



Eastern Plains Timber Bridge Replacement Program (Regions 4/1 Bundle)

In Response to Federal Highway Administration's Notice of Funding Opportunity for the Department of Transportation's Competitive Highway Bridge Program for Fiscal Year 2018



Application Overview



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Application Information

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Project Name	Eastern Plains Timber Bridge Replacement Program – (Regions 4/1 Bundle)
Project Description	This project comprises the replacement of nine (9) rural timber bridges spread across key highway and interstate corridors in eastern and northeastern Colorado. These bridges are located on key corridors for rural mobility as well as intra- and interstate commerce, particularly for the movement of agricultural and resource products. The average age of these bridges is 78 years and the frequency and intensity of maintenance and repair has escalated substantially in recent years.
State Priority Ranking	3
Previously Incurred Project Eligible Costs	N/A
Project Previously Submitted for Federal Grants	N/A
If so, which?	
Total Project Cost	\$21,937,000
Project Cost Expended in Rural Region	100%
Non-Federal Match	\$10,968,500 (50%)
Competitive Bridge Program Grant Funds Requested	\$10,968,500 (50%)
Federal (DOT) Funding including Program Funds Requested	\$10,968,500 (50%)



Project Description

Project Description

Colorado is one of the fastest growing states in the country, and with that growth comes significant strain on aging transportation systems. Significant and tangible consequences in the form of growing safety and mobility problems have been observed throughout the state. The northeast of Colorado is one of the fastest growing regions of the state, both demographically and economically. The rural highways which house the bridges put forward in this grant application are essential to enabling the mobility of the populace which lives in the east and northeast of the state, but are also key to supporting intra- and interstate commerce, particularly regarding the movement of agricultural and resource products. This application seeks partial funding from FHWA for the replacement of nine bridges along, or adjacent to, three rural highway corridors in eastern and northeastern Colorado. As all these bridges are located within either Colorado Department of Transportation's Regions 4 or 1, this grouping of candidate bridges for replacement is called the Region 4/1 Bundle.

All the nine bridges put forth in the application are timber and are an average of eighty years old, decades past their useful design life. Seven of the nine of the bridges are designated as "Poor" per the FHWA National Bridge Inspection Standards (NBIS) and are eligible for funding through CDOT's bridge replacement program, the Colorado Bridge Enterprise (CBE). While the structures are eligible for funding, resources are currently not available to advance the project in its entirety. The remaining two bridges are rated "fair", and it is anticipated that they will continue to deteriorate to "poor" condition in the near future, despite significant maintenance investments.

All of the bridges within the bundle have substandard geometry per CDOT and FHWA standards. Maintenance of these bridges is constant, as age and severe seasonal weather had led to wooden supports and stringers splitting, wooden piles rotting and requiring replacement or reinforcement, and bridge decks deteriorating to the point where a scheduled replacement is required at an average of every five years. Over the past decade, maintenance activities and emergency closures along this corridor have increased substantially in frequency and severity. Frequent repairs of potholes on the bridges has repeatedly led to the identification of more serious underlying issues with the integrity of the bridge decks, and particularly of the timber supports and piles. These findings require emergency resurfacing and strengthening projects that result in the closure (partial or whole) of the bridge.

The continued deterioration of the structures has accelerated in recent years, leading to escalating maintenance costs and an increasing frequency of lane/bridge closures to carry out planned and unplanned repairs. These planned and emergency closures require the corridors' passenger and commercial traffic to experience delays. In the case of full bridge closure to carry out deck replacements, diversions are required, which can be more than 100 miles. These delays and closures not only inconvenience users of these rural highways, but also diminish the economic competitiveness of businesses which rely on these corridors to efficiently move their goods throughout the state and the nation. Many of the structures within this bundle are within Reasonable Access of the Interstate System affecting potential emergency routes. Increasing closures and delays impedes the access for emergency vehicles increasing the risk for public safety and human lives.



Six of the bridges are Load Restricted as defined by FHWA limiting trucking routes through major sections of the corridors. Several of the bridges are nearing the point where they may be posted for weight restrictions (to 36 tons), which could substantially impede the efficiency of movement of multi-trailer commercial trucks. These vehicles frequent these corridors to haul agricultural and resource products. **Table 1** provides an overview of the general attributes of each bridge put forward in this application for partial replacement funding.

Table 1: Overview of Eastern Plains Timber Bridge Replacement Program – (Regions 4/1 Bundle)

National Bridge Structure Number	Bridge Length	Bridge Width (Lanes)	Condition Rating	Load Restrictions	Year Built	Replacement Cost (\$2018M)	ADT (2018)	% Commercial Truck Traffic
D-28-D	120	2	Poor	Yes	1949	3.3	1,312	31%
D-28-C	90	2	Fair	No	1949	2.5	1,312	31%
D-25-E	110	2	Poor	Yes	1952	3.0	858	14%
G-21-A	110	2	Fair	No	1931	3.0	119	8%
F-20-J	80	2	Poor	Yes	1931	2.2	151	14%
C-22-K	70	2	Poor	Yes	1932	1.9	1,237	10%
F-19-E	100	2	Poor	Yes	1931	2.7	3,990	5%
F-20-L	60	2	Poor	No	1931	1.6	221	30%
D-24-O	90	2	Poor	Yes	1952	1.7	5,050	22%

Source: CDOT, AECOM

It's very likely that, to ensure the structural integrity of these bridges and adherence to the mobility safety standards of state highways and roads, it will cost the state more to maintain them over the next two decades than it would to replace them in the near term. The implementation and delivery of the replacement of the Region 4/1 Bundle of bridges represents an opportunity for the State of Colorado to effectively improve mobility and safety outcomes along several of the state's rural corridors, while concurrently ensuring that the economic vitality provided by these crucial commercial freight routes is maintained.

The Region 4/1 bundle is a CDOT and CBE priority, which are committed to providing approximately \$11 million (or 50%) of the required funding to carry out the replacements. Innovative design, contracting, and construction will be utilized throughout the planning and delivery of the bridge replacement. Innovative elements of design will include using similar superstructure types and layouts across all the bridges, which will aid in achieving economy of scale and increased production rates during construction. Construction will be expedited by using precast elements and bridge slide (or bridge move) techniques to minimize the amount of closure/diversion time along the corridor. CDOT will also implement innovative technologies recommended in the Colorado Bridge Enterprise Strategies for Enhancing Service Life Guideline with the goal of providing a 100-year service life for the replacement structures.



The bundle will be procured under a single contract using Construction Manager/General Contractor (CM/GC) project delivery. This delivery method will allow CDOT to solicit contractor input early in the design process on the bridge slide technique, project phasing, and other potential options to minimize impacts to users of these critical corridors. CM/GC will also provide the option to leverage internal design resources to expedite design and long-lead procurement to accelerate construction. It is estimated that bundling the replacement of the bridges together, placing them under a single contract, and utilizing similar design elements and construction activities will result in a total replacement cost 25%, or nearly \$5 million, less than if the bridges were to be replaced individually.

A benefits-cost analysis has been developed for the replacement of the Region 4/1 Bundle of bridges to support application. The findings of the quantitative assessment show that the replacement of the Region 4/1 Bundle will, over a twenty-year period of operation, generate \$10.7M and \$16.9M in benefits at 7% and 3% discounts, respectively. These represent Benefits-Costs Ratio (BCR) of 1.6:1 and 1.9:1 at their respective discounts.



Project Location

Project Location

Project Location

The Region 4/1 Bundle comprised nine timber bridges located in eastern and northeastern Colorado. All of the bridges are located on, or adjacent to U.S. Highways and Interstates which run east to west, and all are located in rural areas. A map of the location of the Region 4/1 Bundle of candidate bridges put forth in this application for grant funding are shown in **Figure 1**.

Figure 1: Locations of Bridges in Regions 4/1 Bundle



Source: CDOT

Bridge C-22-K

Table 2: Bridge C-22-K Summary Information

Year Built	1932
Construction Type	Timber
Condition Rating	Poor
Load Restrictions	Yes
Bridge Span Length	58 feet
Water Crossing	Beaver Creek
Detour Length (if closed)	18 miles
ADT (2018)	1,240
Replacement Cost (\$2018)	\$1,13,459

Bridge C-22-K was built over 85 years ago and is a multi-trestle wooden structure with corrugated metal deck and asphalt overlay which crosses over Beaver Creek. Bridge C-22-K is located on US Highway 6 (which doubles as Interstate 76-Business) northeast of the town of Brush and southwest of Camden. It is located on a key freight corridor connecting Colorado to Nebraska, where it connects with Interstate 80 (and to the major freight rail yards and intermodal centers in North Platte). The location of Bridge C-22-K is shown in **Figure 3**.

The age of, and the advanced deterioration of primary structural components of, Bridge C-22-K warrants frequent inspection and repair, the most significant of which are the reinforcement of the superstructure using temporary bents, as shown in **Figure 4** and the placement of concrete collars around rotted supports, as shown in **Figures 5** and **6**. Additionally, the deck has historically had major repairs on a two to four year interval due to accelerated deterioration related to differential deflection and settlement of the bridge structural components.



Figure 2: Bridge C-22-K
Source: CDOT

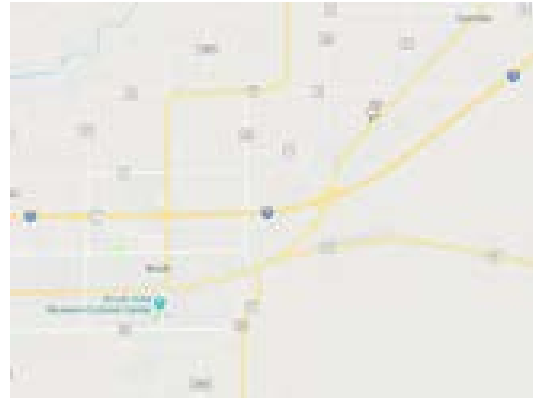


Figure 3: Bridge C-22-K Location
Source: Google, CDOT



Figure 4: Bridge C-22-K – Wooden Bents to Maintain Structural Integrity of the Superstructure

Source: CDOT



Figure 5: Bridge C-22-K – Rotted Supports

Source: CDOT



Figure 6: Bridge C-22-K – Concrete Collars to Address Rotted Supports

Source: CDOT

Bridge D-24-O

Table 3: Bridge D-24-O Summary Information

Year Built	1952
Construction Type	Timber
Load Restrictions	Yes
Condition Rating	Poor
Bridge Span Length	90 feet
Water Crossing	Unnamed Draw
Detour Length (if closed)	116 miles
ADT (2018)	5,060
Replacement Cost (\$2018)	\$1,709,000

Bridge D-24-O was built in the early 1950's and is a multi-trestle wooden structure with asphalt timber deck and asphalt overlay which crosses over a unnamed draw. Bridge D-24-O is located on US 34 east of the town of Akron. The corridor on which it is located connects Colorado to Nebraska and Northern Kansas and is a key freight corridor for the movement of agricultural products, particularly wheat. The location of Bridge D-24-O is shown in **Figure 8** below.



Figure 7: Bridge D-24-O
Source: CDOT

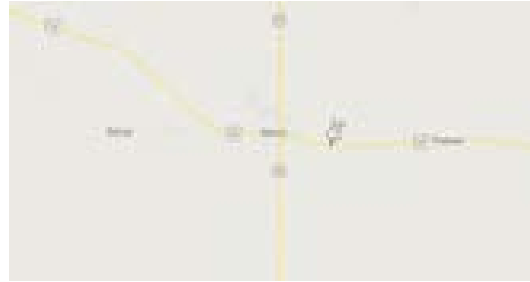


Figure 8: Bridge D-24-O Location
Source: Google, CDOT



Figure 9: Bridge D-24-O – Split Stringer with Lag Bolt Repairs
Source: CDOT

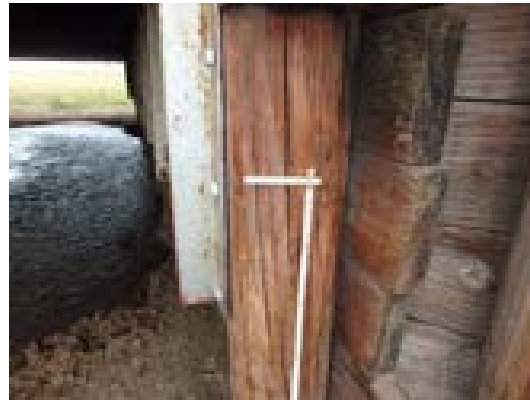


Figure 10: Bridge D-24-O – Split Timber Pile
Source: Google, CDOT

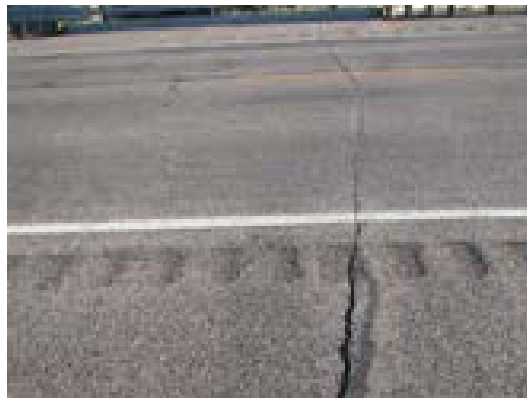


Figure 11: Bridge D-24-O Cracking of the Bridge Deck
Source: CDOT

The age of Bridge D-24-O, coupled with the advanced deteriorated of structural components and frequent commercial truck loads (including double trailers and overweight vehicles), warrants frequent inspection and repair which include: the repair and replacement of split timber stringers and piles (as shown in **Figure 9** and **10** respectively). Regular resurfacing of the bridge deck is required to repair cracking related to differential deflection and settlement of structural components (as shown in **Figure 11**).

Bridge D-25-E

Table 3: Bridge D-25-E Summary Information

Year Built	1952
Construction Type	Timber
Condition Rating	Poor
Load Restrictions	Yes
Bridge Span Length	110 feet
Water Crossing	Unnamed Draw
Detour Length (if closed)	90 miles
ADT (2018)	832
Replacement Cost (\$2018)	\$3,006,865

Bridge D-25-E was built in the early 1950’s and is a wooden structure with corrugated metal deck and asphalt overlay which crosses over an unnamed draw. Bridge D-25-E is located on State Highway 61 north of the town of Otis. Highway 61 is the north-south connector route between US 34 and Interstate 76. Though it accommodates less than 1,000 vehicles a day, it is crucial to the regional community and to interstate commerce, as it provides a distance savings of nearly a hundred miles to vehicles looking to connect from one key freight corridor to another. The location of Bridge D-25-E is shown in **Figure 13** below.

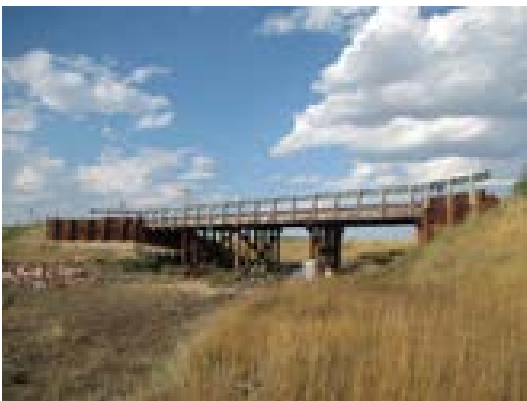


Figure 12: Bridge D-25-E
Source: CDOT

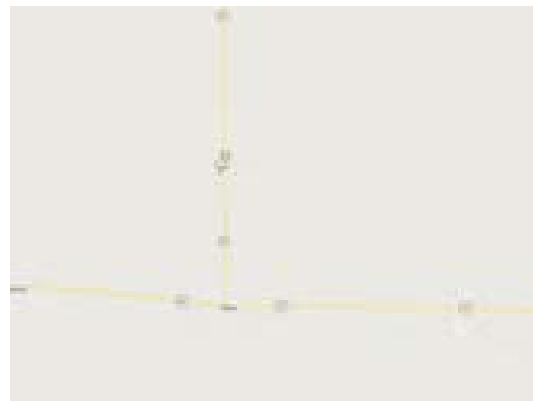


Figure 13: Bridge D-25-E Location
Source: Google, CDOT



Figure 14: Bridge D-25-E – Rotting Timber Support
 Source: CDOT



Figure 15: Bridge D-25-E– Concrete Collars to Reinforce Rotted Timber Supports
 Source: CDOT



Figure 16: Bridge D-25-E – Deck Replacement Requiring Full Closure
 Source: CDOT

Due to its age, and the severity of the deterioration, Bridge D-24-E experiences frequent rotting of its timber supports, necessitating their reinforcement with concrete collars, as shown in **Figure 14**. As is the case with nearly all of the candidate bridges in the Region 4/1 Bundle, the deterioration of its bridge required a full deck replacement as shown in **Figure 15**. During the deck replacement (**Figure 16**), this section of State Highway 61 was closed for traffic in both directions, requiring vehicles to take a detour of approximately 90 miles.

Bridges D-28-C and D-28-D

Table 5: Bridges D-28-C and D-28-D Summary Information

	Bridge D-28-C	Bridge D-28-D
Year Built	1949	1949
Construction Type	Timber	Timber
Condition Rating	Fair	Poor
Bridge Span Length	90ft	110 feet
Water Crossing	Unnamed Draw	Republican River
Detour Length (if closed)	85 miles	85 miles
ADT (2018)	1,345	1,345
Replacement Cost (\$2018)	\$2,460,162	\$3,280,216

Bridges D-28-C and D-28-D were built in the late 1940's and comprise multi-trestle wooden structures with timber decks and asphalt overlays which cross over an unnamed draw and the Republican River, respectively. Bridges D-28-C and D-28-D are located less than a mile apart on US Route 34 equidistant between Laird, CO and Haigler, NE. They are seven miles from State Highway 385 (which runs north-south nearly the length of Colorado) and less than eight miles from northern Kansas. Approximately one third of all vehicular traffic which crosses these bridges is commercial trucks, much of it agricultural products. These bridges are a crucial component connecting the freight movements of four states. Their closure for repairs would necessitate a detour of approximately 85 miles. The locations of Bridges D-28-C and D-28-D are shown in **Figure 18** below.

Due to their age, the severity of the deterioration, and the disproportionately high concentration of commercial traffic that they accommodate compared to most rural bridges, Bridges D-28-C and D-28-D require frequent inspection and repair. The typologies of repairs that are required are symptomatic of split timber stringers and supports (as shown in **Figure 19**) and resurfacing of the bridge deck due to cracking on its superstructure (as shown in **Figure 20**). During the repairs, traffic is either shunted to one lane, or the bridge is closed all together, bringing about substantial delays for commercial traffic or requiring detours of more than 80 miles, respectively.



Figure 16: Bridge D-28-C
Source: CDOT



Figure 17: Bridge D-28-D
Source: CDOT

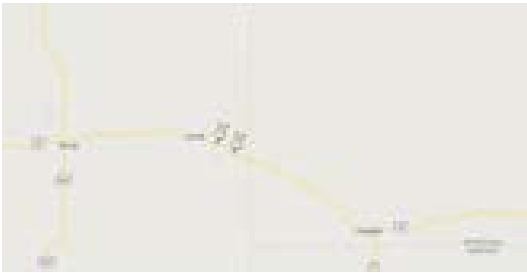


Figure 18: Bridge D-24-C and Bridge D-28-D Locations

Source: Google, CDOT



Figure 19: Bridge D-28-D – Split Timber Pile

Source: Google, CDOT

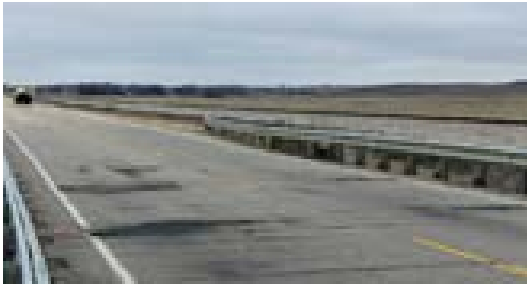


Figure 20: Bridge D-28-D – Cracked and Uneven Bridge Deck

Source: CDOT

Bridge F-19-E

Table 6: Bridge F-19-E Summary Information

Year Built	1931
Construction Type	Timber
Condition Rating	Poor
Load Restricted	Yes
Bridge Span Length	82 feet
Water Crossing	Unnamed Draw
Detour Length (if closed)	12 miles
ADT (2018)	3,859
Replacement Cost (\$2018)	\$2,773,514

Bridges F-19-E is one of the oldest in the Region 4/1 Bundle, having been built in 1931, and comprises a multi-trestle wooden structure with concrete deck and asphalt overlay which crosses over an unnamed draw. It is located along US 36, three miles equidistant from Strasburg to the west and Byers to the east. US 36 runs adjacent, and occasionally overlaps Interstate 70, with the former running into Kansas and eventually to Ohio. With an average daily traffic of approximately 4,000 vehicles, this corridor is important for both the movement of goods and people to and from Denver from all points east. The location of Bridge F-19-E is shown in **Figure 22** below.

Bridge F-19-E is nearly ninety years old and decades past its useful design life. Due to its age, the severity of the deterioration, Bridge F-19-E requires an accelerating frequency of repair and closure. The bridge's stringers are supported in several places by wooden temporary bents, as shown in **Figure 23**. The deck is deteriorating to the point where concrete is spalling from its underside, exposing rebar (as shown in **Figure 24**) while the overlay requires regular replacement. Wooden stringers are regularly replaced due to rot, as shown in **Figure 25**. During the repairs, traffic is either shunted to one lane, or the bridge is closed all together, bringing about substantial delays for personal and commercial traffic requiring detour of approximately 12 miles.



Figure 21: Bridge F-19-E
Source: CDOT



Figure 22: Bridge F-19-E Location
Source: Google, CDOT



Figure 23: Bridge F-19-E – Wooden Bents Supporting Stringers to Maintain Structural Integrity of the Superstructure
Source: CDOT



Figure 24: Bridge F-19-E – Missing Concrete and Exposed Rebar
Source: CDOT



Figure 25: Bridge F-19-E – Rotten Wooden Stringer and Deterioration of Deck
 Source: CDOT

Bridge F-20-L

Table 7: Bridge F-20-L Summary Information

Year Built	1931
Construction Type	Timber
Condition Rating	Poor
Bridge Span Length	39 feet
Water Crossing	Unnamed Draw
Detour Length (if closed)	12 miles
ADT (2018)	218
Replacement Cost (\$2018)	\$1,640,108

Bridge F-20-L is one of the oldest in the Region 4/1 Bundle, having been built in 1931, and comprises a wooden structure with concrete deck and asphalt overlay which crosses over an unnamed draw. It is located along US 40, 5 miles east of Byers. US runs 40 parallel to, and overlaps with, Interstate 70, as it enters Kansas. The location of Bridge F-20-L shown in **Figure 27** below.

Bridge F-20-L is nearly ninety years old and decades past its useful design life. Due to its age and the severity of the deterioration, Bridge F-20-L requires frequent repair and occasional closure. The bridge’s deck is characterized by oft-repaired potholes, cracking, and continued deterioration; several of its stringers are splitting or rotting in various places; several anchor bolts connecting the bridge rail to the stringers are rusted out.

During the repairs, traffic is either shunted to one lane, or the bridge is closed all together, bringing about substantial delays for personal and commercial traffic utilizing US Route 40, requiring detour of approximately 12 miles.



Figure 26: Bridge F-20-L
Source: CDOT



Figure 27: Bridge F-20-L Location
Source: Google, CDOT



Figure 28: Bridge F-20-L – Condition of Bridge Deck
Source: CDOT



Figure 29: Bridge F-20-L – Rotted Posts, Rusted-Out Anchor Bolts and Deteriorating Deck
Source: CDOT

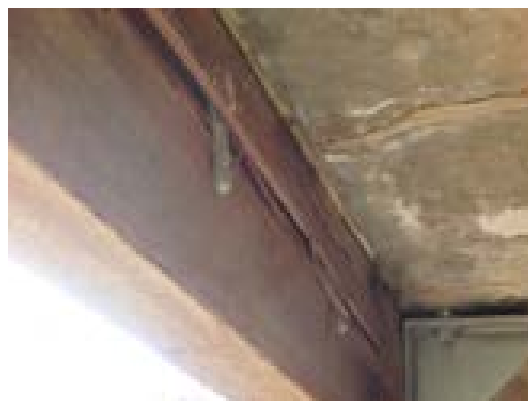


Figure 30: Bridge F-20-L – Curb Bolts Splitting Stringers / Cracked Underside of Deck
Source: CDOT

Bridge F-20-J

Table 8: Bridge F-20-J Summary Information

Year Built	1932
Construction Type	Timber
Condition Rating	Poor
Load Restricted	Yes
Bridge Span Length	58 feet
Water Crossing	Unnamed Draw
Detour Length (if closed)	18 miles
ADT (2018)	1,240
Replacement Cost (\$2018)	\$1,13,459

Bridge F-20-J is one of the oldest in the Region 4/1 Bundle, having been built in 1931, and comprises a wooden structure with concrete deck and asphalt overlay which crosses over an unnamed draw. It is located along US 40, mile north of Deer Trail. US 40 runs parallel to, and overlaps with, Interstate 70, as it enters Kansas. The location of Bridge F-20-J shown in **Figure 32** below.

Bridge F-20-J is nearly ninety years old and decades past its useful design life. Due to its age and the severity of the deterioration, Bridge F-20-J requires frequent repair and occasional closure. The bridge has experienced severe cracking and continued deterioration, including holes appearing in the deck; frequent repair of split and rotting timbers; anchor bolts connecting the bridge rail to the stringers frequently rust out. During the repairs, traffic is either shunted to one lane, or the bridge is closed all together, bringing about substantial delays for personal and commercial traffic utilizing US Route 40, requiring detour of approximately 12 miles.



Figure 31: Bridge F-20-J

Source: CDOT



Figure 32: Bridge F-20-J Location

Source: Google, CDOT



Figure 33: Bridge F-20-J – Hole on the Edge of the Bridge Deck
 Source: CDOT



Photo 34: Bridge F-20-J – Deteriorating Bridge Deck Re-Asphalted
 Source: CDOT

Bridge G-21-A

Table 9: Bridge G-21-A Summary Information

Year Built	1931
Construction Type	Timber
Condition Rating	Fair
Bridge Span Length	94 feet
Water Crossing	Unnamed Wash
Detour Length (if closed)	7 miles
ADT (2018)	114
Replacement Cost (\$2018)	\$3,006,865

Bridge G-21-A is one of the oldest in the Region 4/1 Bundle, having been built in 1931, and comprises a multi-trestle wooden structure with timber deck and asphalt overlay which crosses over an unnamed draw. It is located along US 40, one mile northwest of Agate. US 40 runs parallel to, and overlaps with, Interstate 70, as it enters Kansas. The location of Bridge G-21-A is shown in **Figure 35** below.

Bridge G-21-A is nearly ninety years old and decades past its useful design life. Due to its age and the severity of the deterioration, Bridge G-21-A requires frequent repair and occasional closure. The bridge’s deck has experienced severe cracking and continued deterioration, abutment walls are cracking vertically, and stringers have required frequent repair due to splitting or rotting in various places. During the repairs, traffic is either shunted to one lane, or the bridge is closed all together, bringing about substantial delays for personal and commercial traffic utilizing US 40, requiring detour of approximately seven miles.



Figure 35: Bridge G-21-A
Source: CDOT



Figure 36: Bridge G-21-A Location
Source: Google, CDOT



Figure 37: Bridge G-21-A – Major Cracking on the Bridge Deck
Source: CDOT



Figure 38: Bridge G-21-A – Damp and Rotting Stringers Under the Span
Source: CDOT



Figure 39: Bridge G-21-A – Vertical Cracking on Abutment Walls
Source: CDOT



Figure 40: Bridge G-21-A – Repairs to Split Stringers
Source: CDOT



Project Parties



Project Parties

The Colorado Department of Transportation (CDOT) and the Colorado Bridge Enterprise (CBE) will be the responsible parties to complete the replacement of the bridges in the Regions 4/1 Bundle. These entities have collaborated on over 100 bridge replacement projects throughout the state.

CDOT exists to ensure that Colorado has a safe and efficient highway system by building and maintaining interstates, U.S. highways and state highways. CDOT:

- Maintains, repairs and plows over 23,000 total lane miles of highway
- Maintains 3,447 bridges
- Oversees 28 billion miles of vehicle travel annually

The CBE was formed in 2009 as part of Colorado's Funding Advancement for Surface Transportation and Economic Recovery (FASTER) legislation. CBE operates as a government-owned business within the Colorado Department of Transportation, but derives its dedicated funding from annual vehicle registration fees. The CBE has a separate board of directors that convenes each month to monitor program progress and approve programming plans and budget supplements. The statutory purpose of the CBE is to finance, repair, reconstruct and replace designated bridges.

In addition to the CDOT and CBE, the program to replace the bridge in the Regions 4/1 Bundle is strongly supported by Federal representatives, Governor Hickenlooper, state representatives, and local jurisdictions. Letters of support are provided in **Appendix A – Letters of Support**.



Grants, Funds, Sources and Uses of All Project Funding

Grant Funds, Sources, and Uses of Project Funds

Project Costs

The total estimated project cost for delivering the Eastern Plains Timber Bridge Replacement Program (Regions 4/1 Bundle) is approximately \$21.94 million. Project funding will go toward the staged replacement of the nine candidate rural bridges and include costs for construction, professional services (such as design and project management) and for temporary acquisition of right of way (if required). Project costs were built from a granular level and were subjected to a probabilistic risk assessment. The P70 cost estimate (representing an appropriate level of risk and associated uncertainty with project costs) were used.

A full breakdown of the costs associated with the development and delivery of this program of bridge replacements can be found in **Table 10**.

A full breakdown of costs for each individual bridge can be found in **Appendix B**.

Funding Sources

Table 10: Funding Sources

Entity	Contribution
Colorado Bridge Enterprise	\$10,968,500
Total Non-Federal Match	\$10,968,500 (50%)
Federal Funds Sought	\$10,968,500 (50%)
Total Project Cost	\$21,937,000

The local match of 50% of the project cost will be provided by CDOT's Bridge Enterprise (CBE), an autonomous subsidiary with the single remit to finance, repair, reconstruct, and replace any designated bridge in the state of Colorado. With a budget of approximately \$100M a year, CBE addresses the estimated \$1.5B liability of structures currently eligible for replacement in the state, a figure that is steadily increasing year-over-year.

The letter of funding commitment from CDOT and CBE can be found in **Appendix C**.



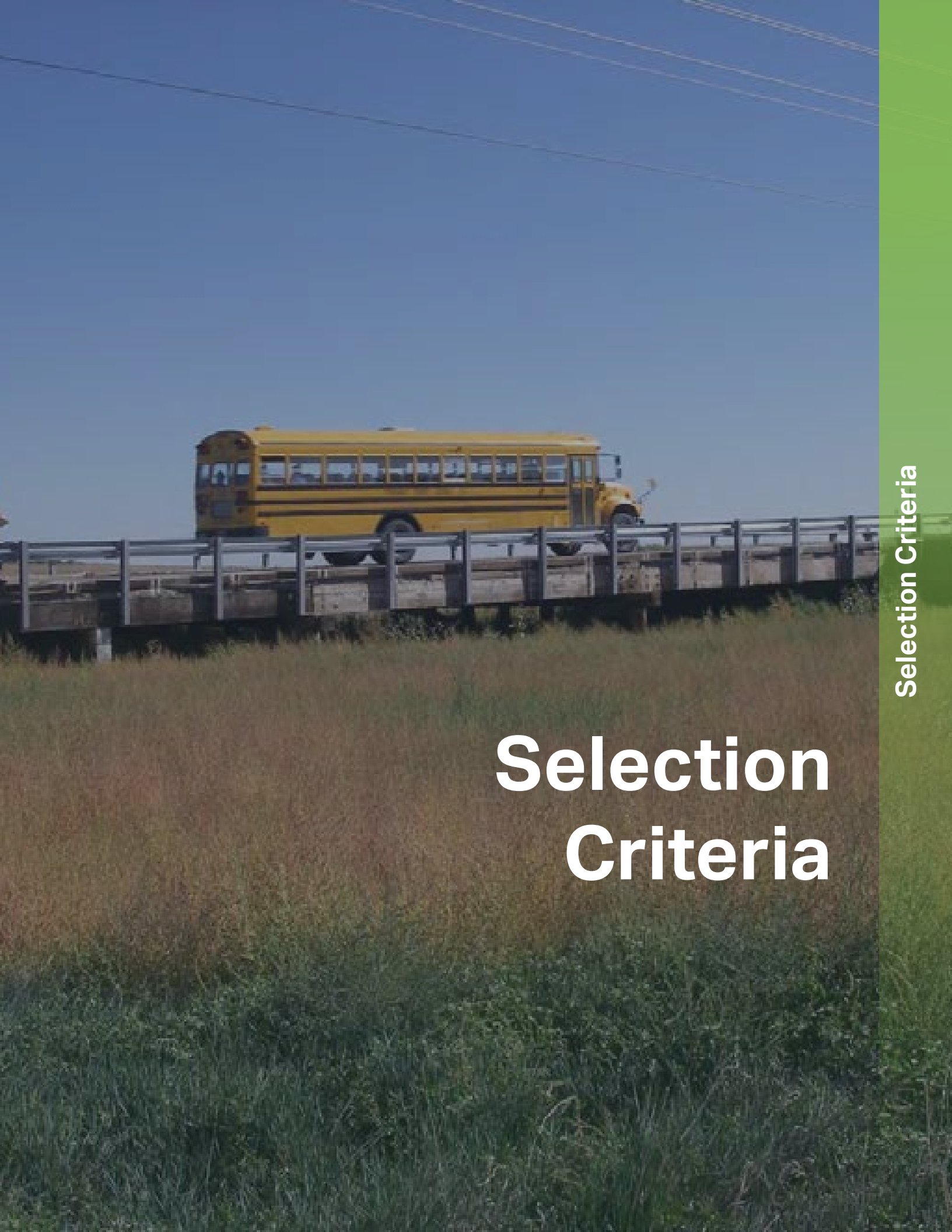
Budget

Table 11 shows the estimated budget for each of the bridges proposed for replacement under, as broken into individual cost categories.

Table11: Estimated Replacement Costs

National Bridge Structure Number	ROW/Utilities \$M (2018)	Professional Services \$M (2018)	Construction \$M (2018)	Total \$M (2018)
D-28-D	0.06	0.28	2.89	3.28
D-28-C	0.05	0.21	2.17	2.46
D-25-E	0.06	0.26	2.65	3.01
G-21-A	0.06	0.26	2.65	3.01
F-20-J	0.04	0.19	1.93	2.19
C-22-K	0.04	0.16	1.69	1.91
F-19-E	0.05	0.23	2.41	2.73
F-20-L	0.03	0.14	1.45	1.64
D-24-O	0.03	0.15	1.51	1.71
Total	0.43	1.88	19.34	21.94

Source: AECOM



Selection Criteria

Selection Criteria

Innovation

This section describes the innovative technologies, project delivery, and financing that will be implemented to successfully replace the bridges in the Regions 4/1 Bundle. The innovative methods will reduce costs and ensure timely completion of the project. CDOT and CBE will use innovative technologies and strategies for the replacement of the bridges in the Regions 4/1 Bundle. Their efforts include using the Accelerated Bridge Construction software and enhancing the service life of the bridges.

Innovative Technologies

Accelerated Bridge Construction

CDOT and CBE have successfully leveraged Accelerated Bridge Construction (ABC) to identify potential methods for replacing a bridge that reduce project and user costs. ABC techniques such as Prefabricated Bridge Elements and Systems (PBES), bridge movement technologies such as bridge moves with Self Propelled Modular Transporters (SPMT) and “lateral sliding” of bridges have been successfully leveraged on numerous bridge projects throughout the state. CDOT and CBE will continue to entertain and investigate numerous other ABC techniques and will champion these techniques where appropriate.

The replacement of the existing structures will be expedited through the use of precast concrete box beams for the replacement bridge superstructure. The beams will be constructed off-site and transported to the site for placement. Constructing the beams off-site allows for greater control over quality (i.e. better control over the concrete mixture and environmental conditions). Bridge slide (or bridge move) techniques will be leveraged to minimize the amount of closure/diversion time that is needed at the site to replace the bridge – saving time and reducing the impact on the public. An assessment on all bridges included in the Region 4/1 bundle was performed to verify that use of the bridge-slide technique would result in a net construction cost savings when compared to conventional construction methods.

Using this method, the replacement bridges can be constructed adjacent to the existing bridges. Once the construction of the replacement structure is complete, the existing bridge will be demolished, and the replacement will be moved into place using strand jacks or cranes. The new substructures will be constructed offset from the existing units, on the same alignment, while the existing bridge is in service. This approach will accommodate the span lengths of the replacement structures. Another potential option is to slide the existing superstructure onto temporary supports, where it can be used as the temporary construction detour, which would leave the existing alignment open to construct the replacement bridge.

CDOT has prior, recent experience with bridge installation using the slide-in method on US Route 34, the same corridor as two of the bridge in the Regions 4/1 Bundle. Photos of this practice being put to use for the aforementioned replacement on US Route 34, is shown in **Figures 41**. Additional representative bridge replacements using the slide-in method are SH 71 and SH 266 over the Ft. Lyon and Holbrook Canal respectively (shown below in **Figures 42** and **43**).



Figure 41: Use of Slide-In Method to Replace a Bridge Along US Route 34 (2013)

Source: CDOT



Figure 42: Use of Slide-In Method to Replace a Bridges Along State Highways 71 and 266

Source: CDOT



Figure 43: Use of Slide-In Method to Replace a Bridges Along State Highways 71 and 266

Source: CDOT

Enhanced Service Life

As part of its mission, the CBE is charged with bringing innovation to the practice of bridge design and construction through research and implementation of innovative practices. As funding for bridge projects becomes impacted by large replacement projects, CBE realized that one way to get the most long-term benefit from available funding was to design and construct bridges that are able to provide significantly longer terms of service, balanced with higher initial costs. As part of the effort, CBE researched and developed strategies for enhancing the service life of bridges.

The current AASHTO Bridge Design Guidelines provide a standardized approach to bridge design and indicates a 75-year design life is expected when the guidelines are implemented. These guidelines are applied nationwide but are not able to account for the microclimates across North America. Taking into consideration the microclimates of Colorado, CBE research¹ identified strategies that enhance the AASTHO guidelines to increase the expected service life of bridges to 100 years. For example, the strategies that reduce corrosion of the superstructure and substructure include macro and micro fiber reinforcement, using corrosion inhibiting admixtures, and using low carbon chromium

reinforcing steel. The strategies will be used to enhance the service life of the bridges in the Regions 4/1 Bundle to 100 years.

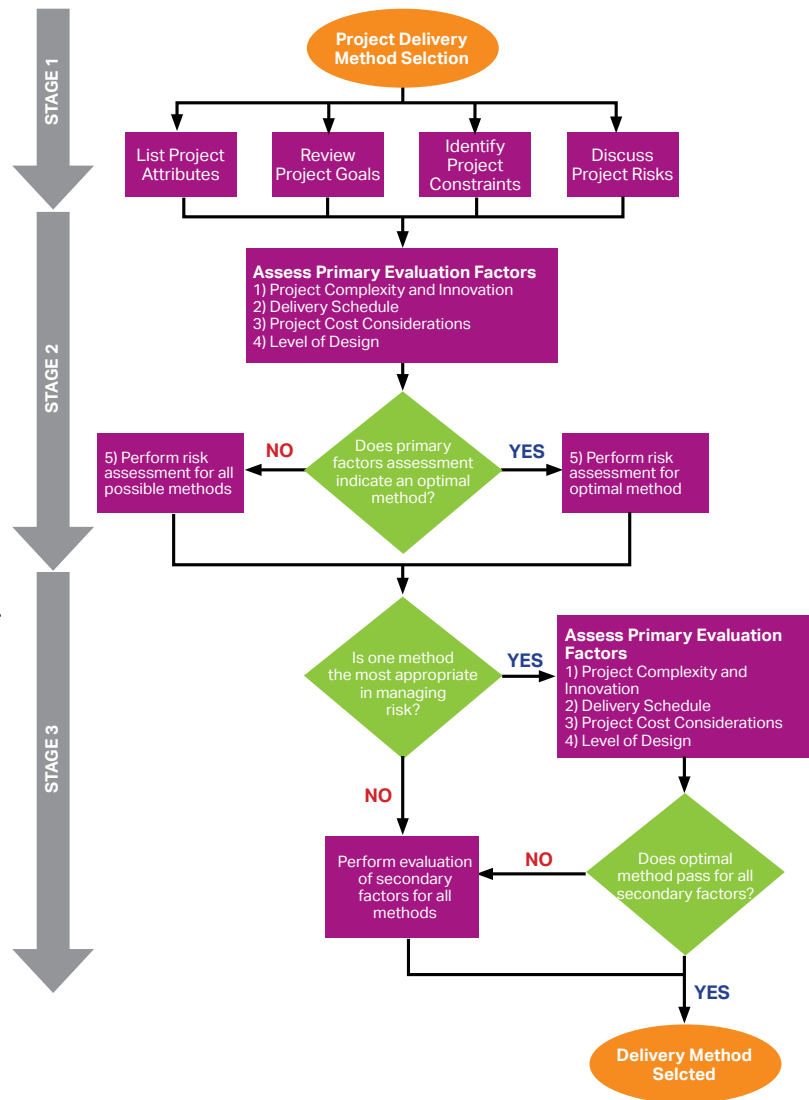
Innovative Project Delivery

The project delivery method is the process by which a construction project is comprehensively designed and constructed including project scope definition, organization of designers, constructors and various consultants, sequencing of design and construction operations, execution of design and construction, and closeout and start-up. Thus, the different project delivery methods are distinguished by the manner in which contracts between the agency, designers and builders are formed and the technical relationships that evolve between each party inside those contracts.

Currently, there are several types of project delivery systems available for publicly funded transportation projects. The most common systems are Design-Bid-Build (DBB), Design-Build (DB), and Construction Manager/General Contractor (CMGC). No single project delivery method is appropriate for every project. Each project must be examined individually to determine how it aligns with the attributes of each available delivery method.

The grant application team has performed a summarized evaluation of the grant application bundles using the CDOT Project Delivery Selection Matrix (PDSM) tool. The general logic of the PDSM tool is illustrated in the flowchart (Figure 44).

Figure 44: CDOT Decision Making Process for Determining Optimal Project Delivery Method
 Source: CDOT



¹ See research document *Strategies for Enhancing Bridge Services Life*, Colorado Bridge Enterprise, June 30, 2015



Both Design-Build and CM/GC were both identified as viable project delivery options. CDOT has selected CM/GC as the preferred project delivery method to utilize in-house resources for design and maintain control over ABC methods to be implemented.

Figure 44 and **Table 12** show the decision-making process for determining the optimal method of delivery for the proposed bundle of bridge replacements.

Table 12: CDOT GRANT APPLICATION #3 (Eastern Plains Timber Bridge Replacement Bundle) PROJECT DELIVERY METHOD OPPORTUNITY/OBSTACLE SUMMARY

	Design/Bid/Build (DBB)	Design/Build (DB)	Const. Mgr./Gen Contractor (CMGC)
Primary Section Factors			
1. Project Complexity & Innovation	-	+	+
2. Project Delivery Schedule	X	+	++
3. Project Cost Considerations	+	++	-
4. Level of Design	-	+	++
5. Risk Assessment	-	++	+
Secondary Selection Factors			
6. Staff Experience/Availability (Agency)	++	+	++
7. Level of Oversight and Control	++	-	+
8. Competition and Contractor Experience	++	+	+

Rating Key

- ++ Most appropriate delivery method
- + Appropriate delivery method
- Least appropriate delivery method
- X Fatal flaw (discontinue evaluation of this method)
- NA Factor not applicable or not relevant to the selection

Project Delivery Selection Summary

Evaluation of Eastern Plains Timber Bridge Replacement Bundle resulted in the following:

- DBB was identified as fatally flawed due to the potential for delays extending beyond the CHBP funding obligation deadline. Additionally, this delivery method limits the contractor's ability to innovate, and does not allow for contractor input on ABC construction techniques.
- DB: This bundle has been optimized to utilize similar ABC methods and replacement structure type and size, which limits the value of input from multiple competing DB teams. Innovation provided by the contractors would likely be related to items such as traffic control, phasing, pavement design, etc. In the DB model, the owner would benefit from a competitive bid, and receive 100% of the value engineering benefits. Known levels of risk for this project would be expected to lead to a more efficient price. Cost certainty would also be achieved earlier in the project life cycle. Design will need to be progressed to an approx. 30% to enter construction phase. Based on the project profile, CDOT is well-positioned to manage and mitigate risks during the construction phase.
- CM/GC would allow CDOT to solicit contractor input on the preferred ABC construction techniques during the design phase, and provide the option to leverage long-lead procurement to accelerate construction. Additionally, CDOT would have the ability to enter into a CM contract at current level of design which gives slight advantage to CM/GC over DB. Design would be performed with in-house staff to eliminate the need to procure a designer, and further compress the schedule. Cost considerations favor DB due to the "CAP" negotiations, and since CDOT will only receive 50% of value engineering benefit. Overall, staff experience lends itself to CM/GC over DB since the contract is administered similar to a DBB model.

Source: CDOT

Innovative Financing

In 2009, former Colorado Governor Bill Ritter signed into law SB 09-108, Funding Advancement for Surface Transportation and Economic Recovery, otherwise known as FASTER. The legislation was the first new dedicated and sustainable funding source for Colorado transportation infrastructure in nearly twenty years.

The law increases revenues from various sources for transportation improvements at the state and local level. A portion of the funding designated as the "Bridge Safety Surcharge" is imposed on vehicle registration based on vehicle weight and ranges from \$13 to \$32. Revenues from the surcharge are dedicated specifically for Colorado's most deficient bridges — those bridges rated "poor" by the Colorado Department of Transportation (CDOT) and by statute cannot be used for other CDOT purposes.

To focus on states poor bridges, as part of legislation in addition to authorizing a Bridge Safety Surcharge, Colorado created the Colorado Bridge Enterprise (CBE). The CBE is an autonomous program that is a wholly owned subsidiary of CDOT, established to "finance, repair, reconstruct, and replace any designated bridge in the state" per C.R.S. 43-4-805 (2) (b) and is, by statute, to have a separate Board of Directors.

On June 18, 2009, the CBE Board officially approved the enactment of the Bridge Safety Surcharge, as required by law. In Fiscal Year 2018, Bridge Safety Surcharge revenues were \$106M. The current outstanding CBE program liability for eligible structures is estimated at \$1.5B, and the funding shortfall is projected to increase over time as additional structures

become eligible for the program. Current forecasts estimate that the outstanding program liability will increase to nearly \$2.5B by Fiscal Year 2040.

Pursuant to one of the program goals adopted by the Bridge Enterprise Board of Directors (a program delivery plan that evaluates various options, encourages creativity, and a variety of innovative solutions), the program continues to explore and deploy innovative contracting delivery methods that (1) expedite the start of construction, and/or (2) accelerate overall project completion. This includes utilization of both Design/Build (D/B), Construction Manager/General Contractor (CM/GC), and Public Private Partnership (P3) contract delivery methods.

Since program inception, CBE has addressed 33 bridges using Design-Build, 8 bridges through CM/GC, and 8 bridges through P3s. This experience, along with CDOT's extensive knowledge of alternative delivery, will be leveraged for the replacement of the bridges in the Regions 4/1 Bundle.

Life-Cycle Costs and State of Good Repair

All the bridges in the Regions 4/1 Bundle are decades past their original design life. Because of their age and deterioration, maintenance activities are increasing in both frequency and severity over time. Several significant recurring issues include: wooden supports and stringers splitting, wooden piles rotting and requiring replacement or reinforcement, and loose connections and differential movement in timber bridges leading to frequent deck repairs. These issues have resulted in all but two of the bridges in the Regions 4/1 Bundle being rated as "poor". It is estimated that the remaining bridges will deteriorate to "poor" condition in the near future despite significant investments by CDOT to curtail this trend. Structural Inventory and Appraisal Item 41 is coded "D" for six of the structures in the bundle. This code indicates that the structures would be load posted or closed without temporary shoring, etc. to allow for unrestricted traffic.

Following bridge replacement, all for the bridges will be ranked as "good", indicating that there are no design or structural issues with the bridges. As discussed previously, enhanced strategies will be used to extend the service life of the replaced bridges to 100 years, which will provide assurance of a good state of repair for a century. In addition, maintenance activities are anticipated to be limited to preventative maintenance for the replaced bridges, leading to less vehicle delays during these activities. Replacement of these structures will allow CDOT to divert resources to keep other bridges throughout Colorado in a state of good repair.

Economic Vitality

The implementation of the Eastern Plains Timber Bridge Replacement Program will deliver a diversified basket of economic benefits. Over an assessment period of 30 years of operation beginning after the replacement of the nine bridges put forth in this application, the Regions 4/1 Bundle will deliver nearly \$11 million in net benefits. An overview of the economic benefits is shown in the following table.



Table 13: CDOT GRANT APPLICATION #3 (Eastern Plains Timber Bridge Replacement Bundle) BENEFITS COSTS ANALYSIS IMPACT MATRIX

Current Status/ Baseline & Problem to be Addressed	Change to Baseline or Alternatives	Types of Impacts	Affected Population	Economic Benefit (Net Present Values, \$2018 M)	
				Discounted at 7%	Discounted at 3%
<p>Nine (9) bridges are past their useful life and as a result require frequent maintenance. The maintenance closures create delays and detours for motorists. These delays and detours result in costs incurred by motorists, CDOT, and trucking businesses.</p>	<p>The project would replace 9 bridges, bringing them up to a state of good repair, and thus reducing maintenance expenditures and VMT incurred by motorists due to detours. The reduced VMT results in travel cost savings for autos, operating cost savings for trucks, emissions savings, safety improvements and crash reductions, and roadway maintenance savings.</p>	Safety			
		Reduced Roadway Fatalities and Crashes	Drivers who reduce VMT after Project opening	\$2.45	\$5.34
		State of Good Repair			
		Roadway Maintenance Savings	CDOT	\$0.03	\$0.06
			Taxpayers		
		Environmental Protection			
		Emissions Savings	All residents and non-residents	\$0.35	\$0.77
		Economic Competitiveness			
		Travel Time Savings	Drivers who reduce VMT after Project opening	\$11.03	\$2.82
		Auto Travel Cost Savings	Drivers who reduce VMT after Project opening	\$2.82	\$6.16
		Residual Savings	CDOT	\$2.24	\$5.29
			Taxpayers		
		Truck Operating Savings	Freight operators	\$5.80	\$10.22
			Shippers		
Customers					
Total Benefits (\$2018M)		\$24.72	\$30.66		
Net Benefits (\$2018M)		\$10.71	\$16.93		
Benefits-Costs Ratio		1.62	1.85		

Source: AECOM



The largest generator of economic benefits is the savings in travel time and truck operating savings reflective of the avoidance of bridge closures for scheduled and emergency repairs and the associated diversions caused by those closures. Additional benefits generated by the implementation of the Eastern Plains Timber Bridge Replacement Program include a reduction in accidents and fatalities and nominal reductions in emissions and roadway wear and tear. The replacement of the Regions 4/1 Bridges will improve the aggregate State of Good Repair along these rural highway and interstate corridors, thereby ensuring that the both commercial and personal traffic can continue to function as normal.

AECOM'S cost estimation team estimated that bundling the replacement of the bridges together, placing them under a single contract, and utilizing similar design elements and construction activities will result in a total replacement cost 25%, or nearly \$5 million, less than if the bridges were to be replaced individually. As this is a comparison between build options, and not viewed against the baseline do-nothing option, this cost savings is not incorporated into the benefits costs analysis.

The benefits-costs analysis technical memo can be found in **Appendix A**.



Project Readiness

Project Readiness

The seven of the bridges in the Region 4/1 Bundle were previously identified by the CBE as candidates for replacement based on their classification of “poor”. These structures were included in the BE Prioritization Plan; the majority of the structures fall within the top two tiers of the plan, which correlates to high or medium priority. Since that time, CDOT engineers in Region 4 have performed high level scoping and preliminary design to identify potential project risks and identify probably replacement types. After review, the project team recommended the inclusion of two “fair” rated structures based on similar site and existing structure characteristics.

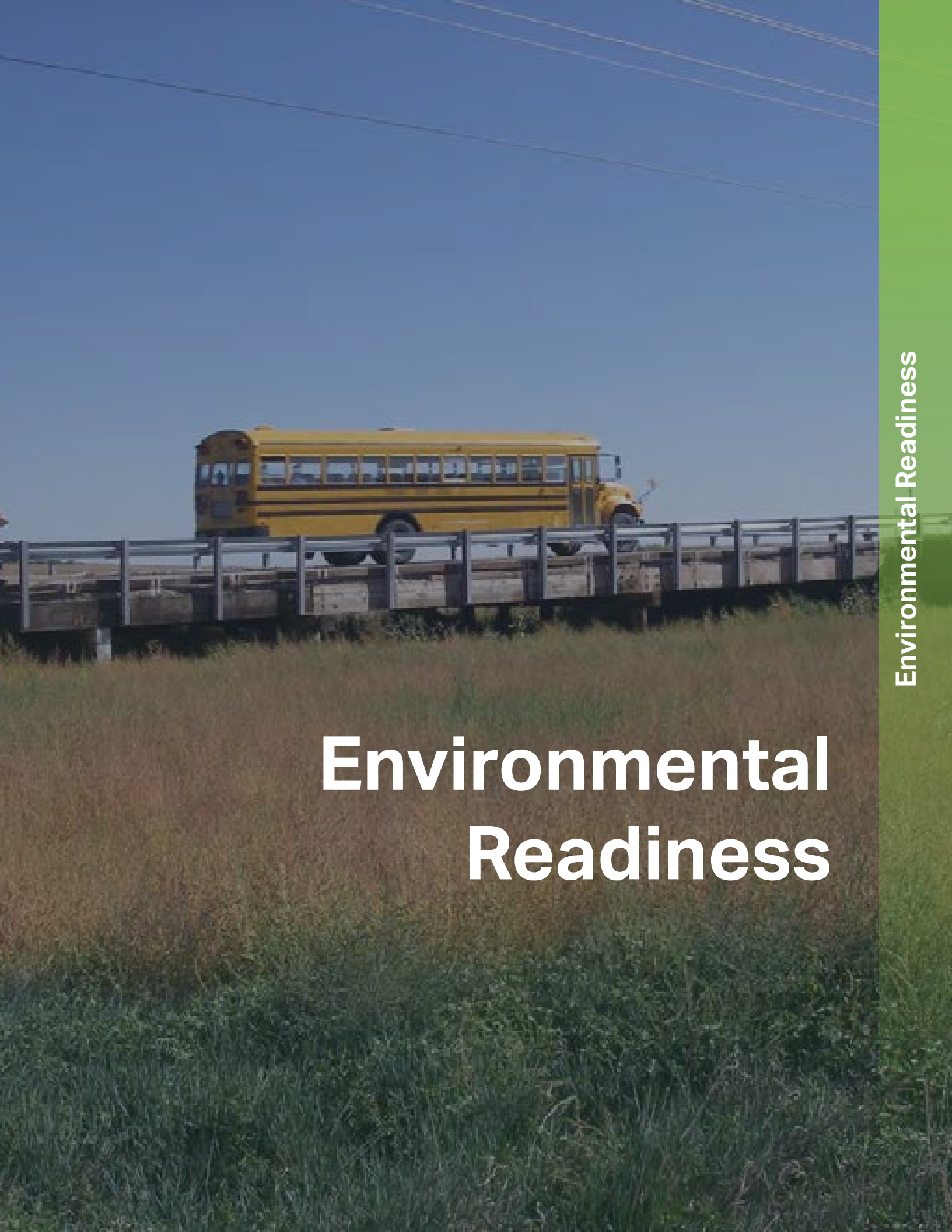
The program of works comprising the replacement of the bridges proposed in this grant application was added to Colorado’s Statewide Transportation Improvement Program (STIP) under STIP ID: SST8000.127. They are current programmed on the STIP to 30% design, with the project currently at a 10% design level. Once there is clarity on the availability of federal funds, the project will be added to the STIP in its entirety. Assuming that award is made in early April, the STIP will be amended to include final design and construction of this project by late April and adopted by the Transportation Commission in late May.

Project Schedule

The schedule for the delivery of the Region 4/1 Bundle is estimated to take approximately three years, with pre-construction activities beginning in late 2019, construction activities commencing in early 2021, and completion of the program of replacement occurring by the end of 2022. CM/GC will provide the option to leverage internal design resources to expedite design and long-lead procurement to accelerate construction. The CM/GC procurement will ensure that funding is obligated approximately a year in advance of the statutory deadline for Competitive Highway Bridge Program funds (September 30, 2021). Additionally, project completion has been scheduled over three years in advance of the September 30, 2026 expiration deadline. A gaant chart of the Region 4/1 Bundle’s complete schedule can be found in **Appendix E**.

Right-of-Way

It is not envisioned that any permanent right of way will need to be required to facilitate the construction and delivery of the replacement of the nine rural bridges put forth in this application. The existing bridges and adjacent property are owned by CDOT; therefore, no permanent easement or land acquisition will be required to replace the bridges. For some bridges, temporary easements may be needed for construction staging and traffic detour efforts. These easements would only be required during construction activities and the property would be brought back to its current state following construction. CDOT and CBE have extensive experience obtaining temporary easements for bridge maintenance and replacement activities; therefore, no issues are expected that would stop or delay replacement activities.



Environmental Readiness

Environmental Readiness

CDOT has institutionalized several FHWA Every Day Counts measures to ensure streamlined project delivery while maintaining regulatory compliance and environmental stewardship.

- **Mitigation Banking:** CDOT has created the first Permanent Water Quality (PWQ) Mitigation program of its type: it uses a mitigation fund for more effective watershed-level projects instead of on-site mitigation-by-project for Permanent Water Quality (PWQ) impacts, it encourages partnerships with our municipal stakeholders that should also reduce the maintenance burden on CDOT crews, and compliance is easily tracked by use of funds instead of tracking water or area treated.
- **Programmatic Agreements:** CDOT has agreements with EPA, CPW, USFWS, CDPHE, USACE, USFS, BLM, FHWA, SHPO. All establish streamlined approaches for handling routine environmental requirements, reducing review times and accelerating project delivery. It is anticipated that all bundled bridge projects will be approved as categorical exclusions (CEs).
- **NEPA 404 Merger:** Integrate NEPA and the permitting process seeks to transform how agencies and stakeholders conduct concurrent, synchronize environmental and permitting reviews, saving time and cost for the agencies involved.
- **Implementing Quality Environmental Documents:** CDOT has developed templates for CEs, EAs and FONSI. This has streamlined the NEPA process: reducing costs and review times while maintaining document quality.
- **Liaisons:** CDOT also uses liaisons with USFWS and the state health department (CDPHE) to ensure consistency and accelerate project delivery.

As noted above, it is anticipated each of the bridges in the Region 4/1 Bundle will be approved as categorical exclusions (CEs) based on existing programmatic agreements. The anticipation of CEs is based on CDOT's previous experience replacing similar bridges (both in type of bridge and existing environment) in similar areas of the corridor.

A yellow school bus is driving on a highway, viewed from a grassy field. The bus is positioned in the middle ground, moving from left to right. The highway has a metal guardrail in the foreground. The background shows a clear blue sky with power lines. The foreground is filled with tall, green grass.

Project Risks and Mitigation Strategies

Project Risks and Mitigation Strategies

Several project risks and their mitigation strategies have been discussed throughout this application. Steps taken by CDOT and CBE include:

- Completed multiple actions to reduce the risk to the schedule (see Project Schedule)
- Use of CM/GC delivery will allow for contractor input early in project development (see Innovative Project Delivery)
- Incorporation of the bridges into the STIP and verification that no local agency approvals are necessary to advance the project (see Project Feasibility)
- Institutionalizing several FHWA Every Day Counts measures to ensure streamlined project delivery (see Environmental Readiness)
- Conducting high level scoping and preliminary design to identify potential project risks and identify probable replacement type and construction methods for the bridges (see Project Feasibility)
- Obtaining a signed resolution from the CBE Board of Directors committing CBE to providing the non-federal match (see Funding)

CDOT and CBE have extensive experience collaborating to replace bridges and care for aging infrastructure, with CBE being established for the purpose of addressing aging bridges in Colorado. This experience reduces the risk since the knowledge and lessons learned will be put to use when replacing the bridges in the Region 4/1 Bundle.



Appendix A Benefit Cost Analysis

Benefit-Cost Analysis Appendix

Department of Transportation's Competitive Highway Bridge Program for Fiscal Year
2018

Eastern Plains Timber Bridge Replacement Program (Regions 4/1 Bundle)

Prepared for CDOT by AECOM

December 4, 2018

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Executive Summary

A benefit-cost analysis (BCA) was conducted to support the grant application for the Eastern Plains Timber Bridge Replacement Program (Regions 4/1 Bundle) by the Colorado Department of Transportation for the Department of Transportation's Competitive Highway Bridge Program for Fiscal Year 2018. There are 9 bridges in Regions 4 and 1 that are bundled for the analysis. This analysis was conducted in accordance with the 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs. Capital outlays are scheduled to begin in 2021, with the last bridges scheduled for completion in 2022. All values are in 2018 dollars discounted to 2018, and cover a 30-year analysis period.

Exhibit 1 presents the Impact Matrix, which describes the baseline, the Project as a whole, and the estimated results.

Exhibit 1 – Impact Matrix

Current Status/Baseline & Problem to be Addressed	Change to Baseline or Alternatives	Types of Impacts	Affected Population	Economic Benefit (Net Present Values, \$2018 M)		Page Reference in BCA
				Discounted at 7%	Discounted at 3%	
<p>Nine (9) bridges are past their useful life and as a result require frequent maintenance. The maintenance closures create delays and detours for motorists. These delays and detours result in costs incurred by motorists, CDOT, and trucking businesses.</p>	<p>The project would replace 9 bridges, bringing them up to a state of good repair, and thus reducing maintenance expenditures and VMT incurred by motorists due to detours. The reduced VMT results in travel cost savings for autos, operating cost savings for trucks, emissions savings, safety improvements and crash reductions, and roadway maintenance savings.</p>	Safety:				
		Reduced Roadway Fatalities and Crashes	Drivers who reduce VMT after Project opening	\$2.45	\$5.34	
		State of Good Repair:				
		Roadway Maintenance Savings	CDOT Taxpayers	\$0.03	\$0.06	
		Environmental Protection:				
		Emissions Savings	All residents and non-residents	\$0.35	\$0.77	
		Economic Competitiveness:				
		Travel Time Savings	Drivers who reduce VMT after Project opening	\$11.03	\$2.82	
		Auto Travel Cost Savings	Drivers who reduce VMT after Project opening	\$2.82	\$6.16	
		Residual Savings	CDOT Taxpayers	\$2.24	\$5.29	
Truck Operating Savings	Freight operators Shippers Customers	\$5.80	\$10.22			

Exhibit 2 summarizes long term outcomes of the Project. Taken in total, the Project provides \$28.1 million in benefits—reduced roadway fatalities and crashes, roadway maintenance savings, travel time savings, congestion savings, travel cost savings, residual savings, freight benefits, and emissions savings—over the analysis period, using a 7 percent discount rate. Compared to a similarly discounted cost estimate, the Benefit-Cost Ratio for the Project is 1.62, a solid return on this critical investment for the region. This ratio rises to 1.85 when benefits and costs are discounted at 3 percent. The net benefits of the Project are \$10.71 million using a 7 percent discount rate and \$16.93 million using a 3 percent discount rate.

Exhibit 2 – Costs and Key Benefits Delivered by Long Term Outcomes (2020 – 2052)

All Bridges

7% Discount Rate 3% Discount Rate

Costs (2018 \$M)		
Capital Cost	\$17.388	\$19.816
<i>Total Costs</i>	<i>\$17.388</i>	<i>\$19.816</i>
Benefits (2018 \$M)		
Safety Benefits		
Reduced Roadway Fatalities and Crashes	\$2.450	\$5.340
Sub-Total	\$2.450	\$5.340
State of Good Repair Benefits		
Roadway Maintenance Savings	\$0.030	\$0.064
Sub-Total	\$0.030	\$0.064
Economic Competitiveness Benefits		
Travel Time Savings	\$11.025	\$2.816
Auto Travel Cost Savings	\$2.820	\$6.156
Residual Savings	\$2.240	\$5.289
Truck Operating Savings	\$5.802	\$10.217
Sub-Total	\$21.887	\$24.478
Environmental Protection		
Emissions Savings	\$0.352	\$0.770
Sub-Total	\$0.352	\$0.770
Net Operating & Maintenance Costs	\$3.380	\$6.089
<i>Total Benefits</i>	<i>\$28.098</i>	<i>\$36.741</i>
Outcome		
Net Benefits (2018 \$M)	\$10.710	\$16.925
Benefit-Cost Ratio	1.62	1.85

Source: AECOM

1. Introduction

The rural highways which house the bridges put forward in this grant application are essential to enabling not just the mobility of the populace which lives in the east and northeast of the state, but are also key to supporting intra- and interstate commerce, particularly regarding the movement of agricultural and resource products. This application seeks partial funding from FHWA for the replacement of nine bridges along, or adjacent to, three rural highway corridors in eastern and northern eastern Colorado. As all these bridges are located within either Colorado Department of Transportation's Regions 4 or 1, this grouping of candidate bridges for replacement is called the Region 4/1 Bundle.

All the nine bridges put forth in the application are timber and are an average of eighty years old, decades past their useful design life. Seven of the nine of the bridges are designated as "Poor" per the FHWA National Bridge Inspection Standards (NBIS) and are eligible for funding through CDOT's bridge replacement program, the Colorado Bridge Enterprise (CBE). While the structures are eligible for funding, resources are currently not available to advance the project in its entirety. The remaining two bridges are rated "fair", and it is anticipated that they will continue to deteriorate to "poor" condition in the near future, despite significant maintenance investments. None of the bridges meet FHWA roadway standard shoulder width. Maintenance of these bridges is constant, as age and severe seasonal weather had led to wooden supports and stringers splitting, wooden piles rotting and requiring replacement or reinforcement, and bridge decks deteriorating to the point where a scheduled replacement is required at an average of every five years. Over the past decade, maintenance activities and emergency closures along this corridor have increased substantially in frequency and severity. Frequent repairs of potholes on the bridges has repeatedly led to the identification of more serious underlying issues with the integrity of the bridge decks, and particularly of the timber supports and piles, leading to emergency resurfacing and strengthening projects resulting in the closure (partial or whole) of that section of the bridge.

Their continued deterioration has accelerated in recent years, leading to escalating maintenance costs and an increasing frequency of lane/bridge closures to carry out planned and unplanned repairs. These planned and emergency closures require the corridors' passenger and commercial traffic to experience delays. In the case of full bridge closure to carry out deck replacements, diversions are required which can be more than 100 miles. These delays and closures not only inconvenience users of these rural highways, but also diminishes the economic competitiveness of businesses who rely on these corridors to efficiently move their goods throughout the state and the nation. Several of the bridges are nearing the point where they may be flagged for weight loading (to 36 tons) which could substantially impede the efficiency of movement of multi-trailer commercial trucks which frequent these corridors hauling agricultural and resource products. Exhibit 3 provides an overview of the general attributes of each bridge put forward in this application for partial replacement funding.

Exhibit 3: Overview of Eastern Plains Timber Bridge Replacement Program – (Regions 4/1 Bundle)

National Bridge Structure ID #	Bridge Length	Bridge Width (Lanes)	Condition Rating	Year Built	Replacement Cost (\$2018M)	ADT (2018)	% Commercial Truck Traffic
D-28-D	120	2	Poor	1949	3.3	1,312	31%
D-28-C	90	2	Fair	1949	2.5	1,312	31%
D-25-E	110	2	Poor	1952	3	858	14%
G-21-A	110	2	Fair	1931	3	119	8%
F-20-J	80	2	Poor	1931	2.2	151	14%
C-22-K	70	2	Poor	1932	1.9	1,237	10%
F-19-E	100	2	Poor	1931	2.7	3,990	5%
F-20-L	60	2	Poor	1931	1.6	221	30%
D-24-O	90	2	Poor	1952	1.7	5,050	22%

Source: CDOT, AECOM

In some cases, the annual cost of maintaining these bridges will be in excess of 10% of its estimated replacement cost, as they will require full deck replacement at least once five to seven years. It's very likely that, to ensure that condition of these bridges meets the acceptable levels of structural integrity and adherence to the mobility safety standards of state highways and roads, it will cost the state more to maintain them over the next two decades than it would to replacement them over the near term. The implementation and delivery of the replacement of the Region 4/1 Bundle of bridges represents an opportunity for the State of Colorado to effectively improve mobility and safety outcomes along several of the state's rural corridors while concurrently ensuring that the economic vitality provided by these crucial commercial freight routes is maintained.

CDOT will also implement innovative technologies recommended in the Colorado Bridge Enterprise Strategies for Enhancing Service Life Guideline with the goal of providing a 100-year service life for the replacement structures.

The bundle will be procured under a single contract using Construction Manager/General Contractor (CM/GC) project delivery. This delivery method will allow CDOT to solicit contractor input early in the design process on the bridge slide technique, project phasing, and other potential options to minimize impacts to users of these critical corridors. CM/GC will also provide the option to leverage internal design resources to expedite design and long-lead procurement to accelerate construction. It is estimated that bundling the replacement of the bridges together, placing them under a single contract, and utilizing similar design elements and construction activities will result in a total replacement cost 25%, or nearly \$5 million, less than if the bridges were to be replaced individually.

2. Benefit Analysis Framework

The benefits analysis was conducted using the Benefit-Cost Analysis Guidance for Discretionary Grant Programs document as a guide for preferred methods and monetized values. The parameters of the benefits analysis follow the protocols set by the Office of Management and Budget (OMB) Circular A-94 as well as the recommended benefit quantification methods by the USDOT, the United States Army Corps of Engineers, the Federal Emergency Management Agency, and U.S. Department of Agriculture, Forest Service. Generally, standard factors and values accepted by federal agencies were used for the benefits calculation except in cases where more Project-specific values or prices were available. In all such cases, modifications are noted and references are provided for data sources. The analysis follows a conservative estimation of the benefits and assesses some of the benefits qualitatively. By adhering to a strict standard of what could be included in the benefits analysis, actual total benefits may be greater than depicted in the results.

The baseline assumes that the Project would not be built and current conditions and operations would continue in the project area. Under the baseline, the purpose of and need for the Project would not be met and would generally be limited to the operation and maintenance of existing infrastructure. The Project was compared to the baseline to identify benefits and costs.

A custom model was developed to estimate the future benefits for the Project. Benefits were estimated over a 30-year period of analysis beginning when construction ends and concluding after 30 full years of operations. Each project schedule varies, but for the group of 9 projects, the construction period is from 2021 through 2022, and operations range from 2023 through 2052 with partial years included as needed. The base year is 2018 and all values were discounted to the base year.

The benefits are expressed in constant 2018 dollars, which avoids forecasting future inflation and escalating future values for benefits and costs accordingly. The gross domestic product chained price index from the OMB was used to adjust past cost estimates or price values into 2018 dollar terms (OMB, 2018).

The use of constant dollar values requires the use of a real discount rate for discounting to the present value. Projects expecting to use federal funding are required to use a 7 percent discount rate. A 3 percent discount rate was also used.

3. Analysis Assumptions

A list of assumptions for the Project is provided in the BCA workbook (see Inputs tab in the file 2018.CDOT.FHWA.Bridge.Replacement.Grant.Application_Regions4-1.(unlocked).xlsx) as well as in Exhibit 4.

Exhibit 4 – BCA Calculation Inputs

Input	Value	Source
General		
Discount Rate	7%	2018 BCA Guidance for Discretionary Grant Programs
Discount Rate	3%	2018 BCA Guidance for Discretionary Grant Programs
Deflator	See "Deflator" Sheet	https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/budget/fy2018/hist10z1.xls
Dollar year	2018	
Discount year	2018	
Start Year	2020	
Analysis period	30	years
Safety		
AIS 0 (2017\$) per vehicle	\$4,327	2018 BCA Guidance for Discretionary Grant Programs
AIS 1 (2017\$)	\$28,800	2018 BCA Guidance for Discretionary Grant Programs
AIS 2 (2017\$)	\$451,200	2018 BCA Guidance for Discretionary Grant Programs
AIS 3 (2017\$)	\$1,008,000	2018 BCA Guidance for Discretionary Grant Programs
AIS 4 (2017\$)	\$2,553,600	2018 BCA Guidance for Discretionary Grant Programs
AIS 5 (2017\$)	\$5,692,800	2018 BCA Guidance for Discretionary Grant Programs
AIS 6 (2017\$)	\$9,600,000	2018 BCA Guidance for Discretionary Grant Programs
Injury (severity unknown)	\$174,000	2018 BCA Guidance for Discretionary Grant Programs
AIS 0 (2018\$) per vehicle	\$4,395	Adjusted by GDP Deflator
AIS 1 (2018\$)	\$29,251	Adjusted by GDP Deflator
AIS 2 (2018\$)	\$458,267	Adjusted by GDP Deflator
AIS 3 (2018\$)	\$1,023,788	Adjusted by GDP Deflator
AIS 4 (2018\$)	\$2,593,595	Adjusted by GDP Deflator
AIS 5 (2018\$)	\$5,781,963	Adjusted by GDP Deflator
AIS 6 (2018\$)	\$9,750,358	Adjusted by GDP Deflator
Injury (severity unknown)	\$176,725	Adjusted by GDP Deflator
Conversion rate for Metric tons to Short Tons	1.1015	2018 BCA Guidance for Discretionary Grant Programs
Emissions Monetization Values		
VOC Value of Emissions (2017\$) per short ton	\$1,905	Source: https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/284031/benefit-cost-analysis-guidance-2018_0.pdf
NOx Value of Emissions (2017\$) per short ton	\$7,508	Corporate Average Fuel Economy for MY2017-MY2025 Passenger Cars and Light Trucks (August 2012), page 922, Table VIII16, "Economic Values Used for Benefits Computations (2010 dollars). Inflated to 2017 dollars.

PM Value of Emissions (2017\$) per short ton	\$343,442	Corporate Average Fuel Economy for MY2017-MY2025 Passenger Cars and Light Trucks (August 2012), page 922, Table VIII16, "Economic Values Used for Benefits Computations (2010 dollars). Inflated to 2017 dollars.
VOC Value of Emissions (2018\$) per short ton	\$1,935	Adjusted by GDP Deflator
NOx Value of Emissions (2018\$) per short ton	\$7,626	Adjusted by GDP Deflator
PM Value of Emissions (2018\$) per short ton	\$348,821	Adjusted by GDP Deflator
Emissions Rates		
Passenger Car Emission Rates per Mile, VOC, 2013-2024	0.6	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, NOx, 2013-2024	0.91	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, PM25, 2013-2024	0.01	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, CO2, 2013-2024	532	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, VOC, 2025-2034	0.27	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, NOx, 2025-2034	0.28	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, PM25, 2025-2034	0.01	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, CO2, 2025-2034	434	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, VOC, 2035-	0.21	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, NOx, 2035-	0.2	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, PM25, 2035-	0.01	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, CO2, 2035-	397	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Conversion rate for Metric tons to Short Tons	1.1015	2018 BCA Guidance for Discretionary Grant Programs
Truck Emissions Rate g per hour VOC (average of 8a and 8b trucks)	3.868	Source: https://www3.epa.gov/otaq/consumer/420f08025.pdf , Class 8 trucks include long-haul semi-tractor trailer rigs ranging from 33,001 lbs to >60,000 lbs
Truck Emissions Rate g per hour Nox (average of 8a and 8b trucks)	39.0515	Source: https://www3.epa.gov/otaq/consumer/420f08025.pdf , Class 8 trucks include long-haul semi-tractor trailer rigs ranging from 33,001 lbs to >60,000 lbs
Truck Emissions Rate g per hour PM2.5 (average of 8a and 8b trucks)	1.092	Source: https://www3.epa.gov/otaq/consumer/420f08025.pdf , Class 8 trucks include long-haul semi-tractor trailer rigs ranging from 33,001 lbs to >60,000 lbs

Truck Emissions Rate g per hour PM10 (average of 8a and 8b trucks)	1.187	Source: https://www3.epa.gov/otaq/consumer/420f08025.pdf , Class 8 trucks include long-haul semi-tractor trailer rigs ranging from 33,001 lbs to >60,000 lbs
Truck Emissions Rate g per mile VOC (average of gasoline and diesel)	1.0165	EPA 420-F-08-027, Average In-Use Emissions from Heavy-Duty Trucks, October 2008, nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVY6.TXT
Truck Emissions Rate g per mile Nox (average of gasoline and diesel)	5.7635	EPA 420-F-08-027, Average In-Use Emissions from Heavy-Duty Trucks, October 2008, nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVY6.TXT
Truck Emissions Rate g per mile PM2.5 (average of gasoline and diesel)	0.123	EPA 420-F-08-027, Average In-Use Emissions from Heavy-Duty Trucks, October 2008, nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVY6.TXT
Truck Emissions Rate g per mile PM10 (average of gasoline and diesel)	0.135	EPA 420-F-08-027, Average In-Use Emissions from Heavy-Duty Trucks, October 2008, nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVY6.TXT
Travel Time Savings		
Value of Time (2017\$), private vehicle travel time per person hour, all purposes	\$14.20	2018 BCA Guidance for Discretionary Grant Programs
Value of Time (2017\$), truck driver per hour	\$28.60	2018 BCA Guidance for Discretionary Grant Programs
Value of Time (2018\$), private vehicle travel time per person hour, all purposes	\$14.42	
Value of Time (2018\$), truck driver per hour	\$29.05	
Average Marginal Costs per Mile, 2016\$ (includes value of driver's time)	\$1.59	Table 8 ATRI Operational Cost of Trucking 2017
Average Marginal Costs per Mile, 2018\$	\$1.64	Adjusted by GDP Deflator
Vehicle Maintenance Cost per Mile, Auto (Gas, maintenance, tires, and depreciation) (2017\$/Mile)	\$0.39	2018 BCA Guidance for Discretionary Grant Programs
Vehicle Maintenance Cost per Mile, Auto (Gas, maintenance, tires, and depreciation) (2018\$/Mile)	\$0.40	
Auto Occupancy	1.39	2018 BCA Guidance for Discretionary Grant Programs
Assumed Speed on Road (mph)	55	Engineering judgement
Average Vehicle Delay Time Due to Maintenance (minutes)	5	Engineering judgement
State of Good Repair		
Roadway Maintenance Cost, Rural Interstate (2000\$/mi) - Auto	\$0.000	Source: FHWA Highway Cost Allocation Study, 2000 Addendum, Table 13
Roadway Maintenance Cost per Mile, Rural Interstate (2018\$) - Auto	\$0.000	Adjusted by GDP Deflator

Roadway Maintenance Cost, Rural Interstate (2000\$/mi) - 40 kip truck	\$0.010	Source: FHWA Highway Cost Allocation Study, 2000 Addendum, Table 13
Roadway Maintenance Cost per Mile, Rural Interstate (2018\$) - 40 kip truck	\$0.014	Adjusted by GDP Deflator
Share of Construction costs that are for bridge structure	75%	Engineering judgement
Useful life for bridge (years)	100	Colorado Bridge Enterprise: Strategies for Enhancing Bridge Service Life, 2015
Maintenance		
Maintenance costs in years 0-5 as percent of CAPEX (inspection)	0.10%	Engineering judgement
Maintenance costs in years 5-20 as percent of CAPEX (inspection and scheduled maintenance)	0.25%	Engineering judgement

4. Benefits Methodology

The methodology used to estimate the benefits of the Project are described in the following sections.

Safety

The Project would result in safety benefits by removing auto trips from the region's roads. The methodologies for calculating this benefit are described in this section.

Reduced Roadway Fatalities and Crashes

The construction of the bridges results in temporary closure of the bridge and therefore forces all traffic to take a longer route. This longer route results in increased vehicle miles traveled for the duration of bridge closure. Offsetting the temporary increase in VMT for construction is the reduction in VMT once the bridges open. Under the baseline condition, closures for repairs would happen more frequently as the bridge deteriorates over time, and trucks and automobiles would need to divert, thus taking a longer route. The diversion mileage was estimated for each bridge.

The annual average daily traffic (AADT) for each bridge, as well as the truck percentages, were provided by CDOT. Annual frequency and duration of bridge closures, as well as detour lengths, were also provided by CDOT. Multiplying the AADT by the bridge closure time, frequency of closure, and the net diversion mileage results in the VMT incurred in the baseline as a result of bridge repairs. For the Build Alternative, multiplying the AADT for each bridge by the detour length and duration of the closure during construction results in additional VMT incurred during the construction period. After construction is complete, the VMT incurred from maintenance-induced detours is realized as savings in the Build Alternative. It is assumed that maintenance closures would not be necessary for new bridges during the analysis period.

The rates of crashes that result in fatalities, injuries, and property damage are applied to the net annual VMT to derive the estimated crashes from the change in VMT. To ensure consistency between the types of crashes, the crash rates for fatalities, injuries, and property damage are the national average crash rates. These crash rates are shown in Exhibit 5.

Exhibit 5 - Crashes by Type per 100,000,000 VMT

Fatalities	1.133692236
Injured persons	78.93618107
Crashes	203.3926964

Source: 2015 BTS Motor Vehicle Safety Data Table 2-17, <https://www.bts.gov/content/motor-vehicle-safety-data>

These crash reduction factors were then converted to the Maximum Abbreviated Injury Score (MAIS) crash types in order to apply US DOT Guidance on the value of avoiding a crash. The conversion is based on the National Highway Safety and Traffic Administration (NHTSA) KABCO-AIS Conversion Table (July 2011) provided on page 12 of the TIGER Benefit-Cost Analysis Resource Guide (USDOT 2016),¹ for Injury (severity unknown), and No Injury crashes. KABCO refers to the letters used to designate five levels of crash severity used by police at a crash scene; AIS refers to the Abbreviated Injury Scale used by hospitals. These factors provide the probability that an injury will range from critical to minor to more accurately capture the total number of different types of injuries associated with the VMT avoided. Estimating the distribution of expected injury types is important because the economic cost of the injury increases as injury severity increases.

¹ Benefit-Cost Analysis (BCA) Resource Guide 2016, <https://www.transportation.gov/sites/dot.gov/files/docs/BCA%20Resource%20Guide%202016.pdf>

The total annual value for crash severity is based on USDOT guidance and the National Highway Safety Council estimates for the value of avoiding a crash. These estimates are applied to the number of crashes avoided to estimate the total value of crashes avoided from auto VMT avoided. Exhibit 4 provides the estimated cost of different types of crashes.

The total reduction in highway fatalities and crashes results in \$2.45 million in benefits, discounted at 7 percent.

State of Good Repair

The Project would result in state of good repair benefits by removing auto trips from the region's roads. The methodology for calculating this benefit is described in this section.

Roadway Maintenance Savings

An increase in auto VMT during construction incurs additional roadway maintenance costs, such as painting and paving. The roadway maintenance cost savings is negligible per auto VMT on rural highways, as obtained from the FHWA Highway Cost Allocation Study. Like autos, trucks incur more VMT during construction but save VMT once the bridges are open; the FHWA Highway Cost Allocation Study values their roadway maintenance cost per mile at \$0.014 for a 40-kip truck. Multiplying the auto and truck VMT by the maintenance costs per VMT results in state of good repair benefits. ***Roadway maintenance savings amount to \$0.3 million, discounted at 7 percent.***

Economic Competitiveness

The Project would produce economic benefits by allowing trucks to take a more direct route, resulting in travel time savings, auto travel cost savings, residual value, and truck operating cost savings. The methodologies for calculating these benefits are described in this section.

Automobile Travel Time Savings

Because vehicles must travel longer routes during the construction period, they incur travel time delays. After the construction period, they incur benefits from fewer maintenance closures, and thus fewer detours. Assuming a 55 mile per hour travel speed on both the through-route and the detour route, the average net travel time savings were estimated for the traffic volumes. Multiplying the hours lost by the average vehicle occupancy (1.39)² and the personal value of time (\$14.42 in 2018 dollars), as found in Exhibit 4, yields the total travel time savings. ***The total travel time savings for the Project amounts to \$11.03 million discounted at 7 percent.***

Auto Travel Cost Savings

Because there will be fewer closures for repairs that will necessitate that drivers take lengthier detours, there will be travel cost savings under the Build Alternative. These savings will be partially offset by detours during bridge replacements. Travel cost savings was estimated using a cost savings per reduced auto VMT of \$0.40, which is based on the vehicle maintenance cost per mile provided by AAA and recommended by guidance, and inflated to 2018 dollars.³ The marginal savings includes gas, maintenance, and tires. ***Auto travel cost savings amount to \$2.82 million discounted at 7 percent.***

² 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs, <https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/284031/benefit-cost-analysis-guidance-2018.pdf>

³ Source: AAA, Your Driving Costs, 2017

Residual Value

Construction of the new bridges results in residual value after the end of the 30-year analysis period, because the useful life of the bridge is 100 years.⁴ It was assumed that 75 percent of the construction costs are for bridge infrastructure. The remaining value of the bridge discounted from the last year of the 30-year analysis period. ***The value of the remaining useful life for the Project discounted at 7 percent is \$2.24 million.***

Truck Operating Savings

Based on the additional truck VMT incurred during construction and the long-term truck VMT savings from avoiding detours when the bridges are closed for repairs, the net truck operating savings is calculated. The savings per mile of \$1.64 in 2018 dollars is the average marginal cost per mile for truck operations from the American Trucking Research Institute. This cost includes both vehicle-based costs and driver-based costs. ***The total truck operating savings for the Project amounts to \$5.80 million discounted at 7 percent.***

Environmental Protection

The Project would result in net environmental protection benefits by temporarily increasing auto and truck VMT during construction but reducing auto and truck VMT in the long-term. The methodology for calculating this net result is described in this section.

Emissions Savings

The increase in auto and truck VMT will result in a temporary increase in emissions during the construction period, but the reduction in auto and truck VMT after the bridges open results in overall emissions savings for the long-term. The two are netted in this analysis.

The emissions increases for autos were estimated using emissions rates from USDOT guidance for volatile organic compounds (VOC), nitrogen oxides (NOx), and particulate matter (PM_{2.5}).⁵ The rates for autos are shown in Exhibit 4 and vary over time as vehicle efficiencies improve. The incremental increase in auto and truck emissions resulting from increases in VMT during construction were netted with the auto and truck VMT savings, respectively, in the long-term when trucks no longer have to take longer routes around posted bridges or detours due to bridge closure. The emissions rates for trucks for VOC, NOx, PM_{2.5}, and PM₁₀ are shown in Exhibit 4 and are constant over the analysis period.

The tons of emissions reduction were summed and monetized using the recommended value of emissions from 2018 USDOT guidance,⁶ also shown in Exhibit 4, and inflated to 2018 dollars. ***In total, the Project results in net emissions savings of \$0.35 million when discounted at 7 percent.***

In addition to VOC, NOx, and PM reductions, carbon dioxide (CO₂) or greenhouse gas emissions would also be reduced. Because there is no official guidance on the value of CO₂ emissions reductions, these benefits were not quantified in the analysis.

⁴ Source: CDOT. Colorado Bridge Enterprise: Strategies for Enhancing Bridge Service Life, 2015

⁵ USDOT, Federal Transit Administration, New and Small Starts Evaluation and Rating Process Final Policy Guidance, August 2013

⁶ 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs, <https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/284031/benefit-cost-analysis-guidance-2018.pdf>

5. Costs

The Project has two cost components: the initial capital costs and ongoing operating and maintenance (O&M) costs. The components used in this analysis are described in this section.

Capital Costs

The capital costs for the Project include the costs for right of way, utilities, design, and construction. The capital costs are applied over the individual project construction periods, beginning in 2021 and ending in 2022. Capital costs were given in 2018 dollars. It is estimated that the individual project costs are expended equally over the construction periods. **The total capital costs for the Project discounted at 7 percent are \$17.38 million.**

Annual Operating and Maintenance Costs

The Project requires annual and periodic O&M expenditures to maintain the new bridge, but the replacement bridge would result in O&M savings from the baseline. In the baseline, the cost to maintain the bridges was provided by CDOT for a 20-year period, as shown in Exhibit 6. This cost was then extrapolated to the full 30 year analysis.

Exhibit 6 – Annual O&M Costs for Existing Bridges by Age

National Bridge Structure ID #	20 Year Cumulative Cost
D-28-D	\$1,186,704
D-28-C	\$840,237
D-25-E	\$991,967
G-21-A	\$1,072,570
F-20-J	\$820,360
C-22-K	\$786,991
F-19-E	\$861,430
F-20-L	\$718,397
D-24-O	\$532,074

Source: CDOT

Maintenance of the new bridges is assumed to be 0.10% of capital costs for the first 5 years, and 0.25% of the capital costs thereafter. This is a lower cost than the existing O&M costs, so many years result in O&M savings from the bridge reconstruction. **The net O&M savings over the analysis period and discounting at 7 percent is \$3.38 million.**

6. BCA Results

The analysis results in a total Project BCA ratio of 1.62 when discounted at a rate of 7 percent, and increases to 1.85 when discounted at 3 percent.

Exhibit 8 displays a summary of the BCA results for the bundle.

Exhibit 7 – BCA Results

All Bridges	7% Discount Rate	3% Discount Rate
Costs (2018 \$M)		
Capital Cost	\$17.388	\$19.816
<i>Total Costs</i>	\$17.388	\$19.816
Benefits (2018 \$M)		
Safety Benefits		
Reduced Roadway Fatalities and Crashes	\$2.450	\$5.340
Sub-Total	\$2.450	\$5.340
State of Good Repair Benefits		
Roadway Maintenance Savings	\$0.030	\$0.064
Sub-Total	\$0.030	\$0.064
Economic Competitiveness Benefits		
Travel Time Savings	\$11.025	\$2.816
Auto Travel Cost Savings	\$2.820	\$6.156
Residual Savings	\$2.240	\$5.289
Truck Operating Savings	\$5.802	\$10.217
Sub-Total	\$21.887	\$24.478
Environmental Protection		
Emissions Savings	\$0.352	\$0.770
Sub-Total	\$0.352	\$0.770
Net Operating & Maintenance Costs	\$3.380	\$6.089
<i>Total Benefits</i>	\$28.098	\$36.741
Outcome		
Net Benefits (2018 \$M)	\$10.710	\$16.925
Benefit-Cost Ratio	1.62	1.85

Source: AECOM

Appendix A List of Supporting Documents

AAA, Your Driving Costs, 2017, http://exchange.aaa.com/wp-content/uploads/2017/08/17-0013_Your-Driving-Costs-Brochure-2017-FNL-CX-1.pdf

FHWA Highway Cost Allocation Study, 2000 Addendum, Table 13,
<https://www.fhwa.dot.gov/policy/hcas/addendum.cfm>

USDOT 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs,
<https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/284031/benefit-cost-analysis-guidance-2018.pdf>

USDOT Benefit-Cost Analysis (BCA) Resource Guide, March 1, 2016,
<https://www.transportation.gov/sites/dot.gov/files/docs/BCA%20Resource%20Guide%202016.pdf>

USDOT Bridge Preservation guide, Maintaining a State of Good Repair Using Cost Effective Investment Strategies, August 2011, page 2,
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiV-8XR8cLLAhVV5WMKHYZ6Ap8QFggcMAA&url=http%3A%2F%2Fwww.fhwa.dot.gov%2Fbridge%2Fpreservation%2Fguide%2Fguide.pdf&usg=AFQjCNEf26d_7T9a9n7jxVGGtwyGvq2zQg&sig2=Z8jY2-M9fT0zre_vXvSplg&bvm=bv.116954456.d.cGc

USDOT, Federal Transit Administration, New and Small Starts Evaluation and Rating Process Final Policy Guidance, August 2013

White House Office of Management and Budget. Historical Tables, Table 10.1 – Gross Domestic Product and Deflators Used in the Historical Tables 1940-2021.
<https://www.whitehouse.gov/omb/budget/Historicals>

2018.CDOT.FHWA.Bridge.Replacement.Grant.Application_Regions4-1.(unlocked).xlsx



Appendix B Detailed Cost Estimation

Key: Auto-Populated

Model Version 3 Rev 03
Last Update: 17-Sep-18

PCPT - EXECUTIVE SUMMARY SHEET

PROJECT PROFILE

Model Version 3 Rev 03
Last Update: 17-Sep-18

Project Name: R1/4 BUNDLE - 8 STRUCTURES
 Project Number: R1/4 BUNDLE
 Sub-Account Number: XXXXX
 Project Description: D-28-D, D-28-C, D-25-E, G-21-A, F-20-J, C-22-K, F-19-E, F-20-L

Project Work Type: BRIDGE REPLACEMENT

Estimator: E.A. Date: 11/6/2018

PROJECT LOCATION & CHARACTERISTICS

Route: 070A Begin MP: 305.4 End MP: 333.2 Length: 27.9
 CDOT Region: 1 FIPS City: NONE FIPS County: Arapahoe Co
 FIPS City: 00000 FIPS County: 005

Segment Mid-point RefPt: 319.305 Latitude: 39.7000 Longitude: -104.1685 [GOOGLE MAP LINK](#)

Functional Classification: 1 Interstate Urban-Rural Class: 1 Rural Terrain: 2 Rolling
 AADT: 13,000 Truck ADT: 260 Tier Class: Tier 1 Primary Surface: 3 Concrete

Design Maturity: 0 - Conceptual NEPA Action: Cat/Ex NEPA Status: Not Started
 Project Delivery Method: Design-Build Construction Start (MMM-YY): Sep-22 Construction Duration (mo): 24.0

REGION'S ESTIMATE

PROJECT CONSTRUCTION COSTS:

A MAJOR CONSTRUCTION ITEMS

PCPT CAT	ITEM DESCRIPTION	QTY	UNIT	PERCENTAGE	COST
A-01	Earthwork	0	CY	0.0%	\$0
A-02	Pavement & Bases	N/A	SY	0.0%	\$0
A-03_repl	Bridge Replacement	31,820	DECK AREA (SF)	100.0%	\$7,955,000
A-03_repa	Bridge Repair	0	DECK AREA (SF)	0.0%	\$0
A-03_wall	Walls	0	SF	0.0%	\$0
A-03_culv	Major Culverts	0	LF	0.0%	\$0
A-03_misc	Miscellaneous Structures	0	LS	0.0%	\$0
A-04	Traffic / ITS	N/A	N/A	0.0%	\$0
A-05	Other Major Items	N/A	N/A	0.0%	\$0
SUBTOTAL (A)				100.0%	\$7,955,000

B MINOR CONSTRUCTION ITEMS

PCPT CAT	ITEM DESCRIPTION	EFFORT	UNIT	PERCENTAGE	COST
B-01	Removals / Resets	5 - Extensive	% OF A	5.0%	\$396,894
B-02	Environmental	3 - Average	% OF A	5.0%	\$397,750
B-03	Structural	5 - Extensive	% OF A	5.0%	\$397,750
B-04	Drainage / Utilities	3 - Average	% OF A	4.5%	\$361,157
B-05	Roadway Appurtenances	3 - Average	% OF A	4.2%	\$335,701
B-06	Mobilization	3 - Average	% OF A	12.8%	\$1,016,649
B-07	Construction Traffic Control / Detour	3 - Average	% OF A	9.8%	\$779,590
B-08	Lighting & Electrical	3 - Average	% OF A	2.8%	\$221,945
B-09	Permanent Signing & Striping	3 - Average	% OF A	1.3%	\$106,597
B-10	Traffic Signalization & ITS	3 - Average	% OF A	1.1%	\$89,096
B-11	Miscellaneous	3 - Average	% OF A	0.3%	\$22,274
SUBTOTAL (B)				51.9%	\$4,125,000

CONSTRUCTION BID ITEMS (A + B) CBI % OF A 151.9% \$12,080,000

C FORCE ACCOUNTS & TSM&O

PCPT CAT	ITEM DESCRIPTION	UNIT	PERCENTAGE	COST	
C-01	F/A - General	% OF CBI	6.0%	\$724,800	
C-02	F/A - Minor Contract Revisions (MCR's)	% OF CBI	3.0%	\$362,400	
C-03	F/A - Project Communications	% OF CBI	0.2%	\$24,588	
C-04	TSM&O Traffic & Operations	% OF CBI	0.0%	\$0	
SUBTOTAL (C)				9.2%	\$1,112,000

CONSTRUCTION ITEMS (A + B + C) CI % OF A 165.8% \$13,192,000

D CONSTRUCTION ENGINEERING & INDIRECTS

PCPT CAT	ITEM DESCRIPTION	UNIT	PERCENTAGE	COST	
D-01	Construction Engineering	% OF CI	11.0%	\$1,444,524	
D-02	Construction Indirects	% OF CI	9.5%	\$1,253,240	
SUBTOTAL (D)				20.5%	\$2,698,000

PROJECT CONSTRUCTION BUDGET (A + B + C + D) \$15,890,000

PROJECT PRECONSTRUCTION COSTS:

E PRECONSTRUCTION ITEMS

PCPT CAT	ITEM DESCRIPTION	UNIT	PERCENTAGE	COST	
E-01	Right-of-Way [Phase R]	% OF CI	2.0%	\$288,905	
E-02	Utilities + Railroad Work [Phase U]	% OF CI	0.0%	\$0	
E-03	Design & Engineering [Phase D]	% OF CI	12.0%	\$1,733,429	
E-03.1	Subsurface Utility Engineering (SUE) Budget	% OF CI	0.8%	\$108,339	
E-03.2	Transportation Systems Management & Operation (TSM&O) Budget	% OF CI	0.0%	\$0	
E-04	Environmental (NEPA) [Phase E]	% OF CI	0.0%	\$0	
E-05	Miscellaneous [Phase M]	% OF CI	0.0%	\$0	
SUBTOTAL (E)				16.2%	\$2,131,000

PROJECT BASE COST ESTIMATE (CONSTRUCTION + PRECONSTRUCTION) \$18,021,000

RISK RESERVE

PROBABILISTIC COST ESTIMATE RISK RESERVE DATE: 11/6/2018 RISK RESERVE 12.2% OF BASE COST \$2,207,000

TOTAL PROJECT COST \$20,228,000

ESCALATION

Construction Start Duration (mo): Sep-22 24.0 Escalation from Estimate Date: Nov-18 to Construction Mid-Point Date: Sep-23

ESCALATION 14.1% OF BASE COST \$2,851,000

ESCALATED PROJECT COST \$23,079,000

67.0% of Base Cost

73.2% of Base Cost

88.2% of Base Cost

11.8% of Base Cost

100.0% of Base Cost

112.2% of Base Cost

128.1% of Base Cost

Key:
Auto-Populated Data Provided in Input Form
Model Estimate Auto-populated from Pricing Database Uploads
Region Estimate Region Input
Region Overwrite Overwritten by Region

Model Version 3 Rev 03
 Last Update: 17-Sep-18

PCPT - MODEL & REGION ESTIMATE FORM

PROJECT PROFILE

Project Name: R1/4 BUNDLE - 8 STRUCTURES
 Project Number: R1/4 BUNDLE
 Sub-Account Number: XXXXX
 Project Description: D-28-D, D-28-C, D-25-E, G-21-A, F-20-J, C-22-K, F-19-E, F-20-L

Project Work Type: BRIDGE REPLACEMENT
 Estimator: E.A. Date: 11/6/2018

PROJECT LOCATION & CHARACTERISTICS

Route: 070A Begin MP: 305.4 End MP: 333.2 Length: 27.9
 CDOT Region: 1 City: NONE County: Arapahoe Co
 FIPS City: 00000 FIPS County: 005

Segment Mid-point RefPt: 319.305 Latitude: 39.7000 Longitude: -104.1685 [GOOGLE MAP LINK](#)

Functional Classification: 1 Interstate Urban-Rural Class: 1 Rural Terrain: 2
 AADT: 13,000 Truck ADT: 260 Tier Class: Tier 1 Primary Surface: 3 Concrete

Design Maturity: 0 - Conceptual NEPA Action: Cat/Ex NEPA Status: Not Started
 Project Delivery Method: Design-Build Construction Start (MMM-YY): Sep-22 Construction Duration (mo): 24.0

				Model Estimate		Region Estimate							
A-01 EARTHWORK				Unit	Qty	Unit Cost	Cost						
				A-01 Cost: 0.0%		\$0	\$0						
A-02 PAVEMENT & BASES				Unit	Qty	Unit Cost	Cost						
				A-02 Cost: 0.0%		\$0	\$0						
A-03 MAJOR STRUCTURES (CAT 300 ITEMS)													
A-03 repl BRIDGE REPLACEMENT													
BRIDGE TYPE				STR ID	ROUTE CARRIED	FEATURE INTERSECT	L (ft)	W (ft)	Deck Area (SF)	Unit Cost	Cost	Unit Cost	Cost
A-03 repl	VEHICULAR BRIDGE	D-28-D	US 34 ML	REPUBLICAN RIVER	120.0	43.0	5,160.0	\$195.0	\$1,006,200	\$250.0	\$1,290,000		
A-03 repl	VEHICULAR BRIDGE	D-28-C	US 34 ML	REPUBLICAN RIVER	90.0	43.0	3,870.0	\$195.0	\$754,650	\$250.0	\$967,500		
A-03 repl	VEHICULAR BRIDGE	D-25-E	SH 61 ML	SURVEYOR CREEK	110.0	43.0	4,730.0	\$195.0	\$922,350	\$250.0	\$1,182,500		
A-03 repl	VEHICULAR BRIDGE	G-21-A	0	0	110.0	43.0	4,730.0	\$195.0	\$922,350	\$250.0	\$1,182,500		
A-03 repl	VEHICULAR BRIDGE	F-20-J	US 40 ML	DRAW	80.0	43.0	3,440.0	\$195.0	\$670,800	\$250.0	\$860,000		
A-03 repl	VEHICULAR BRIDGE	C-22-K	US 6 ML	UPRR, PLATTE; BEAVER C	70.0	43.0	3,010.0	\$195.0	\$586,950	\$250.0	\$752,500		
A-03 repl	VEHICULAR BRIDGE	F-19-E	US 36 ML	DRAW	100.0	43.0	4,300.0	\$195.0	\$838,500	\$250.0	\$1,075,000		
A-03 repl	VEHICULAR BRIDGE	F-20-L	I 70 SERVICE RD	DRAW	60.0	43.0	2,580.0	\$195.0	\$503,100	\$250.0	\$645,000		
				A-03_REPL Cost: 100.0%		\$6,205,000	\$7,955,000						
A-03_repa BRIDGE REPAIR				A-03_REPA Cost: 0.0%		\$0	\$0						
A-03_wall WALLS				A-03_WALL Cost: 0.0%		\$0	\$0						
A-03_culv MAJOR CULVERTS				A-03_CULV Cost: 0.0%		\$0	\$0						
A-03_misc MISCELLANEOUS STRUCTURES				A-03_MISC Cost: 0.0%		\$0	\$0						
				A-03 Cost: 100.0%		\$6,205,000	\$7,955,000						
A-04 TRAFFIC/ITS				A-04 Cost: 0.0%		\$0	\$0						
A-05 OTHER CATEGORY OTHER MAJOR ITEMS				A-05 Cost: 0.0%		\$0	\$0						
A MAJOR CONSTRUCTION ITEMS				SUBTOTAL (A) (% of A)		100.0%	\$6,205,000	100.0%	\$7,955,000				

B - MINOR CONSTRUCTION ITEMS											
		Work Type: BRIDGE REPLACEMENT									
		MIN %	MEAN %	MAX %	EFFORT	Adjusted	% of (A)	Cost	% of (A)	Cost	
B-01	Removals / Resets	0.0%	2.9%	6.0%	5 - Extensive	Adjusted	4.99%	\$309,583	4.99%	\$396,894	
B-02	Environmental	0.0%	5.0%	13.4%	3 - Average	Adjusted	5.00%	\$310,250	5.00%	\$397,750	
B-03	Structural	0.0%	1.2%	2.3%	5 - Extensive	Adjusted	1.91%	\$118,645	5.00%	\$397,750	
B-04	Drainage / Utilities	0.0%	4.5%	14.9%	3 - Average	Adjusted	4.54%	\$281,707	4.54%	\$361,157	
B-05	Roadway Appurtenances	0.0%	4.2%	5.5%	3 - Average	Adjusted	4.22%	\$261,851	4.22%	\$335,701	
B-06	Mobilization	0.0%	12.8%	23.5%	3 - Average	Adjusted	12.78%	\$792,999	12.78%	\$1,016,649	
B-07	Construction Traffic Control / Detour	0.0%	9.8%	26.1%	3 - Average	Adjusted	9.80%	\$608,090	9.80%	\$779,590	
B-08	Lighting & Electrical	0.0%	2.8%	3.2%	3 - Average	Adjusted	2.79%	\$173,120	2.79%	\$221,945	
B-09	Permanent Signing & Striping	0.0%	1.3%	1.8%	3 - Average	Adjusted	1.34%	\$83,147	1.34%	\$106,597	
B-10	Traffic Signalization & ITS	0.0%	1.1%	3.4%	3 - Average	Adjusted	1.12%	\$69,496	1.12%	\$89,096	
B-11	Miscellaneous	0.0%	0.3%	1.2%	3 - Average	Adjusted	0.28%	\$17,374	0.28%	\$22,274	
B MINOR CONSTRUCTION ITEMS		SUBTOTAL (B) (% of A)		48.77%	\$3,026,000	51.86%	\$4,125,000				

C - FORCE ACCOUNTS & TSM&O											
				% of CBI	Cost	% of CBI	Cost				
C-01	F/A - General			6.00%	\$553,860	6.00%	\$724,800				
C-02	F/A - Minor Contract Revisions (MCR's)			3.00%	\$276,930	3.00%	\$362,400				
C-03	F/A - Project Communications	Level 3	\$12,080,000 X 0.26%	0.20%	\$18,789	0.20%	\$24,588				
C-04	TSM&O Traffic & Operations (for Reconstruction/Resurfacing projects only)			0.00%	\$0	0.00%	\$0				
C F/A's & TSM&O		SUBTOTAL (C) (% of CBI)		9.20%	\$850,000	9.20%	\$1,112,000				
CI CONSTRUCTION ITEMS		SUBTOTAL (A + B + C) (% of A)		162.47%	\$10,081,000	165.83%	\$13,192,000				

D - CONSTRUCTION ENGINEERING & INDIRECTS											
				% of CI	Cost	% of CI	Cost				
D-01	Construction Engineering (Default: 10.95%)			10.95%	\$1,103,870	10.95%	\$1,444,524				
D-02	Construction Indirects (Default: 9.5%)			9.50%	\$957,695	9.50%	\$1,253,240				
D CONSTRUCTION ENGINEERING & INDIRECTS		SUBTOTAL (D) (% of CI)		20.45%	\$2,062,000	20.45%	\$2,698,000				
PROJECT CONSTRUCTION BUDGET		CONSTRUCTION (A + B + C + D)			\$12,143,000		\$15,890,000				

E - PRECONSTRUCTION ITEMS											
				Indirect %	Cost	Indirect %	Cost				
E-01	Right-of-Way (Phase R)	AVG %	EFFORT	5.2%	3 - Average	Adjusted	5.16%	\$569,597	2.00%	\$288,905	
E-02	Utilities + Railroad Work (Phase U)						0.00%	\$0	0.00%	\$0	
E-03	Design & Engineering (Phase D)	Design Maturity: 0 - Conceptual					12.00%	\$1,324,643	12.00%	\$1,733,429	
E-03.1	Subsurface Utility Engineering (SUE) Budget						0.75%	\$82,790	0.75%	\$108,339	
E-03.2	Transportation Systems Management & Operation (TSM&O) Budget						0.00%	\$0	0.00%	\$0	
E-04	Environmental (NEPA) (Phase E)						0.00%	\$0	0.00%	\$0	
E-05	Miscellaneous (Phase M)						0.00%	\$0	0.00%	\$0	
E PRECONSTRUCTION ITEMS		SUBTOTAL (E) (% of CI)		19.61%	\$1,977,000	16.15%	\$2,131,000				
PROJECT BASE COST ESTIMATE (CONSTRUCTION + PRECONSTRUCTION)					\$14,120,000		\$18,021,000				
							RE/ME Ratio: 1.28				

RISK RESERVE											
		DATE: 11/6/2018		RISK RESERVE		12.2% OF BASE COST					
PROBABILISTIC COST ESTIMATE RISK RESERVE						\$2,207,000					
TOTAL PROJECT COST (P70)						\$20,228,000					
ESCALATION		Escalation from Estimate Date: Nov-18 to Construction Mid-Point Date: Sep-23		ESCALATION		14.1% OF BASE COST					
						\$2,851,000					
ESCALATED COST						\$23,079,000					

COMMENTS: Please document any key assumptions on unit costs or percentages.

Key: **RISK INPUT FUNCTION** Defined Probabilistic Input Function
INPUT PARAMETER Input Function Parameter (may be overwritten)
OVERWRITTEN Overwritten Input Function Parameter
RISK OUTPUT FUNCTION Probabilistic Output (Results)
RISK STATISTIC FUNCTION Probabilistic Statistic Values (i.e. percentile values)

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PROBABILISTIC COST ESTIMATE SHEET				RISK QUANTITY / % PARAMETERS			RISK UNIT COST PARAMETERS			COMMENTS/NOTES	
<p>TORNADO DIAGRAM: @RISK graph</p> <p>The project's tornado diagram is the graphical output of a comparative sensitivity analysis, focusing on the top 10 critical items. It is meant to give you, the analyst, an idea of which factors are most important to the MOST LIKELY cost estimate output for the project. It is used to give the decision makers some insight into the quantity, unit cost, and/or % range uncertainties found in this project and their potential impact.</p>											
A - MAJOR ITEMS				RISK QUANTITY / % PARAMETERS			RISK UNIT COST PARAMETERS				
A-01	QTY RISK	UNIT COST RISK	COST RISK	MIN %	MAX %	MIN	ML	MAX	MIN	ML	MAX
A-01 Cost:	0.0%		\$0								
A-02	QTY RISK	UNIT COST RISK	COST RISK	MIN %	MAX %	MIN	ML	MAX	MIN	ML	MAX
A-02 Cost:	0.0%		\$0								
A-03 repl	QTY RISK	UNIT COST RISK	COST RISK	MIN %	MAX %	MIN	ML	MAX	MIN	ML	MAX
5375.0	\$258.2	\$1,387,646	-15%	40%	4,386	5,160	7,224	\$109.0	\$250.0	\$440.0	
4031.3	\$258.2	\$1,040,734	-15%	40%	3,290	3,870	5,418	\$109.0	\$250.0	\$440.0	
4927.1	\$258.2	\$1,272,009	-15%	40%	4,021	4,730	6,622	\$109.0	\$250.0	\$440.0	
4927.1	\$258.2	\$1,272,009	-15%	40%	4,021	4,730	6,622	\$109.0	\$250.0	\$440.0	
3583.3	\$258.2	\$925,097	-15%	40%	2,924	3,440	4,816	\$109.0	\$250.0	\$440.0	
3135.4	\$258.2	\$809,460	-15%	40%	2,559	3,010	4,214	\$109.0	\$250.0	\$440.0	
4479.2	\$258.2	\$1,156,372	-15%	40%	3,655	4,300	6,020	\$109.0	\$250.0	\$440.0	
2687.5	\$258.2	\$693,823	-15%	40%	2,193	2,580	3,612	\$109.0	\$250.0	\$440.0	
A-03_REPL Cost:	100.0%	\$8,557,149									
A-03_REPA Cost:	0.0%	\$0									
A-03_WALL Cost:	0.0%	\$0									
A-03_CULV Cost:	0.0%	\$0									
A-03_misc	QTY RISK	UNIT COST RISK	COST RISK	MIN %	MAX %	MIN	ML	MAX	MIN	ML	MAX
A-03_MISC Cost:	0.0%	\$0									
A-03 Cost:	100.0%	\$8,557,149									
A-04	QTY RISK	UNIT COST RISK	COST RISK	MIN %	MAX %	MIN	ML	MAX	MIN	ML	MAX
A-04 Cost:	0.0%	\$0									
A-05	QTY RISK	UNIT COST RISK	COST RISK	MIN %	MAX %	MIN	ML	MAX	MIN	ML	MAX
A-05 Cost:	0.0%	\$0									
SUBTOTAL (A)	100.0%	\$8,557,000									
<p>*MODIFY LS estimate ranges as seem appropriate --></p> <p>LUMP SUM COST ESTIMATE RANGES</p> <p>*If unit type = "L S", "ACRE", or "EACH", no quantity uncertainty applies.</p> <p>*If unit type = "L S", "ACRE", or "EACH", no quantity uncertainty applies.</p> <p>*If unit type = "L S", "ACRE", or "EACH", no quantity uncertainty applies.</p>											
B - MINOR ITEMS				RISK QUANTITY / % PARAMETERS			RISK UNIT COST PARAMETERS				
	% of (A) RISK	COST RISK	MIN	ML	MAX	MIN	ML	MAX			
B-01	4.99%	\$426,930	0.0%	5.0%	10.0%						
B-02	5.00%	\$427,850	0.0%	5.0%	10.0%						
B-03	4.33%	\$370,803	0.0%	5.0%	6.0%						
B-04	4.54%	\$388,488	0.0%	4.5%	9.1%						
B-05	4.22%	\$361,105	0.0%	4.2%	8.4%						
B-06	12.78%	\$1,093,585	0.0%	12.8%	25.6%						
B-07	9.80%	\$838,586	0.0%	9.8%	19.6%						
B-08	2.79%	\$238,740	0.0%	2.8%	5.6%						
B-09	1.34%	\$114,664	0.0%	1.3%	2.7%						
B-10	1.12%	\$95,838	0.0%	1.1%	2.2%						
B-11	0.28%	\$23,960	0.0%	0.3%	0.6%						
SUBTOTAL (B)	51.2%	\$4,381,000	0.0%	51.9%	99.7%						
CBI	151.2%	\$12,938,000									
<p>*If ML value CLOSE TO or GREATER THAN historical max, MAX = ML*1.2 *If ML value WITHIN historical range, MAX = ML*2 (NEED TO ENSURE APPROPRIATE % RANGES)</p>											
C - F/A's & TSM&O				RISK QUANTITY / % PARAMETERS			RISK UNIT COST PARAMETERS				
	% of CBI RISK	COST RISK	MIN	ML	MAX	MIN	ML	MAX			
C-01	6.00%	\$776,280	6.0%	6.0%	6.0%						
C-02	3.00%	\$388,140	3.0%	3.0%	3.0%						
C-03	0.20%	\$26,334	0.2%	0.20%	0.2%						
C-04	0.00%	\$0	0.0%	0.00%	0.0%						
SUBTOTAL (C)	9.2%	\$1,191,000									
CI	165.1%	\$14,129,000									
D - CE & INDIRECTS				RISK QUANTITY / % PARAMETERS			RISK UNIT COST PARAMETERS				
	% of CI RISK	COST RISK	MIN	ML	MAX	MIN	ML	MAX			
D-01	10.95%	\$1,547,126	10.95%	10.95%	10.95%						
D-02	9.50%	\$1,342,255	9.50%	9.50%	9.50%						
SUBTOTAL (D)	20.5%	\$2,889,000									
CONST		\$17,018,000									
E - PRECON ITEMS				RISK QUANTITY / % PARAMETERS			RISK UNIT COST PARAMETERS				
	% of CI RISK	COST RISK	MIN %	MAX %	MIN	ML	MAX	MIN	ML	MAX	
E-01	2.10%	\$296,709	-20%	50%	1.60%	2.00%	3.00%				
E-02	0.0%	\$0	-20%	50%				\$0	\$0	\$0	
E-03	12.50%	\$1,766,125	-15%	40%	10.20%	12.00%	16.80%				
E-03.1	0.75%	\$105,968	0%	0%	0.75%	0.75%	0.75%				
E-03.2	0.00%	\$0	0%	0%	0.00%	0.00%	0.00%				
E-04	0.0%	\$0	-20%	50%				\$0	\$0	\$0	
E-05	0.0%	\$0	0%	0%				\$0	\$0	\$0	
SUBTOTAL (E)	15.4%	\$2,169,000									
<p>MOST LIKELY (CONST + PRECON) P-VALUE 51 \$19,187,000 @RISK graph</p> <p>BASE COST P-VALUE 29 \$18,021,000</p> <p>RISK RESERVE 12.2% \$2,207,000</p> <p>P70 VALUE 70 \$20,228,000</p> <p>Probabilistic Ranges:</p> <p>P10 \$16,589,000 P50 \$19,136,000 P70 \$20,228,000 P90 \$21,862,000</p>											

Key: Auto-Populated

Model Version 3 Rev 03
Last Update: 17-Sep-18

PCPT - EXECUTIVE SUMMARY SHEET

PROJECT PROFILE

Model Version 3 Rev 03
Last Update: 17-Sep-18

Project Name: R1/4 BUNDLE - 1 STRUCTURES
 Project Number: D-24-O
 Sub-Account Number: XXXXX
 Project Description: D-24-O

Project Work Type: BRIDGE REPLACEMENT

Estimator: E.A. Date: 11/6/2018

PROJECT LOCATION & CHARACTERISTICS

Route: 034B Begin MP: 198.8 End MP: 198.8 Length: 0.0
 CDOT Region: 4 FIPS City: NONE FIPS County: Washington Co
 FIPS City: 00000 FIPS County: 121

Segment Mid-point RefPt: 198.800 Latitude: 40.1537 Longitude: -103.1779 [GOOGLE MAP LINK](#)

Functional Classification: Principal Arterial - Oth Urban-Rural Class: 1 Rural Terrain: 1 Plains

AADT: 5,100 Truck ADT: 360 Tier Class: Tier 2 Primary Surface: 1 Asphalt

Design Maturity: 0 - Conceptual NEPA Action: Cat/Ex NEPA Status: Not Started

Project Delivery Method: Design-Build Construction Start (MMM-YY): Sep-22 Construction Duration (mo): 24.0

REGION'S ESTIMATE

PROJECT CONSTRUCTION COSTS:

A MAJOR CONSTRUCTION ITEMS

PCPT CAT	ITEM DESCRIPTION	QTY	UNIT	PERCENTAGE	COST
A-01	Earthwork	0	CY	0.0%	\$0
A-02	Pavement & Bases	N/A	SY	0.0%	\$0
A-03_repl	Bridge Replacement	2,160	DECK AREA (SF)	100.0%	\$648,000
A-03_repa	Bridge Repair	0	DECK AREA (SF)	0.0%	\$0
A-03_wall	Walls	0	SF	0.0%	\$0
A-03_culv	Major Culverts	0	LF	0.0%	\$0
A-03_misc	Miscellaneous Structures	0	LS	0.0%	\$0
A-04	Traffic / ITS	N/A	N/A	0.0%	\$0
A-05	Other Major Items	N/A	N/A	0.0%	\$0
SUBTOTAL (A)				100.0%	\$648,000

B MINOR CONSTRUCTION ITEMS

PCPT CAT	ITEM DESCRIPTION	EFFORT	UNIT	PERCENTAGE	COST
B-01	Removals / Resets	5 - Extensive	% OF A	5.1%	\$33,314
B-02	Environmental	3 - Average	% OF A	5.4%	\$35,186
B-03	Structural	5 - Extensive	% OF A	5.0%	\$32,400
B-04	Drainage / Utilities	3 - Average	% OF A	8.8%	\$57,089
B-05	Roadway Appurtenances	3 - Average	% OF A	2.4%	\$15,746
B-06	Mobilization	3 - Average	% OF A	14.6%	\$94,543
B-07	Construction Traffic Control / Detour	3 - Average	% OF A	15.0%	\$97,200
B-08	Lighting & Electrical	3 - Average	% OF A	0.0%	\$0
B-09	Permanent Signing & Striping	3 - Average	% OF A	0.7%	\$4,666
B-10	Traffic Signalization & ITS	3 - Average	% OF A	0.0%	\$0
B-11	Miscellaneous	3 - Average	% OF A	0.2%	\$1,361
SUBTOTAL (B)				57.3%	\$372,000

CONSTRUCTION BID ITEMS (A + B) CBI % OF A 157.4% \$1,020,000

C FORCE ACCOUNTS & TSM&O

PCPT CAT	ITEM DESCRIPTION	UNIT	PERCENTAGE	COST	
C-01	F/A - General	% OF CBI	6.0%	\$61,200	
C-02	F/A - Minor Contract Revisions (MCR's)	% OF CBI	3.0%	\$30,600	
C-03	F/A - Project Communications	% OF CBI	0.1%	\$1,109	
C-04	TSM&O Traffic & Operations	% OF CBI	0.0%	\$0	
SUBTOTAL (C)				9.1%	\$93,000

CONSTRUCTION ITEMS (A + B + C) CI % OF A 171.8% \$1,113,000

D CONSTRUCTION ENGINEERING & INDIRECTS

PCPT CAT	ITEM DESCRIPTION	UNIT	PERCENTAGE	COST	
D-01	Construction Engineering	% OF CI	11.0%	\$121,874	
D-02	Construction Indirects	% OF CI	9.5%	\$105,735	
SUBTOTAL (D)				20.5%	\$228,000

PROJECT CONSTRUCTION BUDGET (A + B + C + D) \$1,341,000

PROJECT PRECONSTRUCTION COSTS:

E PRECONSTRUCTION ITEMS

PCPT CAT	ITEM DESCRIPTION	UNIT	PERCENTAGE	COST	
E-01	Right-of-Way [Phase R]	% OF CI	2.0%	\$24,375	
E-02	Utilities + Railroad Work [Phase U]	% OF CI	0.0%	\$0	
E-03	Design & Engineering [Phase D]	% OF CI	12.0%	\$146,248	
E-03.1	Subsurface Utility Engineering (SUE) Budget	% OF CI	0.8%	\$9,141	
E-03.2	Transportation Systems Management & Operation (TSM&O) Budget	% OF CI	0.0%	\$0	
E-04	Environmental (NEPA) [Phase E]	% OF CI	0.0%	\$0	
E-05	Miscellaneous [Phase M]	% OF CI	0.0%	\$0	
SUBTOTAL (E)				16.2%	\$180,000

PROJECT BASE COST ESTIMATE (CONSTRUCTION + PRECONSTRUCTION) \$1,521,000

RISK RESERVE

PROBABILISTIC COST ESTIMATE RISK RESERVE DATE: 11/6/2018 RISK RESERVE 12.4% OF BASE COST \$188,000

TOTAL PROJECT COST \$1,709,000

ESCALATION

Construction Start Duration (mo): Sep-22 24.0 Escalation from Estimate Date: Nov-18 to Construction Mid-Point Date: Sep-23

ESCALATION 14.1% OF BASE COST \$241,000

ESCALATED PROJECT COST \$1,950,000

67.1% of Base Cost

73.2% of Base Cost

88.2% of Base Cost

11.8% of Base Cost

100.0% of Base Cost

112.4% of Base Cost

128.2% of Base Cost

Key:
Auto-Populated Data Provided in Input Form
Model Estimate Auto-populated from Pricing Database Uploads
Region Estimate Region Input
Region Overwrite Overwritten by Region

Model Version 3 Rev 03
 Last Update: 17-Sep-18

PCPT - MODEL & REGION ESTIMATE FORM

PROJECT PROFILE

Project Name: R1/4 BUNDLE - 1 STRUCTURES
 Project Number: D-24-0
 Sub-Account Number: XXXXX
 Project Description: D-24-0

Project Work Type: BRIDGE REPLACEMENT
 Estimator: E.A. Date: 11/6/2018

PROJECT LOCATION & CHARACTERISTICS

Route: 034B Begin MP: 198.8 End MP: 198.8 Length: 0.0
 CDOT Region: 4 City: NONE County: Washington Co
 FIPS City: 00000 FIPS County: 121

Segment Mid-point RefPt: 198.800 Latitude: 40.1537 Longitude: -103.1779 [GOOGLE MAP LINK](#)
 Functional Classification: 3 Principal Arterial - Oth Urban-Rural Class: 1 Rural Terrain: 1
 AADT: 5,100 Truck ADT: 360 Tier Class: Tier 2 Primary Surface: 1 Asphalt

Design Maturity: 0 - Conceptual NEPA Action: Cat/Ex NEPA Status: Not Started
 Project Delivery Method: Design-Build Construction Start (MMM-YY): Sep-22 Construction Duration (mo): 24.0

		Model Estimate		Region Estimate							
A-01	EARTHWORK	Unit	Qty	Unit Cost	Cost						
		A-01 Cost:		0.0%	\$0						
A-02	PAVEMENT & BASES	Unit	Qty	Unit Cost	Cost						
		A-02 Cost:		0.0%	\$0						
A-03	MAJOR STRUCTURES (CAT 300 ITEMS)										
A-03_repl	BRIDGE REPLACEMENT										
	BRIDGE TYPE	STR ID	ROUTE CARRIED	FEATURE INTERSECT	L (ft)	W (ft)	Deck Area (SF)	Unit Cost	Cost	Unit Cost	Cost
A-03_repl	VEHICULAR BRIDGE	D-24-0	US 34 ML	DRAW	90.0	24.0	2,160.0	\$150.0	\$324,000	\$300.0	\$648,000
		A-03_REPL Cost:		100.0%	\$324,000	100.0%	\$648,000				
A-03_repa	BRIDGE REPAIR										
		A-03_REPA Cost:		0.0%	\$0	0.0%	\$0				
A-03_wall	WALLS										
		A-03_WALL Cost:		0.0%	\$0	0.0%	\$0				
A-03_culv	MAJOR CULVERTS										
		A-03_CULV Cost:		0.0%	\$0	0.0%	\$0				
A-03_misc	MISCELLANEOUS STRUCTURES	Unit	Qty	Unit Cost	Cost						
		A-03_MISC Cost:		0.0%	\$0	0.0%	\$0				
		A-03 Cost:		100.0%	\$324,000	100.0%	\$648,000				
A-04	TRAFFIC/ITS	Unit	Qty	Unit Cost	Cost						
		A-04 Cost:		0.0%	\$0	0.0%	\$0				
A-05	OTHER CATEGORY	OTHER MAJOR ITEMS	Unit	Qty	Unit Cost	Cost					
		A-05 Cost:		0.0%	\$0	0.0%	\$0				
A	MAJOR CONSTRUCTION ITEMS	SUBTOTAL (A)		(% of A)	100.0%	\$324,000	100.0%	\$648,000	42.6% of Base Cost		

		Work Type: BRIDGE REPLACEMENT									
		MIN %	MEAN %	MAX %	EFFORT	Adjusted→	% of (A)	Cost	% of (A)	Cost	
B-01	Removals / Resets	0.0%	3.4%	6.0%	5 - Extensive	Adjusted→	5.14%	\$16,657	5.14%	\$33,314	
B-02	Environmental	0.0%	5.4%	13.4%	3 - Average	Adjusted→	5.43%	\$17,593	5.43%	\$35,186	
B-03	Structural	0.0%	0.5%	2.3%	5 - Extensive	Adjusted→	1.70%	\$5,522	5.00%	\$32,400	
B-04	Drainage / Utilities	0.0%	8.8%	14.9%	3 - Average	Adjusted→	8.81%	\$28,544	8.81%	\$57,089	
B-05	Roadway Appurtenances	0.0%	2.4%	5.5%	3 - Average	Adjusted→	2.43%	\$7,873	2.43%	\$15,746	
B-06	Mobilization	0.0%	14.6%	23.5%	3 - Average	Adjusted→	14.59%	\$47,272	14.59%	\$94,543	
B-07	Construction Traffic Control / Detour	0.0%	15.0%	26.1%	3 - Average	Adjusted→	15.00%	\$48,600	15.00%	\$97,200	
B-08	Lighting & Electrical	0.0%	0.0%	3.2%	3 - Average	Adjusted→	0.00%	\$0	0.00%	\$0	
B-09	Permanent Signing & Striping	0.0%	0.7%	1.8%	3 - Average	Adjusted→	0.72%	\$2,333	0.72%	\$4,666	
B-10	Traffic Signalization & ITS	0.0%	0.0%	3.4%	3 - Average	Adjusted→	0.00%	\$0	0.00%	\$0	
B-11	Miscellaneous	0.0%	0.2%	1.2%	3 - Average	Adjusted→	0.21%	\$680	0.21%	\$1,361	
B	MINOR CONSTRUCTION ITEMS	SUBTOTAL (B)		(% of A)	54.04%	\$175,000	57.33%	\$372,000	67.1% of Base Cost		

		% of CBI		Cost							
C-01	FIA - General	6.00%	\$29,940	6.00%	\$61,200						
C-02	FIA - Minor Contract Revisions (MCR's)	3.00%	\$14,970	3.00%	\$30,600						
C-03	FIA - Project Communications	0.11%	\$543	0.11%	\$1,109						
C-04	TSM&O Traffic & Operations (for Reconstruction/Resurfacing projects only)	0.00%	\$0	0.00%	\$0						
C	FIA's & TSM&O	SUBTOTAL (C)		(% of CBI)	9.11%	\$45,000	9.11%	\$93,000	73.2% of Base Cost		

		% of CI		Cost							
D-01	Construction Engineering (Default: 10.95%)	10.95%	\$59,568	10.95%	\$121,874						
D-02	Construction Indirects (Default: 9.5%)	9.50%	\$51,880	9.50%	\$105,735						
D	CONSTRUCTION ENGINEERING & INDIRECTS	SUBTOTAL (D)		(% of CI)	20.45%	\$111,000	20.45%	\$228,000	88.2% of Base Cost		

PROJECT CONSTRUCTION BUDGET	CONSTRUCTION (A + B + C + D)	\$655,000	\$1,341,000
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		Indirect %		Indirect %							
		9.50%		9.50%							
		AVG %	EFFORT	Adjusted→	% of CI	Cost	% of CI	Cost			
E-01	Right-of-Way [Phase R]	5.2%	3 - Average	Adjusted→	5.16%	\$30,737	2.00%	\$24,375			
E-02	Utilities + Railroad Work [Phase U]				0.00%	\$0	0.00%	\$0			
E-03	Design & Engineering [Phase D]				12.00%	\$71,482	12.00%	\$146,248			
E-03.1	Subsurface Utility Engineering (SUE) Budget				0.75%	\$4,468	0.75%	\$9,141			
E-03.2	Transportation Systems Management & Operation (TSM&O) Budget				0.00%	\$0	0.00%	\$0			
E-04	Environmental (NEPA) [Phase E]				0.00%	\$0	0.00%	\$0			
E-05	Miscellaneous [Phase M]				0.00%	\$0	0.00%	\$0			
E	PRECONSTRUCTION ITEMS	SUBTOTAL (E)		(% of CI)	19.67%	\$107,000	16.17%	\$180,000	11.8% of Base Cost		

PROJECT BASE COST ESTIMATE (CONSTRUCTION + PRECONSTRUCTION)	\$762,000	\$1,521,000	RE/ME Ratio: 2.00
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RISK RESERVE	PROBABILISTIC COST ESTIMATE RISK RESERVE	DATE: 11/6/2018	RISK RESERVE	12.4% OF BASE COST	\$188,000
			TOTAL PROJECT COST (P70)		\$1,709,000
			ESCALATION	14.1% OF BASE COST	\$241,000
			ESCALATED COST		\$1,950,000

COMMENTS: Please document any key assumptions on unit costs or percentages.

Key: **RISK INPUT FUNCTION** Defined Probabilistic Input Function
INPUT PARAMETER Input Function Parameter (may be overwritten)
OVERWRITTEN Overwritten Input Function Parameter
RISK OUTPUT FUNCTION Probabilistic Output (Results)
RISK STATISTIC FUNCTION Probabilistic Statistic Values (i.e. percentile values)

Model Version 3 Rev 03
 Last Update: 17-Sep-18

PROBABILISTIC COST ESTIMATE SHEET RISK QUANTITY / % PARAMETERS RISK UNIT COST PARAMETERS COMMENTS/NOTES

TORNADO DIAGRAM: @RISK graph

The project's tornado diagram is the graphical output of a comparative sensitivity analysis, focusing on the top 10 critical items. It is meant to give you, the analyst, an idea of which factors are most important to the MOST LIKELY cost estimate output for the project. It is used to give the decision makers some insight into the quantity, unit cost, and/or % range uncertainties found in this project and their potential impact.

A - MAJOR ITEMS

A-01	QTY RISK	UNIT COST RISK	COST RISK
A-01 Cost:	0.0%		\$0
A-02	QTY RISK	UNIT COST RISK	COST RISK
A-02 Cost:	0.0%		\$0
A-03_repl	QTY RISK	UNIT COST RISK	COST RISK
2250.0	\$289.8	\$652,125	
A-03_REPL Cost:	100.0%		\$652,125
A-03_REPA Cost:	0.0%		\$0
A-03_WALL Cost:	0.0%		\$0
A-03_CULV Cost:	0.0%		\$0
A-03_misc	QTY RISK	UNIT COST RISK	COST RISK
A-03_MISC Cost:	0.0%		\$0
A-03 Cost:	100.0%		\$652,125
A-04	QTY RISK	UNIT COST RISK	COST RISK
A-04 Cost:	0.0%		\$0
A-05	QTY RISK	UNIT COST RISK	COST RISK
A-05 Cost:	0.0%		\$0
SUBTOTAL (A)	100.0%		\$652,000

MIN %	MAX %	MIN	ML	MAX
-15%	40%	1,836	2,160	3,024

MIN	ML	MAX
\$99.0	\$300.0	\$440.0

*MODIFY LS estimate ranges as seem appropriate -->

LUMP SUM COST ESTIMATE RANGES

B - MINOR ITEMS

	% of (A) RISK	COST RISK
B-01	5.14%	\$33,520
B-02	5.43%	\$35,404
B-03	4.33%	\$28,253
B-04	8.81%	\$57,441
B-05	2.43%	\$15,844
B-06	14.59%	\$95,127
B-07	15.00%	\$97,800
B-08	0.00%	\$0
B-09	0.72%	\$4,694
B-10	0.00%	\$0
B-11	0.21%	\$1,369
SUBTOTAL (B)	56.7%	\$369,000
CBI	156.7%	\$1,021,000
	(% of A)	

MIN	ML	MAX
0.0%	5.1%	10.3%
0.0%	5.4%	10.9%
0.0%	5.0%	6.0%
0.0%	8.8%	17.6%
0.0%	2.4%	4.9%
0.0%	14.6%	29.2%
0.0%	15.0%	30.0%
0.0%	0.0%	0.0%
0.0%	0.7%	1.4%
0.0%	0.0%	0.0%
0.0%	0.2%	0.4%
SUBTOTAL (B)	0.0%	57.3%

*If ML value CLOSE TO or GREATER THAN historical max, MAX = ML*1.2
 *If ML value WITHIN historical range, MAX = ML*2
 (NEED TO ENSURE APPROPRIATE % RANGES)

C - FIA's & TSM&O

	% of CBI RISK	COST RISK
C-01	6.00%	\$61,280
C-02	3.00%	\$30,630
C-03	0.11%	\$1,110
C-04	0.00%	\$0
SUBTOTAL (C)	9.1%	\$93,000
CI	170.9%	\$1,114,000

MIN	ML	MAX
6.0%	6.0%	6.0%
3.0%	3.0%	3.0%
0.1%	0.11%	0.1%
0.0%	0.00%	0.0%

D - CE & INDIRECTS

	% of CI RISK	COST RISK
D-01	10.95%	\$121,983
D-02	9.50%	\$105,830
SUBTOTAL (D)	20.5%	\$228,000
CONST		\$1,342,000

10.95%	10.95%	10.95%
9.50%	9.50%	9.50%

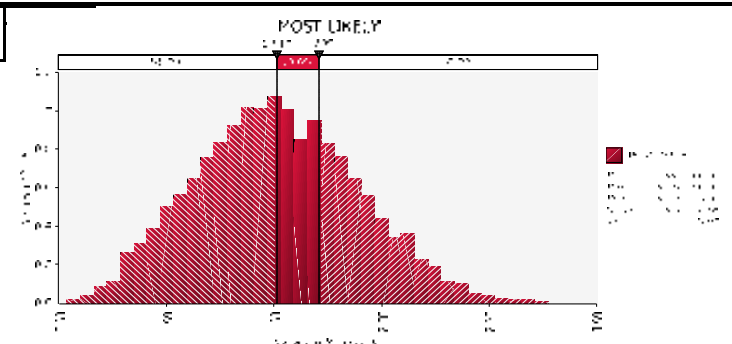
E - PRECON ITEMS

	% of CI RISK	COST RISK
E-01	2.10%	\$23,394
E-02	0.0%	\$0
E-03	12.50%	\$139,250
E-03.1	0.75%	\$8,355
E-03.2	0.00%	\$0
E-04	0.0%	\$0
E-05	0.0%	\$0
SUBTOTAL (E)	15.4%	\$171,000

MIN %	MAX %	MIN	ML	MAX
-20%	50%	1.60%	2.00%	3.00%
-20%	50%			
-15%	40%	10.20%	12.00%	16.80%
0%	0%	0.75%	0.75%	0.75%
0%	0%	0.00%	0.00%	0.00%
-20%	50%			
0%	0%			

MIN	ML	MAX
\$0	\$0	\$0
\$0	\$0	\$0
\$0	\$0	\$0
\$0	\$0	\$0

MOST LIKELY (CONST + PRECON)	P-VALUE: 51	\$1,513,000
BASE COST	P-VALUE: 52	\$1,521,000
RISK RESERVE	12.4% OF BASE COST	\$188,000
P70 VALUE	70	\$1,709,000
Probabilistic Ranges:		
P10		\$1,024,000
P50		\$1,503,000
P70		\$1,709,000
P90		\$2,010,000



A yellow school bus is driving on a highway that runs over a field of tall, dry grass. The sky is clear and blue. The bus is positioned in the middle ground, moving from left to right. The foreground is dominated by the tall grass, and the background shows the horizon line.

Appendix C Letters of Support and Commitment

MEMORANDUM

TO: BRIDGE ENTERPRISE BOARD OF DIRECTORS
FROM: JERAD ESQUIBEL, DIRECTOR OF PROJECT SUPPORT
DATE: NOVEMBER 15, 2018
SUBJECT: RESOLUTION TO APPROVE STATE FUNDING MATCH FOR FY 2018-19 FHWA COMPETITIVE HIGHWAY BRIDGE GRANT

Purpose:

The Bridge Enterprise Board of Directors (Board) is being asked to approve the attached resolution that endorses the grant applications for the fiscal year (FY) 2018-19 FHWA Competitive Highway Bridge Program, and commits Bridge Enterprise funding for BE eligible structures as a portion of the state funding match.

Background:

In October, CDOT Staff Bridge Branch and BE Staff held a joint workshop to inform the Board and the Transportation Commission of key details provided in the Notice of Funding Opportunity (NOFO) released by the FHWA on September 5, 2018, and to provide the selection methodology for the structure bundles being submitted in the grant applications. State funding match levels are recommended at 50% or greater to increase the probability of award. Based on the selection criteria outlined in the NOFO, the following projects and funding matches were recommended:

App#	Description	Requested CBE Match (est.)	Requested TC Match	USDOT Grant	Total Cost (est.)
1	R1: I-70 between Colfax Ave. and Harlan St. (10 Structures)	\$41.7M	\$15M	\$24.3M	\$81M
2	R2: Concrete Box Culvert and Corrugated Metal Pipe Culvert Program (14 Structures)	\$17M	-	\$17M	\$34M
3	R1/R4: Eastern Plains Timber Bridge Replacement Program (9 Structures)	\$11M	-	\$11M	\$22M
Total Match Being Requested		\$69.7M	\$15M	\$52.3M	\$137M

Staff requested consideration and feedback from the Board and the Transportation Commission regarding the proposed grant applications and funding levels and the response was positive. As discussed in the October workshop, the potential exists for USDOT to award multiple grants. Based on BE program forecasts, the estimated \$69.7M maximum in CBE match funding is currently available between FY 2019-20 and FY 2024-25 in the unlikely event that all three grants are awarded.

Next Steps:

1. Staff will submit applications for all three project bundles by the FHWA December 4th deadline
2. If any bundle is awarded, BE staff will return to the Board requesting specific funding for each project within the bundles as part of the monthly budget supplement process.

Attachment:

Attachment A: Resolution # BE 18-11-X: Instructing the Department to submit an application under the Competitive Highway Bridge Program and support priority bridge projects submitted by the Colorado Bridge Enterprise and CDOT Staff Bridge Program



Resolution #EE-18-11-07

Instructing the Department to submit an application under the USDOT Competitive Highway Bridge Program and support priority bridge projects submitted by the Colorado Bridge Enterprise and CDOT Staff Bridge Program

Approved by the Colorado Bridge Enterprise Board of Directors on November 15, 2018

WHEREAS, the Colorado General Assembly created the Colorado Bridge Enterprise (CBE) in C.R.S. 43-4-805 as a government-owned business within the Colorado Department of Transportation (CDOT or Department) for the business purpose of financing, repairing, reconstructing, and replacing Designated Bridges, defined in C.R.S. 43-4-803(10) as those bridges identified as structurally deficient or functionally obsolete and rated poor; and

WHEREAS, The Consolidated Appropriations Act of 2018 made available \$225 million for highway bridge replacement and rehabilitation projects on public roads through the Competitive Highway Bridge Program, (Pub. L. 115-141, March 23, 2018); and

WHEREAS, a Notice of Funding Opportunity (NOFO) was issued by U.S. Department of Transportation (USDOT) on September 5, 2018 for the FY 2018 Competitive Highway Bridge Program; and

WHEREAS, applications for the Competitive Highway Bridge Program; are due to the U.S. Secretary of Transportation on December 4, 2018; and

WHEREAS, the USDOT's consideration of Competitive Highway Bridge Program discretionary grant applications will be based on four key program objectives: innovation, supporting economic vitality, life cycle cost and state of good repair and project readiness;and

WHEREAS, projects that are eligible for the Competitive Highway Bridge Program discretionary grant funding must be considered major structures, demonstrate cost savings through bundling and be located on a public road; and

WHEREAS, both CBE and CDOT Staff Bridge have analyzed potential bridge structures for the Department to submit under a unified grant application and identified three project bundles that will be submitted for consideration; and

WHEREAS, all project bundles include CBE eligible structures and project bundles #1 and #3 include non-CBE eligible structures, both the CBE Board and the Transportation Commission are being asked to commit matching funds to increase the competitiveness of the Departments application.

NOW THEREFORE BE IT RESOLVED, the Department is instructed to submit the maximum allowed three applications for the following three different bridge project bundles as part of the Competitive Highway Bridge Program:

1. I-70 between Colfax Ave. and Harlan St. - Region 1
2. Concrete Box Culvert and Corrugated Metal Pipe Culvert Program - Region 2
3. Eastern Plains Timber Bridge Replacement Program - Regions 1 and 4

NOW THEREFORE BE IT FURTHER RESOLVED, the CBE Board commits to providing up to \$41.7 million of state match for CBE eligible structures under grant application #1: I-70 between Colfax Ave. and Harlan St. in Region 1 if this grant application is successful.

NOW THEREFORE BE IT FURTHER RESOLVED, the CBE Board commits to providing up to \$17 million of state match for CBE eligible structures under grant application #2: Concrete Box Culvert and Corrugated Metal Pipe Culvert Program in Region 2 if this grant application is successful.

NOW THEREFORE BE IT FURTHER RESOLVED, the CBE Board commits to providing up to \$11 million of state match for BE eligible structures under grant application #3: Eastern Plains Timber Bridge Replacement Program in Regions 1 and 4 if this grant application is successful.

NOW THEREFORE BE IT FURTHER RESOLVED, in order to show the Department's financial commitment to project bundles and because a state match is required and enhances the viability of the application, the CBE commits to providing up to a combined maximum of \$69.7 million of Bridge Safety Surcharge revenue to be used on CBE eligible structures if all three of the Department's grant applications are awarded by the USDOT.



Herman Stockinger, Secretary
Bridge Enterprise Board of Directors



Date



November 30, 2018

The Honorable Elaine Chao
Secretary
U.S. Department of Transportation
1200 New Jersey Avenue, SE
Washington, D.C. 20590

RE: Colorado Department of Transportation USDOT Competitive Highway Bridge Replacement Grant Applications

Dear Secretary Chao:

I am writing in support of the Colorado Department of Transportation's (CDOT) application for funding under the USDOT Competitive Highway Bridge Replacement Grant Program for our bridge projects. The three grant requests include partial funding for the replacement of 33 bridges throughout the state, including 1) The replacement of ten bridges on Interstate 70 (I-70) near Golden between Colfax Ave. and Harlan Street; 2) The replacement of fourteen bridges on US 350 in Colorado between Delhi and La Junta and in the area of US 24 near Hartsel, CO; and 3) The replacement of 9 bridges on rural highways and service roads in Northeastern Colorado.

The State of Colorado is facing severe and growing transportation challenges that threaten the safety, efficiency, and economy of Colorado. The State's transportation infrastructure has seen usage and congestion grow significantly, reflective of both the increased population and economic boom the state has enjoyed over the past decade. This has meant a substantial cohort of the state's bridges are now operating past their design life and/or are in poor condition. In the case of the bridges proposed for replacement in CDOT's applications, their deterioration has accelerated in recent years, leading to escalating maintenance costs and an increasing frequency of lane and bridge closures to carry out planned and unplanned repairs.

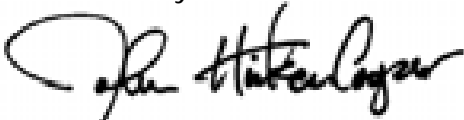
Interstate 70 is the primary gateway to the recreational areas of the Rocky Mountains and, as part of the National Freight System, it is the most significant east-west highway for goods movement in the state. Seven of the bridges in the second bundle of 14 are along US 350, which is a significant rural highway that provides a crucial transportation corridor for agriculture and freight between La Junta and Trinidad, connecting Interstate 25 and US 50. The other seven bridges are located on US 24 and Route 9, near Hartsel, which is another primary gateway to the recreational areas of the Rocky Mountains.



These corridors are some of the most highly trafficked roadways in the state and ensuring improvements that maintain their condition is imperative. Road closures and delays as a result of planned and unplanned maintenance on bridges due to their deterioration have had an adverse impact on the efficacy of the larger transportation network. In fact, closures of these bridges incur significant delays, causing detour distances of over 100 miles in some instances. Improving their condition will ensure Colorado's continued economic competitiveness.

The implementation and delivery of the replacement of these three bundles of bridges represent an opportunity for the State of Colorado to effectively improve mobility and safety outcomes along the state's busiest road corridors while concurrently ensuring that the economic vitality provided by these crucial routes are maintained. Thank you for your consideration.

Sincerely,

A handwritten signature in black ink, appearing to read "John W. Hickenlooper". The signature is fluid and cursive, with a large initial "J" and "H".

John W. Hickenlooper
Governor



ARAPAHOE COUNTY
COLORADO'S FIRST

Board of County Commissioners

5334 South Prince Street
Littleton, Colorado 80120-1136
Phone: 303-795-4630
Fax: 303-738-7894
Relay Colorado 711
www.arapahoegov.com
commissioners@arapahoegov.com

November 28, 2018

The Honorable Elaine Chao
Secretary, U.S. Department of Transportation
1200 New Jersey Avenue, SE
Washington, D.C. 20590

KATHLEEN CONTI
District 1

NANCY N. SHARPE
District 2

JEFF BAKER
District 3

NANCY JACKSON
District 4

BILL L. MOLEN
District 5

RE: Colorado Department of Transportation FHWA Rural Bridge Replacement Grant Application – Eastern Plains Timber Bridge Replacement Program – (Regions 4/1 Bundle).

Honorable Secretary Chao:

I am writing on behalf of **Arapahoe County, Colorado** to express our support the Colorado Department of Transportation's (CDOT) application for the funding under the FHWA Rural Bridge Replacement Grant Program for their project, Regions 4/1 Bundle. The grant request is for partial funding for the replacement of 9 bridges on rural highways and service roads in Northeastern Colorado.

The State of Colorado is facing severe and growing transportation problems that threaten the safety, efficiency, and economy of Colorado. Within the context of stagnate or declining funding, the State's transportation infrastructure has seen usage and congestion grow significantly, reflective of both the increased population and economic boom the state has endured over the past decade. A substantial cohort of the state's bridges are operating past their design life and/or are in poor condition. In the case of the bridges proposed for replacement in CDOT's application, their deterioration has accelerated in recent years, leading to escalating maintenance costs and an increasing frequency of lane/bridge closures to carry out planned and unplanned repairs.

The majority of the bridges in this bundle are located along key east to west highways and interstates connecting Colorado with Kansas and Nebraska. These are key freight corridors for agricultural and resource products and they enable the commercial lifeblood of the region. Planned and unplanned closures of these bridges incur significant delays, causing detour distances over 100 miles in some cases. All of the bridges are past their useful design lives, and their continued deterioration could likely lead to the imposition of load limit restrictions, thereby hindering the mobility of commercial trucks and farm equipment. Road closures and delays along these corridors as a result of planned and unplanned maintenance on its bridges due to their deterioration have had an adverse impact on the efficacy of the

MISSION

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intra- and interstate transportation network and will hinder the region's economic competitiveness if they are not replaced in the near term.

The implementation and delivery of the replacement of the Regions 4/1 Bundle of bridges represents an opportunity for the State of Colorado to effectively improve mobility and safety outcomes along important state road corridors while concurrently ensuring that the economic vitality provided by these crucial rural routes is maintained.

Sincerely,

A handwritten signature in black ink, appearing to read "Jeff Baker". The signature is fluid and cursive, with the first name "Jeff" written in a larger, more prominent script than the last name "Baker".

Jeff Baker, Chair, Arapahoe County Board of County Commissioners

Cc: Bryan D. Weimer, Director, Public Works and Development
Brian R. Love, Acting Transportation Division Manager



BOARD OF COUNTY COMMISSIONERS

Trent Bushner
District 1

Robin Wiley
District 3

Dean Wingfield
District 2

Andrea Calhoun
Administrator

November 14th, 2018

The Honorable Elaine Chao
Secretary, U.S. Department of Transportation
1200 New Jersey Avenue, SE
Washington, D.C. 20590

RE: Colorado Department of Transportation FHWA Rural Bridge Replacement Grant Application – Eastern Plains
Timber Bridge Replacement Program – (Regions 4/1 Bundle).

Honorable Secretary Chao:

I am writing on behalf of Yuma County to express our support the Colorado Department of Transportation's (CDOT) application for the funding under the FHWA Rural Bridge Replacement Grant Program for their project, Regions 4/1 Bundle. The grant request is for partial funding for the replacement of 9 bridges on rural highways and service roads in Northeastern Colorado.

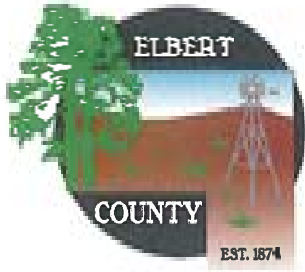
The State of Colorado is facing severe and growing transportation problems that threaten the safety, efficiency, and economy of Colorado. Within the context of stagnate or declining funding, the State's transportation infrastructure has seen usage and congestion grow significantly, reflective of both the increased population and economic boom the state has endured over the past decade. A substantial cohort of the state's bridges are operating past their design life and/or are in poor condition. In the case of the bridges proposed for replacement in CDOT's application, their deterioration has accelerated in recent years, leading to escalating maintenance costs and an increasing frequency of lane/bridge closures to carry out planned and unplanned repairs.

The majority of the bridges in this bundle are located along key east to west highways and interstates connecting Colorado with Kansas and Nebraska. These are key freight corridors for agricultural and resource products and they enable the commercial lifeblood of the region. Planned and unplanned closures of these bridges incur significant delays, causing detour distances over 100 miles in some cases. All of the bridges are past their useful design lives, and their continued deterioration could likely lead to the imposition of load limit restrictions, thereby hindering the mobility of commercial trucks and farm equipment. Road closures and delays along these corridors as a result of planned and unplanned maintenance on its bridges due to their deterioration have had an adverse impact on the efficacy of the intra- and interstate transportation network and will hinder the region's economic competitiveness if they are not replaced in the near term.

The implementation and delivery of the replacement of the Regions 4/1 Bundle of bridges represents an opportunity for the State of Colorado to effectively improve mobility and safety outcomes along important state road corridors while concurrently ensuring that the economic vitality provided by these crucial rural routes is maintained.

Sincerely,

Trent Bushner, Chairman



ELBERT COUNTY GOVERNMENT

Chris Richardson, Commissioner District 1
Danny Willcox, Commissioner District 2
Grant Thayer, Commissioner District 3
Office 303-621-2341 Fax 303-621-2343
PO Box 7, 215 Comanche St, Kiowa, CO, 80117

November 29th, 2018

The Honorable Elaine Chao
Secretary, U.S. Department of Transportation
1200 New Jersey Avenue, SE
Washington, D.C. 20590

RE: Colorado Department of Transportation FHWA Rural Bridge Replacement Grant Application – Eastern Plains Timber Bridge Replacement Program – (Regions 4/1 Bundle).

Honorable Secretary Chao:

I am writing on behalf of Elbert County, Colorado to express our support the Colorado Department of Transportation's (CDOT) application for the funding under the FHWA Rural Bridge Replacement Grant Program for their project, Regions 4/1 Bundle. The grant request is for partial funding for the replacement of 9 bridges on rural highways and service roads in Northeastern Colorado.

The State of Colorado is facing severe and growing transportation problems that threaten the safety, efficiency, and economy of Colorado. Within the context of stagnate or declining funding, the State's transportation infrastructure has seen usage and congestion grow significantly, reflective of both the increased population and economic boom the state has endured over the past decade. A substantial cohort of the state's bridges are operating past their design life and/or are in poor condition. In the case of the bridges proposed for replacement in CDOT's application, their deterioration has accelerated in recent years, leading to escalating maintenance costs and an increasing frequency of lane/bridge closures to carry out planned and unplanned repairs.

The majority of the bridges in this bundle are located along key east to west highways and interstates connecting Colorado with Kansas and Nebraska. These are key freight corridors for agricultural and resource products and they enable the commercial lifeblood of the region. Planned and unplanned closures of these bridges incur significant delays, causing detour distances over 100 miles in some cases. All of the bridges are past their useful design lives, and their continued deterioration could likely lead to the imposition of load limit restrictions, thereby hindering the mobility of commercial trucks and farm equipment. Road closures and delays along these corridors as a result of planned and unplanned maintenance on its bridges due to their deterioration have had an adverse impact on the efficacy of the intra- and interstate transportation network and will hinder the region's economic competitiveness if they are not replaced in the near term.

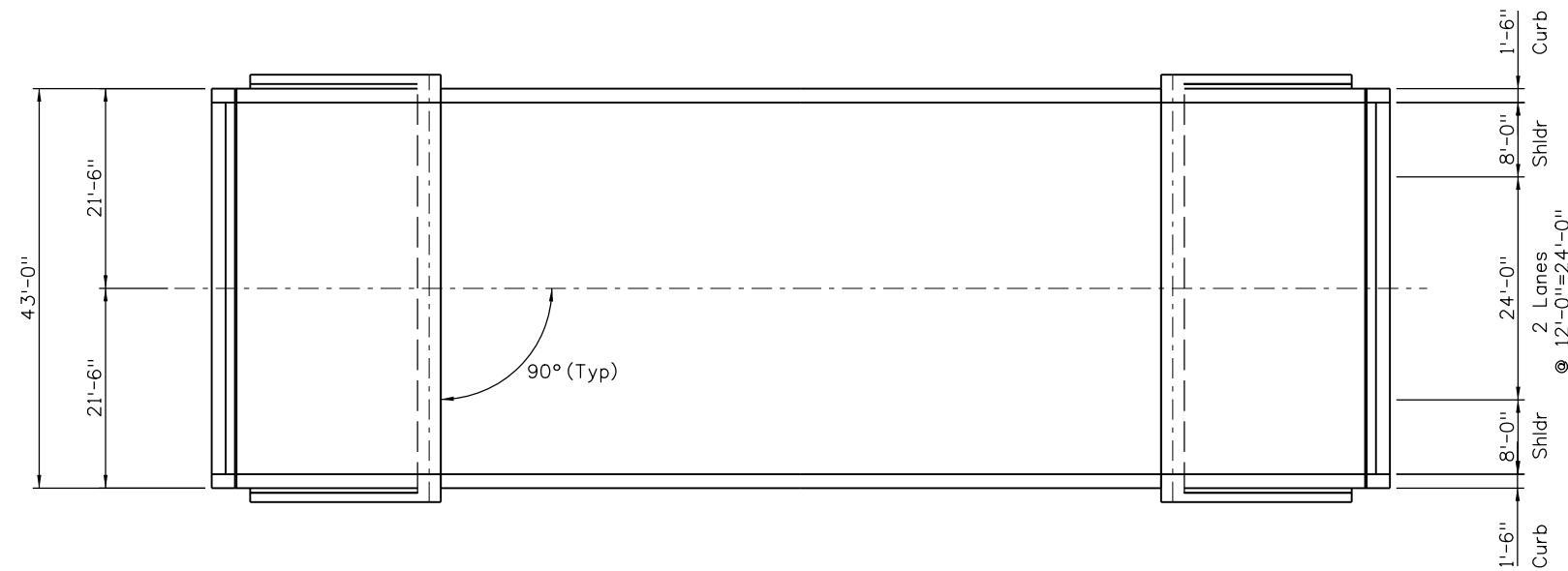
The implementation and delivery of the replacement of the Regions 4/1 Bundle of bridges represents an opportunity for the State of Colorado to effectively improve mobility and safety outcomes along important state road corridors while concurrently ensuring that the economic vitality provided by these crucial rural routes is maintained.

Sincerely,

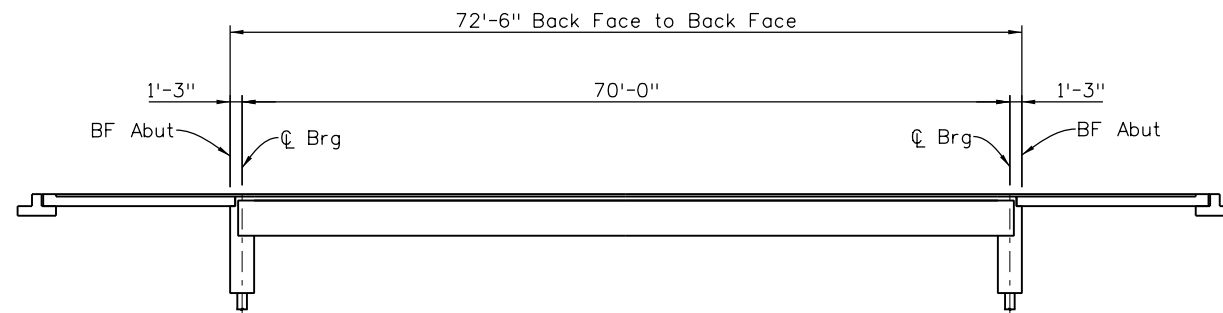
Morgan County Colorado Board of Commissioners sent their endorsement letter directly to Sec. Chao.
No copy was able to be obtained.

A yellow school bus is driving across a bridge with a metal guardrail. The bridge spans over a field of tall, dry grass. The sky is clear and blue. The bus is positioned in the middle ground, moving from left to right. The foreground is dominated by the tall grass, and the background shows the horizon under a clear sky.

Appendix D Design Examples



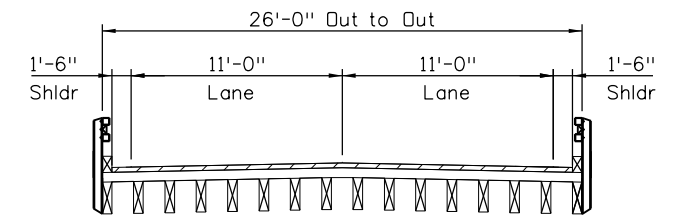
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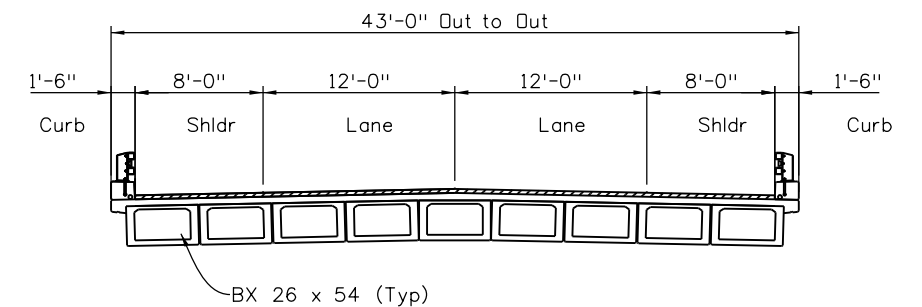
ELEVATION



PHOTO OF EXISTING TYPICAL SECTION



EXISTING TYPICAL SECTION



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 Checked By Checked By Checked By

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 Staff Bridge Branch AAH



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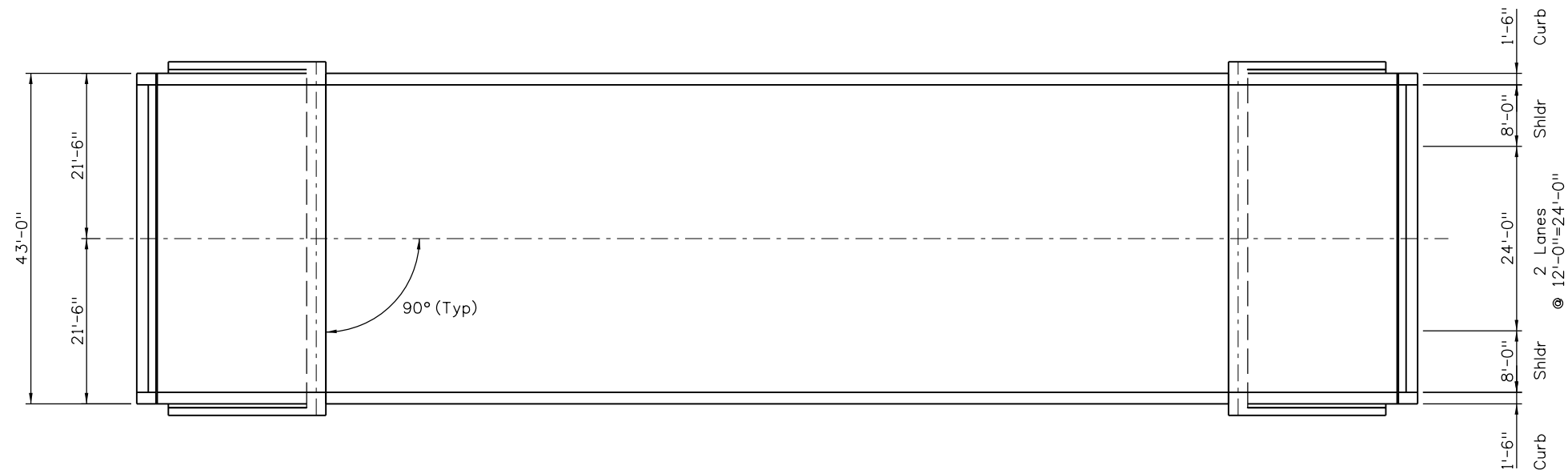
Colorado Department of Transportation
 2829 West Howard Place
 3rd Floor
 Denver, CO 80204
 Phone: 303-512-4078 FAX: 303-757-9197
Staff Bridge Branch **AAH**

As Constructed
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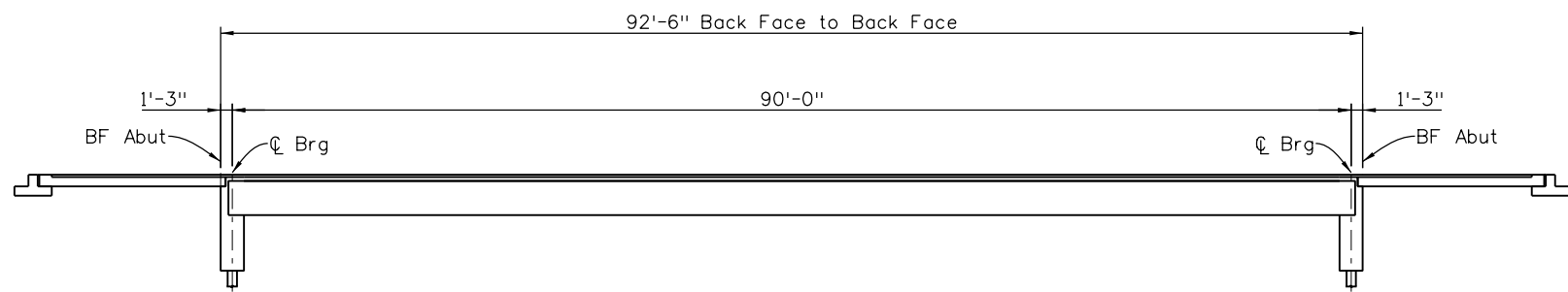
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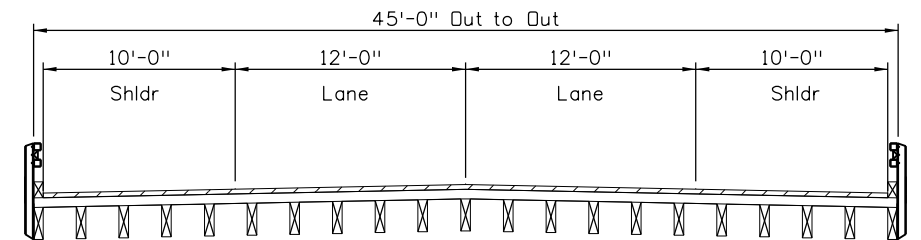
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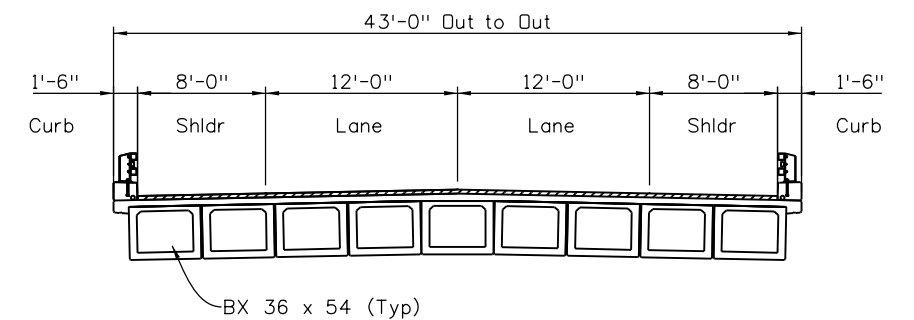
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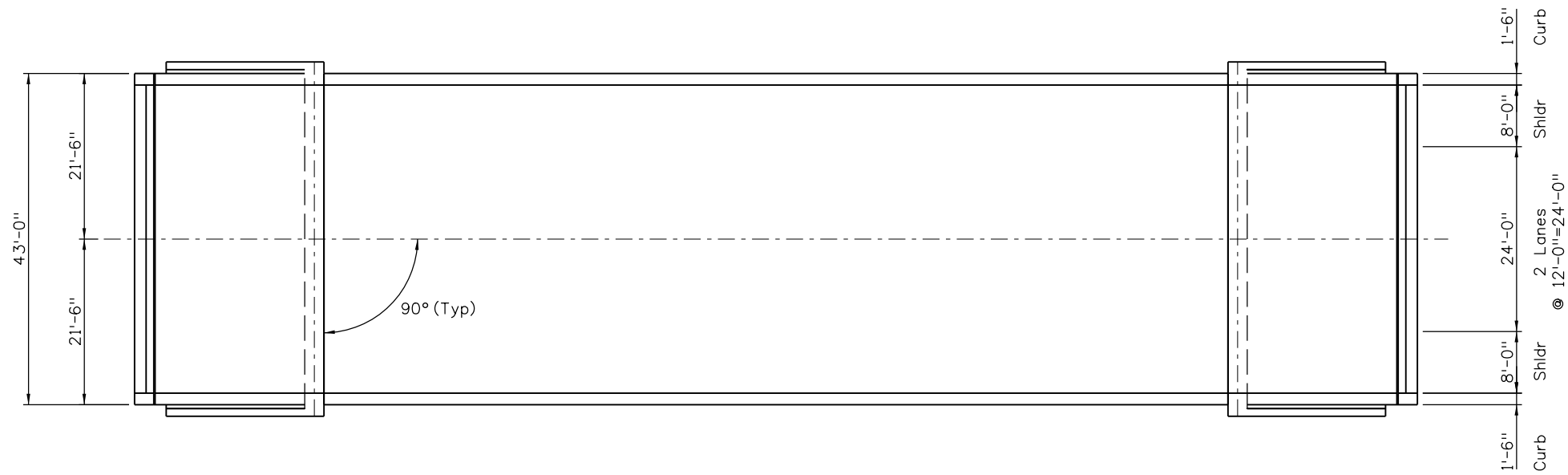
Colorado Department of Transportation
 2829 West Howard Place
 3rd Floor
 Denver, CO 80204
 Phone: 303-512-4078 FAX: 303-757-9197
Staff Bridge Branch AAH

As Constructed
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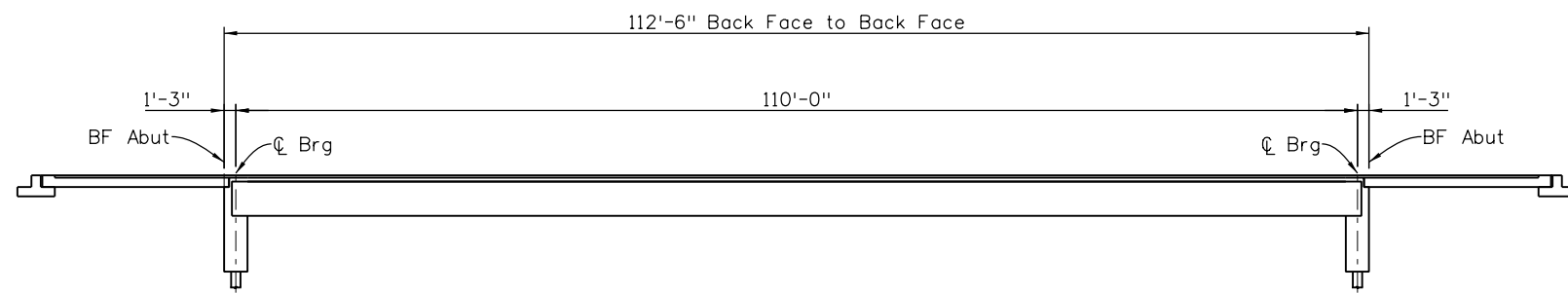
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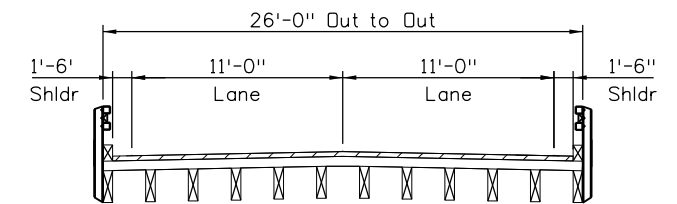
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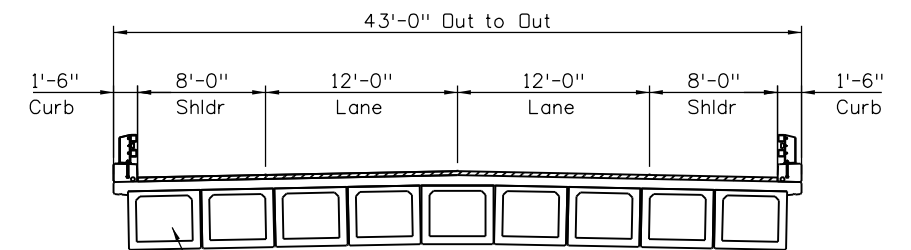
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 Staff Bridge Branch AAH



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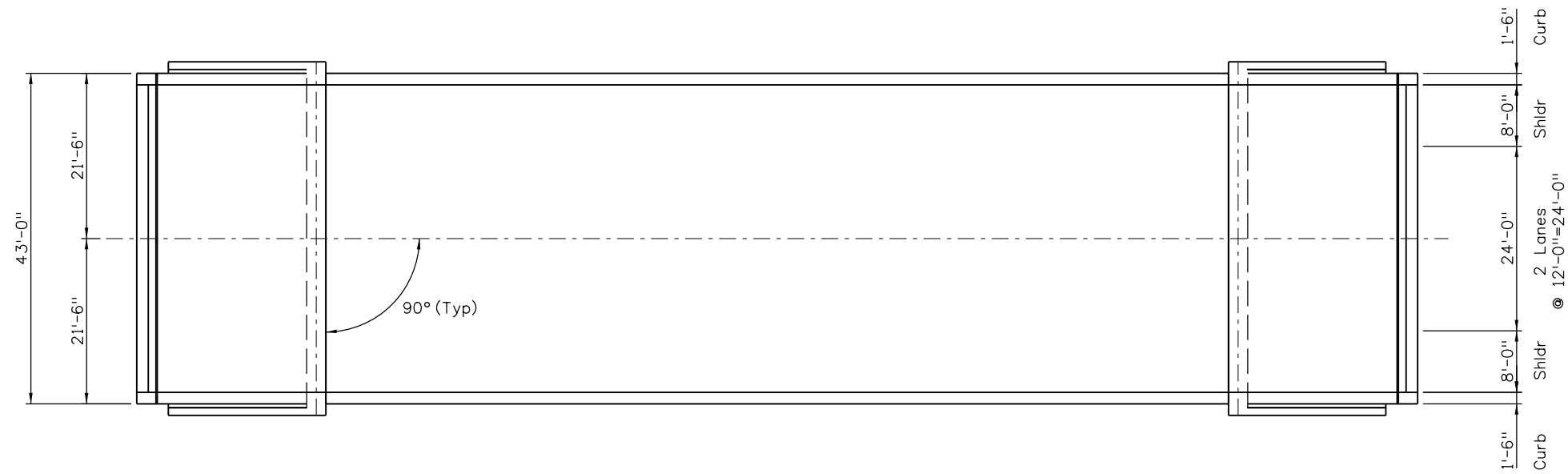
Colorado Department of Transportation
 2829 West Howard Place
 3rd Floor
 Denver, CO 80204
 Phone: 303-512-4078 FAX: 303-757-9197
Staff Bridge Branch **AAH**

As Constructed
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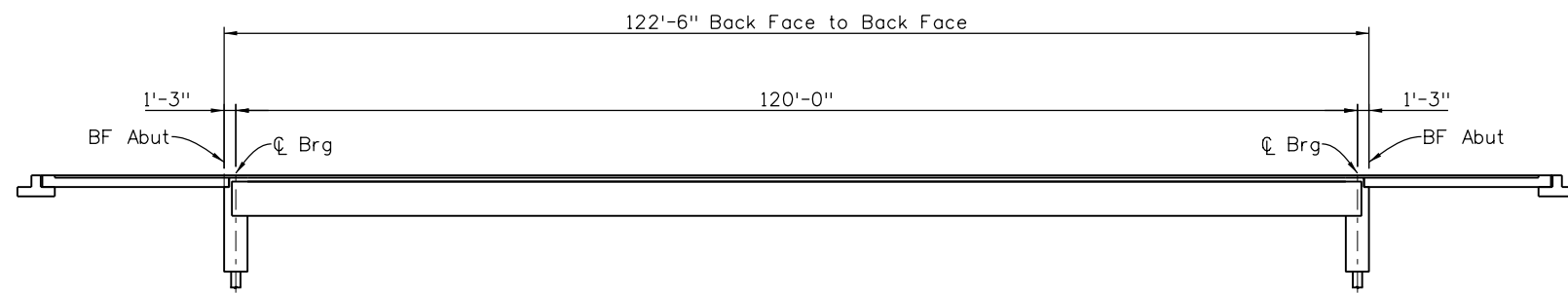
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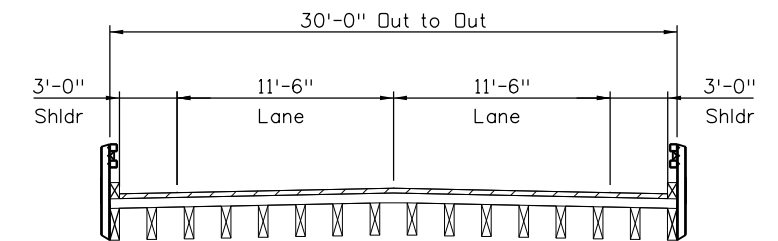
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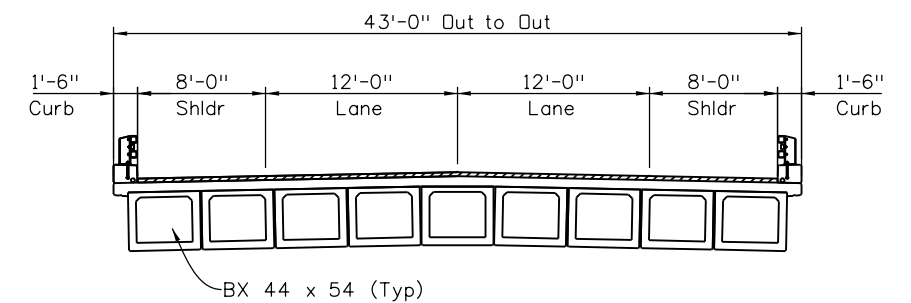
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 Staff Bridge Branch AAH



Sheet Revisions

Date:	Comments	Init.

Colorado Department of Transportation
 2829 West Howard Place
 3rd Floor
 Denver, CO 80204
 Phone: 303-512-4078 FAX: 303-757-9197
Staff Bridge Branch AAH

As Constructed

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Revised:

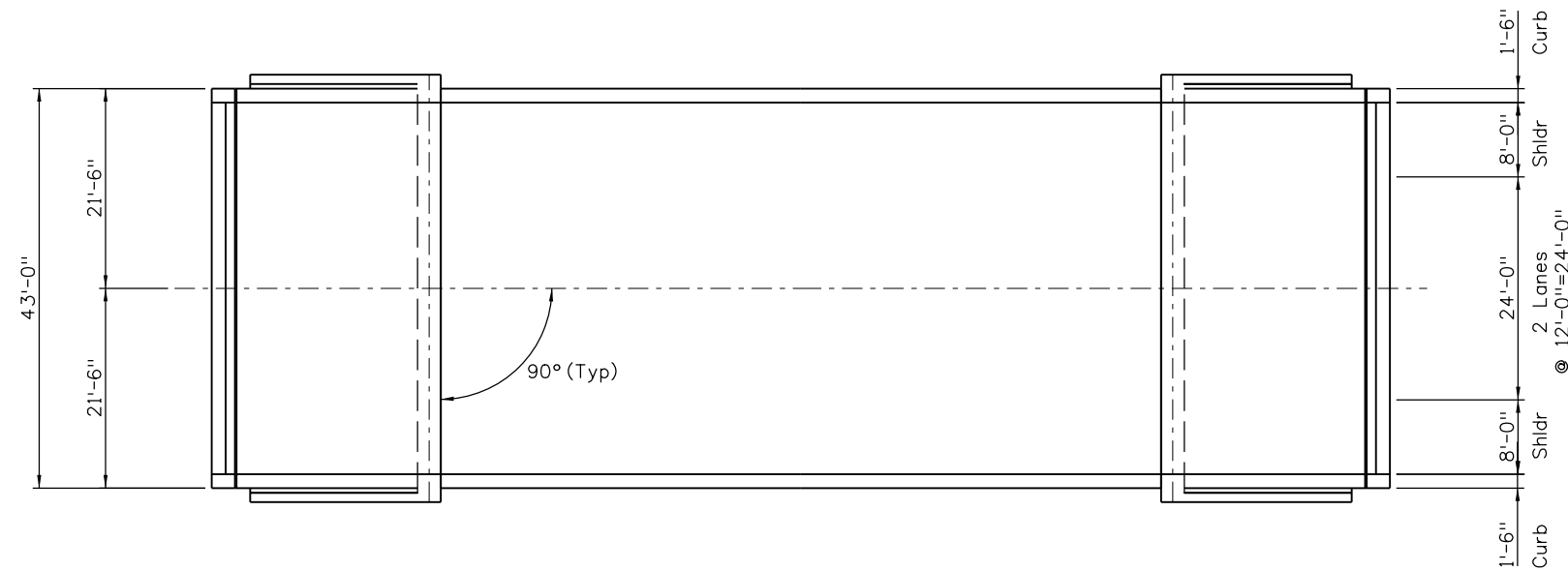
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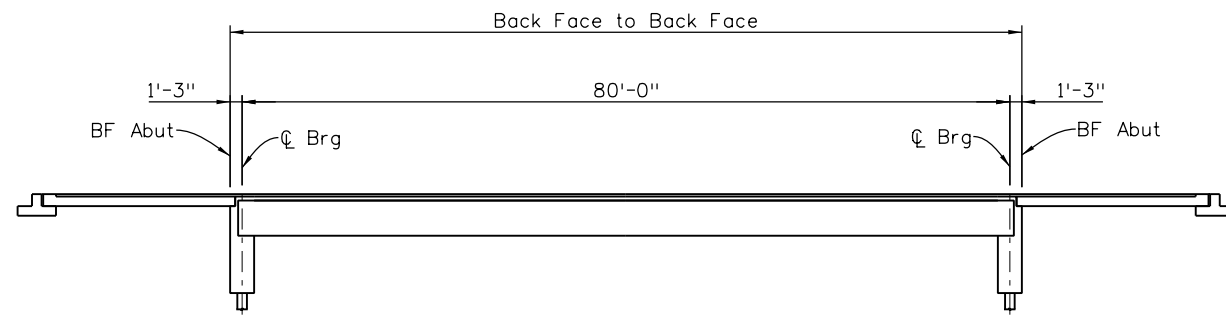
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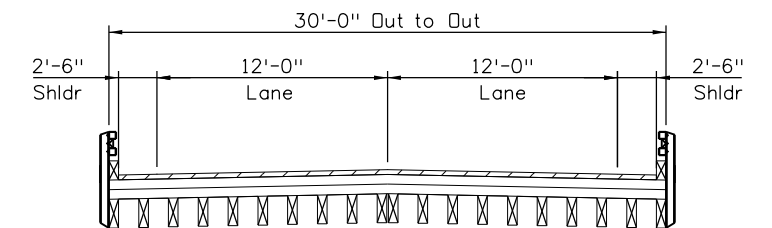
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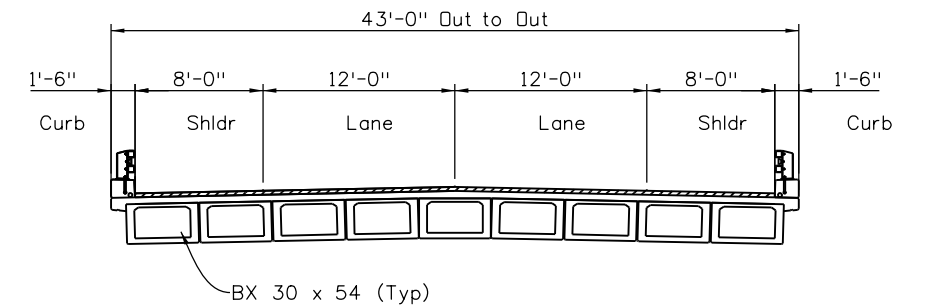
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Staff Bridge Branch AAH	

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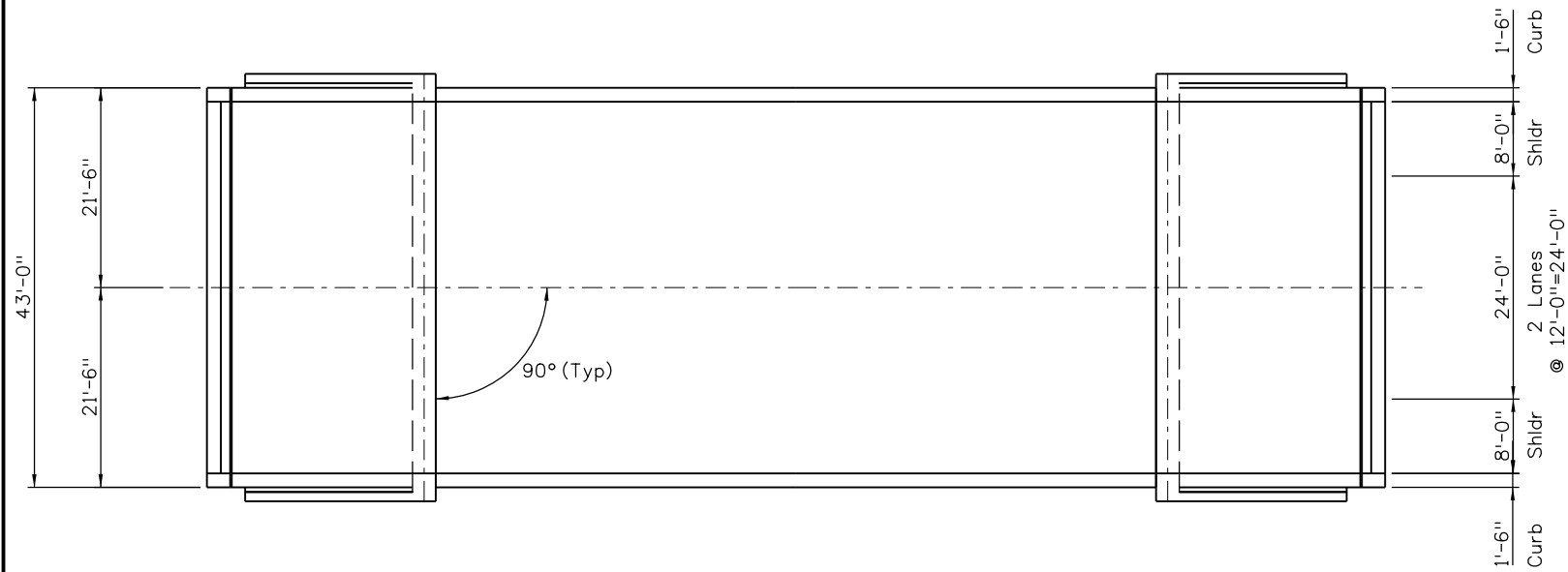
Colorado Department of Transportation
 2829 West Howard Place
 3rd Floor
 Denver, CO 80204
 Phone: 303-512-4078 FAX: 303-757-9197
Staff Bridge Branch **AAH**

As Constructed
No Revisions:
Revised:
Void:

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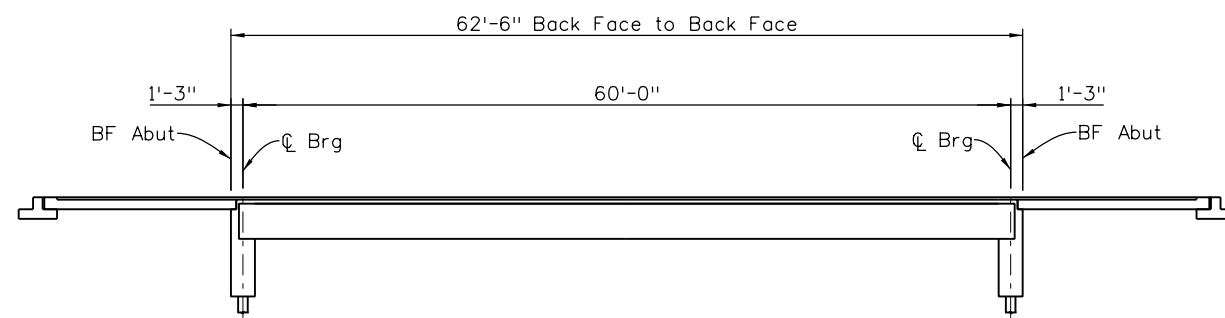
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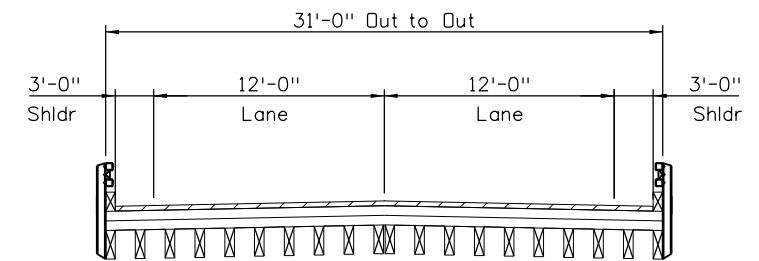
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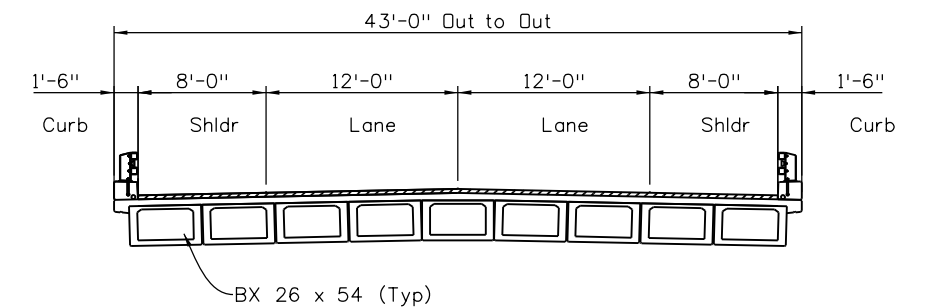


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PHOTO OF PROPOSED TYPICAL SECTION

Typical of all structures



PROPOSED TYPICAL SECTION

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 Staff Bridge Branch AAH

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
 2829 West Howard Place
 3rd Floor
 Denver, CO 80204
 Phone: 303-512-4078 FAX: 303-757-9197
Staff Bridge Branch **AAH**

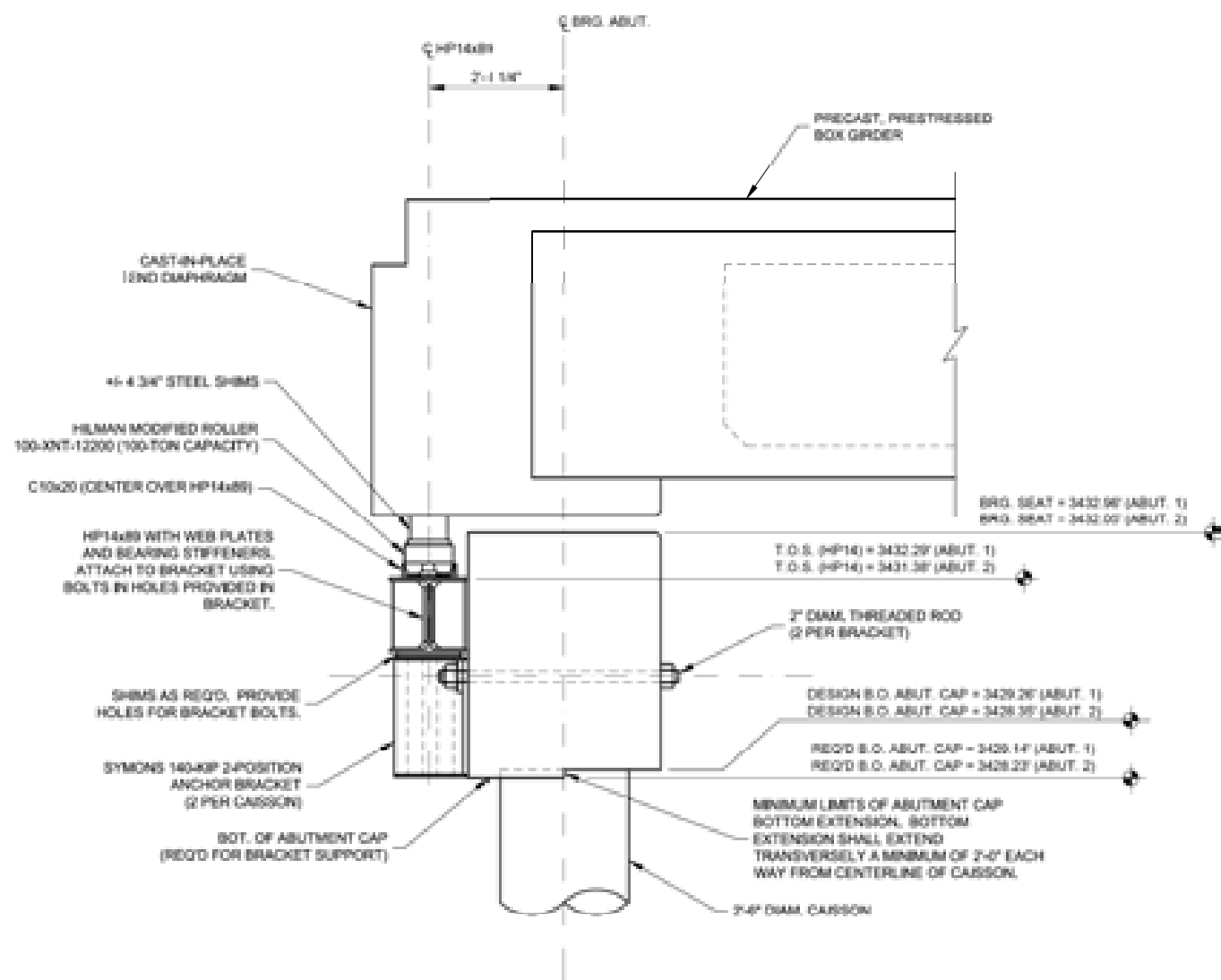
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Sheet Subset:	RBG	Subset Sheets:	2 of 7

Project No./Code
 Project Number
 Code
 Sheet Number

SLIDE-IN PHASE 3 PROCEDURE

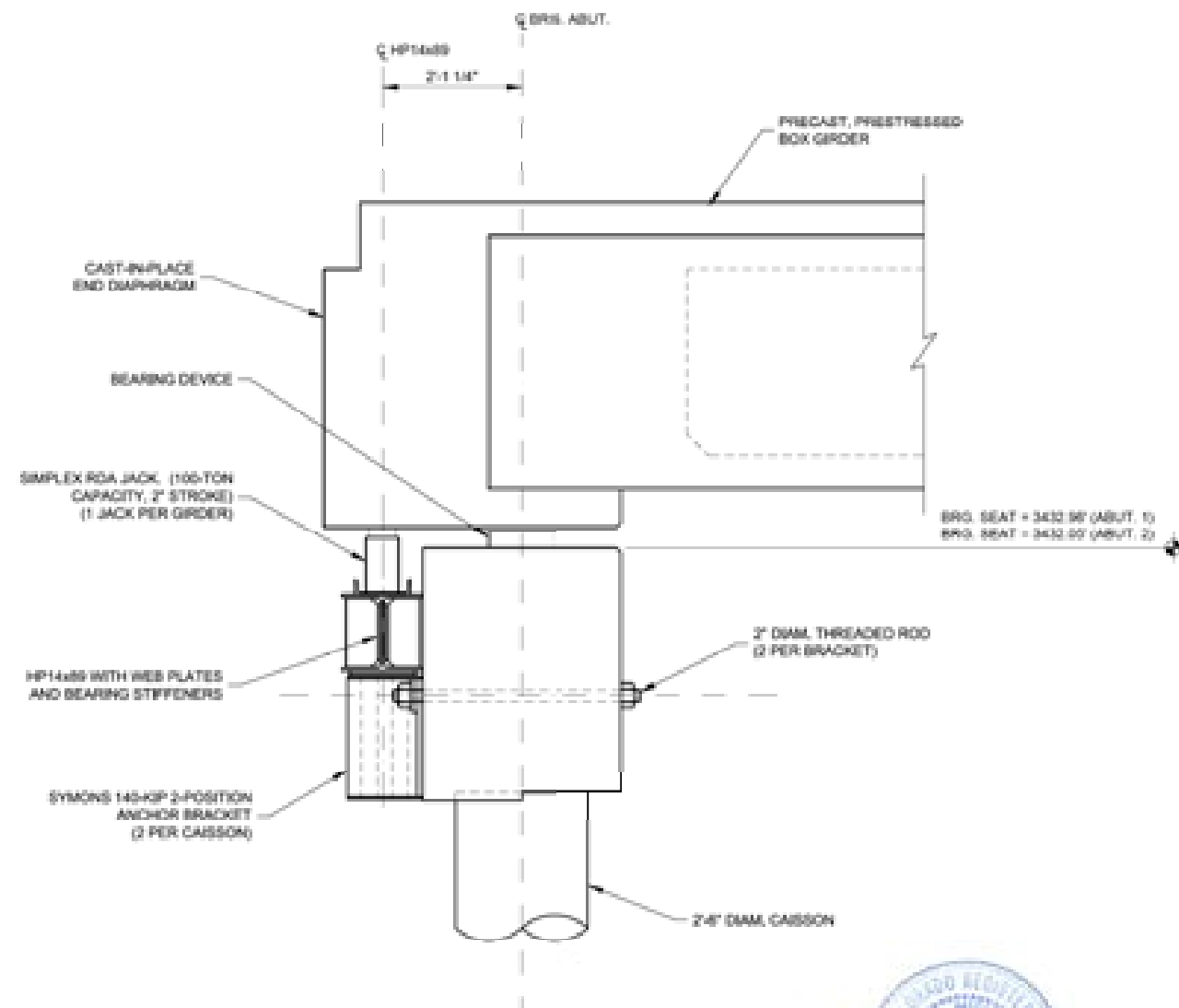
1. INSTALL ABUTMENT BRACKETS.
2. INSTALL HP14x89 BEAM.
3. INSTALL SHIMS ON C10x20 AS REQUIRED TO MATCH TOP FLANGES OF HP14x89 BEAMS.
4. INSTALL CHANNEL SPLICE PLATE.
5. INSTALL CHANNEL OVER SHIMS ON HP14x89 BEAM.
6. ROLL SUPERSTRUCTURE TO FINAL LOCATION.



**SLIDE-IN PHASE 3
ABUTMENT SECTION**

SLIDE-IN PHASE 4 PROCEDURE

1. RAISE JACKS TO 12" HEIGHT.
2. PLACE BEARING DEVICES PER SHEET B18.
3. REMOVE ROLLERS AND SHIMS.
4. LOWER JACKS AS REQUIRED TO SUPPORT SUPERSTRUCTURE OR BEARING DEVICES.
5. REMOVE JACKS, BEAM, AND BRACKETS.



**SLIDE-IN PHASE 4
ABUTMENT SECTION**

Professional Engineer
 J. Migliaccio
 8/15/12

Revision	DATE	INITIAL	DESCRIPTION
Design	DATE	INITIAL	DESCRIPTION

Print Date:	8/15/12
Drawing File Name:	US34 over Republican River
Horiz. Scale: As Indicated	Vert. Scale: As Indicated
Unit Information:	Unit Leader Initials

Sheet Revisions		
Date	Comments	Init.

Colorado Department of Transportation

120 North Riverside Road
 Sterling, CO 80751
 Phone: 970-522-0481
 Fax: 970-521-9739

Region 4

LBL

As Constructed
No Revisions:
Revised:
Void:

US34 BRIDGE OVER REPUBLICAN RIVER	
SUPERSTRUCTURE TEMPORARY SUPPORT DETAILS	
Designer: J. Migliaccio	Structure Numbers: D-28-U
Detailer: J. Migliaccio	
Subset: FALSEWORK	Subset Sheet: F03 of F04

ALTBI02
Project No./Code
FBR 0343-034
18432
Sheet Number

A yellow school bus is driving on a highway bridge. The bridge has a metal guardrail. Below the bridge is a field of tall grass. The sky is blue with some power lines.

Appendix E Project Schedule

