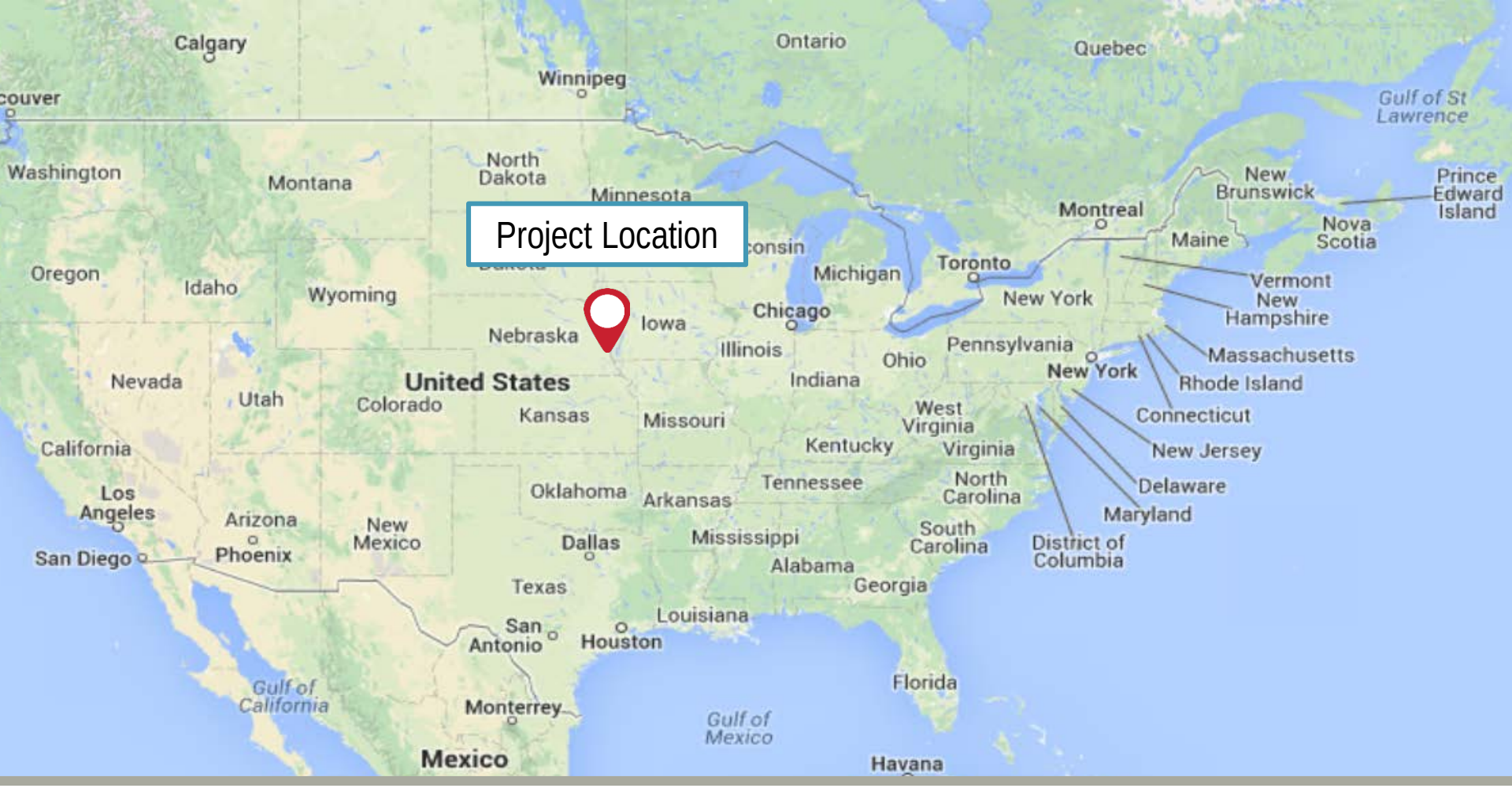
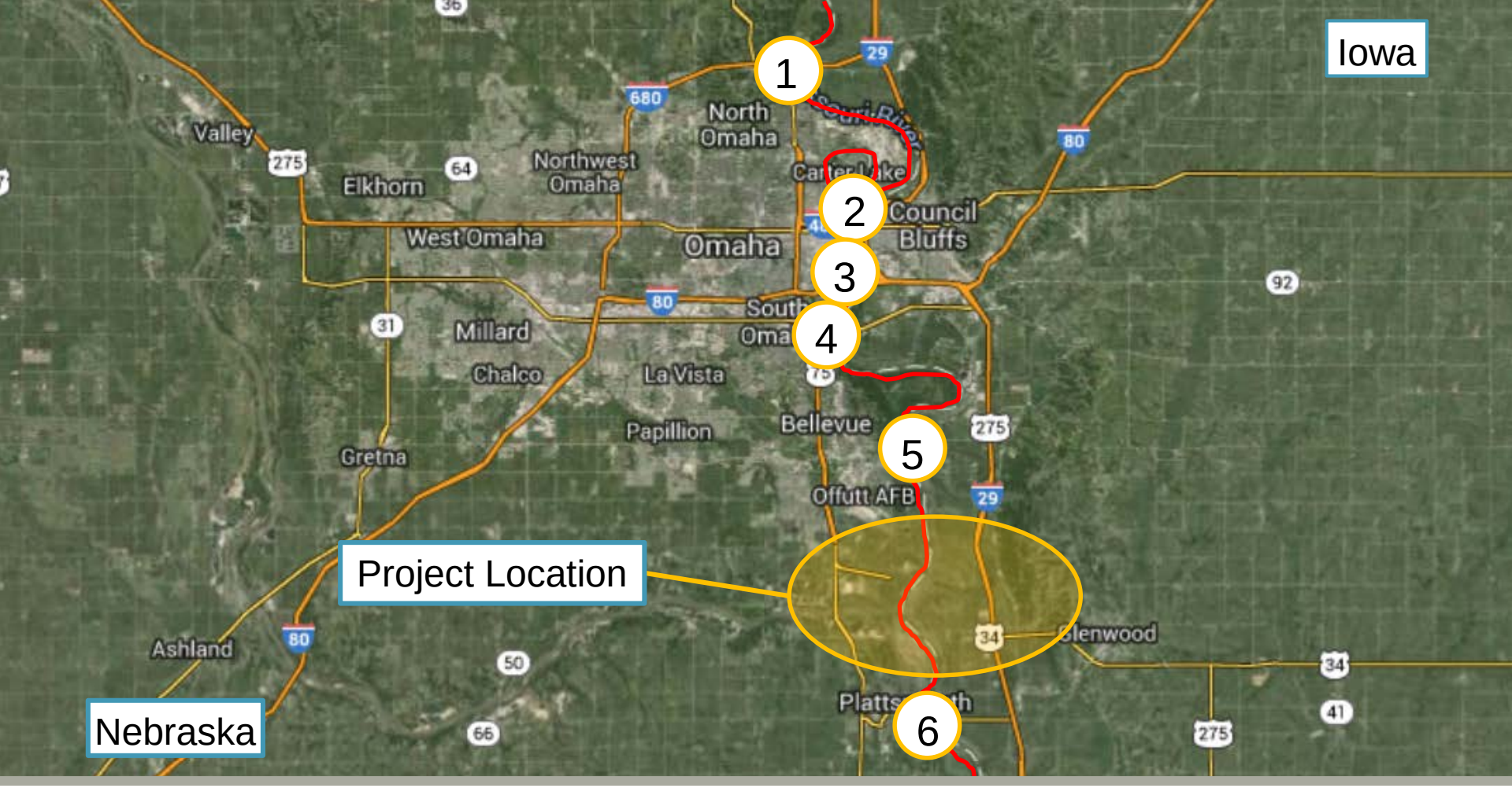
US 34 Over the Missouri River

Philip Rossbach, PE - HDR

Western Bridge Engineers' Seminar



Project Information



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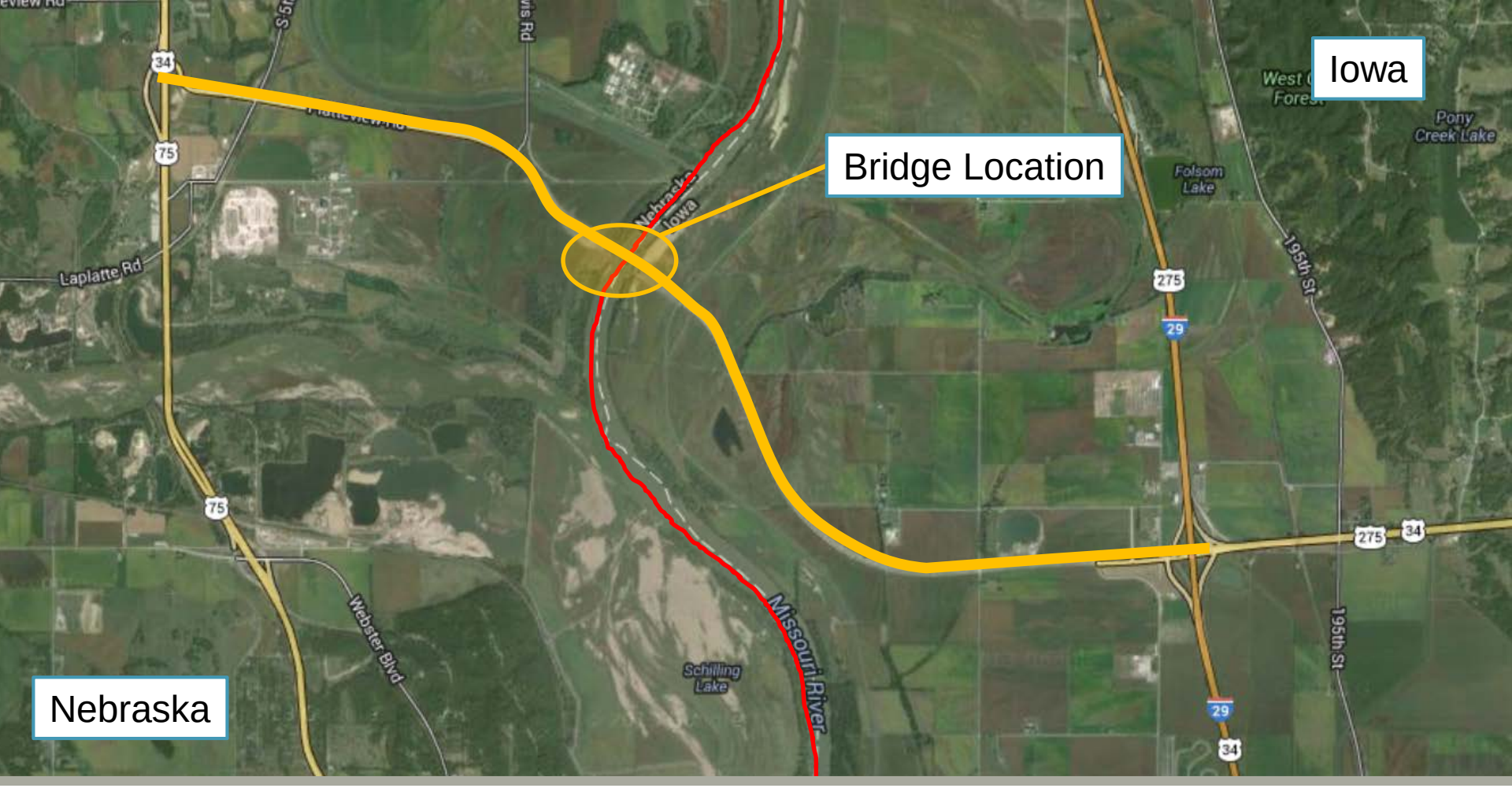
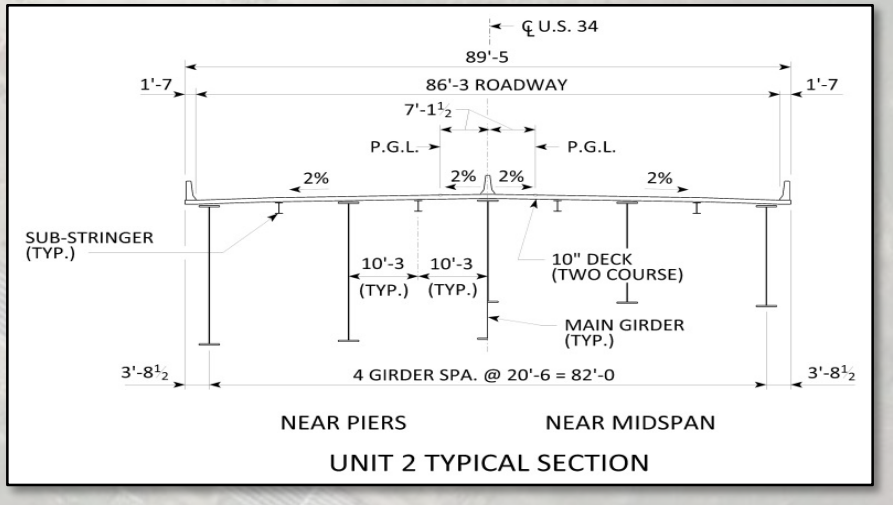


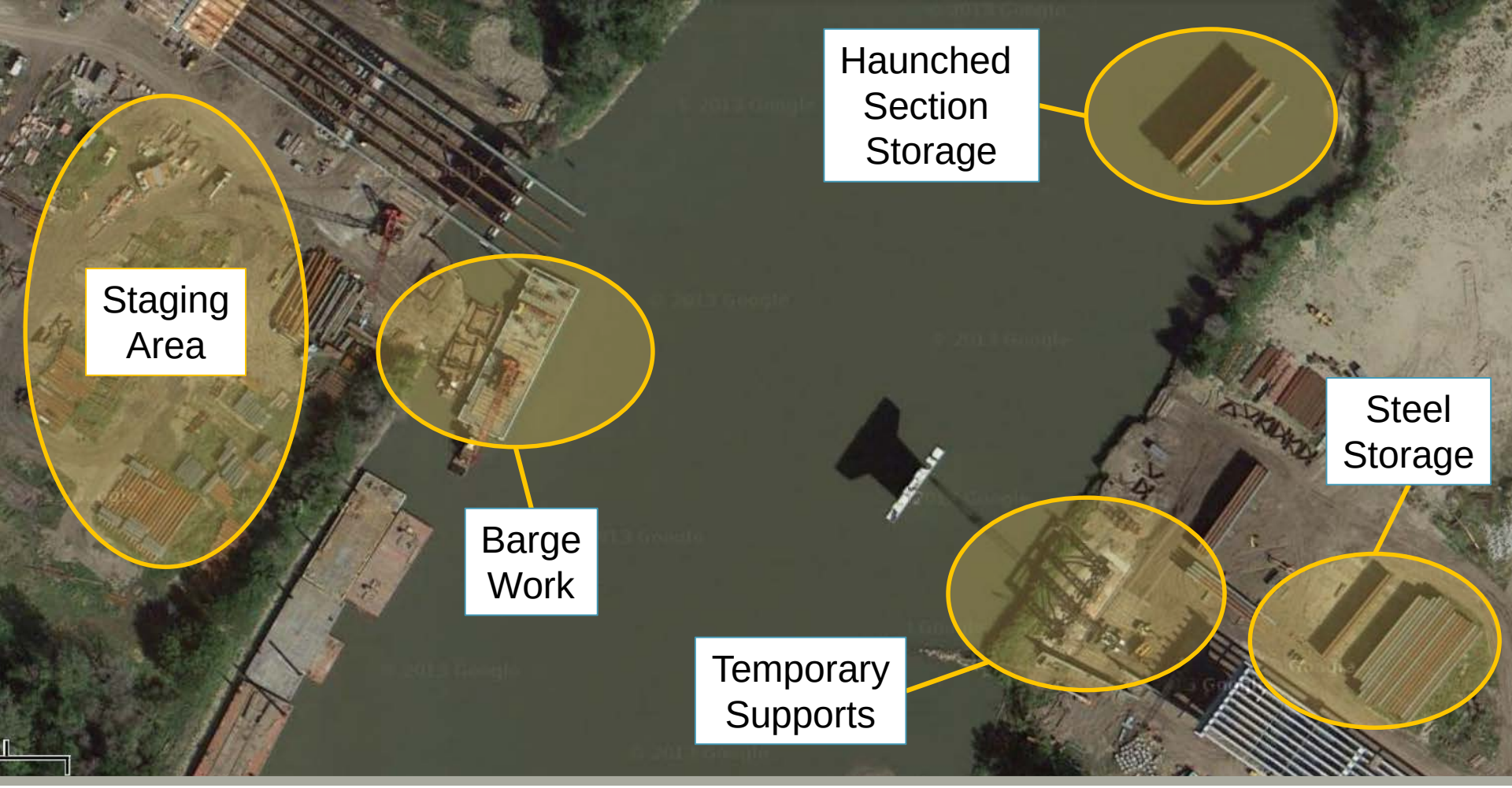
Project Information

Bridge Information

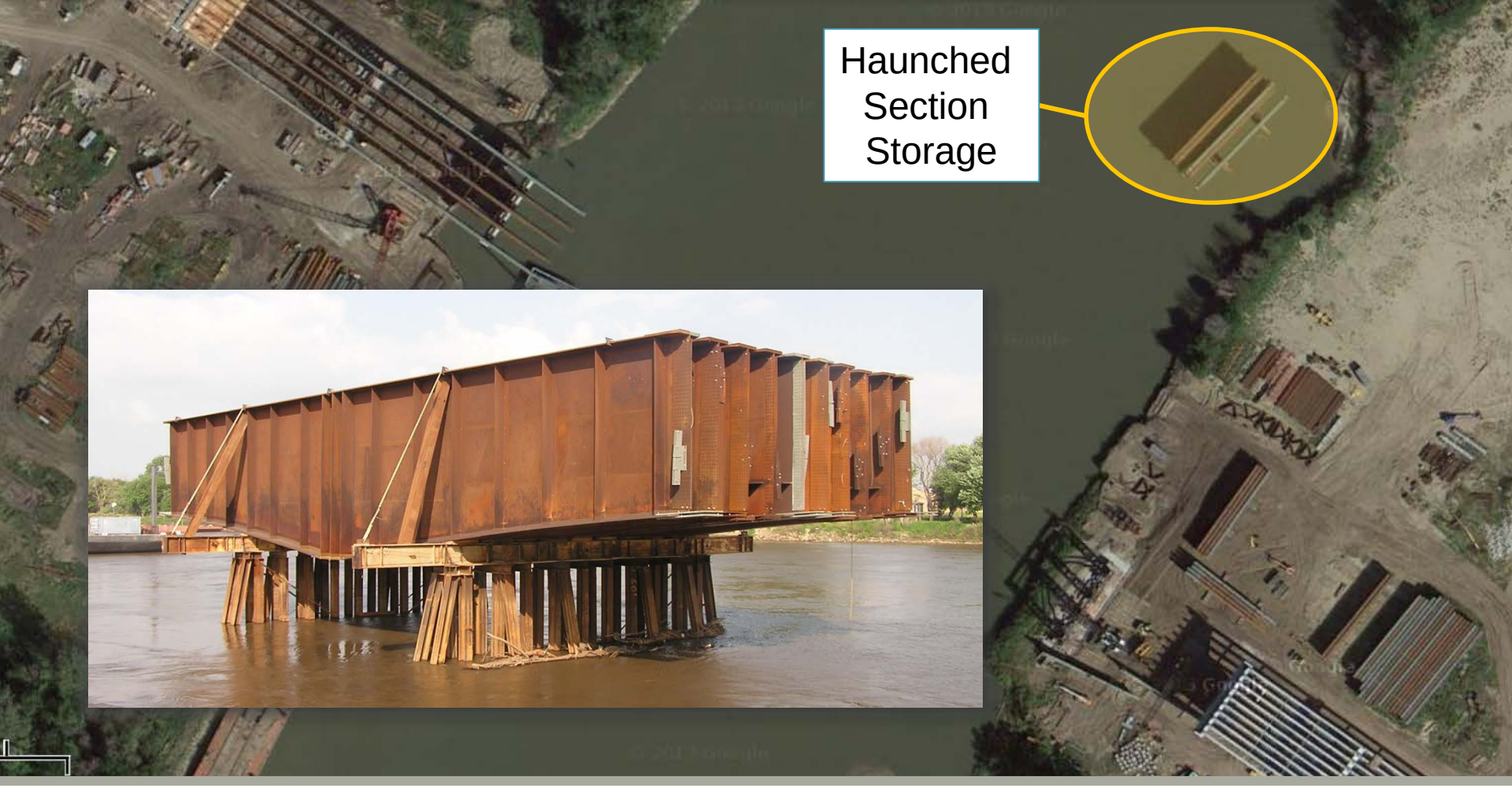
- 89’-5” deck width
- 20’-6” girder spacing
- 10” two course deck



Bridge Information



Project Site Characteristics



Steel Storage

Temporary Supports

Preliminary Type Study

Options Investigated (July 2008)

1. Haunched Plate Girder
2. Haunched Plate Girder w/Substringers
3. Truss
4. Steel Box
5. Concrete Segmental

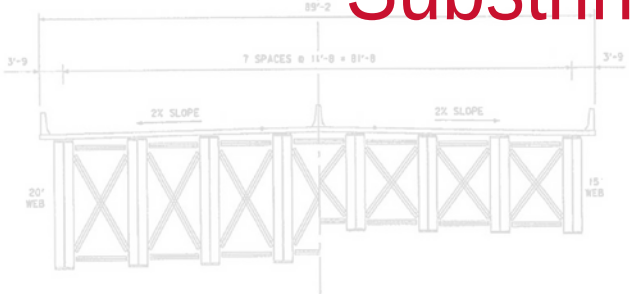
Preliminary Type Study

Steel Plate Girder Options

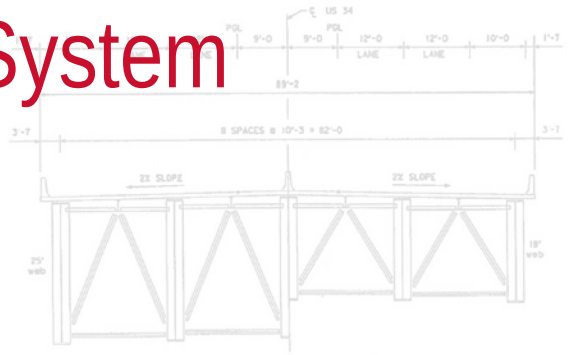
- Multi-girder vs. Substringer
- Weights based on prelim design and experience
- Fabricator discussions
- Review of existing structures

ADVANTAGE:

Substringer System



Multi-girder Section

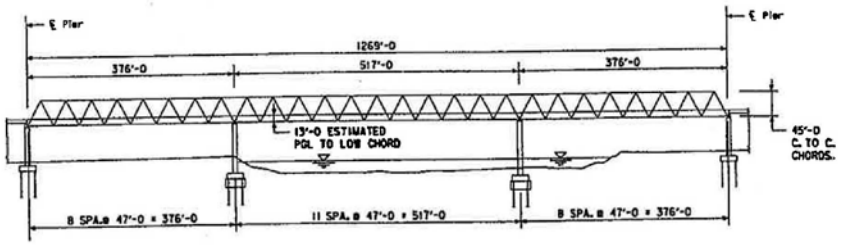


Substringer Section

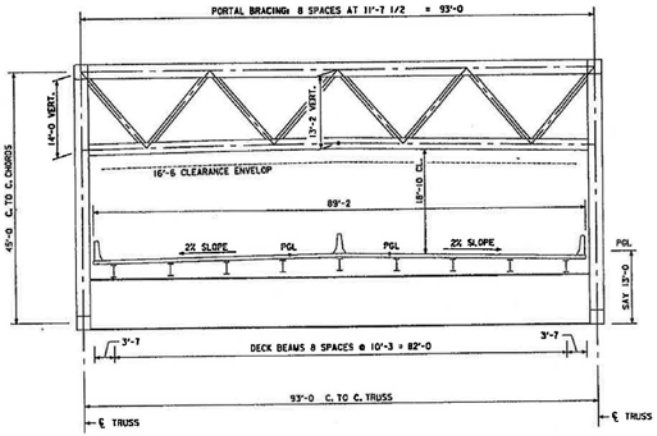
Preliminary Type Study

Truss Option

- Constant depth Warren Truss
- Weights based on prelim design and experience
- Fabricator discussions
- Review of existing structures



Truss Elevation



Truss Section

Preliminary Type Study

Steel Girder vs. Truss Comparison

Quantities (prelim member sizing)

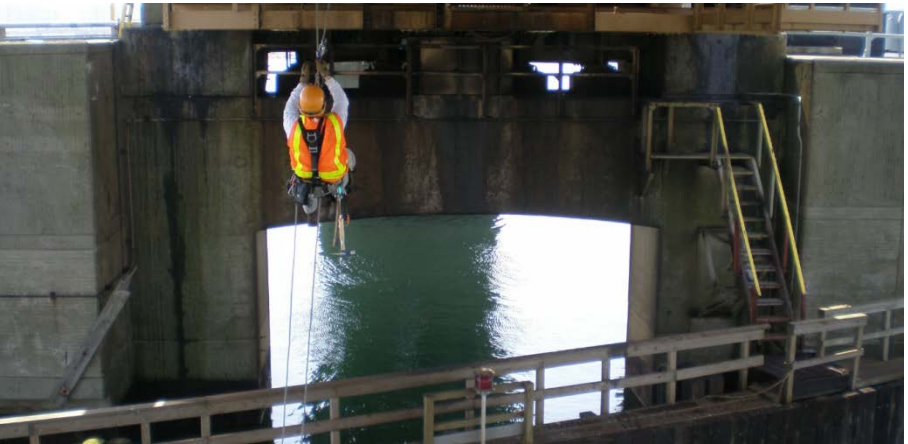
\+ Unit prices (fabricator & contractor input)

\+ Life cycle costs

Prelim cost for comparison

Preliminary Type Study

- Life Cycle Costs
  - Painting
    - Truss
    - Plate girder – fascia girder only
  - Similar Costs
    - Annual maintenance
    - Inspection
    - Overlay
    - Deck replacement



Preliminary Type Study

Life Cycle Costs

	Unit Rate for Structural Steel - Erected	Structural Steel - Erected Cost	Relative Grade Reduction Cost	Future Painting Cost	Comparative Cost
Steel Plate Girder	$2.35 / Lb.	$26.1 Mil	$0	$0.56 Mil	$26.66 MIL
Steel Truss	$2.47 / Lb.	$25.9 Mil	-$0.5 Mil	$1.45 Mil	$26.85 MIL

SLIGHT ADVANTAGE: Girder System

Preliminary Type Study

Other Considerations

Advantages

Plate Girder

- Steel below deck
- Fewer erection pieces
- No fracture critical

Truss

- Cantilever construction
- Lighter pieces
- Shipping (no barges)

Preferred Alternative: Substringer System

Design Considerations

What is of interest to design engineers?

- Appropriate level of analysis?
- Reliable/accurate design forces
- Preliminary design vs. final design

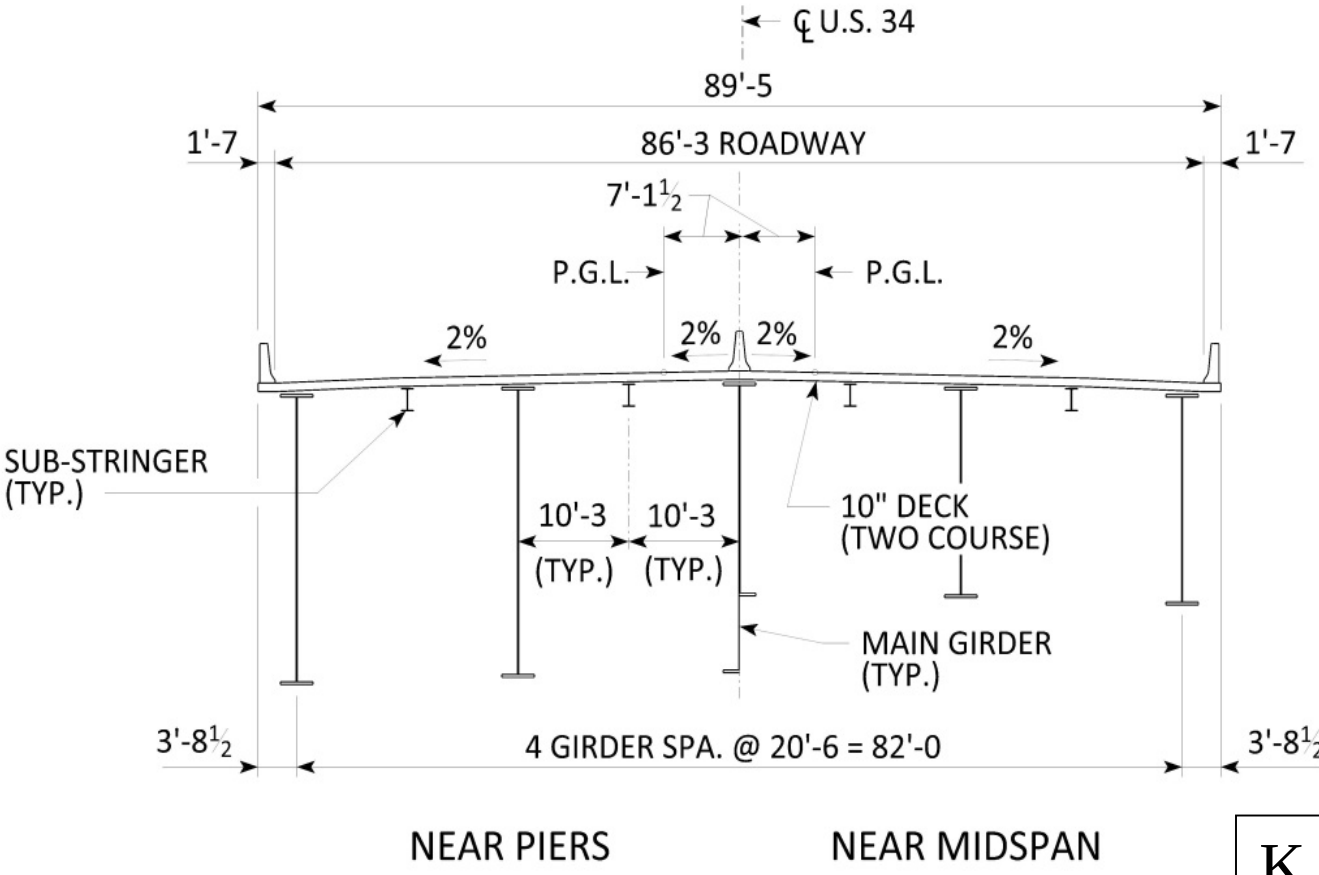
Design Considerations

AASHTO LRFD Criteria

- Live load distribution – approximate equations

	AASHTO LRFD Approximate Equation Range of Applicability	Criteria Satisfied?
1	3.5ft ≤ Girder Spacing, S ≤ 16.0ft	NO
2	4.5in ≤ Depth of Slab, t_s ≤ 12.0in	YES
3	20ft ≤ Span of beam, L ≤ 240ft	NO
4	Number of beams, $N_b \geq 4$	YES
5	10,000 ≤ Longitudinal Stiffness Parameter, K_g ≤ 7,000,000	NO
6	-1.0ft ≤ Horizontal distance from exterior beam to gutterline, d_e ≤ 5.5ft	YES

Design Considerations



$d_e < 5.5ft$ (**OK**)

$N_b \geq 4$ (**OK**)

$t_s < 12in$ (**OK**)

$S \geq 16ft$ (**NG**)

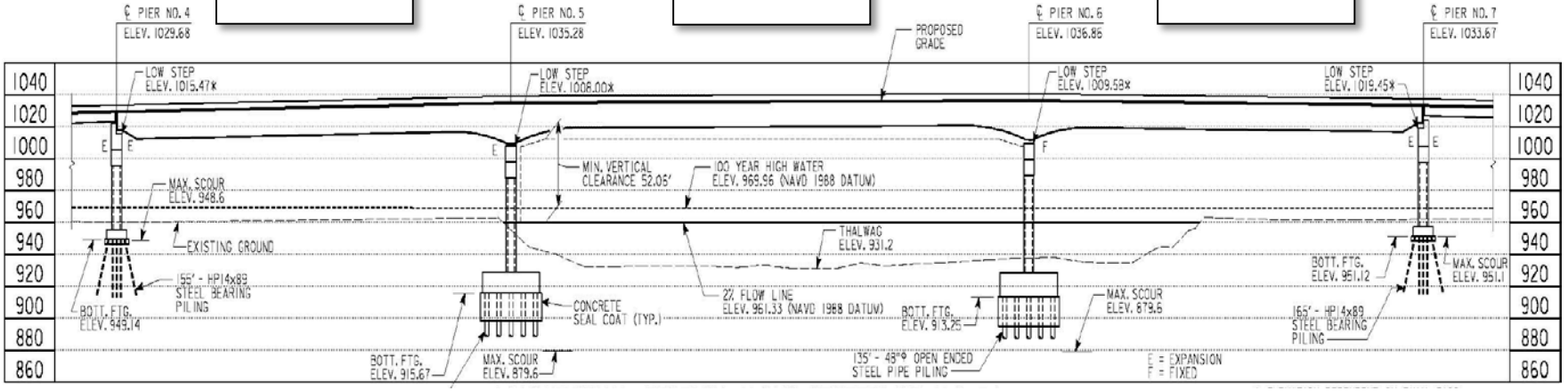
$K_g \geq 7{,}000{,}000$ (**NG**)

Design Considerations

391ft

515ft

391ft



$L \geq 240ft$ (**NG**)

Design Considerations

Is line girder accurate enough for prelim design?

- Evaluate accuracy of AAHSTO equations
- Compare 3D FEM results to line girder
- Investigated similar project

Results?

- Line girder results were conservative
- Exterior girder compared favorably

Design Considerations

Moment Comparison

Girder	Analysis Type	Max Positive Moment End Span	Max Negative Moment Interior Pier	Max Positive Moment Middle Span
		Ft-Kips	Ft-Kips	Ft-Kips
A Exterior	3D FEM (3D)	18397	-26608	19287
	Line Girder (LG)	19741	-29665	20053
	Delta (LG/3D)	+7.3%	+11.5%	+4.0%

Shear Comparison

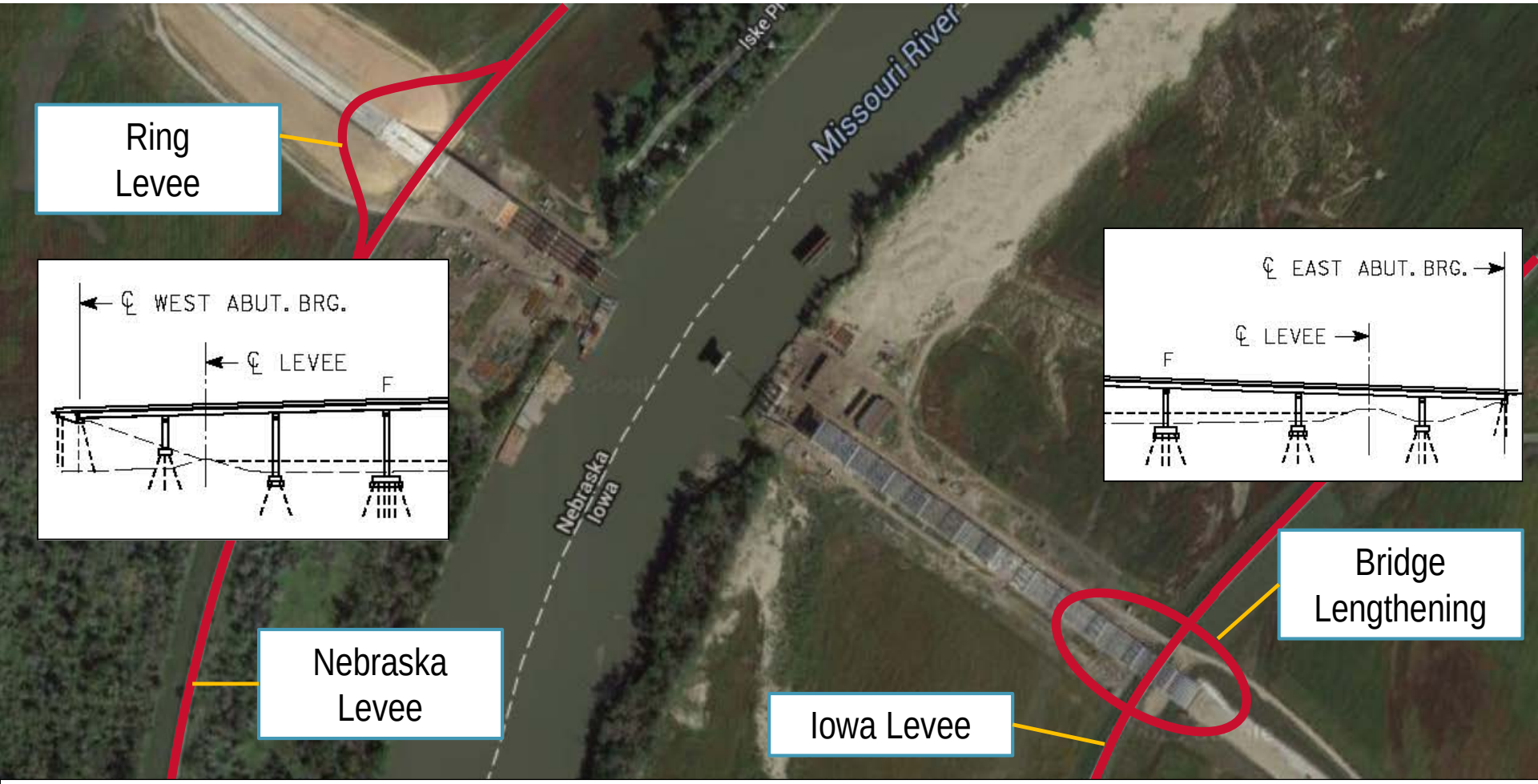
Girder	Analysis Type	Max Shear End Support	Max Shear Interior Support End Span Side	Max Shear Interior Support Middle Span Side
		Kips	Kips	Kips
A Exterior	3D FEM (3D)	207	297	293
	Line Girder (LG)	220	285	297
	Delta (LG/3D)	+6.3%	-4.0%	+1.4%

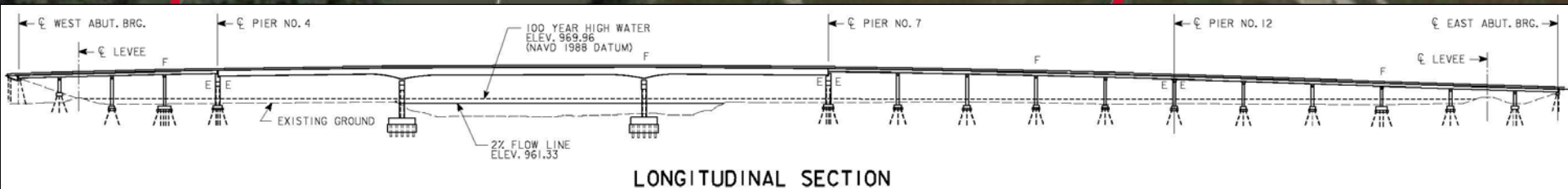
Design Considerations

Practical take away:

Approximate LRFD live load distribution equations can be reliably used for preliminary sizing of plates for a girder with substringer bridge.

Levee Implications



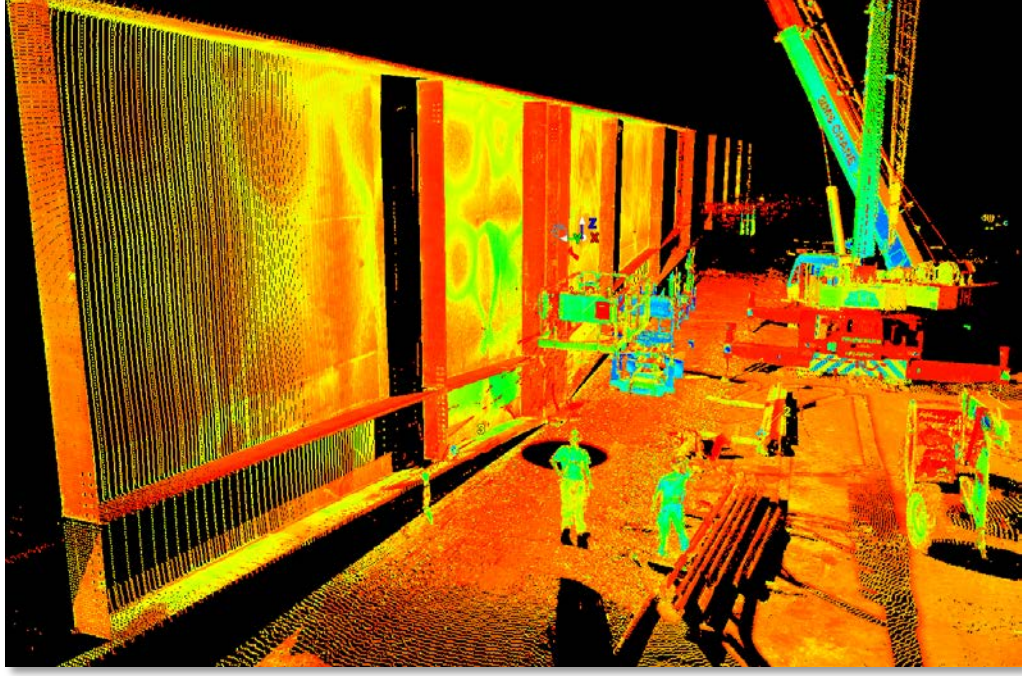


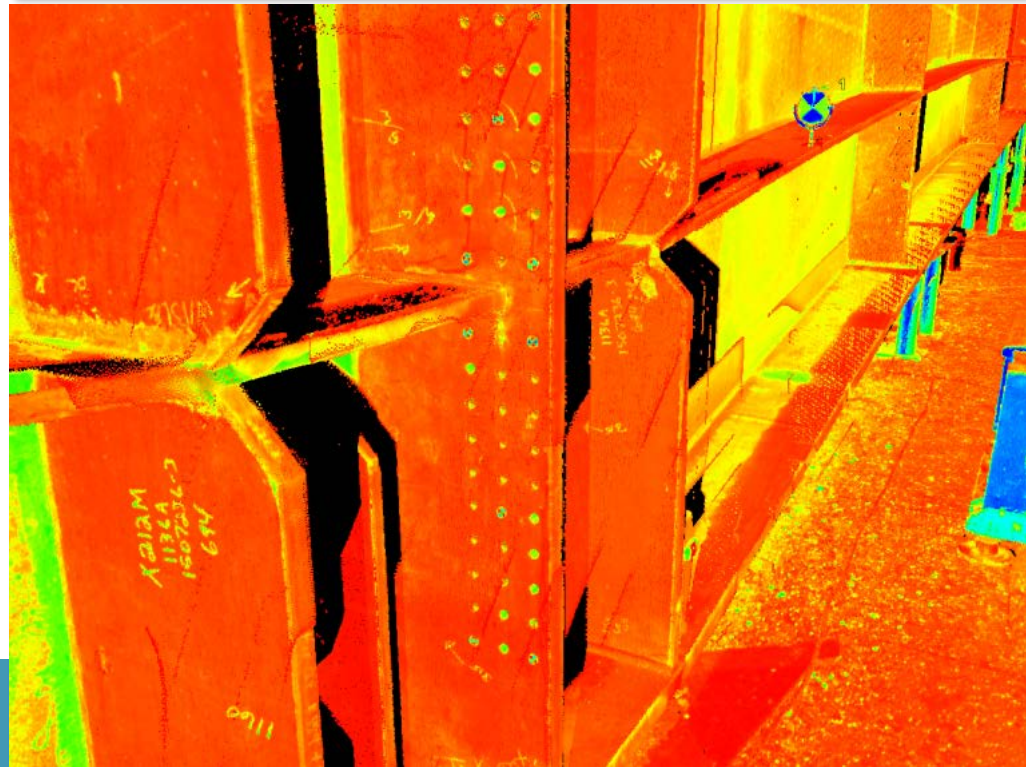
Fabrication

- Veritas Steel
  - Palatka, FL
- Barge shipment
- Field Sections
  - 135’ long
  - 24’ deep
  - 150 Ton pieces

Fabrication

- Laser scanning (similar to LiDAR)
- CNC equipment
  - Field splices
  - Crossframe connections





Shipping

Challenges

- 24’ deep girders
- Height restrictions
- Deck v. hopper barges

Shipping Route

Shipping

Additional Challenges

- 2012 drought v. 2011 floods
- Stranded barges?
- Maritime Law => Arrested Girders

Construction/Erection

Erection picks

- Office scale mode

Laser Scanning

- Field confirmation

Construction/Erection

Falsework Towers

Wing Struts

Construction/Erection

48”φ Pipe Piles

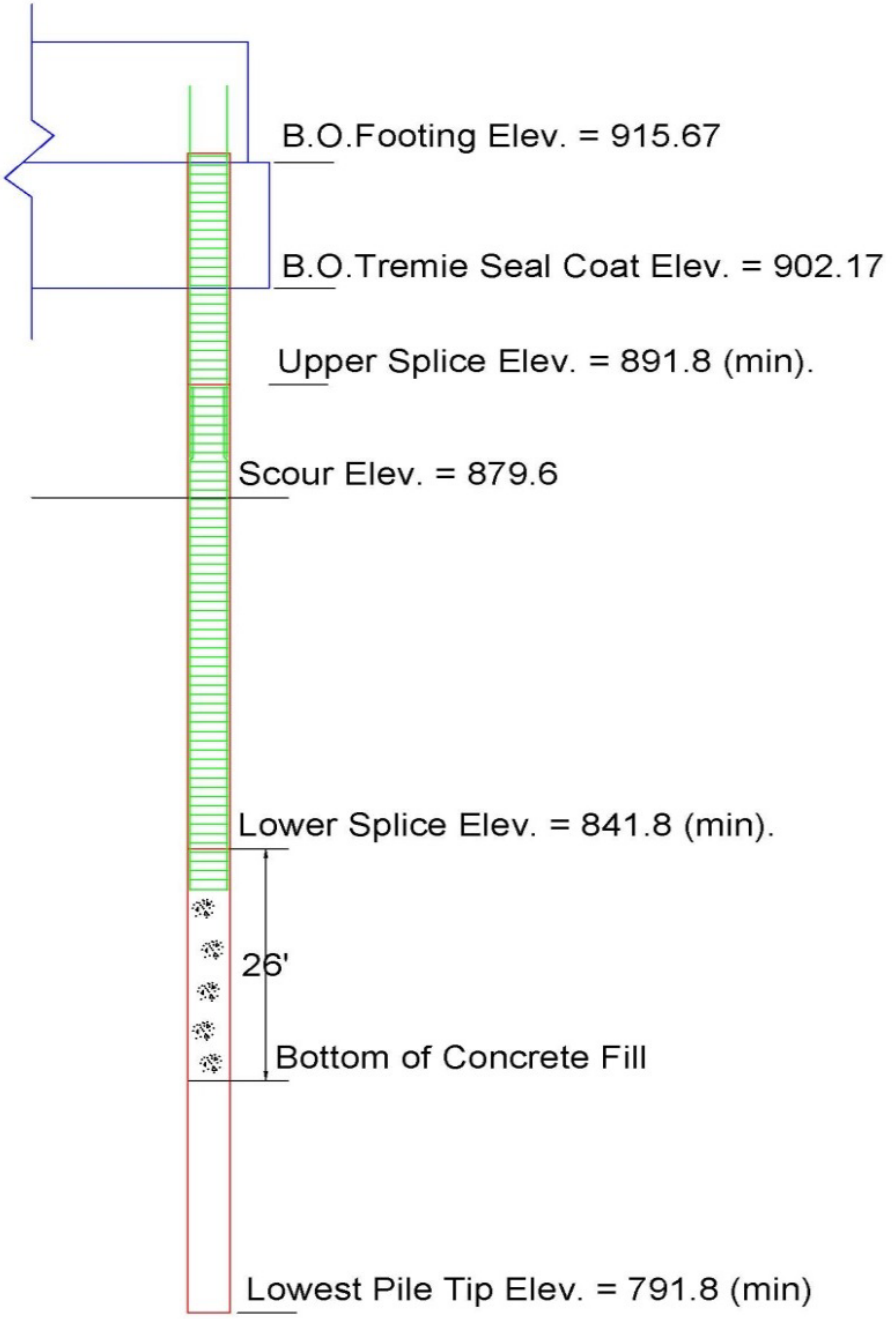
Pipe Pile Construction

Problem:

- Insufficient steel shell full penetration welds

Solution:

- Extend rebar cage below lower splice
- Extend concrete core 26’ below lower splice
- Load shedding from concrete core to steel shell
- Limit settlement in confined gravel core



Construction/Erection

Acknowledgements

Owners

Iowa Dept. of Transportation

Nebraska Dept. of Roads

Contractor

Jensen Construction Co.

Fabricator

Veritas Steel

Questions?

Western Bridge Engineers' Seminar