4. Bridge Type Evaluation

4.1 Evaluation Criteria

This section describes in detail each of the project evaluation criteria and presents results of the evaluation of each bridge option against these criteria. This evaluation is summarized in a selection matrix that gives each alternate a rating of between one (1) and five (5) based on how well each criterion is satisfied. A score of one (1) indicates that the criterion is not satisfied, while a score of five (5) is the highest possible rating for the criterion. An overall rating is then calculated for each option and a final comparison made to determine the bridge option that best satisfies all of the criteria and provides the best overall value to the project. This option is then the recommended structure for the new 4th St. Bridge, and with CDOT concurrence, will be advanced into the final design phase.

The project evaluation criteria are based on the structural and functional requirements of the bridge and are listed in Table 4.1 below. Also included in the table, is a weighting factor associated with each criterion. In the calculation of an overall rating for each option, each criterion is given a weighting factor based on its importance in the overall project. Criteria that represent more critical issues are more heavily weighted.

Table 4.1 Evaluation Criteria and Weighting Factors

Evaluation Criteria	**Weighting Factor**
Impact to the Arkansas River Floodwall	**5 %**
Impact to UPRR and BNSF Railroad Yards	**15 %**
Arkansas River Impacts	**5 %**
Bridge Aesthetics	**5 %**
Bridge Cost	**50 %**
Constructibility	**10 %**
Durability / Maintainability	**10 %**

4.2 Description of Criteria

This section describes in detail each of the evaluation criteria as they apply to construction of the new 4th St. Bridge and the specific constraints of the site and goals and critical issues of the Project. Ratings that are shown in the selection matrix are described for each of the criteria.

4.2.1 Impact to the Arkansas River Floodwall

This reach of the Arkansas River was re-channelized by the construction of the Arkansas River Floodwall following the devastating Pueblo flood of 1921. The floodwall is paved on its western slope adjacent to the river and is earthen embankment on its eastern slope adjacent to the Pueblo railroad yard. The floodwall is controlled by the Pueblo Conservancy District and is not suitable for vehicular or pedestrian traffic. As such, the Pueblo Conservancy District does not require a minimum vertical clearance over the wall.

Bridge option evaluation during Conceptual Design considered impacts to the floodwall based on pier placement in or near the wall. Floodwall concerns include access and maintaining wall integrity during and after construction. Those options without piers in this location were given the best rating since there were no associated floodwall impacts. Options with a pier located at the floodwall toe of slope were assigned a “good” rating since only minor impacts were anticipated. An unacceptable rating was given if the option resulted in a pier located completely in the wall.

All of the options studied in Preliminary Design feature a pier located at the toe of floodwall on the railroad yard side. Thus, all are expected to have only minor impacts to the wall both during construction and in the final configuration. Results of preliminary engineering indicate that drilled shafts and footings will be larger for the long span option as compared to the match existing and moderate span alternates; however, differences are not significant enough to warrant a different rating for each option. Therefore, for structure selection, each bridge option was assigned a rating of (4) for floodwall impacts.

4.2.2 Impact to the UPRR and BNSF Railroad Yards

The new bridge will cross 28 closely spaced railroad tracks in the Pueblo Yard, including two UPRR mainline tracks and one BNSF mainline track. The Pueblo Yard is very active and commonly utilizes all available track space. Existing track spacing and horizontal pier clearances are less than current design requirements. Inadequate horizontal clearance between the bridge piers and adjacent tracks is a major safety issue and the predominate reason for the functional obsolescence of the existing bridge. A new bridge would also be functionally obsolete if adequate clearances are not provided.

The affected railroads have no plans to remove, relocate, or add tracks since the yard is running at or above capacity and the site is landlocked by the Arkansas River and Midtown Center mall. Coordination with railroad personnel and activities will be critical to the success of the project. Railroad flagmen will be needed on site at all times while construction is occurring in the yard, and special railroad operations may be required depending on the span layout, structure type, and construction methods chosen.

Impacts to the railroad yard may be in the form of track delays or stoppages, track relocations or removals, crossing construction, railroad personnel requirements, temporary construction requirements, disruption and delay of normal railroad operations, and increased yard congestion during and after construction. Ground-based construction activities, such as pier and foundation construction, crane movements and positioning, girder delivery and placing, and material delivery can all be expected to impact railroad operations. In addition, construction access to the railroad yard is limited and existing yard roads far apart. The crossing of tracks to facilitate construction would create major impacts to yard operations and track schedules for the railroad system and region. As a minimum, the construction of track crossings (temporary and permanent) would be required.

Pier congestion in the yard is also a concern for the UPRR and BNSF. Not matching current pier locations or adding pier locations would increase yard congestion, further limiting railroad operations. Alternately, yard congestion would be reduced through the selection of a bridge solution that results in fewer piers in the yard compared to existing conditions. Fewer piers in the yard would provide the railroads with opportunities to expand their facilities, if desired, after removal of the existing substructure.

In the selection matrix, ratings are assigned based the level of impact to railroad operations anticipated for each bridge option both during construction and in the final configuration. The Match Existing Railroad Spans with Modified River Spans Layout has the greatest number of substructure piers and requires significant access, movement, and staging capabilities for cranes and other heavy equipment to facilitate girder placement and superstructure construction from the yard. Because substantial impacts to railroad operations are anticipated, both structure type options for this layout are given a rating of (2) in the selection matrix.

Three piers are required in the railroad yard with the Moderate Span Layout 2 option, two less than the existing bridge. Piers are also in more desirable locations such that railroad impacts are lessened. However, substantial impacts are anticipated due to significant access, movement, and staging capabilities for cranes and other heavy equipment to facilitate girder placement and superstructure construction from the yard. For these reasons, both structure type options for the Moderate Span Layout 2 option are given a rating of (3).

Long Span Layout 3 minimizes both construction and configuration impacts by reducing the number of piers in the railroad yard to two, locating these piers such that both the UPRR and BNSF yards are completely spanned, and providing a final configuration in which horizontal clearance requirements are satisfied without yard modification. Once the substructure and tables for these piers are built, construction in the yard is complete, and the superstructure can be placed entirely from above allowing railroad operations to continue with minimal disruption. For these reasons, the Long Span Layout 3 option is given a rating of (5) for railroad impacts.

4.2.3 Arkansas River Impacts

Phase 1 construction of the Arkansas River Corridor Legacy Project sponsored by the U.S. Army Corps of Engineers and the City of Pueblo is scheduled to commence in

August 2003. The Legacy Project seeks to improve the riverine environment, fish and wildlife habitat, and encourage recreational use of the Arkansas River from Pueblo Dam on the north to the confluence with Fountain Creek on the south. The 4th Street Bridge Project site is within these limits. Planned improvements include redefining the river channel, re-vegetating and modifying the riverbanks, creating a fish ladder at the West Plains Energy Diversion Structure, and creating boating and kayaking facilities near the bridge. A trailhead with parking lot exists on the western bluff to the south of the existing bridge, which the City is also planning on enhancing to improve river access in this area. Pier placement in or near the river channel may limit improvement possibilities, and also raises scour concerns for the river channel, undermining of the floodwall, and improvements planned under the Legacy Project.

Careful selection of bridge pier locations west of the floodwall will minimize project environmental and recreational impacts of the Arkansas River and surrounding area. Ratings in the selection table are based the number of piers and proposed pier locations in or near the river. Both structure types for the Match Existing Railroad Spans with Modified River Spans Layout received a rating of (3) since two piers are required west of the floodwall. One pier is located in the river channel and adjacent to the wall, and one between the river and existing trail at the toe of bluff. Both structure types for the Moderate Span 2 option received a rating of (4) since only one pier is required west of the wall. However, this pier is located along the western bank of the river limiting somewhat the planned improvements. Long Span Layout 3 requires one pier west of the floodwall and this pier is located between the river and the existing trail at the toe of bluff. This is the minimum number of piers possible in this region with the optimum location for planned improvements. Therefore the long span option received a rating of (5) for Arkansas River Impacts.

4.2.4 Bridge Aesthetics

Aesthetics are an important consideration for this project. The City of Pueblo sees the new bridge as a “gateway” from the western neighborhoods into historic downtown. Pueblo has undertaken a major redevelopment effort in and around the project site and would like the bridge to be a centerpiece for this development. The Arkansas River Legacy Project and nearby Historic Arkansas River Project (HARP) are examples of Pueblo’s commitment to redevelopment and urban design. Redevelopment of industrial and commercial areas near the bridge has also been stated as a future City goal. Both CDOT and the City of Pueblo have indicated that the new structure should be a “signature” bridge.

Structure type selection is the beginning step towards providing an aesthetic bridge structure. The cast-in-place twin single cell box girder shape for Long Span Layout 3 creates clean lines and an uncluttered appearance. Longer deck overhangs create shading tending to reduce the appearance of mass. Substructure elements can be minimized due to the narrow bottom soffits of the box girders, and through elimination of multiple column bents with massive pier caps. The dual variable depth girders with long wings create a sweeping and favorable appearance from below. The aesthetic benefits of this structure type are well documented in aesthetic theory and can be witnessed in many completed bridges. Figures 4.1 and 4.2 show two examples of this structure type illustrating the aesthetic benefits described above. For these reasons, Long Span Layout 3 with dual concrete box girders is given an aesthetic rating of (5).

Figure 4.1
17th St. Bridge
Ft. Lauderdale, Florida
Dual Concrete Box Girders (From Below)
Figg Bridge Engineers, Inc.

Figure 4.2
Wabasha Freedom Bridge
St. Paul, Minnesota
Dual Concrete Box Girders
Figg Bridge Engineers, Inc.

Precast concrete 'U' girder and steel box girder options received a rating of (4) since more girder lines are required as compared to the box girder bridge. While some improvement is made over I-shapes related to structural lines and appearance, multiple girder lines, multi-column bents, and large pier caps create a cluttered appearance. This is an important consideration in the public areas at each end of the bridge, and when viewing the structure as a whole from nearby vantage points.

Precast Bulb-T and steel plate girder options received an aesthetic rating of (3) since the "I' shape creates requires numerous girder lines, additional cross bracing (steel option), multiple column bents, and massive pier caps. All result in an unaesthetic and cluttered appearance, especially from below and from nearby viewing points.

4.2.5 Bridge Cost

4.2.5.1 Bridge Structure Costs

Bridge cost is an important project consideration since the selected solution must be feasible given the budget allocated to the project by CDOT. CDOT has indicated that the 4th St. Bridge Project is being funded with federal Bridge Replacement (BR) monies. Therefore funds are available for construction of a new bridge and appropriate approach tie-ins.

The Structure Concept Report (FIGG, 2001) presented comparison cost estimates for the construction of each bridge alternate and structure type considered. These costs were based on historical CDOT square footage cost data and engineering experience.

As part of engineering studies during this phase of the project, preliminary designs were completed for each of the bridge options being considered. Overall member sizes and approximate reinforcing and post-tensioning requirements were determined, and the viability of each option verified for preliminary design adjustments, including roadway geometry and bridge layout revisions. Preliminary design level quantities were then calculated for each bridge option studied.

Using historical data from CDOT and other sources, unit costs for each bridge quantity were determined. With preliminary quantities calculated and unit costs developed, an opinion of bridge structure cost was developed for each bridge option. These detailed quantity-based cost estimates are included in Appendix C.

4.2.5.2 Railroad Impact Costs

Before making a cost comparison of bridge options, railroad impact costs must be considered. The very active Pueblo railroad yard is the largest challenge to the new bridge crossing due to numerous closely spaced tracks, lack of adequate horizontal clearance, and the potential for significant disruption to railroad operations. Bridge construction costs will be greatly influenced by railroad impacts, which are governed by the structure type, final configuration, and method of construction chosen. To account for these costs when comparing alternates, a Railroad Impact Cost analysis was performed to determine an overall railroad impact cost for each bridge option. The analysis was divided into two distinct areas: railroad costs associated with bridge construction in the yard, and permanent yard modification costs incurred to provide required horizontal clearances in the final configuration. A description of each analysis is included below.

Railroad Impact Cost Data

In estimating railroad impact costs, it is necessary to obtain reliable and consistent cost data from multiple sources. Sources for the data used in the study include James L. Ozment & Associates (project railroad consultant), the BNSF and UPRR railroads, Railroad Specialties, Inc. (railroad contractor), and data from the I-25 Transportation Expansion Project (TREX) currently underway in Denver. A summary of the cost data gathered from these sources and used in the railroad impact cost study is included in Table 4.2.

Table 4.2 Railroad Cost Data

Railroad Impact	Cost
Flagger Costs	\$500 - \$700 / Day / Flagger Use \$1000 / Day for (2)
Crossings	
Improved Crossings	\$10,000 / Crossing (\$300 / Ft)
Temporary Crossings (Work Platform)	\$15,000 / Crossing (\$500 / Ft)
Permanent New Crossings	\$32,000 ea. (\$1000 / Ft)
Planned Track Shutdown	\$3000 / Day
Yard Track Replacement	\$200 / Ft (Functional Length Lost)
Yard Track Reroute	\$132 / Ft (700 Ft Min. Std.)
Mainline Reroute	\$200 / Ft (2000 Ft Min.)

Construction in the Yard Cost Study

A study of construction in the railroad yard was performed to determine a railroad impact cost for each bridge option based on bridge site access requirements through the railroad yard, access and equipment staging needs during erection, and length of time needed in the yard to complete construction. As part of this study, yard and construction access plans were developed, and a construction schedule determined for each bridge option.

Construction equipment movement to the bridge site will require adequate access through the railroad yard and over existing track crossings. Evaluation of the condition of existing track crossings led to the conclusion that improvements would be necessary prior to construction to ensure that damage does not occur while moving heavy equipment to and from the bridge site. Two yard access plans were considered, both resulting in approximately the same projected number of improved crossings and cost. These included access to the site from the 'B' Street yard entrance and access to the site from the Midtown Center mall parking lot. The 'B' Street entrance scenario was chosen as the more feasible.

For each bridge option, access and equipment staging needs on, over, and near tracks were determined. Transverse and longitudinal work platforms constructed as temporary crossings were sized and positioned to accommodate substructure construction and, for those options requiring cranes for girder erection, superstructure erection. Crane movements, necessary set-up zones, and operational clearances were considered. Girder delivery was assumed to be from the existing bridge. Costs were calculated for construction of the required work platform based on temporary crossing (work platform) length, and for track delay times associated with crane positioning and girder erection times. Girder erection would require the positioning of cranes on active rail tracks. In addition, the railroads will not permit train movement while girders are being placed.

Construction schedules developed for each bridge option were based on the parameters shown in Table 4.3.

Table 4.3 Construction Schedule Parameters

Bridge Element	Schedule
Foundations	1 Drilled Shaft / Week
	1 Footing / Week
Substructure	1 Rigid Frame Bent / Month
	1 Column / 2 Weeks
Superstructure	4 Girder Pieces Erected / Day
	140 Ft of Deck Cast / Week
	1 Pier Table / Month
	1 Pair of Segments / Week

Drawings and cost estimates for each bridge option for the railroad yard construction cost study are included in Appendix D. Study results are summarized below and in Table 4.4.

Flagger Costs

Railroad safety flagmen (flaggers) will be required at all times while construction is occurring in and over the railroad yard. Since the Pueblo Yard is a shared facility, it is likely that both a BNSF and UPRR flagger will be required. To account for these costs, railroad flagger days were computed for each bridge option based on the total anticipated construction time in the yard. Total construction time in and above the yard was based on anticipated construction schedules. For the Match Existing Railroad Spans with Modified River Spans Layout (ME/MR), a total of 256.5 days (BT's) and 249 days (U's) are anticipated. For Moderate Span 2, a total of 212 days (steel plates) and 204.5 days (Steel Boxes) are anticipated, and for Long Span 3, a total of 263 days are anticipated.

Railroad Crossing Costs

As stated above, improvement to existing track crossings is likely to allow access to the bridge site for heavy equipment. Using the 'B' Street entrance, access to the east yard road requires improvement of two (2) track crossings at the south end of the yard, and access to the west yard road requires improvement of four (4) track crossings. Therefore six (6) improved crossings are required for all bridge options. Additional improved crossings are required specific to each bridge option based on required movements from the east and west yard roads. Three (3) additional improved track crossings are required for the ME/MR option, one (1) for Moderate Span 2, and none for Long Span 3. These additional improved crossings are located on the yard road extension to the railroad parking facilities.

New temporary crossings are required for construction of a work platform to provide longitudinal and transverse construction equipment and crane access to all pier locations for girder erection. Crossing costs are based on 32-foot wide units measured along the track. Single unit crossings transverse to the tracks were also required for moving cranes to each girder pick location from the existing yard roads. Two units were required along the tracks at each girder pick location to facilitate longitudinal crane movements needed to place all girders in a given span. The amount of crossings (platform) required varies depending on the number and location of piers for a given bridge option. A total of 69 temporary crossing units are required for construction of the ME/MR option, 53 for Moderate Span 2, and 12 for Long Span 3.

Track Block Days

A Manitowoc 4100 crane was assumed for girder erection of the ME/MR and Moderate Span 2 options. A footprint of this crane was superimposed on a plan view of the site at substructure pier locations and at each required pick location. For each phase of construction, the crane footprint location is determined, and the number of resulting tracks blocked counted. The number blocked tracks are then multiplied by the number of days blocked for pier construction and girder erection, and the number of "Track Block Days" computed. Since pier construction requires smaller equipment, a reduced crane footprint is assumed, and fewer tracks are blocked. Additional days are added for girder erection time since all tracks in a given span will be blocked while the girder is being placed, per railroad requirements. The total number of computed "track block days" for the ME/MR option was 446.75, for Moderate Span 2, 291.5, and for Long Span 3, 108. Track block day costs for the Long Span 3 option are incurred only during substructure construction, since the superstructure is built entirely from above.

Table 4.4 Construction in the Railroad Yard Costs

Bridge Option	FLAGGER COSTS			R.R. CROSSING COSTS				TRACK BLOCK DAY COSTS				Total RR Construction Cost
				Temporary		Improved		Substructure		Superstructure		
	Quantity (Days)	Unit Cost (per Day)	Flagger Cost	No.	Cost	No.	Cost	TBD	Cost	TBD	Cost	
Match Existing with Modified River Spans												
Precast Spliced Bulb-T	256.5	$1,000	$256,500	69	$1,035,000	9	$90,000	308	$924,000	139	$416,250	**$2,721,750**
Precast Spliced U-Girder	249.0	$1,000	$249,000	69	$1,035,000	9	$90,000	308	$924,000	139	$416,250	**$2,714,250**
Moderate Span Layout 2												
Steel Plate Girder	212.0	$1,000	$212,000	53	$795,000	7	$70,000	176	$528,000	116	$346,500	**$1,951,500**
Steel Box Girder	204.5	$1,000	$204,500	53	$795,000	7	$70,000	176	$528,000	116	$346,500	**$1,944,000**
Long Span Layout 3												
CIP Concrete Box Girder	263	$1,000	$263,000	12	$180,000	6	$60,000	108	$324,000	0	$0	**$827,000**

TBD denotes Track Block Days, defined as the number of tracks blocked multiplied by days blocked.

Permanent Yard Modification Cost Study

Required horizontal safety clearances between piers and adjacent tracks are not satisfied for the ME / MR and Moderate Span Layout 2 bridge options given existing yard conditions. Therefore, these options require permanent modifications to the railroad yard such that these requirements are met in the final configuration. The affected railroads have indicated that modifications to the yard are not acceptable; however, this study assumes that the proposed modifications could be negotiated.

There are many ways that the railroad yard could be modified to achieve the necessary clearances. These were discussed with the project railroad consultant (Ozment & Assoc.) and other sources, and the most economical and feasible alternate selected for study and cost analysis purposes. The railroads have indicated that if tracks are moved, they must be replaced such that spacing to all adjacent tracks and facilities meets their current requirements and criteria. Since the existing yard tracks are closely spaced and the yard is land-locked, there is the potential for a significant "domino" affect resulting in the movement of many tracks away from the one in question to meet clearances. The project could then be responsible for re-building a large portion of the yard at a significant cost due to track shifts away from the tracks in question.

To avoid the "domino" affect in cases where space was not available for reroute, the track in question was cut 200-feet on each side of the pier and stubbed, provided that it was not continuous through the yard and did not feed additional tracks elsewhere. Storage capacity on the stubbed tracks is thus largely preserved; however, their functionality in yard switching operations reduced or eliminated. To account for this functional loss, costs computed represent reimbursement of the track over its functional length, at current track replacement costs. This allows the railroads to reconstruct the length of track as desired. This is common policy in construction projects involving railroad facilities. Where meeting the conditions for stubbing tracks was not possible, rerouting was provided to maintain all existing track operations. Spacing and clearance requirements for these tracks were achieved. If a track reroute affected an existing crossing, cost for a new permanent crossing was included.

Drawings and cost estimates for the permanent yard modification cost study for each bridge option are included in Appendix D. Study results are summarized below and in Table 4.5.

Clearances

The following clearances were used to determine necessary track modifications and rerouted track layout:

- Centerline Track to Face of Pier (w/ crash-walls) 18 ft
- Yard Track Center to Center Spacing 14 ft
- Mainline Center to Center Spacing 20 ft

Match Existing Railroad Spans with Modified River Spans

The Match Existing Railroad Spans with Modified River Spans layout results in many tracks not satisfying minimum railroad horizontal clearances. This is due to the existing yard conditions, pier locations, and current railroad clearance requirements. The following tracks are affected and would need modification:

- BNSF Crossover Track
- BNSF Fuel Track North
- BNSF Fuel Track South
- UPRR East Mainline
- UPRR West Mainline
- UPRR Yard Track 1
- UPRR Yard Track 2
- UPRR Yard Track 13
- UPRR Yard Track 14

BNSF Crossover & Fuel Tracks

The BNSF Crossover track encroaches on clearance with Pier 7. To meet horizontal clearance requirements at this pier, a 25-foot lateral shift of this track to the northeast would be necessary. Since this is a large shift, 1000 ft of track was assumed. The standard 700-foot length for yard track reroutes is based on the minimum length required to shift a track 8’ to 10’ and accommodate two track ‘S’ curves. Larger lateral shifts such as this require additional tangent track between the curves.

As a result of the Crossover track reroute, the two (2) BNSF Fuel Tracks would also require a shift to the northeast such that the minimum 14-foot track-to-track spacing is maintained. The standard 700-foot reroute applies to the South BNSF Fuel Track, but due to existing and reconfigured yard geometry, the North BNSF Fuel Track reroute length was reduced to 400 ft. Since shifting these tracks affects existing crossings, two (2) new permanent crossings would be required where the yard road is now crossed. It is also probable that the yard road would require modification, however, costs for this were not included in the study.

UPRR East and West Mainlines

The location of Pier 6 requires the rerouting of the UPRR East Mainline in order to meet minimum horizontal clearances. This, in turn, causes the UPRR West Mainline to be rerouted in order to provide 20-foot center-to-center spacing between these mainline tracks, as requested by the railroad. The rerouting of both tracks would be preferable over the stubbing and lost functionality of the East Mainline track, which is not feasible given that it is continuous through the yard, and critical to the performance of the overall railroad system.

UPRR Yard Tracks 1 and 2

While space is not available to reroute UPRR Yard Track 1 without causing the relocation of many adjacent tracks (“domino” affect), stubbing the track either side of

Pier 6 would involve the loss of functionality of UPRR Yard tracks 1A, 1B, & 1C since they branch off of UPRR Yard Track 1. A more cost-effective modification would involve stubbing UPRR Yard Track 1 on either side of Pier 6 and providing a bypass around the pier by switching this track onto UPRR Yard Track 2. Horizontal clearances at the pier are then satisfied, however, the current functionality of UPRR Yard Track 2 would be permanently reduced. Therefore, replacement of UPRR Yard Track 2 over its full locked-in length was included in the modification cost analysis.

UPRR Yard Tracks 13 & 14

Yard tracks 13 and 14 do not meet minimum horizontal clearance requirements to Pier 5. These tracks are locked-in yard tracks, ending at track diagonals bounding the yard, and do not feed other tracks elsewhere. Rerouting the tracks was deemed infeasible due to the potential "domino" affect, so for cost purposes, these tracks were ended and stubbed 200 ft either side of the pier. The cost analysis of these two tracks provides for track replacement reimbursement to the Union Pacific Railroad.

Moderate Span Layout 2

Union Pacific Railroad Yard Tracks 13 and 14 do not meet minimum horizontal clearance requirements to Pier 4 in the Moderate Span Layout 2 option. As stated for the previous bridge option, these tracks are locked-in yard tracks, ending at track diagonals bounding the yard, and do not feed other tracks elsewhere. Rerouting the tracks was deemed infeasible due to the potential "domino" affect, so for cost purposes, these tracks were ended and stubbed 200 ft either side of the pier. The cost analysis of these two tracks provides for track replacement reimbursement to the Union Pacific Railroad. No other modifications were necessary since the final configuration provides required clearances elsewhere.

Long Span Layout 3

Since Long Span Layout 3 results in a final configuration where all clearances are satisfied given existing yard conditions, there are no permanent rail yard modifications required, and subsequently, there are no yard modification costs associated with these options.

Table 4.5 Permanent Yard Modification Cost

Bridge Option	Yard Modification Costs			Total Cost
	Replace	Re-Route	Crossings	
Match Exiting / Modified River Spans Layout	$ 2.09 M	$ 1.17 M	$ 0.06 M	**$ 3.32 M**
Moderate Span Layout 2	$ 1.37	$ 0 M	$ 0 M	**$ 1.37 M**
Long Span Layout 3	$ 0 M	$ 0 M	$ 0 M	**$ 0 M**

Summary of Bridge Cost

Table 4.6 summarizes the structure and railroad cost studies performed for each of the bridge options, and provides a total opinion of cost for the bridge structures for comparison purposes. The total bridge cost is the summation of the structure cost based on quantity-based estimates, the railroad impact cost during construction, and the permanent yard modification costs.

Table 4.6 Summary of Bridge Cost

Bridge Option	Structure Type	Structure Cost	Railroad Impact Cost		Total Bridge Cost
			Construct.	Mod.	
Match Existing w/ Modified River Spans	Precast PT Spliced Bulb-T	$ 9.8 M	$ 2.7 M	$ 3.3 M	**$15.8 M**
	Precast PT Spliced U Girders	$ 10.6 M	$ 2.7 M	$ 3.3 M	**$ 16.6 M**
Moderate Span 2	Steel Plate Girder	$ 13.2 M	$ 1.9 M	$ 1.4 M	**$ 16.5 M**
	Steel Box Girder	$ 14.9 M	$ 1.9 M	$ 1.4 M	**$ 18.2 M**
Long Span 3	CIP Box w/ Form Travelers	$ 13.8 M	$ 0.8 M	$ 0 M	**$ 14.6 M**

The total bridge cost results in Table 4.6 show that the Long Span 3 option is the least expensive solution considering structure cost and railroad impact cost.

It is important to note that bridge replacement (BR) monies are allocated for the construction of the new bridge and approach tie-ins. Therefore, spending a large portion of the allocated funds on mitigation of railroad impacts does not seem prudent. Not only is Long Span 3 the least cost alternate, but it also requires the minimum possible expenditure on railroad impacts.

In the selection matrix, a rating of (5) is assigned to the least cost alternate, Long Span Layout 3. Ratings for the other bridge options are calculated by normalizing to the least cost option. A cost index is determined by dividing the cost of the option being considered by the cost of the least cost option. The least cost rating (5) is then divided by the cost index to determine a rating for the option being considered. Normalization results and final cost ratings are shown in Table 4.7.

Table 4.7 Bridge Cost Indices and Ratings

Bridge Option	Structure Type	Total Bridge Cost	Index	Rating
Match Existing w/ Modified River Spans	Precast PT Spliced Bulb-T	$15.8 M	1.08	**4.62**
	Precast PT Spliced U Girders	$ 16.6 M	1.14	**4.40**
Moderate Span 2	Steel Plate Girder	$ 16.5 M	1.13	**4.42**
	Steel Box Girder	$ 18.2 M	1.25	**4.01**
Long Span 3	CIP Box w/ Form Travelers	$ 14.6 M	1.0	**5**

4.2.6 Constructibility

Constructibility is an important consideration when evaluating different bridge options as it relates to the method of construction and access complexity of the site. Construction utilizing precast concrete or steel girders requires large cranes and is best suited where space below the structure is available to facilitate equipment movement, set-up, and girder erection. For the 4th St. Bridge Project, the Arkansas River, floodwall, and railroad yards make access of heavy equipment suitable for girder erection difficult. Therefore, the Match Existing Railroad Spans with Modified River Spans and Moderate Span 2 layouts, which feature precast concrete and steel girder structure types, are given a lower rating in the selection matrix. Due to the difference in number of operations required, the Match Existing Railroad Spans with Modified River Spans option received a rating of (3), while the Moderate Span Layout 2 option received a rating of (4).

Construction of cast-in-place concrete box girders from above using form travelers for the Long Span 3 option is much more constructible as it is less intrusive to the railroad yard and Arkansas River region below the bridge. Concrete is cast-in-place, and other construction materials such as forms and reinforcing are lighter and more manageable.

The need for delivery and placement of large, heavy elements intrusive to the space below is eliminated. Concrete pump trucks positioned on the existing bridge or other remote area can deliver material to the pour without disruption to railroad operations. An integral post-tensioned deck eliminates the several construction steps associated with deck placement and required with girder bridges. By progressing in balanced cantilever from pier locations, completed portions provide the work platform for subsequent operations. It is anticipated that the east and west end spans would be cast on falsework since this method of construction is available at these locations and can progress simultaneously with the form traveler operations, minimizing construction time. When all spans are closed, the full cross section is complete and only wearing surface, sidewalk, and barrier construction remains. For these reasons, Long Span Layout 3, which features a cast-in-place concrete box girder built from above, received a rating of (5) for constructibility.

4.2.7 Durability / Maintainability

Pre-stressed concrete bridges have been documented to have superior durability and require less maintenance than steel bridges. Bridge options that utilize girders and a mildly reinforced concrete deck are less durable than those that feature an integral deck pre-stressed in two directions. Mildly reinforced decks are prone to the development of cracks, allowing chloride penetration leading to reinforcing corrosion and deterioration of the deck and supporting concrete and steel elements. Deck life is substantially reduced and replacement required. Structure continuity affects bridge durability by reducing the number of expansion joints, typically high maintenance items. Failed, leaking joints are a major factor in substructure deterioration of bridges.

Long Span Layout 3 is a completely concrete structure, and includes an integrally cast deck pre-stressed both longitudinally and transversely, resulting in a higher strength lower permeability bridge. In addition, the number of expansion joints has been kept to a minimum through structure continuity and the location of joints at each abutment only. Another element prone to deterioration and maintenance are bridge bearings common to girder structures. These may be of steel, neoprene, or a combination of the two. To eliminate durability issues and maintenance requirements surrounding these elements, an integral connection between the superstructure and substructure is preferable, eliminating all bearings, except at the abutments. As a result of these benefits, structure life is extended, and maintenance over the life of the structure is expected to be relatively minimal. For the above reasons, this bridge option was given the highest durability and maintainability rating of (5).

While precast, pre-tensioned concrete girders have a good record of durability, they include a mildly reinforced concrete deck placed as a secondary pour and vulnerable to deterioration. With deck deterioration comes cracking, moisture and chloride intrusion, reinforcing corrosion, and deterioration of the supporting girders. Bearing and substructure deterioration is a direct result of poor superstructure condition. Girder continuity is possible where there is no change in cross section through the use of integral diaphragms, placed as a secondary pour. For the above reasons, the Match Existing Railroad Spans with Modified River Spans option was given a rating of (4).

Moderate Span Layout 2 utilizes steel plate girders or steel box girders. These options were given a rating of (3) for durability and maintainability since they too include a mildly reinforced concrete deck prone to cracking, moisture and chloride intrusion, and deterioration, and also feature steel girders prone to corrosion and a higher level of maintenance. Girder continuity is achieved through field splicing such that joints are required at the abutments only; however, girders must be painted and a scheduled maintenance program strictly followed to prevent the onset and subsequent rapid progression of corrosion of these elements. Weathering steel can mitigate some corrosion and maintenance issues, but not completely eliminate deterioration of the superstructure, bearings, and substructure. Weathering steel also creates aesthetic issue as it is rust colored and tends to bleed onto substructure elements and the space beneath the bridge.

4.3 Summary of Evaluation

Ratings for each of the bridge options and each of the evaluation criteria discussed above are summarized in the Structure Selection Matrix presented in the next section. The bridge option that has the overall highest rating is the preferred alternate and recommended structure for final design.