TRUCKEE RIVER BRIDGE (Tahoe City, CA): *A Unique Cellular Abutment Approach Provides Significant Reduction of Cost and Bridge Deck Area as Well as a Pleasant Trail User Experience*

TRAIL ACCESS BELOW A RIVER BRIDGE

John Rohner, PE, CH2M

Presentation Outline

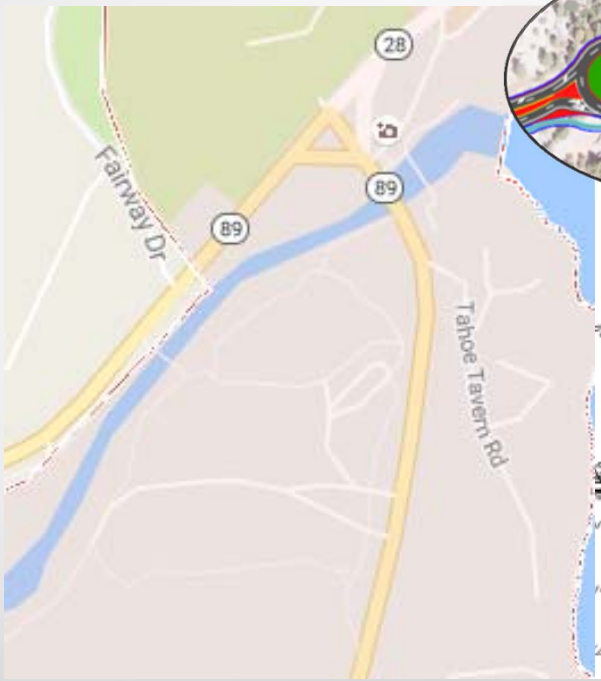
- Introduction
- Structure Type Selection
- Scour Considerations
- Brief Overview of Superstructure Design
- Brief Overview of Substructure Design

Project Location

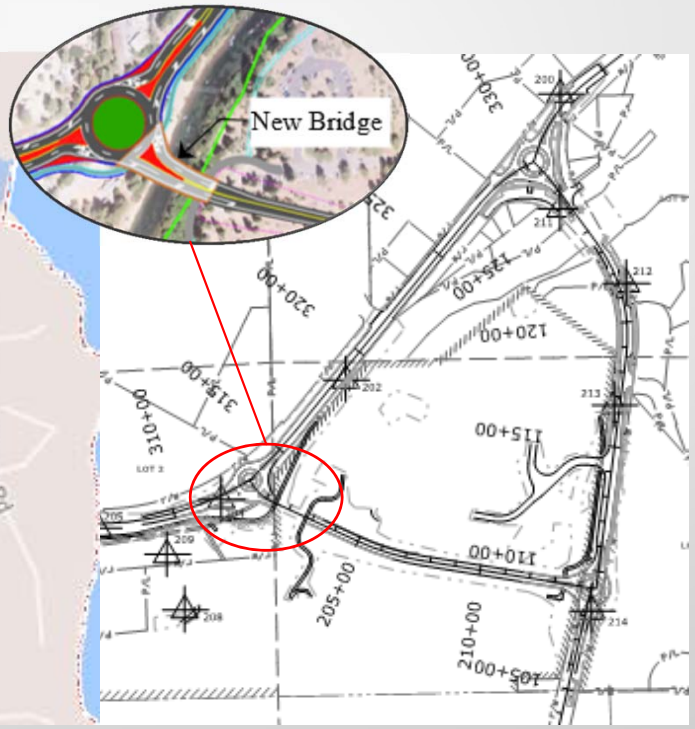
- Tahoe National Forest
- Placer County, CA
- Tahoe City, CA

Project Purpose

- To address present and future travel demand on SR 89/28, the river crossing and associated intersections



Current Alignment



Revised Alignment

Project Purpose

- **Improving pedestrian, cyclist and driver safety**
- Making public transportation more effective with better connectivity, reliability and travel times
- Providing **two viable emergency evacuation routes** from the West Shore
- Lessening environmental impacts by reducing vehicle emissions and improving storm water treatment
- **Enhance trail user experience**
  - Bring pedestrians closer to the river

Project History

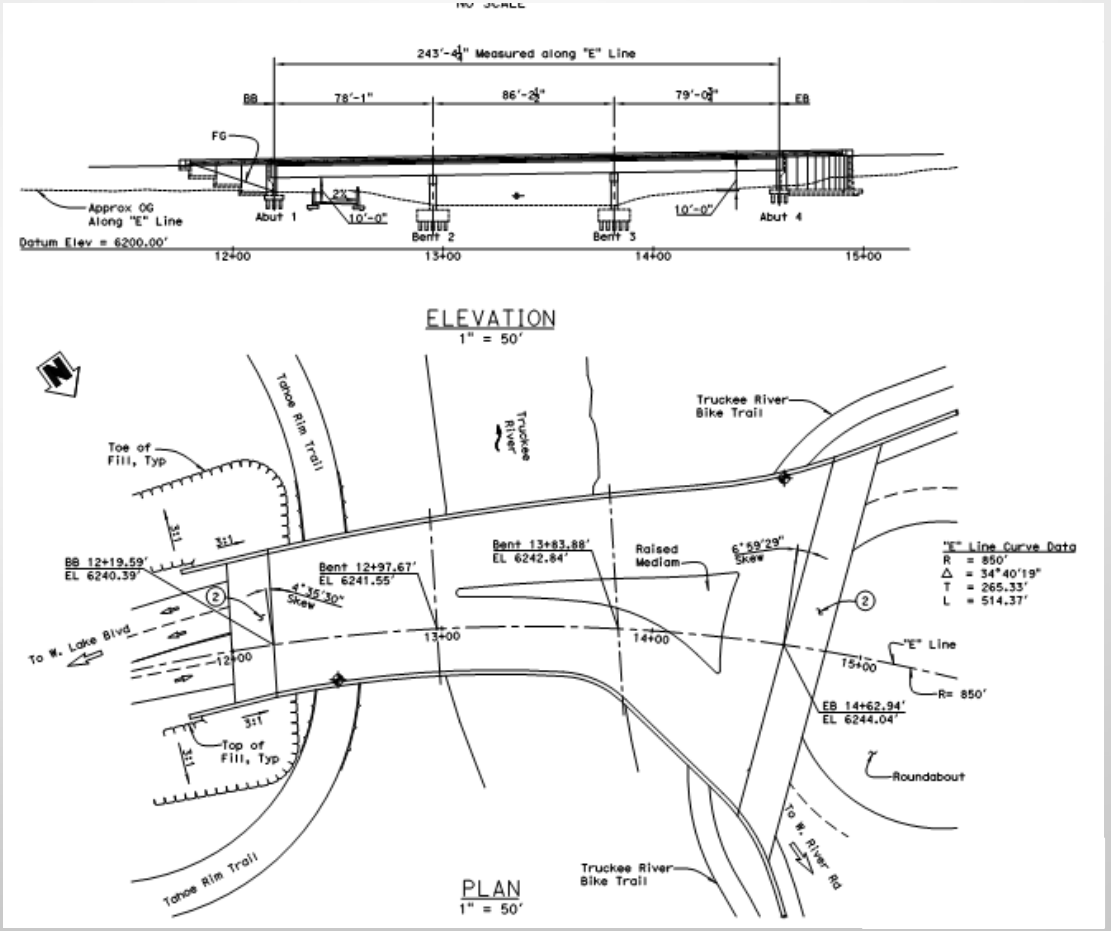
- **1994** Project identified in Tahoe City Community Plan
- November 2000 – SR89/SR28 Transportation Concept Reports
- March 2002 – Project Study Report
- … More Studies
- April 2013 – FLAP Application Submitted
- July 2013 – Notified of FLAP Project Acceptance
- **September 2013** – CFLHD/CH2M Scoping Trip & Report
- July 2016 – Bid Opening
- **October 2016** – Construction Began, Bridge construction in August 2017

Structure Type Selection

Initial Proposed Option

Caltrans Advanced Planning Study (APS) Stage

- Three Spans
- Deep Foundations
- Complicated Geometry

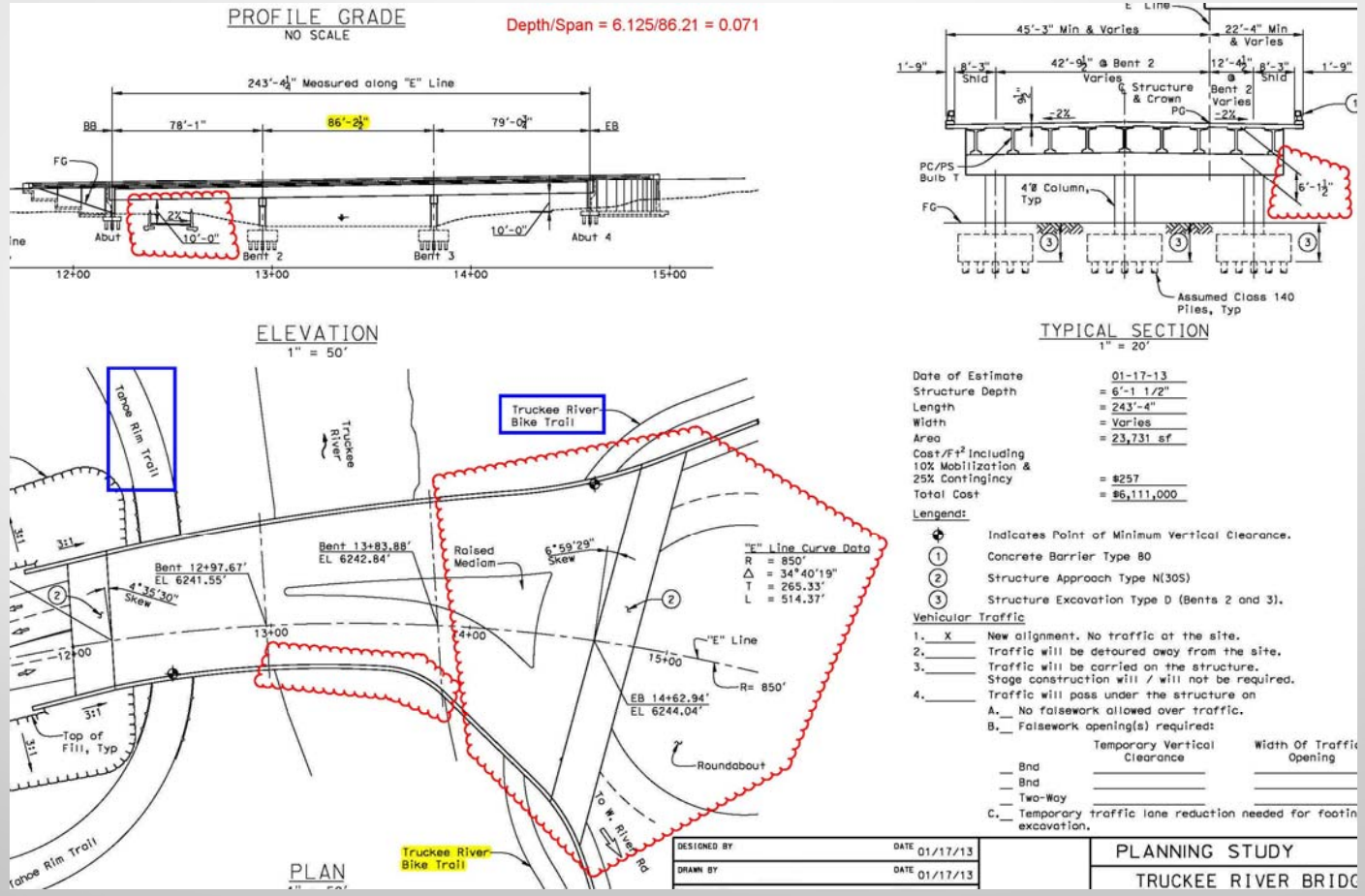


Initial Proposed Option

- Tasked to validate design and cost estimate

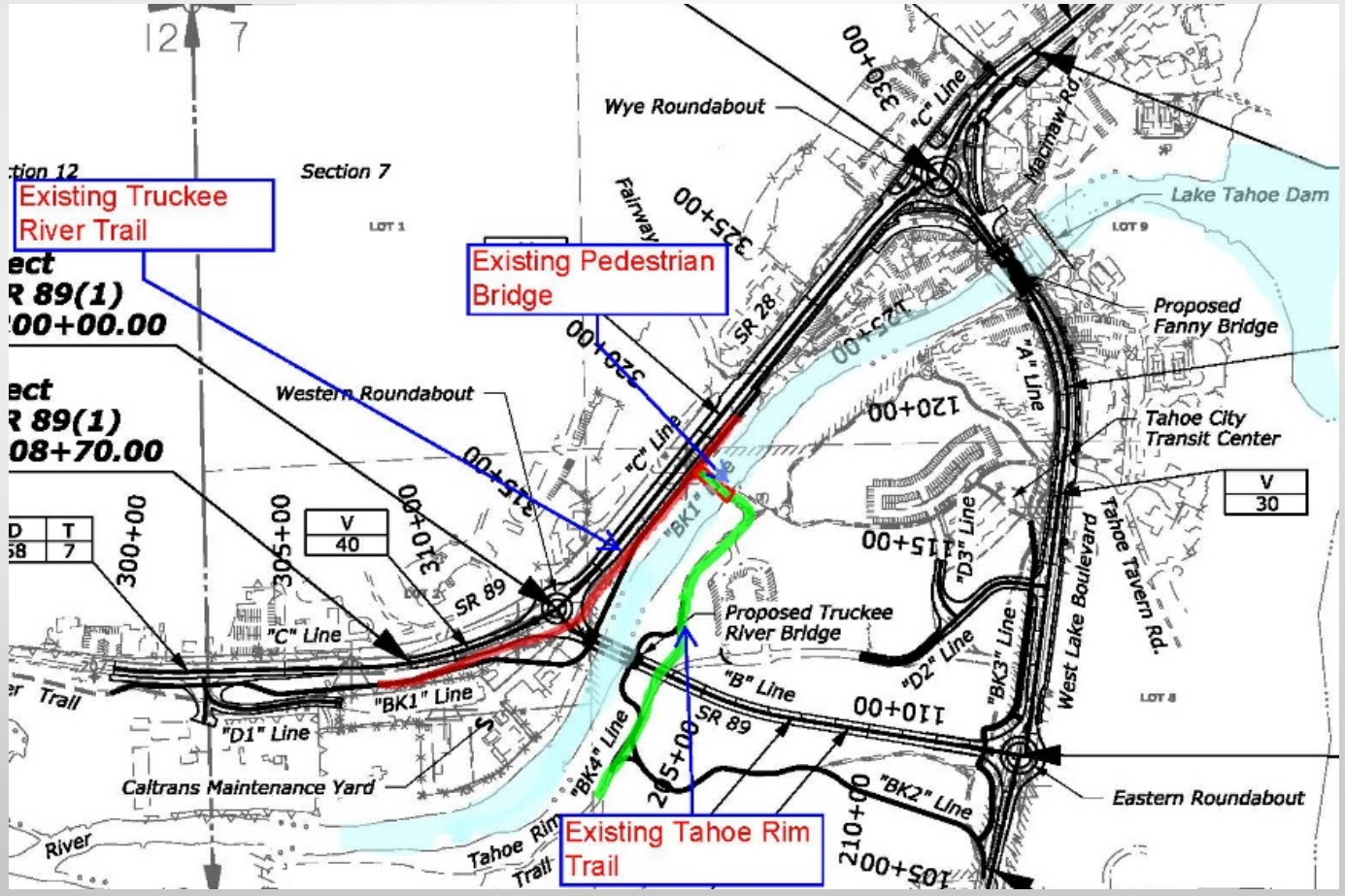
ISSUES

- Retaining walls under east span
- Span-to-depth ratio
- Roundabout on west bridge span



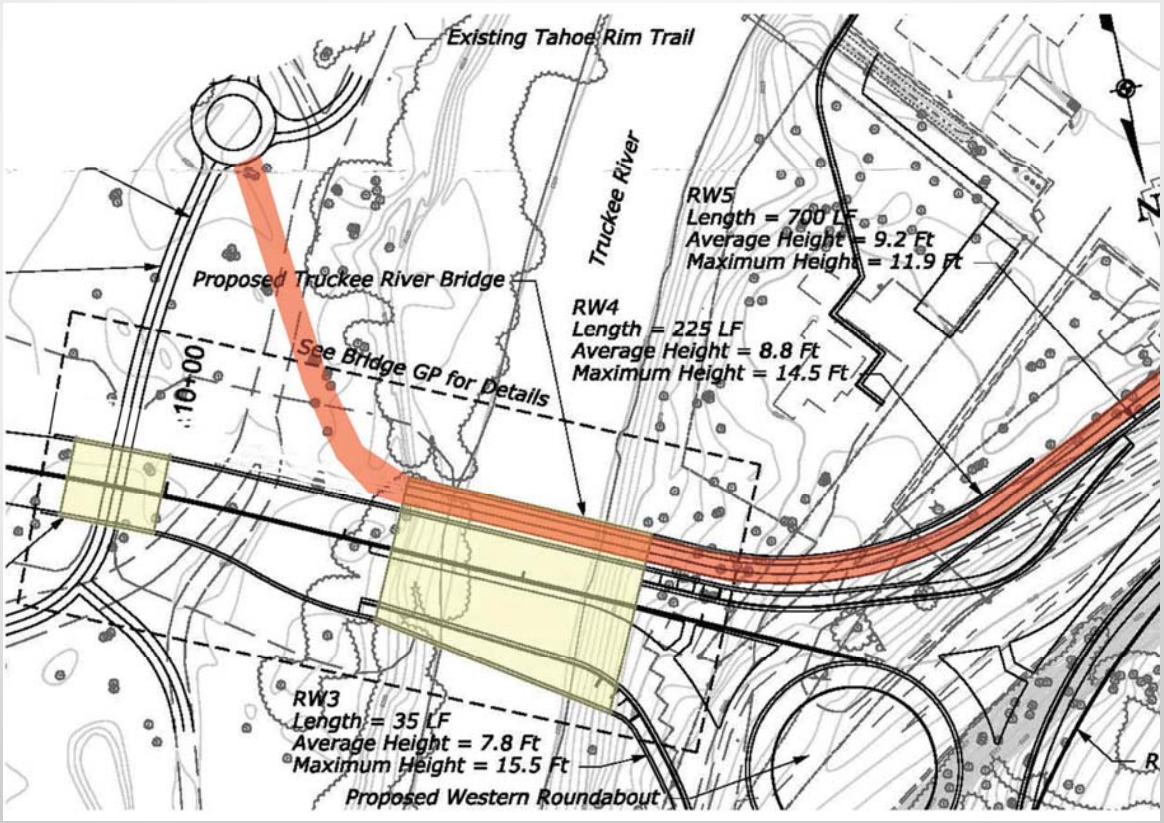
Scoping Trip Evaluation

- Existing Tahoe Rim Trail
  - Culvert undercrossing to remove retaining wall sump
- Shorten bridge crossing to help get roundabout off west span



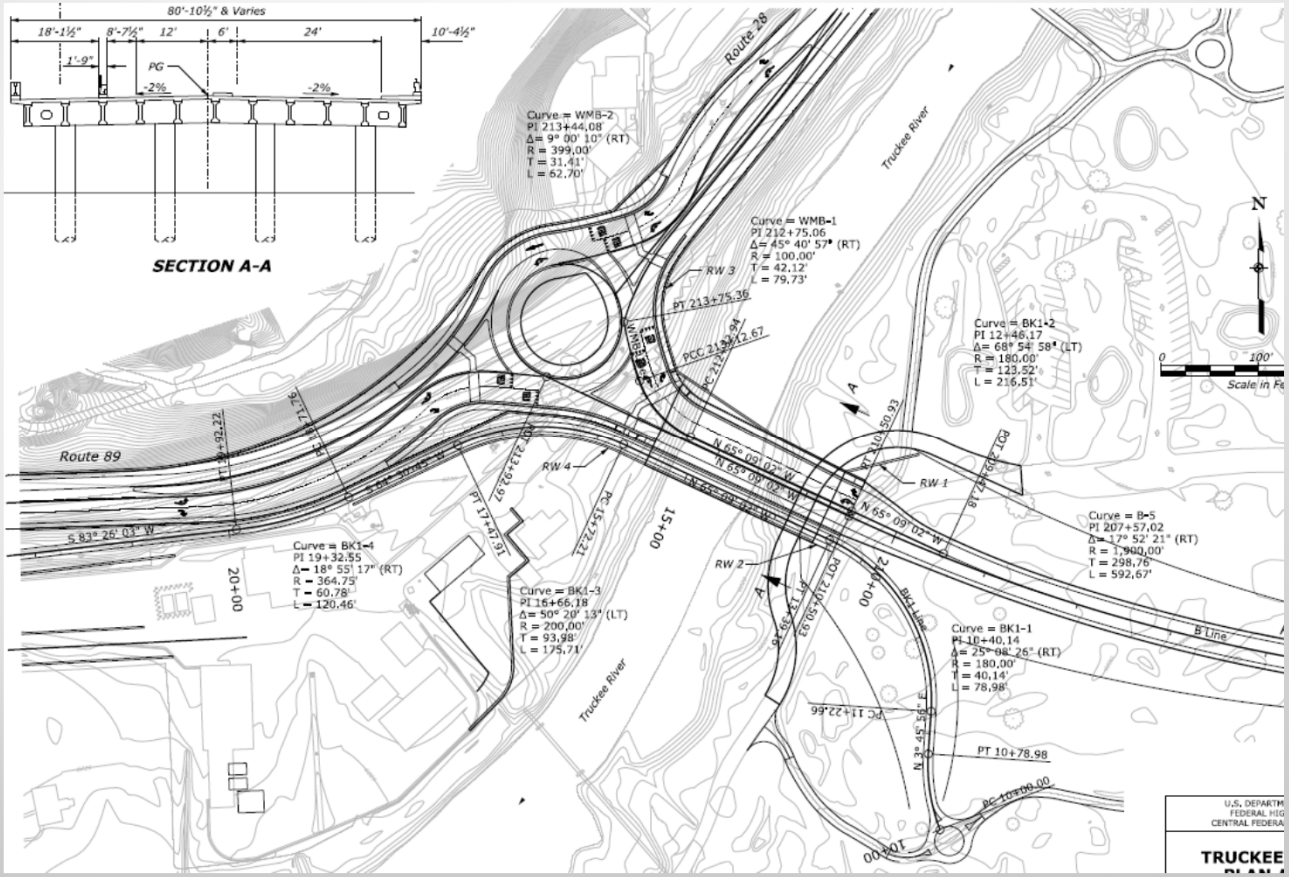
Scoping Trip Proposal

- **Two single span** GRS bridges to reduce deck area
  - River bridge to carry Truckee River Trail
- Utilize existing upstream pedestrian bridge
- Wall type change: CIP walls on piles to Rockery Walls
- Over **$3.5 million anticipated savings**



30% Design Proposed Option

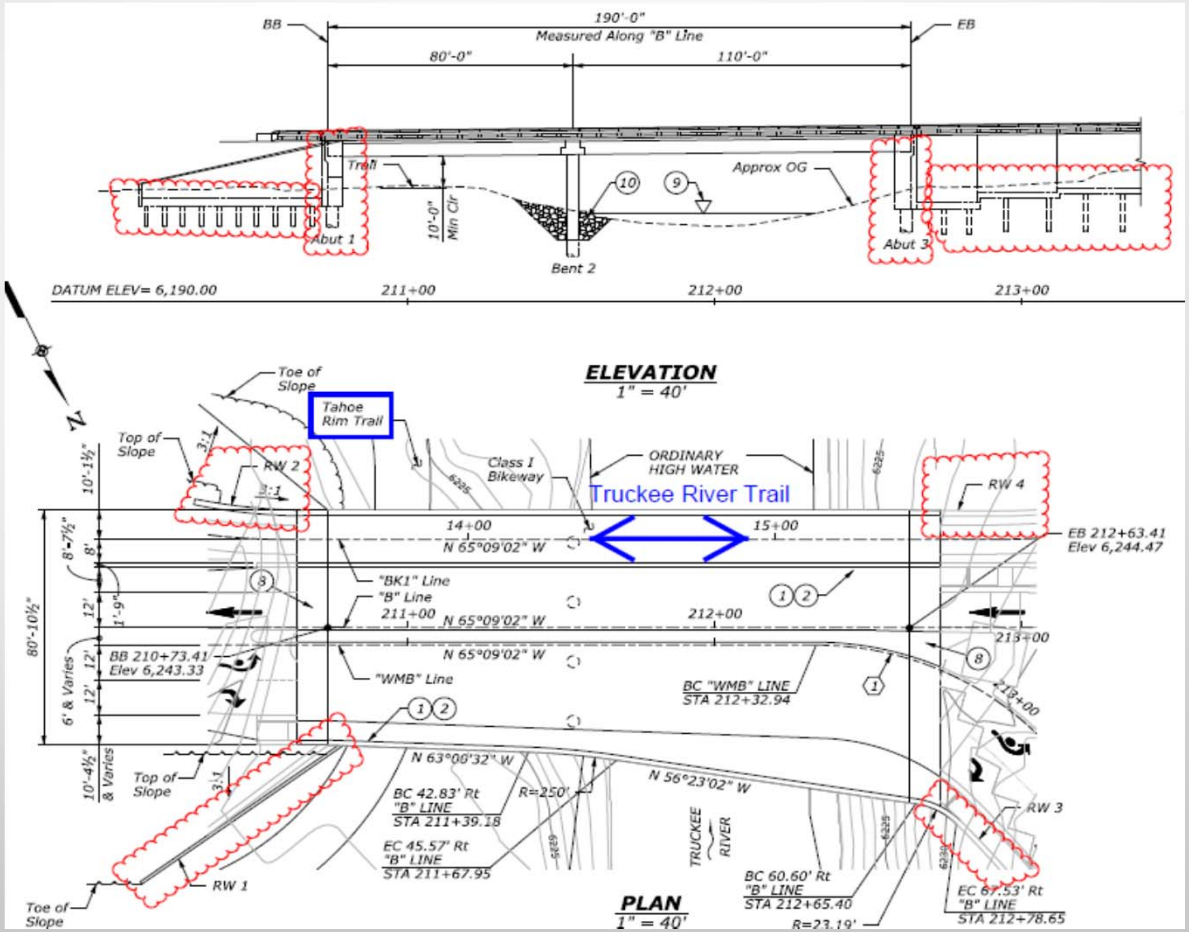
- Two bridge suggestion changed consultant's proposed bridge
- 2-span now vs. 3-span
- Cast-In-Steel-Shell (CISS) deep foundations



30% Design Proposed Option

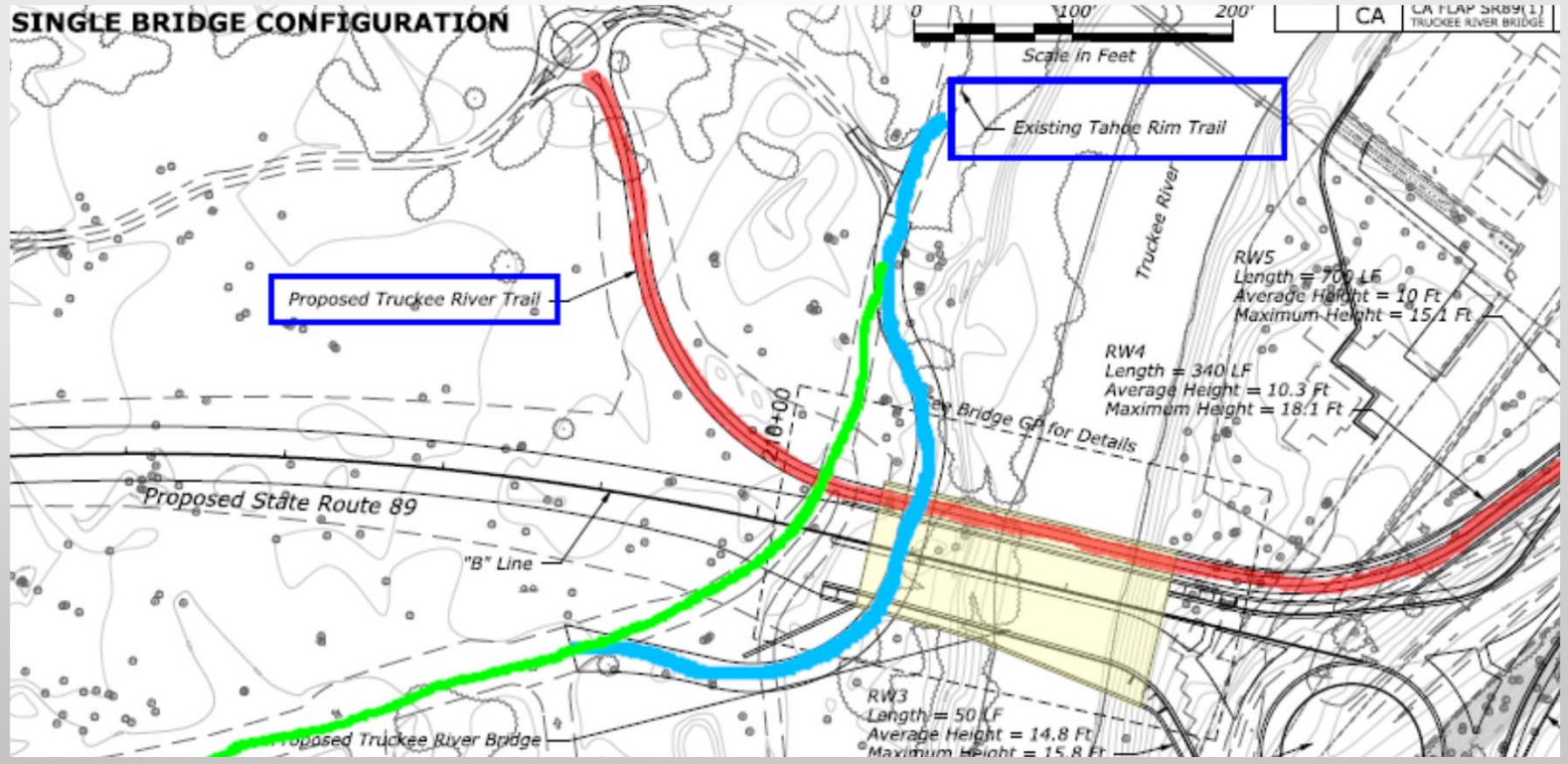
ISSUES

- Tall cantilevered abutment walls
- Retaining walls supported by deep foundations



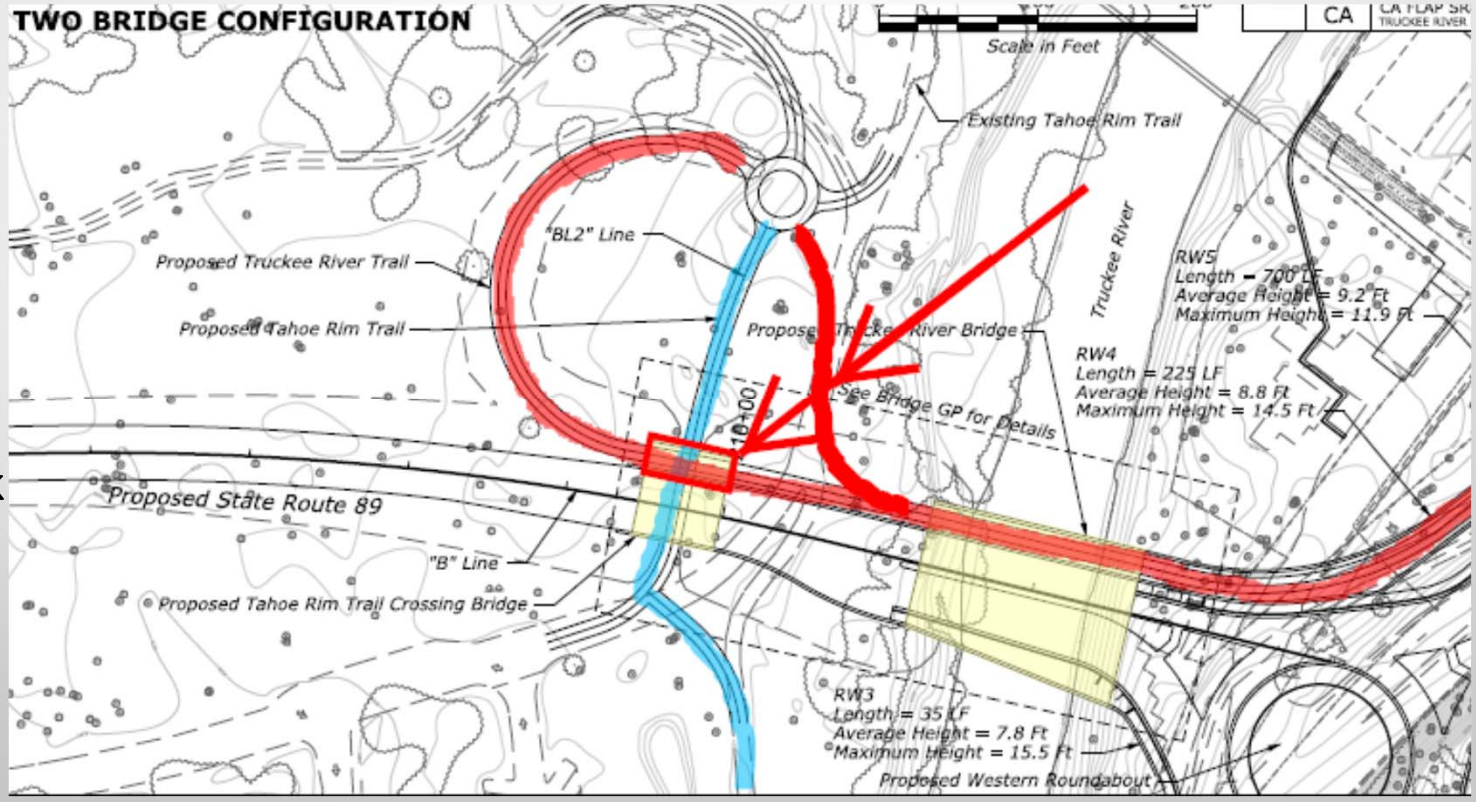
30% Design Proposed Option

- Project was projected to be over construction budget
- Still not two separate bridges and felt this was an opportunity for savings



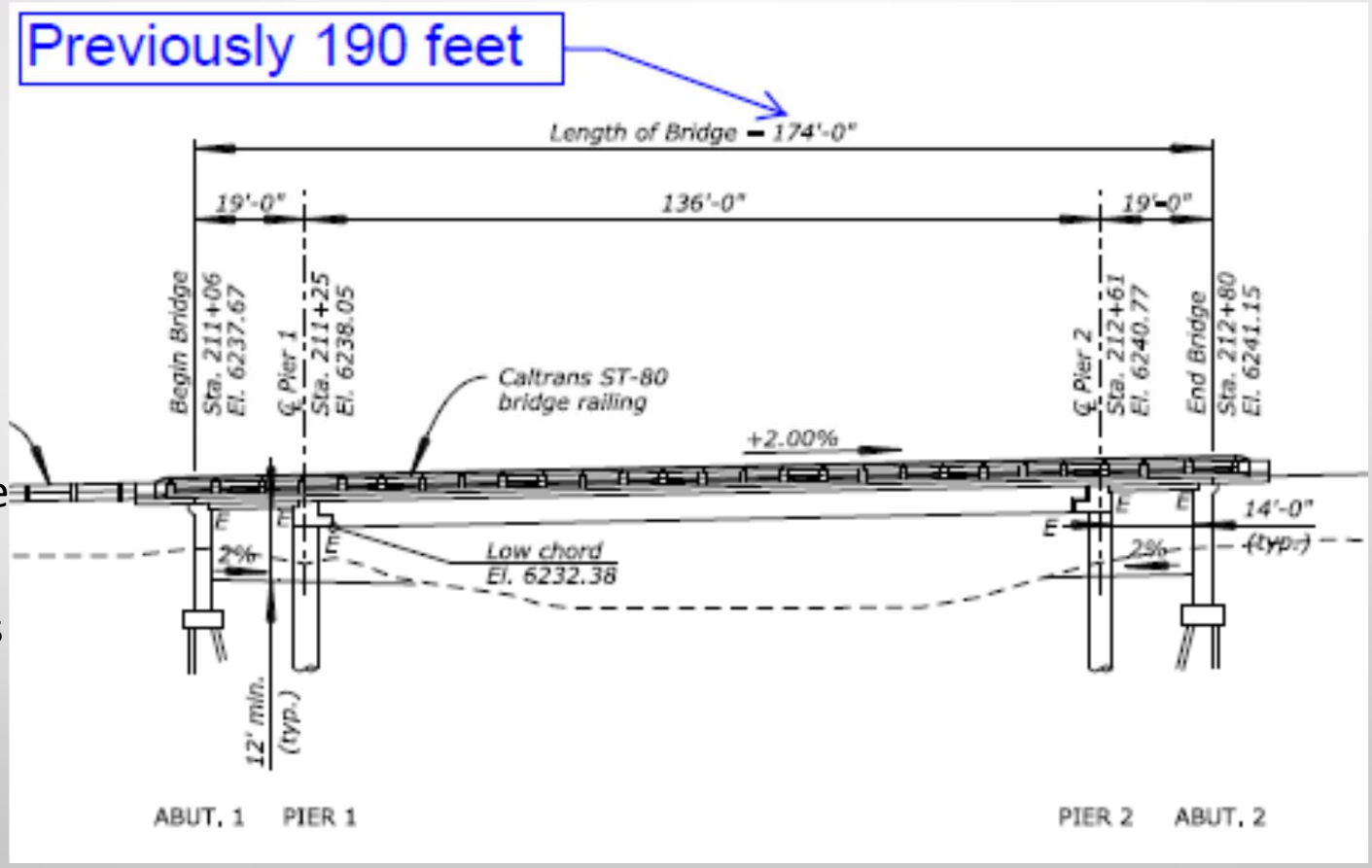
Post-30% Design Study

- Two bridge layout was 1,277 sf less than proposed two-span bridge
- Really 2,350 SF less...
- Study showed savings of $345k but closer to a $725k savings



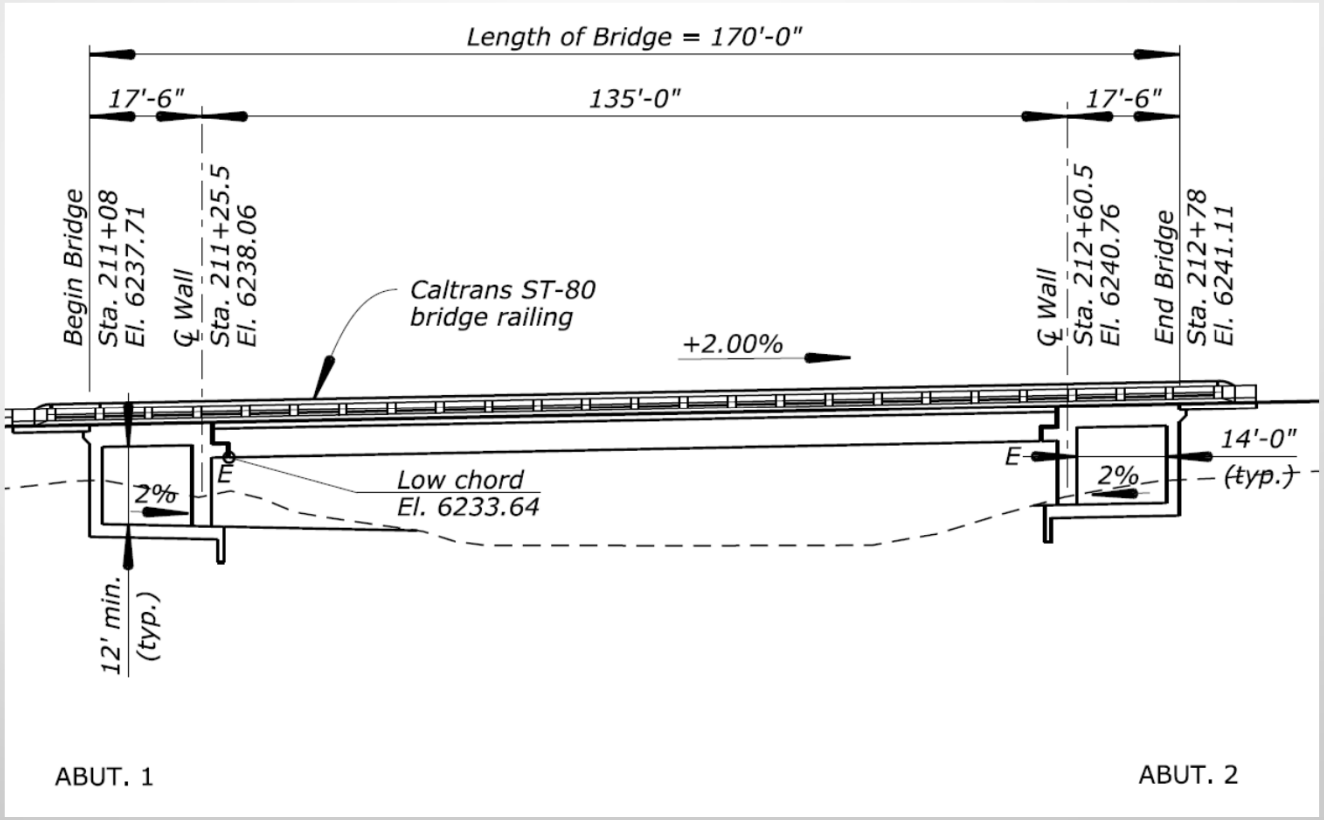
Revised 30% Design, Option 1

- No other consultant now…
- Stakeholder requested both paths along river
- Short end span option, conventional style bridge
- Deep foundations
- $2.95 million



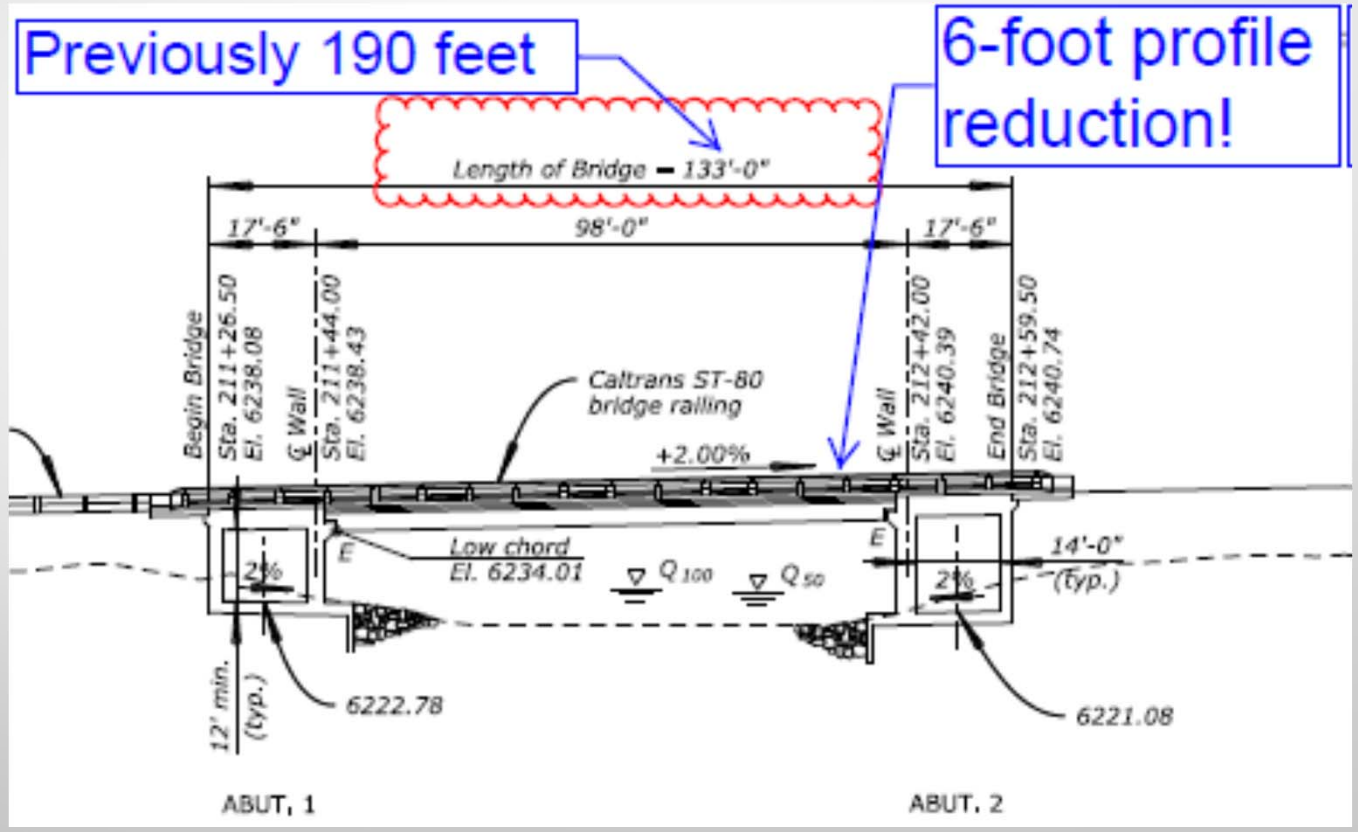
Revised 30% Design, Option 2

- Short end span option, cellular abutments
- Shallow foundations
- $2.83 million



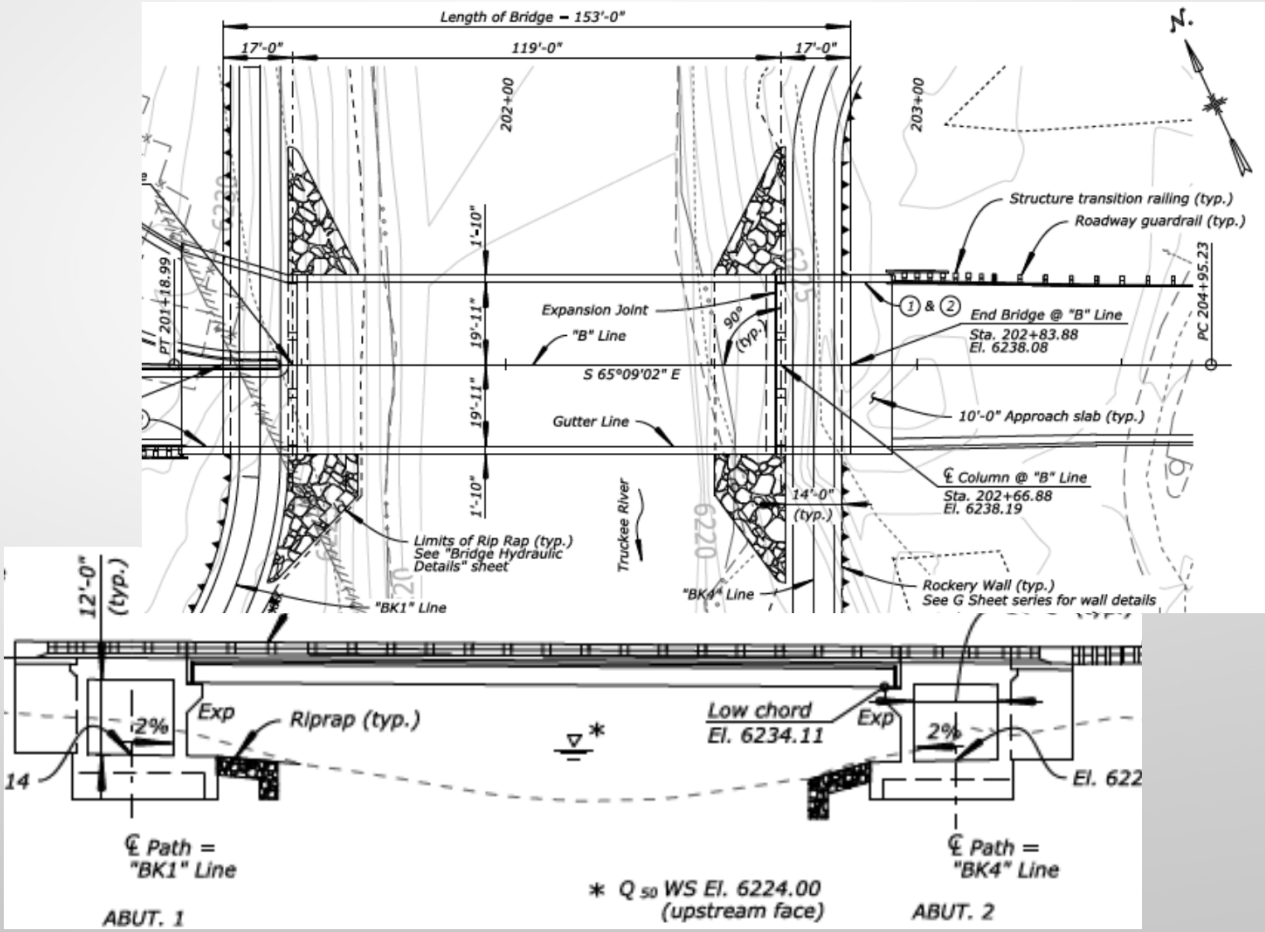
Revised 30% Design, Option 3

- Same as option 2 but hugged ordinary high water mark
- Purposely shrunk to the absolute minimum to see what reaction would be
- $2.56 million



Selected Design Option

- Single Span supported by Cellular Abutments
- Shallow Foundations
- Simplified Geometry
- Decked Bulb Tee Girders
- Huge savings from 30% PS&E submittal!
- Bridge deck area reduced by **72%**
  - 23,731 sf = $6.1M
    other consultant 3-span APS
  - 6,656 sf = $2.6M CH2M
- 6-foot profile reduction and revised approach to retaining walls,
  34,000 sf wall area reduction
  - 39,700 sf = $12.1M
    other consultant
  - 5,440 sf = $0.3M CH2M



Selected Design Renderings

Selected Design Renderings

Scour Considerations

State Scour Requirements

- 100 year design flood for stability (vs. 500 year for FHWA)
- Top of pier footing is not to be exposed when Total Scour has occurred
  - *Structure type not covered*
- Scour is referenced to piers, not abutments
  - *Structure type not covered*
- Preferred use of deep foundations

15.3.2 Embedment and Depth of Footings

The footing embedment shall be carefully determined for degradation and contraction scour for the base (100 year) flood, as well as short term scour depth. The embedment depth of the footing should be adequate to ensure the top of the footing is not exposed when total scour has occured, as shown in Figure 15.3-1. If the footing is not in water and freezing is not of concern, a minimum cover of 2 to 3 ft is recommended.

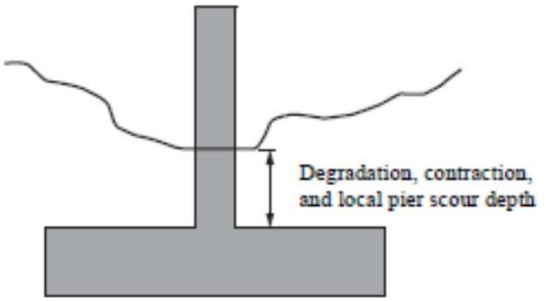


Figure 15.3-1 – Minimum Embedment for Scour Protection

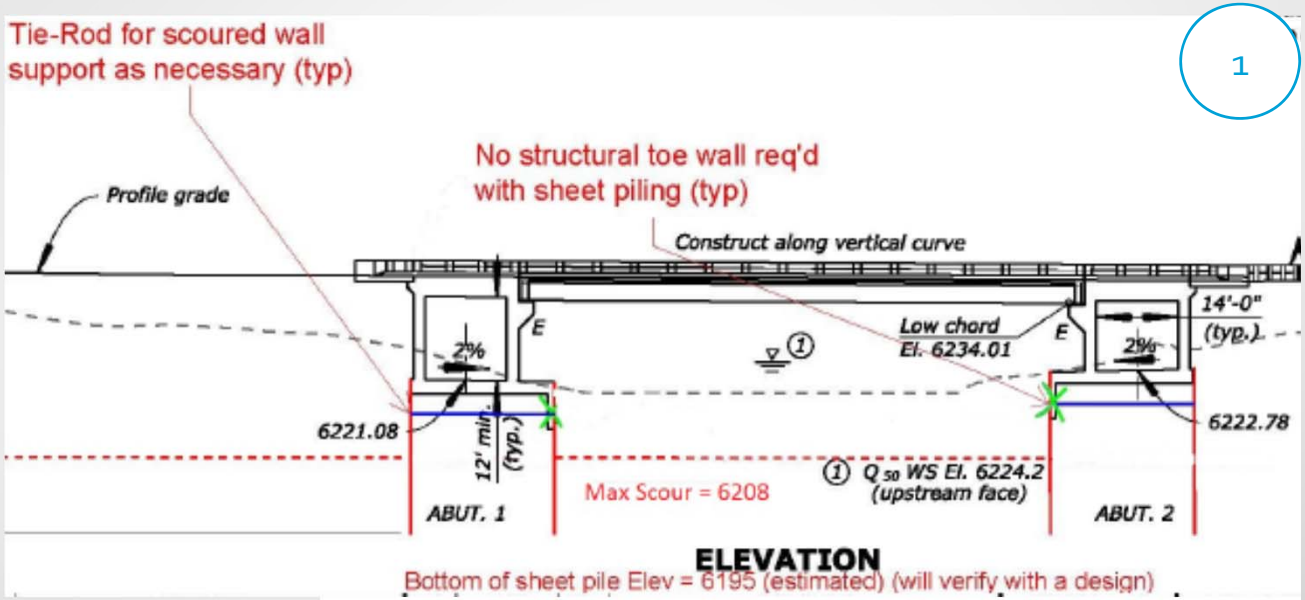
NCHRP/FHWA Requirements

- FHWA/CFL wanted us to follow new method not yet published in HEC-18
- NCHRP Scour Condition A requires depth below channel thalweg
- NCHRP Scour Condition B requires depth below abutment toe
- HEC 23 DG 14, protection of abutments with rip rap on new bridges wasn't being allowed
- No rise requirement for floodway
- Less than 1 ft of rise for floodplain

Solutions to Keep Shallow Foundations

- West Abutment Scour Condition A
- East Abutment Scour Condition B
- **Worst case applies to both abutments**
- 1 - Sheet Piling around perimeter of spread footing
- 2 - Lengthen bridge by 20 feet to move the West Abutment into Scour Condition B

1



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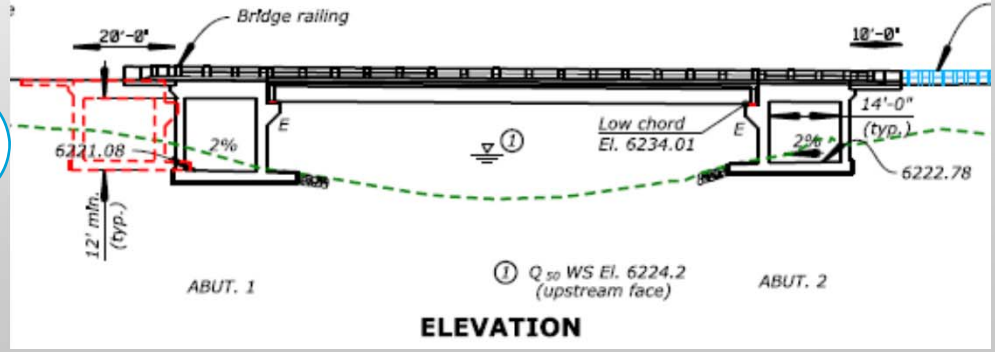
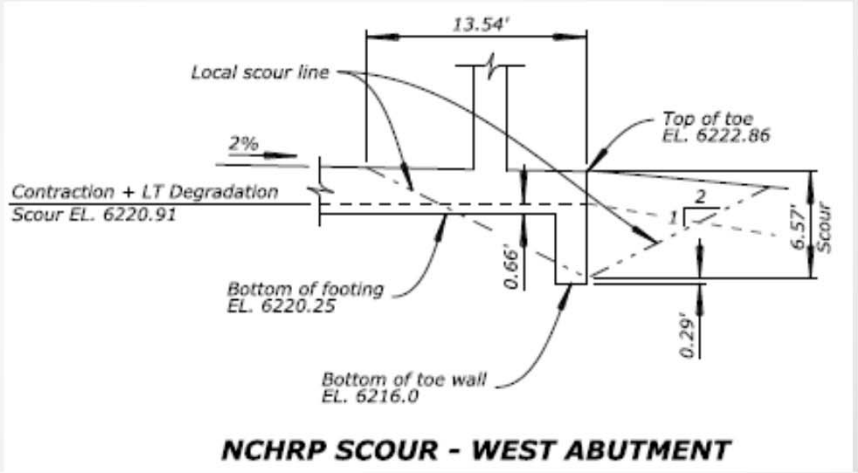
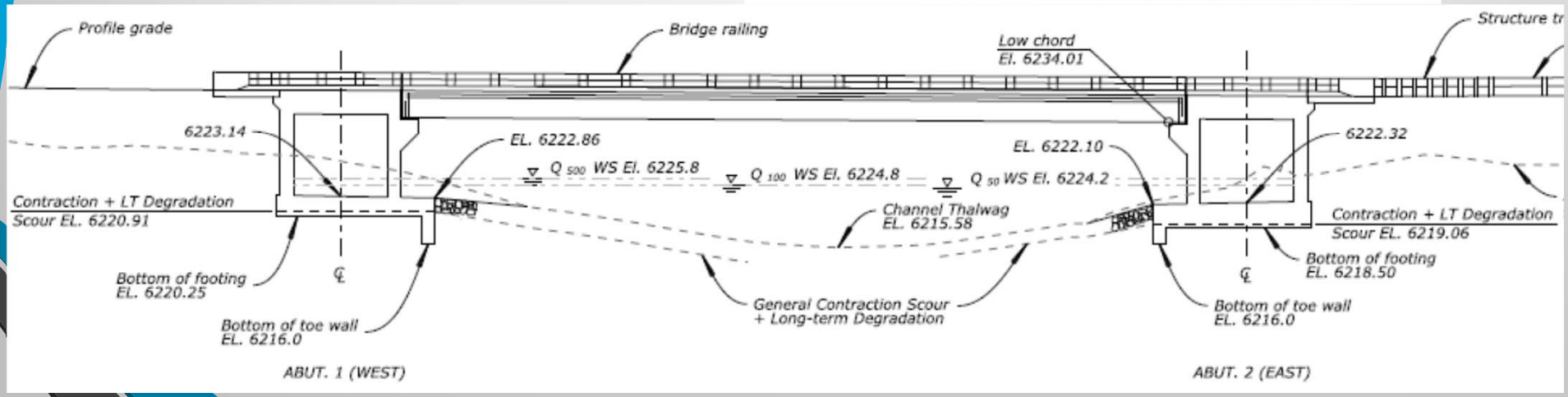


Scour Solution

- Moved west abutment 20 ft away from channel
- Curtain wall on three sides of abutments
- Bottom of footings 6” +/- below 500 year scour depths vs 100 year state requirement

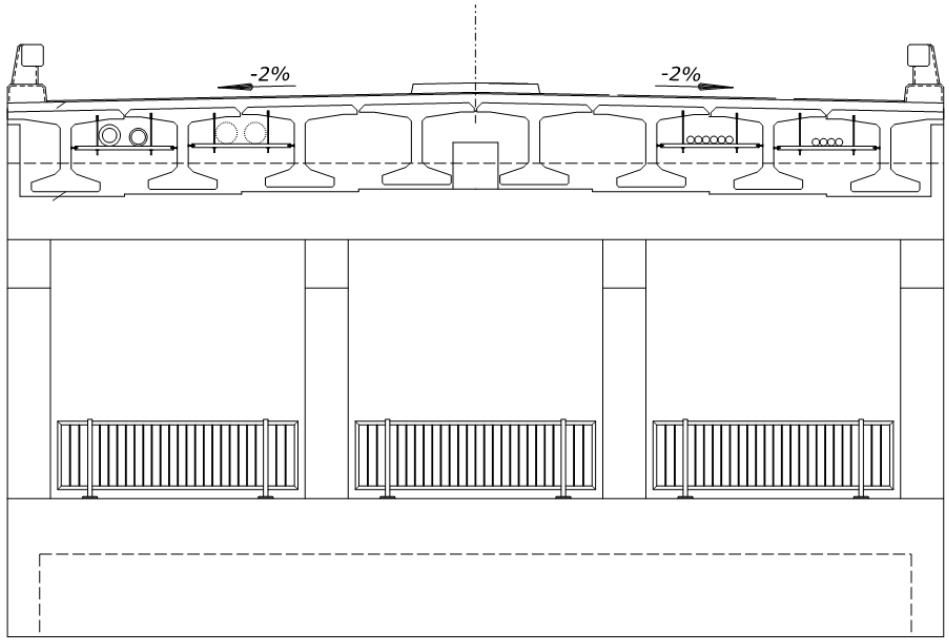




Superstructure Design

Superstructure Overview

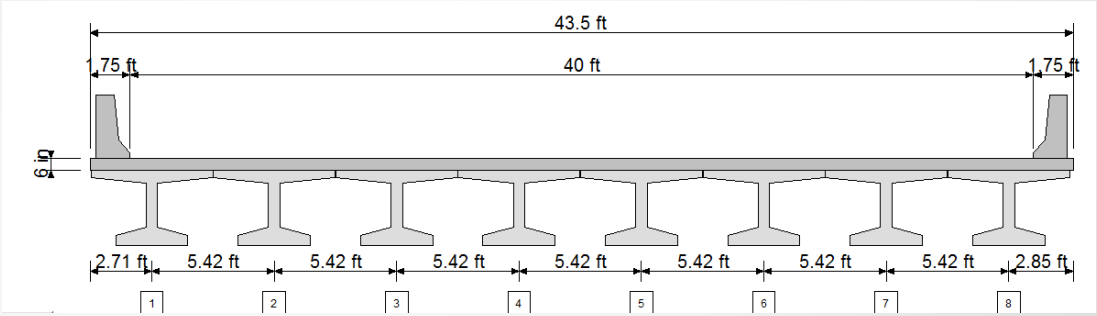
- AASHTO LRFD 2012 6th Edition Caltrans Amendments
- Decked Bulb Tee Girders
- Level Bearing Seats
- Steel Reinforced Elastomeric Bearing Pads
- CIP Concrete Topping
- CIP Diaphragms
- CIP Barriers



TYPICAL SECTION
(Looking back station)

Superstructure Analysis and Design

- 2D Model in CONSPAN
- Design Load Combinations
  - Strength 1
  - **Strength 2 (Caltrans P15)**
  - Service 1
  - Service 3
- Hand Checks
- Grillage Model in MIDAS Civil 3D to Verify Distribution Factors
- For Interior Moment with 2 trucks
  - AASHTO Equations g=0.52
  - CONSPAN Grillage g=0.46
  - MIDAS Grillage g=0.41



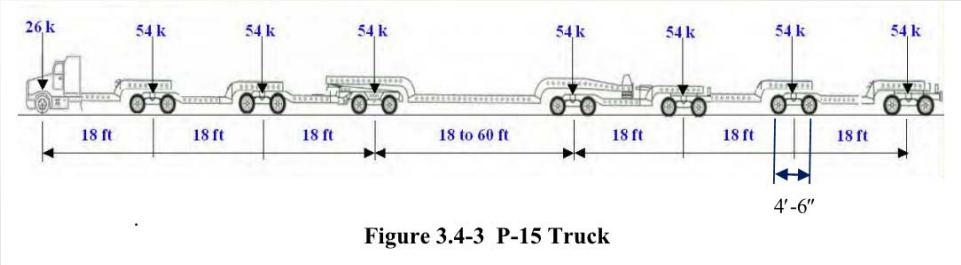
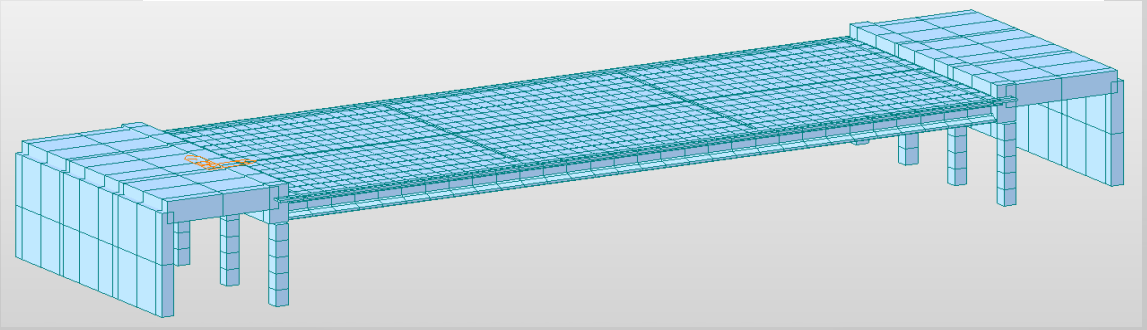
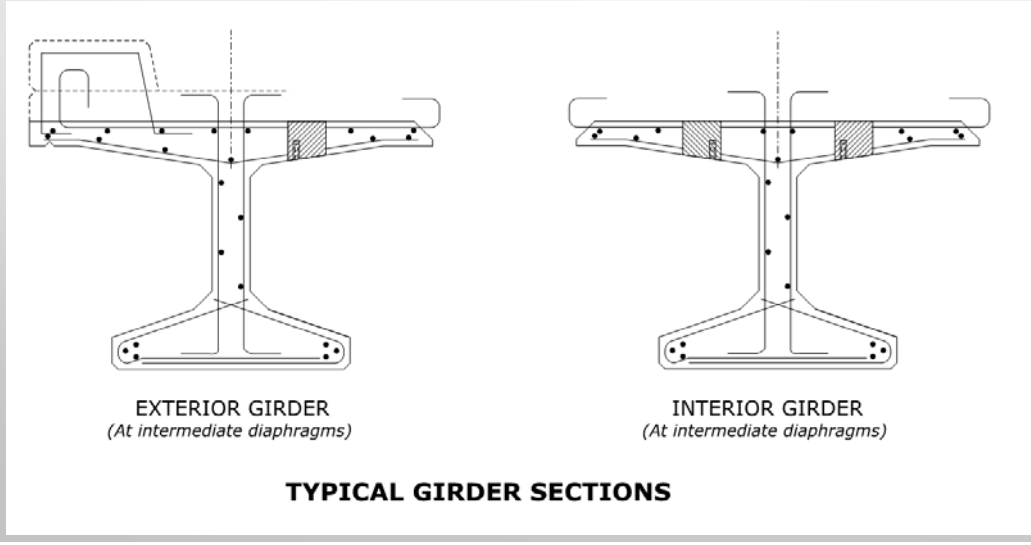


Figure 3.4-3 P-15 Truck



Decked Bulb Tee Girders

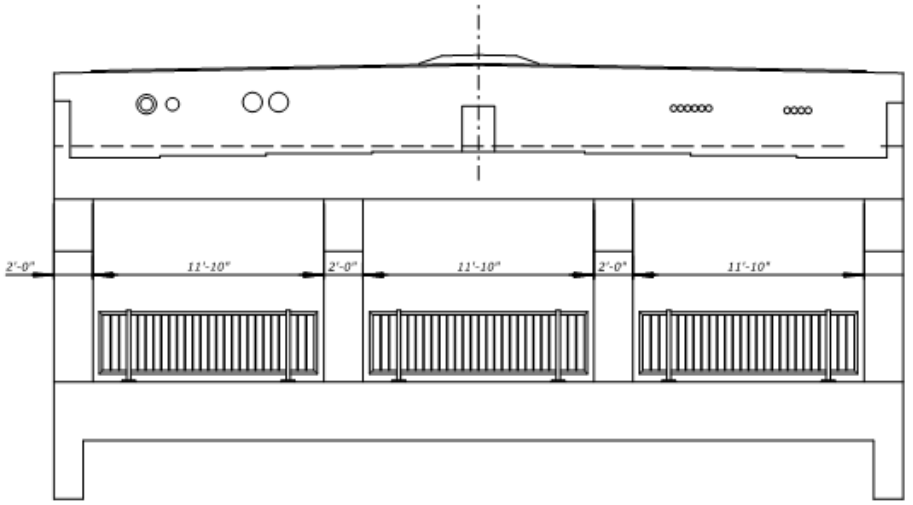
- UDOT Standard Section
- 4” Min. Top Flange Thickness
  - Modified from 6”
- 5” CIP Composite Concrete Topping
- Utility Hanger Inserts
- Embedded Curb Bars
- Projected Interface bars
- Blockouts for diaphragm pour



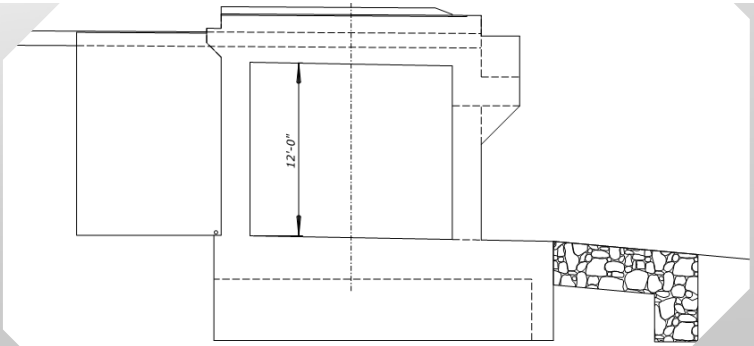
Substructure Design

Substructure Overview

- AASHTO LRFD 2012 6th Edition with Caltrans Amendments
- Caltrans Seismic Design Criteria 2013 v.1.7
- Design Load Combinations
  - Strength 1
  - Strength 2
  - Service 1
  - **Extreme Event 1**
- Spread Footing with Toe Walls
- Columns with Corbel Beam
- Retaining Wall as Backwall
- Solid Top Slab with Utility Voids



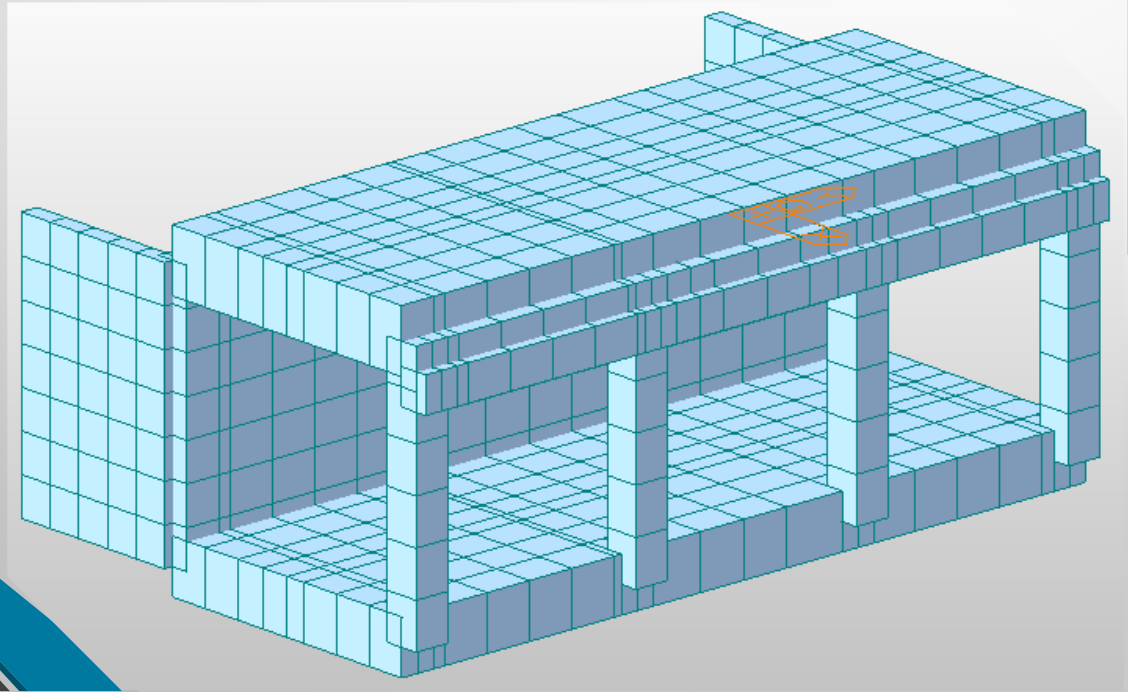
ABUTMENT FRONT ELEVATION
(Looking Back Station)

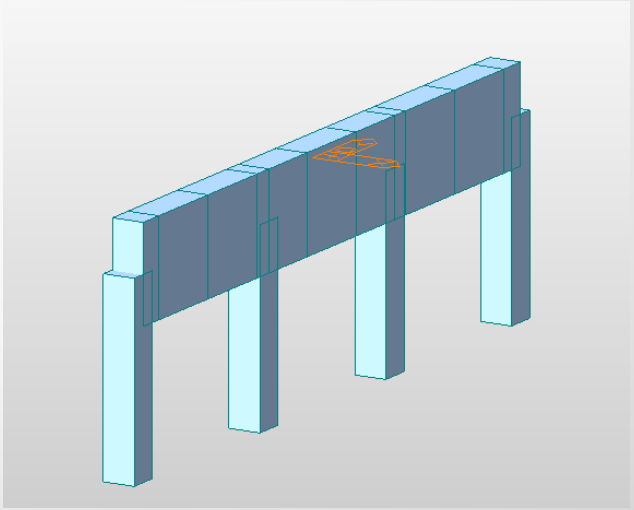


ABUTMENT ELEVATION

Substructure Analysis

- Solid Element Model in SAP 2000
- Plate Element Model in MIDAS Civil 3D
- Beam Element Model was used for Corbel Design





Substructure Design

- Corbel Beam Design
  - Ledge Designed with AASHTO 5.13.2.4
  - Beam Designed using conservative assumptions
  - Detailed for Crack Control and Force Spreading
  - TxDOT Design Example from AASHTO 2010

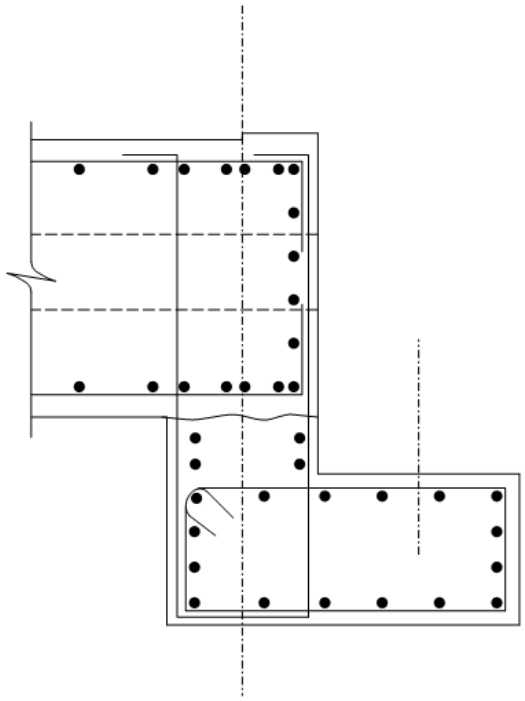
Texas Department of Transportation

BRIDGE DIVISION

County: Any Hwy: Any Design: BRG Date: 6/2010

Inverted Tee Bent Cap Design Example

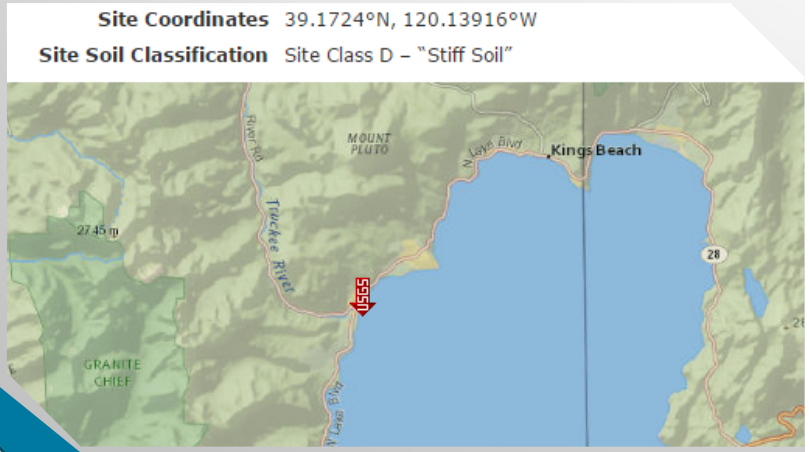
Design example is in accordance with the AASHTO LRFD Bridge Design Specifications, 5th Ed. (2010) as prescribed by TxDOT Bridge Design Manual - LRFD (May 2009).

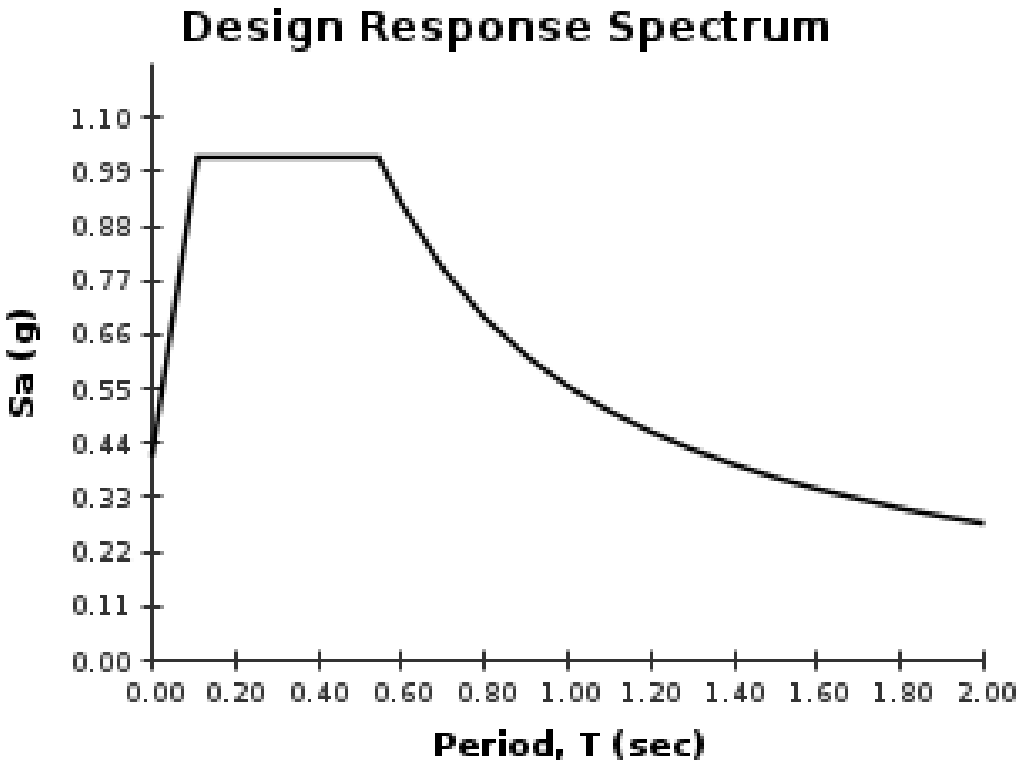


CORBEL DETAILING

Design Parameters

- PGA 0.44g T=0
- Site Class D
- Seismic Design Category D





http://earthquake.usgs.gov/

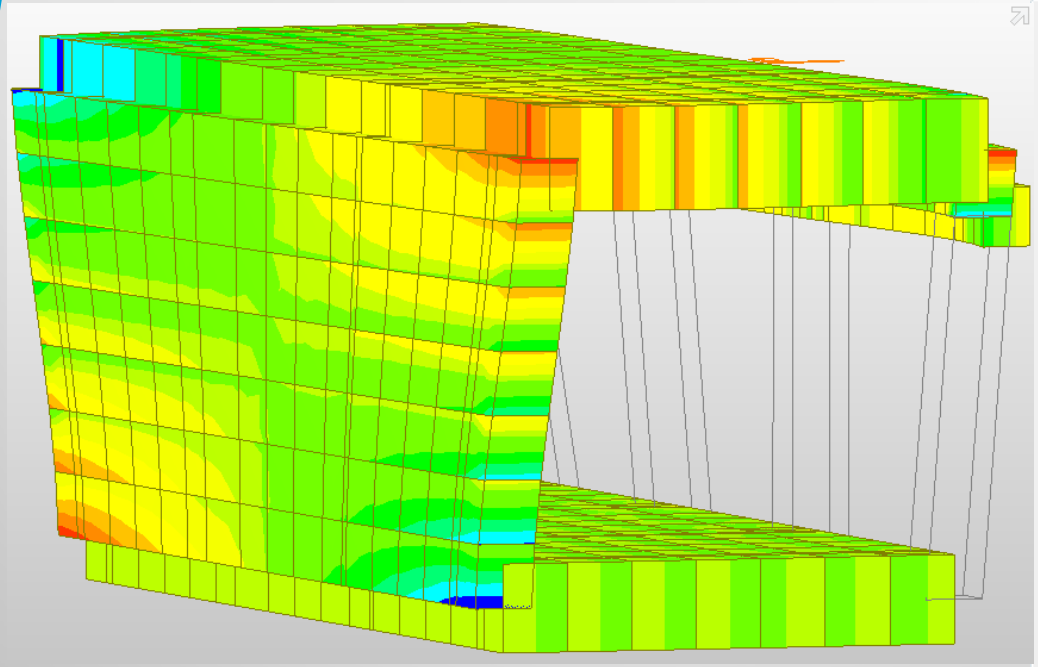
Inelastic Seismic Design

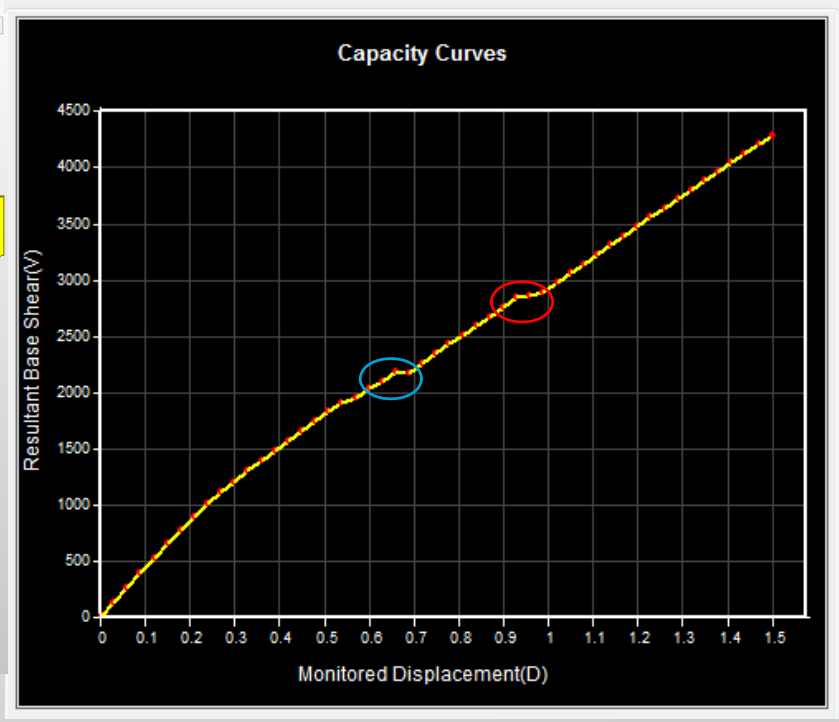
- Purpose of Analysis
  - Ensure ductile plastic hinging in column so it is repairable

http://www.arch.virginia.edu/~km6e/tti/tti-summary/full/mex-city-shear-col-noted.jpeg

http://www.dot.ca.gov/hq/esc/earthquake_engineering/damage_report/1_Visual_Catalog_of_RC_Bridge_Damage.pdf

Full Model Results

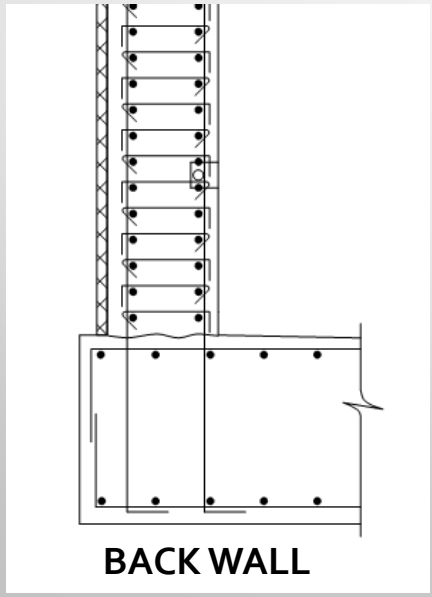




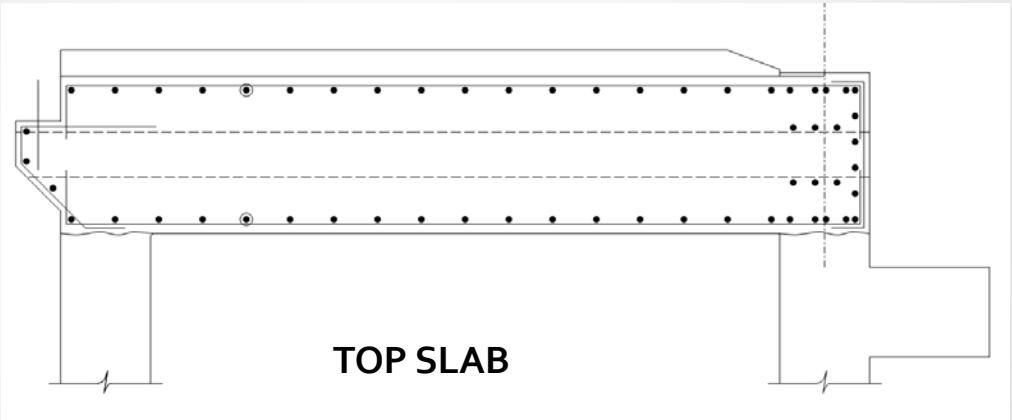
- Columns hinged but system continued to gain strength due to backwall

Substructure Seismic Detailing

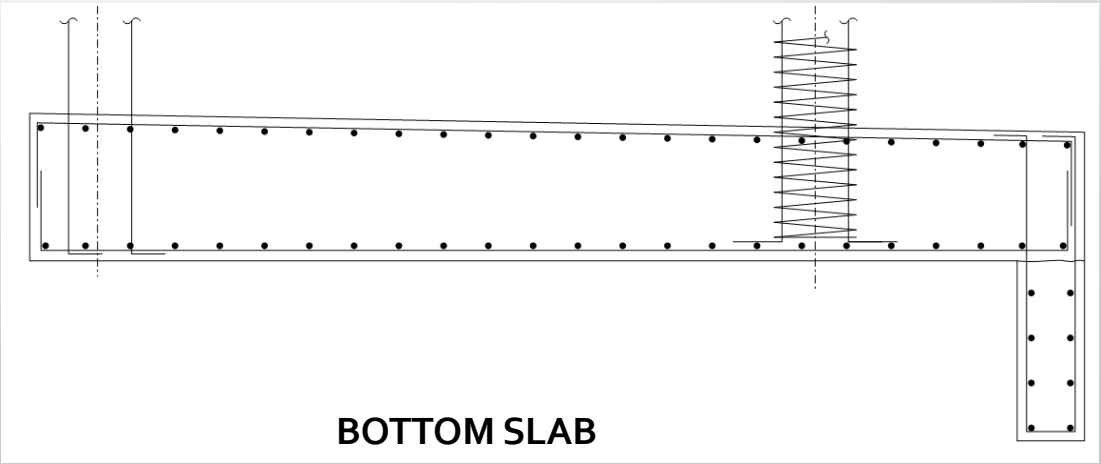
- Slabs
  - Hooks and Embedment
  - Seismic Ties in Back Wall



BACK WALL



TOP SLAB



BOTTOM SLAB

Conclusions

Awards

- Project received FHWA's Corporate Award for implementing innovative solutions.

Presentation Take-Away Points

- Designing for Constructability from Initial Design Phase
- Design for Efficiency
- Allow Design to Incorporate New Details
- Accept Input from Others to Improve Design
- Take Advantage of Refined Design Techniques when Needed
- Don’t be too wrapped up into a ‘standard’ way of doing things
- Simple Span Bridges can Still be Interesting

Questions