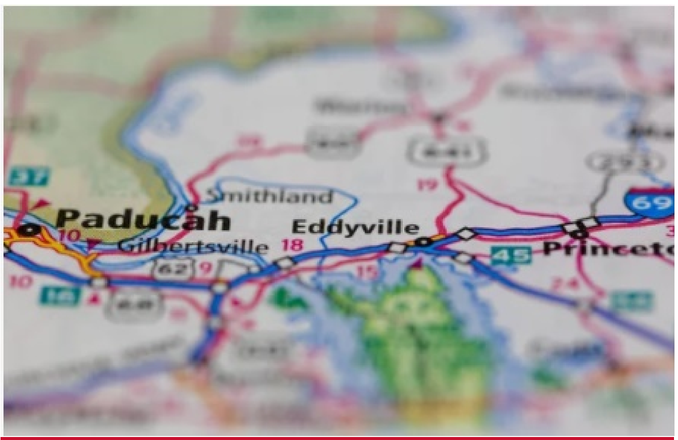

DRAFT

Value Engineering Study Report

US 641 Connect Eddyville to Fredonia

Kentucky Transportation Cabinet (KYTC)

Item #1-187.31

Caldwell and Lyon Counties, Kentucky

June 28 - July 2, 2021

Prepared by:

HDR Engineering, Inc.
401 West Main Street
Suite 500
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Disclaimer

The information contained in this report is based on the professional opinions of the Value Engineering (VE) team members as developed during the study. These opinions are based on the information that was provided to the team at the time of the study. As the project continues to develop, recommendations and findings should be reevaluated as new information is received.

All costs displayed in the report are based on best available information at the time of the study and, unless otherwise noted, used the estimate as provided to the VE team. All drawings, graphics, maps, photos, etc., used in the report were supplied by the study sponsor or developed during the study.

The disposition of recommendations is based on the information in this report; it is independent of the resolutions generated after the study. HDR has no participation, direct or indirect, in such decisions.

For any recommendations that are accepted by the owner and design team as a result of this VE study, the responsibility for implementation into the design rests with the designer of record.

Study Statistics	
Baseline Cost:	$68.8M
Number of Recommendations:	6
Recommended Cost Savings:	$26.23M
Total Number of Team Members:	8
KYTC Employees:	2
Others:	6
Facilitator Consultant:	HDR

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Executive Summary

Introduction

This report summarizes the events and results of the virtual VE study conducted by HDR Engineering, Inc. for the Kentucky Transportation Cabinet (KYTC) on the US 641 Connect Eddyville to Fredonia project in Caldwell and Lyon Counties, Kentucky. The VE study consisted of a 5-day workshop that was conducted virtually with a multidisciplinary team on June 28 - July 2, 2021 using Webex and Microsoft Teams.

Project Overview

This project includes the relocation and reconstruction of US 641 from Eddyville to Fredonia, Kentucky. This is part of a larger effort to improve freight mobility to the City of Marion in Crittenden County, north of Fredonia along the US 641 corridor. This relocation and reconstruction project will also improve safety and emergency vehicle response and expand access to recreation and tourist areas.

The proposed project typical section will consist of four lanes (two 12-foot lanes in each direction), outside shoulders of 12 feet (10 foot paved), and inside shoulders of 6 feet (4 foot paved), with a 40-foot depressed median. For additional information regarding the preferred alignment, please see Section 2.3, Proposed Improvements.

At the time of the VE study, the total cost of construction was estimated at $68.8 million. An estimate for other items such as right-of-way, utilities, construction engineering, and design was not provided.

Scope of VE Study

The primary objectives of the study, through execution of the Value Methodology Job Plan (Appendix A), were to:

- Verify or improve on the various design concepts for the identified section of the US 641 Connect Eddyville to Fredonia project.
- Conduct a thorough review and analysis of the key project functions using an independent, multidiscipline, cross-functional team.
- Improve the value of the project through innovative measures aimed at improving the performance while reducing costs of the project.

VE Recommendations and Study Results

The VE team generated 40 ideas for the project. These concepts were compared against the baseline developed by the project team. The concepts that resulted in improved performance were further developed by the VE team and resulted in six recommendations.

The individual recommendations are summarized below; the detailed information about each recommendation is included in Section 7.3.

1—Strengthen Access Control – Remove unnecessary access points and associated median openings throughout the corridor. Purchase access control for all frontage between the designed access points. Develop a corridor access management policy and agreement to be adopted by KYTC and local governments to support enforcement as permit requests are made in the future.

2—Design for Two Construction Sections – Divide the design into two construction sections with a temporary tie-in to existing alignment south of Bakers Road. Build the northern section first.

3—Optimize Profile to Promote Earthwork Balance – Use the known constraints of major utility crossings, approximate stream high water, and intersection tie-ins, to optimize the profile to promote earthwork balance.

4—Modify Structures 1, 2, & 3 – The VE team reviewed preliminary layouts for the structures and recommend changes to three structures:

- Structure 1: Modify alignment to avoid channel change and use a cast-in-place box culvert in lieu of precast prestressed concrete bridge
- Structure 2: Evaluate the drainage opening requirements and consider limiting the rise to no more than 1.0 foot
- Structure 3: Use a cast-in-place box culvert in lieu of precast prestressed concrete bridge

5—Alternative 4-Lane Typical Section – The VE team evaluated three options for changing the Preferred Typical Section regarding the ultimate configuration of the project. The VE team's recommended alternative eliminates the 40-foot depressed median and replaces it with a 4-foot paved median, while maintaining the rest of the Preferred Typical Section.

6—Alternative 2+1 Typical Section – Change the typical section from what is proposed to a 2+1 roadway for the length of the new route. The 2+1 roadway would have two 12-foot lanes with an alternating 12-foot passing lane and 12-foot outside shoulders.

After developing the VE recommendations, the VE team reviewed and discussed each alternative and developed a consensus relative to its prioritization for implementation. The prioritization was based on factors that include improved performance, likelihood of implementation, cost savings, or any combination thereof. The following two VE strategies were developed as complimentary combinations of individual VE recommendations that were deemed the highest in priority, as shown within Table 1. Summary of Recommendations and Value Strategies below.

Value Strategy—4-Lane Ultimate – This strategy includes Recommendations 1, 2, 3, 4, and 5. The strategy suggests an ultimate configuration that eliminates the 40-foot depressed median and replaces it with a 4-foot paved median while maintaining the rest of the Preferred Typical Section.

Value Strategy—2+1 Ultimate – This strategy includes Recommendations 1, 2, 3, 4, and 6. This strategy proposes an alternative typical section of a 2+1 roadway for the length of the new route as the ultimate configuration.

The cost savings shown in Table 1 for the Ultimate 4-Lane and Ultimate 2+1 VE strategies were determined by comparing the strategies to the preferred ultimate four-lane baseline configuration (described in more detail within Section 2.3, Proposed Improvements).

Table 1. Summary of Recommendations and Value Strategies

#	Recommendation Title	Cost Savings/ (Cost Added) ($M)	
		4-Lane Ultimate	2+1 Ultimate
1	Strengthen Access Control	$0.96	$0.96
2	Design for Two Construction Sections	($0.67)	($0.67)
3	Optimize Profile to Promote Earthwork Balance	$7.93	$3.97
4	Modify Structures 1, 2, & 3	$3.25	$1.62
5	Alternative 4-Lane Typical Section	$7.20	
6	Alternative 2+1 Typical Section		$20.35
	Total Savings	$18.67	$26.23

A summary of the cost, performance, and value change of the VE strategies is provided in Table 2. The performance scores for each VE strategy were divided by the total cost scores to derive a value index. The value indices for the VE strategies were then compared against the value index of the baseline concept and the difference is expressed as a percent (±%) deviation. Please refer to Section 7.4, Performance Assessment, for more information on the value comparison of the VE strategies.

Table 2. Value Matrix – Baseline vs VE Strategies

Strategy	Performance (P)	% Change Performance	Cost (C) $ millions	Cost Change $ millions	% Change Cost	Value Index	% Value Improvement
Preferred - Ultimate	500	---	$68.8	---	---	7.27	---
Value Strategy - 4-Lane Ultimate	530	+6.0%	$50.1	($18.67)	-27.1%	10.57	+45.4%
Value Strategy - 2+1 Ultimate	573	+14.6%	$42.6	($26.23)	-38.1%	13.46	+85.2%

Implementation of Recommendations

To facilitate implementation, a Value Engineering Recommendation Approval Form is included as Appendix B. If the state elects to reject or modify a recommendation, please include a brief explanation of the decision.

The VE team wishes to express its appreciation to the project design managers for the excellent support they provided during the study. We hope that the recommendations and design considerations provided will assist in the management decisions necessary to move the project forward through the project delivery process.

Blane Long, CVS®
VE Facilitator

1 Introduction

This VE report summarizes the events of the virtual VE study conducted for the Kentucky Transportation Cabinet (KYTC) and facilitated by HDR using WebEx. The subject of the study was the US 641 Connect Eddyville to Fredonia project. The VE study was conducted June 28 - July 2, 2021 while the project was in the 30 percent to 35 percent design phase.

1.1 Scope of VE Study

Value is expressed as the relationship between functions and resources, where function is measured by the performance attributes defined by the customer, and resources are measured in materials, labor, price, and time required to accomplish that function. VE focuses on improving value by identifying the most resource-efficient way to reliably accomplish a function that meets the performance expectations of the customer.

The primary objectives of the study, through execution of the Value Methodology Job Plan (Appendix A), were to:

- Verify or improve on the various concepts for the identified section of the US 641 Connect Eddyville to Fredonia project.
- Conduct a thorough review and analysis of the key project functions using a multidiscipline, cross-functional team.
- Improve the value of the project through innovative measures aimed at improving the performance while reducing costs of the project.

With this process, the VE team identified the essential project functions and alternative ways to achieve those functions; the team then selected the optimal recommendations to develop into workable solutions for value improvements.

1.2 VE Team Members

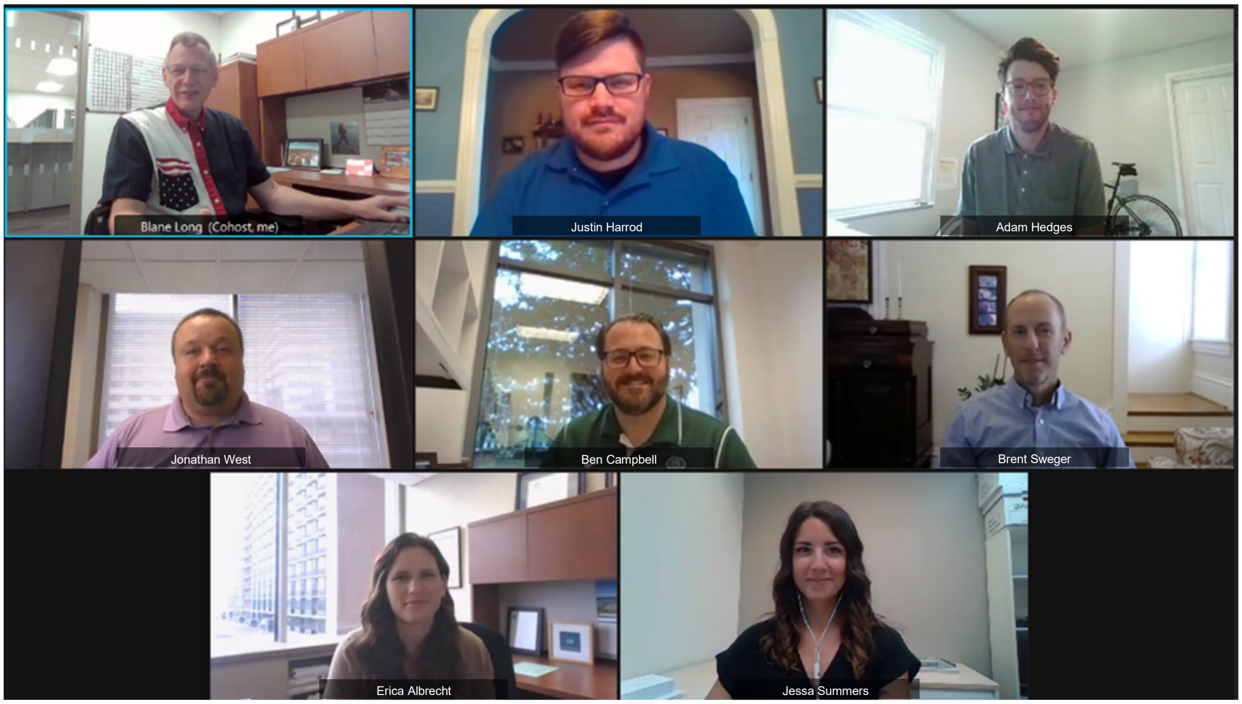
The VE study was facilitated by a Certified Value Specialist (CVS) from HDR. Multiple representatives and members of the KYTC project team also participated in the VE process to provide insight into the project's background and design development, as well as their requirements for the project and expectations for the VE study. Their support of this study is greatly appreciated, and the results provided herein reflect the information they provided throughout the study.

The VE team included the following individuals. See Appendix C for details of attendees.

- Blane Long, CVS | HDR
- Jessa Summers | HDR
- Ben Campbell, PE | HDR
- Erica Albrecht, PE | HDR
- Jonathan West, PE | HDR

- Adam Hedges, PE | HDR
- Justin Harrod | KYTC
- Brent Sweger | KYTC

Figure 1. Team Photo



2 Information Phase

To successfully identify alternatives, it is essential that the VE team first understand the project objectives and problems that must be solved. The VE team received the documentation and drawings from the project design team as shown in Table 3. The design team also introduced the project and its characteristics on the first day of the study. Project details and challenges as presented by the design team are summarized below.

2.1 Information Provided to VE Team

Table 3 lists the project documents provided to the VE team for use during the study.

Table 3. Information Provided to the VE Team

Document/Drawing/Schematic	Document Date
1-187.31 Cost Estimate	May 2021
1-187.31 Preferred Alternate Cross Sections	May 2021
1-187.31 Preferred Alternate Exhibit	May 2021
1-187.31 Preferred Alternate Profile	May 2021
1-187.31 Preferred Alternate Typicals	May 2021
1-187.31 Lyon- Caldwell County, US 641, Environmental Assessment	May and June 2021
US 641 Corridor D Alignment	2013
US 641 Preliminary Preferred Alternate	2019
Lyon and Caldwell Counties Traffic Forecast	February 2008
US 641 Crash Analysis Files	October 2016 to February 2020
US 641 Preferred Drainage Areas.dgn File	N/A
US 641 Manuscript.dgn File	N/A

2.2 Project History and Purpose and Need

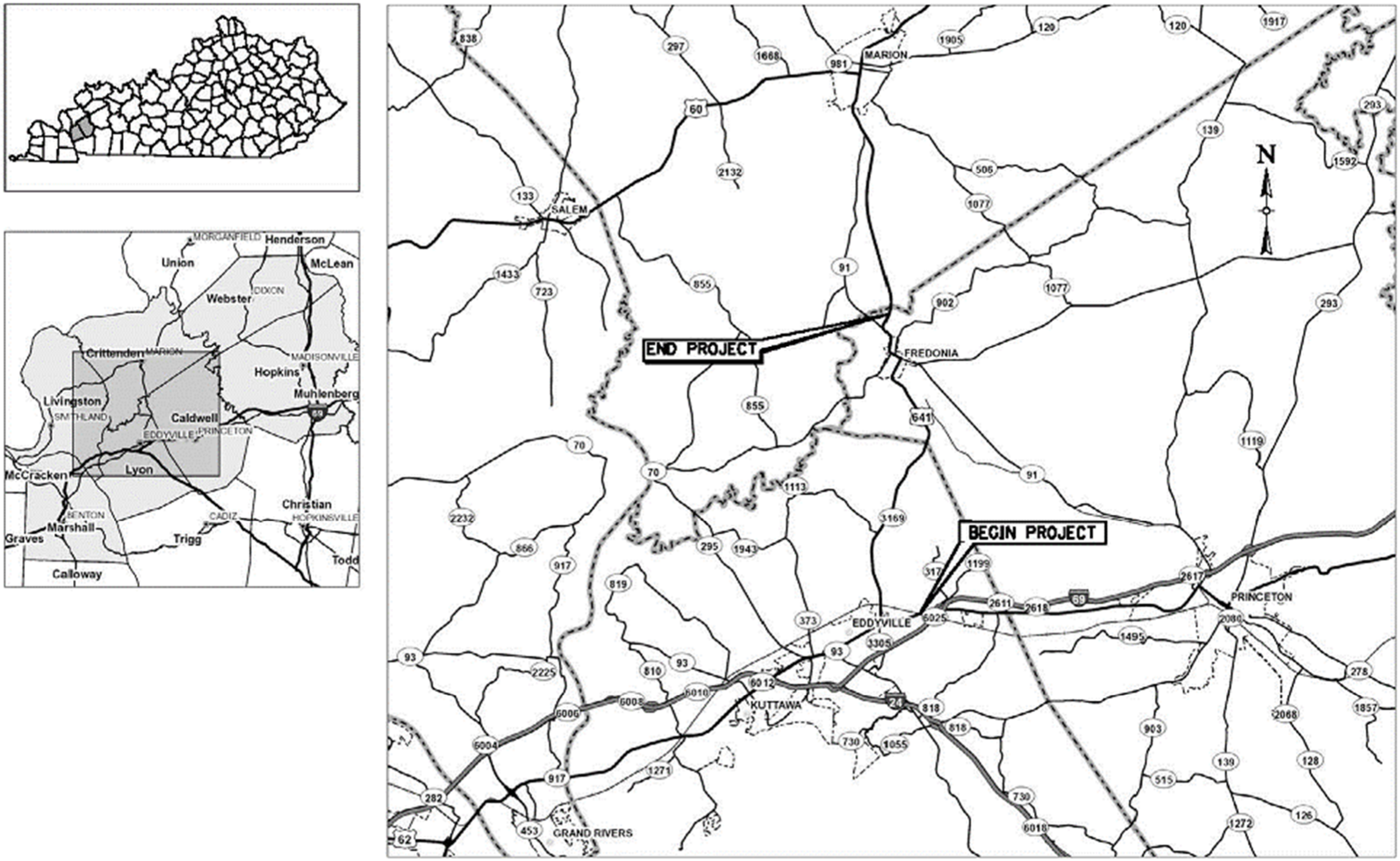
The following project history and information was extracted from the information and documentation provided by EA Partners, LLC (design team).

This project includes the relocation and reconstruction of US 641 from Eddyville to Fredonia, Kentucky. This is part of a larger effort to improve freight mobility to the City of Marion in Crittenden County, north of Fredonia along the US 641 corridor.

The project begins at the US 62/US 641 intersection approximately 1.7 miles west of the I-69 overpass (see Figure 2). The existing alignment extends north, generally, through Fredonia and then to the west, leaving the study corridor. The existing roadway has two 11-foot driving lanes with two to four-foot shoulders. There are numerous deficiencies in both the horizontal and vertical geometry. The existing road has a posted speed limit of 55 mph, except in Fredonia where it drops to 35 mph. US 641 has residences on either side and is used by a significant number of large trucks. US 641 in the project area is a Minor Arterial and an “AAA” truck weight class roadway.

The project purpose is to facilitate freight movement along the US 641 corridor from I-24 and I-69 to Marion as the last of three sections of US 641 improvement projects to Marion. This project will improve safety and emergency vehicle response times between Eddyville and Fredonia, to maintain connectivity while minimizing the potential detrimental economic effects of bypassing Fredonia, to provide improved access to regional recreational and tourist areas and reduce congestion, and to minimize the acquisition of privately owned land in favor of using publicly owned land to help maintain the property tax base.

Figure 2. Project Vicinity Map

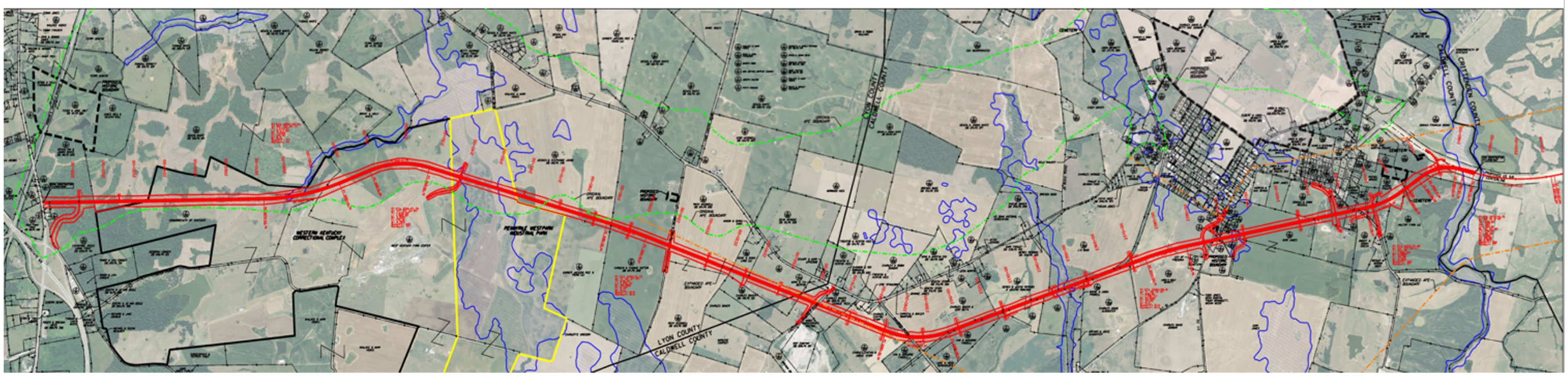


2.3 Proposed Improvements

Years of study and analysis by environmental specialists, planning and design engineers, and local and state elected officials were undertaken in the development of this project. Additionally, extensive public involvement (public meetings, comments and letters, numerous meetings with local government officials, property owners, Section 106 consulting parties, and other interested parties) provided input on how to revise proposed alignments to minimize environmental impacts while fulfilling the purpose and need of the project.

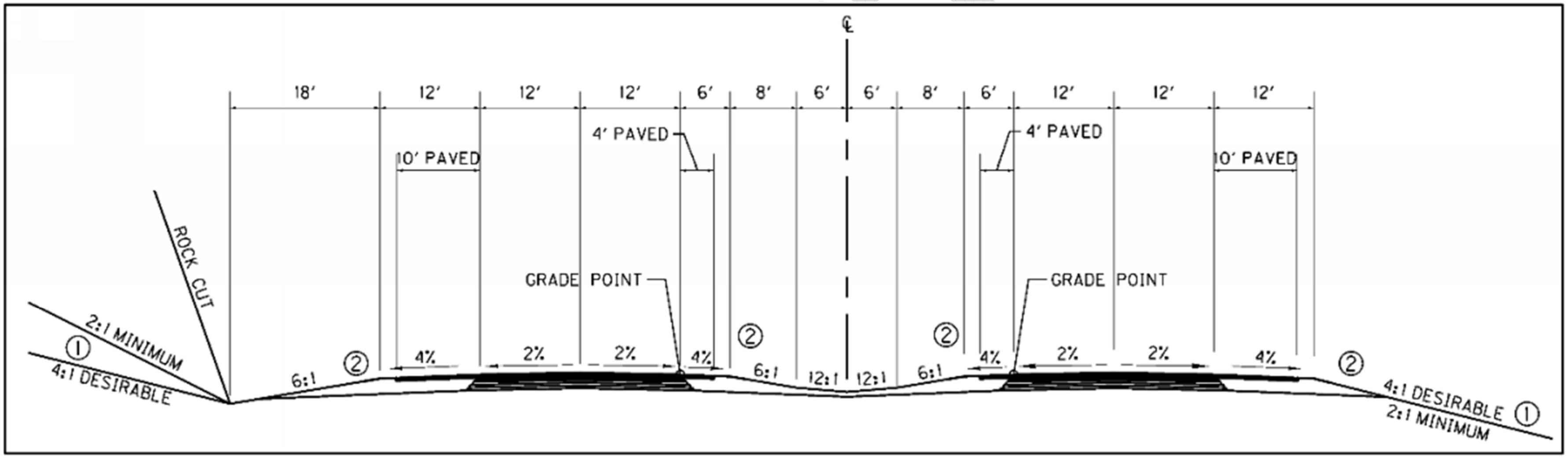
The Preferred Alternate (Figure 3), used as the baseline for this VE study, begins on US 62 approximately 1,300 feet west of the I 69/US 62 interchange. The alignment generally runs northwest approximately 2.0 miles and then curves to the northeast approximately 3000 feet south of New Bethel Church Road. It continues northeast approximately 3.2 miles crossing Beck Road approximately 0.5 miles east of the US 641 intersection. In these two segments it crosses approximately 2.8 miles of Commonwealth of Kentucky property. The alignment curves to the left approximately 1,600 feet south of Bakers Road and runs generally northwest for approximately 3.2 miles crossing KY 91 on the east side of Fredonia approximately 1200 feet west of the KY 70 intersection. The Item 1-187.31 alignment curves to the northwest and then back to the north and ties into Item 1-187.23. The total length of this project is approximately 9.2 miles.

Figure 3. Preferred Alternate



The proposed project typical section (Figure 4) will consist of four lanes (two 12-foot lanes in each direction), outside shoulders of 12 feet (10 foot paved), and inside shoulders of 6 feet (4 foot paved) with a 40-foot depressed median. Initial construction will be two lanes with provisions for four lanes in the future. The design speed is 55 mph and the posted speed will remain at 55 mph for this facility. Access will be partially controlled.

Figure 4. Preferred Typical Section (Ultimate)



2.4 Project Issues

As part of the project briefing, the VE team was given the following project constraints, controlling factors, and other issues that needed to be considered when evaluating ideas:

- The current preferred alignment has undergone many iterations since 2006. There have been extensive efforts to minimize property acquisition, both of homes and private land. The most recent alignment was reviewed during a public meeting in 2019 with local leaders in Lyon, Caldwell, and Crittenden counties. The current preferred alignment was revised based on comments from that meeting and will be presented during a public hearing in July 2021. While alternatives that adjust the alignment will be reviewed, changes to the right-of-way may cause additional environmental and public involvement efforts.
    - The key areas to avoid or minimize impacts on for this project are:
        - Western Kentucky Correctional Facility
            - Right-of-way cannot encroach closer than 500 yards from existing Prison internal fence
        - Environmental
            - Holt-Goodman Farm
            - Rice-Beck-Sutton Farm
            - Crider-Stock Farm
        - Rock Quarry
- The alignment can follow abandoned rail line north of the rock quarry
- The Western Pennyrile Industrial Park can be bisected by the alignment
- Project should consider a 4-lane roadway as the ultimate configuration

2.5 Project Schedule

The project was at the 30 to 35 percent design stage with final design expected to be completed in 2022. Right-of-way acquisition is scheduled for 2023 with construction planned to begin in 2025.

2.6 Project Cost Estimate

At the time of the study, the VE team was provided with the most recent cost estimate. An abbreviated estimate is shown in Table 4. See Appendix D for a detailed estimate.

Table 4. Cost Estimate – Baseline Concept

Cost Item	Cost	Percent of Total	Cumulative Percentage
Paving & Surfacing	$28,724,020.00	41.7%	42%
Contingency	$13,768,913.00	20.0%	62%
Embankment	$10,717,679.00	15.6%	77%
Bridge	$9,169,440.00	13.3%	91%
Mobilization & Demobilization	$3,361,425.00	4.9%	95%
Drainage	$3,103,089.00	4.5%	100%
Total	$68,844,566.00	100.0%	

3 Project Analysis

3.1 VE Focus Points and Observations

Prior to the VE study and during the Information Phase, several activities were conducted to better understand the baseline concept. The following summarizes key focus points and observations identified during these sessions and the VE team's initial analysis.

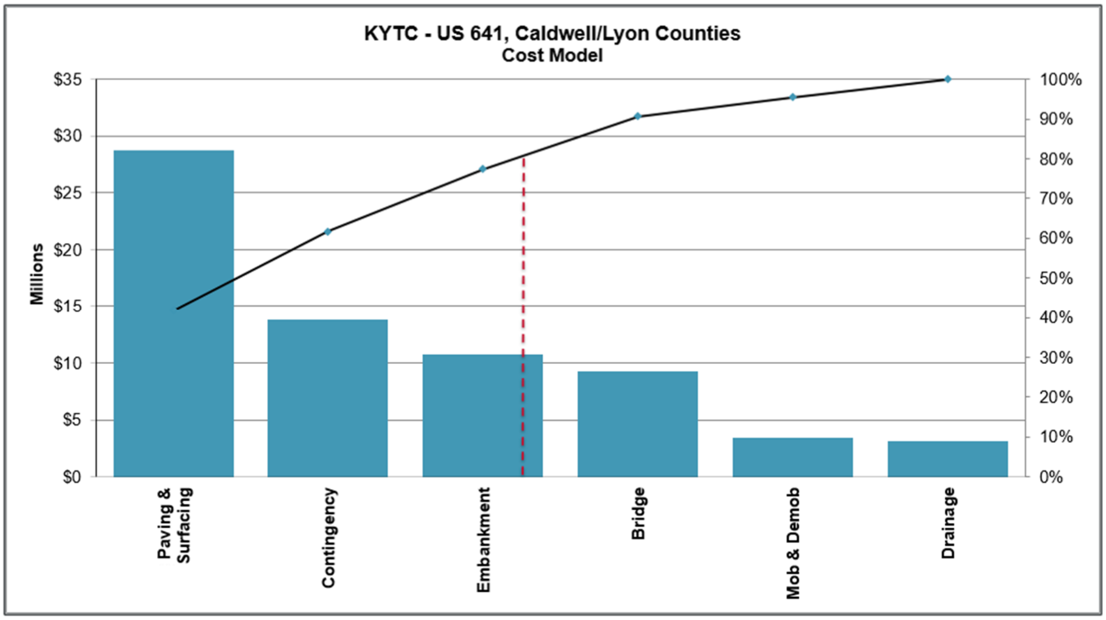
- Design Speed and Posted Speed are both 55 mph.
- There are four natural gas transmission lines along this portion of the US 641 corridor. They are 3 to 3.5 feet deep. If an additional 3 feet of fill is added on top (to maintain 6 feet total), then the lines should not need to be relocated.
- Average daily traffic (ADT) volumes in Lyon County was 2,969 in 2020 and 2,515 in Caldwell County in 2018.
- There is karst topography and sinkholes in the area.

3.2 Cost Model

The VE facilitator prepared a cost model from the cost estimate, which was provided by the project team. The model was organized to identify major construction elements or trade categories, the design team's estimated costs, and the percent of total project cost for the significant cost items (Figure 5).

The cost model allows the team to focus on project elements with the highest degree of impact and utilize their time most effectively.

Figure 5. Cost Model



3.3 Value Metrics

The value metrics process was used as an analysis tool to evaluate the baseline project and the VE recommendations. Value metrics is a system of techniques predicated on the theory that value is an expression of the relationship between the performance of a function and the cost of acquiring it. It provides a standardized means of identifying, defining, evaluating, and measuring performance. Performance is quantified in terms of how well a set of attributes contribute to the overall functional purpose of a given project.

The basic equation used for calculating value is:

$$Value = \frac{Performance}{Cost + Time}$$

In other words, value is equivalent to the relationship of the resources needed to provide a certain level of performance for a given function. Performance is defined as a set of requirements and attributes of a project’s scope that are pertinent to the project's purpose and need. Participant responses are elicited for a series of paired comparisons in which the performance of alternatives are compared, with consideration of the project purpose and need, while taking into account the relative intensity of preference of one criterion over another.

The following pages describe the steps in the value metrics process.

3.3.1 Performance Requirements

Performance requirements represent essential, nondiscretionary aspects of project performance. Any concept that fails to meet the project’s performance requirements, regardless of whether it was developed during the project’s design process or during the VE study, cannot be considered a viable solution.

Concepts that do not meet a performance requirement cannot be considered further unless such shortcomings are addressed through the VE study process in the form of VE recommendations. It should be noted that in some cases, a performance requirement may also represent the minimum acceptable level of a performance attribute.

3.3.2 Performance Attributes

Performance attributes are an integral part of the value analysis process. The performance of each project must be properly defined and agreed on by the project team, VE team, and representatives at the beginning of the study. These attributes represent those aspects of a project's scope and schedule that possess a range of potential values.

Performance attributes can generally be divided between project scope components (highway operations, environmental impacts, maintainability, and system preservation) and project delivery components. It is important to make a distinction between performance *attributes* and performance *requirements*. Performance requirements are mandatory and binary in nature. All performance requirements must be met by any VE alternative concept being considered. Performance attributes possess a range of acceptable levels of performance. For example, if the project was the design and construction of a new bridge, a performance requirement might be that the bridge must meet all current seismic design criteria. In contrast, a performance attribute might be project schedule, which means that a wide range of alternatives could be acceptable that had different durations.

Typical standardized project performance attributes are shown below. The VE team, along with the project team, identified and defined the performance attributes for this project and then defined the baseline concept as it pertains to these attributes (Table 5). The following performance attributes were used throughout the study to identify, evaluate, and document ideas and recommendations.

Table 5. Performance Attributes and Description

Performance Attribute	Description of Attribute	Baseline Concept
Main Line Operations	An assessment of traffic operations and safety on the main line within the project limits. Operational considerations include level of service relative to the 20-year traffic projections, as well as geometric considerations such as design speed, sight distance, and lane and shoulder widths.	• Design and posted speed is 55 mph. • Typical section is four 12-foot lanes, separated by a 40-foot median. • Lanes have 4-foot paved inside shoulder and 10-foot outside shoulder.

Table 5. Performance Attributes and Description

Performance Attribute	Description of Attribute	Baseline Concept
Local Operations	An assessment of traffic operations and safety on the local roadway infrastructure. Local Operations include frontage roads as well as crossroads. Operational considerations include level of service relative to the 20-year traffic projections; geometric considerations such as design speed, sight distance, lane and shoulder widths; bicycle and pedestrian operations and access.	• US 641 will have minor county road intersections. Lanes will accommodate WB-62 truck size. • Various private and field approaches along the highway are accommodated through breaks in the median. • Bike/peds allowed on US 641.
Maintainability	An assessment of the long-term maintainability of the facilities and equipment. Maintenance considerations include the overall durability, longevity, and maintainability of structures and systems; ease of maintenance; accessibility and safety considerations for maintenance personnel.	• Typical section is asphalt pavement. • Bridges along the alignment will likely be precast concrete girders. • Median has 6:1 slopes; bottom of median ditch is 12:1. • Fill slopes are 4:1, with 2:1 where there is guard rail. Maintenance will involve mowing the grass on the slopes.
Construction Impacts	An assessment of the temporary impacts to the public during construction related to traffic disruptions, detours and delays; impacts to existing utilities; impacts to businesses and residents relative to access, visual effects, noise, vibration, dust, and construction traffic; environmental impacts.	• The relocated US 641 alignment is being built in greenfield conditions, so through traffic will not need to be actively maintained. • Secure access will need to be maintained to the Western Kentucky Correctional Facility. • Access to rock quarry will also need to be maintained. • Borrow source is currently unknown.
Environmental Impacts	An assessment of the permanent impacts to the environment including ecological (i.e., flora, fauna, air quality, water quality, visual, noise); socioeconomic impacts; impacts to shore edge; impacts to cultural, recreational and historic resources.	• Six homes may be relocated. • Variety of other properties will need to be acquired. • Wetland and stream impacts anticipated. • Endangered bat species in the area, so impact to habitat is assumed.

3.3.3 Performance Attribute Matrix

The performance attribute matrix was used to determine the relative importance of the performance attributes for the project. The project and VE team evaluated the relative importance of the performance attributes that would be used to evaluate the creative ideas.

These attributes were compared in pairs (Table 6), asking the question: “Which one is more important to the purpose and need of the project?” (e.g., A or B, A or C, A or D, etc.) The letter code (e.g., “A”) was entered into the matrix for each pair. After all pairs were discussed they were tallied (after normalizing the scores by adding a point to each attribute) and the percentages calculated. These scores were then used to calculate the value of each recommendation during the VE team’s performance evaluation scoring (Section 6).

Table 6. Performance Attribute Matrix

Paired Comparison						**Total Points**	**% of Total**
Main Line Operations	A	A	A/C	A	A	4.5	30.0%
Local Operations		B	C	B	B	3.0	20.1%
Maintainability			C	C	C	4.5	30.0%
Construction Impacts				D	E	1.0	6.6%
Environmental Impacts					E	2.0	13.3%
Total						**15.0**	**100.0%**

4 Function Analysis Phase

4.1 Overview

Function analysis results in a unique view of the project. It transforms project elements into functions, which help guide the VE team in considering the functional concepts of the project–independent of the current design. Functions are defined in verb-noun statements to reduce the needs of the project to their most elemental level (Table 7). Identifying the functions of the major design elements of the project allows a broader consideration of alternative ways to accomplish the functions.

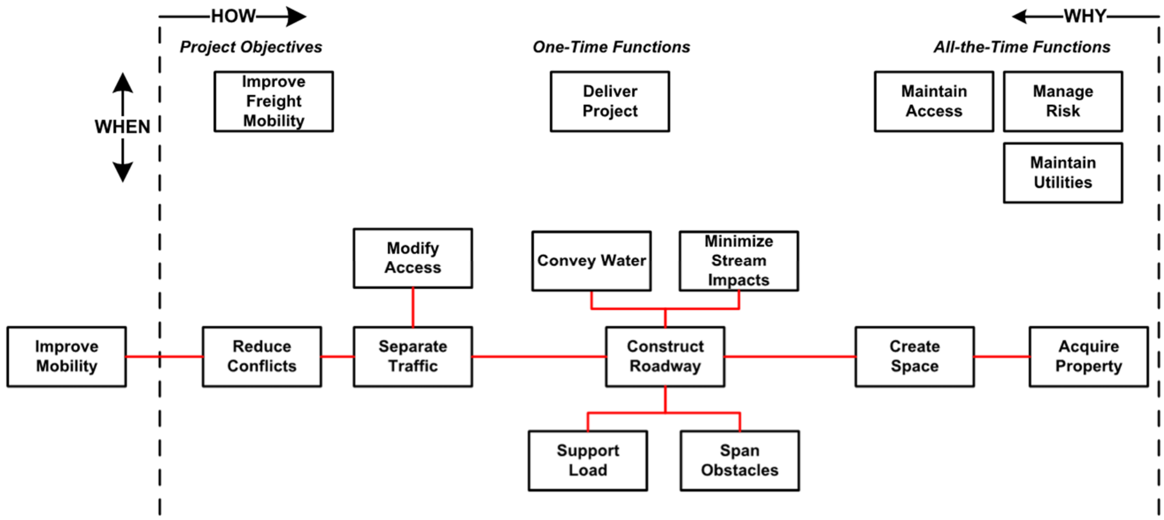
Table 7. Random Function Identification

Project Element	Functions
Project Purpose	Reduce Collisions Reduce Conflicts Deliver Project Improve Freight Mobility Minimize Risk Permit Recovery
Drainage	Convey Water
Pavement	Support Load
Right-of-way	Create Space Modify Access Maintain Access
Structures	Span Obstacle
Traffic Control	Convey Traffic
Utilities	Maintain Utilities

4.2 Function Analysis System Technique Diagram

The Function Analysis System Technique or "FAST" diagram arranges the functions in logical order so that when read from left to right, the functions answer the question "How?" If the diagram is read from right to left, the functions answer the question "Why?" Functions connected with a vertical line are those that happen at the same time as, or are caused by, the function at the top of the column. The FAST diagram (Figure 6) provided the VE team with an understanding of which functions offer the best opportunity for cost or performance improvement.

Figure 6. FAST Diagram



5 Creative Phase

During the Creative Phase, the VE team generated ideas on how to perform the various functions. The idea list was grouped by function or major project element. All of the ideas generated are recorded in Table 8. The final disposition of each idea is included at the end of Section 6.

Table 8. Creative Idea List

Idea No.	Description
Function: Convey Water	
1.	Eliminate the crown and slope the roadway toward outside to allow drainage
Function: Create Space	
2.	Buy access rights along US 641
Function: Deliver Project	
3.	Break the alignment into two construction contracts and build north Fredonia section first
4.	Construct a 2-lane road for NB traffic on preferred alignment and improve the existing road to provide 2-lane SB roadway
Function: Maintain Access	
5.	Match the grade of the side roads at the intersections
Function: Maintain Utilities	
6.	Ensure crossings over gas lines (US 641 and local roads) are as perpendicular as possible
7.	Construct encasement pipe around gas line to allow maintenance
8.	Retain the existing alignment for Fredonia quarry road to minimize impacts to the gas lines
Function: Minimize Risk	
9.	Make new fence adjacent to the prison. Needs to be installed before other work begins.
Function: Modify Access	
10.	Reduce the number of median openings and utilize right-in/right-out for private approaches where possible
11.	Reduce number of accesses to US 641
Function: Permit Recovery	
12.	Use 4:1 side slopes in lieu of 2:1
Function: Span Obstacle	
13.	Replace the bridge at STA 2080 with a box culvert
14.	Optimize bridge span arrangements

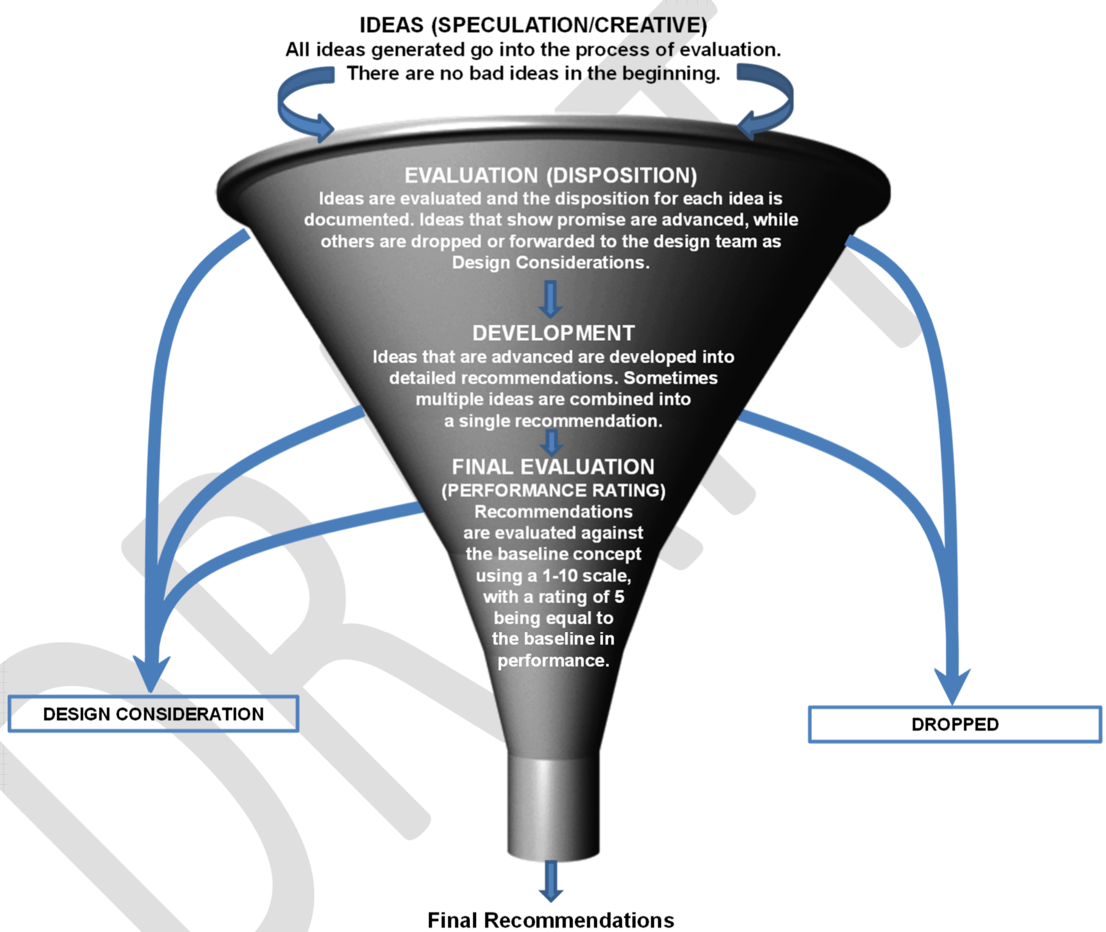
Table 8. Creative Idea List

Idea No.	Description
15.	Early advancement of geotechnical investigations to inform design
16.	Eliminate bridge at STA 2080
17.	Adjust alignment near bridge at STA 2080 to reduce impact on stream
Function: Modify Access	
18.	Eliminate the 40' depressed median and replace with 4' paved median
19.	Optimize profile to match existing grade
20.	Change typical section to a 2+1
21.	If the project is phased, then purchase only the amount of right-of-way needed for initial buildout
22.	Reduce outside paved shoulder width from 10' to 6'
23.	Build a 2-lane road with a performance-based shoulder width selection for the ultimate.
24.	Tie in the alignment to existing US 641 just south of Fredonia with a reduced cross section
25.	Reduce the 40' depressed median to 20'
26.	Use retaining walls to reduce R/W acquisition as needed
27.	Construct a 2-lane roadway utilizing 12' lanes and 12' full pavement depth shoulders to allow for future expansion
28.	Use the Alabama 55 cross section (four 12' lanes, 2' paved outside shoulders, 4' median)
29.	Utilize rumble strips on the inside and outside shoulders
30.	Only pave the SB lanes and utilize for 2-way traffic. Construct only SB bridges.
31.	Build initial 2+1 that is expandable to a 4-lane ultimate (with a flush median - Alabama 55)
32.	Balance the earthwork as much as possible
33.	Source embankment material from local rock quarry
34.	Reduce the width of the cross section on the approach roads to 11' travel lane and 4' shoulders
35.	Match width of existing approach roads
36.	Reduce US 641 lane width to 11'
37.	Build one 12' lane in each direction with 12' inside and outside shoulders and smaller 26'-wide future flush median
38.	Utilize alternative bids for pavement section
39.	Reduce the overall outside shoulder width to 10' with 4' paved
40.	Reduce pavement section to 30-year life expectancy

6 Evaluation Phase

Although each project is different, the evaluation process for each VE effort can be thought of in its simplest form as a way of combining, evaluating, and narrowing ideas until the VE team agrees on the recommendations to be forwarded. Figure 7 depicts the typical information flow for this part of the Value Methodology Job Plan.

Figure 7. VE Process Information Flow



6.1 Evaluation Process

The evaluation process begins by going through the ideas brainstormed during the Creative Phase. Considering the information provided to the VE team at the time of the study and the constraints and controlling decisions that were also given to them, the team discussed the ideas and documented their advantages and disadvantages based on their relationship to the baseline concept.

The VE team also compared each idea with its baseline concept to determine whether the performance of the attribute (as introduced in Section 3.3) was better than, equal to, or worse than the baseline concept.

Each idea was then carefully evaluated, with the VE team reaching consensus on the overall ranking of the idea (ranking values 0 through 3, as defined below).

3 = Advance for further development

2 = Design consideration; include as a comment or consideration for design team

1 = Poor Opportunity/dropped from further development

0 = Unacceptable impact/fatal flaw

This ranking resulted in the initial disposition of the idea. Those ideas ranked as a 3 were developed further; low-ranking ideas (those ranked 0 or 1) were dropped from further consideration; and those that were ranked 2 were brought forward as ideas the design team should pursue.

6.2 Evaluation Summary

All of the ideas that were generated during the Creative Phase using brainstorming techniques are detailed in Table 9.

Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
Function: Convey Water					
1	Eliminate the crown and slope the roadway toward outside to allow drainage	• Minimize number of cross pipes between median and outside throughout project • Should reduce embankment	• Creates more sheet flow across roadway	2	
Function: Create Space					
2	Buy access rights along US 641	• Less access points in the future to be added which would increase safety	• Added cost	3	Baseline is a partially controlled access. Ideas 2, 10, and 11 combined to become Recommendation 1.
Function: Deliver Project					
3	Break the alignment into two construction contracts and build north Fredonia section first	• Easier to obtain funding to start construction • Improves truck movement around Fredonia	• May impact construction schedule • May impact NEPA document • The second contract may delay funding	3	Advanced as Recommendation 2
4	Construct a 2-lane road for NB traffic on preferred alignment and improve the existing road to provide 2-lane SB roadway	• Maintains some traffic through town • Reduces construction cost • Reduces R/W acquisition • Reduces future maintenance costs	• Impacts local traffic flow • Creates one-way in/one-way out access for private driveways • Local driver expectancy • County stakeholder acceptance	1	May provide opportunity to improve geometrics for truck traffic through town

Ranking Scale:
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0 = Unacceptable impact/fatal flaw

(green) = Advanced for further development
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Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
Function: Maintain Access					
5	Match the grade of the side roads at the intersections	• Reduces embankment cost • Reduces impacts to local roadway during construction • Reduces R/W acquisition	• Potential drainage concerns	3	Advanced with Ideas 19 and 32 as Recommendation 3
Function: Maintain Utilities					
6	Ensure crossings over gas lines (US 641 and local roads) are as perpendicular as possible	• Reduces length of conflict with utility • Improves ability to protect in place	• May provide undesirable geometrics for roadway	2	
7	Construct encasement pipe around gas line to allow maintenance	• Provides ability to protect in place, but still allow maintenance of the gas line	• Increases cost	2	Utilize if Protect in Place becomes a requirement during utility coordination
8	Retain the existing alignment for Fredonia Quarry Road to minimize impacts to the gas lines	• Leaves existing utility in place • Reduces construction zone over the utilities	• Creates a skewed intersection (65 degrees)	2	
Function: Minimize Risk					
9	Make new fence adjacent to the prison. Needs to be installed before other work begins.	• Provides separation from prison and contractor	• None noted	2	

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Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
Function: Modify Access					
10	Reduce the number of median openings and utilize right-in/right-out for private approaches where possible	• Improves driver safety • Reduces conflict points • Reduces the number of crossover accidents • May improve drainage due to reduced crossovers	• May increase number of rear-end accidents • Increases out of direction travel • May complicate ability to maintain level of access in the future	3	Ideas 2, 10, and 11 combined to become Recommendation 1
11	Reduce number of accesses to US 641	• Reduces conflict points	• None noted	3	Ideas 2, 10, and 11 combined to become Recommendation 1
Function: Permit Recovery					
12	Use 4:1 side slopes in lieu of 2:1	• Eliminate guard rail • Provides for better off-road recovery	• Increases amount of embankment needed	2	
Function: Span Obstacle					
13	Replace the bridge at STA 2080 with a box culvert	• Decreases construction cost • Decreases future maintenance cost • May decrease construction schedule • Allows for phased construction	• May create more stream impacts	3	Ideas 13, 16, and 17 combined to become Recommendation 4
14	Optimize bridge span arrangements	• Decreases construction cost	• None noted		Assumed to be the baseline

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Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
15	Early advancement of geotechnical investigations to inform design	• Provides information early to allow substructure to be optimized • Allows for better coordination between roadway and structural design	• If there are late changes in alignment, boring information may not be accurate	2	
16	Eliminate bridge at STA 2080	• Decreases construction cost • Decreases future maintenance cost • May decrease construction schedule	• May create more stream impacts	3	Ideas 13, 16, and 17 combined to become Recommendation 4
17	Adjust alignment near bridge at STA 2080 to reduce impact on stream	• Reduces or eliminates channel realignment • May require shorter span structure	• May cause adverse impacts to properties (prison) • May cause adverse impacts to proposed horizontal and vertical geometry	3	Ideas 13, 16, and 17 combined to become Recommendation 4
Function: Support Load					
18	Eliminate the 40’ depressed median and replace with 4’ paved median	• Requires less R/W acquisition • Improves stormwater drainage • Reduces embankment	• Potential for more vehicle crossovers • Access management strategies limited	3	Ideas 18, 22, and 28 combined to become Recommendation 5

Ranking Scale:
3 = Advance for further development
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Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
19	Optimize profile to match existing grade	• Reduces embankment • Reduces R/W acquisition • Improves private drive access • Decreases construction cost • Reduces environmental impacts • Allows ability to match into existing driveways and other access points	• May create drainage issues	3	Ideas 5, 19, and 32 combined to become Recommendation 3
20	Change typical section to a 2+1 road	• Requires less R/W acquisition • Improves stormwater drainage • Reduces embankment • Reduces construction cost	• County stakeholder acceptance	3	Ideas 20, 23, 24, 27, and 31 combined to become Recommendation 6
21	If the project is phased, then purchase only the amount of right-of-way needed for initial buildout	• Reduces overall cost • May reduce number of homes and farms impacted • Improved public perception	• May increase the cost if road is ever expanded	2	
22	Reduce outside paved shoulder width from 10' to 6'	• Reduces footprint • Reduces impervious surface • Reduces construction cost	• May have safety impacts • Less refuge for vehicles • Less room for maintenance activities	3	Ideas 18, 22, and 28 combined to become Recommendation 5

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Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
23	Build a 2-lane road with a performance-based shoulder width selection for the ultimate	• Reduces footprint • Reduces impervious surface • Reduces construction cost • Requires less R/W impacts • Reduces number of homes and farms impacted • Improves public perception	• May have safety impacts • Less refuge for vehicles • Less room for maintenance activities • Less room for farm equipment • Stakeholder approval	3	Ideas 20, 23, 24, 27, and 31 combined to become Recommendation 6
24	Tie in the alignment to existing US 641 just south of Fredonia with a reduced cross section	• Reduces construction costs • Reduces environmental impacts • Reduces R/W impacts • Reduces maintenance costs • Provides improved roadway • Allows truck mobility	• May impact some homes • May require additional NEPA investigations	3	Ideas 20, 23, 24, 27, and 31 combined to become Recommendation 6
25	Reduce the 40' depressed median to 20'	• Reduces footprint • Reduces impervious surface • Reduces construction cost • Requires less R/W impacts • May reduce number of homes and farms impacted	• May create drainage issues • Crossover length not adequate • Clear zone issues	2	Use the minimum amount of median width that would not require some form of barrier
26	Use retaining walls to reduce R/W acquisition as needed	• Decreases R/W cost • Reduces embankment	• Added construction cost for walls • Increases maintenance	1	
27	Construct a 2-lane roadway utilizing 12' lanes and 12' full pavement depth shoulders to allow for future expansion	• Reduces footprint • Reduces impervious surface • Reduces construction cost • Requires less R/W impacts • Reduces number of homes and farms impacted	• May have safety impacts • Stakeholder approval	3	Allows for various types of future expansion. Ideas 20, 23, 24, 27, and 31 combined to become Recommendation 6.

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Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
28	Use the Alabama 55 cross section (four 12' lanes, 2' paved outside shoulders, 4' median)	• Reduces footprint • Reduces impervious surface • Reduces construction cost • Requires less R/W impacts • Reduces number of homes and farms impacted	• May have safety impacts • Farm equipment would be in outside lane	3	Ideas 18, 22, and 28 combined to become Recommendation 5
29	Utilize rumble strips on the inside and outside shoulders	• None noted	• None noted		Assumed to be in baseline concept
30	Only pave the SB lanes and utilize for 2-way traffic. Construct only SB bridges.	• Reduces footprint Reduces impervious surface Reduces construction cost	• None noted		Baseline for an interim project
31	Build initial 2+1 that is expandable to a 4-lane ultimate (with a flush median - Alabama 55)	• Reduces bridge square footage • Reduces footprint • Reduces impervious surface • Reduces construction cost • Requires less R/W impacts • Reduces number of homes and farms impacted	• County stakeholder acceptance may be a concern	3	Ideas 20, 23, 24, 27, and 31 combined to become Recommendation 6
32	Balance the earthwork as much as possible	• None noted	• None noted	3	Ideas 5,19, and 32 combined to become Recommendation 3
33	Source embankment material from local rock quarry	• Provides possibility of embankment material within project limits	• Accepts risk normally transferred to contractor	1	
34	Reduce the width of the cross section on the approach roads to 11' travel lane and 4' shoulders	• Reduces footprint • Reduces impervious surface	• County approval • Movements of trucks and farm equipment	2	Assumes standard turning radii

Ranking Scale:
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Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
35	Match width of existing approach roads	• Reduces footprint • Reduces impervious surface	• County approval • Movements of trucks and farm equipment	2	Assumes standard turning radii
36	Reduce US 641 lane width to 11'	• None noted	• None noted	0	Proposed to be a National Truck Network route, fatal flaw if less than 11'
37	Build one 12' lane in each direction with 12' inside and outside shoulders and smaller 26'-wide future flush median	• Reduces footprint • Reduces impervious surface • Reduces R/W impacts • Reduces construction cost • Reduces embankment	• 2-lane divided highway not typical in US	1	
38	Utilize alternative bids for pavement section	• Promotes competition	• Control of specifications	2	
39	Reduce the overall outside shoulder width to 10' with 4' paved	• Reduces footprint • Reduces impervious surface • Reduces R/W impacts • Reduces construction cost • Reduces embankment • Reduces bridge square footage	• Potential safety concerns	2	
40	Reduce pavement section to 30-year life expectancy	• Reduces construction costs	• Decreases lifecycle costs • May not be appropriate for NTN route	1	Baseline assumed to be 40-year life expectancy

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3 = Advance for further development
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7 Development Phase

This phase of the Value Methodology Job Plan takes the ideas that ranked the highest in the Evaluation Phase and further develops them into full VE recommendations. In many cases, it is possible that one or more ideas were combined to form an overall recommendation, which was then evaluated further by the VE team.

In the case of this project, of the 40 ideas that were generated during the Creative Phase, 18 of those ideas were evaluated high enough to be taken forward, combined, and developed further. Some of the ideas were deemed more appropriate as a design consideration for the project team, rather than developed into a VE recommendation (Section 7.5). For the Development Phase, narratives, drawings, calculations, and cost estimates were prepared for each recommendation.

The VE recommendation documents in this section are presented as written by the team during the VE study. While they have been edited from the draft VE report to correct errors or better clarify the recommendation, they represent the VE team's findings during the VE study.

Each recommendation consists of a summary of the baseline concept, a description of the suggested change, a listing of its advantages and disadvantages, discussion of schedule and risk impacts (if applicable), a cost comparison, change in performance, and a brief narrative comparing the baseline design with the recommendation. Sketches, calculations, and performance measure ratings are also presented. The cost comparisons reflect a comparable level of detail as in the baseline estimate.

7.1 Summary of Recommendations

Table 10 is a summary of all recommendations generated and their cost impact to the project.

The recommendations identified all consider multiple aspects of total value, including assessing the impacts to performance, cost, time, and risk in comparison to the baseline concept. The potential of each recommendation summarized in Table 10 is based on the following:

- Initial Cost Savings Potential – A quantified indication of the recommendation's impact to the project's initial cost in comparison with the baseline concept. Initial cost savings are conceptual and reflective of the VE team's parametric estimation of possible savings and represent orders of magnitude cost impact of the VE recommendation. Because the cost data depicted represent savings, a number in parentheses represents a cost increase.

Table 10. Summary of Recommendations

#	Recommendation Title	Cost Savings/ (Cost Added) ($M)	
		Ultimate 4-Lane	Ultimate 2+1
1	Strengthen Access Control	$0.96	$0.96
2	Design for Two Construction Sections	($0.67)	($0.67)
3	Optimize Profile to Promote Earthwork Balance	$7.93	$3.97
4	Modify Structures 1, 2, & 3	$3.25	$1.62
5	Alternative 4-Lane Typical Section	$7.20	
6	Alternative 2+1 Typical Section		$20.35
	Total Savings	$18.67	$26.23

7.1.1 FHWA Functional Benefit Criteria

Each year, state departments of transportation are required to report on VE recommendations to the Federal Highway Administration (FHWA). In addition to cost implications, FHWA requires state departments of transportation to evaluate each approved recommendation in terms of the project features that recommendation benefits. If a specific recommendation can be shown to provide benefit to more than one feature described below, count the recommendation in each category that is applicable. These same criteria can be found on each of the individual recommendations that follow.

- **Safety:** Recommendations that mitigate or reduce hazards on the facility.
- **Operations:** Recommendations that improve real-time service and/or local, corridor, or regional levels of service of the facility.
- **Environment:** Recommendations that successfully avoid or mitigate impacts to natural and or cultural resources.
- **Construction:** Recommendations that improve work zone conditions or expedite the project delivery.
- **Right-of-way:** Recommendations that lower the impacts or costs of right-of-way.

7.2 Value Engineering Recommendation Approval

The resolution or disposition of recommendations is based on the information in this report and is independent of the proceeding of the VE study. HDR has no participation, direct or indirect, in such decisions. The VE Recommendation Approval form shown in Appendix B is intended to aid the project manager in tracking and informing the state Value Engineer in annual reporting of VE activities to FHWA. Resolution and disposition of recommendations contained in Appendix B are pending.

7.3 Individual Recommendations

Based on the evaluation process, individual recommendations were developed. Each recommendation consists of a summary of the baseline concept, a description of the recommendation, a listing of its advantages and disadvantages, and a brief narrative that includes justification, sketches, photos, assumptions, and calculations as developed by the VE team. Final recommendations can be found beginning on page 7-5.

VE RECOMMENDATION NO. 1: STRENGTHEN ACCESS CONTROL	Idea Nos. 2, 10, 11

Baseline Concept

The project has been designed with access spacing and median openings at approximately 1,200 feet.

Recommendation Concept

Remove unnecessary access points and associated median openings throughout the corridor. Purchase access control for all frontage between the designed access points. Develop a corridor access management policy and agreement to be adopted by KYTC and local governments to support enforcement as permit requests are made in the future.

Advantages

- Reduces conflict points associated with intersections and entrances– locations with potential vehicle to vehicle crashes
- Improves driver expectancy
- Ensures safe freight mobility throughout the region.
- Protects the mobility of the corridor far into the future
- Allows for future development along existing public roads, including old US 641
- Minor reduction in construction costs

Disadvantages

- New approach for design of access along a partially controlled corridor
- May be a challenge for permitting staff to maintain access as specified in a corridor agreement.

Cost Summary	Construction	Right-of-Way	Total
Baseline Concept			
Recommendation Concept			
Cost Avoidance	$0.96M		$0.96M

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Right-of-Way*
✓	✓			

VE RECOMMENDATION NO. 1: STRENGTHEN ACCESS CONTROL	Idea Nos. 2, 10, 11

Discussion/Sketches/Photos/Calculations

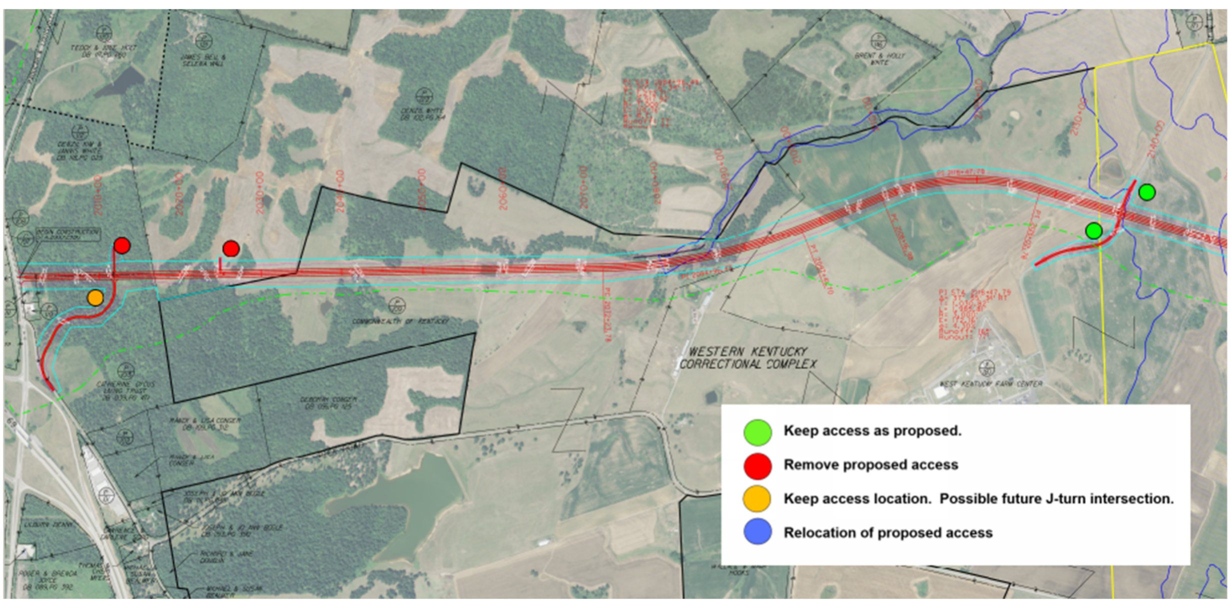
Technical Discussion/Sketches

Research completed by the Kentucky Transportation Center for KYTC recommends necessary median openings and access points be separated by at least 2400’ on high-speed rural arterials such as US 641. The purpose of this is to maintain the long-term mobility and safety of the corridors that connect cities and other destinations over long distances. Local access is meant to be achieved primarily from lower functional classification roadways.

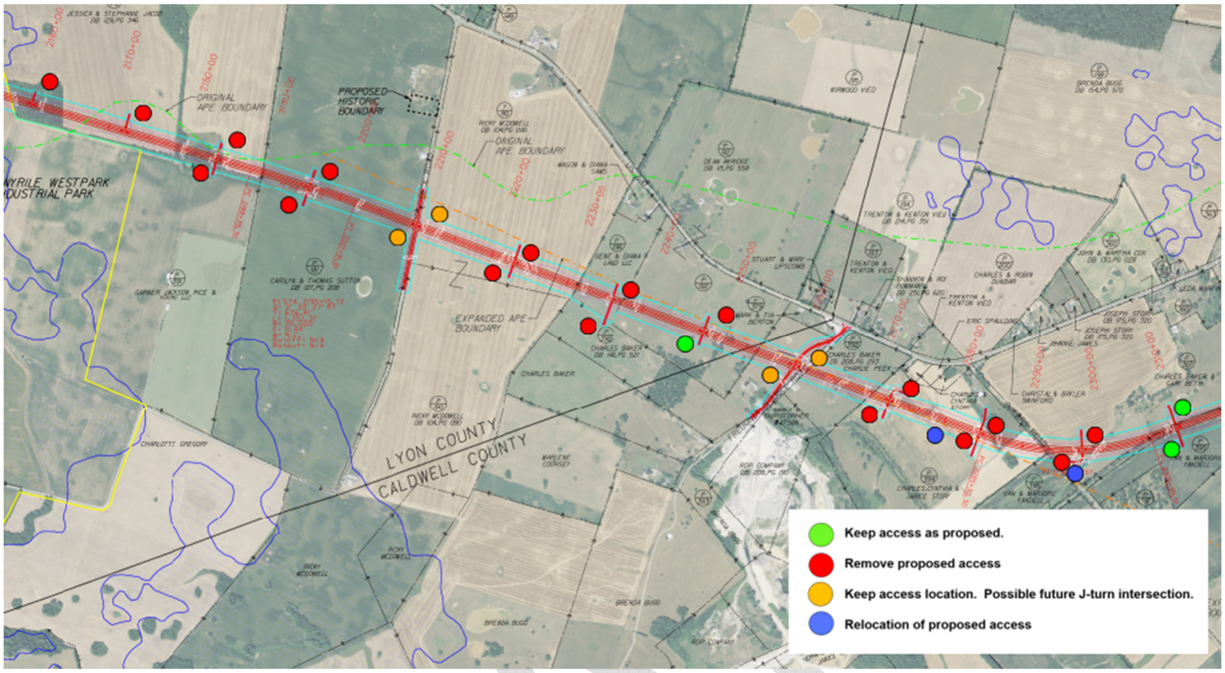
There are many opportunities to reduce the number of access points and median openings in the current design. The below sketches demonstrate potential changes. Locations recommended for removal from the design are marked in red (29). Those properties already have adequate access from either existing US 641 or other public roads or are duplicative along the proposed route. Those colored blue (5) are relocated from the current design. Those colored green (7) should remain to avoid land locking the adjacent property. Intersections along the route are recommended to remain with the caveat that significant increases in traffic or crashes at those locations may warrant conversion to a J-turn design.

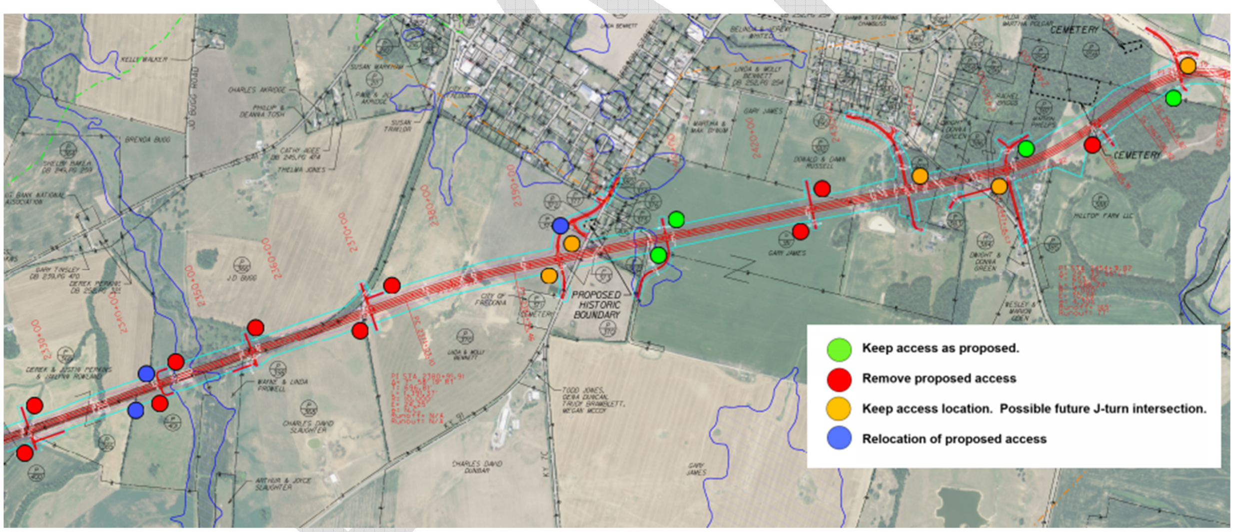
To avoid access points in the future due to subdivision of land, access rights should be purchased and a Memorandum of Understanding (MOU) between the local counties and KYTC should developed. The MOU should identify as-built access locations, future acceptable locations (if any), and median opening/U-turn locations. Agreements of this nature which have been implemented on other corridors in Kentucky can serve as a model for US641.

This recommendation is primarily to preserve the mobility and safety of the corridor. However, there are cost savings nearing $1 million from the removal of so many entrances.



VE RECOMMENDATION NO. 1: STRENGTHEN ACCESS CONTROL	Idea Nos. 2, 10, 11





Assumptions/Calculations

There are 29 entrances being proposed for removal, however five of them would be relocated, making a net of 24 being removed. Approximate average length: 150’ embankment, rock, and pavement.

Using a ballpark estimate of $40,000 per entrance: 24 x $40,000 = $960,000 savings

VE RECOMMENDATION NO. 2: DESIGN FOR TWO CONSTRUCTION SECTIONS	Idea No. 3

Baseline Concept

The current design is prepared as a single, stand-alone construction project.

Recommendation Concept

Divide the design into two construction sections with a temporary tie-in to existing alignment south of Bakers Road. Build the northern section first.

Advantages	Disadvantages
• Likely to receive construction funding sooner if segmented • Addresses highest freight mobility need by removing trucks from Fredonia • Potential cost savings associated with avoiding escalation	• Risk of tie-in section to existing US 641 to be short lived.

Cost Summary	Construction	Right-of-Way	Total
Baseline Concept			
Recommendation Concept			
Added Cost	$0.67M		$0.67M

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Right-of-Way*
			✓	

VE RECOMMENDATION NO. 2: DESIGN FOR TWO CONSTRUCTION SECTIONS	Idea No. 3

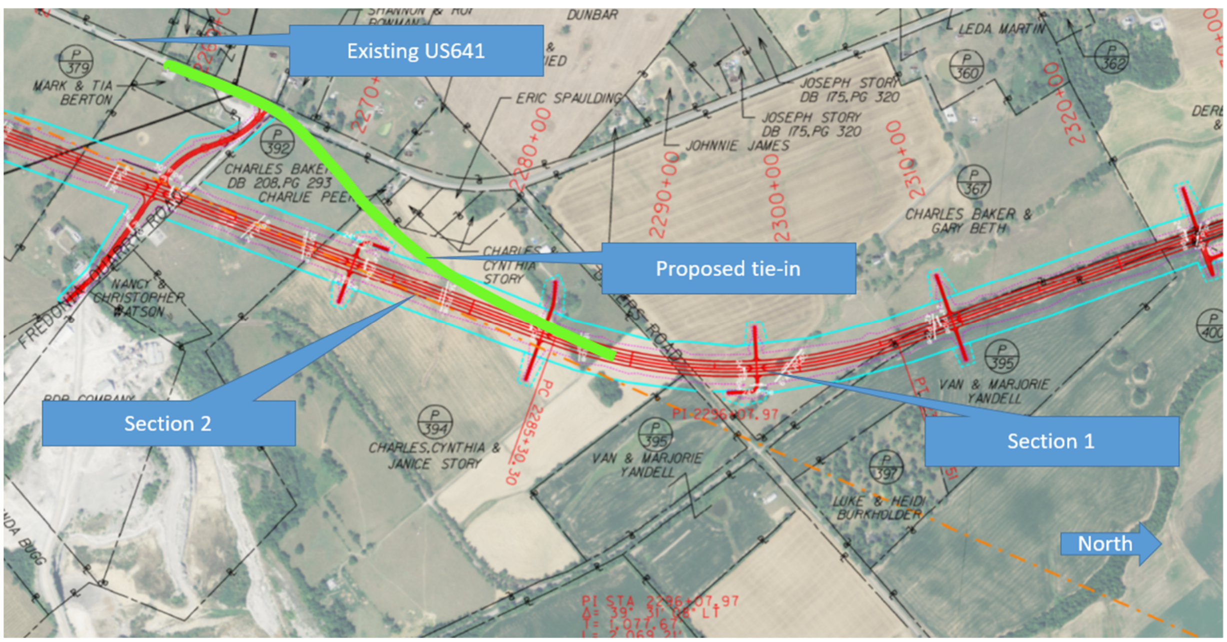
Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

This proposal is to divide the project into two construction sections, the first of which can be operational upon completion. Because this is such a large project requiring over $50 million in funding to complete (the initial 2-lane phase), it is unlikely to receive all the funding it needs in the next several highway plan cycles. Splitting into smaller sections with logical termini will increase the likelihood of advancing the project to phases beyond design and getting construction underway.

The project is broken into two projects in the current highway plan. However, the division is identified at Beck Road, a location on the corridor that does not facilitate a quality temporary tie-in to the existing route.

A logical location to make the division is just south of Bakers Road, where the existing and proposed alignments are at their closest proximity. There are options on precisely how to align the tie-in that will connect the two routes. One option is presented below. It is assumed that the new corridor would be built with an initial two-lane roadway, so no lane drop or lane add would be needed in the tie-in.



Building Section 1 (3.8 miles), the northern section, first will facilitate the removal of truck traffic through Fredonia and improve the freight travel time for the corridor, thus supporting a key piece of the project's purpose. Section 2 (5.4 miles) would be advanced in the future to complete the connection to US 62 near the I-69 interchange.

It is recommended to advance right-of-way acquisition and utility relocations for Section 1 and the tie-in first in order to expedite the construction of that section. Right-of-way acquisition and utility relocations for Section 2 should begin after the construction contract for Section 1 is let.

Because it is unknown how long it will be between the opening of traffic on Section 1 and completion of Section 2, there is some risk to this approach. Should Section 2 advance quickly, the life of the tie-in would be short lived, thus reducing the benefit to cost ratio. However, it is also a distinct possibility that the time between each could be significant.

VE RECOMMENDATION NO. 2: DESIGN FOR TWO CONSTRUCTION SECTIONS	Idea No. 3

Assumptions/Calculations:

Assumed length of tie-in connection: 2400 feet.

Embankment: average 5' fill. Assume 3:1 slope.

5' x 2400' x (32' + 30'/2))/27 x $5.99/CY	=	$125,124
Pavement travel lanes: 12'x 2 x 2400 x $7.32/SF	=	$421,632
Pavement shoulders: 4' x 2 x 2400 x $6.17/SF	=	$118,464
Total additional cost	**=**	**$665,220**

VE RECOMMENDATION NO. 3: OPTIMIZE PROFILE TO PROMOTE EARTHWORK BALANCE

Idea Nos. 5, 19, 32

Baseline Concept

The baseline vertical alignment results in a "borrow" or embankment project in the magnitude of approximately 1.8 million cubic yards. It is anticipated that the awarded contractor will source materials locally on adjoining parcels as much as possible. The highwater elevations at the major crossings were assumed and the primary vertical constraint resulting in the baseline design was positive drainage from intersections and medians.

Recommendation Concept

Use the known constraints of major utility crossings, approximate stream high water, and intersection tie-ins to optimize the profile to promote earthwork balance.

Advantages

- Reduces embankment required
- Reduces right-of-way impacts
- Improves private drive access
- Decreases construction cost
- Reduces environmental impacts
- Better matches existing and proposed access grades
- Allows for flatter side slopes and less guardrail

Disadvantages

- May result in promoting excessive longitudinal drainage patterns

Cost Summary	Construction	Right-of-Way	Total
Baseline Concept	$14.09M		$14.09M
Recommendation Concept	$6.16M		$6.16M
Cost Avoidance	$7.93M		$7.93M

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Right-of-Way*
		✓	✓	✓

VE RECOMMENDATION NO. 3: OPTIMIZE PROFILE TO PROMOTE EARTHWORK BALANCE	Idea Nos. 5, 19, 32

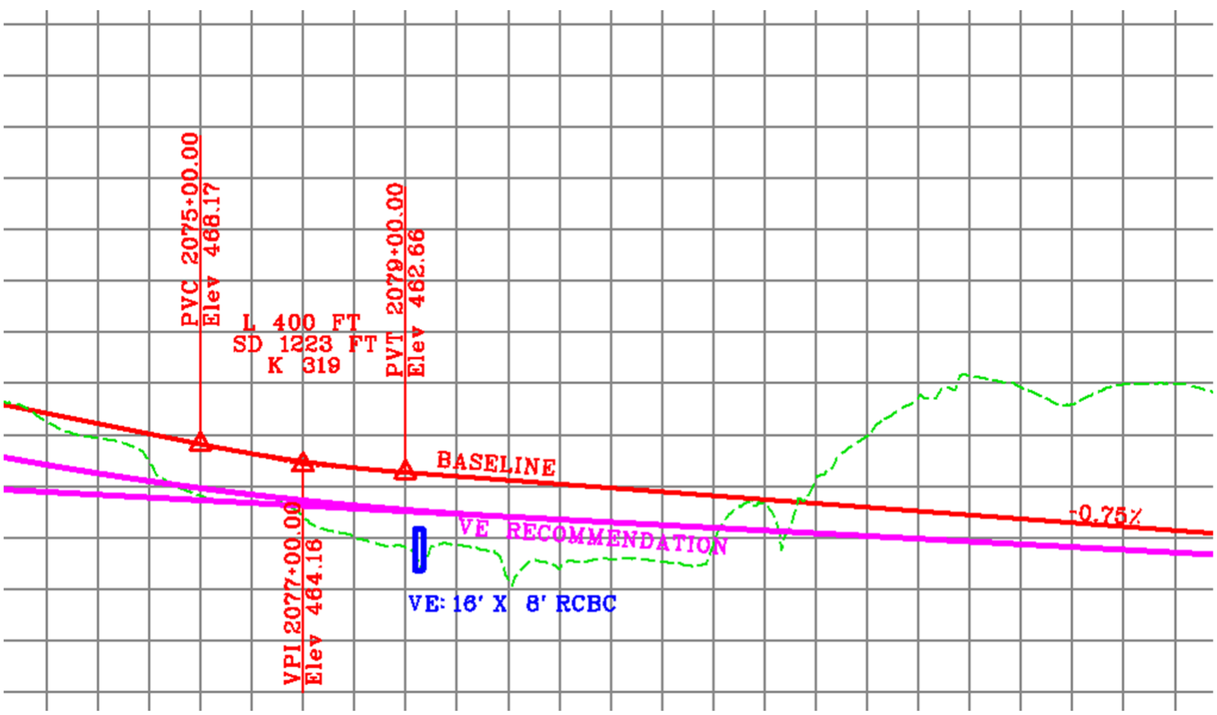
Discussion/Sketches/Photos/Calculations

Due to the relatively high cost of embankment in place in the baseline Preliminary Line & Grade (PL&G) estimate, the VE team evaluated the baseline profile along with design assumptions to determine if optimizing the profile could better balance the earthwork needed.

Grade constraints:

1. Intersection and approach road tie-ins
2. Major utilities specifically four gas lines near the quarry
3. Drainage including major streams and cross drainage along the route

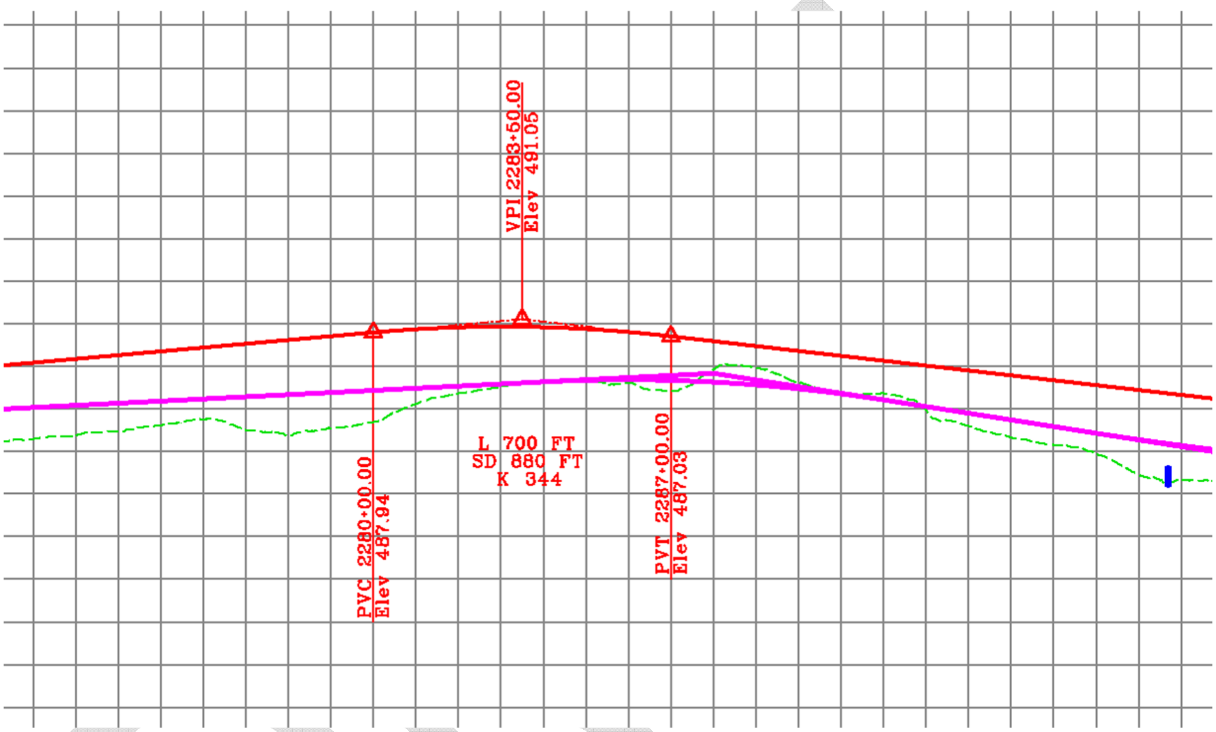
Due to a lack of hydrologic and hydraulic information provided to the VE team at the major stream crossings (bridges), the team evaluated these locations using StreamStats flow information which is based on Regional Regression equations along with HY8 (culvert alternatives) and HECRAS (bridge floodplain WSEL). Using this methodology, it was determined that the bridge at STA 2080+00 may be replaced with a 16'x8' RCBC which allowed for a lowering of the profile in this area of approximately 7'.



VE RECOMMENDATION NO. 3: OPTIMIZE PROFILE TO PROMOTE EARTHWORK BALANCE	Idea Nos. 5, 19, 32

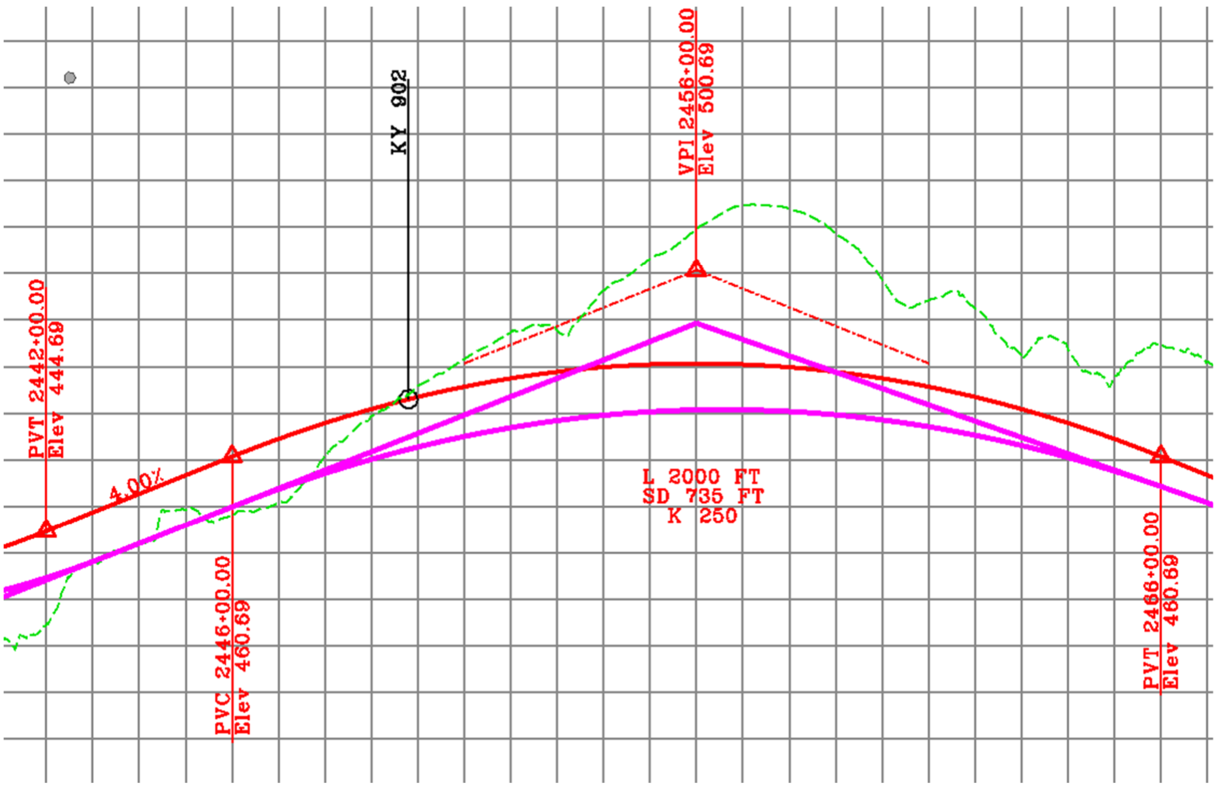
Another location that we were able to lower slightly was near the stream crossing at STA 2148+00. Although the bridge hydraulic analysis determined that the span arrangement needed to be lengthened, it also allowed for a profile grade of approximately 417.65.

Several crest locations were adjusted lower where constraints allowed. One example location is near STA 2285+00 as illustrated below:



VE RECOMMENDATION NO. 3: OPTIMIZE PROFILE TO PROMOTE EARTHWORK BALANCE	Idea Nos. 5, 19, 32

Near the end of the project, the profile was adjusted lower significantly while considering the road approach tie-ins with KY 902. The required maintenance of traffic will require further consideration as the project progresses through Phase 2 design as this provides an excellent source of raw material within the baseline right of way limits.



Note: The .dgn file for this recommendation is available for the project team's use.

Assumptions/Calculations:

To determine the cost savings by optimizing the profile, the team used the average profile adjustment along with an assumed average width of impact of 140'.

The average profile adjustment ended up being a lowering of 4' overall.

The length of the project is 48,603 feet and a total embankment quantity of approximately 780,000 cubic yards resulting in an overall savings of 1,006,980 cubic yards.

Using the baseline unit price of $5.99 per cubic yard along with project markups, the overall savings from this recommendation is $7.93 million.

VE RECOMMENDATION NO. 3: OPTIMIZE PROFILE TO PROMOTE EARTHWORK BALANCE	Idea Nos. 5, 19, 32

VE COST COMPARISON

CONSTRUCTION ELEMENT		***BASELINE***			***RECOMMENDATION***		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
Embankment in Place	CUYD	1,789,262	$6	$10,717,679	782,282	$6	$4,685,869
				$0			$0
				$0			$0
SUB-TOTAL				$10,717,679			$4,685,869
PROJECT MARK-UPS	31.5%			$3,376,069			$1,476,049
TOTAL				$14,094,000			$6,162,000
						SAVINGS	**$7,932,000**

VE RECOMMENDATION NO. 4: MODIFY STRUCTURES 1, 2, & 3	Idea Nos. 13, 16, 17

Baseline Concept

The baseline design includes three bridges. The baseline design includes approximate locations and lengths for each structure, a summary of the preliminary layouts are as follows.

Structure #1

- Approximate Location: Station 2080
- Structure type is assumed to be precast prestressed concrete bridge
- Baseline length measures approximately 221 feet

Structure #2

- Location: Station 2149
- Structure type is assumed to be precast prestressed concrete bridge
- Baseline length measures approximately 178 feet

Structure #3

- Approximate Location: Station 2335
- Structure type is assumed to be precast prestressed concrete bridge
- Baseline length measures approximately 123 feet

Recommendation Concept

The VE team reviewed preliminary layouts for the structures and recommend changes to the following three structures:

Structure #1 Recommendation

- Modify alignment to avoid channel change and use a cast-in-place box culvert
- The alignment modification can be accomplished by taking additional right-of-way from the property west of the Western Kentucky Correctional Facility and avoiding additional impacts to the correctional facility
- Size = 16ft x 8ft x 200ft

Structure #2 Design Consideration

- The baseline concept may increase high water elevations which may result in the need for a Conditional Letter of Map Revision (CLOMR). An item to consider as design advances would be to evaluate the drainage opening requirements and consider limiting the rise to no more than 1.0 foot. This may result in the structure increasing in length that is close to 500 feet.

Structure #3 Recommendation

- Use a cast-in-place box culvert
- Size = 16ft x 8ft x 200ft

Advantages	Disadvantages
Structure #1 • Decreases construction cost • Decreases future maintenance cost • May decrease construction schedule	**Structure #1** • May cause adverse impacts to properties • May cause adverse impacts to proposed horizontal and vertical geometry
Structure #2 • Improves hydraulic conditions • Reduces likelihood of future maintenance and property damage associated with flooding	**Structure #2** • Increases construction cost • Increases future bridge maintenance cost • Could require updates to the NEPA document

<table>
<tr><th colspan="3">VE RECOMMENDATION NO. 4:
MODIFY STRUCTURES 1, 2, & 3</th><th colspan="2">Idea Nos.
13, 16, 17</th></tr>
<tr><td colspan="3">• Eliminates channel change construction and associated in-lieu fees
• Reduces potential for project delays due to environmental impacts</td><td colspan="2"></td></tr>
<tr><td colspan="3">Structure #3
• Decreases construction cost
• Decreases future maintenance cost
• May decrease construction schedule</td><td colspan="2">Structure #3
• May cause adverse impacts to properties
• May cause adverse impacts to proposed horizontal and vertical geometry</td></tr>
</table>

Cost Summary	Construction	Total
Baseline Concept	$9.17M	
Recommendation Concept	$6.70M	
Cost Avoidance	$2.47M + 31.5% markup =	$3.25M

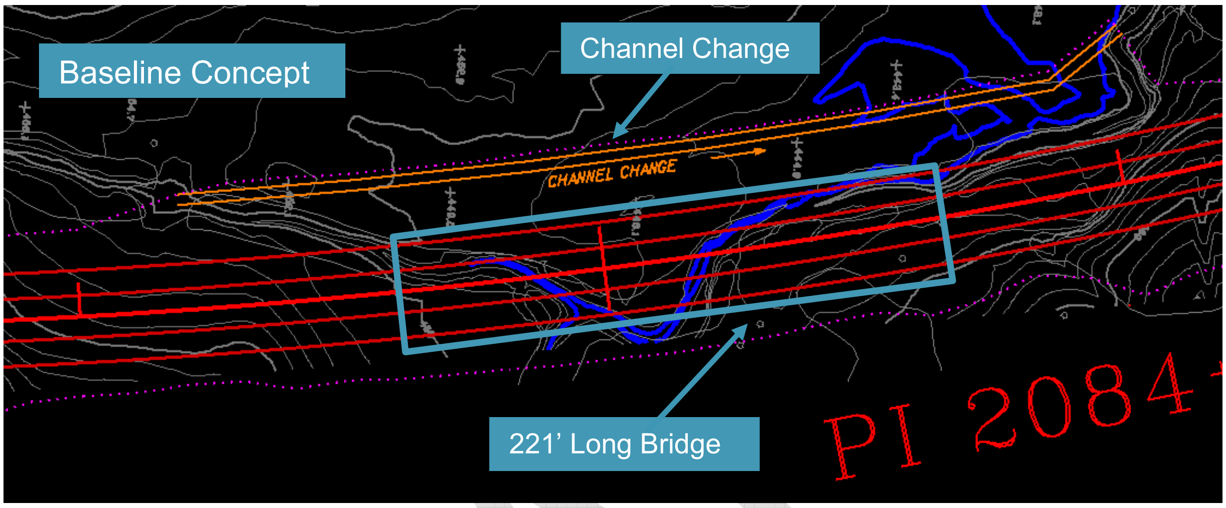
FHWA Function Benefit				
Safety	***Operations***	***Environment***	***Construction***	***Right-of-Way***
		✓		

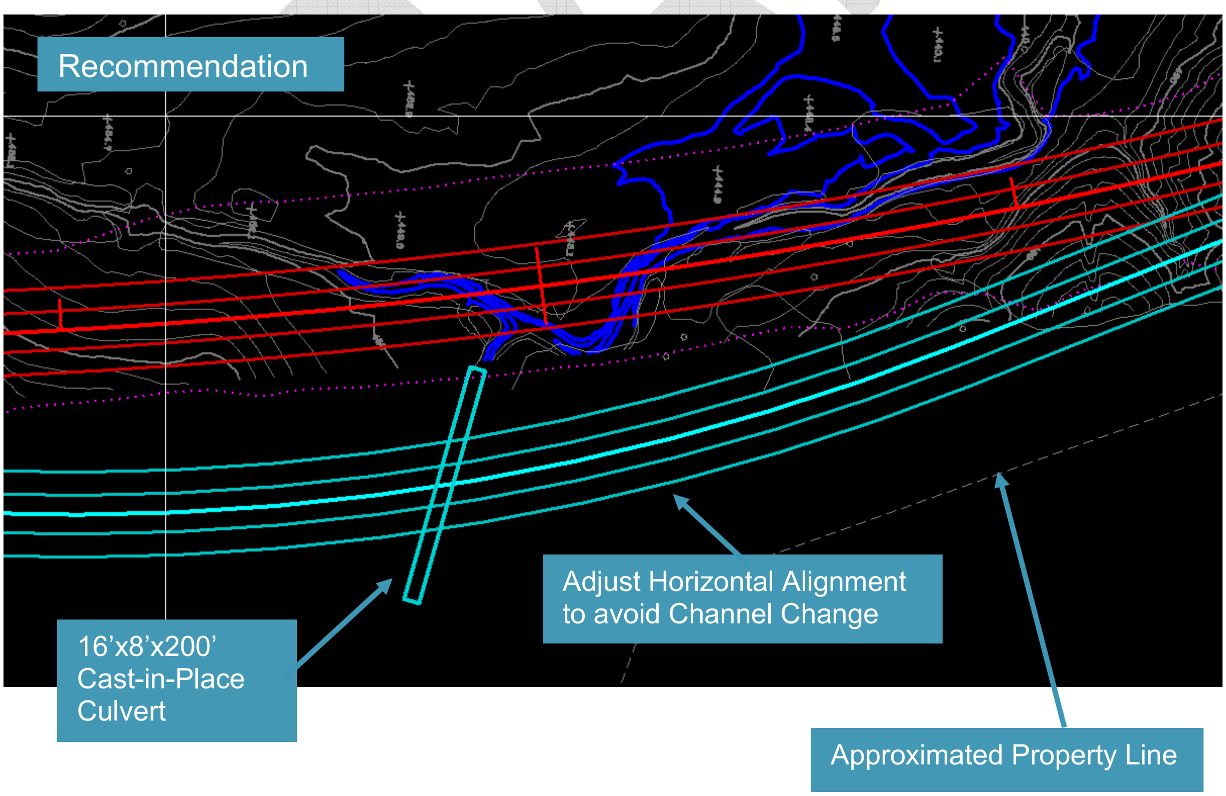
VE RECOMMENDATION NO. 4: MODIFY STRUCTURES 1, 2, & 3	Idea Nos. 13, 16, 17

Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches:

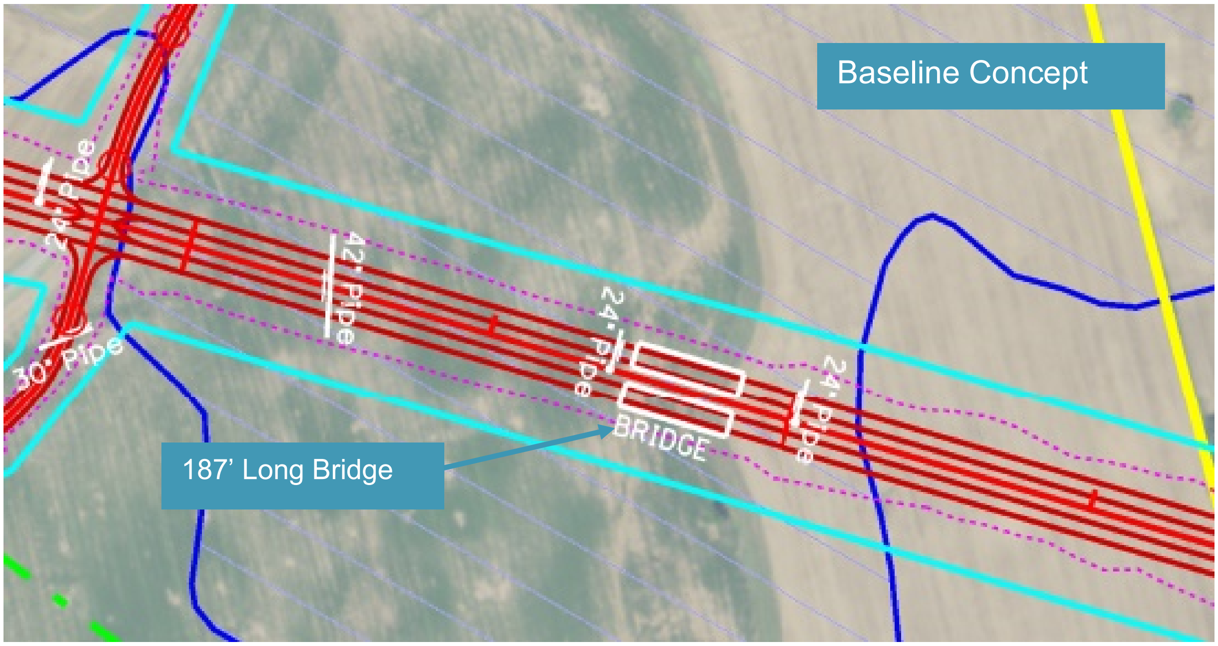
Structure #1 - Recommendation

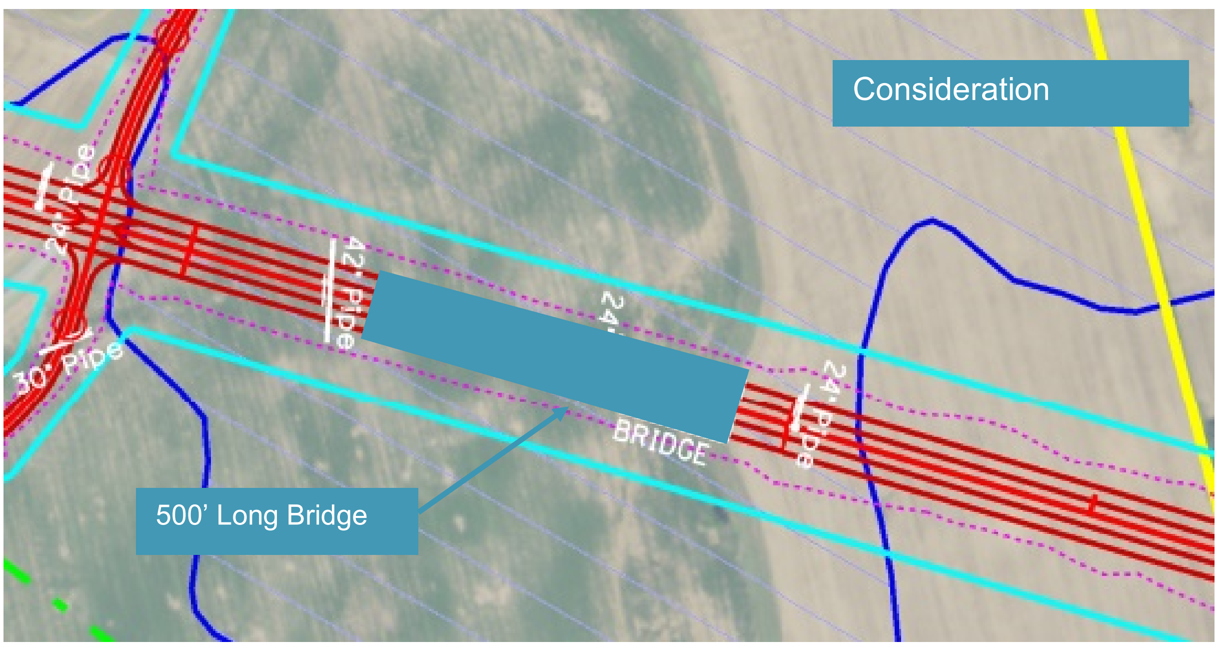




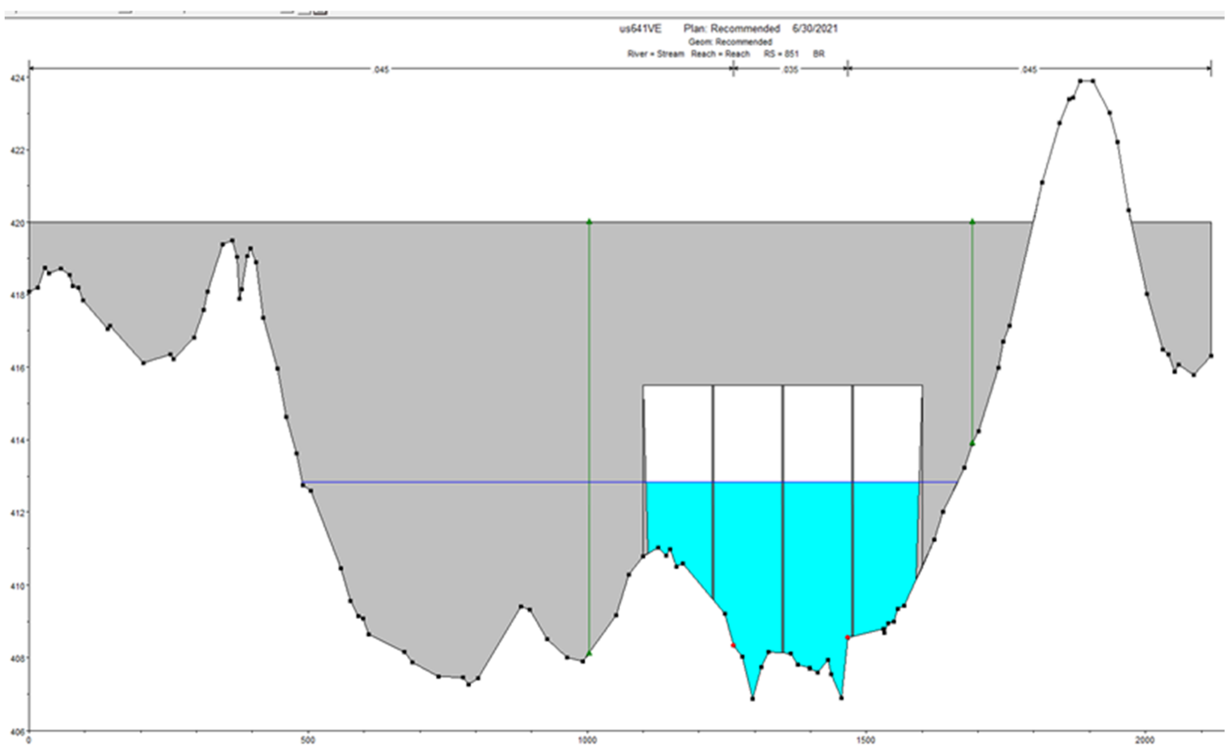
VE RECOMMENDATION NO. 4: MODIFY STRUCTURES 1, 2, & 3	Idea Nos. 13, 16, 17

Structure #2 – Design Consideration





VE RECOMMENDATION NO. 4: MODIFY STRUCTURES 1, 2, & 3	Idea Nos. 13, 16, 17



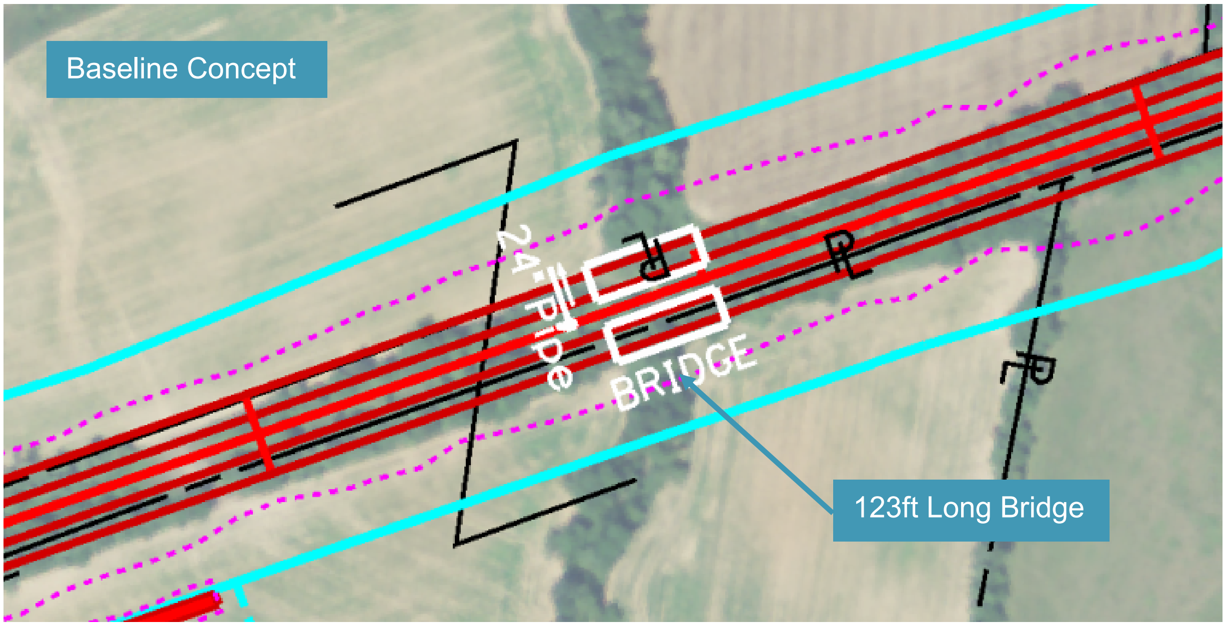
US 641 Drainage Profile at Structure #2

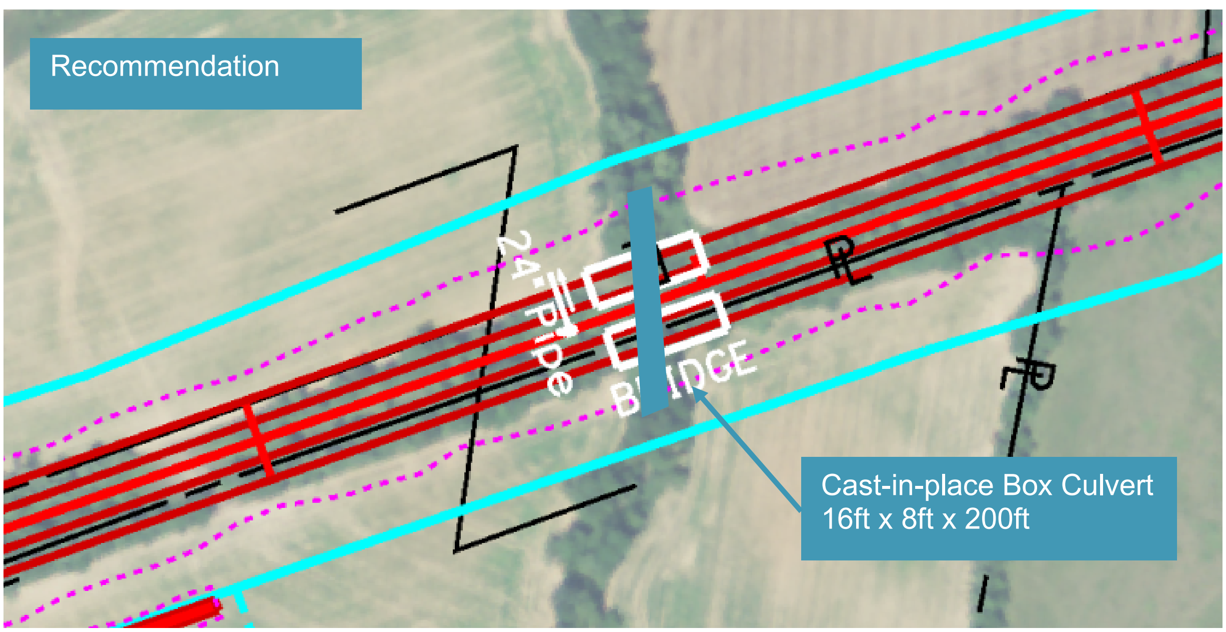
Water Surface Elevations

Reach	1009.009	PF 1	Existing	8410.00	412.15
Reach	1009.009	PF 1	Baseline Concept	8410.00	417.03
Reach	1009.009	PF 1	Recommended	8410.00	413.14

VE RECOMMENDATION NO. 4: MODIFY STRUCTURES 1, 2, & 3	Idea Nos. 13, 16, 17

Structure #3 - Recommendation





Assumptions/Calculations

Baseline Cost Estimate Verification

The VE team completed a preliminary review of the estimated structure costs for comparison purposes. As part of that review, assumptions associated with the bridge typical section width were developed. Structure costs for both the baseline and recommended concepts were developed to compare against the 4-lane preferred typical section which would include twin

VE RECOMMENDATION NO. 4: MODIFY STRUCTURES 1, 2, & 3	Idea Nos. 13, 16, 17

structures. The cost estimate matches closely to what was provided in the Preliminary Line and Grade (PL&G) estimate of $9,169,440 which validates the assumptions used. The information used to validate the PL&G estimate is provided in the table below. Additionally, it is assumed that the bridges would be either single or multi-span bridges consisting of precast prestressed concrete.

Typical Section			**Structure #1**				
Barrier	1.5	ft	Length	221	ft		
Outside Shoulder	10	ft	Area	18122	sq ft	$ 160	$ 2,899,520
Lane	12	ft					
Lane	12	ft	**Structure #2**				
Inside Shoulder	4	ft	Length	178	ft		
Barrier	1.5	ft	Area	14596	sq ft	$ 160	$ 2,335,360
Total Width	41	ft					
For Twin Bridges	82	ft	**Structure #3**				
			Length	123	ft		
Total Cost			Area	10086	sq ft	$ 160	$ 1,613,760
$ 2,899,520							
$ 2,335,360			**Structure #4**				
$ 1,613,760			Length	196	ft		
$ 2,571,520			Area	16072	sq ft	$ 160	$ 2,571,520
$ 9,420,160							

Recommendation Cost Estimate

The unit costs for culverts were based on what was provided in the PL&G estimated $ per cu ft of opening. Then lengths for the culverts are approximated estimates.

Total Cost		**Structure #1**				
$ 896,000		16ft x 8ft x 180ft	25600	Cu ft	$ 35	$ 896,000
$ 2,335,360						
$ 896,000		**Structure #3**				
$ 2,571,520		16ft x 8ft x 180ft	25600	Cu ft	$ 35	$ 896,000
$ 6,698,880						
		Elimination of Channel Change				
		Could decrease construction cost by approximately $400,000-$500,000 total for earthwork, in-lieu fees and permitting.				

VE RECOMMENDATION NO. 5: ALTERNATIVE 4-LANE TYPICAL SECTION	Idea Nos. 18, 22, 28

Baseline Concept

The proposed preferred typical section includes four 12’ lanes, 12’ outside shoulders, and a 40’ depressed median which includes 6’ inside shoulders.

Recommendation Concept

The VE team looked at three options for changing the typical section in regard to the ultimate configuration of the project. The team’s recommended alternative eliminates the 40' depressed median and replaces it with a 4' paved median, while maintaining the rest of the original typical section.

Advantages

- Requires less right-of-way acquisition
- Improves stormwater drainage
- Reduces embankment
- Reduces construction cost

Disadvantages

- Potential for more vehicle crossovers leading to head-on or sideswipe crashes
- Access management strategies limited

Cost Summary	Construction	Right-of-Way	Total
Baseline Concept	$62.98M	$1.57M	$64.55M
Recommendation Concept	$56.28M	$1.06M	$57.35M
Cost Avoidance	$6.70M	$0.50M	$7.20M

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Right-of-Way*
		✓		✓

VE RECOMMENDATION NO. 5: ALTERNATIVE 4-LANE TYPICAL SECTION	Idea Nos. 18, 22, 28

Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

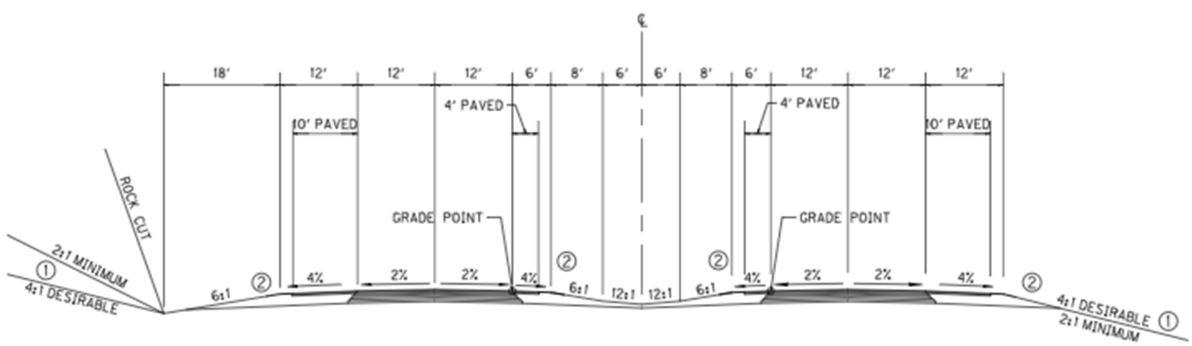
The primary functions of the US 641 project are to improve the existing roadway (safety and capacity) and improve freight mobility between I-24 and Marion (providing a route on the National Truck Network).

The VE team looked at three options to be able to achieve the primary functions of the project. Those three options were:

A. Eliminate the 40' depressed median and replace it with a 4' paved median, while also maintaining the rest of the original Typical Section.
B. Reduce outside paved shoulder width from 10’ to 4’. This would leave a 2’ gravel shoulder in addition to the 4’ paved for a total outside shoulder width of 6’ vs. the 12’ in the typical section.
C. Use the Alabama 55 cross section (four 12' lanes, 2' paved outside shoulders, 4' median).

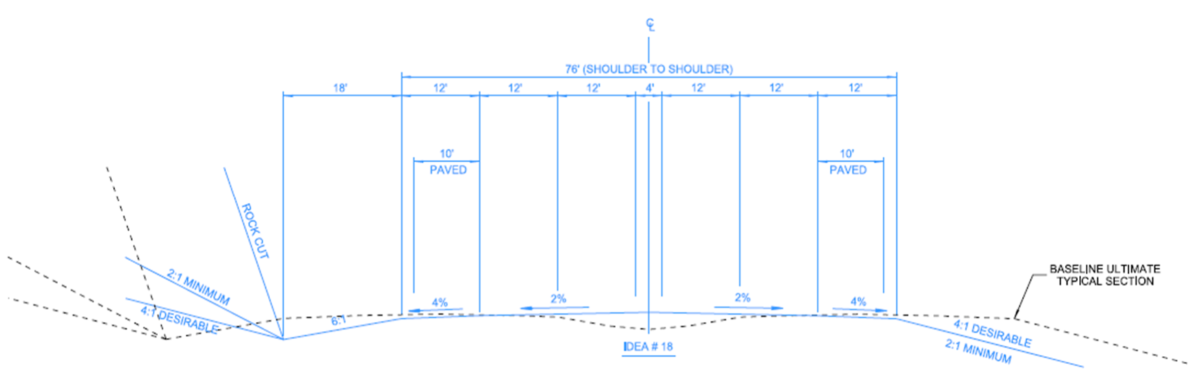
Ultimately, the VE Team recommendation is Option A.

The Preferred Typical Section is the following:



NORMAL SECTION

The VE team is recommending eliminating the 40’ depressed median and replacing it with a 4’ paved median. The following is the recommended typical section:



VE RECOMMENDATION NO. 5: ALTERNATIVE 4-LANE TYPICAL SECTION	Idea Nos. 18, 22, 28

ADT on the existing US 641 route is currently averaging 2,500 to 3,000 vehicles, which includes a truck percentage of 10% to 20%. Given the low ADT volume on the existing route, the team believes that the 40’ depressed median on the proposed new US 641 route could be modified to a simpler median. For that reason, a 4’ paved median would still act as a buffer between the lanes of travel and would also reduce the amount of R/W acquisition, embankment, construction cost, and improve drainage.

- Option A - The VE Team understands the Project Team was looking at the Alabama 55 cross section as a possible alternative, and the VE Team also believes this is a possibility. The only difference between what the Project Team was looking at compared to this recommendation is the outside shoulder width would not be 2’, but 12’. The primary purpose of the outside shoulder along this new route would be to provide a recoverable area for roadway departure and the occasional emergency parking. The safety benefits associated with wider outside shoulders are significant.
- Option B - One of the other options that the Team looked at included reducing the outside paved shoulder width from 10’ to 4’. However, The VE Team believes this would not allow for a safe refuge area, especially for trucks and emergency vehicles. Additionally, one of the primary purposes of this project is to make this route part of the National Truck Network and having 4’ paved shoulders could hinder the route qualifying under the specified criteria.

- Option C - The last option the Team looked at was just using the Alabama 55 cross section as is, which included four 12' lanes, 2' paved outside shoulders, and 4' median. The team had a similar concern with this option on the shoulder widths, because like stated previously, could hinder the route in qualifying for the National Truck Network. There was also a significant increase in potential crashes with the shoulder widths being just 2’.

Recommendation - It is for those main reasons why the VE Team went with a hybrid approach between the Typical Section and the Alabama 55 cross section and arrived at Option A.

Safety Analysis

Option A will have little impact on project safety performance compared to the proposed design. With comparing the proposed alternative to the baseline proposed design, below are the projected crashes and safety analysis over a 20-year period:

The safety analysis (conducted using IHSDM) considers the baseline scenario as it compares with the proposed VE recommendation of eliminating the median to replace it for a 4-ft flush median (with centerline rumble strips). Due to limitations of the Highway Safety Manual with regard to analyzing rural multilane facilities with flush medians a hybrid approach of using IHSDM and CMF research was applied. To calculate the safety performance most accurately for this concept, it was coded in IHSDM as a 4-lane undivided roadway with no median separation. (The HSM clearly states the limitation to analyze these roadways, but additionally notes that flush medians should be treated as undivided facilities; therefore this seemed to be the most applicable approach given the abilities of the software). Once the predictive crash analysis was calculated a CMF was applied to head-on and sideswipe crashes to account for the presence of centerline rumble strips. *(CMF ID: 3355 was used. This CMF is primarily for 2-lane roadways, but as research is limited for centerline rumbles on 4-lane roadways and the proposed concept would have a larger median and it is only applicable to a small subset of crashes it was assumed to be applicable).*

VE RECOMMENDATION NO. 5: ALTERNATIVE 4-LANE TYPICAL SECTION	Idea Nos. 18, 22, 28

The resulting crashes were monetized based comprehensive crash costs for fatal & injury crashes (FI) and property damage only (PDO) crashes. The comprehensive crash cost provided blended crash cost rates based on the severity breakdown of crashes throughout KY. These severity crash costs were compared against the baseline.

The resulting safety impact of this recommendation is an increase in 64 total crashes over a 20-year period (3 crashes per year) and a crash cost of approximately $17.1million. *It should be noted that this is likely a conservative estimate due to the limitations in safety methodology available and that the actual crash experience would likely be less significant than the values stated.*

				CMF ID: 3355	0.63	0.63
		Baseline	VE22 4	VE22 6	VE18 v2 w CMF	VE28 v2 w CMF
Segment	FI	90.17	98.29	93.78	141.86	152.65
	PDO	70.67	77.03	73.50	83.27	89.72
	Total Crashes	161	175	167	225	242
	Crashes/Year	8	9	8	11	12
	FI Crash Cost	$ 29,717,494	$ 32,392,338	$ 30,906,431	$ 46,751,768	$ 50,307,286
	PDO Crash Cost	$ 684,715	$ 746,329	$ 712,114	$ 806,811	$ 869,303
	Total Crash Cost	$ 30,402,208	$ 33,138,667	$ 31,618,545	$ 47,558,579	$ 51,176,589
Compared to Baseline			$ (2,736,459)	$ (1,216,337)	$ (17,156,370)	$ (20,774,381)

Assumptions/Calculations

The VE Team looked at construction cost savings and the safety analysis in determining which option was best to bring forward to the Project Team.

<u>Construction Cost Savings</u>

The VE Team's calculations of Option A show that there is a construction cost savings of $7.2 million. A breakdown of that cost can be seen below:

VE RECOMMENDATION NO. 5: ALTERNATIVE 4-LANE TYPICAL SECTION	Idea Nos. 18, 22, 28

VE COST COMPARISON

CONSTRUCTION ELEMENT		BASELINE			RECOMMENDATION		
Description	Unit	Qty	Cost/Unit	Total	Qty	Cost/Unit	Total
DRAINAGE BLANKET-TYPE II-ASPH	TON	59,730	$51	$3,018,754	64,706	$51	$3,299,981
DGA BASE	TON	417,598	$19	$7,905,130	283,382	$19	$5,384,258
ASPHALT SEAL AGGREGATE	TON	2,227	$42	$93,512	1,591	$42	$66,811
ASPHALT SEAL COAT	TON	267	$691	$184,508	191	$691	$131,786
CL2 ASPH BASE 1.00D PG64-22	TON	24,978	$60	$1,498,680	17,842	$60	$1,070,507
CL3 ASPH BASE 1.00D PG64-22	TON	157,656	$52	$8,218,607	170,789	$52	$8,881,015
CL3 ASPH BASE 1.00D PG76-22	TON	45,424	$64	$2,888,966	49,208	$64	$3,149,300
CL2 ASPH SURF 0.50D PG64-22	TON	12,489	$80	$993,125	8,921	$80	$713,671
CL3 ASPH SURF 0.50B PG76-22	TON	22,489	$111	$2,499,203	24,362	$111	$2,704,219
ASPHALTIC MATERIAL FOR TACK NON-TRACKING AT ONE TIME WAS TRACKLESS TACK	TON	886	$794	$703,741	601	$794	$477,384
				$0			$0
EMBANKMENT IN PLACE	CY	1,789,262	$6	$10,717,679	1,437,314	$6	$8,623,885
				$0			$0
BRIDGES ($160/SF OF DECK AREA)	SF	57,309	$160	$9,169,440	51,853	$160	$8,296,509
				$0			$0
				$0			$0
SUB-TOTAL				$47,891,346			$42,799,328
PROJECT MARK-UPS	31.5%			$15,085,774			$13,481,788
CONSTRUCTION TOTAL				$62,977,119			$56,281,116
RIGHT OF WAY ACQUISITION (9.2 MILES X 175' WIDTH)	ACRE	196	$8,000	$1,568,000	133	$8,000	$1,064,045
TOTAL W/ROW				$64,545,119			$57,345,161
						SAVINGS	**$7,199,959**

Option A

Shoulder and Base Material

% Difference vs. Baseline Buildout = -32.14%

Asphalt Pavement

% Difference vs. Baseline Buildout = -5.26%

Embankment

% Difference vs. Baseline Buildout = -19.67%

ROW Acquisition

% Difference vs. Baseline Buildout = -32.14%

VE RECOMMENDATION NO. 5: ALTERNATIVE 4-LANE TYPICAL SECTION	Idea Nos. 18, 22, 28

Option B
Shoulder and Base Material
% Difference vs. Baseline Buildout = -10.71%
Asphalt Pavement
% Difference vs. Baseline Buildout = -15.79%
Embankment
% Difference vs. Baseline Buildout = -14.94%
ROW Acquisition
% Difference vs. Baseline Buildout = -10.71%

Option C
Shoulder and Base Material
% Difference vs. Baseline Buildout = -46.43%
Asphalt Pavement
% Difference vs. Baseline Buildout = -26.32%
Embankment
% Difference vs. Baseline Buildout = -37.32%
ROW Acquisition
% Difference vs. Baseline Buildout = -46.43%

VE RECOMMENDATION NO. 6: ALTERNATIVE 2+1 TYPICAL SECTION	Idea Nos. 20, 23, 24, 27, 31

Baseline Concept

The proposed Typical Section includes four 12' lanes, 12' outside shoulders, and a 40' depressed median which includes 6' inside shoulders for the length of the new route.

Recommendation Concept

Change the Typical Section from what is proposed to a 2+1 for the length of the new route. The 2+1 would have two 12' lanes with an alternating 12' passing lane and 12' outside shoulders.

Advantages	Disadvantages
• Requires less R/W acquisition • Improves stormwater drainage • Reduces embankment • Reduces construction cost • Allows for expansion to future 4-lane typical	• Potential County stakeholder acceptance

Cost Summary	Construction	Right-of-Way	Total
Baseline Concept	$62.98M	$1.57M	$64.55M
Recommendation Concept	$43.14M	$1.06M	$44.20M
Cost Savings	$19.84M	$0.51M	$20.35M

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Right-of-Way*
✓	✓			✓

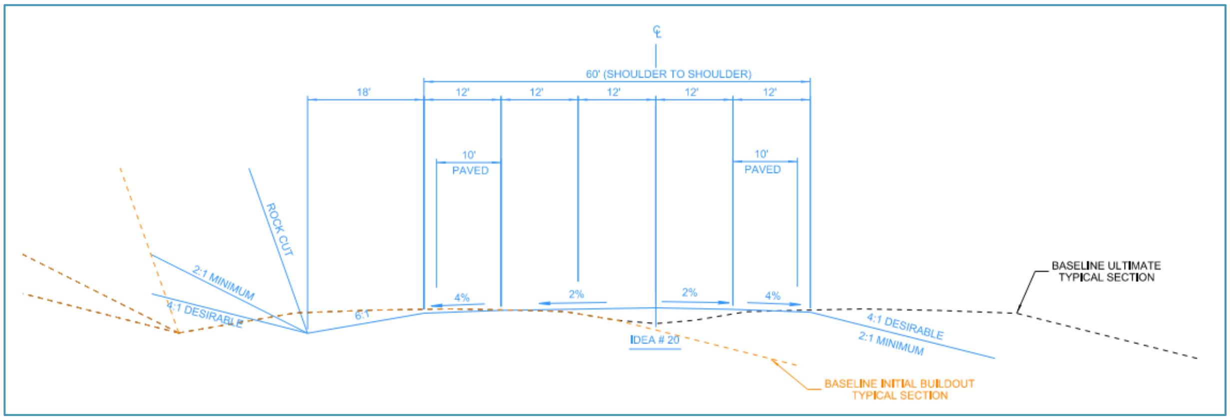
VE RECOMMENDATION NO. 6: ALTERNATIVE 2+1 TYPICAL SECTION	Idea Nos. 20, 23, 24, 27, 31

Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

The primary functions of the US 641 project are to improve the existing roadway (safety and capacity) and improve freight mobility between I-24 and Marion (providing a route on the National Truck Network). This can be achieved by constructing a 2+1 roadway throughout the corridor.

The typical section for the 2+1 corridor is shown below. This typical would consist of two 12' travel lanes, an alternating passing lane (12'), and 12' outside shoulders (10' paved, 2' gravel) on each side of the roadway. The total pavement width in passing sections would be 56'. Through sections without a passing lane would have a total pavement width of 42'.

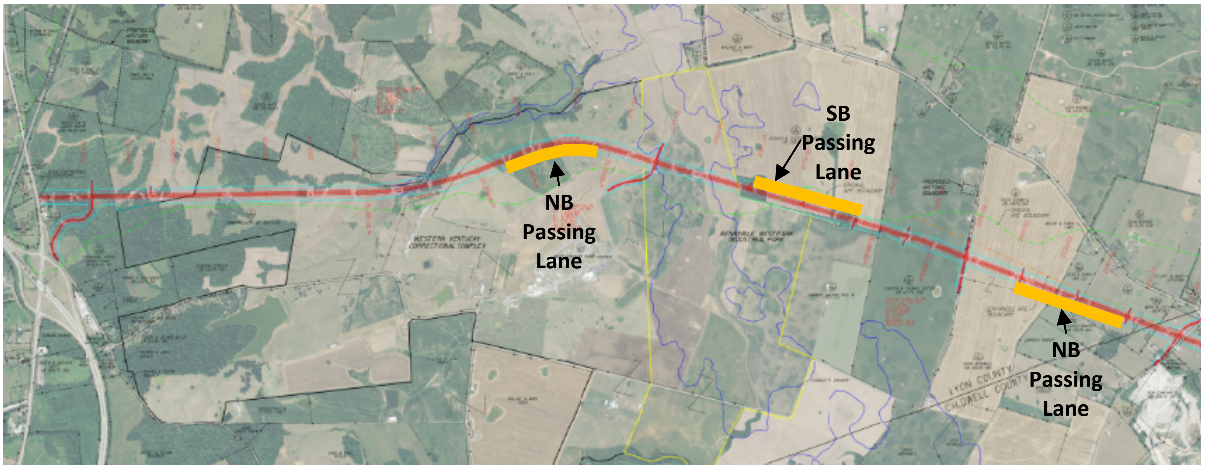


The preferred alignment could be utilized for the 2+1 configuration accounting for 4 passing lanes (2 in each direction) throughout the project area. Based on KYTC guidance, passing lanes for roadways with this volume should be between 0.5 to 0.75mi in length. Assuming the appropriate taper lengths and approximately 0.5mi of passing lane length, it is feasible to accommodate the passing lanes while avoiding the bridges and having the passing lanes at intersections.

Considering the existing and projected volumes and truck percentages it is anticipated that the 2+1 functionality will perform adequately through the design year for the project. It does not improve the capacity provided by the full-build baseline, but it is anticipated that both will operate with reasonable LOS and minimal delays.

VE RECOMMENDATION NO. 6: ALTERNATIVE 2+1 TYPICAL SECTION	Idea Nos. 20, 23, 24, 27, 31

A basic sketch of the location of the passing lanes as discussed is shown below.



From a safety perspective, the 2+1 provides an improved predictive safety performance to the full-build option. The magnitude of crashes is a decline from the full-baseline, but the severity distribution of crashes changes significantly to show overall benefit to the 2+1 in comparison to the full baseline scenario. Based on the calculated crashes (IHSDM) and cost breakdown, the 2+1 should show an improvement of $5M of societal crash cost savings.

Constructing the 2+1 concept allows for a significant footprint reduction as compared to the full baseline scenario. As such, the 2+1 concept represents a significant cost savings to the full baseline. Despite these reductions, the 2+1 concept functions with adequate operational performance through the lifecycle of the project with respect to the full-baseline.

This option also affords the ability to expand the typical section to a 4-lane ultimate configuration should the traffic volume dictate. The pavement width is comparable to a modified Alabama 55 typical section with 4x12’ lanes, 4’ flush median, and 2’ shoulders (which could be expanded for safety benefits [see VE recommendation 5]). Additionally, the bridges would need to be expanded to accommodate this scenario.

VE RECOMMENDATION NO. 6: ALTERNATIVE 2+1 TYPICAL SECTION	Idea Nos. 20, 23, 24, 27, 31

In addition to the 2+1 concept, the team considered a variety of 2-lane options which included:

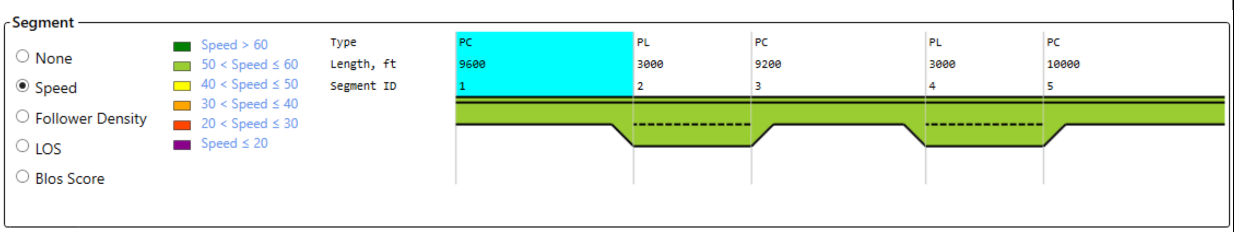
- 2-lane on the proposed alignment with 12’ lanes and PBFS shoulder
    - 10’, 8’, and 6’ shoulders were examined
- 2-lane on the proposed alignment with 12’ lanes and 12’ full-depth shoulders
- 2-lane on the proposed alignment around Fredonia, with a tie-in to the existing alignment near STA 2280+00 and utilizing the existing US641 alignment from that point onward. This would include 12’ lanes and a PBFS shoulder.

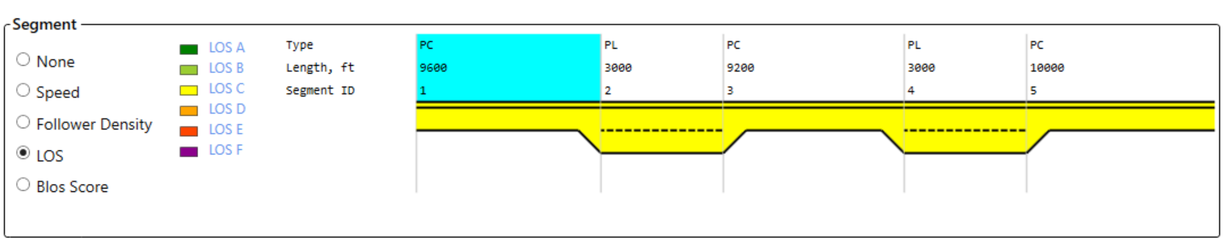
While each of these concepts had merit in safety and project cost savings, the 2+1 concept was recommended as it provides greater safety benefits in conjunction with operational benefits not included with other 2-lane concepts.

Operational Analysis:

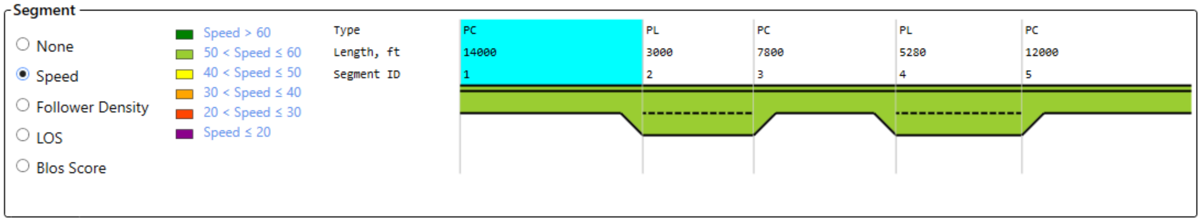
HCS7 Two-Lane Highways module was used to analyze the operations for the 2+1 configuration. Assumptions from the revised volume projections were used to determine DHV volumes. *It should be noted that the revised traffic projections are likely conservative when comparing to historic growth trends for this roadway and similar facilities.* A K factor of 10% was used to derive the volumes, and it was assumed that the directional split would be even 50/50. The volumes used for analysis range from 550 to 730vph. The truck percentages ranging from 25%-34% were used throughout the corridor. Based on those assumptions it is anticipated that the 2+1 configuration will operate with adequate speeds (>50mph) and adequate LOS (LOS C) through the 2040 design year. The analysis was based on peak volumes which are likely to occur one-hour per day, the remaining hours of the day will operate better than the LOS C conditions. The images below show the results of the DHV analysis for NB and SB.

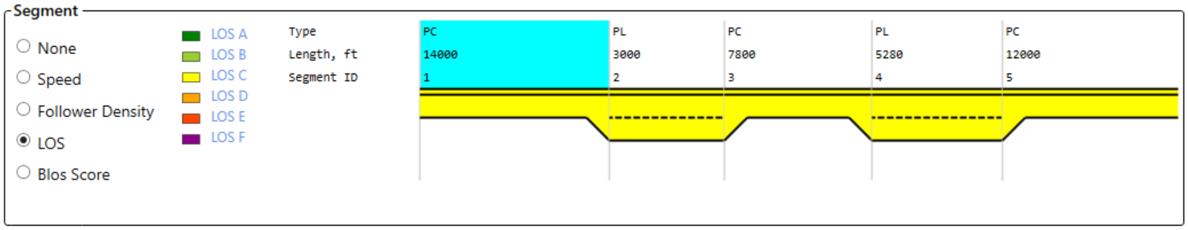
Northbound





Southbound





Safety Analysis:

The IHSDM results indicate an increase of crashes as compared with the full-baseline of approximately 64 crashes (3 crashes/year). However, the severity of those crashes is anticipated to be impacted. In calculating the severity breakdown and cost, the FI crashes are reduced in the 2+1 while the PDO crashes increase.

When costs are applied (assuming a blended severity cost of $329,564.54 for FI crashes and a PDO crash cost of $9,689.00) the overall cost difference between the 2+1 and the baseline scenario shows a benefit of $5M in societal costs.

Predictive Crash Results (assumed 20-year lifecycle)			
		Baseline	VE20
			2+1 Typical (12’ lanes, 12’ OS)
	FI	90.172	72.3196
Segment	PDO	70.6693	152.9742
	Total Crashes	*161*	*225*
	Crashes/Year	*8*	*11*
	FI Crash Cost	$ 29,717,494	$ 23,833,976
	PDO Crash Cost	$ 684,715	$ 1,482,167
	Total Crash Cost	$ 30,402,208	$ 25,316,143
	Compared to Full Baseline		$ 2,050,050

VE RECOMMENDATION NO. 6: ALTERNATIVE 2+1 TYPICAL SECTION	Idea Nos. 20, 23, 24, 27, 31

Assumptions/Calculations

The project cost performance of the 2+1 as compared to the full baseline is shown in the table below. As shown, the cost of the 2+1 as compared with the full baseline is a cost savings of approximately $20M. The below table shows the breakdown and assumptions used to calculate these costs.

VE COST COMPARISON							
CONSTRUCTION ELEMENT		*BASELINE*			*RECOMMENDATION*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
DRAINAGE BLANKET-TYPE II-ASPH	TON	59,730	$51	$3,018,754	39,819	$51	$2,030,769
DGA BASE	TON	417,598	$19	$7,905,130	298,290	$19	$5,667,515
ASPHALT SEAL AGGREGATE	TON	2,227	$42	$93,512	1,591	$42	$66,807
ASPHALT SEAL COAT	TON	267	$691	$184,508	191	$691	$131,777
CL2 ASPH BASE 1.00D PG64-22	TON	24,978	$60	$1,498,680	17,841	$60	$1,070,432
CL3 ASPH BASE 1.00D PG64-22	TON	157,656	$52	$8,218,607	105,104	$52	$5,465,394
CL3 ASPH BASE 1.00D PG76-22	TON	45,424	$64	$2,888,966	30,283	$64	$1,938,086
CL2 ASPH SURF 0.50D PG64-22	TON	12,489	$80	$993,125	8,920	$80	$713,621
CL3 ASPH SURF 0.50B PG76-22	TON	22,489	$111	$2,499,203	14,992	$111	$1,664,144
ASPHALTIC MATERIAL FOR TACK NON-TRACKING AT ONE TIME WAS TRACKLESS TACK	TON	886	$794	$703,741	633	$794	$502,499
				$0			$0
EMBANKMENT IN PLACE	CY	1,789,262	$6	$10,717,679	1,167,404	$6	$7,004,424
				$0			$0
BRIDGES ($160/SF OF DECK AREA)	SF	57,309	$160	$9,169,440	40,936	$160	$6,549,731
				$0			$0
				$0			$0
SUB-TOTAL				$47,891,346			$32,805,199
PROJECT MARK-UPS	31.5%			$15,085,774			$10,333,638
CONSTRUCTION TOTAL				$62,977,119			$43,138,837
RIGHT OF WAY ACQUISITION (9.2 MILES X 175' WIDTH)	ACRE	196	$8,000	$1,568,000	133	$8,000	$1,064,045
TOTAL W/ROW				$64,545,119			$44,202,882
						SAVINGS	**$20,342,237**

7.4 Performance Assessment

As the VE team developed each recommendation they considered how it would impact the performance of the project as it relates to the baseline concept. Changes in performance are always based on the overall impact to the total project. Once performance and cost data was developed by the VE team, two VE strategies were created using all six individual recommendations and the net change in value can then be compared to the baseline concept as described in 2.3, Proposed Improvements.

For this exercise, the baseline was given a score of 5. The resulting value improvement scores provide a way for KYTC to assess the potential impact of the VE Strategy on total project value. Understanding the relationship of cost, performance, and value of the project baseline and VE Strategy is essential in evaluating VE recommendations.

7.4.1 Performance of VE Strategy

VE studies result in the development of a number of recommendations. While each recommendation is developed as an independent concept, typically the cumulative impact of select recommendations provides the best value solution for the project. This is because some recommendations may be competing ideas or different ways to address the same issue. Some recommendations are developed to answer a question raised by a decision maker or to resolve an open issue and found not to be beneficial to the ultimate project.

The following two VE strategies were developed as complimentary combinations of individual VE recommendations that were deemed the highest in priority:

Value Strategy—4-Lane Ultimate – This strategy includes Recommendations 1, 2, 3, 4, and 5. The strategy suggests an ultimate configuration that eliminates the 40-foot depressed median and replaces it with a 4-foot paved median while maintaining the rest of the Preferred Typical Section.

Value Strategy—2+1 Ultimate – This strategy includes Recommendations 1, 2, 3, 4, and 6. This strategy proposes an alternative typical section of a 2+1 roadway for the length of the new route as the ultimate configuration.

7.4.2 Rating Rationale

The rating rationale for the performance of the baseline concept as compared to the VE strategies developed by the VE team is provided in Table 11.

Table 11. Attributes and Rating Rationale for VE Strategies

Performance Attribute Ratings				
Attribute	**Attribute Weight**	**Concept**	**Performance Rating**	**Total Performance**
Main Line Operations	30.0	Preferred - Ultimate	5	150.0
		Value Strategy - 4-Lane Ultimate	5	150.0
		Value Strategy - 2+1 Ultimate	5	150.0
Local Operations	20.1	Preferred - Ultimate	5	100.5
		Value Strategy - 4-Lane Ultimate	4	80.4
		Value Strategy - 2+1 Ultimate	4	80.4
Maintainability	30.0	Preferred - Ultimate	5	150.0
		Value Strategy - 4-Lane Ultimate	6	180.0
		Value Strategy - 2+1 Ultimate	7	210.0
Construction Impacts	6.6	Preferred - Ultimate	5	33.0
		Value Strategy - 4-Lane Ultimate	6	39.6
		Value Strategy - 2+1 Ultimate	6	39.6
Environmental Impacts	13.3	Preferred - Ultimate	5	66.5
		Value Strategy - 4-Lane Ultimate	6	79.8
		Value Strategy - 2+1 Ultimate	7	93.1

Table 12 reflects the discussion held by the VE team as they rated each VE strategy against the baseline for each performance attribute.

Table 12. Value Strategy Performance Assessment Discussion

Value Strategies	
4-Lane Ultimate	**2+1 Ultimate**
Mainline Operations	
• Free flow speed calculation showed it would be beneficial to have inside shoulders and a median • Drivers would feel more comfortable with preferred typical section. Traffic won't feel as comfortable to drive as fast; however, the speed limit is 55 mph. • Access control slightly improved. • Increased conflicts with this configuration. Because there is not the 40' median, there might be an increase in crossover accidents. However, access control may help reduce some conflicts.	• From traffic control standpoint, it may be slightly worse than preferred 4-lane ultimate but would be safer than 4-Lane Ultimate value strategy. • 2+1 may be safer than baseline due to breakdown of crash severity. More run-off-the-road accidents rather than 2+ vehicle fatal injury crashes. Reduction to 2 lanes may decrease sideswipes. 4-lane depressed median may cause people to drive faster. • Peak hour traffic flow is not as good as ultimate 4-lane for the few hours of the day that it might be a concern but performs similarly to the baseline for the majority of the day.
Local Operations	
• Performs slightly worse compared to the baseline due to the impact on local operations. However, reducing access points reduces conflict points. Performance slightly reduced due to reduction in access points, but the local area is farmland rather than personal driveways. • This recommendation includes the elimination of median access points. Discussed that it may be illegal to cross 4' median without designated crossovers. ADT is low, so may not be a major concern, but this recommendation performs slightly worse when compared to the baseline.	• When compared to baseline 40' median, it rates similarly to 4-Lane Ultimate value strategy

Table 12. Value Strategy Performance Assessment Discussion

Value Strategies	
4-Lane Ultimate	**2+1 Ultimate**
Maintainability	
• This strategy performs slightly better than the preferred typical section because the 4’ paved median would only require one bridge. Maintenance access may be improved because the added lanes allow for additional traffic control options. • Grass in the baseline 40’ median would not have to be maintained. • Debris from a vehicle in 4’ paved median may slightly increase hazards; however, litter control would be reduced overall without the 40’ median.	• The bridges in this strategy are smaller and there is no 4’ median, so there is less impervious surface to maintain and pave.
Construction Impacts	
• Slight improvement due to optimized profile and fewer trucks required to haul embankment.	• Slight improvement due to optimized profile and fewer trucks required to haul embankment.
Environmental Impacts	
• Less embankment needed, so impact on the environment is reduced. • No significant reduction in impervious pavement, but slightly reduced. • The creek does not have to be realigned with this strategy.	• This strategy requires significantly less pavement (only has four passing lane areas) and smaller bridges. • It does not require stream realignment.

7.4.3 Compare Value

The cost and elements were compared and normalized for the baseline concept and the VE strategies. A value matrix was prepared that facilitated the comparison of the baseline and the VE strategies by organizing and summarizing this data into a tabular format. The performance for the strategy was divided by the total cost for the strategies to derive a value index. The value index for the VE strategies were then compared against the value index of the baseline concept and the difference is expressed as a percent (± %) deviation. A comparison of the strategies' value is shown in Table 13.

Table 13. Value Matrix – Baseline vs VE Strategies

Strategy	Performance (P)	% Change Performance	Cost (C) $ millions	Cost Change $ millions	% Change Cost	Value Index	% Value Improvement
Preferred - Ultimate	500	---	$68.8	---	---	7.27	---
Value Strategy - 4-Lane Ultimate	530	+6.0%	$50.1	($18.67)	-27.1%	10.57	+45.4%
Value Strategy - 2+1 Ultimate	573	+14.6%	$42.6	($26.23)	-38.1%	13.46	+85.2%

7.5 Design Considerations

The VE team generated the following design suggestions for the project design team's consideration. These items represent ideas that are general in nature and are listed below in Table 14. Additional details can be found in the evaluation form in Section 6.2.

Table 14. Design Considerations

Idea No.	Description
1	Eliminate the crown and slope the roadway toward outside to allow drainage
6	Ensure crossings over gas lines (US 641 and local roads) are as perpendicular as possible
7	Construct encasement pipe around gas line to allow maintenance
8	Retain the existing alignment for Fredonia quarry road to minimize impacts to the gas lines
9	Make new fence adjacent to the prison. Needs to be installed before other work begins.
12	Use 4:1 side slopes in lieu of 2:1
15	Early advancement of geotechnical investigations to inform design
21	If the project is phased, then purchase only the amount of right-of-way needed for initial buildout
25	Reduce the 40' depressed median to 20'
34	Reduce the width of the cross section on the approach roads to 11' travel lane and 4' shoulders
35	Match width of existing approach roads
38	Utilize alternative bids for pavement section
39	Reduce the overall outside shoulder width to 10' with 4' paved

Appendix A. Value Methodology Process

Value Methodology is a systematic process using a multidisciplinary team to improve the value of a project through the analysis of its functions. This process incorporates, to the extent possible, the values of design, construction, maintenance, contractor, state, local, and federal approval agencies, other stakeholders, and the public.

The primary objective of a Value Engineering (VE) study is value improvement. Value improvements might relate to scope definition, functional design, constructability, coordination (both internal and external), or the schedule for project development. Other possible value improvements are reduced environmental impacts, reduced public (traffic) inconvenience, or reduced project cost.

Pre-VE Study

Prior to the start of a VE study, the Project Manager, and the VE facilitator carry out the following activities:

- Initiate study – Identify study project and define study goals
- Organize study – Conduct pre-VE study meeting and select team members
- Prepare data – Collect and distribute data and prepare cost models.

All of the information gathered prior to the VE study is given to the team members for their use.

Value Methodology

The VE team employed the six-phase Value Methodology in analyzing the project. This process is recommended by SAVE International® and is composed of the following phases:

Information – The team reviews and defines the current conditions of the project and identifies the goals of the study.

Function Analysis – The team defines the project functions using a two-word active verb/ measurable noun context. The team reviews and analyzes these functions to determine which need improvement, elimination, or creation to meet the project's goals.

Creative – The team employs creative techniques to identify other ways to perform the project's function(s).

Evaluation – The team follows a structured evaluation process to select those ideas that offer the potential for value improvement while delivering the project's function(s) and considering performance requirements and resource limits.

Development – The team develops the selected ideas into alternatives (or proposals) with a sufficient level of documentation to allow decision makers to determine if the alternative should be implemented.

Presentation – The team facilitator develops a report and/or presentation that documents and conveys the adequacy of the alternative(s) developed by the team and the associated value improvement opportunity.

The following is a general discussion and overview of the Performance-Based VE process. Ideas that have been introduced and warrant further consideration, will be documented with their advantages and disadvantages; each idea will then be carefully evaluated against project-specific attributes.

Performance-Based Value Engineering

Performance measures an integral part of the VE process. It provides the cornerstone of the VE process by giving a systematic and structured way of considering the relationship of a project's performance and cost as they relate to value. Project performance must be properly defined and agreed on by the stakeholders at the beginning of the VE study. The performance attributes and requirements that are developed are then used throughout the study to identify, evaluate, and document alternatives.

INTRODUCTION

Value engineering has traditionally been perceived as an effective means for reducing project costs. This paradigm only addresses one part of the value equation, oftentimes at the expense of overlooking the role that VE can play with regard to improving project performance. Project costs are fairly easy to quantify and compare through traditional estimating techniques. Performance is not so easily quantifiable.

The VE facilitator will lead the team and external stakeholders through the methodology, using the power of the process to distill subjective thought into an objective language that everyone can relate to and understand. The dialogue that develops forms the basis for the VE teams understanding of the performance requirements of the project and to what degree the current design concept is meeting those requirements. From this baseline, the VE team can focus on developing alternative concepts that will quantify both performance and cost and contribute to overall project value.

Performance-based VE yields the following benefits:

- Builds consensus among project stakeholders (especially those holding conflicting views)
- Develops a better understanding of a project's goals and objectives
- Develops a baseline understanding of how the project is meeting performance goals and objectives
- Identifies areas where project performance can be improved through the VE process
- Develops a better understanding of a VE alternative's effect on project performance
- Develops an understanding of the relationship between performance and cost in determining value
- Uses value as the true measurement for the basis of selecting the right project or design concept

- Provides decision-makers with a means of comparing costs and performance (i.e., costs vs. benefits) in a way that can assist them in making better decisions.

METHODOLOGY

The application of Performance-based VE consists of the following steps:

1. Identify key project (scope and delivery) performance attributes and requirements for the project.
1. Establish the hierarchy and impact of these attributes on the project.
2. Establish the baseline of the current project performance by evaluating and rating the effectiveness of the current design concepts.
3. Identify the change in performance of alternative project concepts generated by the study.
4. Measure the aggregate effect of alternative concepts relative to the baseline project's performance as a measure of overall value improvement.

The primary goal of value engineering is to improve the value of the project. A simple way to think of value in terms of an equation is as follows:

$$Value = \frac{Performance}{Cost}$$

ASSUMPTIONS

Before embarking on the details of this methodology, some assumptions need to be identified. The methodology described in the following steps assumes the project functions are well established. Project functions are defined as what the project delivers to its users and stakeholders; a good reference for the project functions can be found in the environmental document's purpose and need statement. Project functions are generally well defined prior to the start of the VE study. In the event that project functions have been substantially modified, the methodology must begin anew (Step 1).

Step 1 – Determine the Major Performance Attributes

Performance attributes can generally be divided between project scope components (highway operations, environmental impacts, and system preservation) and project delivery components. It is important to make a distinction between performance *attributes* and performance *requirements*. Performance requirements are mandatory and binary in nature. All performance requirements MUST be met by any VE alternative concept being considered. Performance attributes possess a range of acceptable levels of performance. For example, if the project was the design and construction of a new bridge, a performance requirement might be that the bridge meets all current seismic design criteria. In contrast, a performance attribute might be project schedule, which means that a wide range of alternatives could be acceptable that had different durations.

The VE facilitator will initially request representatives from project team and external stakeholders identify performance attributes that they feel are essential to meeting the overall need and purpose of the project. Usually four to seven attributes are selected. It is important that all potential attributes be thoroughly discussed. The information that comes out of this discussion will be valuable to both the VE team and the project owner. It is important that each attribute be discretely defined and be quantifiable in some form. The vast majority of performance attributes that typically appear in transportation VE studies have been standardized. This standardized list can be used "as is" or adopted with minor adjustments as required.

Typical standardized project performance attributes are shown below. Specific definitions of each attribute can be found below.

- Main Line Operations
- Local Operations
- Maintainability
- Construction Impacts
- Environmental Impacts

PERFORMANCE ATTRIBUTE AND DEFINITIONS	
Performance Attribute	**Description of Attribute**
Main Line Operations	An assessment of traffic operations and safety on the main line. Operational considerations include level of service relative to the 20-year traffic projections as well as geometric considerations such as design speed, sight distance, and lane and shoulder widths.
Local Operations	An assessment of traffic operations and safety on the local roadway infrastructure. Operational considerations include level of service relative to the 20-year traffic projections; geometric considerations such as design speed, sight distance, lane widths; bicycle and pedestrian operations and access, including shared use path.
Maintainability	An assessment of the long-term maintainability of the transportation facility(s). Maintenance considerations include the overall durability, longevity, and maintainability of pavements, structures, and systems; ease of maintenance; accessibility and safety considerations for maintenance personnel.
Construction Impacts	An assessment of the temporary impacts to the public during construction related to traffic disruptions, detours and delays; impacts to businesses and residents relative to access, visual, noise, vibration, dust, and construction traffic. Temporary environmental impacts related to water quality, air quality, soil erosion, and local flora and fauna.
Environmental Impacts	An assessment of the permanent impacts to the environment, including ecological (i.e., flora, fauna, air quality, water quality, visual, noise); socioeconomic impacts (i.e., environmental justice, business, residents); impacts to cultural, recreational and historic resources.

Step 2 – Determine the Relative Importance of the Attributes

Once the group has agreed on the project's performance attributes, the next step is to determine their relative importance in relation to each other. This is accomplished through the use of an evaluative tool termed in this report as the "Performance Attribute Matrix." This matrix compares the performance attributes in pairs, asking the question: "An improvement in which attribute will provide the greatest benefit to the project relative to purpose and need?"

A letter code (e.g., "A") is entered into the matrix for each pair, identifying which of the two is more important. If a pair of attributes is considered to be of essentially equal importance, both letters (e.g., "A/B") are entered into the appropriate box. This, however, should be discouraged, as it has been found that in practice a tie usually indicates that the pairs have not been adequately discussed. When all pairs have been discussed, the number of "votes" for each is tallied and percentages (which will be used as weighted multipliers later in the process) are calculated. It is not uncommon for one attribute to not receive any "votes." If this occurs, the attribute is given a token "vote," as it made the list in the first place and should be given some degree of importance.

An example of this exercise is shown below.

PERFORMANCE ATTRIBUTE MATRIX

[Project Name]

Which attribute is more important to the project?							**TOTAL**	**%**
Main Line Operations	A	B	A	A	[illegible]	A	5.0	**23.8%**
Local Operations		B	[illegible]	B	B	B/F	5.5	**26.2%**
Maintainability			C	C	E	F	2.0	9.5%
Construction Impacts				D	E	D/F	1.5	7.1%
Environmental Impacts					E	E	4.0	19.0%
Project Schedule						F	3.0	14.3%
						Total	21.0	100%

Without emphasis on preference

A = A is of greater importance

A/B = A and B are of equal importance

For the example project above, the project owner, design team, and stakeholders determined that main line operations, followed by environmental, gave the greatest improvement relative to the projects purpose and need, while construction impacts and project schedule gave the least improvement.

Step 3 – Establish the Performance Baseline for the Original Design

The next step in the process is to document the project-specific elements for the performance attributes developed in Step 1. This step establishes a baseline against which the VE alternative concepts can be compared. An example of project-specific elements is shown below.

Evaluation of Baseline Project		
Standard Performance Attribute	**Description of Attribute**	**Baseline Design Rating Rational**
Main Line Operations	An assessment of traffic operations and safety on the project. Operational considerations include level of service relative to the 20-year traffic projections as well as geometric considerations such as design speed, sight distance, lane widths, and shoulder widths.	Design Speed - __ MPH Bridge – __' Lanes, __' shoulders Roadway - __' Lanes, __' shoulders Bridge ___ Loading
Local Operations	An assessment of traffic operations and safety on the local roadway infrastructure. Operational considerations include level of service relative to the 20-year traffic projections; geometric considerations such as design speed, sight distance, lane widths; bicycle and pedestrian operations and access.	Revisions will need to be made to the existing streets and private approaches due to vertical alignment
Maintainability	An assessment of the long-term maintainability of the transportation facility(s). Maintenance considerations include the overall durability, longevity, and maintainability of pavements, structures, and systems; ease of maintenance; accessibility and safety considerations for maintenance personnel.	Baseline design assumes a replacement bridge Bridge design – low slump overlay on a 7" deck Steel welded plate girder 100' - 150' - 250' - 250' - 150' - 100' spans
Construction Impacts	An assessment of the temporary impacts to the public during construction related to traffic disruptions, detours and delays; impacts to businesses and residents relative to access, visual, noise, vibration, dust and construction traffic; environmental impacts.	Maintain traffic across river Noise permit required Short term detour to construct tie-ins to existing highways
Environmental Impacts	An assessment of the permanent impacts to the environment including ecological (i.e., flora, fauna, air quality, water quality, visual, noise); socioeconomic impacts (i.e., environmental justice, business, residents); impacts to cultural, recreational and historic resources.	In-water window Considered a navigable body of water Existing bridge is under consideration for historical significance

Once the baseline definitions for the various attributes have been established, their total performance should be calculated by multiplying the attribute's weight (which was developed in Step 2) by its rating. While one could assign a 0 to 10 rating for each attribute, using the definitions and scales developed in Step 1, a baseline rating of 5 is typically used as a mid-point so that alternatives can be evaluated – better than or worse than the baseline.

Total baseline performance is calculated by multiplying the attribute's weight (which was developed in Step 2) by its rating (5). The baseline design's total performance of 500 points can be calculated by adding all of the scores for the attributes. This numerical expression of the original design's performance forms the baseline against which all alternative concepts will be compared.

Step 4 – Evaluate the Performance of the VE Alternative Concepts

Once the performance of the baseline has been established for the original design concept, it can be used to help the VE team develop performance ratings for individual VE alternative concepts as they are developed during the study. The Performance Measures Form is used to capture this information. This form allows a side-by-side comparison of the original design and VE alternative concepts to be performed.

It is important to consider the alternative concept's impact on the entire project (rather than on discrete components) when developing performance ratings for the alternative concept.

Proposals are evaluated against the baseline for all attributes to compare and contrast the potential for value improvement. As discussed in Step 3, the baseline is given a rating of 5. The following ratings were used to evaluate the performance of the alternative concepts relative to the baseline concept.

Rating	Performance Attribute Scale
10	Alternative concept is extremely preferred
9	Alternative concept is very strongly preferred
8	Alternative concept is strongly preferred
7	Alternative concept is moderately preferred
6	Alternative concept is slightly preferred
5	***Baseline***
4	Baseline concept is slightly preferred
3	Baseline concept is moderately preferred
2	Baseline concept is strongly preferred
1	Baseline concept is very strongly preferred
0	Baseline concept is extremely preferred

Step 5 – Compare the Performance Ratings of Alternative Concepts to the Baseline Project

As the VE team develops alternatives, the performance of each is rated against the original design concept (baseline). Changes in performance are always based on the overall impact to the total project. Once performance and cost data have been developed by the VE team, the net change in value of the VE alternatives can be compared to the baseline design concept. The resulting "Value Matrix" provides a summary of these changes and allows a way for the Project Team to assess the potential impact of the VE recommendations on total project value.

The VE team groups the VE alternatives into a strategy (or strategies) to provide the decision-makers a clear picture of how the alternatives fit together into possible solutions. At least one strategy is developed to present the VE team's consensus of what should be implemented. Additional strategies are developed as necessary to present other combinations to the decision-makers that should be considered. The strategy(s) of VE alternatives are rated and compared against the baseline concept. The performance ratings developed for the VE strategies are entered into the matrix, and the summary portion of the Value Matrix is completed. The summary provides details on net changes to cost, performance, and value, using the following calculations:

- % Performance Improvement = ∆ Performance VE Strategy/Total Performance Original Concept
- Value Index = Total Performance/Total Cost (in Millions)
- % Value Improvement = ∆Value Index VE Strategy/Value Index Original Concept.

The following is an example of a Value Matrix worksheet.

Performance Attribute Ratings

Attribute	Attribute Weight	Concept	Performance Rating	Total Performance
Main Line Operations	28.9	Baseline	5	144.5
		1	7	202.3
		2	7	202.3
		3	5	144.5
Local Operations	14.2	Baseline	5	71.0
		1	5	71.0
		2	5	71.0
		3	8	113.6
Maintainability	14.2	Baseline	5	71.0
		1	3	42.6
		2	6	[illegible]
		3	4.5	[illegible]
Environmental Impacts	16.6	Baseline	5	[illegible]
		1	[illegible]	[illegible]
		2	[illegible]	83.0
		3	[illegible]	74.7
Construction Impacts	14.2	Baseline	5	71.0
		1	4	56.8
		2	[illegible]	85.2
		3	5	71.0
Project Schedule	[illegible]	[illegible]	5	59.5
		1	5	59.5
		2	5	59.5
		3	5	59.5

Recommendation Summary

	Recommendations	Perform[illegible]	% Change Performance	Cost (C) $ millions	Cost Change $ millions	% Change Cost	Value Index	% Value Improvement
	Baseline	500	---	$46.1	---	---	10.85	---
1	Recommendation No. 1 - Title	540	+8.0%	$46.6	$0.5	+1.2%	11.58	+6.8%
2	Recommendation No. 2 - Title	586	+17.2%	$46.5	$0.4	+0.9%	12.60	+16.2%
3	Recommendation No. 3 - Title	527	+5.4%	$46.1	$0.0	+0.0%	11.43	+5.4%
			Total		$3.9			

Appendix B. VE Recommendation Approval Form

Project: US 641 Connect Eddyville to Fredonia
VE Study Date: June 28 - July 2, 2021

			FHWA Functional Benefit						
	Recommendation	**Approved Y/N**	**Safety**	**Operations**	**Environment**	**Construction**	**Right-of-Way**	**VE Team Estimated Cost Avoidance or (Cost Added)**	**Actual Estimated Cost Avoidance or Cost Added**
1	Strengthen Access Control		x	x				$0.96M	
2	Design for Two Construction Sections					x		($0.67M)	
3	Optimize Profile to Promote Earthwork Balance				x	x	x	$3.97M	
4	Modify Structures 1, 2, & 3				x			$1.62M	
5	Alternative 4-Lane Typical Section				x		x	N/A	
6	Alternative 2+1 Typical Section		x	x			x	$20.35M	
	TOTALS		2	2	3	2	3	**$26.23M**	

The VE Team Estimated Cost Avoidance in the table above is based upon using the Value Strategy Ultimate 2+1.

Please provide justification if the value engineering study recommendations are **not** approved or are implemented in a modified form.

KYTC is required to report Value Engineering results annually to FHWA. To facilitate this reporting requirement, the Value Engineering Recommendation Approval Form is included herein. If the Cabinet elects to reject or modify a recommendation, please include a brief explanation of why.

______________________________ ______________________________

Signature – Project Manager Date

____

Name (please print)

FHWA Functional Benefit Criteria

Each year, State DOTs are required to report on VE recommendations to FHWA. In addition to cost implications, FHWA requires the DOTs to evaluate each approved recommendation in terms of the project feature or features that recommendation benefits. If a specific recommendation can be shown to provide benefit to more than one feature described below, count the recommendation in *each category that is applicable*.

Safety: Recommendations that mitigate or reduce hazards on the facility.

Operations: Recommendations that improve real-time service and/or local, corridor, or regional levels of service of the facility.

Environment: Recommendations that successfully avoid or mitigate impacts to natural and/or cultural resources.

Construction: Recommendations that improve work zone conditions or expedite the project delivery.

Right-of-Way: Recommendations that lower the impacts or costs of right-of-way.

Appendix C. VE Study Agenda and Attendees

Value Engineering Workshop
US 641
Caldwell/Lyon Counties
June 28 – July 2, 2021

Scope of the Value Engineering Study:

The scope of this Value Engineering Workshop is to identify, develop, and present recommendations for the project team to consider as the project moves forward.

The study will follow the approved SAVE-International Value Methodology Job Plan that includes the following phases:

1) Information
2) Function Analysis
3) Creative
4) Evaluation
5) Development
6) Presentation

Considerations & Comments:

- As part of the preparation for the study, each team member should review the project information package relevant to their subject matter expertise. This will be sent out one week before the workshop.
- This VE study will be held as a virtual workshop utilizing WebEx. Meeting invites will be sent out prior to the workshop.
- Virtual Meeting Ground Rules:
    - Join WebEx by following the link in the meeting invite.
    - Turn on your video so we can see you.
    - Use either the call-in number listed within the meeting invitation or your laptop audio (please mute when not talking).
    - Clicking the chat icon will reveal/hide the chat panel.
    - We request that only one person talk at a time. If you want to respond to a topic, please raise your hand in the participants list. This will trigger the facilitator to call on you to talk.
- You have been selected to participate in this VE study so please provide your full attention to the process and discussion.
- Please keep multitasking during the workshop to a minimum. We all have responsibilities back at the office, however our primary responsibility and commitment during the workshop is to the VE study and the process. It is important that each team member actively participate in all the team activities and phases. Please be aware of this and keep any outside contacts to a minimum. If absolutely required, as a team, we can schedule breaks for our other obligations. I will ensure that we have lengthy breaks in the morning and afternoon.
- If anyone has any questions regarding the upcoming workshop or the information contained herein, please contact me at 360-742-7682 or Blane.Long@hdrinc.com. Also, do not hesitate to ask questions or clarifications regarding the VE process at any time during the study. I look forward to working with you towards a successful study.
-

Day 1	Monday, June 28, 2021 Objective for the day: Learn about VE and the Project	
8:30 AM	**Workshop Kick-off Meeting** • Study kickoff • Team introductions • Workshop objectives	**All audiences:** Project owner, management, stakeholders, designers, etc.
8:45 AM *Information Phase*	**VE Process Overview** • An instructional presentation on the principles of value engineering and their application to the project	**VE Facilitator**
9:00 AM *Information Phase*	**Project Overview** • Purpose and Need of the project • Goals and objectives of the project • Constraints • Key Decisions • Areas for discussion: o Roadway Design o Traffic Analysis o Structures o Drainage/Hydraulics o Utilities o Environmental Conditions o Staging/Phasing	**Project Team/ Designer**
10:00 AM	**Define and Prioritize Performance Attributes**	**VE Facilitator** **VE Team**
11:00 AM *Function Analysis Phase*	**Function Analysis, Function-Cost Analysis** • Review project cost model • Random Function Identification • Build / Review FAST diagram	**VE Facilitator** **VE Team**
Noon	**Lunch**	
1:00 PM *Information Phase*	**Project Documentation Review** • Review plans/schematics, cross sections, typical sections, traffic control plans, construction constraints • Cost estimate, including construction, right-of-way, utilities, railroad, environmental, etc. • Project schedule, including construction phasing/sequencing, work windows	**VE Facilitator** **VE Team**
4:30 PM	**Adjourn for the day**	

Day 2	**Tuesday, June 29, 2021** **Objective for the day: Brainstorming Ideas & Evaluation**	
8:30 AM *Creative Phase*	**Brainstorming Ideas** • Brainstorm alternative ways to perform key functions	**VE Team**
Noon	**Lunch**	
1:00 PM *Evaluation Phase*	**Begin Evaluation Phase** • Score/Rate ideas based on predetermined criteria	**VE Team**
4:30 PM	**Adjourn**	

Day 3	**Wednesday, June 30, 2021** **Objective for the day: Complete Evaluation and Begin Developing Alternatives**	
8:30 AM *Evaluation Phase*	**Complete Evaluation of Ideas** • Select ideas to develop further into recommendations	**VE Team**
9:00 AM *Development Phase*	**Develop Ideas into Recommendations** • Individual/team assignments • Development of recommendations: o Test design feasibility o Design analysis o Technical narratives o Further discussion on advantages and disadvantages o Cost analysis (life cycle cost comparison)	**VE Team**
Noon	**Lunch**	
1:00 PM	**Mid-point Review (as needed)**	**VE Facilitator, VE Team, Project Manager Management**
1:00 PM *Development Phase*	**Continue Development of Recommendations**	**VE Team**
4:30 PM	**Adjourn**	

Day 4	**Thursday, July 1, 2021** **Objective for the day: Continue Development of Alternatives and Draft the Close-out Presentation**	
8:30 AM *Development Phase*	**Continue Development of Recommendations** • Wrap up recommendations write-ups **Prepare Close-out Presentation**	**VE Team**
Noon	**Lunch**	
1:00 PM *Development Phase*	**Finalize Recommendations** • Peer review of recommendations	**VE Team**
3:30 PM *Development Phase*	**Evaluate Performance of VE Strategy**	**VE Team**
4:30 PM	**Adjourn**	

Day 5	**Friday, July 2, 2021** **Objective for the day: Deliver Close-out Presentation**	
8:00 AM *Presentation Phase*	**Finalize Close-out Presentation** **Team Rehearsal**	**VE Team**
10:00 AM *Presentation Phase*	**Presentation of VE Findings** • Team presents recommendations to management • Questions and answers	**All Audiences:** Project owner, management, stakeholders, designers, etc.
Noon	**Adjourn**	

Value Engineering (VE) Study Attendees
Kentucky Transportation Cabinet (KYTC)
US 641 Connect, Caldwell/Lyon Counties

2021					Name	Organization	Role/Discipline	Work	Cell	E-MAIL
June			July							
28	29	30	1	2						
✓	✓	✓	✓	✓	Blane Long, CVS	HDR	VE Facilitator	360-570-4411		blane.long@hdrinc.com
✓	✓	✓	✓	✓	Jessa Summers	HDR	VE Assistant	208-387-7035		jessamyn.summers@hdrinc.com
✓	✓	✓	✓	✓	Ben Campbell, PE	HDR	Roadway	901-805-6719		ben.campbell@hdrinc.com
✓	✓	✓	✓	✓	Erica Albrecht, PE	HDR	Structures	502-909-3245		erica.albrecht@hdrinc.com
✓	✓	✓	✓	✓	Jonathan West, PE	HDR	Construction	502-909-3263		jonathan.west@hdrinc.com
✓	✓	✓	✓	✓	Adam Hedges, PE	HDR	Traffic / Safety	859-629-4872		adam.hedges@hdrinc.com
✓	✓	✓	✓	✓	Justin Harrod	KYTC	Value Engineering Coordinator / Traffic and Roadway	502-782-5059		justin.harrod@ky.gov
✓	✓	✓	✓	✓	Brent Sweger	KYTC	Value Engineering Coordinator			brent.sweger@ky.gov
✓				✓	Chris Kuntz, PE	KYTC	TEBM-Project Development, Project Manager	270-898-2431		chris.kuntz@ky.gov

Value Engineering (VE) Study Attendees
Kentucky Transportation Cabinet (KYTC)
US 641 Connect, Caldwell/Lyon Counties

2021 June 28	June 29	June 30	July 1	July 2	Name	Organization	Role/Discipline	Work / E-MAIL	Cell
✓				✓	Tim Layson, PE	KYTC	Highway Design, TE Director	270-564-3280 tim.layson@ky.gov	
✓				✓	Patrick Perry, PE	KYTC	Statewide Roadway Design Services, Location Engineer	patrick.perry@ky.gov	
✓					Jean Claude Niyonshima, MSCE, PE	KYTC	Transportation Engineer / Traffic	jniyonshima@ky.gov	
				✓	John W. Moore, PE	KYTC	Assistant State Highway Engineer	270-564-3280 johnw.moore@ky.gov	
				✓	Kyle Poat, PE	KYTC	Chief District Engineer	270-898-2431 kyle.poat@ky.gov	
✓				✓	Marc Wirtzberger, PE	EA	Consultant Design Team	mwirtzberger@eapartners.com	
✓				✓	Paul Looney, PE	EA	Consultant Design Team, Project Manager	plooney@eapartners.com	
✓				✓	Jill Asher, PE	FHWA	Civil Engineer - Highway	jill.asher@dot.gov	
✓					Eileen Vaughan, PE	FHWA	Civil Engineer - Highway	eileen.vaughan@dot.gov	

Appendix D. Project Estimate

Estimate 1-187.31

Estimated Cost:$55,075,652.80

Contingency: 25.00%

Estimated Total: $68,844,566.00

US 641 Caldwell/Lyon Counties
Item # 1-187.31
Preliminary Line & Grade Estimate

Base Date: 05/18/21

Spec Year: 08

Unit System: E

Work Type: ASPHALT SURFACE WITH GRADE & DRAIN

Highway Type: FEDERAL ROUTE

Urban/Rural Type: RURAL

Season: SUMMER

County: LYON

Midpoint of Latitude: 370842

Midpoint of Longitude: 880211

District: 01

Federal/State Project Number:

Estimate Type: Preliminary Line & Grade

Prepared by Marc Wirtzberger, P.E. on 05/18/21

Estimate: 1-187.31

Line #	Item Number / Description / *Supplemental Description*	Quantity	Units	Unit Price	Extension
Group 0001: PAVING					
0005	00018 DRAINAGE BLANKET-TYPE II-ASPH	59,730.00	TON	$50.54	$3,018,754.20
0006	00001 DGA BASE	417,598.00	TON	$18.93	$7,905,130.14
0007	00020 TRAFFIC BOUND BASE	2,100.00	TON	$18.79	$39,459.00
0008	00100 ASPHALT SEAL AGGREGATE	2,227.00	TON	$41.99	$93,511.73
0009	00103 ASPHALT SEAL COAT	267.00	TON	$691.04	$184,507.68
0010	00212 CL2 ASPH BASE 1.00D PG64-22	24,978.00	TON	$60.00	$1,498,680.00
0011	00214 CL3 ASPH BASE 1.00D PG64-22	157,656.00	TON	$52.13	$8,218,607.28
0012	00216 CL3 ASPH BASE 1.00D PG76-22	45,424.00	TON	$63.60	$2,888,966.40
0013	00221 CL2 ASPH BASE 0.75D PG64-22	7,069.00	TON	$71.24	$503,595.56
0014	00301 CL2 ASPH SURF 0.38D PG64-22	2,307.00	TON	$76.61	$176,739.27
0015	00309 CL2 ASPH SURF 0.50D PG64-22	12,489.00	TON	$79.52	$993,125.28
0016	00326 CL3 ASPH SURF 0.50B PG76-22	22,489.00	TON	$111.13	$2,499,202.57
0017	24970EC ASPHALT MATERIAL FOR TACK NON-TRACKING AT ONE TIME WAS TRACKLESS TACK	886.00	TON	$794.29	$703,740.94
				Total for Group 0001:	$28,724,020.05
Group 0002: ROADWAY					
0018	02230 EMBANKMENT IN PLACE	1,789,262.00	CUYD	$5.99	$10,717,679.38
				Total for Group 0002:	$10,717,679.38

10:50:59AM
Tuesday, May 18, 2021

Page 2 of 4

Estimate: 1-187.31

Line #	Item Number / Description / *Supplemental Description*	Quantity	Units	Unit Price	Extension
	Group 0003: DRAINAGE				
0021	00462 CULVERT PIPE-18 IN	2,955.00	LF	$103.68	$306,374.40
0023	00464 CULVERT PIPE-24 IN	4,754.00	LF	$45.61	$216,829.94
0024	00466 CULVERT PIPE-30 IN	1,610.00	LF	$106.61	$171,642.10
0025	00468 CULVERT PIPE-36 IN	1,164.00	LF	$110.36	$128,459.04
0026	00469 CULVERT PIPE-42 IN	862.00	LF	$171.56	$147,884.72
0027	00471 CULVERT PIPE-54 IN	422.00	LF	$242.14	$102,183.08
0028	00472 CULVERT PIPE-60 IN	97.00	LF	$300.39	$29,137.83
0029	01204 PIPE CULVERT HEADWALL-18 IN	44.00	EACH	$1,070.77	$47,113.88
0030	01208 PIPE CULVERT HEADWALL-24 IN	66.00	EACH	$1,444.14	$95,313.24
0031	01210 PIPE CULVERT HEADWALL-30 IN	28.00	EACH	$1,712.18	$47,941.04
0032	01212 PIPE CULVERT HEADWALL-36 IN	18.00	EACH	$2,097.70	$37,758.60
0033	01214 PIPE CULVERT HEADWALL-42 IN	10.00	EACH	$1,910.88	$19,108.80
0034	24026EC PIPE CULVERT HEADWALL-54 IN	4.00	EACH	$5,812.19	$23,248.76
0035	01220 PIPE CULVERT HEADWALL-60 IN	2.00	EACH	$5,436.56	$10,873.12
0036	01502 DROP BOX INLET TYPE 5A	46.00	EACH	$7,600.00	$349,600.00
0037	24694ED BOX CULVERT 6'x4' RCBC - 255 LF Estimated @ $35/cubic foot of culvert opening	6,120.00	CUFT	$35.00	$214,200.00

10:50:59AM
Tuesday, May 18, 2021

Estimate: 1-187.31

Line #	Item Number / Description / *Supplemental Description*	Quantity	Units	Unit Price	Extension
0038	24694ED BOX CULVERT 10'x6' RCBC - 141 LF Estimated @ $35/cubic foot of culvert opening	8,460.00	CUFT	$35.00	$296,100.00
0039	24694ED BOX CULVERT 12'x6' RCBC - 227 LF Estimated @ $35/cubic foot of culvert opening	16,344.00	CUFT	$35.00	$572,040.00
0040	24694ED BOX CULVERT 6'x6' RCBC - 228 LF Estimated @ $35/cubic foot of culvert opening	8,208.00	CUFT	$35.00	$287,280.00

Total for Group 0003:$3,103,088.55

Group 0004: BRIDGE

Line #	Item Number / Description / *Supplemental Description*	Quantity	Units	Unit Price	Extension
0041	Bridges estimated @ $160/square foot of bridge deck area	57,309.00	SQ FT	$160.00	$9,169,440.00

Total for Group 0004:$9,169,440.00

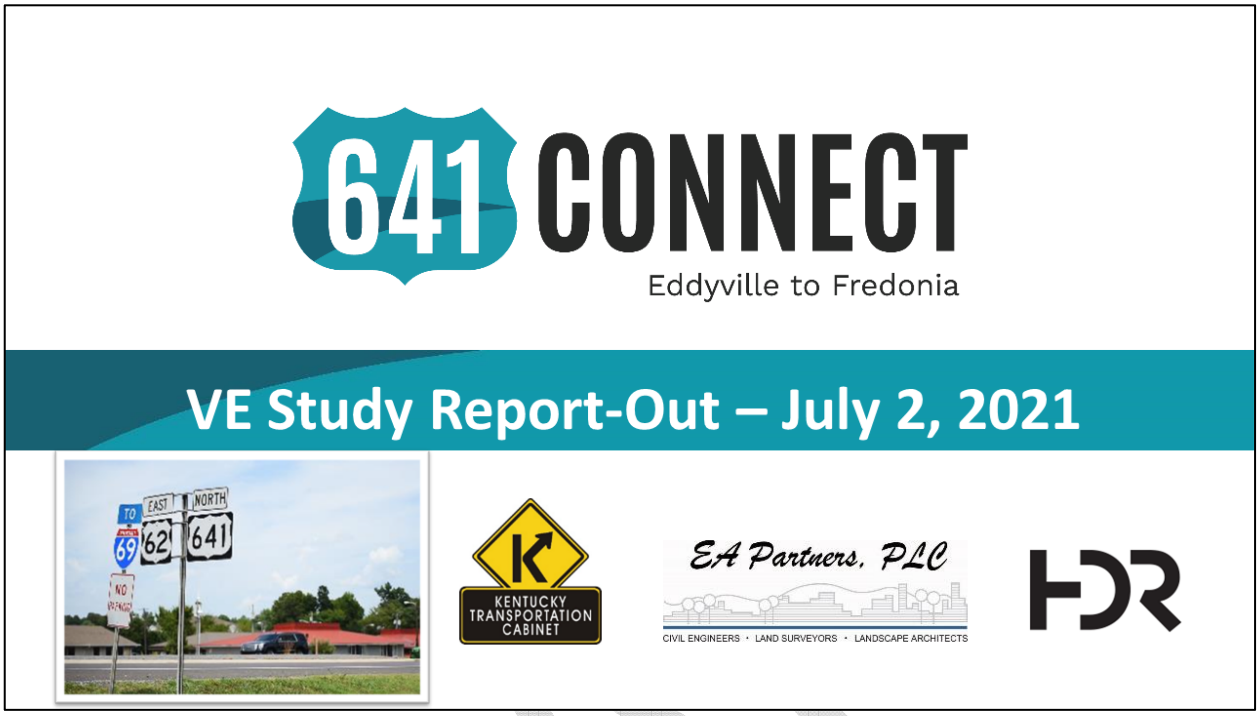
Group 0019: DEMOBILIZATION &OR MOBILIZATION

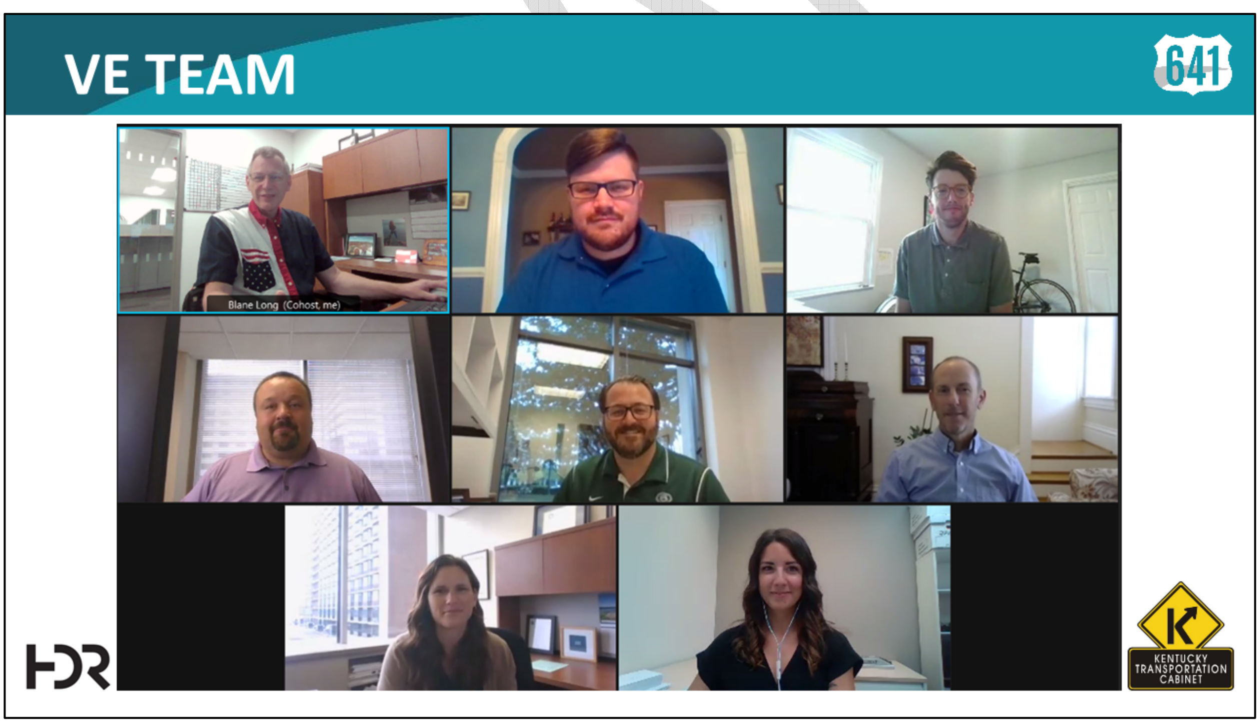
Line #	Item Number / Description / *Supplemental Description*	Quantity	Units	Unit Price	Extension
0019	02568 MOBILIZATION 5% of Total Cost	1.00	LS	$2,585,711.40	$2,585,711.40
0020	02569 DEMOBILIZATION 1.5% of Total Cost	1.00	LS	$775,713.42	$775,713.42

Total for Group 0019:$3,361,424.82

10:50:59AM
Tuesday, May 18, 2021

Appendix E. Closing Presentation





PROJECT PURPOSE AND NEED

Primary Reasons for the Project

- Improve safety and emergency vehicle response
- Facilitate freight movement along US 641 corridor
- Improve access to recreational and tourist areas

PROJECT OBJECTIVES

Priorities During Alternate Analysis

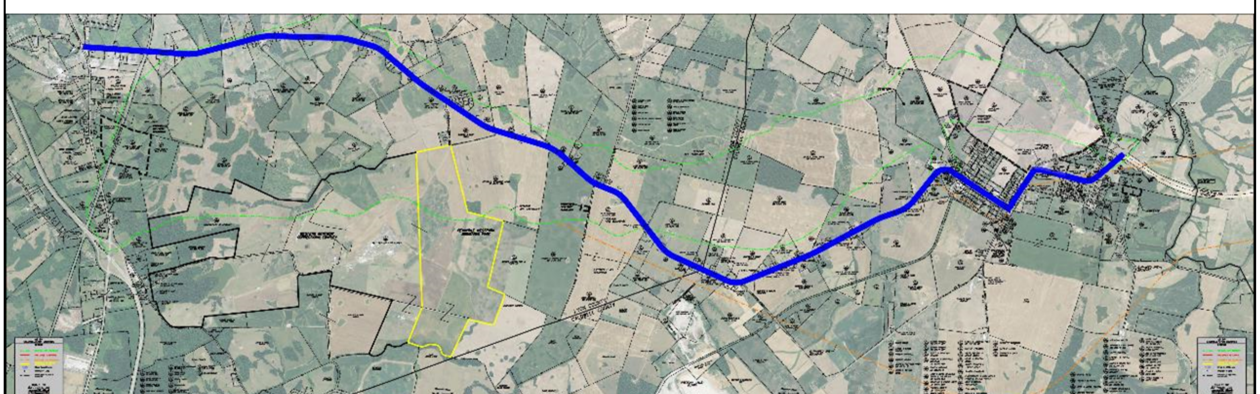
- Minimize taking of homes
- Minimize taking of private land
- Minimize splitting of farms that leaves small areas

KEY DECISIONS

Project Determinations

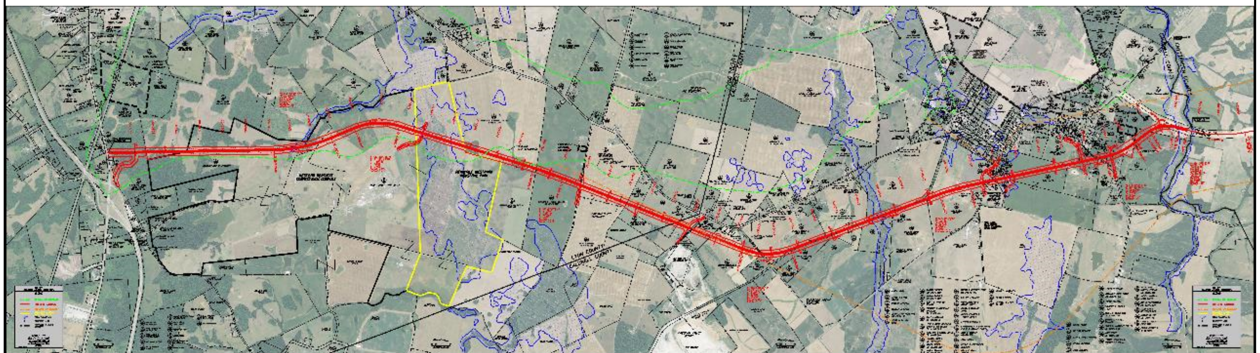
- R/W can encroach no closer than 500 yards from existing Prison internal fence
- Alignment can follow abandoned rail line north of quarry
- The Western Pennyrile Industrial Park can be bisected by the alignment
- Project should consider a 4-lane ultimate section

US 641 (Current Alignment)



PREFERRED ALTERNATE

641



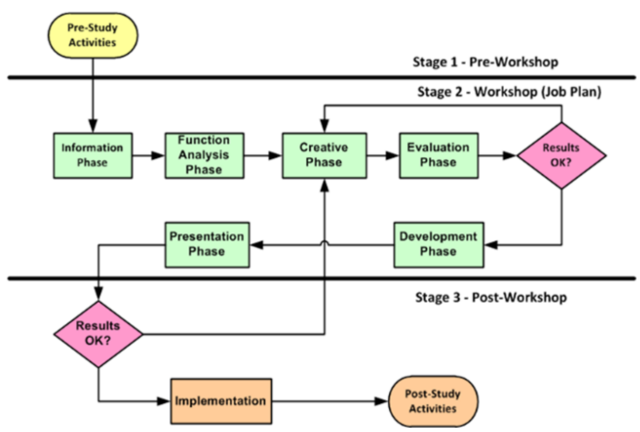
HDR

KENTUCKY TRANSPORTATION CABINET

VALUE METHODOLOGY JOB PLAN

641

- Provides the structure for the Value Study which is part of a 3-stage process
  1. Pre-Workshop
  2. Value Study
  3. Post-Workshop



HDR

KENTUCKY TRANSPORTATION CABINET

VE RECOMMENDATION NO. 1

641

Strengthen Access Control

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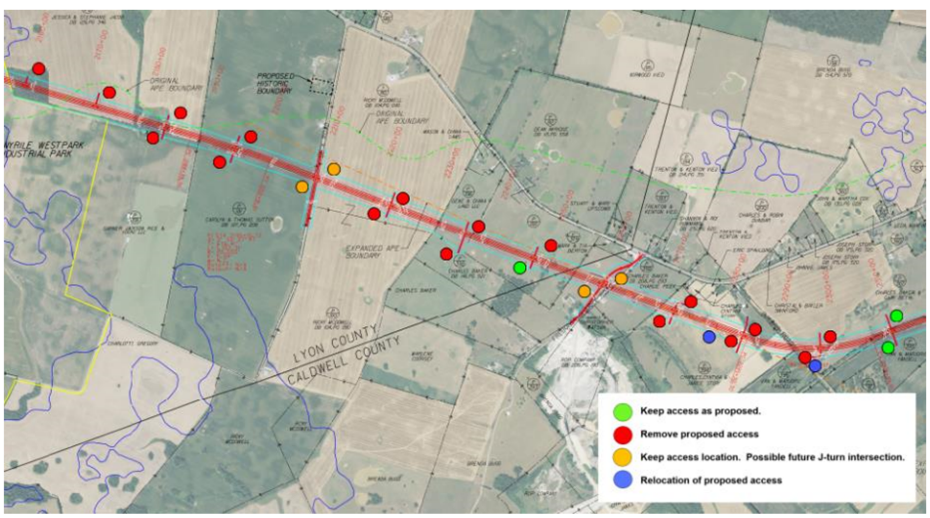
KENTUCKY TRANSPORTATION CABINET

VE RECOMMENDATION NO. 1

641

Strengthen Access Control

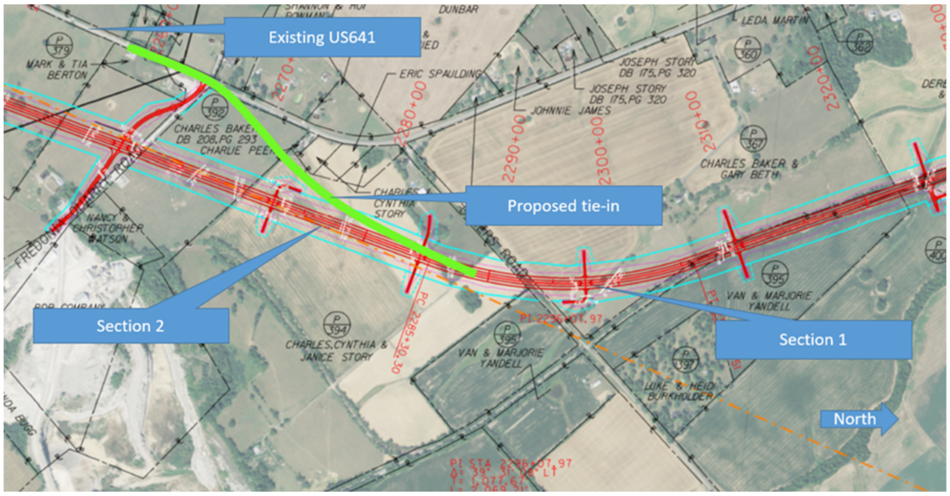


HDR

KENTUCKY TRANSPORTATION CABINET

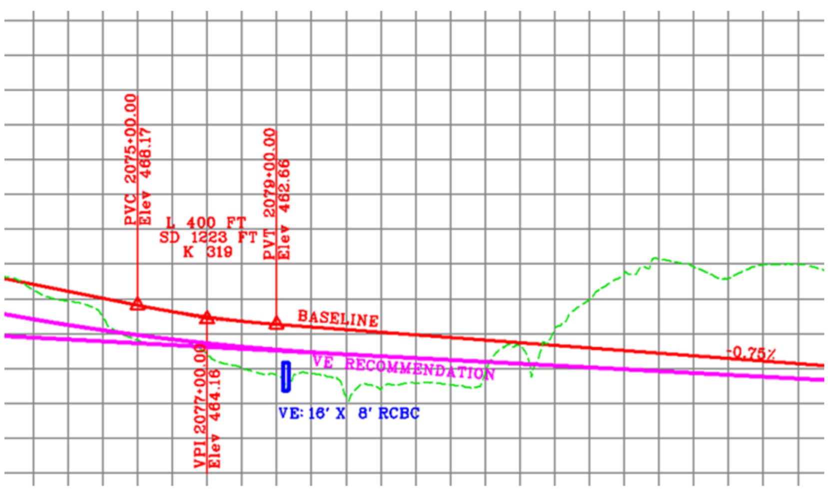
VE RECOMMENDATION NO. 2

Design for Two Construction Sections



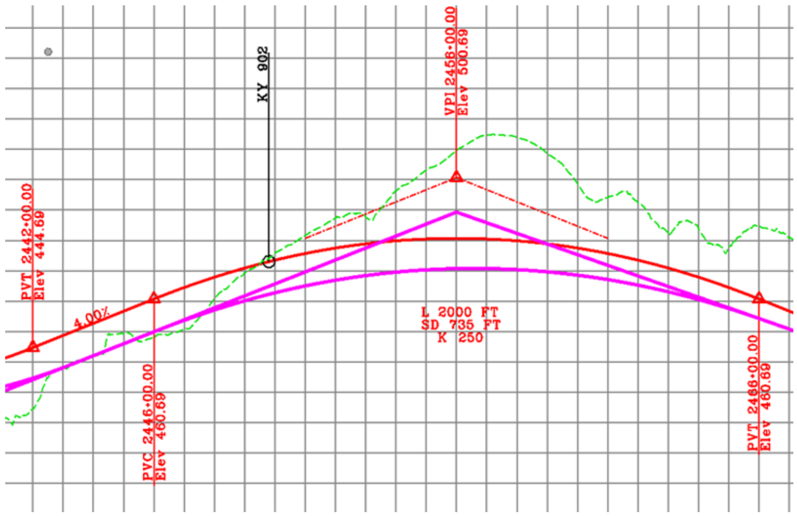
VE RECOMMENDATION NO. 3

Optimize Profile to Promote Earthwork Balance



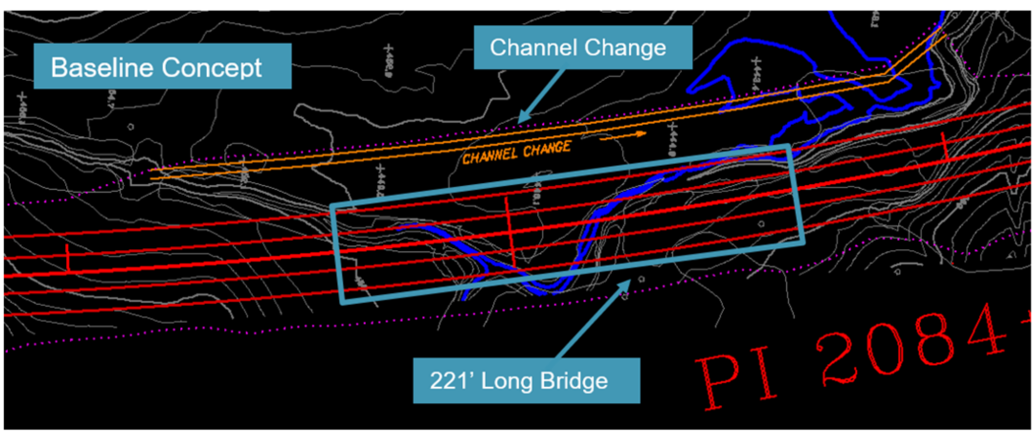
VE RECOMMENDATION NO. 3

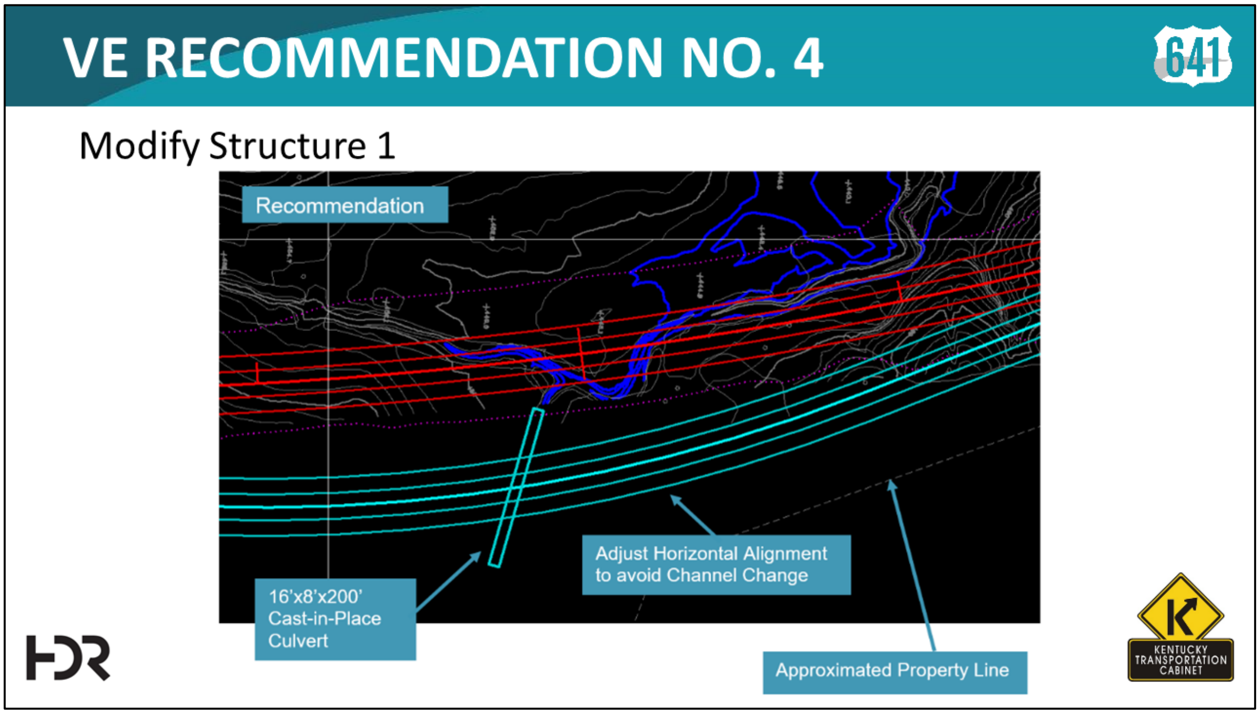
Optimize Profile to Promote Earthwork Balance

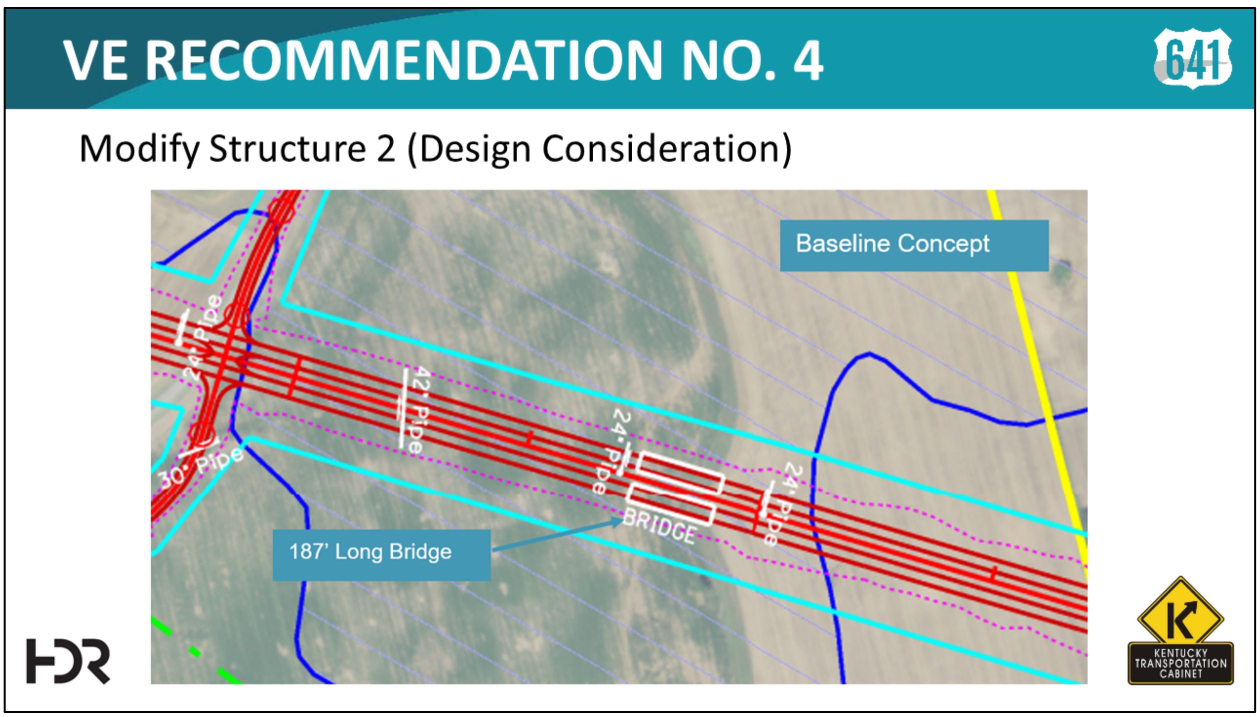


VE RECOMMENDATION NO. 4

Modify Structure 1

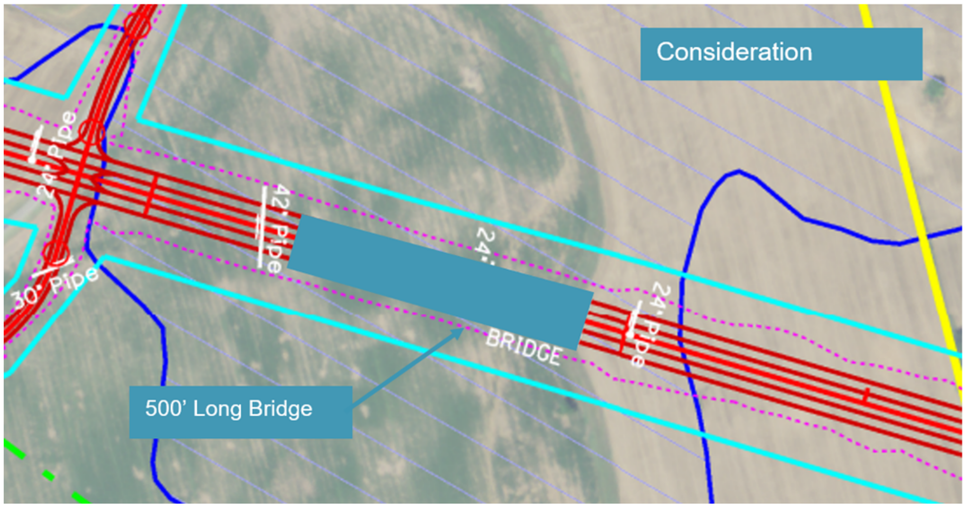



VE RECOMMENDATION NO. 4
641
Modify Structure 1
Recommendation
16'x8'x200' Cast-in-Place Culvert
Adjust Horizontal Alignment to avoid Channel Change
Approximated Property Line
HDR
KENTUCKY TRANSPORTATION CABINET


VE RECOMMENDATION NO. 4
641
Modify Structure 2 (Design Consideration)
Baseline Concept
24" Pipe
42" Pipe
30" Pipe
24" Pipe
BRIDGE
24" Pipe
187' Long Bridge
HDR
KENTUCKY TRANSPORTATION CABINET

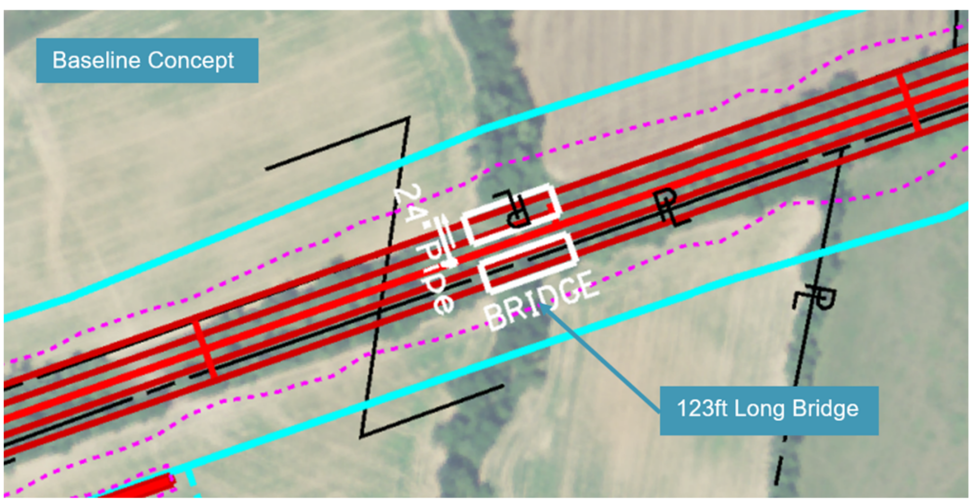
VE RECOMMENDATION NO. 4

Modify Structure 2 (Design Consideration)



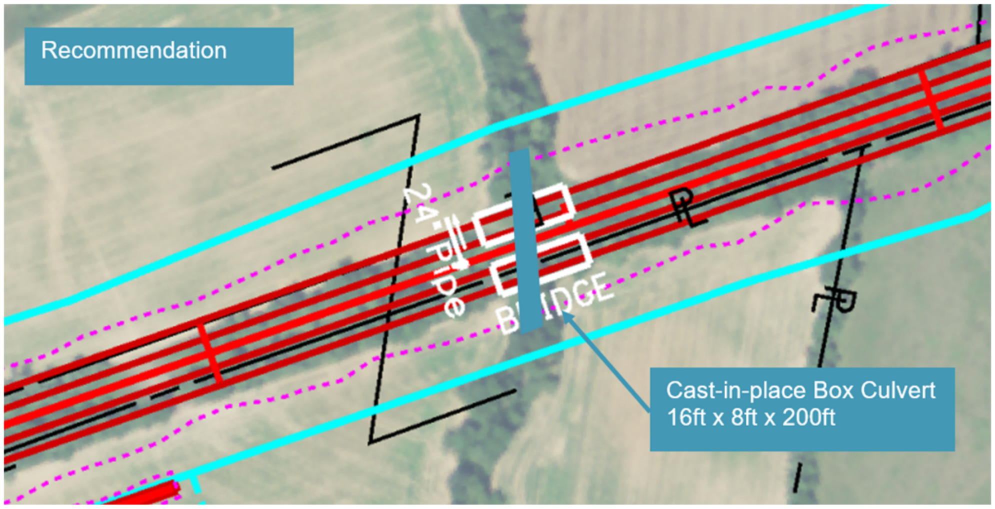
VE RECOMMENDATION NO. 4

Modify Structure 3



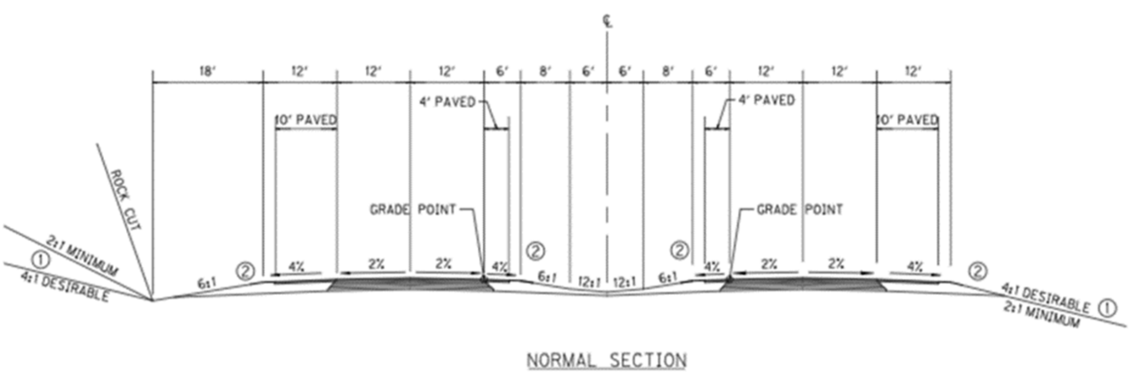
VE RECOMMENDATION NO. 4

Modify Structure 3



VE RECOMMENDATION NO. 5

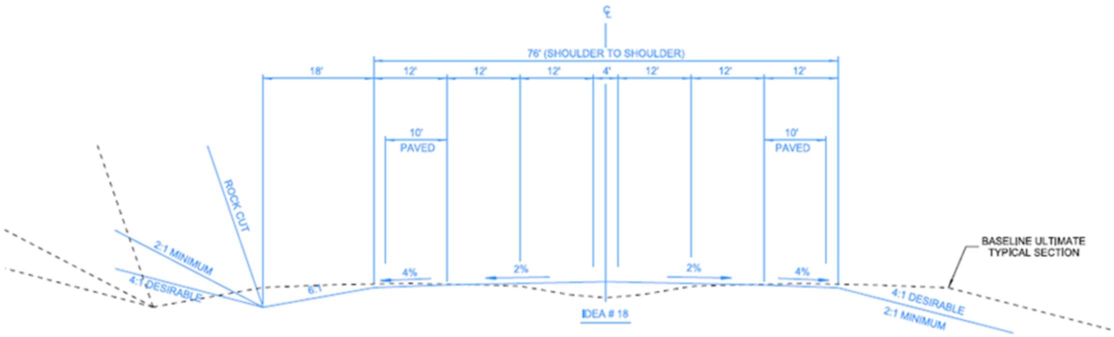
Preferred - Ultimate Section



VE RECOMMENDATION NO. 5

641

VE Recommended - Ultimate Section



HDR

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VE RECOMMENDATION NO. 5

641

VE Recommended - Ultimate Section Example

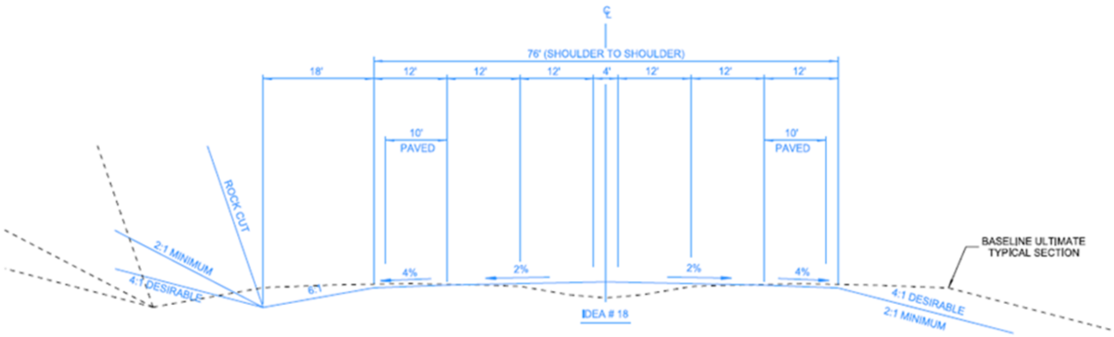
HDR

KENTUCKY TRANSPORTATION CABINET

VE RECOMMENDATION NO. 5

641

VE Recommended - Ultimate Section



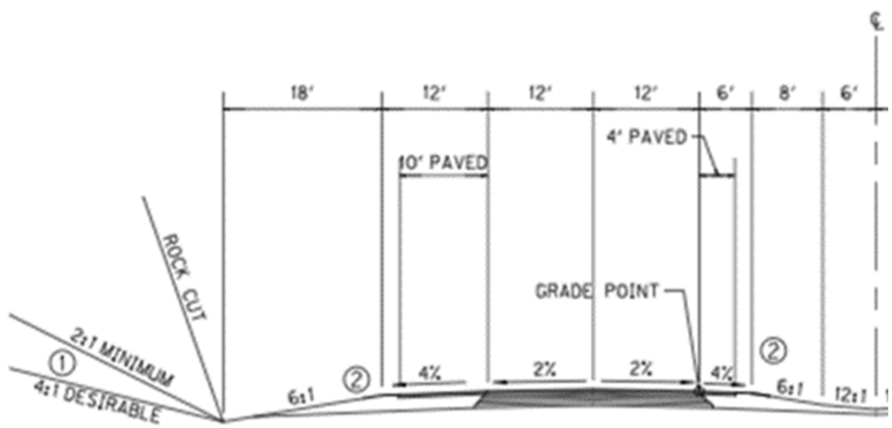
HDR

KENTUCKY TRANSPORTATION CABINET

VE RECOMMENDATION NO. 6

641

Preferred - Initial Buildout

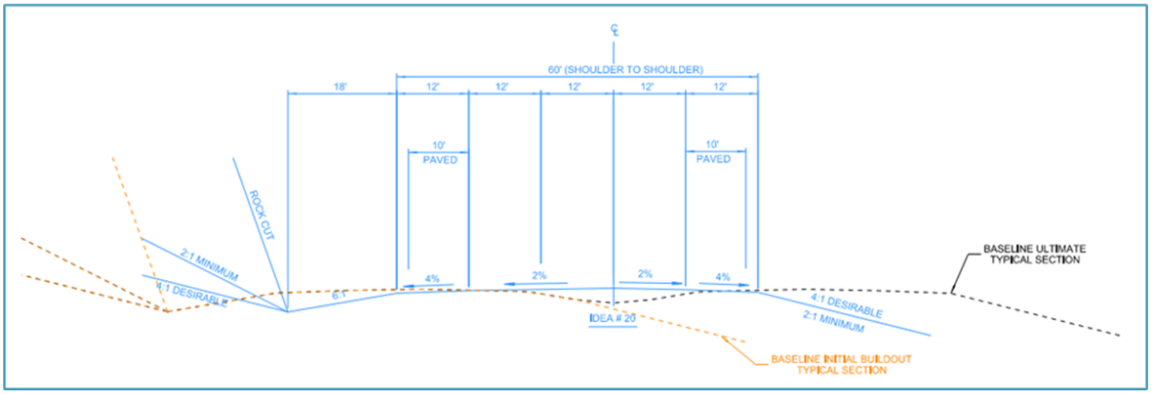


HDR

KENTUCKY TRANSPORTATION CABINET

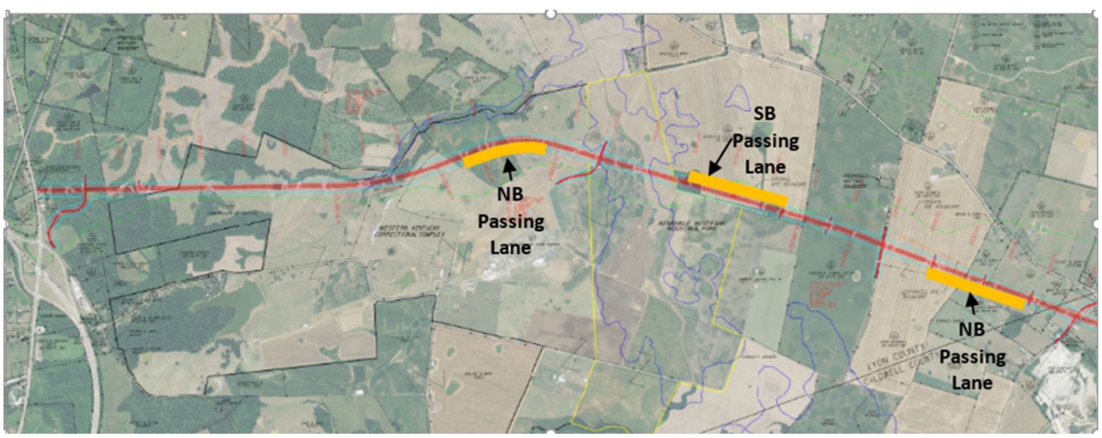
VE RECOMMENDATION NO. 6

VE Recommended - Initial Buildout



VE RECOMMENDATION NO. 6

VE Recommended - Initial Buildout



VE RECOMMENDATION NO. 6

VE Recommended - Initial Buildout

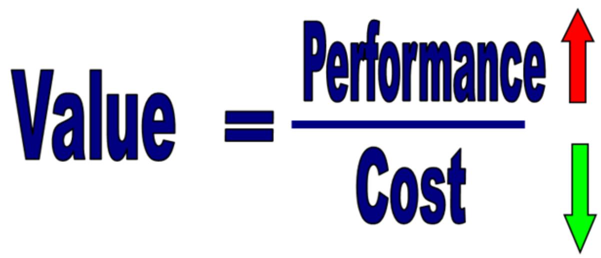
VE SUMMARY

#	Recommendation Title	Cost Savings/ (Cost Added) ($M)		
		Ultimate 4-Lane	Ultimate 2+1	Initial Buildout 2+1
1	Strengthen Access Control	$0.96	$0.96	$0.96
2	Design for Two Construction Sections	($0.67)	($0.67)	($0.67)
3	Optimize Profile to Promote Earthwork Balance	$7.93	$3.97	$3.97
4	Modify Structures 1, 2, & 3	$3.25	$1.62	$1.62
5	Preferred - Ultimate Section	$7.20	$20.35	
6	Preferred - Initial Buildout			($11.15)
	Total Savings	$18.67	$26.23	($5.27)

PERFORMANCE BASED VE

Value Engineering is not just about reducing project costs, but can also improve project performance

- Mainline Operations
- Local Operations
- Maintainability
- Construction Impacts
- Environmental Impacts



VALUE IMPROVEMENT

Recommendation Summary							
Recommendations	Performance (P)	% Change Performance	Cost (C) $ millions	Cost Change $ millions	% Change Cost	Value Index	% Value Improvement
Ultimate	500	---	$68.8	---	---	7.27	---
Value Strategy - 4-Lane Ultimate	530	+6.0%	$50.1	($18.67)	-27.1%	10.57	+45.4%
Value Strategy - 2+1 Ultimate	573	+14.6%	$42.6	($26.23)	-38.1%	13.46	+85.2%
Preferred - Initial Buildout	500	---	$33.1	---	---	15.12	---
Value Strategy - 2+1 Initial	560	+12.0%	$38.3	$5.27	+15.9%	14.61	-3.4%