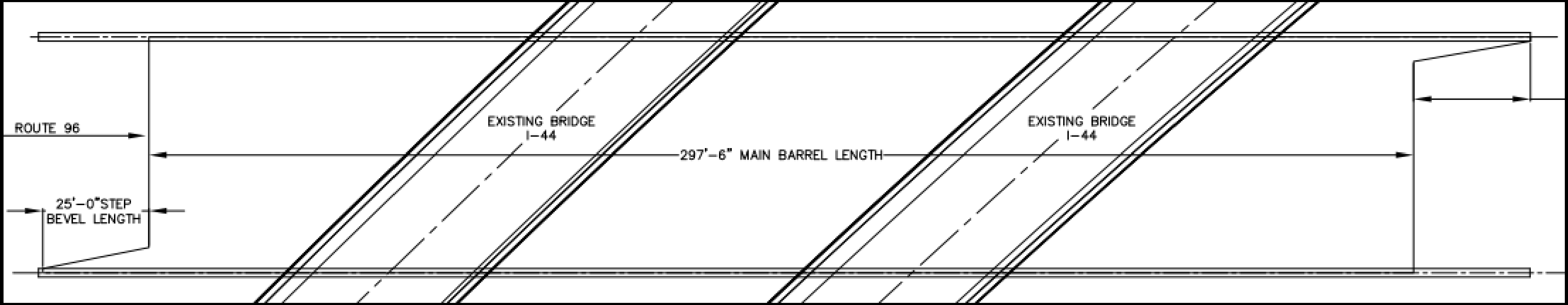
Final Geometries: Box shape for Rt 96 & Arch for CR 1147



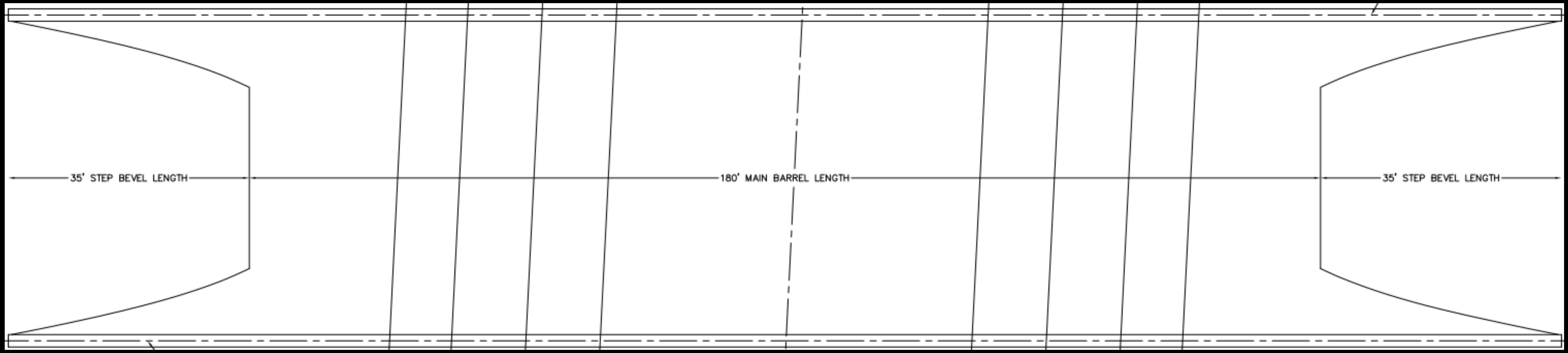


Customized layouts & end treatments to accommodate site configurations:

Rte 96 – unbalanced step bevel to address skewed alignment with I-44



Customized layouts & end treatments to accommodate site configurations:
CR1147– step beveled ends to match fill slope



Assembly & backfilling took place with existing bridges in service – Route 96






Assembly & backfilling took place with existing bridges in service – CR 1147






- **Structure Selection Factors**
  - Weight vs. span capabilities
  - Limited head room to construct below existing bridges
  - Speed of construction
  - Lower cost of maintenance (no bridge deck, bearings, barrier walls, approach slabs, abutments, joints)
  - No head to head traffic during construction
  - Simpler / faster bridge inspection
  - Mowable slopes
  - Ability to extend to add future lanes

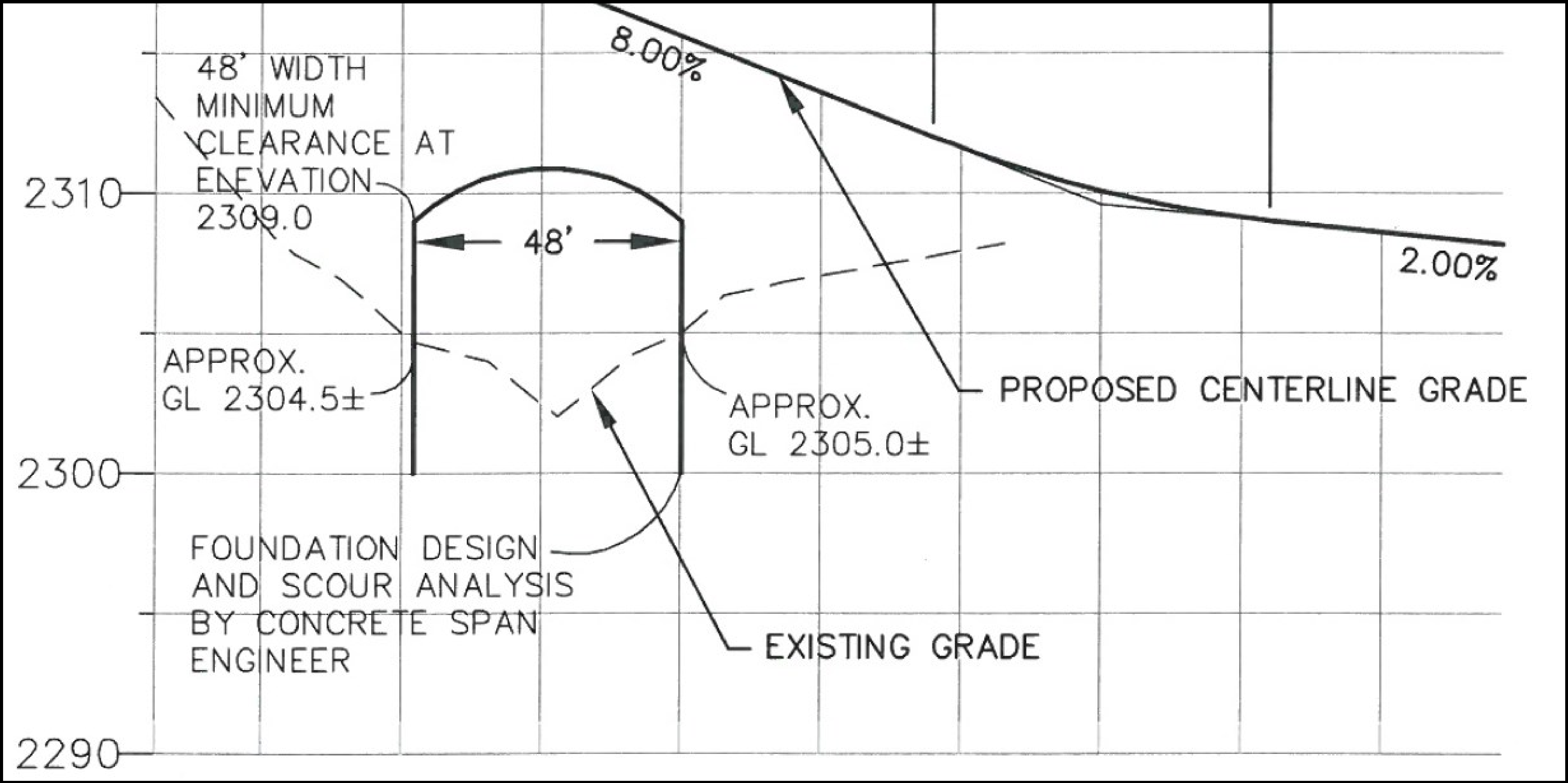
- **Installed Cost & Time Comparisons**
  - Anticipated construction time was 8 months for precast/conventional options vs. 5 months for buried bridges
  - $3.5 million estimated installed cost for precast/conventional options vs. $3.0 million for buried bridges
  - Foundation construction time & cost savings, advantages of spread footings vs. deep foundations
  - Reduction in long term maintenance costs

56’5” span x 15’ rise box structure
Black Mountain, North Carolina

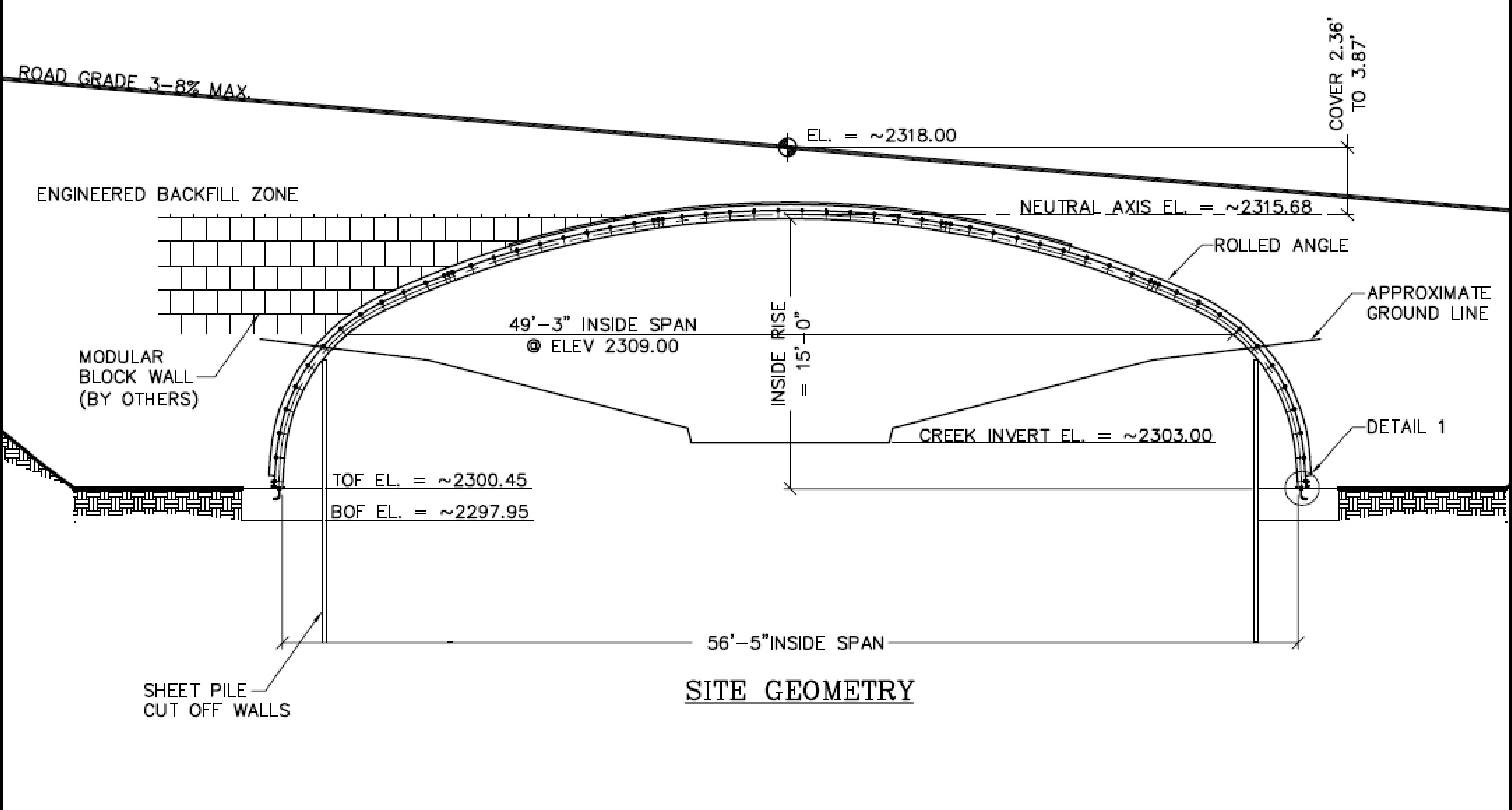
Design Requirements

- **New road to access new facility**
- **~15’ distance from creek invert to road**
- **48’ min clear span at 6’ above creek invert**
- **Creek bed soils sensitive to scour (sands)**
- **Wide span to get beyond limits of disturbance**
- **Sloping transverse grade**
- **Considered traditional bridge early on – would have required ~100 ft + span based on creek banks.**

As Detailed in Project Documents



Flexible Steel Buried Bridge Option



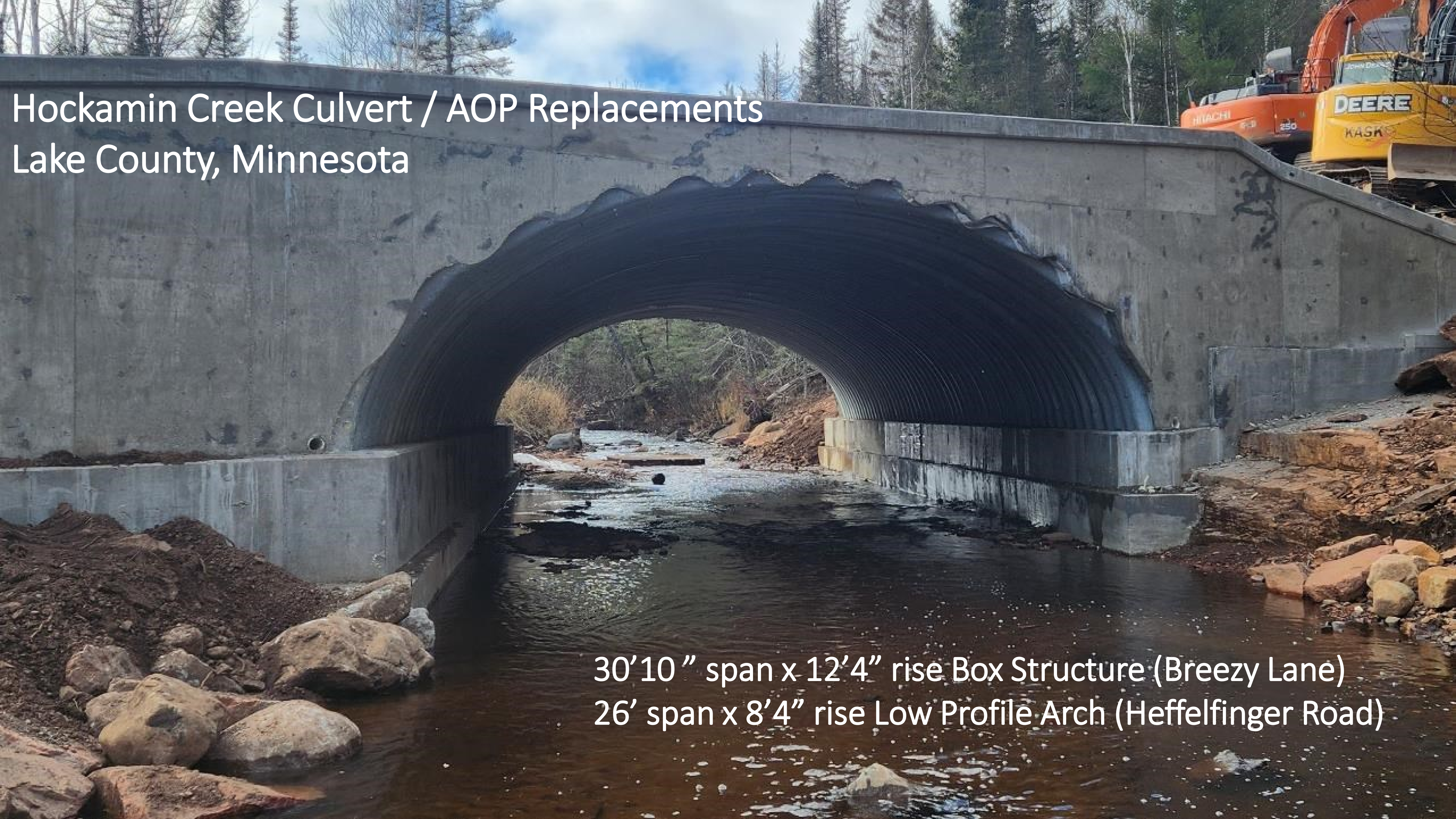
Cost Comparison

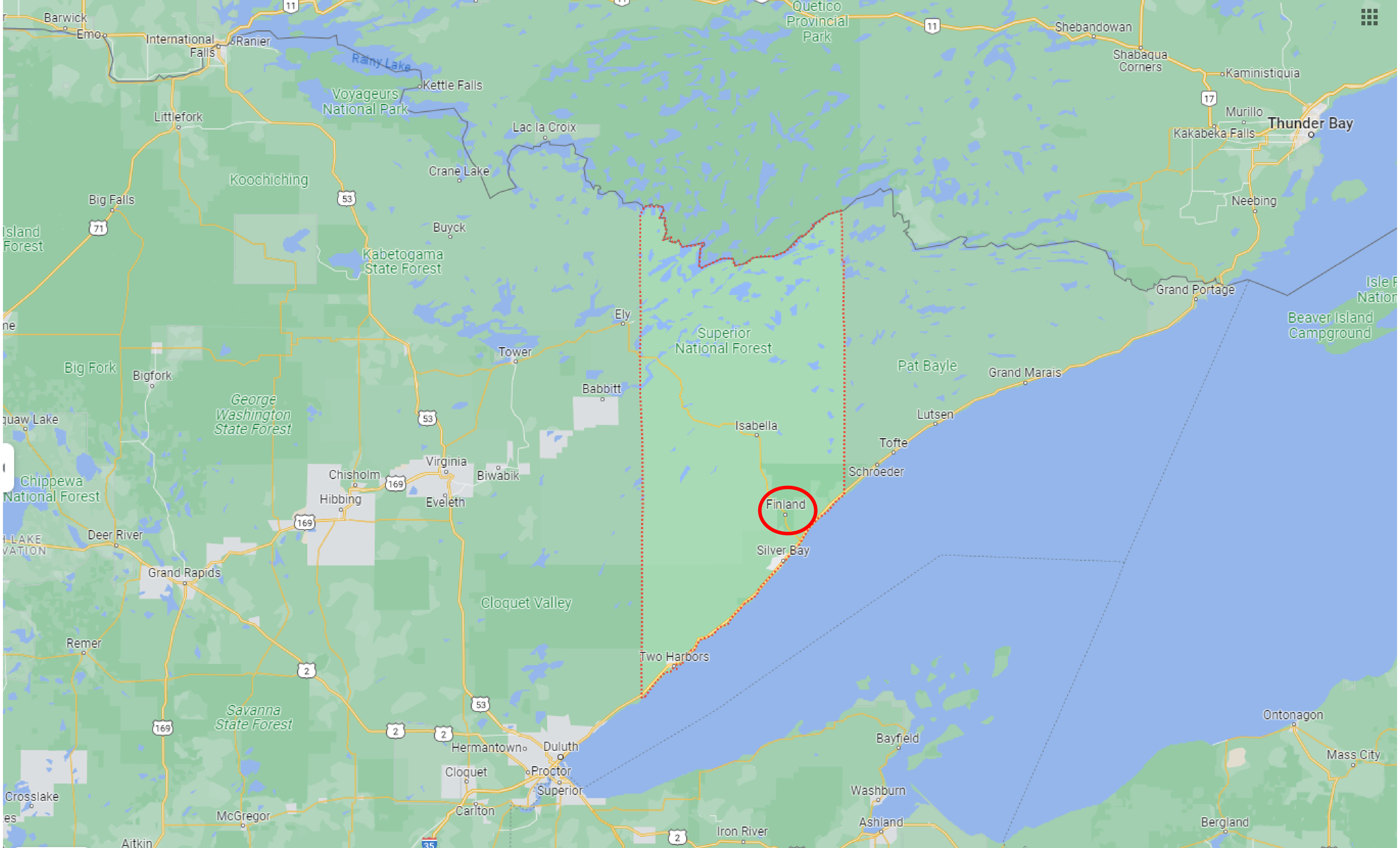
Item	Rigid Bridge Structure Cost	Flexible Steel Buried Bridge Structure Cost
Design, Installation, and Structure	$213,650	$205,950
Footings / Pile Caps, Ftg Excavation & Dewatering	$52,500	$101,780* * Includes cost for fnd soil improvement. Ftg larger than pile cap.
Sheet Pile Cutoff Walls	$39,250	$39,250
H-Pile Deep Foundations	$360,000	-----------
Backfill Foundation Cut	$10,000	$15,000
Total Cost	**$675,400**	**$361,980 (-45%)**


MID-EXTEND


WATER

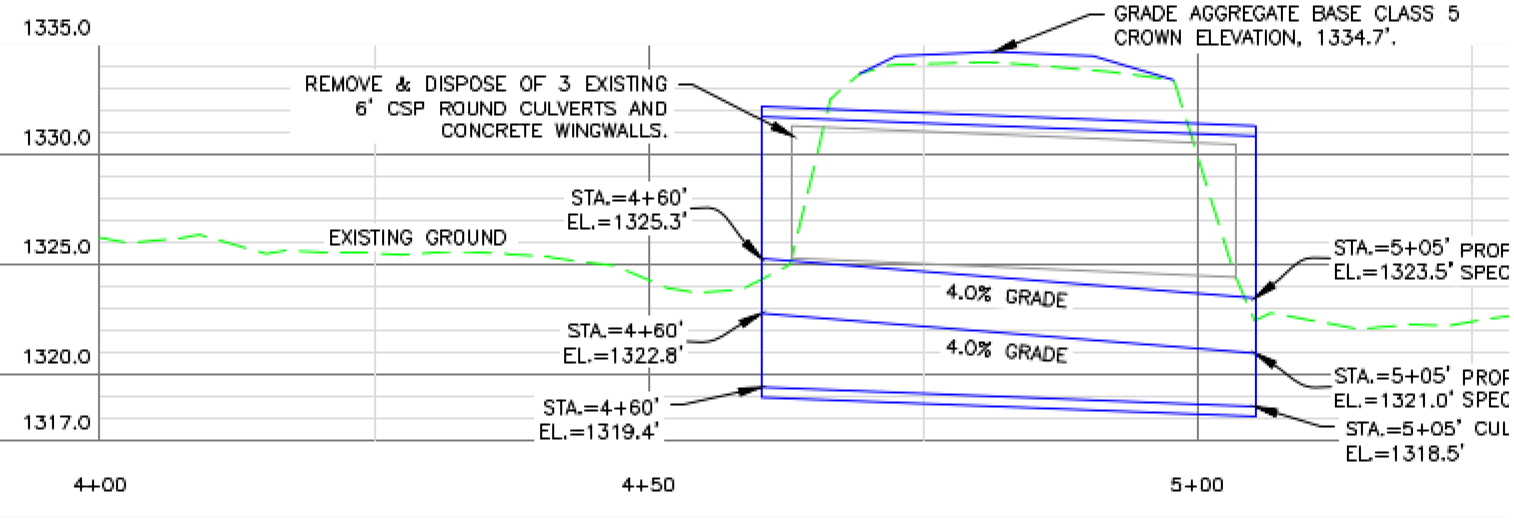
November 2024 - After Hurricane Helene


Hockamin Creek Culvert / AOP Replacements
Lake County, Minnesota
DEERE
30’10 ” span x 12’4” rise Box Structure (Breezy Lane)
26’ span x 8’4” rise Low Profile Arch (Heffelfinger Road)


Barwick
Emo
International Falls
Ranier
Rainy Lake
Kettle Falls
Voyageurs National Park
Quetico Provincial Park
Shebandowan
Shabaqua Corners
Kaministiquia
Murillo
Kakabeka Falls
Thunder Bay
Neebing
Littlefork
Lac la Croix
Crane Lake
Koochiching
Big Falls
Buyck
Kabetogama State Forest
Island Forest
Grand Portage
Isle R Nation
Beaver Island Campground
Ely
Superior National Forest
Tower
Big Fork
Bigfork
Babbitt
Pat Bayle
Grand Marais
George Washington State Forest
Lutsen
Isabella
Tofte
Schroeder
Virginia
Chisholm
Biwabik
Hibbing
Eveleth
Chippewa National Forest
Finland
Deer River
Silver Bay
Grand Rapids
Cloquet Valley
Remer
Two Harbors
Savanna State Forest
Hermantown
Duluth
Proctor
Cloquet
Superior
Carlton
Crosslake
McGregor
Aitkin
Bayfield
Washburn
Ashland
Iron River
Ontonagon
Mass City
Bergland

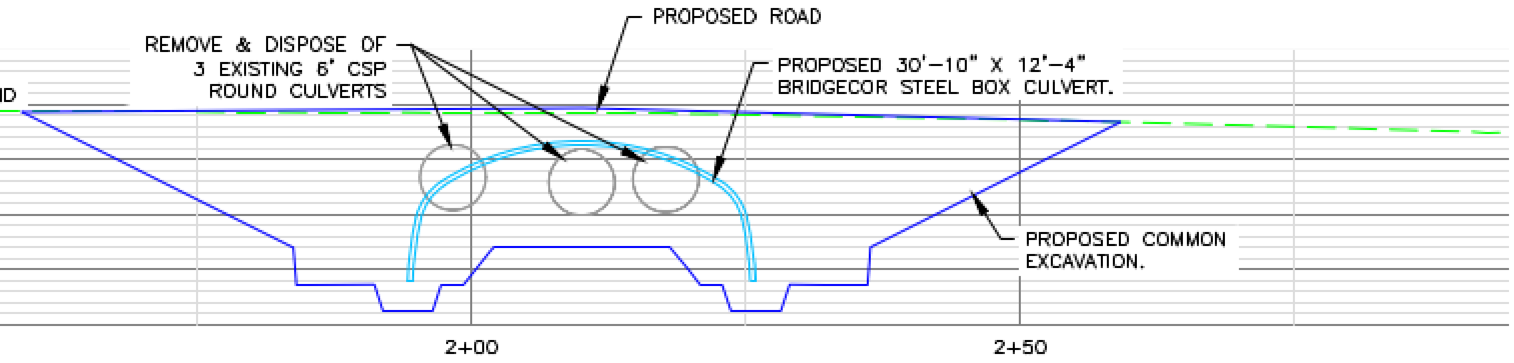
Breezy Lane

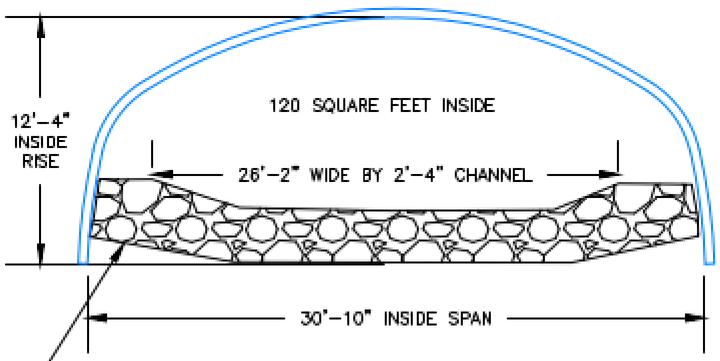
- Replace 3 culverts
- Maintain existing road grade
- Flexible foundations extended to frost depth
- Sloped grades to eliminate need for headwalls



PROFILE OF HOCKAMIN CREEK THALWEG (2:

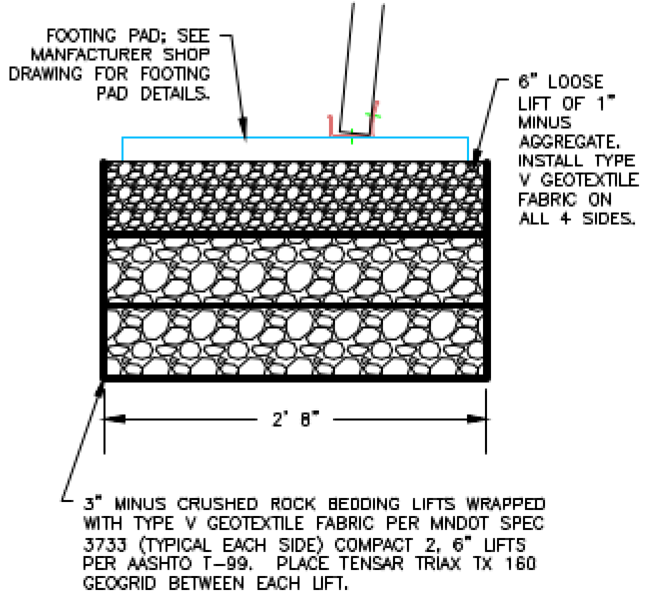
NOT TO SCALE





MEDIUM PROFILE STRUCTURAL PLATE ARCH

NOT TO SCALE



FOOTING PAD BEDDING DETAIL

NOT TO SCALE

Breezy Lane

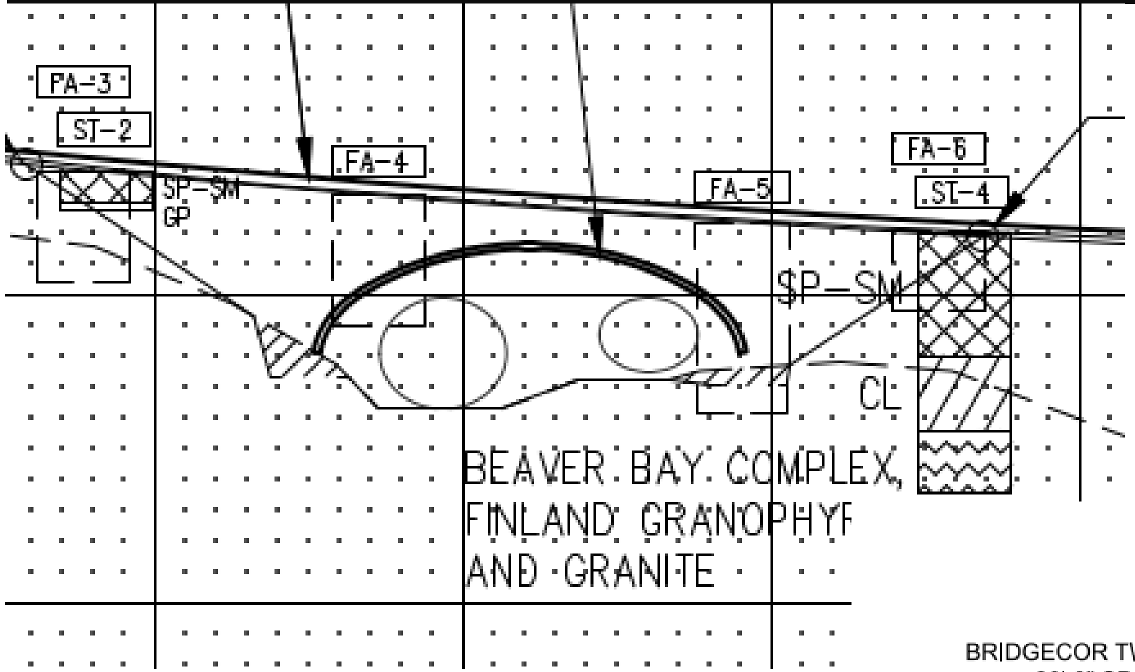
Breezy Lane

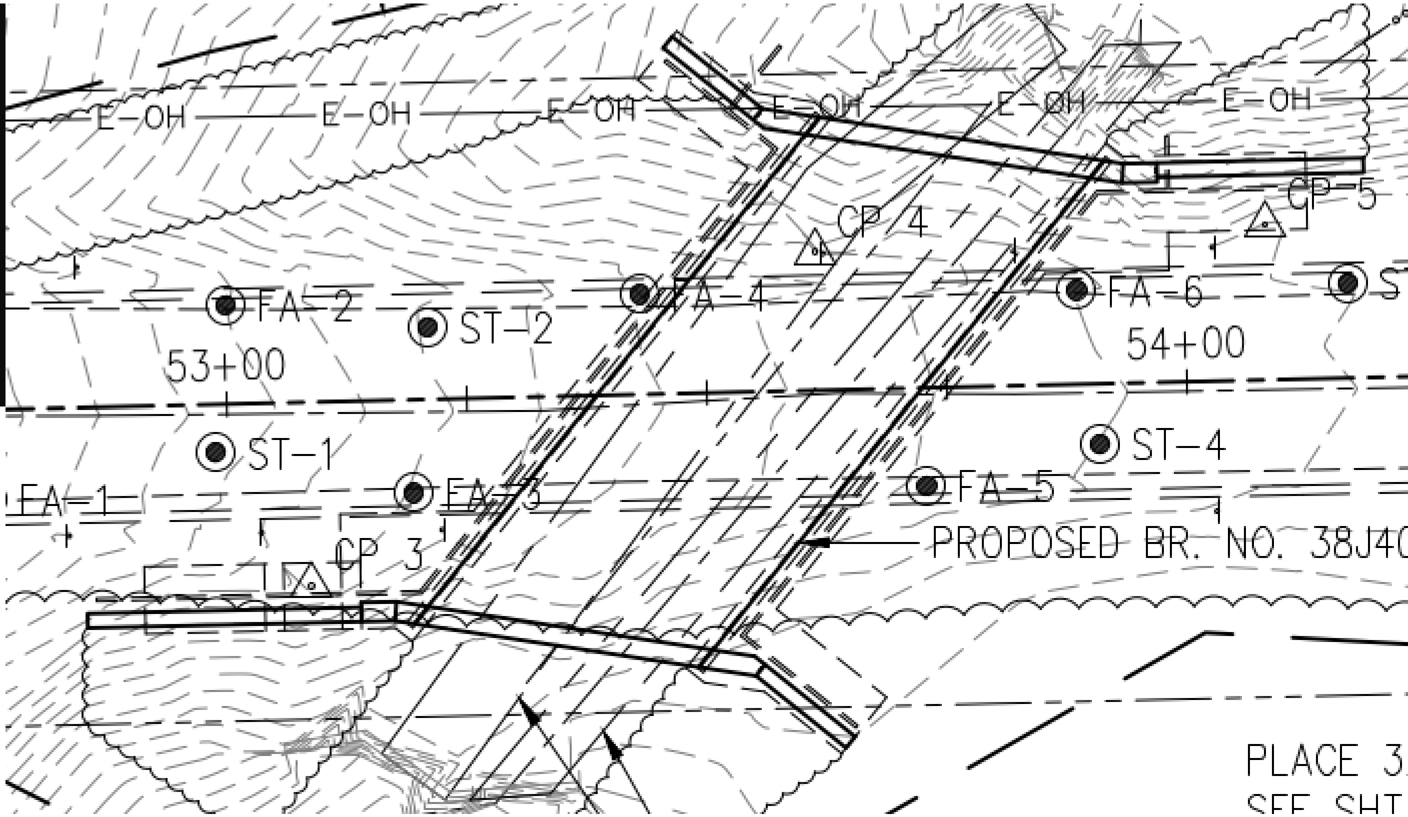
Breezy Lane

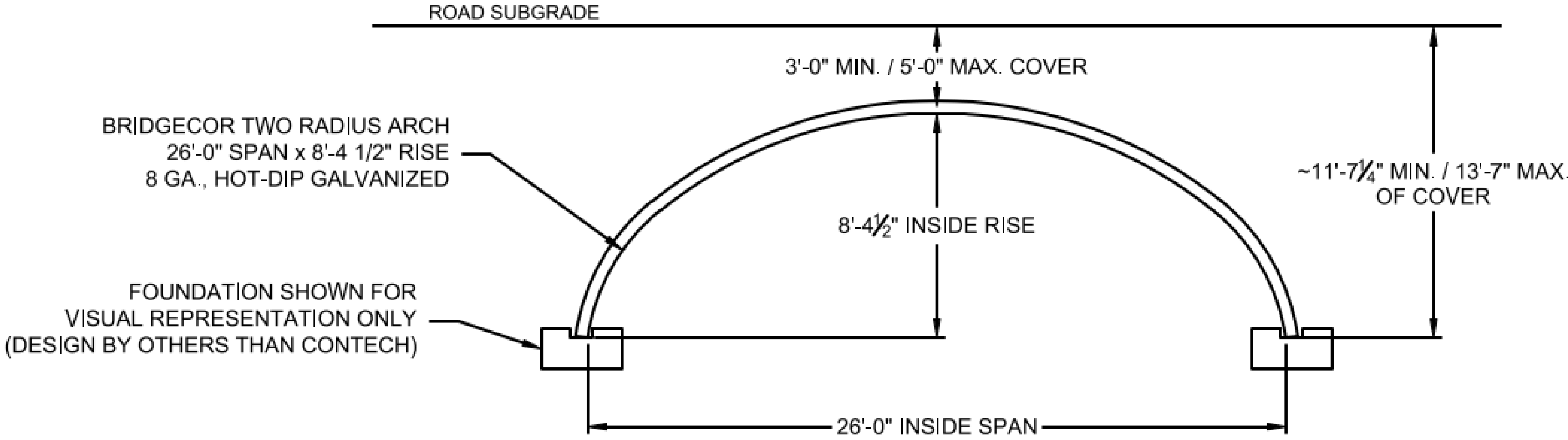

Breezy Lane

Hefflefinger Road

- Replace 2 culverts
- Raise road grade
- Skewed alignment with road grade
- Concrete headwalls to limit structure footprint & maintain stream alignment







Hefflefinger Road

Hefflefinger Road

Hefflefinger Road

Additional Projects


Spokane, Washington
40’ cover, phased construction
KOMATSU
PC 400 LC

Knox County, Indiana 53’ x 24’
E80 Loading


Union Township, Pennsylvania
Bridge Replacement, Skewed Ends


Gray, Maine
Bridge Replacement, Reused Foundation


Craig, Alaska
Built by tribal forces


Knoxville, Tennessee
~33'+ span with step beveled ends

Findlay, Ohio 48’ x 21’
I-75 Bridge Replacement, Staged Construction

Topeka, Kansas
Reline of 40’ span x 200’ long concrete arch under I-70

Randolph, Nebraska 50’ x 17’
Grade Separation with E80 Loading


Irvine, California
Pedestrian Crossing, Sustainable Construction


Laguna Niguel, California
Twin 39.7’ span x 13.2’ rise Buried Bridges
Hydraulic Improvements & Signature Entrance to City Park


Houston, Texas
Phased Construction
Recycled Concrete Backfill
Architectural Requirements

LaCygne, Kansas 53’ x 25’
Grade Separation

Skagway, Alaska 75’x25’
75’ cover with RCC

The picture can't be displayed.

Banff, Alberta Animal Crossing

Thank You

Joel Hahm, PE
Joel.hahm@conteches.com
970.347.2208

Resources:

National Corrugated Steel Pipe Association:
www.ncspa.org

Short Span Steel Bridge Alliance:
https://www.shortspansteelbridges.org/products/buried-bridge/

American Galvanizers Association:
https://galvanizeit.org/webinar

Contech Buried Bridge Resources:
https://www.conteches.com/bridges-structures/plate/bridgecor/

SHORT SPAN STEEL BRIDGE ALLIANCE™

American Galvanizers Association
Protecting Steel for a Sustainable Future

Building Better Bridges in 2025

AIA Approved Continuing Education

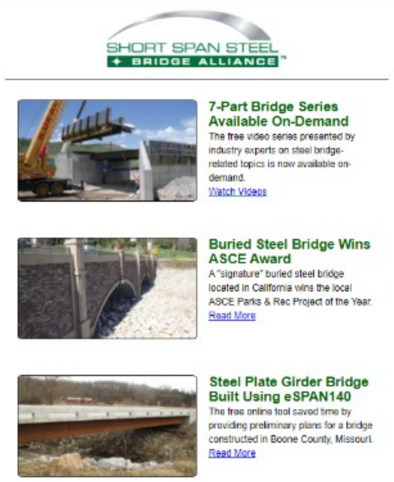
ENGINEERING RCEP REGISTERED CONTINUING EDUCATION PROGRAM

Feb 19, 1 pm ET	Steel vs Concrete Life Cycle Performance and Costs
April 23, 1 pm ET	Unlocking the Potential of Buried Steel Structures
Sept 10, 1 pm ET	Next-Gen Steel Bridge Design Tools for Smarter Solutions
Dec 10, 1 pm ET	Simple for Dead, Continuous for Live Designs for Optimal Performance

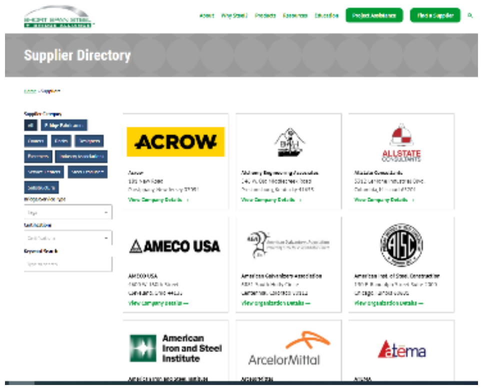
www.shortspansteelbridges.org

5 Ways to Keep Learning About Steel Bridges

1. Subscribe to the Weekly Newsletter



2. Find a Supplier



3. Design a Bridge in 5-Minutes

eSPAN140™

4. Receive Free Project Assistance

5. Schedule a Workshop/Webinar

www.ShortSpanSteelBridges.org

Questions? Dan Snyder, Director, SSSBA, dsnyder@steel.org, (301) 367-6179

Website: ShortSpanSteelBridges.org
Twitter: @ShortSpanSteel
Facebook: Short Span Steel Bridge Alliance