MCCracken & Livingston Bridge
US 60 Over Tennessee River
MCCracken & Livingston Counties, KY
Item Number 01-1115.00

Final Report
Study Date:
May 8 - 12, 2006

Value Engineering Study
Prepared by URS Corporation
for Kentucky Transportation Cabinet
MCCracken & Livingston BRIDGE,  
US 60 OVER TENNESSEE RIVER

McCracken & Livingston Counties, Kentucky  
Item Number 01-1115.00

VALUE ENGINEERING STUDY  
for the  
Kentucky Transportation Cabinet

Study Date: May 8-12, 2006

Final Report  
June 16, 2006

URS Corporation
EXECUTIVE SUMMARY

General
URS conducted a Value Engineering Study on McMcracken-Livingston Bridge project, Highway US 60 over Tennessee River located in McMcracken and Livingston counties, Kentucky. The topic of the VE study was the proposed superstructure of the bridge, which consists of three spans of a truss, measuring 400 ft, 900 ft, and 500 ft for a total length for the entire bridge of 1800 ft. A construction contract for the four substructure piers, including one in the river has been awarded in the amount of approximately $28 million. Plans for the approach road and bridge are under development.

The VE team undertook the task using the value engineering work plan and approach. The work plan depends on what is commonly referred to as a “bottom up” approach. With this approach, the VE Team subdivided the project into its component parts, examined the functions, purpose, and requirements of each part, and then identified alternate approaches to accomplishing the identified functions. The ideas generated from this process and selected for full development as VE Team Recommendations are presented in Section 3 of this report. These recommendations are presented to all project stakeholders for judgment as to whether they should be implemented or not.

Estimate of Construction Costs and Budget
A construction cost estimate for the superstructure was not provided to the VE team. At the entrance briefing, it was stated by KYTC that the estimated cost of the superstructure including decking but excluding approaches was approximately $44 million. A future discussion of project cost is included in the project description section of this report. The total cost of the bridge as designed, including the substructure contract, is estimated at $72.2 million.

Discussion
The VE team was told at the entrance briefing that the KYTC was not satisfied with the current superstructure design. The design is similar to a bridge built several years ago by KYTC and neither KYTC nor the public using the bridge are happy with the structure. It is a massive truss bridge with large members use for cross bracing. The deck is 90 some feet wide with only an 18-foot vertical clearance for a structure that is over 60 feet high. This produces an affect of entering a tunnel when approaching the bridge. Usually a VE team is given a design and a cost estimate and tasked to come up with recommended changes to that design that will maintain all of the necessary functions at a reduced life cycle cost. The team did generate several ideas to improve upon the existing design. However, the majority of this report is recommendations to entirely change the design of the bridge. A significant restriction is the fact that a contract has been awarded for the substructure. Several of the suggested alternatives would include major changes to that contract. If any of those alternatives are preferred by KYTC, expeditious action will be needed to minimize cost impacts.

Recommendations & Design Alternatives
During the speculation phase of this VE study, 39 creative ideas were identified. Two of these ideas, which are changes to the existing truss bridge and procurement methods, were developed into VE recommendations. In addition, ten ideas were developed into design comments. Due to the timing of this study, the level of design, and other factors, these ideas did not fit into the same
Neither of the recommendations to the exist bridge design will change the design to the extent that the “tunnel” effect upon approaching the bridge would be eliminated. At the entrance briefing, the structural engineer responsible for the current design stated that the amount of cross bracing could be reduced by using moment connection thereby opening up the entrance appearance. The VE team, as presented in the alternatives, believes that to significantly improve the appearance of the bridge, an entire redesign is necessary. This could be expeditiously accomplished by design-build procurement. This design comment is included in the report.

Compared to other VE studies, there is a rather limited number of recommendations and design comments for this size of project. This is because the alternative superstructure designs are the real significant components of this study and report. The alternatives present entirely different superstructure designs compared to the truss design as originally proposed. These alternatives present numerous other bridge types with an array of costs. As the Alternatives are mutually exclusive of each other, only one of these Alternatives can be chosen. Given that the factors for the selecting a preferred alternative are out of the scope of this study, the VE team did not attempt to choose one of these alternatives over the other. However, if cost is the only consideration, the choices are limited. If the appearance of the bridge is paramount, several alternatives remain available.

The following tables present a summary of the ideas developed into recommendations, design comments, and superstructure design alternatives.
<table>
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<tr>
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<th>Recommendation Title / Description</th>
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<td>Paint only the steel above the deck on the original bridge or revised bridge in lieu of painting all of the steel</td>
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<td>2</td>
<td>Decrease the total amount of steel used in the truss by economizing the design and decreasing the member sizes</td>
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<table>
<thead>
<tr>
<th>DC#</th>
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<tbody>
<tr>
<td>1</td>
<td>Use tube rail in lieu of jersey barriers for sides and center medians</td>
</tr>
<tr>
<td>2</td>
<td>Utilize an alternative barrier design with a rail on top of a concrete barrier to provide better aesthetics and a better scenic view</td>
</tr>
<tr>
<td>3</td>
<td>Increase the 5’ width bike lane to a more user-friendly width</td>
</tr>
<tr>
<td>4</td>
<td>Add aesthetic lighting on the bridge structure</td>
</tr>
<tr>
<td>5</td>
<td>Add a theme lighting plan on the approaches of the structure</td>
</tr>
<tr>
<td>6</td>
<td>Use colored concrete for the bridge deck construction</td>
</tr>
<tr>
<td>7</td>
<td>Have public involvement meetings to select paint color, an aesthetic lighting plan, and provide public with correct and updated information</td>
</tr>
<tr>
<td>8</td>
<td>Decorate and enhance the portal appearance to minimize the tunnel effect of the proposed design</td>
</tr>
<tr>
<td>9</td>
<td>Design at least one more superstructure and send multiple designs out for bidding</td>
</tr>
<tr>
<td>10</td>
<td>Make the superstructure a design/build project in lieu of a design/bid/build project</td>
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Acknowledgements
The team appreciates the input and able assistance of all of the staff members of the Kentucky Transportation Cabinet and the Federal Highway Administration who participated in the study. Without their participation, this successful value engineering study would not have been possible.

A very special thanks is extended to Tim Choate, and Dexter Newman of the KYTC and John Bargo of the FHWA for their dedication and technical input.

Value Engineering Study – Core Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Discipline/Role</th>
<th>Organization</th>
<th>Telephone</th>
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</thead>
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<tr>
<td>Ken True</td>
<td>Team Leader</td>
<td>URS</td>
<td>402-516-2635</td>
</tr>
<tr>
<td>Dave Jeakle</td>
<td>Bridge Design</td>
<td>URS</td>
<td>813-636-2467</td>
</tr>
<tr>
<td>John Bargo</td>
<td>Bridge Design</td>
<td>FHWA</td>
<td>502-223-6763</td>
</tr>
<tr>
<td>Dexter Newman</td>
<td>Team Member</td>
<td>KYTC</td>
<td>502-564-4555</td>
</tr>
<tr>
<td>Tim Choate</td>
<td>Team Member</td>
<td>KYTC</td>
<td>502-898-2431</td>
</tr>
<tr>
<td>Greg Sanders</td>
<td>Recorder</td>
<td>URS</td>
<td>913-344-1000</td>
</tr>
</tbody>
</table>

Certification
This is to verify that the Value Engineering Study was conducted in accordance with the standard Value Engineering principles and practices.

______________________________
Kenneth True, PE, CVS, CCE
Value Engineering Team Leader
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<table>
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<th>Page No.</th>
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<td>3. VE Recommendations</td>
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SECTION 1 - INTRODUCTION

This report documents the results of a value engineering study on the proposed bridge design for Highway US 60 crossing over the Tennessee River in McCreacken and Livingston counties. The study workshop was held at the offices of the Kentucky Transportation Cabinet (KYTC) District 1 in Paducah, KY on May 8th and KYTC Headquarters in Frankfort, KY on May 9-12, 2006. The study team was from KYTC and URS and was facilitated by Ken True, a Professional Engineer and Certified Value Specialist (CVS) team leader from URS. The names and telephone numbers of all participants in the study are listed in Appendix A.

The Job Plan
The study followed the value engineering methodology as endorsed by SAVE International, the professional organization of value engineers. This report does not include an explanation of standard value engineering / value analysis processes used during the workshop in development of the results presented herein. This would greatly expand the size of the report. The purpose of the report is to document only the results of the study.

Ideas and Recommendations
Part of the value engineering methodology is to generate as many ideas as practical, evaluate each idea, and then select candidates for further development. If an idea thus selected, turns out to work in the manner expected, that idea is presented as a formal value engineering recommendation or alternative. Recommendations represent those ideas that are proven to the VE team’s satisfaction.

Design Comments
Some ideas that did not make the selection for development as recommendations, were, nevertheless judged worthy of further consideration. These ideas have been written up as Design Comments and are included in Section 5.

Level of Development
Value Engineering studies are working sessions for the purpose of developing and recommending alternative approaches to a given project. As such, the results and recommendations presented are of a conceptual nature, and are not intended as a final design. Detailed feasibility assessment and final design development of any of the recommendations presented herein, should they be accepted, remain the responsibility of the designer.

Organization of the Report
The report is organized in the following outline.
1. Introductory information
   a. Section 1 - Introduction
   b. Section 2 - Project Description
2. Primary body of results
   a. Section 3 - Recommendations
   b. Section 4 - Alternatives
   c. Section 5 - Design Comments
3. Supporting documentation ……Appendices
SECTION 2 – PROJECT DESCRIPTION

The project includes building a new roadway, the approaches and the bridge for Highway US 60 crossing over the Tennessee River. US 60 connects the two towns of Riedland and Ledbetter along the border of McCreacken and Livingston counties.

An existing bridge is located 2200 feet downstream from the proposed site. The existing bridge is two lanes wide (approximately 24 feet) with no walkway or shoulders. The current bridge design is 71 feet wide with 4, 11.5 foot driving lanes with a four foot shoulder and one five foot shoulder that is designated as a bike lane.

The total project includes relocating the existing road, construction of approaches, bridge substructure and a 3 span bridge with span lengths of 400, 900, and 500 feet for a total length of 1800 feet. The proposed superstructure is a Warren truss bridge with sway bracing producing a structure approximately 70 feet high. The clearance under the bridge must be maintained for barge traffic. The current design has one river pier. The environmental considerations involved with moving endangered mussels have already been satisfied for the pier locations on both river shores. A construction contract for the four bridge piers was awarded in the spring of 2006 for $28.4 million to CJ Mahan Construction. Site work has started and several construction site photos, taken during the VE team site visit, are included in Appendix F.

Due to the existing bridge, vehicle traffic should have no impact on bridge construction. However, the construction of piers in the channel and the superstructure construction could be impacted by river barge traffic.

Right of way has been obtained for the project.

This VE study is limited to analyzing the bridge superstructure. The constraints given at the entrance briefing are:

- Bridge width of 71 feet with 4 traffic lanes and 4 to 5 foot shoulders
- Construction contract awarded for 4 bridge piers. That contract includes language to vary pier caps

Project Cost

A total project cost was not available for the VE study team. A partial superstructure cost was furnished to the VE team (see Appendix C). This cost estimate dated 5/5/2006 is $27,736,970 for the truss structural steel. It is assumed this includes sway bracing. In the entrance brief Mr. Allen W Frank stated the total cost of the superstructure including deck steel, deck concrete, etc at approximately $44 million. The estimate of $27.7 million is based on 15,409,000 pounds of steel at $1.80 per pound erected. The Kentucky 90 bridge a truss superstructure, let on December 20, 2002 had a steel cost of $1.48 per pound or $35.2 million. A construction contract for the four bridge piers has been awarded to CJ Mahan Construction Company in the amount of $28.4 million. Therefore the total estimated cost of the bridge, substructure and superstructure, is $72,200,000 excluding the cost for the approach bridges and roadway.
The bridge is 71 feet wide and 1,800 feet long (3 spans) or 127,800 sqft. This means the cost of the superstructure is $344.29 per SF. Steel usage is 121 pounds per SF.

**Funding**

The substructure construction contract for $28.2 million is funded with FY 2006 money. In the entrance meeting additional funding was stated in the six-year highway plan as:

<table>
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<th>Year</th>
<th>Funding</th>
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<td>FY 2008</td>
<td>$15 million</td>
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<td>FY 2009</td>
<td>$15 million</td>
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<tr>
<td>FY 2010</td>
<td>$10 million</td>
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**Funding Total** $40 million

For comparing the current design to the purposed alternatives the following information is tabulated.

- Substructure cost (under contract) $28.2 million
- Super structure steel cost $27.7 million
- Deck steel, deck, painting, misc.* $16.3 million

*Rough estimate verbally stated at entrance briefing*

**Total Estimated Project Cost** $72.2 million
SECTION 3 - VE RECOMMENDATIONS

This section contains the complete documentation of all of the recommendations that resulted from this study. The parent idea, or ideas, from which the recommendation began, can be determined from the Creative Idea List located in Appendix E of this report.

Each recommendation is documented by a separate write-up that includes a description of both the original design and recommended change, a list of advantages and disadvantages, and the economic impact of the recommendation on the project’s cost where applicable.
VALUE ENGINEERING RECOMMENDATION # 1

PROJECT: MCCracken & Livingston Bridge, US 60 Over Tennessee River
LOCATION: Paducah, Kentucky
STUDY DATE: May 8 - 12, 2006

DESCRIPTIVE TITLE OF RECOMMENDATION:
Paint only the steel above the deck on the original bridge or revised bridge in lieu of painting all of the steel.

ORIGINAL DESIGN:
Proposed painting all steel on the current bridge design.

RECOMMENDED CHANGE:
Paint only the steel above the deck on the original bridge or revised bridge. Delete painting on all the non-visible steel.
Note: The Recommended change cost savings is computed for only the present design. Savings for not painting under deck steel for other recommendations are included in those recommendations.

SUMMARY OF COST ANALYSIS

<table>
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<tr>
<th></th>
<th>First Cost</th>
<th>O &amp; M Costs (Present Worth)</th>
<th>Total LC Cost (Present Worth)</th>
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<tr>
<td>ORIGINAL DESIGN</td>
<td>$863,000</td>
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<tr>
<td>RECOMMENDED DESIGN</td>
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<td>ESTIMATED SAVINGS OR (COST)</td>
<td>$863,000</td>
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</table>
VALUE ENGINEERING RECOMMENDATION # 1

ADVANTAGES:

- Save the painting cost associated with effected members ($0.15 per pound)
- Provide paint for visible members which improves the aesthetics of the current bridge design

DISADVANTAGES:

- Deicing agents could affect the life of the unpainted bridge

JUSTIFICATION:

At the value engineering entrance briefing it was stated that the proposed design is to use 50W (weathering) steel and painting all of the steel. The only reason to paint 50W is for aesthetics, with the exception of pockets in the steel between members. The cost difference between 50W and 50 steel is approximately 1.5% the cost of the steel. Deleting the painting on the non-visible steel does not impact the bridge aesthetics. This recommendation includes only the first cost savings.
# VALUE ENGINEERING RECOMMENDATION # 1

## COST ESTIMATE - FIRST COST

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Units</th>
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<td>Painting</td>
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<td>$862,650</td>
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Subtotal: $862,650  
Mark-up (included): $0  
Redesign Costs: $0  
Total: $862,650  

**SOURCE CODE:**
1. Project Cost Estimate  
2. CES Data Base  
3. CACES Data Base  
5. National Construction Estimator  
6. Vendor Lit or Quote (list name / details)  
7. Professional Experience (List job if applicable)  
8. Other Sources (specify)
VALUE ENGINEERING RECOMMENDATION # 2

PROJECT: MCCRACKEN & LIVINGSTON BRIDGE, US 60 OVER TENNESSEE RIVER
LOCATION: PADUCAH, KENTUCKY
STUDY DATE: MAY 8 - 12, 2006

DESCRIPTIVE TITLE OF RECOMMENDATION:
Decrease the total amount of steel used in the truss by economizing the design and decreasing the member sizes.

ORIGINAL DESIGN:
The US 60 bridge design is a steel warren truss with deep lateral sway bracing at panel points. The truss as design and stated to the VE team has 27,736,920 pounds of structural steel NOT including the deck reinforcement.

RECOMMENDED CHANGE:
Decrease the total amount of steel used in the truss by economizing the design and decreasing the member sizes.

<table>
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<tr>
<th></th>
<th>First Cost</th>
<th>O &amp; M Costs (Present Worth)</th>
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VALUE ENGINEERING RECOMMENDATION # 2

ADVANTAGES:

- Decreases the total amount of steel needed
- Decreases dead load
- Improves the bridge appearance by decrease the total mass of the bridge
- Decreases painting necessary
- Decreases the total cost of the bridge

DISADVANTAGES:

- May slightly increase the bridge deflections, however, values will still be within code limits

JUSTIFICATION:

The current design has a 71-foot wide deck 1800 feet long, or 127,800 square feet. This equates to 125 lbs/ft\(^2\) of steel for the truss steel (not the deck rebar).

I-526 over the Cooper River, North Charleston, SC
Parallel Chord 3-Span Modified Warren Truss
400’ – 800’ – 400’ Span Lengths
93’-7” Wide
83 lbs/ft\(^2\) of structural steel for superstructure truss

US-27 over the Ohio River, Cincinnati OH – Newport, KY
Parallel Chord 3-Span Warren Truss
574’ – 850’ – 425’ Span Lengths
67’-0” Wide
93 lbs/ft\(^2\) of structural steel for superstructure truss

Assume design can be refined and optimized to achieve 100 lbs/ft\(^2\) of structural steel for the truss superstructure.

Assume reduction: 25 lbs/ft\(^2\) * 127,800 ft\(^2\) * $1.80/lbs = $5,750,000
## VALUE ENGINEERING RECOMMENDATION # 2

### COST ESTIMATE - FIRST COST

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<th>Cost Item</th>
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**SOURCE CODE:**
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2. CES Data Base
3. CACES Data Base
5. National Construction Estimator
6. Vendor Lit or Quote
7. Professional Experience (List job if applicable)
8. Other Sources (specify)
SECTION 4 – ALTERNATIVES

This section presents the alternative superstructure designs that resulted from the workshop. The alternatives are the real significant components of this study and report. The alternatives present entirely different superstructure designs compared to the Warren truss design as originally proposed. These alternatives present numerous other bridge types with an array of costs.

As the Alternatives are mutually exclusive of each other, only one of these Alternatives can be chosen. Given that the factors for the selecting a preferred alternative are out of the scope of this study, the VE team did not attempt to choose one of these alternatives over the other. However, if cost is the only consideration, the choices are limited. If piers are preferred, the choices are also limited. If the appearance of the bridge is paramount, several alternatives remain available.
VALUE ENGINEERING ALTERNATIVE # 0

DESCRIPTIVE TITLE OF ALTERNATIVE:
Use existing steel truss superstructure design

DESCRIPTION OF ALTERNATE:
The current design of the river crossing consists of a three-span parallel chord through truss with spans of 500'-900'-400'. The superstructure consists of a traditional Warren Truss, including vertical members on the side truss and a transverse lateral sway bracing system at all panel points consisting of K-frames. The substructure and foundation designs are complete and a contract for construction of these elements (Piers 6, 7, 8, and 9) has been awarded to C.J. Mahan in early 2006. The superstructure design and plans have been estimated to be approximately 60% complete with little drafting being complete.

ADVANTAGES:
- Design is already being completed in house
- Existing substructure contract will be unaffected

DISADVANTAGES:
- Entrance of bridge has a tunneling affect
- Superstructure design is relatively heavy (approx. 121 psf) for a parallel chord truss bridge

COST ESTIMATE:
- $28.4 million Existing contract for Piers 6 to 9
- $44.0 million Engineer of Record's preliminary cost estimate for superstructure of truss
- $72.4 million Total estimated for full cost of 1800' of parallel chord truss bridge
VALUE ENGINEERING ALTERNATIVE # 1

DESCRIPTIVE TITLE OF ALTERNATIVE:
Traditional 3-Span Parallel Chord Through Truss

DESCRIPTION OF ALTERNATE:
This 3-span traditional parallel chord through truss is based upon the existing US-60 over Tennessee River design with the following modifications:

- Remove the lateral sway bracing and replace with a moment resisting frame to improve the appearance
- Redesign the truss to reduce quantity of steel. Current design has approximately 125 psf of structural steel, other parallel chord truss bridges with similar span lengths and widths (Taylor-Southgate, Cincinnati, OH and I-526 Bridge over the Cooper River, Charleston, SC) have about 83 and 95 psf of structural steel, respectively (approximately $5,750,000 savings with steel reduction).

Precast/Prestressed Concrete Beam Approach structures leading up to the 3-span continuous unit will not require modification. The existing pier and foundation contract with C.J. Mahan to construct Piers 6 to 9 can be completed as-is without modification.

ADVANTAGES:
- Changes to existing plans can be performed in-house and meet letting schedules.
- Minor improvement in aesthetics relative to current design in progress.
- Does not require modification or termination of existing contract to construct Piers 6 to 9.
- Removal of lateral sway bracing will clean up and simplify the appearance and create additional clearance to the top lateral bracing, thus reducing the tunnel effect.
- Redesigning for efficiency will reduce material consumption and cost.
- The three span continuous system allows for simpler construction over the navigation channel compared to simple span alternatives. Simple span alternatives will require either temporary works within the navigation channel or to float in the completed structural system, which has risks associated with it. The three span continuous system can be built over the navigation channel without the need for large temporary works within the navigation channel.

DISADVANTAGES:
- Even though this modified truss will have improved aesthetics, it is the team’s opinion that this design will not be as aesthetically appealing as the truss in Alternate 32 or other bridge types discussed in this report.
- Requires additional time and effort to redesign the truss; however, the cost of redesigning will be more than offset by the savings from reducing quantity of steel required.
- Removal of lateral sway bracing will require larger top lateral bracing members with more complicated connections.
- The steel will need to be painted and on-going maintenance on the painting for the life of the structure.

COST ESTIMATE:
- $275/sf * 1800’ * 73.5’ = $36.4M (1800’ Truss Superstructure)
- = $28.4M (Existing Construction Contract for Piers 6 to 9)
- TOTAL = $64.8M
VALUE ENGINEERING ALTERNATIVE # 1
SKETCH OF RECOMMENDED DESIGN

3-Span Parallel Chord Truss (Warren Truss)
(Alternate 1)
VALUE ENGINEERING ALTERNATIVE # 1

ARTISTIC RENDERING OF RECOMMENDED DESIGN
VALUE ENGINEERING ALTERNATIVE # 2

DESCRIPTIVE TITLE OF ALTERNATIVE:
Modified 3-Span Parallel Chord Through Truss

DESCRIPTION OF ALTERNATE:
This alternate is the same as Alternate 1 with the exception that the detailing of the truss will be enhanced to provide higher aesthetic appeal. First, the vertical elements of the truss will be eliminated and the diagonals will carry the entire load. Second, the number of members for the top chord lateral bracing will be reduced in an effort to improve the appearance. Both of these revisions are meant to create a clean and distinctive truss system with improved aesthetics; however, these revisions also have the affect of complicating the connections and decreasing the efficiency of some of the members, both of which will increase the cost slightly.

ADVANTAGES:
- Does not require modification or termination of existing contract to construct Piers 6 to 9.
- Improved aesthetics relative to Alternate 1 and the current truss design. The elimination of the verticals and reconfiguration of the top lateral bracing creates a more open and transparent design, which leads to enhanced visual appeal.
- Still a cost effective solution.
- Does not require major temporary works within the river for constructing the superstructure over the navigation channel.

DISADVANTAGES:
- Requires painting of the structural steel.
- The removal of the verticals and the reconfiguration of the top lateral bracing is not as structurally efficient as Alternate 1.

COST ESTIMATE:

$285/sf \times 1800' \times 73.5' = $37.7M \ (1800' \ Truss \ Superstructure) 

= $28.4M \ (Existing \ Construction \ Contract \ for \ Piers \ 6 \ to \ 9) 

TOTAL = $66.1M
VALUE ENGINEERING ALTERNATIVE # 2
SKETCH OF RECOMMENDED DESIGN

3-Span Modified Parallel Chord Truss (Warren Truss) (Alternate 32)
VALUE ENGINEERING ALTERNATIVE # 2

ARTISTIC RENDERING OF RECOMMENDED DESIGN
VALUE ENGINEERING ALTERNATIVE # 3

DESCRIPTIVE TITLE OF ALTERNATIVE:
Use Closed Sections for Mainspan Bridge

DESCRIPTION OF ALTERNATE:
This alternate applies to the two alternates that have truss elements above deck (Alt. 1 and 32). In general, instead of using wide flange steel sections for the truss members, we would use closed sections like welded or bolted steel box shapes to improve the aesthetics of the structure. The custom fabrication of the steel boxes compared to using rolled sections will drive up the fabrication cost of the steel without increasing the quantity of steel.

ADVANTAGES:
- Use of closed sections has a marginal increase in the aesthetic appearance of the above deck structure.

DISADVANTAGES:
- Drives up the price of the steel because many of the members will need to be custom fabricated instead of using rolled sections.

COST ESTIMATE:

$64.8M * 1.10 = $71.3M (Alternate 1 modified to include closed sections for all members)

$66.1M * 1.10 = $72.7M (Alternate 32 modified to include closed sections for all members)
VALUE ENGINEERING ALTERNATIVE # 4

DESCRIPTIVE TITLE OF ALTERNATIVE:
Tied Arch Mainspan with Steel Plate Girder Flanking Spans

DESCRIPTION OF ALTERNATE:
Span the navigation channel with a steel tied arch structure with one arch rib on each side of the roadway. Consideration should be given to using a diagonal hanger system to reduce flexural demands on the arch rib and increase the stiffness of the system. On each side of the mainspan will be a two-span continuous steel plate girder structure, beyond the steel plate girder structure will be the currently planned precast/prestressed concrete beams spans. The flanking spans with steel plate girders are recommended as two-span structures since single spans at 500’ and 400’ will be very expensive and difficult to erect.

The existing design for Piers 7 and 8 under contract with C.J. Mahan should be acceptable and can continue construction. However, Piers 6 and 9 will need to be evaluated for adequacy considering the new structure type being supported and may require a new design and modification to the existing construction contract.

With the two-span flanking spans a single substructure unit on each side (Piers 5 and 10) can be eliminated. Eliminated two precast/prestressed concrete beam approach spans on each side of the river to accommodate the second steel plate girder span.

ADVANTAGES:
- The arch structure is an aesthetically pleasing bridge.
- Existing contract to construct Piers 7 and 8 should be able to proceed as-is.
- Steel plate girders on flanking spans can utilize weathering steel if desired.
- Current technology for tied arch bridge design includes special detailing of the lower tension tie so it will not be classified as a fracture critical element.
- Matches other newer long span bridges in the area (i.e. I-24 over Ohio and Tennessee River).
- No painting of steel plate girders.

DISADVANTAGES:
- Requires significant time and effort for a complete redesign of 2462’ of bridge.
- There is a significant cost premium associated with this alternate.
- Long span steel plate girders will be about 16’ deep which is substantially deeper than the tied arch and prestressed concrete beams on both sides of the steel spans, thus creating a visual discontinuity when viewed from the side.
- Existing contract to construct Piers 6 and 9 may need to be modified in order to build more substantial piers and foundations.
- Steel for tied arch would be recommended as painted steel.
VALUE ENGINEERING ALTERNATIVE # 4

DISADVANTAGES (continued):

- Construction of a simple span tied arch bridge over the navigation channel will require either temporary bents located within the navigation channel to erect the superstructure from or the partially completed superstructure will be floated in on barges and lowered onto Pier 7 and Pier 8. Both of these options carry inherent risks to contractor and the river traffic. Using temporary bents within the navigation channel is the more common approach and is being used on the Blennerhassett Island (WV) tied arch bridge over the Ohio River that is currently under construction. This bridge requires temporary bents in the navigation channel that temporarily reduces the channel opening to 600' and required that the contractor obtain a permit from the Coast Guard for this provision. The significant difference between Blennerhassett Island and the US-60 bridge is that the Blennerhassett bridge is on a tangent section of river, whereas the US-60 bridge crosses the Tennessee River on a bend. Due to the bend in the river the Coast Guard may not allow a temporary narrowing of the navigation channel in which case the tied arch superstructure must then be partially assembled on barges and floated into position. Floating in the partial superstructure may require a substantial dredging of the river in the vicinity of Pier 8 along with the relocation of mussels. Obtaining the Coast Guard permit for temporary works is typically performed by the contractor as part of their means and methods of erection; however, if this option is pursued then it is recommended to work with the Coast Guard during the early stages of design development to create a permutable project from the standpoint of temporary works. This process could take from three to six months to develop a workable solution assuming there is a workable solution from the Coast Guard's perspective.

COST ESTIMATE:

$$425/sf \times 900' \times 73.5' = 28.1M \ (900' \ Arch \ Superstructure)$$

$$200/sf \times 875' \times 69.7' = 12.2M \ (375'-500' \ Steel \ Plate \ Girder \ Flanking \ Span \ Sub \ and \ Superstr)$$

$$200/sf \times 687' \times 69.7' = 9.6M \ (400'-287' \ Steel \ Plate \ Girder \ Flanking \ Span \ Sub \ and \ Superstr)$$

$$-70/sf \times 662' \times 69.7' = -3.2M \ (Deduct \ 375'+287' \ of \ Precast \ Concrete \ Beam \ Superstructure)$$

= $28.4M \ (Existing \ Construction \ Contract \ for \ Piers \ 6 \ to \ 9)$

TOTAL = $75.1M
VALUE ENGINEERING ALTERNATIVE # 4

SKETCH OF RECOMMENDED DESIGN

STEEL PLATE GIRDER
375'-0"  500'-0"  900'-0"

STEEL PLATE GIRDER
400'-0"  287'-0"

TIED ARCH MAINSPAN WITH STEEL PLATE GIRDER FLANKING SPANS
(ALTERNATE 4)
VALUE ENGINEERING ALTERNATIVE # 5

DESCRIPTIVE TITLE OF ALTERNATIVE:
Tied Arch Mainspan with Shorter Steel Plate Girder Flanking Spans

DESCRIPTION OF ALTERNATE:
Span the navigation channel with a steel tied arch structure with one arch rib on each side of the roadway. The sidespans of the existing truss design will be replaced with two-span continuous steel plate girder structures with span lengths of 250’ on the west and 200’ on the east. Providing a two-span structure for the flanking spans requires the addition of one land based pier between Piers 8 and 9, and one water based pier between Piers 6 and 7.

The existing design for Piers 6 to 9 under contract with C.J. Mahan should be acceptable and can continue construction without major modification.

ADVANTAGES:
- The tied arch structure is an aesthetically pleasing bridge.
- The shorter span lengths for the flanking spans allows for a shallower structural depth, which will match those of the tied arch span and the precast/prestressed concrete beam spans.
- Do not have to modify the existing contract for Piers 6 to 9.
- This is a very cost effective solution.

DISADVANTAGES:
- Requires significant time and effort for a complete redesign of 1800’ of bridge.
- Construction of the central tied arch span will require either temporary works within the navigation channel or to float in the completed structural system, both of which carry significant risks.
- Requires an additional pier in the water that will be both expensive and subject to impact from barges. The cost of this pier is also difficult to estimate without performing the analysis.
- Steel for tied arch span would need to be painted.

COST ESTIMATE:
$425/sf * 900’ * 73.5’ = $28.1M (900’ Tied Arch Superstructure)
$70/sf * 500’ * 69.7’ = $2.4M (250’-250’ Steel Plate Girder Superstructure)
$70/sf * 400’ * 69.7’ = $2.0M (200’-200’ Steel Plate Girder Superstructure)
$30/sf * 200’ * 69.7’ = $0.4M (Added substructure unit on land)
= $8.0M (Added substructure unit in river)
= $28.4M (Existing Construction Contract for Piers 6 to 9)
TOTAL = $69.3M
VALUE ENGINEERING ALTERNATIVE #5

SKETCH OF RECOMMENDED DESIGN

TIED ARCH MAINSPAN WITH SHORTER STEEL PLATE GIRDER FLANKING SPANS
(ALTERNATE 9)
DESCRIPTIVE TITLE OF ALTERNATIVE:
Tied Arch Mainspan with Shorter Precast Concrete Girder Flanking Spans

DESCRIPTION OF ALTERNATE:
This alternative is the same as Alternate 9 with the exception that the steel plate girder flanking spans are replaced with post-tensioned segmented concrete I-girders and represents only a minor adjustment to Alternate 9.

ADVANTAGES:
- The tied arch structure is an aesthetically pleasing bridge.
- The shorter span lengths for the flanking spans allows for a shallower structural depth, which will match those of the tied arch span and the precast/prestressed concrete beam approach spans.
- Do not have to modify the existing contract for Piers 6 to 9.
- This is a very cost effective solution.

DISADVANTAGES:
- Requires significant time and effort for a complete redesign of 1800’ of bridge.
- Construction of the central tied arch span will require either temporary works within the navigation channel or to float in the completed structural system, both of which carry risks.
- Requires an additional pier in the water that will be both expensive and subject to impact from barges. The cost of this pier is also difficult to estimate without performing the analysis.

COST ESTIMATE:

$425/sf * 900’ * 73.5’ = $28.1M (900’ Tied Arch Superstructure)

$55/sf * 500’ * 69.7’ = $2.0M (250’-250’ Precast Segmented Concrete Girder Superstructure)

$55/sf * 400’ * 69.7’ = $1.5M (200’-200’ Precast Segmented Concrete Girder Superstructure)

$30/sf * 200’ * 69.7’ = $0.4M (Added substructure unit on land)

= $8.0M (Added substructure unit in river)

= $28.4M (Existing Construction Contract for Piers 6 to 9)

TOTAL = $68.4M
VALUE ENGINEERING ALTERNATIVE # 7

DESCRIPTIVE TITLE OF ALTERNATIVE:
Support Elements Along Centerline of Bridge

DESCRIPTION OF ALTERNATE:
This alternate is the same as Alternate 9 with the exception that three planes of arch ribs would be provided, one along each outside edge of the roadway plus one additional rib down the centerline of the bridge. To accommodate this median arch rib the roadways would need to be separated by about 5’ and an additional concrete barrier would be added.

By increasing the width of the superstructure by about 6’, this would require substantial modifications to the existing pier designs, which would modify C.J. Mahan’s existing construction contract.

ADVANTAGES:
- By adding a third structural arch rib down the middle the transverse floorbeams supporting the roadway will be substantially decreased in size since they are only spanning half the distance.

DISADVANTAGES:
- The addition of the third rib adds substantial complication to the structural system by creating a statically indeterminate system in the transverse direction.
- Adds cost to the overall system.
- Requires modification to the existing construction contract.

COST ESTIMATE:

\$425/sf \times 900’ \times 79.5’ = \$32.2M \ (900’ \ Tied \ Arch \ Superstructure) \\
= \$4.4M \ (Steel \ Plate \ Girder \ Span \ Superstructure) \\
= \$0.4M \ (Added \ substructure \ unit \ on \ land) \\
= \$8.0M \ (Added \ substructure \ unit \ in \ river) \\
= \$2.0M \ (Funds \ to \ modify \ C.J. \ Mahan \ construction \ contract) \\
= \$28.4M \ (Existing \ Construction \ Contract \ for \ Piers \ 6 \ to \ 9) \\
TOTAL = \$75.4M
VALUE ENGINEERING ALTERNATIVE # 7

SKETCH OF RECOMMENDED DESIGN
VALUE ENGINEERING ALTERNATIVE # 8

DESCRIPTIVE TITLE OF ALTERNATIVE:
Three Tied Arch Spans

DESCRIPTION OF ALTERNATE:
Three independent simple span tied arch structures are used to span the navigation channel plus the flanking span on each side of the channel. Each arch span will have one arch rib on each side of the roadway. Consideration should be given to using a diagonal hanger system to reduce flexural demands on the arch rib and increase the stiffness of the system.

The existing design for Piers 7 and 8 under contract with C.J. Mahan should be acceptable and can continue construction. However, Piers 6 and 9 will need to be evaluated for adequacies considering the new structure type being supported and will probably require a re-design and modification to the existing construction contract. The estimated cost for this alternate includes money for increasing the size of the foundations; however, the potential dollar value that may be incurred due to modifying the C.J. Mahan contract (time delays, in-house engineering, re-mobilization, etc.) has not been included.

ADVANTAGES:
- The arches create a very aesthetically pleasing site.
- Existing contract to construct Piers 7 and 8 should be able to proceed as-is.
- Current technology for tied arch bridge design includes special detailing of the lower tension tie so it will not be classified as a fracture critical element.

DISADVANTAGES:
- Requires significant time and effort for a complete redesign of 1800’ of bridge.
- There is a significant cost premium associated with this alternate.
- Existing contract to construct Piers 6 and 9 will probably need to be modified in order to build more substantial piers and foundations.
- Steel for tied arch would be recommended as painted steel.
- Construction of the central tied arch span will require either temporary works within the navigation channel or to float in the completed structural system, both of which carry risks.

COST ESTIMATE:

$425/sf * 900’ * 73.5’ = $28.1M  (900’ Arch Superstructure)

$300/sf * 500’ * 73.5’ = $11.0M  (500’ Arch Superstructure)

$300/sf * 400’ * 73.5’ = $8.8M  (400’ Arch Superstructure)

$300/sf * 400’ * 73.5’ = $0.3M  (Increase capacity of Pier 6 and 9)

$28.4M  (Existing Construction Contract for Piers 6 to 9)

TOTAL = $76.6M
VALUE ENGINEERING ALTERNATIVE # 8

SKETCH OF RECOMMENDED DESIGN

THREE TIED ARCH SPANS
(ALTERNATE 6)
VALUE ENGINEERING ALTERNATIVE # 9

DESCRIPTIVE TITLE OF ALTERNATIVE:
Two Tied Arches with Precast Concrete Girder Approach Spans

DESCRIPTION OF ALTERNATE:
This alternate consists of two independent tied arch spans with lengths of 500’ and 900’. The 500’ tied arch span allows for the use of the piers associated with the existing construction contract while keeping additional piers out of the river. Precast/Prestressed concrete girder spans will be used as approaches on both sides of the tied arch spans. In the cost estimate, 400’ of concrete girder spans was included so a direct comparison can be made between the various alternates.

The existing design for Piers 7 and 8 should be adequate to support the revised structural system; however, Pier 6 will more than likely require additional strengthening. Pier 9 will no longer be necessary and would be removed from the existing construction contract.

Leading up to Pier 6 will utilize 6 spans of concrete beams at 125’-0”, while the after Pier 8 there will be 11 spans of concrete beams at 140’-9”.

ADVANTAGES:
- Existing contract to construct Piers 7 and 8 should be able to proceed as-is.
- Current technology for tied arch bridge design includes special detailing of the lower tension tie so it will not be classified as a fracture critical element.
- Relatively cost effective alternative.
- Does not place any additional piers in the river.

DISADVANTAGES:
- Requires significant time and effort for a complete redesign of twin arches.
- Existing contract to construct Piers 6 will need minor modification and Pier 9 will need to be removed from the contract.
- Steel for tied arch would be recommended as painted steel.
- Construction of the central tied arch span will require either temporary works within the navigation channel or to float in the completed structural system, both of which carry risks.

COST ESTIMATE:

\[
\begin{align*}
\text{900’ Arch Superstructure} & : 425/\text{sf} \times 900’ \times 73.5’ = 28.1\text{M} \\
\text{500’ Arch Superstructure} & : 300/\text{sf} \times 500’ \times 73.5’ = 11.0\text{M} \\
\text{400’ of precast concrete beam sub and superstructure} & : 100/\text{sf} \times 400’ \times 69.7’ = 2.8\text{M} \\
\text{Remove Pier 9, Modify Pier 6, Buyout partial Mahan contract} & : -2.0\text{M} \\
\text{Existing Construction Contract for Piers 6 to 9} & : 28.4\text{M} \\
\text{TOTAL} & = 68.3\text{M}
\end{align*}
\]
VALUE ENGINEERING ALTERNATIVE # 9

SKETCH OF RECOMMENDED DESIGN

TWO TIED ARCHES WITH PRECAST CONCRETE GIRDER APPROACH SPANS
(ALTERNATE 38)
VALUE ENGINEERING ALTERNATIVE # 9
ARTISTIC RENDERING OF RECOMMENDED DESIGN
VALUE ENGINEERING ALTERNATIVE # 10

DESCRIPTIVE TITLE OF ALTERNATIVE:
Deck Truss

DESCRIPTION OF ALTERNATE:
This alternate would consist of a traditional variable depth below deck truss with a 900’ mainspan length. Since the supporting structural system is placed completely below deck the profile will need to be raised by approximately 43’ to maintain required clearances within the navigation channel. Raising the profile impacts the substructures for all the approach spans plus the quantity of fill beyond the limits of the bridge. The additional fill required beyond the bridge limits also will require a power line to be raised, ROW to be purchased and additional wetland mitigations. Costs associated with these impacts have been included in cost estimate. With the raising of the profile over the mainspan unit the capacity of the foundations for Piers 6 to 9 will probably be deemed inadequate and will need to be modified to account for the additional design loads. Modifying the foundations will necessitate the modification of the C.J. Mahan contract to construct these piers, the cost of which has been incorporated into the estimate.

ADVANTAGES:
- Deck truss structures can make for relatively pleasing bridges.
- Construction of the mainspan can be performed without the need for temporary works within the navigation channel.
- Structural steel can be unpainted weathering steel since all steel is below deck.
- Relatively cost–effective system.
- Existing construction contract for Piers 7 and 8 will probably not need to be modified. For this alternate the concrete deck is place higher above the water and therefore, the impact to the seismic evaluation to the Pier 7 and 8 foundation needs to be confirmed.

DISADVANTAGES:
- Requires significant time and effort for a complete redesign of 1800’ of bridge.
- Existing construction contract for Piers 6 and 9 need to be terminated.
- Raising the profile makes significant impacts to a substantial length of the project.
- Roadway grades on the approach to the river, although within code limits, are increased to 4%, which creates concerns with snow and ice.
- Requires additional right-of-way and utility relocation.
- Borrow material for fills must be identified.

COST ESTIMATE:

\[
\begin{align*}
275/sf \times 1800' \times 69.7' &= 34.5M \quad \text{(1800' Deck Truss Superstructure)} \\
15/sf \times 1898' \times 69.7' &= 2.0M \quad \text{(Increase substructure cost for concrete beam pp spans)} \\
                      &= 0.5M \quad \text{(Raise power line)} \\
                      &= 1.0M \quad \text{(Increased fill for raising profile)} \\
                      &= 0.5M \quad \text{(Additional ROW and wetland mitigation)} \\
100psf \times 1800' \times 69.7' \times 0.15/lbs &= -1.9M \quad \text{(Deduct for not painting the steel)} \\
                      &= 3.0M \quad \text{(Modify/Strengthen Piers 6 to 9)} \\
                      &= 28.4M \quad \text{(Existing Construction Contract for Piers 6 to 9)} \\
\text{TOTAL} &= 68.0M
\end{align*}
\]
VALUE ENGINEERING ALTERNATIVE # 10

SKETCH OF RECOMMENDED DESIGN

DECK TRUSS
(ALTERNATE 12)
VALUE ENGINEERING ALTERNATIVE # 10

ARTISTIC RENDERING OF RECOMMENDED DESIGN
VALUE ENGINEERING ALTERNATIVE # 11

DESCRIPTIVE TITLE OF ALTERNATIVE:
Extradosed Steel Girder Bridge

DESCRIPTION OF ALTERNATE:
An extradosed bridge is a hybrid between a cable-stayed bridge and a true girder bridge. For a true cable-stayed bridge the superstructure is extremely thin and flexible and requires the stay-cables to provide nearly 100% of the support. On the other hand, a girder bridge has a deep and stiff superstructure that can span between piers without the aid of stay-cables. An extradosed bridge is somewhere in between the cable-stayed and girder bridge, using a girder that is shallower than a girder bridge but deeper than a cable-stayed bridge, therefore small cables are needed to assist in the superstructure support. Typically, the towers are relatively short compared to a cable-stayed structure and the cables are only provided along a portion of the span.

This alternate calls for a three span extradosed steel girder bridge with a plane of cables along each edge of the roadway. The foundations and piers associated with this alternate are not consistent with the piers under the existing construction contract; therefore the contract with C.J. Mahan would need to be terminated.

ADVANTAGES:

- The extradosed structure will create an aesthetically pleasing signature bridge.
- Construction of the mainspan can be performed without the need for temporary works within the navigation channel.
- The 900’ span length is within the practical span lengths for an extradosed bridge. The superstructure can be either concrete or steel.
- Bridge can be designed so deck is replaceable.

DISADVANTAGES:

- Requires significant time and effort for a complete redesign of 1800’ of bridge.
- Existing construction contract for Piers 6 to 9 needs to be terminated.
- Extremely limited experience with this bridge type in United States for both design and construction.
- Cost estimating with minimal historical data points is of limited accuracy.
- Not a cost effective solution.

COST ESTIMATE:

\[
\begin{align*}
$450/\text{sf} \times 1800' \times 78.0' & = $63.2M \text{ (900' Mainspan Extradosed Sub and Superstructure)} \\
& = -$20.4M \text{ (Remaining Funds after buyout of Mahan Contract)} \\
& = $28.4M \text{ (Existing Construction Contract for Piers 6 to 9)} \\
\text{TOTAL} & = $71.2M
\end{align*}
\]
VALUE ENGINEERING ALTERNATIVE # 11

SKETCH OF RECOMMENDED DESIGN

EXTRADOSED STEEL GIRDER BRIDGE
(ALTERNATE 11)
VALUE ENGINEERING ALTERNATIVE # 12

DESCRIPTIVE TITLE OF ALTERNATIVE:
Cable-Stayed Bridge with 900-ft Span

DESCRIPTION OF ALTERNATE:
This alternate consists of a traditional 3-span symmetrical cable-stayed bridge with two planes of cables, one along each roadway edge. This alternate would require that the existing construction contract for Piers 6 to 9 be terminated and the piers/foundations be redesigned to accommodate a cable-stayed bridge.

The estimated cost for this alternate includes the price for building the entire substructure and superstructure for the three span cable-stayed bridge plus a substantial dollar cost for canceling the C.J. Mahan contract.

ADVANTAGES:
- The cable-stay structure is an aesthetically pleasing and signature bridge.
- The mainspan structure can be built without temporary works interfering with the navigation channel.

DISADVANTAGES:
- Requires significant time and effort for a complete redesign of 1800’ of bridge. Slows progress of project by 18 months.
- There is a significant cost premium associated with this alternate.
- Existing contract to build Piers 6 to 9 would need to be terminated and significant expenses incurred due to this termination.
- Foundations for the cable-stayed towers will be larger than the currently proposed foundations for Piers 7 and 8.
- Deck is not replaceable.
- Political implications.

COST ESTIMATE:

\[ \text{Total Cost} = \text{Cost of Mainspan + Remaining Funds + Existing Contract} \]

\[ \text{Cost of Mainspan} = 500 \times 1800 \times 78 = 70.2 \text{M} \]

\[ \text{Remaining Funds} = -20.4 \text{M} \]

\[ \text{Existing Contract} = 28.4 \text{M} \]

\[ \text{TOTAL} = 78.2 \text{M} \]
VALUE ENGINEERING ALTERNATIVE # 12

SKETCH OF RECOMMENDED DESIGN

CABLE-STAYED BRIDGE WITH 900-FT SPAN
(ALTERNATE 7)
VALUE ENGINEERING ALTERNATIVE # 13

DESCRIPTIVE TITLE OF ALTERNATIVE:
Cable-Stayed Bridge with 1,200-ft Span

DESCRIPTION OF ALTERNATE:
This alternate consists of a traditional 3-span symmetrical cable-stayed bridge that spans the entire river with two planes of cables, one along each roadway edge. The main towers would be placed near each bank at normal pool, eliminating all piers from the river. This alternate would require that the existing construction contract for Piers 6 to 9 be terminated.

The estimated cost for this alternate includes the price for building the entire substructure and superstructure for the three span cable-stayed bridge plus a substantial dollar cost for canceling the C.J. Mahan contract.

ADVANTAGES:
- The cable-stay structure is an aesthetically pleasing signature bridge.
- The mainspan structure can be built without temporary works interfering with the navigation channel.
- All piers are out of the river at normal pool, therefore the risk of barge impact is greatly reduced.
- Steel does not require paint and can be left as weathering steel.

DISADVANTAGES:
- Requires significant time and effort for a complete redesign of major cable-stayed bridge.
- There is a significant cost premium associated with this alternate.
- Existing contract to build Piers 6 to 9 would need to be terminated and significant expenses incurred due to this termination.
- Deck is not replaceable.
- Political implications.

COST ESTIMATE:

$550/sf * 2360’ * 78.0’ = $101.2M (1200’ Cable-Stayed Substructure and Superstructure)
$100/sf * 560’ * 69.7’ = $-3.9M (Deduct 500’ of concrete beam approach sub and superstr)
-= $-20.4M (Remaining Funds after buyout of C.J. Mahan Contract)
+= $28.4M (Existing Construction Contract for Piers 6 to 9)
TOTAL = $105.3M
VALUE ENGINEERING ALTERNATIVE # 13

SKETCH OF RECOMMENDED DESIGN

CABLE-STAYED BRIDGE WITH 1200-FT SPAN
(ALTERNATE 37)
VALUE ENGINEERING ALTERNATIVE # 14

DESCRIPTIVE TITLE OF ALTERNATIVE:
Tied Arch Mainspan with Steel Box Girder Flanking Spans

DESCRIPTION OF ALTERNATE:
This alternate is the same as Alternate 4 with the exception that the steel plate girders will be replaced with steel box girders in an effort to improve the aesthetics. This is probably not a reasonable alternative because the size and weight of the steel box beam field sections will make delivery and installation very challenging. In general, steel box girder bridges are more expensive than an equivalent steel plate girder bridge for straight alignments.

Conclusion is that the additional aesthetic value offered by the closed steel box girder relative to the plate girder alternative is not worth the cost increase and construction complexity. Cost estimating was not performed on this alternate.

ADVANTAGES:
- The arch structure is an aesthetically pleasing bridge.
- Existing contract to construct Piers 7 and 8 should be able to proceed as-is.
- Steel box girders on flanking spans can utilize weathering steel if desired.
- Current technology for tied arch bridge design includes special detailing of the lower tension tie so it will not be classified as a fracture critical element.

DISADVANTAGES:
- Requires significant time and effort for a complete redesign of 2462’ of bridge.
- There is a significant cost premium associated with this alternate.
- Long span steel box girders will be about 16’ deep which is substantially deeper than the tied arch and prestressed concrete beams on both sides of the steel spans, thus creating a visual discontinuity when viewed from the side.
- Existing contract to construct Piers 6 and 9 may need to be modified in order to build more substantial piers and foundations.
- Steel for tied arch would be recommended as painted steel.
- Construction of tied arch span will require either temporary works within the navigation channel or to float in the completed structural system, both of which carry risks.
- Delivery and installation of the large box girder field sections will add complication.

COST ESTIMATE:
Not calculated due to significant disadvantages.
Design Comments are ideas that in the opinion of the team were good ideas, but for any number of reasons were not selected for development as VE recommendations. Design Comments can be notes to the owner or designer, a documentation of various thoughts that come up during the course of the study, a reference to possible problems, suggested items that might need further study, or questions that the owner and designer might want to explore. Some comments might relate to things of which the owner or designer is already aware. Because the study is done on a design in progress and as an independent team, the VE team may not be aware of everything intended by the owner and designer. The following comments are presented with the intent that there might be a few comments that aid the design team in some way.
VALUE ENGINEERING DESIGN COMMENT # 1

DESCRIPTIVE TITLE OF DESIGN COMMENT:
Use tube rail in lieu of jersey barriers for sides and center medians.

COMMENTARY:
The present design proposes using Jersey barriers for sides and center medians. Utilizing tube rail would provide more daylight and counter the box effect of the current truss design. A rail would also provide a better scenic view of the river and its surroundings. Given the reduced shoulder width of 4 feet as designed; this would give the appearance of a wider bridge. Sketches of several railing types are attached.
VALUE ENGINEERING DESIGN COMMENT # 1

SKETCH OF RECOMMENDED DESIGN
VALUE ENGINEERING DESIGN COMMENT # 1

SKETCH OF RECOMMENDED DESIGN
VALUE ENGINEERING DESIGN COMMENT # 2

DESCRIPTIVE TITLE OF DESIGN COMMENT:
Utilize an alternative barrier design with a rail on top of a concrete barrier to provide better aesthetics and a better scenic view.

COMMENTARY:
Utilize an alternative barrier design with a rail on top of a concrete barrier to provide better aesthetics and a better scenic view.
VALUE ENGINEERING DESIGN COMMENT # 2

SKETCH OF RECOMMENDED DESIGN
DESCRIPTIVE TITLE OF DESIGN COMMENT:
Increase the 5’ width bike lane to a more user-friendly width.

COMMENTARY:
The current bridge design includes a 5-foot bikeway. The proposed 5-foot painted non-vehicular non-separated lane is perceived as a minimal width for the anticipated pedestrian bike use on the bridge. This bridge connects two populations. A 5-foot wide painted bike lane for an 1800-foot bridge is very narrow. Considerations could be given to widening the bike lane.
VALUE ENGINEERING DESIGN COMMENT # 4

DESCRIPTIVE TITLE OF DESIGN COMMENT:
Add aesthetic lighting on the bridge structure.

COMMENTARY:
Kentucky Transportation Cabinet has previously committed to lighting the proposed structure. An appropriate lighting plan could enhance nighttime aesthetics of the bridge.
VALUE ENGINEERING DESIGN COMMENT # 5

DESCRIPTIVE TITLE OF DESIGN COMMENT:
Add a theme lighting plan on the approaches of the structure.

COMMENTARY:
The approach span lighting theme should be coordinated with the main span lighting to achieve an overall aesthetic appearance. A gradual illumination transition would be desirable as the driver enters and exits the structure.
VALUE ENGINEERING DESIGN COMMENT # 6

DESCRIPTIVE TITLE OF DESIGN COMMENT:
Use colored concrete for the bridge deck construction.

COMMENTARY:
Colored concrete could be used to help mitigate the stains that are a result of the use of weathering steel.
VALUE ENGINEERING DESIGN COMMENT # 7

DESCRIPTIVE TITLE OF DESIGN COMMENT:
Have public involvement meetings to select paint color, an aesthetic lighting plan, and provide public with correct and updated information.

COMMENTARY:
A public involvement process could facilitate positive public perception of the project as a whole. Public participation in paint color selection and comments on the proposed aesthetic lighting plan could help promote community ownership of the final bridge design.
VALUE ENGINEERING DESIGN COMMENT # 8

DESCRIPTIVE TITLE OF DESIGN COMMENT:
Decorate and enhance the portal appearance to minimize the tunnel effect of the proposed design.

COMMENTARY:
A portal façade could be utilized to minimize the tunnel effect of the proposed design. It could also be used to provide a gateway theme to the communities on each end of the structure.
VALUE ENGINEERING DESIGN COMMENT # 9

DESCRIPTIVE TITLE OF DESIGN COMMENT:
Design at least one more superstructure and send multiple designs out for bidding.

COMMENTARY:
The original design calls for only one design to be bid and awarded for construction. The VE Team recommends designing at least one more superstructure and sending multiple designs out for bidding. This allows the owner, KYTC, options on weighing cost and alternate bridge types. This could somewhat limit some options throughout the design/build process, and it will require another complete bridge design. The owner can gather more information about the cost of different bridge types instead of using standard hard bidding. This will require more design work up front, but the end result will likely be a better bridge for a reduced cost.
VALUE ENGINEERING DESIGN COMMENT # 10

DESCRIPTIVE TITLE OF DESIGN COMMENT:
Make the superstructure a design/build project in lieu of a design/bid/build project.

COMMENTARY:
The original plan for awarding of the superstructure contract was to use a conventional
design/competitive bid procurement process. The VE Team proposes that a design/build contract
be utilized for the superstructure. This will allow more options to be considered for the
superstructure, which can improve the value of the project from a cost and aesthetic approach. A
design/build contract could save considerable time over a conventional design/bid/build contract.
Depending on the alternative selected, the existing construction contract could be negatively
impacted (i.e. partial buyout or modification to substructure design). Design/Build procurement
creates a favorable consideration for the superstructure to optimize cost while not sacrificing
aesthetics for several different bridge types. If one or several of the alternatives were desired, a
design/build contract would definitely be a recommended procurement method.
APPENDICES

The appendices in this report contain backup information supporting the body of the report, and the mechanics of the workshop. The following appendices are included.

CONTENTS

G. Study Participants .......................................................... A-2
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# Workshop Attendance

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization and Address (Organization first, with complete address underneath)</th>
<th>Tel # and FAX, (Tel first with FAX underneath)</th>
<th>Role in wk shop</th>
<th>Meetings</th>
<th>Study Sessions</th>
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<tbody>
<tr>
<td>Ken True</td>
<td>URS</td>
<td>(402) 516 2635</td>
<td>VE Team Leader</td>
<td>X</td>
<td>X X X X X X</td>
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<tr>
<td>Dave Jeakle</td>
<td>URS</td>
<td>(813) 636-2467</td>
<td>VE Team Bridge Engineer</td>
<td>X X X X X X X</td>
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<tr>
<td>Greg Sanders</td>
<td>URS</td>
<td>(913) 344-1105</td>
<td>VE Technical Recorder</td>
<td>X X X X X X X</td>
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<tr>
<td>Danny Jasper</td>
<td>KYTC</td>
<td>(502) 564-3280</td>
<td>VE Team Member</td>
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<tr>
<td>Allan Frank</td>
<td>KYTC</td>
<td>(502) 564-4560</td>
<td>Bridge Engineer</td>
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<tr>
<td>John Bargoe</td>
<td>FHWA</td>
<td>(502) 223-6763</td>
<td>Bridge Engineer</td>
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<tr>
<td>Robert Semones</td>
<td>KYTC</td>
<td>(502) 564-3280</td>
<td>VE Coordinator</td>
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<tr>
<td>Dexter Newman</td>
<td>KYTC</td>
<td>(502) 564-4555</td>
<td>VE Coordinator</td>
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<tr>
<td>David Davis</td>
<td>KYTC D-1</td>
<td>(270) 898-2431</td>
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<tr>
<td>Allen W. Thomas</td>
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<tr>
<td>Chris Kuntz</td>
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<tr>
<td>Mike McGregor</td>
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<tr>
<td>Tim Choate</td>
<td>KYTC D-1</td>
<td>(270) 898-2431</td>
<td>Pre-Construction Project Manager</td>
<td>X X X X X X X</td>
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<tr>
<td>Siamak Shafaghri</td>
<td>KYTC-Program Perf.</td>
<td>(502) 564-4555</td>
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<tr>
<td>Frank Bush, Jr.</td>
<td>KYTC-Design</td>
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<tr>
<td>Kyle Poat</td>
<td>KYTC-D1</td>
<td>(270) 444-0087</td>
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<td>Steve Criswell</td>
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<tr>
<td>Darrin Beckett</td>
<td>KYTC-Geotech</td>
<td>(502) 564-2374</td>
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<tr>
<td>Marcie Mathews</td>
<td>KYTC 0 SHE Office</td>
<td>(502) 564-3730</td>
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<tr>
<td>Kyle Schafersman</td>
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<tr>
<td>David Kratt</td>
<td>KYTC-Highway Design</td>
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<tr>
<td>Ray Polly</td>
<td>DSHE</td>
<td>(202) 564-3730</td>
<td>Project Development</td>
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<tr>
<td>Jim Rummage</td>
<td>DSHE</td>
<td>(202) 564-3730</td>
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<tr>
<td>Jim Wathen</td>
<td>KYTC-Director</td>
<td>(502) 564-4555</td>
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</table>
Assume truss steel at 1.80 (KY-90 went for 1.50)

\[
\begin{align*}
\text{TrussSS} &:= (13614.0\text{kips} + 1795.4\text{kips}) - \frac{1800}{\text{kips}} \\
\text{TrussSS} &= 27736920 \\
\text{From KY-90 Deck}
\end{align*}
\]

\[
\text{rebar\_ratio2} := \frac{572105\text{kg}}{3407.2\text{m}^3} = \frac{283.0225}{\text{yd}^3} \\
\text{TrussAA} := (13148.6\text{-kips} + 2750.6\text{-kips} + 1800.4\text{-kips}) - \frac{\text{yd}^3}{4.05\text{-kips}} \left(\frac{450}{\text{yd}^3} + \text{rebar\_ratio}\cdot\frac{1.00}{\text{lb}}\right)
\]

\[
\text{TrussAA} = 2333956.0834
\]

\[
\text{MainSpans} := \text{PierAcost} + \text{PierBcost} + \text{PierCcost} + \text{PierDcost} + \text{TrussSS} + \text{TrussAA}
\]

\[
\text{TrussSS} + \text{TrussAA} = 30070876.0834
\]

\[
\text{MainSpans} = 49516568.1039
\]

\[
\text{Estimate for main spans}
\]

\[
\frac{\text{MainSpans}}{(\text{rwidth} + 2\cdot\text{BW})\cdot1600\text{ft}} = 444.2276 \frac{1}{\text{ft}^2}
\]

\[
\text{EstimatedCost} := (\text{WA} + \text{MainSpans} + \text{EA})\cdot1.065 \quad \text{EstimatedCost} = 65355714.5307
\]

\[
(\text{PierBcost} + \text{PierCcost})\cdot1.065 = 15329283.9522
\]

\[
(\text{PierAcost} + \text{PierBcost} + \text{PierCcost} + \text{PierDcost})\cdot1.065 = 20709662.0018
\]
APPENDIX C
Steel Weight Summary

APPENDIX C – Steel Weight Summary
### STEEL WEIGHT FOR 1 TRUSS LINE

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<th>Grade</th>
<th>Steel</th>
<th>Weight</th>
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<tr>
<td>36</td>
<td></td>
<td>487867.2030 Lb</td>
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<td>50</td>
<td></td>
<td>3260395.0795 Lb</td>
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<td>70W</td>
<td></td>
<td>393815.9248 Lb</td>
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<td></td>
<td><strong>Total for 1 Truss Line</strong></td>
<td><strong>4142078.2073 Lb</strong></td>
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### STEEL WEIGHT FOR 2 TRUSS LINES

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<td>975734.4061 Lb</td>
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<td>6520790.1590 Lb</td>
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<td>70W</td>
<td></td>
<td>787631.8496 Lb</td>
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<td></td>
<td><strong>Total for 2 Truss Lines</strong></td>
<td><strong>8284156.4147 Lb</strong></td>
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APPENDIX D
VE Study Cost Estimating Background and Development
1. OVERVIEW

The objective of this Value Engineering study is to evaluate numerous bridge options for crossing the Tennessee River as alternatives to the currently proposed design. In order to draw meaningful conclusions from the cost estimates of the various alternate it is of utmost importance to make all comparisons on an equal basis.

For this study it was decided to use historical unit prices for various bridge types and span lengths from around the country as a basis for evaluating the relative probable cost for each alternative, as opposed to estimating quantities of steel and concrete and applying material prices to estimate cost. The first task was to compile a database of historical costs for relevant bridge types and span lengths from around the country. Since the costs from these projects are potentially from different geographical locations and of different ages, the data must be manipulated to so it is relevant to the current day (2006) and western Kentucky region. Table 1 contains cost data for numerous long span bridge projects from around the country, with a majority of the data being cable-stayed bridges. The resulting unit prices for each bridge project are then brought forward to the year 2006 using ENR Construction Cost Indexes and also transferred to the western Kentucky region using RS Means Geographic Indexes. As everyone is aware, using historical unit price data requires good engineering judgment realizing that extracting costs out of bid tabs can be misleading and also realizing that each and every project represents a unique situation when it comes to long span bridges and these special situations can have potentially large impacts on the resulting cost. The data presented in Table 1 is also graphed in Figure 1 which depicts the general trend of increasing unit cost as the span length increases. What is not explicitly evident in this figure is the story behind or unique situation associated with each of these data points that may have substantially affected the project’s final cost.

With that being said the use of the manipulated historical data presented in Figure 1 represents the most appropriate information available for making relative cost comparisons between numerous long-span bridge concepts within a reasonable time frame. The important aspect of this exercise is that all concepts are evaluated on a consistent basis. This means that the relative cost comparison between various alternates should be sufficiently accurate; however, this method may not be as accurate in determining the absolute cost for any given concept.

In the Cost Estimate section for each bridge alternative the total cost indicated is an estimate for constructing the foundations, columns and superstructure for an 1,800-foot long section of bridge. This cost also includes the $28.4 million contract that has already been awarded to C.J. Mahan to construct the foundations and columns for Piers 6, 7, 8 and 9. Additionally, if a particular bridge alternate cannot utilize the foundations and columns for Piers 6 to 9, then this construction contract will need to be bought out and the cost associated with this buyout has been estimated and included with the cost estimate.

The following sections detail the development of estimated unit prices for each structure type and span lengths.
<table>
<thead>
<tr>
<th>Structure</th>
<th>Location</th>
<th>Date Bid</th>
<th>Bid Price (million)</th>
<th>Main Span Length (ft)</th>
<th>Total Length (ft)</th>
<th>Deck Width (ft)</th>
<th>Deck Area (ft²)</th>
<th>ENR Index</th>
<th>RS Means Geographic Index</th>
<th>Raw Unit Cost ($/ft)</th>
<th>Time Adjusted Cost ($/ft)</th>
<th>Time + Loc. Adjusted Cost ($/ft)</th>
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<td>18.0</td>
<td>336</td>
<td>830</td>
<td>137.0</td>
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<td>6390</td>
<td>88.4</td>
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<td>Lake Cumberland</td>
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<td>49.2</td>
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<td>1572</td>
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<td>134,668</td>
<td>6538</td>
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<td>878</td>
<td>107.0</td>
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<td>7500</td>
<td>93.6</td>
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<td>Fox River</td>
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<td>17.0</td>
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<td>-</td>
<td>102,531</td>
<td>5408</td>
<td>103.4</td>
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<td>Lower Buffalo</td>
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<td>$136</td>
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<td>Acosta</td>
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<td>-</td>
<td>-</td>
<td>4615</td>
<td>84.1</td>
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<td>Savannah, Ga.</td>
<td>1987</td>
<td>25.7</td>
<td>1100</td>
<td>2040</td>
<td>75.0</td>
<td>153,000</td>
<td>4406</td>
<td>82.3</td>
<td>$168</td>
<td>$293</td>
<td>$323</td>
</tr>
<tr>
<td>Cape Girardeau</td>
<td>Cape Girardeau, Mo</td>
<td>1997</td>
<td>50.8</td>
<td>1150</td>
<td>2086</td>
<td>93.8</td>
<td>195,729</td>
<td>5826</td>
<td>96.8</td>
<td>$260</td>
<td>$343</td>
<td>$321</td>
</tr>
<tr>
<td>Sunshine Skyway</td>
<td>Tampa, Fl</td>
<td>1987</td>
<td>71.1</td>
<td>1200</td>
<td>4000</td>
<td>95.0</td>
<td>380,000</td>
<td>5825</td>
<td>84.2</td>
<td>$187</td>
<td>$370</td>
<td>$405</td>
</tr>
<tr>
<td>Owensboro</td>
<td>Owensboro, Ky.</td>
<td>1997</td>
<td>27.1</td>
<td>1200</td>
<td>2127</td>
<td>75.2</td>
<td>155,127</td>
<td>5805</td>
<td>89.6</td>
<td>$164</td>
<td>$217</td>
<td>$219</td>
</tr>
<tr>
<td>Maumee River</td>
<td>Toledo, OH</td>
<td>2002</td>
<td>63.2</td>
<td>1225</td>
<td>1825</td>
<td>114.0</td>
<td>207,943</td>
<td>6538</td>
<td>98.0</td>
<td>$304</td>
<td>$357</td>
<td>$331</td>
</tr>
<tr>
<td>Fred Hartman</td>
<td>Baytown, TX.</td>
<td>1987</td>
<td>50.0</td>
<td>1250</td>
<td>2214</td>
<td>156.0</td>
<td>345,384</td>
<td>4406</td>
<td>89.3</td>
<td>$145</td>
<td>$253</td>
<td>$257</td>
</tr>
<tr>
<td>Sydney Lanier</td>
<td>Brunswick, Ga.</td>
<td>1996</td>
<td>54.3</td>
<td>1250</td>
<td>2496</td>
<td>79.5</td>
<td>196,432</td>
<td>5719</td>
<td>82.0</td>
<td>$274</td>
<td>$368</td>
<td>$406</td>
</tr>
<tr>
<td>Dames Point</td>
<td>Jacksonville, Fl</td>
<td>1984</td>
<td>47.0</td>
<td>1300</td>
<td>2300</td>
<td>100.0</td>
<td>273,000</td>
<td>4146</td>
<td>84.1</td>
<td>$172</td>
<td>$319</td>
<td>$344</td>
</tr>
<tr>
<td>Greenville</td>
<td>Greenville, Miss.</td>
<td>2001</td>
<td>55.4</td>
<td>1378</td>
<td>2560</td>
<td>95.0</td>
<td>243,170</td>
<td>6334</td>
<td>78.9</td>
<td>$228</td>
<td>$277</td>
<td>$318</td>
</tr>
<tr>
<td>Annacis</td>
<td>Vancouver, BC.</td>
<td>1984</td>
<td>45.7</td>
<td>1525</td>
<td>2724</td>
<td>105.0</td>
<td>286,020</td>
<td>4146</td>
<td>108.2</td>
<td>$160</td>
<td>$296</td>
<td>$248</td>
</tr>
<tr>
<td>Carquinez</td>
<td>San Francisco, CA</td>
<td>1999</td>
<td>190.0</td>
<td>2388</td>
<td>3474</td>
<td>84.0</td>
<td>291,705</td>
<td>6059</td>
<td>124.2</td>
<td>$651</td>
<td>$837</td>
<td>$664</td>
</tr>
<tr>
<td>Tacoma Narrows</td>
<td>Tacoma, Wa.</td>
<td>2002</td>
<td>340.0</td>
<td>2800</td>
<td>5400</td>
<td>78.0</td>
<td>421,052</td>
<td>6538</td>
<td>103.4</td>
<td>$807</td>
<td>$950</td>
<td>$833</td>
</tr>
</tbody>
</table>

Current ENR Construction Cost Index (May 2006) = 7690
Base Geographic Index (Paducah, KY) = 90.7

Notes:
1. All bridges are cable-stayed unless noted otherwise.
2. Segmental concrete CIP
3. Parallel chord truss
4. Steel box girder
5. Steel plate girder
6. Suspension
7. Tied Arch
8. 2-Span Through Truss
2. TIED ARCH WITH 900' SPAN

Use the Blennerhassett Island, WV tied arch bridge that is currently under construction as the basis of unit price for the Tied Arch alternates.

Blennerhassett is an excellent data point due to the similarity in span length, bridge width and geographical location.
Span Length = 878’
Bridge Width = 107’
Bid in 2005, currently under construction
Bid price for mainspan structure was approximately $45.0 million; however, use $50.0 million as basis to account for construction issues and cost overruns that will occur during construction.
Assume that of the $50.0 million, $40.0 million of this represents the superstructure value:

\[
\frac{40,000,000}{878' \times 107'} = \$425/sf \text{ for the superstructure alone}
\]

**Use $425/sf for the superstructure.**
3. 3-SPAN PARALLEL CHORD THROUGH TRUSS WITH MAINSPAN LENGTH OF 900’

This bridge type represents the unit price development for an efficiently designed traditional through truss using a moment resisting frame in the transverse direction as opposed to lateral sway bracing portals at all verticals.

The Talyor-Southgate bridge in Cincinnati, Ohio is an excellent example of an efficiently designed parallel chord truss; however, it was built in 1991 which means it must be extrapolated forward 15 years reducing the reliability of the results.

Span lengths: 574’ – 850’ – 425’; Width = 67’
Characteristics are very similar to US-60 over Tennessee River.

$209/sf in 1991, extrapolate forward using ENR Indexes to $322/sf in 2006 (based upon Figure 1 this value is in the middle of the available data)

Engineering Judgment – Use $400/sf for substructure plus superstructure as a more conservative estimate.

Assume superstructure represents 65% of total bridge costs, therefore:
Superstructure cost = $400/sf * 0.65 = $260/sf

Use $275/sf for the superstructure

3.1 MODIFIED 3-SPAN PARALLEL CHORD THROUGH TRUSS WITH MAINSPAN LENGTH OF 900’

This concept is essentially the same as above; however, minor modifications are made to improve the aesthetics of the truss. The modifications include eliminating the verticals from the truss and providing fewer top chord lateral bracing members. An excellent example of this concept is the I-526 Bridge over Cooper River, Charleston, South Carolina. This bridge was constructed in 1992 and cost data was not available.

The modifications to the traditional parallel chord truss are relatively minor and should have a result of increasing the unit cost of the bridge. By eliminating the verticals the structural efficiency of the diagonals will be slightly reduce, and the connections between the transverse floor beams, lower lateral bracing and top lateral bracing to the chord members will be more complicated.

Use $285/sf for the superstructure
4. CABLE-STAYED BRIDGE WITH 900’ MAINSPAN LENGTH

There are several relevant data points for estimating the unit cost for a cable-stayed bridge with short to medium span lengths. From Figure 2 the following projects are considered relevant in determining a unit cost:

- Cochrane Bridge; Mobile, AL (800’ Span, 1985)
- East Huntington Bridge; Huntington, WW (900’ Span, 1981)
- U.S. Grant Bridge; Portsmouth, OH (875’ Span, 2001)
- Maysville Bridge; Maysville, KY (1050’ Span, 1997)
- Clark Bridge, Alton, IL (756’ Span, 1991)
- Weirton-Steubenville Bridge, Steubenville, OH (820’ Span, 1988)
- Talmadge Bridge, Savannah, GA (1100’ Span, 1987)
- Cape Girardeau Bridge, MO (1150’ Span, 1997)

The data point associated with the U.S. Grant bridge, which is currently under construction by C.J. Mahan, has been adjusted upward to approximately $400/sf to account for construction issues and claims that have occurred over the past several years that is running the effective price for the bridge up substantially. The Weirton-Steubenville Bridge data point is being ignored as it is an outlying point and appears to be inconsistent with the remainder of the cable-stayed bridge points.

Based upon the data points indicated above and in Figure 2, engineering judgment is utilized to recommend a unit price of $500/sf taking into consideration the poor foundation conditions that exist at this Tennessee River site.

Use $500/sf for the substructure plus superstructure
5. CABLE-STAYED BRIDGE WITH 1,200’ MAINSPAN LENGTH

There are several relevant data points for estimating the unit cost for a cable-stayed bridge with medium to long span lengths. From Figure 3 the following projects are considered relevant in determining a unit cost:

- Fred Hartman Bridge, Baytown, TX (1250’ Span, 1987)
- Owensboro Bridge, Owensboro, KY (1200’ Span, 1997)
- Annacis Bridge, Vancouver, BC (1524’ Span, 1984)
- Dame Point Bridge, Jacksonville, FL (1300’ Span, 1984)
- Cape Girardeau Bridge, MO (1150’ Span, 1997)
- Sunshine Skyway Bridge, Tampa, FL (1200’ Span, 1982)
- Sydney Lanier Bridge, Brunswick, GA (1250’ Span, 1996)
- Greenville Bridge, Greenville, MS (1378’ Span, 2001)
- Maumee River Bridge, Toledo, OH (1225’ Span, 2002)

The data points associated with Fred Hartman (foreign steel), Owensboro and Annacis Island Bridge all appear to be of questionable accuracy and have not been used to pick an appropriate unit cost for a cable-stayed bridge.

Based upon the data points indicated above and Figure 3, engineering judgment is utilized to recommend a unit price of $550/sf taking into account the poor foundation conditions that exist at this Tennessee River site.

**Use $550/sf for the substructure plus superstructure**
6. STEEL PLATE GIRDER AND BOX GIRDERS WITH 400’ TO 500’ SPAN LENGTHS

Use the Lower Buffalo Bridge in West Virginia as a data point for continuous steel girder structures in the 400’ to 500’ span lengths.

5-Span continuous steel plate girder over the Kanawha River. Total bridge length is 1850’ with a mainspan of 525’. Bridge width = 38.7’
Bid in 1997

For Tennessee River use $300/sf (substructure and superstructure)
For superstructure only = 0.65 * $300/sf = $195/sf

   **Use $200/sf for the superstructure**

7. STEEL PLATE GIRDERS WITH 200’ TO 250’ SPAN LENGTHS

Assume that the steel plate girders are at a minimum 2-span continuous units for efficiency.

   **Use $125/sf for the superstructure**

8. DECK TRUSS

Make the assumption that a below deck truss is nearly equivalent in unit cost to an above deck through truss. However, the cost implications of raising the profile to accommodate a below deck structural system will need to be addressed.

9. EXTRADOSED BRIDGE

There are essentially no data points for Extradosed bridges in the United States that have gone through the bidding process; therefore, assumptions must be made in order to estimate a reasonable unit price.

In general, at 900’ span length the Extradosed structural system should be slightly more efficient than a cable-stayed bridge. For a cable-stayed bridge, the 900’ span length is on the shorter end of the spectrum. For this reason assume that the Extradosed is slightly less expensive than a cable-stayed bridge.

   **Use $450/sf for the substructure plus superstructure**
APPENDIX E
Creative Idea List and Evaluation

APPENDIX E - Creative Idea List and Evaluation
<table>
<thead>
<tr>
<th>ID #</th>
<th>Name of Idea / description</th>
<th>Develop Status</th>
<th>TM Resp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>New superstructure design removing the sway bracing, lowering the deck and using moment connections</td>
<td>Develop</td>
<td>A Thomas T Choate D Jasper</td>
</tr>
<tr>
<td>2</td>
<td>Paint all steel on the original bridge design</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Paint only the steel above the deck on the original bridge or the revised bridge</td>
<td>Develop</td>
<td>A Thomas T Choate D Jasper</td>
</tr>
<tr>
<td>4</td>
<td>New superstructure design with a 900 ft tied arch and plate girder tail spans</td>
<td>Develop</td>
<td>J Bargo D Jeakle</td>
</tr>
<tr>
<td>5</td>
<td>New superstructure design 900 ft truss and box girder tail spans</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>New superstructure design with three tied arches</td>
<td>Develop</td>
<td>J Bargo D Jeakle</td>
</tr>
<tr>
<td>7</td>
<td>Cancel current contract and replace it with a new design using a 900 ft center span cable stay bridge</td>
<td>Develop</td>
<td>J Bargo D Jeakle</td>
</tr>
<tr>
<td>8</td>
<td>New superstructure design 900 ft trussed arch and plate girder tail spans</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Replace the current design with 900 ft tied arch and shortened plate girder tail spans (250/250,200/200)</td>
<td>Develop</td>
<td>J Bargo D Jeakle</td>
</tr>
<tr>
<td>10</td>
<td>New superstructure design using concrete segmental</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Replace the current design with extradosed design (hybrid cable girder)</td>
<td>Develop</td>
<td>J Bargo D Jeakle</td>
</tr>
<tr>
<td>12</td>
<td>Replace the current design with a below deck truss design</td>
<td>Develop</td>
<td>J Bargo D Jeakle</td>
</tr>
<tr>
<td>13</td>
<td>Replace the current design with a below deck arched truss design</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Replace the current design with a K-frame design</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Replace the current design with concrete segmented post tension tail spans</td>
<td>Develop</td>
<td>J Bargo D Jeakle</td>
</tr>
<tr>
<td>16</td>
<td>Replace the current design with 900 ft suspension bridge</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>New 900 ft tied arch design using steel box sections in the construction of the 400 ft and 500 ft tail spans</td>
<td>Develop</td>
<td>J Bargo D Jeakle</td>
</tr>
<tr>
<td>18</td>
<td>Use closed sections for the main span</td>
<td>Develop</td>
<td>J Bargo D Jeakle</td>
</tr>
<tr>
<td>19</td>
<td>New superstructure design using Vierendeel Truss</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Cancel current contract and change spans to 500 ft 800 ft 500 ft</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Add vertical supports in the center lane</td>
<td>Develop</td>
<td>D Jeakle</td>
</tr>
</tbody>
</table>
## List of CREATIVE IDEAS

<table>
<thead>
<tr>
<th>ID #</th>
<th>Name of Idea / description</th>
<th>Develop Status</th>
<th>TM Resp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>Use tube rail instead of jersey barriers</td>
<td>Design comment +cost</td>
<td>A Thomas T Choate D Jasper</td>
</tr>
<tr>
<td>23</td>
<td>Add more aesthetic barriers</td>
<td>Design comment +cost</td>
<td>A Thomas T Choate D Jasper</td>
</tr>
<tr>
<td>24</td>
<td>Increase the width for more user friendly bike lane</td>
<td>Design comment +cost</td>
<td>A Thomas T Choate D Jasper</td>
</tr>
<tr>
<td>25</td>
<td>Replace the jersey barriers with see through steel barriers</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Add aesthetic lighting on the structure</td>
<td>Design comment +cost</td>
<td>A Thomas T Choate D Jasper</td>
</tr>
<tr>
<td>27</td>
<td>Add a theme lighting plan on the approach structure</td>
<td>Design comment +cost</td>
<td>A Thomas T Choate D Jasper</td>
</tr>
<tr>
<td>28</td>
<td>Use colored concrete for the bridge deck construction</td>
<td>Design comment +cost</td>
<td>A Thomas T Choate D Jasper</td>
</tr>
<tr>
<td>29</td>
<td>Replace the current design with design similar to cooper bridge design</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Have public involvement meeting to discuss the color light and provide information</td>
<td>Design comment</td>
<td>A Thomas T Choate D Jasper</td>
</tr>
<tr>
<td>31</td>
<td>Enclose the current structure and add lighting</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Replace the current design with new truss bridge design using moment connections, a lower bridge deck, and lighter members (similar to cooper river)</td>
<td>Develop</td>
<td>J Bargo D Jeakle</td>
</tr>
<tr>
<td>33</td>
<td>Use alternative bidding method (summit multiple designs).</td>
<td>Develop</td>
<td>J Bargo</td>
</tr>
<tr>
<td>34</td>
<td>Make the superstructure a design/build project</td>
<td>Develop</td>
<td>J Bargo</td>
</tr>
<tr>
<td>35</td>
<td>Contract out bridge design</td>
<td>Eliminated</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Decorate and enhance the portal appearance</td>
<td>Design comment +cost</td>
<td>A Thomas T Choate D Jasper</td>
</tr>
<tr>
<td>37</td>
<td>Delete the center pier and build a cable stay or suspension bridge</td>
<td>Develop</td>
<td>J Bargo D Jeakle</td>
</tr>
<tr>
<td>39</td>
<td>Decrease total steel weight in proposed truss design</td>
<td>Develop</td>
<td>D Jeakle</td>
</tr>
<tr>
<td>ID #</td>
<td>Name of Idea / Description</td>
<td>Reason for Elimination</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>---------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Paint all steel on the original bridge design</td>
<td>Painting is already included in the current design</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>New superstructure design 900 ft truss and plate girder tail spans</td>
<td>Will add less aesthetic value than idea number 4 and will have a higher cost</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>New superstructure design 900 ft trussed arch and plate girder tail spans</td>
<td>It complicates a tied arch design, adds little aesthetic value and adds cost</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>New superstructure design using concrete segments</td>
<td>Weight of new structure would be too great</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Replace current design with a below deck arched truss design</td>
<td>Depth of structure is too great for approaches and does not provide enough clearance for barge traffic.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Replace current design with a K-frame design</td>
<td>Depth of structure is too great for approaches and does not provide enough clearance for barge traffic.</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Replace current design with 900ft suspension bridge</td>
<td>Not economical</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>New superstructure design using Vierendeel Truss</td>
<td>Not efficient</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Cancel current contract and change spans to 500ft 800ft 500ft</td>
<td>Design causes conflicts with easement, environmental concerns, constructability, and river migration</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Replace jersey barriers with see through steel barriers</td>
<td>No real benefit</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Replace current design with cooper bridge design</td>
<td>Same as idea number 32</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Enclose the current structure and add lighting</td>
<td>Does not add significant aesthetic value without added significant cost</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Contract out bridge design</td>
<td>Decision will be made by KTC if necessary</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX F
Site Pictures
Site Picture 1: Existing US 60 Bridge over the Tennessee River

Site Picture 2: Ground breaking/clearing on riverbank in preparation for pier construction
Site Picture 3: Driven piling for pier construction

Site Picture 4: Cleared site ready for pier construction
END OF REPORT

This report was compiled and edited by:
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