KENTUCKY TRANSPORTATION CABINET

Value Engineering Study Final Report

KY 15 north of Hazard
Kentucky Transportation Cabinet (KYTC)

Value Engineering Study
Item #10-269.20 VE202104

Perry County, Kentucky

November 29 - December 3, 2021

Prepared by:

HDR Engineering, Inc.
401 West Main Street
Suite 500
Louisville, KY 40202-2936

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 Capital Cost:	$77.8M
Baseline Lifecycle Cost:	$123.32M
Number of Recommendations:	7
Recommended Lifecycle Cost Savings (VE Strategy 3):	$43.5M
Total Number of Team Members:	9
KYTC Employees:	2
Others:	7
Facilitator Consultant:	HDR

Contents

Tables

Figures

Appendices

Executive Summary

Introduction

This report summarizes the events and results of the virtual Value Engineering (VE) study conducted by HDR Engineering, Inc. for the Kentucky Transportation Cabinet (KYTC) on the KY 15 north of Hazard project in Perry County, Kentucky. The VE study consisted of a 5-day workshop that was conducted virtually with a multidisciplinary team on November 29 - December 3, 2021 using Microsoft Teams.

Project Overview

KYTC, in cooperation with the Federal Highway Administration (FHWA), has proposed improvements to approximately 7.5 miles of Kentucky Highway 15 (KY 15) north of Hazard in Perry County, Kentucky. The improvements will result in converting the existing primarily two-lane road to a divided four-lane highway through construction of a new cross-country route to the west of KY 15. The project corridor extends from Bonneyman in the south to Shady Ridge Drive just to the north of the Kentucky Highway 28 (KY 28) intersection.

The proposed project typical section will consist of four lanes (two 12-foot lanes in each direction), shoulders of 12 feet 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, right-of-way, and utilities was estimated at $77.8 million. An estimate for other items such as 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 KY 15 north of Hazard project.
- Conduct a thorough review and analysis of the key project functions using an independent, multidiscipline, cross-functional team.
- Make recommendations that could 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 51 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 seven recommendations.

The cost savings are shown in Table 1 (described in more detail within Section 2.3, Proposed Improvements).

Table 1. Summary of Recommendations

#	Recommendation Title	Cost Savings / (Cost Added) ($M)				
		Construction	Life Cycle	Utility	ROW	Total Cost
	Baseline	**$68.90**	**$45.51**	**$2.16**	**$6.75**	**$123.32**
1	Shift KY 28 Intersection to the South	$2.59	$0.47		$1.75	$118.51
2	Use At-Grade Intersection at KY 28	$7.26	$0.92			$115.14
3	Reduce Typical Section	$27.99	$2.11		$2.36	$90.86
4	Upgrade Existing KY 15 Alignment in lieu of Constructing the Baseline Alternative	$58.42	$41.73	$1.16	$4.75	$17.26
5	Shift Alignment West of Cemetery and Provide At-Grade Intersection at KY 28	$5.65	$1.12			$116.55
6	Shift Access to KY 28 North of Proposed KY 28 Interchange	$2.48				$120.84
7	Use Continuous High T at Southern Split	($3.08)	($0.84)			$127.24

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

1—Shift KY 28 Intersection to the South – Improve local operations by realigning KY 28 and connecting KY 28 to the existing KY 15. Construct a Tight Diamond Interchange south of the baseline Tight Diamond Interchange.

2—Use At-Grade Intersection at KY 28 – Eliminate the smaller set of twin bridges by using an innovative at-grade unsignalized continuous green T at the intersection of KY 15 and KY 28 on the baseline alignment. A channelized acceleration lane for traffic turning left onto NB KY 15 will be incorporated.

3—Reduce Typical Section – Reduce the typical section from a 4-lane with 40-foot depressed median to a 2+1 typical section to ensure project fundability while meeting operational requirements of traffic projections and reducing the environmental impacts.

4—Upgrade Existing KY 15 Alignment in lieu of Constructing the Baseline Alternative – Provide a consistent typical 2+1 section along the existing alignment and implement other operational improvements to right-size the project, reduce environmental impacts, and improve the project schedule.

5—Shift Alignment West of Cemetery and Provide At-Grade Intersection at KY 28 – Modify the horizontal curve radius to shift the alignment to the west of Miller cemetery,

eliminating twin structures at KY 28 under the new KY 15. Provide a new at-grade intersection or a high green T interchange at KY 15 and KY 28 to improve maintainability.

6—Shift Access to KY 28 North of Proposed KY 28 Interchange – Shift the KY 28 intersection to the north to maintain free-flow between KY 28 and KY 15, reduce conflict points, and eliminate impacts to the cemetery.

7—Use Continuous High T at Southern Split– Construct a continuous high green T intersection at the southern intersection of the newly aligned KY 15 and the existing KY 15 to reduce conflict points and improve operations.

Based on discussions during the presentation the VE facilitator developed several VE strategies as complimentary combinations of individual VE recommendations.

Table 2. Summary of Value Strategies

VE Strategy	VE Rec #	Cost Savings / (Cost Added) ($M)				Total Savings
		Construction	Life Cycle	Utility	ROW	
1	1, 3, 7	$27.51	$1.74		$4.11	$33.36
2	3, 6, 7	$27.39	$1.27		$2.36	$31.02
3	2, 3, 5, 7	$37.83	$3.31		$2.36	$43.50
4	4	$58.42	$41.73	$1.16	$4.75	$106.06

Value Strategy 1 — VE Recommendations 1, 3, and 7 – This strategy suggests a modified 2+1 typical section along the baseline alignment, shifts the KY 28 Tight Diamond Intersection south, and utilizes a continuous high green T intersection at the southern split.

Value Strategy 2 — VE Recommendations 3, 6, and 7 – This strategy suggests a modified 2+1 typical section along the baseline alignment, shifts the KY 28 intersection north, and utilizes a continuous high green T intersection at the southern split.

Value Strategy 3 — VE Recommendations 2, 3, 5, and 7 – This strategy suggests a modified 2+1 typical section along the baseline alignment, shifts the KY 28 intersection west and provides an at-grade intersection, and utilizes a continuous high green T intersection at the southern split.

Value Strategy 4 — VE Recommendation 4 – This strategy proposes utilizing a reduced typical section along the existing KY 15 alignment.

A summary of the cost, performance, and value change of each VE Recommendation is provided in Table 3. 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 recommendations 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 recommendations.

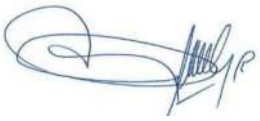
Table 3. Value Index

Recommendation	Performance (P)	% Change Performance	Cost (C) $ millions	Cost Change $ millions	% Change Cost	Value Index	% Value Improvement
Baseline	499	---	$123.3	---	---	4.00	---
1 - Shift KY 28 Intersection to the South	540	+8.2%	$118.5	-$4.81	-3.9%	4.60	+13.0%
2 - Use At-Grade Intersection at KY 28	553	+10.7%	$115.1	-$8.18	-6.6%	4.80	+16.7%
3 - Reduce Typical Section	534	+6.9%	$90.9	-$32.46	-26.3%	5.90	+32.2%
4 - Upgrade Existing KY 15 Alignment in lieu of Constructing the Baseline Alternative	520	+4.3%	$17.3	-$106.06	-86.0%	30.10	+86.7%
5 - Shift Alignment West of Cemetery and Provide At-Grade Intersection at KY 28	538	+7.9%	$116.5	-$6.77	-5.5%	4.60	+13.0%
6 - Shift Access to KY 28 North of Proposed KY 28 Interchange	488	-2.1%	$120.8	-$2.48	-2.0%	4.00	0.0%
7 - Use Continuous High T at Southern Split	512	+2.6%	$127.2	+$3.92	+3.2%	4.00	0.0%

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.



Jose Theiler, PE, 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 Microsoft Teams. The subject of the study was the KY 15 north of Hazard project. The VE study was conducted November 29 - December 3, 2021 while the project was in the preliminary 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 KY 15 north of Hazard project.
- Conduct a thorough review and analysis of the key project functions using a multidiscipline, cross-functional team.
- Make recommendations that could 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.

Tim Adams, PE | HDR
Erica Albrecht, PE | HDR
Rachel Bernhard, EIT, VMA | HDR
Andrew Brown, PE | Palmer
Justin Harrod | KYTC
Will Hume, PE | HDR
Brent Sweger, PE | KYTC
Jose Theiler, PE, CVS | HDR
Clint Young, PE | HMB

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 4. 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 4 lists the project documents provided to the VE team for use during the study.

Table 4. Information Provided to the VE Team

Document/Drawing/Schematic	Document Date
Cost Estimate	November 2021
Project Story Map	November 2021
3D Divided Typical Section	November 2021
Cut Slope Recommendations	October 2003
VE Study Prep/Project Overview Meeting Recording	October 2021
Finding of No Significant Impact (FONSI)	June 2004
Google Earth .KMZ File	November 2021
Crash Data	November 2021
KY 15 Profile Roll Plot	November 2021
KY 15 From Campton to Hazard – Programming Study Final Report	April 2013
KY 15 Public Meeting Layouts	November 2021
Traffic Forecast Report	November 2021
HMB Design Baseline Information	November 2021
Project Information Sheet, Location Map, Accident Data, and Estimate	2008
Original Geotechnical Data, Cut Slope Recommendations, Preliminary Exploration Plans	2003

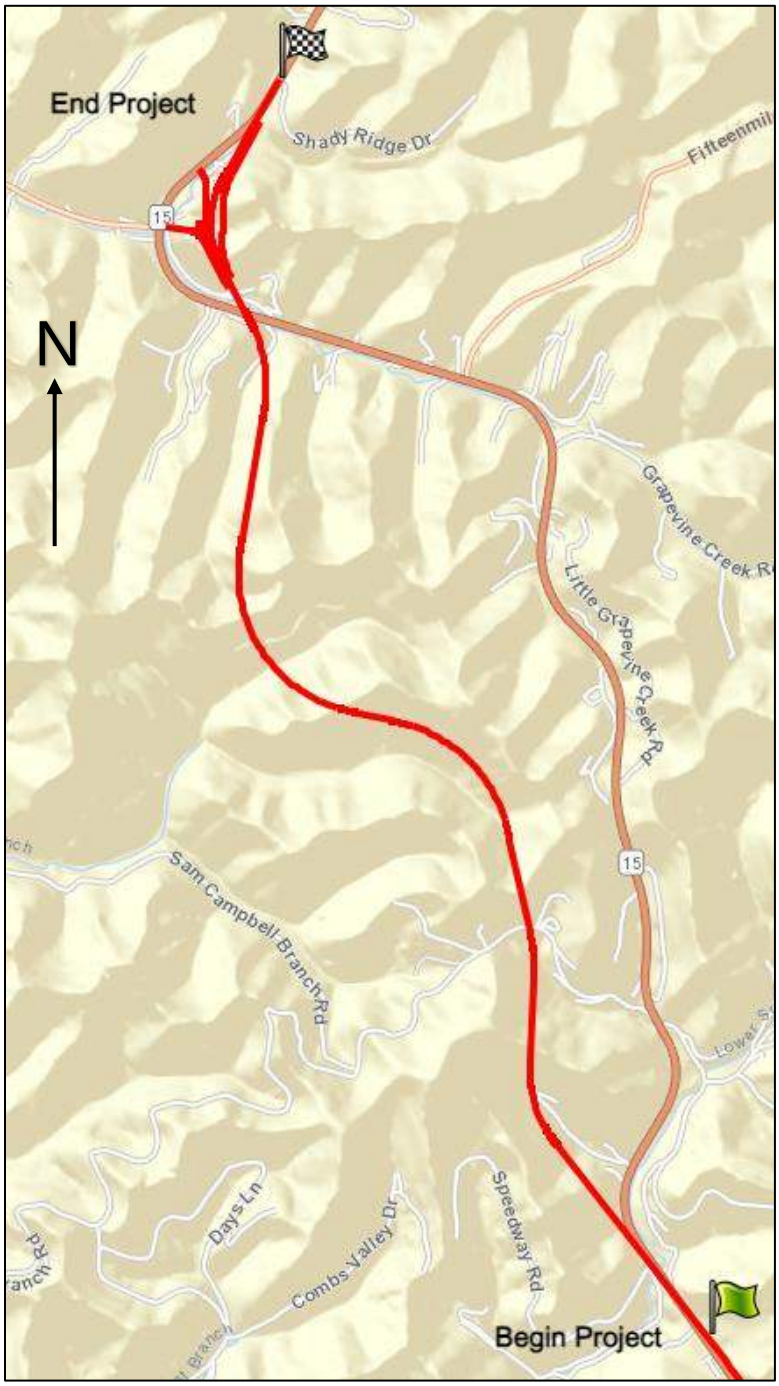
2.2 Project History and Purpose and Need

The following project history and information was extracted from the information and documentation provided by KYTC.

KYTC in cooperation with the Federal Highways Administration (FHWA) is proposing improvements to approximately 7.5 miles of Kentucky Highway (KY 15) north of Hazard, Perry County, Kentucky. The existing KY 15 is a major rural arterial, which plays an important system linkage role in the region. However, the current two-lane width, sharp curves, steep grades, and essential lack of median and shoulders have led to traffic congestions and safety concerns. The purpose of the project is to improve traffic congestion and safety. The project will serve to meet current safety, design and economic needs in the area.

This project is Section G of a larger Corridor Planning Study from Campton to Hazard. The planning study was completed in 2013 and was updated again in 2021. Preliminary Line and Grade plans were completed in 2002 that evaluated alignments on existing and two cross country alternatives. The new cross-country alignment west of KY 15 was selected as the revised preferred alignment shown in Figure 2. The FONSI was completed in 2004.

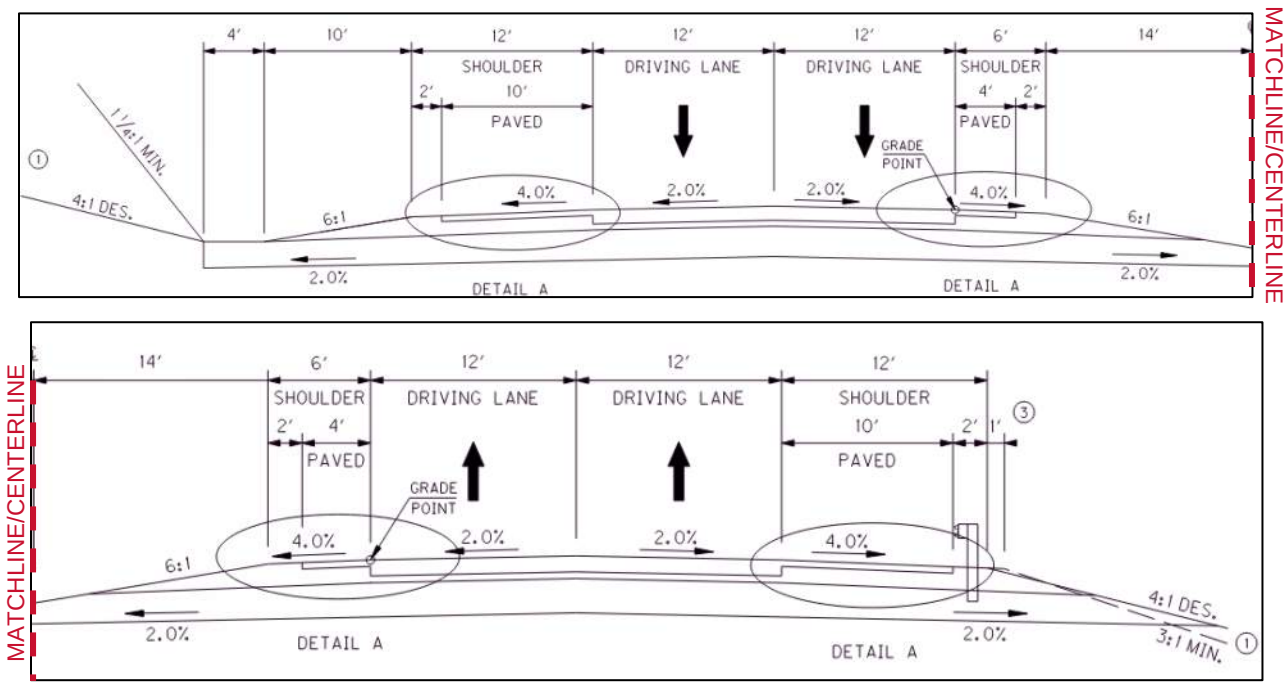
Figure 2. Project Vicinity Map



2.3 Proposed Improvements

A new cross-country roadway will be constructed west of the existing KY 15. It will be a four-lane divided highway with a 40-foot depressed median. The Selected Alternative (Figure 3) has been designed to avoid and minimize impacts to the existing resources to as great an extent as possible and still meet project needs to resolve traffic congestion and safety issues.

Figure 3. Selected Typical Section



2.4 Project Risks

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. A risk analysis was not completed as part of this VE; however, during the VE study, the team identified several risks.

- Impacts to cemeteries and churches should be limited
- There is a desire to remain within the existing FONSI footprint, but the potential to reopen environmental documentation/footprint changes is significant
- Stream impacts should be limited
- Funding constraints are a risk, construction costs are higher in eastern Kentucky per mile than western Kentucky and there is a desire to deliver and economical project
- Traffic counts may be outdated and current traffic demands may not justify the cost of an interchange at KY 28; however, safety improvements may help justify the additional costs
- The project schedule is aggressive
- Impacts to the cemetery near KY 28 may impact design progression
- There may be public disapproval of any potential changes that could lead to petition
- There is an opportunity to have the project ready for potential infrastructure funding
- There is an opportunity for this project to take advantage of alternative project delivery
- There is an opportunity for this project to deliver “innovation” (ITS, intersection/interchange at KY 28)

2.5 Project Observations

The first day of the VE study included a presentation from the project design team and a virtual tour of the project using Google Earth and KMZ files. The following summarizes project issues, project drivers, and observations identified during this session:

- This project is coming off the shelf after quite a bit of time
    - There is a desire to right-size the project and bring it up to date
- Legislature highway plan funding currently includes $66.6 million, however, of that total, only $1.5 million for design is funded within the biennium
- Current safety analysis tools were not available the last time this project was analyzed, any potential recommendations will have this technology opportunity
- Cemetery impacts/constraints are significant at KY 28

- Safety concerns at KY 28 may warrant a grade separated interchange or intersection
- There is a desire for corridor consistency, however, traffic volumes may not warrant a full build
    - A similarly low-traffic Mountain Parkway is currently under expansion
- Safety improvements within funding limitations may meet project goals without addressing the desire for corridor consistency
- There may be an opportunity to utilize the existing corridor with a reduced roadway typical section
- Traffic forecasts/assumed growth rates from the 2004 FONSI were calculated using differing methods and may be significantly different than today; the updated traffic forecast report uses a 0.5% growth rate
- There may be advantages to maintaining the existing alignment of KY 15 for structures and local access; some safety improvements will be required
- Access point safety must be addressed, therefore, a no build is not an option
- Crashes cluster at access points on curves and not necessarily near KY 28
- Access management near SR 1067 may require attention regardless of whether the existing alignment is retained
- There is a significant drainage area near KY 28 and an existing 12’x10’ box culvert under the intersection that will need to be addressed
- The pavement section thickness may be able to be reduced
- Earthwork balancing should take place as the design progresses
- There are no pedestrian/bicycle facilities included in the project
- There was a significant increase in crashes in the 2004 FONSI (42% increase from 53 in 1999 to 75 in 2000); however the past 5 year crash data is probably more accurate (while it may include COVID-19 lockdown periods)
- Project limits that included an interchange at KY 28 may be outdated
- Truck traffic operations may be improved by providing truck lanes
- Alternative project delivery should be considered

2.6 Project Schedule

The project was at the preliminary design stage with an alignment review scheduled for January 2022. A preferred interchange type at KY 28 will be selected in May 2022 and Phase 1 (50-60% plans) will be completed in July 2022. The project letting is scheduled for 2025 and the construction duration is expected to be 24-30 months. The project delivery is Design-Bid-Build.

2.7 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 5. See Appendix D for the HMB expanded estimate.

Table 5. Cost Estimate – Baseline Concept

Cost Item	Cost	Percent of Total	Cumulative Percentage
Earthwork	$26,200,000	33.7%	34%
Contingency	$13,782,000	17.7%	51%
Pavement	$12,121,000	15.6%	67%
Bridge	$11,944,800	15.4%	82%
Right of Way	$6,748,000	8.7%	91%
Culverts	$4,858,840	6.2%	97%
Utilities	$2,160,000	2.8%	100%
Total	$77,814,640	100.0%	100%

This page intentionally left blank.

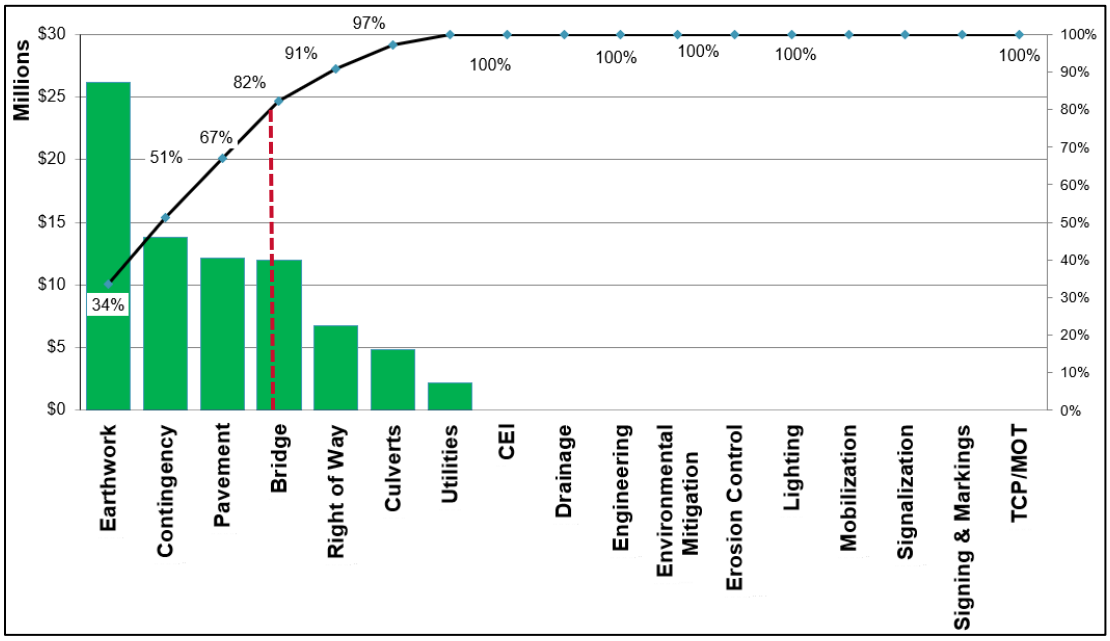
3 Project Analysis

3.1 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, the design team's estimated costs, and the percent of total project cost for the significant cost items (Figure 4).

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

Figure 4. Cost Model



3.2 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.

3.2.1 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 6). The following performance attributes were used throughout the study to identify, evaluate, and document ideas and recommendations.

Table 6. 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.	• LOS B, Design Speed: 60 MPH, No design exceptions • Four 12' lanes (divided) with 6' inside shoulders (4' paved) shoulders, 12' outside shoulders (10' paved), 40' depressed median (6:1)

Table 6. 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.	• Diamond overpass at KY 15/KY 28 (28 goes under), lighting • Two lane undivided 11' lanes, 6' shoulders (4' paved), 9% maximum grade Design Speed: 55 MPH • Two-way stop signs at approaches
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.	• Asphalt roadway, typical bridge maintenance • Lighting
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.	• KY 15 - maintain one lane each direction, minor permissive lane closures • Blasting for solid rock removal • Nighttime work expected
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.	• Some stream and wetland impacts - avoids two archaeological sites (rock shelters) • Phase II UST/HazMat investigation (two sites, Highwayman Chevron and Hazard Double Kwik #2) • 36 residences, six businesses, two churches • Three cemeteries (Miller Family, Campbell/Fugate, First Creek) impacting ten graves • Endangered Indiana bat

Table 6. Performance Attributes and Description

Performance Attribute	Description of Attribute	Baseline Concept
Project Schedule	An assessment of the total project delivery from the time as measured from the time of the VE Study to completion of construction.	• January 2022 Alignment Review to feed environmental process start • May 2022 preferred alternative (interchange selected) • EES June 2022 • July 2022 Phase 1 (50-60%) plans • Right-of-way start second half of 2022 • June/Sept environmental approvals • Let project December 2024, pending funding • Construction duration 24-30 months • Design-Bid-Build

3.2.2 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 7), 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 7. Performance Attribute Matrix

Paired Comparison							Total Points	% of Total
Main Line Operations	A	A	A/C	A	A/E	A	5.0	24%
Local Operations		B	B/C	B	B/E	B	4.0	19%
Maintainability			C	C	C	C	5.0	24%
Construction Impacts				D	E	D/F	1.5	7%
Environmental Impacts					E	E	4.0	19%
Project Schedule						F	1.5	7%
Total							**21.0**	**100%**

This page intentionally left blank.

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 8). Identifying the functions of the major design elements of the project allows a broader consideration of alternative ways to accomplish the functions.

Table 8. Random Function Identification

Project Element	Functions
Project Purpose/Need	Reduce Congestion Enhance Safety Improve System Linkage Reduce Conflicts Minimize Environment Impacts Meet Standards Minimize Maintenance Implement Design Introduce Traffic
Pavement	Support Loads Protect Base Increase Friction Add Lanes Remove Water Improve Geometry Improve Sight Distance Increase Capacity Improve Driver Expectation
Structures	Span Obstacle Support Loads Create Elevation
Earthwork	Create Profile Flatten Slopes Clear Space Move Soil Reduce Grades
Right-of-way	Create Space Control Access

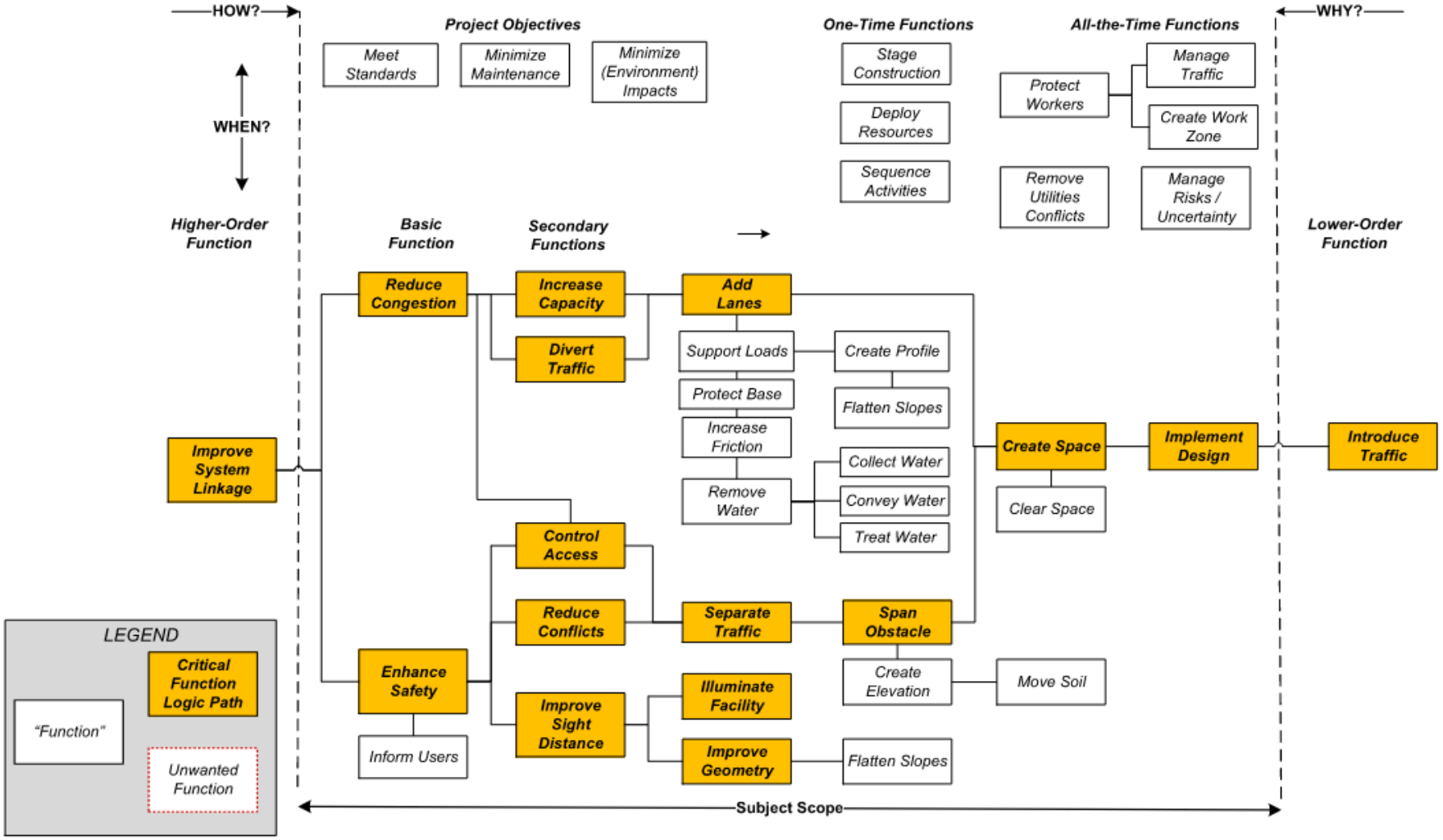
Table 8. Random Function Identification

Project Element	Functions
Traffic Control	Separate Traffic Control Access Inform Users Protect Workers Divert Traffic Improve Signage Control Movements
Drainage	Collect Water Convey Water Treat Water Control Water Discharge Water
Utilities	Remove Utility Conflicts
Other	Manage Risks / Uncertainty Stage Construction Deploy Resources Sequence Activities Create Work Zone Illuminate Facility Prepare Site Control Erosion Introduce Technology

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 5) provided the VE team with an understanding of which functions offer the best opportunity for cost or performance improvement.

Figure 5. FAST Diagram



This page intentionally left blank.

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 9. The final disposition of each idea is included at the end of Section 6.

Table 9. Creative Idea List

Idea No.	Description
Function: Control Access	
3	Maintain 1200' between access points throughout corridor
19	Continuous high T at southern limit of new alignment
22	Minimize number of access points
39	Consolidate access points near 1067 before intersecting with KY 15
40	Use green T intersection at 1067 (existing alignment)
42	Use r-cuts to reduce access points (baseline alignment)
43	Combine Rome Napier Br Rd, Baker Ln, and Grapevine Creek Rd
48	Make crossroad access perpendicular/combine
49	R-cut for EB KY 28 to NB KY 15
Function: Control Traffic	
14	Implement Transportation Systems Management and Operations (TSM&O) strategies/ITS
Function: Enhance Safety	
9	Utilize existing alignment with reduced median, make traffic operation improvements
17	Improve crash hotspot conditions using low cost safety improvements along existing alignment
23	Reduce design speed on KY 28 to 35 mph
31	Avoid shaded areas for KY 15/KY 28 intersection/approaches
32	Utilize ice detection system
33	Use heated pavement at intersections
47	Reduce posted speed on existing KY 15 to 35 mph
Function: Improve System Linkage	
1	Shift at-grade intersection northwest at KY 15/KY 28 (avoid cemetery and excavation at mountain)
4	Shift tie in from KY 28 to KY 15 to maintain freeflow from KY 28 to KY 15
5	Utilize bowtie interchange at KY 15/KY 28
6	Utilize horsecollar interchange at KY 15/KY 28

Table 9. Creative Idea List

Idea No.	Description
12	Maintain existing alignment, construct high green-T at KY 28 (Option B Rec 6)
13	Shift diamond south to eliminate long structures over existing KY 15
15	Eliminate T-intersection at KY 15/KY 28, abandon northern piece of KY 15
16	Realign KY 15 west at KY 28, increase curve radius to eliminate twin structures (KY 28 under new KY 15)
20	At-grade unsignalized continuous green T at KY 28 intersection on baseline alignment
27	Utilize jughandle interchange at KY 15/KY 28
50	Use existing alignment for one direction of traffic and baseline alignment for the other
Function: Inform Users	
37	Use an intersection conflict warning system at KY 15/KY 28 intersection
38	Implement DMS at high crash areas
Function: Minimize Environmental Impacts	
25	Steepen side slopes to reduce earthwork
29	Allow 7% grades (design exception) for short spans with plateaus
Function: Mitigate Risk	
10	Purchase right-of-way and complete design for full build out, construct two lanes at this time
24	Use performance based approach at rock areas
34	Allow contractor to use GPS and drone technologies
36	Investigate mining area reclamation funding sources
51	Design-Build alternative project delivery
Function: Reduce Congestion	
28	Use acceleration lanes in median for trucks at KY 28
Function: Separate Traffic	
2	Utilize 14' flush median (5 lane section) in lieu of 40-foot depressed median
8	Use barrier wall for median to reduce typical section baseline alignment
21	Use barrier wall for median to reduce typical section existing alignment
26	Split level (bifurcation) typical section to reduce earthwork
41	Carry passing lane through 1067/KY 15 intersection
46	Use barrier wall for median to reduce typical section (existing alignment)
Function: Span Obstacle	
11	Validate bridge layouts

Table 9. Creative Idea List

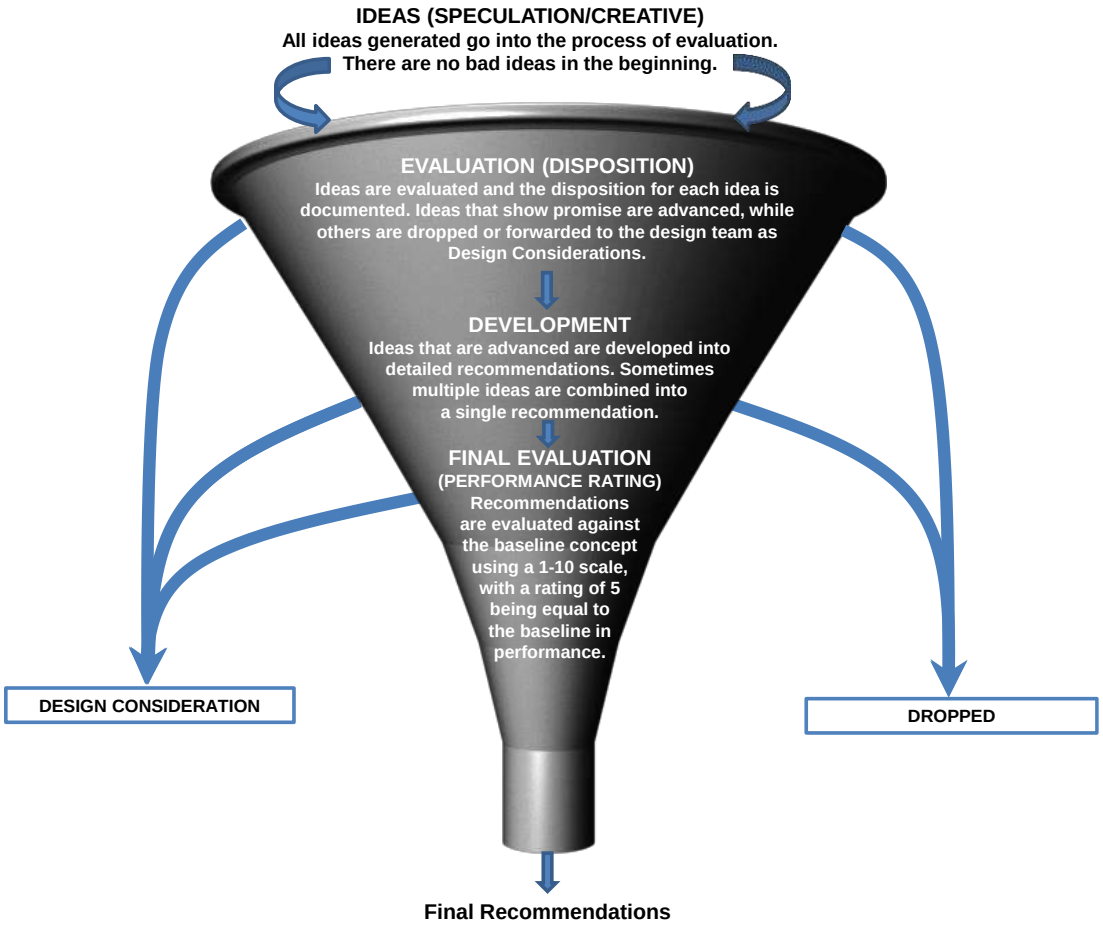
Idea No.	Description
Function: Stage Construction	
35	Phase construction of KY 28 area first then rest of project as a second phase
Function: Support Loads	
7	Reduce typical section to 2+1 along new alignment
18	Reduce cross section of new alignment
30	Reduce pavement section
44	Reduce typical section to 2+1 along existing alignment and other operational improvements
45	Use 4+1 in lieu of median (baseline alignment)

This page intentionally left blank.

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 6 depicts the typical information flow for this part of the Value Methodology Job Plan.

Figure 6. 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 3.2) 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 10.

Table 10. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
Function: Control Access					
3	Maintain 1200' between access points throughout corridor	• Reduces conflict points along mainline	• Reduces property owner access	*2*	*Assumed baseline as design progresses.*
19	Continuous high T at southern limit of new alignment	• Reduces conflicts • Improves operations	• May increase impervious • Adds structure • Increases maintenance	*3*	*Moved forward as VE Recommendation 7.*
22	Minimize number of access points	• Reduces conflicts • Improves operations • Reduces access	• May require some u-turns or extra pavement	*2*	*Design Consideration #2 for the design team to consider further.*
39	Consolidate access points near 1067 before intersecting with KY 15	• Reduces conflict points • Reduces access to mainline	• Increases cost • Increases maintenance • May increase right-of-way impacts	*2*	*Potentially use break-away bollards, islands/curb. Baseline alignment is assumed to resolve safety concerns.*
40	Use green T intersection at 1067 (existing alignment)	• Reduces conflicts	• Access control surrounding 1067 may not allow green T	*1*	*Dropped from further consideration.*
42	Use r-cuts to reduce access points (baseline alignment)	• Reduces access • May reduce conflict points	• Reduces speed of turning vehicles • May increase conflicts • May not be practical with 40' depressed median • Out of direction travel • Driver expectancy	*1*	*Dropped from further consideration.*
43	Combine Rome Napier Br Rd, Baker Ln, and Grapevine Creek Rd	• Reduces conflict points • Reduces access to mainline	• Increases cost • Increases maintenance • May increase right-of-way impacts	*2*	*Good idea for design team to pursue.*

Table 10. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
48	Make crossroad access perpendicular/combine	• None noted	• None noted	*1*	*Assumed baseline as design progresses.*
49	R-cut for EB KY 28 to NB KY 15	• Reduces cost • Reduces ramps • Reduces structures	• May require acceleration lane • Out of direction travel (minor traffic) • Driver expectancy	*3*	*Combine 20, 28, 37, 49. Moved forward for further consideration in Development Phase; the VE Team looked into adding an R-cut for EB KY 28 to NB KY 15, however, upon further analysis the geometry does not work at this location.*
Function: Control Traffic					
14	Implement Transportation Systems Management and Operations (TSM&O) strategies/ITS	• Improves operations by adapting real-time traffic • Informs public of better/faster routes and/or delays	• Increases cost • May require local agency coordination/agreement • Increases maintenance • May require larger investment (corridor wide) • May require TMC (traffic management centers)	*1*	*May need to implement corridor-wide to obtain full benefit.*

Table 10. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
Function: Enhance Safety					
9	Utilize existing alignment with reduced median, make traffic operation improvements	• Reduces footprint • Reduces cost • Eliminates structures • Accomodates future traffic needs • Reduces excavation significantly • Increases project fundability	• May require reducing design speed • May increase right-of-way impacts/impact additional parcels • May increase utility impacts • Public opposition • May require environmental reevaluation • Corridor inconsistency • Substandard curves • Increases construction impacts to	*3*	*Combine 9, 12, 21. Moved forward for further consideration in Development Phase but dropped from recommendation. District opposition to be determined. Potential interim solution.*
17	Improve crash hotspot conditions using low cost safety improvements along existing alignment	• May reduce number of conflicts • May reduce severity of conflicts • Informs users • Addresses root cause of crashes	• Increases cost • May increase maintenance • Access complexity/coordination • Increases impacts during construction • Public opposition	*2*	*Originally combined 17, 38, 41 but then separated and dropped from further development because remaining traffic volumes may not warrant significant improvements. Additional investment for improvements may not be worth it since traffic is split between ex*
23	Reduce design speed on KY 28 to 35 mph	• Improves stopping distance • Reduces severity of conflicts • May reduce driver speed prior to end of roadway	• None noted	*2*	*Good idea for design team to pursue.*

Table 10. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
31	Avoid shaded areas for KY 15/KY 28 intersection/approaches	• Reduces icy conditions at critical locations	• May not be practical to reposition intersection, etc.	*2*	*Should be considered by the project team as design progresses, if possible.*
32	Utilize ice detection system	• Assists with early deployment of salt trucks	• Increases cost • Increases maintenance	*1*	*Sensors are common in western and central Kentucky.*
33	Use heated pavement at intersections	• Reduces icy conditions at critical locations • Relieves some of maintenance snow plow drivers	• Increases cost • Increases maintenance	*1*	*Experimental pilot project potential.*
47	Reduce posted speed on existing KY 15 to 35 mph	• May reduce conflicts • Allows for improved intersection flow	• Public opposition • May increase speed differentials • Requires additional traffic calming infrastructure	*1*	*Dropped from further consideration.*
Function: Improve System Linkage					
1	Shift at-grade intersection northwest at KY 15/KY 28 (avoid cemetery and excavation at mountain)	• Reduces cemetery impacts • May reduce earthwork • Eliminates twin structures • Reduces severity of conflict points • Improves sight distance	• May require culvert/hydraulics redesign • Increase number of conflict points • May require additional features (high friction surface, etc.) to address 6% superevevation • At-grade intersection at bottom of hill	*3*	*Same idea as 16. Moved forward as VE Recommendation 5.*

Table 10. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
4	Shift tie in from KY 28 to KY 15 to maintain freeflow from KY 28 to KY 15	• Reduces cemetery impacts • May reduce earthwork • Eliminates one tight diamond structure and ramps • Reduces number of conflict points on mainline	• Adds one structure • Eliminates direct EB to SB movements • Eliminates direct NB to WB movements • Driver expectancy	*3*	*Moved forward as VE Recommendation 6.*
5	Utilize bowtie interchange at KY 15/KY 28	• None noted	• Increases earthwork significantly • Increases footprint	*1*	*Interchange type not conducive in this application.*
6	Utilize horsecollar interchange at KY 15/KY 28	• Eliminates left-turn movements • Matches corridor/consistency • Right-in, right-out access • Reduces ramp work • Reduces conflict points • May reduce earthwork	• Winter concerns of interchange in shade • Lengthens acceleration/deceleration • Truck turning movement is low speed • Increases footprint • May increase structures	*2*	*Design team already to investigate this option. Same idea as 27.*
12	Maintain existing alignment, construct high green-T at KY 28 (Option B Rec 6)	• None noted	• None noted	*3*	*Combine 9, 12, 21. Consider high T. Moved forward as VE Recommendation 4.*
13	Shift diamond south to eliminate long structures over existing KY 15	• Eliminates twin bridges • May reduce cost • Eliminates bridge maintenance • May reduce cemetery impacts	• May increase earthwork • Increases length of culverts	*3*	*Combined 13, 15. Moved forward as VE Recommendation 1.*
15	Eliminate T-intersection at KY 15/KY 28, abandon northern piece of KY 15	• May reduce structures	• None noted	*3*	*Combine 13, 15. Moved forward as VE Recommendation 1.*

Table 10. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
16	Realign KY 15 west at KY 28, increase curve radius to eliminate twin structures (KY 28 under new KY 15)	• None noted	• None noted	*3*	*Same idea as 1. Moved forward as VE Recommendation 5.*
20	At-grade unsignalized continuous green T at KY 28 intersection on baseline alignment	• Reduces cost • Reduces structures • Reduces footprint • May reduce earthwork • Provides crossing vehicle refuge	• Increases number of conflict points • Geometric complexity/superelevation compatibility	*3*	*Combine 20, 28, 37, 49. Moved forward as VE Recommendation 2.*
27	Utilize jughandle interchange at KY 15/KY 28	• None noted	• None noted	*1*	*Same idea as 6. Dropped from further development.*
50	Use existing alignment for one direction of traffic and baseline alignment for the other	• Reduces earthwork	• Driver expectancy • Reduces local access • Circuitous route for locals • Public opposition • Existing alignment substandard curves	*1*	*Dropped from further consideration.*
Function: Inform Users					
37	Use an intersection conflict warning system at KY 15/KY 28 intersection	• Informs users • May reduce conflicts	• Increases cost • Increases maintenance	*2*	*May be needed on at-grade intersection. Design Consideration #3 for the design team to consider further.*
38	Implement DMS at high crash areas	• None noted	• None noted	*2*	*Originally combined 17, 38, 41 but then separated and dropped from further development because remaining traffic volumes may not warrant significant improvements.*

Table 10. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
Function: Minimize Environmental Impacts					
25	Steepen side slopes to reduce earthwork	• Reduces cost • Reduces earthwork	• Requires design exception • Complicates maintainability • Introduces guardrail hazard • Widens clear zone requirement	*1*	*Dropped from further consideration.*
29	Allow 7% grades (design exception) for short spans with plateaus	• Reduces excavation significantly	• Requires design exception • Precludes at-grade intersection at KY 28 • Complicates maintenance • May reduce pavement life • Slows uphill traffic	*2*	*Good idea for design team to pursue.*
Function: Mitigate Risk					
10	Purchase right-of-way and complete design for full build out, construct two lanes at this time	• Reduces construction schedule • Defers pavement • Defers structures • Improves fundability	• May increase cost overall • Reduces performance of mainline operations • Reduces capacity (for passing vehicles) • Reduces separation between opposing traffic • Throwaway work/costs • Ultimate condition may never be constructed/funded	*3*	*Combine 7, 10. Moved forward for further consideration in Development Phase but dropped from recommendation.* *May construct full depth shoulders for truck climbing lanes.* *May work with 2+1.* *Kentucky law regarding full build-out and property owner.*

Table 10. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
24	Use performance based approach at rock areas	• Reduces cost • Reduces earthwork	• May not be applicable to this project • May not be practical • District opposition to rockfall risk	*1*	*Dropped from further consideration.*
34	Allow contractor to use GPS and drone technologies	• None noted	• Contractor means and methods	*1*	*Contractor means and methods.*
36	Investigate mining area reclamation funding sources	• May supplement funding through grant(s)	• May impose project restrictions/strings attached • Support required • Eligibility requirements	*1*	*Dropped from further consideration.*
51	Design-Build alternative project delivery	• Promotes innovation • May reduce cost • May reduce construction schedule • Risk transferred to contractor	• Reduces owner control/input	*1*	*Right-of-way is schedule driver so D-B may not be a good match. If funding was available this could be a potential solution.*
Function: Reduce Congestion					
28	Use acceleration lanes in median for trucks at KY 28	• None noted	• None noted	*3*	*Combine 20, 28, 37, 49. Moved forward as VE Recommendation 2.*

Table 10. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
Function: Separate Traffic					
2	Utilize 14-foot flush median (5 lane section) in lieu of 40-foot depressed median	• Reduces earthwork • May reduce structure	• Reduces space between opposing vehicles • Increases pavement • May require physical barrier such as guardrail • Increases impervious surface	*1*	*Goes against safety which is a main objective. May need to update SF of baseline bridge estimate to compare apples to apples.*
8	Use barrier wall for median to reduce typical section baseline alignment	• Reduces footprint • Reduces earthwork • May reduce structures	• Complicates snow/ice removal/maintenance • Increases drainage infrastructure • Increases drainage maintenance	*1*	*Dropped from further consideration.*
21	Use barrier wall for median to reduce typical section existing alignment	• None noted	• None noted	*3*	*Combine 9, 12, 21. Moved forward for further consideration in Development Phase but dropped from recommendation.*
26	Split level (bifurcation) typical section to reduce earthwork	• Reduces earthwork	• May require wider footprint • May increase right-of-way impacts • Increases need for guardrail	*2*	*Good idea for design team to pursue.*
41	Carry passing lane through 1067/KY 15 intersection	• None noted	• None noted	*2*	*Originally combined 17, 38, 41 but then separated and developed into Design Consideration #1 for the design team to consider further.*

Table 10. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
46	Use barrier wall for median to reduce typical section (existing alignment)	• Reduces footprint • Reduces earthwork • May reduce structures	• Complicates snow/ice removal/maintenance • Increases drainage infrastructure • Increases drainage maintenance • Public opposition	*1*	*Dropped from further consideration.*
Function: Span Obstacle					
11	Validate bridge layouts	• None noted	• None noted	*2*	*Typical section/shoulder widths need to be verified. 150' spans suggested.*
Function: Stage Construction					
35	Phase construction of KY 28 area first then rest of project as a second phase	• May improve project fundability • May improve cash flow availability • May have shovel-ready project sooner	• Increases mobilization • May increase throwaway work/costs • Public perception • Letting/contract coordination	*1*	*Right-of-way acquisition process may not coordinate with this idea. Potential to let project with option.*
Function: Support Loads					
7	Reduce typical section to 2+1 along new alignment	• Reduces footprint • Reduces earthwork • Reduces pavement • Reduces structures • Accomodates future traffic volumes	• Inconsistent with corridor • Reduces capacity • Reduces separation between opposing traffic • Reduces future flexibility/expansion potential	*3*	*Combine 7, 10. Moved forward as VE Recommendation 3.*
18	Reduce cross section of new alignment	• None noted	• None noted	*1*	*Specific strategies already discussed in previous ideas.*
30	Reduce pavement section	• May reduce cost	• May reduce pavement life span	*2*	*Assumed baseline as design progresses.*

Table 10. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
44	Reduce typical section to 2+1 along existing alignment and other operational improvements	• Reduces earthwork • Reduces cost • Reduces bridges • May reduce right-of-way impacts	• May increase right-of-way impacts • Public opposition • Inconsistent with corridor (roadway section) • Reduces capacity • Does not address substandard curves • Reduces separation between opposing traffic	*3*	*Fundable backup option. Moved forward as VE Recommendation 4.*
45	Use 4+1 in lieu of median (baseline alignment)	• Reduces earthwork • May reduce structure	• Reduces space between opposing vehicles • Increases pavement • May require physical barrier such as guardrail • Increases impervious surface	*1*	*Same idea as 2. Goes against safety which is a main objective. May need to update SF of baseline bridge estimate to compare apples to apples.*

This page intentionally left blank.

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 51 ideas that were generated during the Creative Phase, 15 of those ideas were evaluated high enough to be developed further and combined. 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 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 11 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 11 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 11. Summary of Recommendations

#	Recommendation Title	Cost Savings / (Cost Added) ($M)				Total Cost
		Construction	Life Cycle	Utility	ROW	
	Baseline	**$68.90**	**$45.51**	**$2.16**	**$6.75**	**$123.32**
1	Shift KY 28 Intersection to the South	$2.59	$0.47		$1.75	$118.51
2	Use At-Grade Intersection at KY 28	$7.26	$0.92			$115.14
3	Reduce Typical Section	$27.99	$2.11		$2.36	$90.86
4	Upgrade Existing KY 15 Alignment in lieu of Constructing the Baseline Alternative	$58.42	$41.73	$1.16	$4.75	$17.26
5	Shift Alignment West of Cemetery and Provide At-Grade Intersection at KY 28	$5.65	$1.12			$116.55
6	Shift Access to KY 28 North of Proposed KY 28 Interchange	$2.48				$120.84
7	Use Continuous High T at Southern Split	($3.08)	($0.84)			$127.24

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 7-4.

VE RECOMMENDATION NO. 1: SHIFT KY 28 INTERSECTION TO THE SOUTH	Idea Nos. 13,15

Baseline Concept

The baseline concept realigns KY 15 and uses a Tight Diamond Interchange at KY 15/KY 28. The Tight Diamond Interchange is located to the northeast of the existing T-intersection. The baseline alignment of the Tight Diamond Interchange impacts the Miller Cemetery and two private properties.

The baseline concept uses the existing KY 15 access to KY 28 for the local roadway connections. To maintain the existing KY 15 roadway, two 500-foot bridges over existing KY 15, Grapevine Creek, and Kennedy Road.

Recommendation Concept

Shift the Tight Diamond Interchange south to eliminate long structures over existing KY 15 and eliminate the T-intersection at KY 15/KY 28. Abandon the northern piece of KY 15.

Advantages	Disadvantages
• Eliminates twin bridges • Reduces bridge maintenance • Mitigates cemetery impacts • Reduces impacts to private property	• May increase earthwork • Increases length of culverts • Adds additional pavement for KY 28 realignment and connection to existing KY 15

Cost Summary	Construction	Right-of-way	Lifecycle	Total
Baseline Concept	$48,424,063	$6,748,000	$725,652	$56,637,549
Recommendation Concept	$45,831,010	$5,000,000	$253,383	$51,454,310
Cost Avoidance/(Added Value)	$2,593,052	$1,748,000	$472,269	$5,183,239

FHWA Function Benefit

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

VE RECOMMENDATION NO. 1: SHIFT KY 28 INTERSECTION TO THE SOUTH	Idea Nos. 13,15

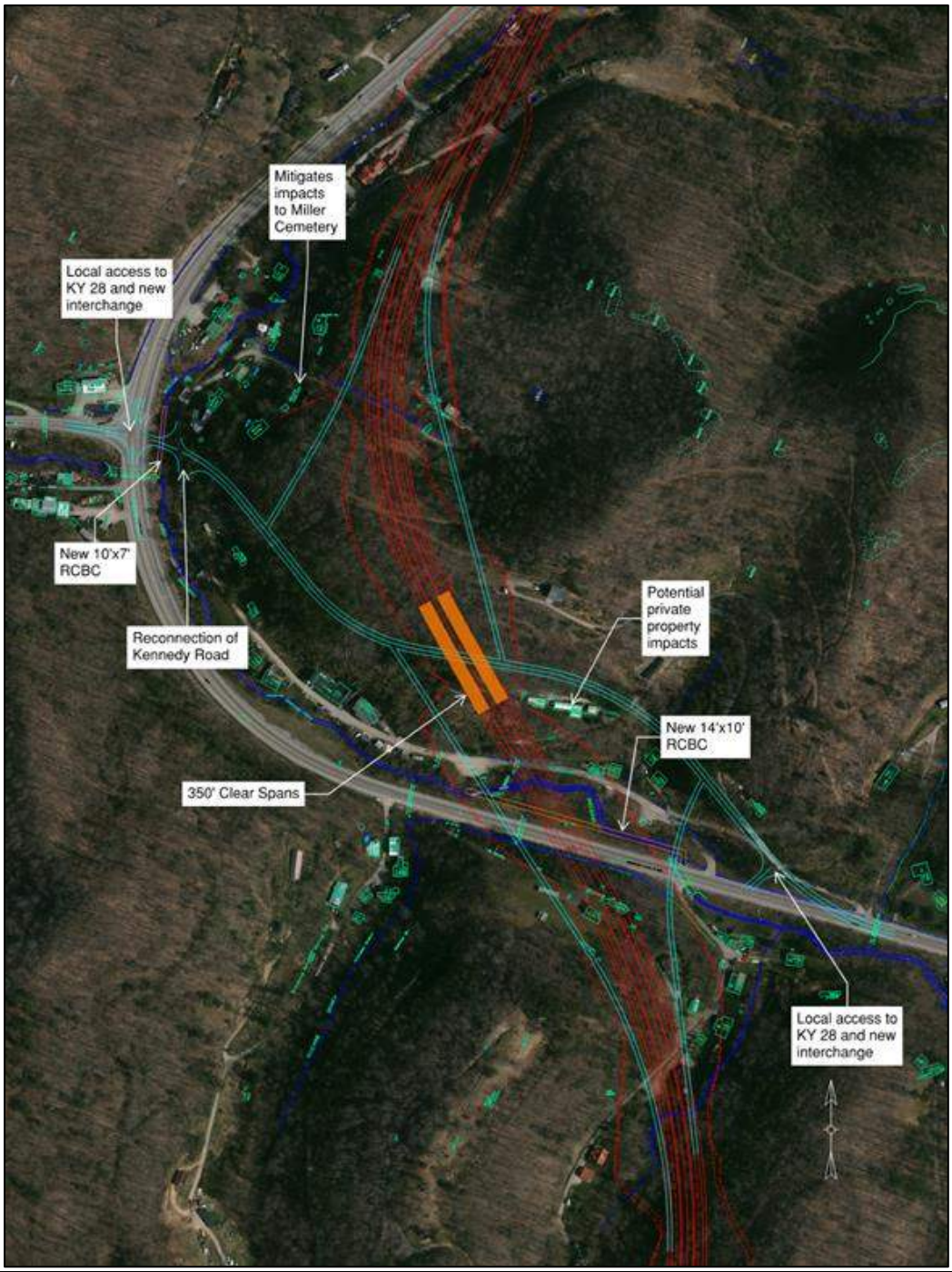
Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

Baseline concept – Includes a proposed Tight Diamond Interchange for the intersection of KY 15 at KY 28. The proposed intersection would take the Tight Diamond Interchange into the side of the mountain to the east of existing KY 15 and extend KY 28 to the baseline alignment. This would also include a set of twin bridges carrying KY 15 traffic over KY 28.

VE RECOMMENDATION NO. 1: SHIFT KY 28 INTERSECTION TO THE SOUTH	Idea Nos. 13,15

This recommendation realigns KY 28, constructs a Tight Diamond Interchange south of the proposed Tight Diamond Interchange, and connects KY 28 to existing KY 15. New KY 15 will bisect existing KY 15 and Kennedy Road, severing local connections to KY 28 and KY 15. Local roadway connections will be reestablished as necessary, requiring additional roadway improvements to reconnect existing KY 15 and Kennedy Road to realigned KY 28. The Tight Diamond Interchange ramp alignments have been placed to minimize impacts to private property and with consideration of earthwork.



VE RECOMMENDATION NO. 1: SHIFT KY 28 INTERSECTION TO THE SOUTH	Idea Nos. 13,15

The proposed KY 28 horizontal alignment is set to the south of the mountain, located north of private properties and Kennedy Road, and maintains a 35 mph design speed, with a minimum radius of 500 feet. The vertical profile of the KY 28, new KY 15, and the KY 15 exit/entrance ramps can be optimized to best balance earthwork and material needs required for the realignment of KY 15. The 35 mph design speed exceeds the baseline concept design speed at the Tight Diamond Interchange. The baseline concept maintains a 25 mph design speed with a minimum radius of 200 feet.

Allowing the proposed KY 15 to bisect existing KY 15 and Kennedy Road eliminates the need for the long twin structures. Reestablishing connections will require additional grading and pavement. The reestablished connections include:

- Existing KY 15 at existing KY 28 intersection
- Kennedy Road to new KY 28 (west of Tight Diamond Interchange)
- Existing KY 15 to new KY 28 (east of Tight Diamond Interchange)

Eliminating the twin structures will require a large 14'x10' RBCB for Grapevine Creek, approximately 700 feet long. A smaller 7'x10' RBCB will be required near the existing KY 28/KY 15 intersection, approximately 210 feet long.

Assumptions/Calculations

Earthwork

The earthwork associated with the entrance and exit ramps for Recommendation 1 and the baseline concept is assumed to be equivalent. A conceptual vertical alignment was developed for the new alignment of KY 28. InRoads was used to determine a concept level order of magnitude for the additional excavation required for this Recommendation.

Cut volume from InRoads output = 7,550,000 CY

Structures

The assumed bridge length of the new bridges over KY 28 are assumed to be 350' clear spans. This assumption was made considering the existing topography. The assumed structure length may be conservative.

Bridge square footage was developed using a ratio between our proposed 350 foot span and the baseline concept's 500 foot spans.

New Twin Bridge SF = 44,688 x 350/500 = 31,282 SF

RBCB 14x10 for 700 feet and 10x7 for 210 feet.

RBCB quantity calculations are as shown:

210' 10x7 Culvert	Thickness	Width	Length	Volume
Top Slab	1.33	11.67	210.00	3267
Bottom Slab	1.33	12.33	210.00	3453
Wall 1	0.83	7.00	210.00	1225
Wall 2	0.83	7.00	210.00	1225
Headwall	2.00	1.00	11.67	23
Wingwall 1	1.00	7.00	16.00	112
Wingwall 1	1.00	7.00	16.00	112
Wingwall Footing	2.00	7.00	18.00	252
Wingwall Footing	2.00	7.00	18.00	252
Apron Square	1.00	20.00	20.00	400
Apron Flare	1.00	20.00	20.00	400
				10721
700' 14x10 Culvert				
Top Slab	1.33	15.67	710.00	14831
Bottom Slab	1.33	16.33	710.00	15462
Wall 1	0.83	10.00	710.00	5917
Wall 2	0.83	10.00	710.00	5917
Headwall	2.00	1.00	15.67	31
Wingwall 1	1.00	10.00	16.00	160
Wingwall 1	1.00	10.00	16.00	160
Wingwall Footing	2.00	10.00	18.00	360
Wingwall Footing	2.00	10.00	18.00	360
Apron Square	1.00	20.00	20.00	400
Apron Flare	1.00	20.00	20.00	400
				43998

Pavement

The typical section of KY 28 is assumed to be a 2-lane section with12 foot lanes and 4 foot right shoulders. The total width of pavement is 32 feet. Based on the horizontal alignment, the total length of the KY 28 realignment is 2,900 linear feet.

2,900'x32' = 92,800 SF = 10,3111 SY

Right of Way: it's assumed that a reduction in right-of-way is most likely, including the avoidance of impacts to cemetery and its property. Assumed savings $1.75 million.

VE RECOMMENDATION NO. 1: SHIFT KY 28 INTERSECTION TO THE SOUTH	Idea Nos. 13,15

VE Study Life-Cycle Costs Calculations

VE Recommendation 1

		Baseline Concept				VE Recommended Concept		
Component	**Unit**	**Quantity**	**Cost/Unit**	**Total**		**Quantity**	**Cost/Unit**	**Total**
Roadway Excavation	CU YD	6,550,000	$ 4.00	$ 26,200,000		7,550,000	$ 4.00	$ 30,200,000
195+62 Bridge	SQ FT	44,688	$ 200.00	$ 8,937,600		-	$ 200.00	$ -
208+63 Bridge	SQ FT	15,036	$ 200.00	$ 3,007,200		-	$ 200.00	$ -
210' 10x7 Culvert	CU FT	-	$ 32.50	$ -		10,721	$ 32.50	$ 348,443
700' 14x10 Culvert	CU FT	-	$ 32.50	$ -		43,998	$ 32.50	$ 1,429,935
New Twin Bridges	SQ FT	-	$ 200.00	$ -		20,854	$ 200.00	$ 4,170,880
KY 28 Realignment Pavement	SY	-	$ 50.00	$ -		10,311	$ 50.00	$ 515,550
Diamond Interchange Pavemen	SY	11,889	$ 50.00	$ 594,450		-	$ 50.00	$ -
				$ -			$ -	$ -
Subtotal Construction				$ 38,739,250				$ 36,664,808
Mark-Up (MOT, Mob., PE, CEI)	25%			$ 9,684,813				$ 9,166,202
Total Construction				**$ 48,424,063**				**$ 45,831,010**
Monetized Time Savings								$ -
Right of Way Costs				$ 6,748,000				$ 5,000,000
TOTAL CAPITAL COST				**$ 55,172,063**				**$ 50,831,010**
COST CAPITAL SAVINGS / (VALUE ADDED)								**$ 4,341,052**

Life Cycle Cost Analysis

			Baseline Concept	Alternative Concept
Life Cycle Period	75	Years		
Discount Rate	3.6%	https://www.whitehouse.gov/wp-content/uploads/2018/12/M-19-05.pdf		
A. Initial Costs			$ 55,172,063	$ 50,831,010
B. Annual Costs		**Total Capital Cost Savings / (Value Added)**		**$ 4,341,052**
1. Annual Maintenance:	Bridge inspection and minor repairs ($10,000/yr per pair)		$ 10,000	$ 5,000
2. Annual Energy:				
3. Other:				
		Total Annual Costs:	$ 10,000	$ 5,000
		Present Value Factor (P/A):	73.9834	$ 74
		Present Value of Annual Costs:	$ 739,834	$ 369,917

C. Single Future Expenditures	**Amount**	**Year**	**PV Factor**	**Present Value**	**Present Value**
Bridge Re-decking baseline alignment	$ 2,986,200.00	40	0.2430	$ 725,652	
Bridge Re-decking recommended alignment	$ 1,042,720.00	40	0.2430		$ 253,383
			1.0000	$ -	
			1.0000		$ -
			1.0000	$ -	
			1.0000		$ -
			1.0000	$ -	
			1.0000		$ -
Residual Value		40	0.2430	$ -	$ -
		Present Value of Future Single Expenditures and Residual Value:		$ 725,652	$ 253,383
D. TOTAL PRESENT VALUE COST (A+B+C)				$ 56,637,549	$ 51,454,310
TOTAL LIFE CYCLE SAVINGS / (VALUE ADDED):					$ 5,183,239

VE RECOMMENDATION NO. 1: SHIFT KY 28 INTERSECTION TO THE SOUTH	Idea Nos. 13,15

VE RECOMMENDATION NO. 1	IDEA NOS.		
Shift KY 28 Intersection to the South	13,15		
PERFORMANCE MEASURES	*Performance*	*Baseline*	*Recommendation*
Attributes and Rating Rationale for Recommendation			
Main Line Operations	*Rating*	5	5
No change	*Weight*	23.8	
	Contribution	119	119
Local Operations	*Rating*	5	6
Improved geometry on KY 28 Direct access from KY 28 to old KY 15 Improved operation speeds	*Weight*	19.0	
	Contribution	95	114
Maintainability	*Rating*	5	6
Two less bridges to maintain	*Weight*	23.8	
	Contribution	119	142.8
Construction Impacts	*Rating*	5	4.75
Impacting Kennedy Road slightly more	*Weight*	7.1	
	Contribution	35.5	33.7
Environmental Impacts	*Rating*	5	5
Cemetery impacts avoided Additional stream impacts, realignment required	*Weight*	19.0	
	Contribution	95	95
Project Schedule	*Rating*	5	5
No change	*Weight*	7.1	
	Contribution	35.5	35.5
Total Performance		499	540
Net Change in Performance			8%

VE RECOMMENDATION NO. 2: USE AT-GRADE INTERSECTION AT KY 28	Idea Nos. 20,28,49

Baseline Concept

Utilizes a Tight Diamond Interchange to access the new proposed KY 15 alignment at KY 28.

Recommendation Concept

Use an innovative at-grade unsignalized continuous green T at the intersection of KY 15 at KY 28 on the baseline alignment. Incorporate a channelized acceleration lane for traffic turning left onto NB KY 15.

Advantages	Disadvantages
• Reduces cost • Reduces structures • Reduces ramp • Reduces footprint • May reduce earthwork	• Increases number of conflict points • Geometric complexity/superelevation compatibility • May require acceleration lane • Out of direction travel (minor traffic) • Driver expectancy

Cost Summary	Construction	Lifecycle	Total
Baseline Concept	$7,502,063	$922,523	$8,424,586
Recommendation Concept	$241,667	$0	$241,667
Cost Avoidance/(Added Value)	$7,260,396	$922,523	$8,182,919

FHWA Function Benefit

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

VE RECOMMENDATION NO. 2: USE AT-GRADE INTERSECTION AT KY 28	Idea Nos. 20,28,49

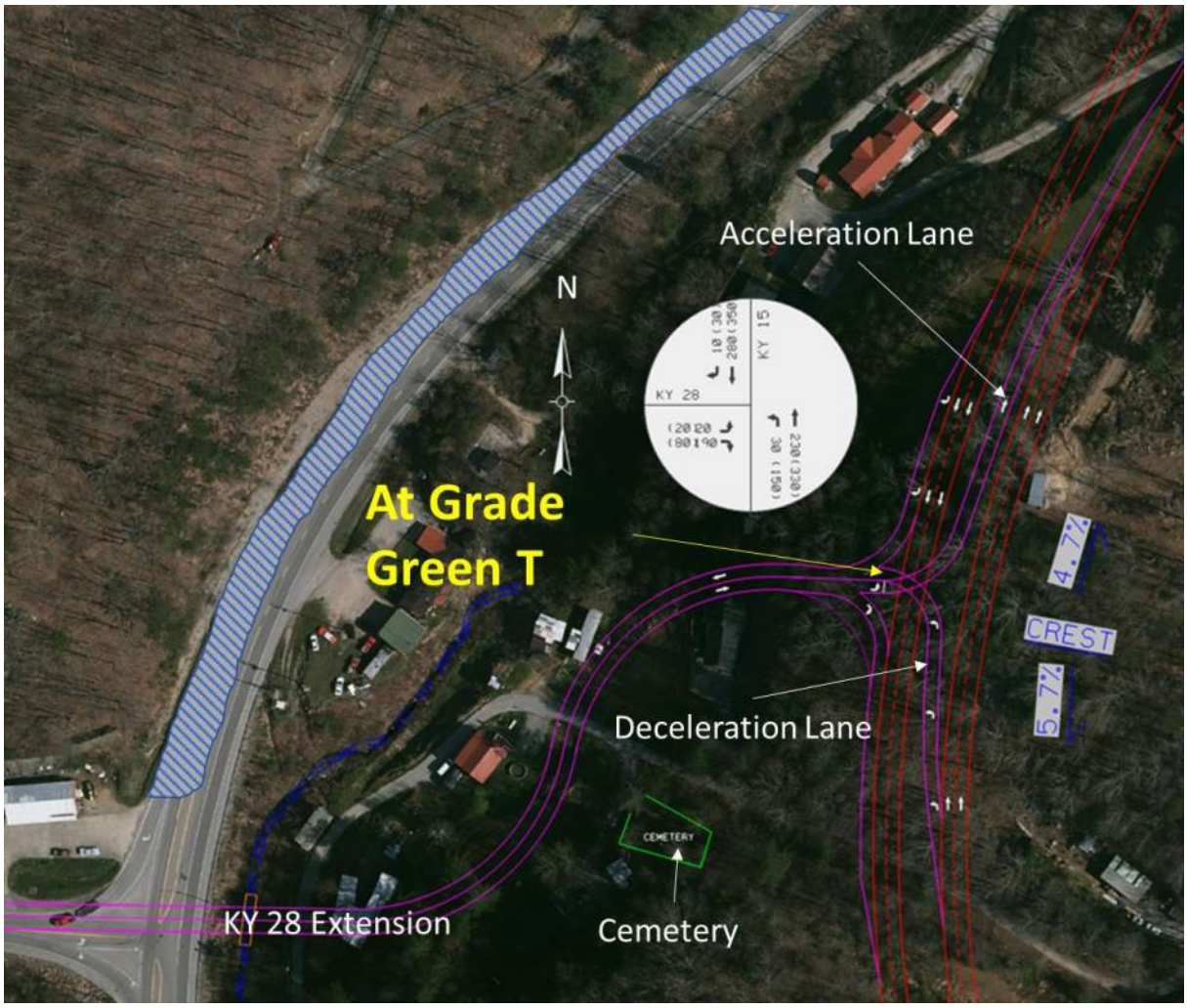
Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

Baseline concept includes a proposed Tight Diamond Interchange for the intersection of KY 15 @ KY 28. The design calls for the Tight Diamond Interchange to be placed into the side of the mountain to the east of existing KY 15 and extend KY 28 to the baseline alignment. This would also include a set of twin bridges carrying KY 15 traffic over KY 28.

VE RECOMMENDATION NO. 2: USE AT-GRADE INTERSECTION AT KY 28	Idea Nos. 20,28,49

The recommendation concept involves an innovative at-grade unsignalized continuous green T at the intersection of KY 15 at KY 28 on the baseline alignment. The use of an acceleration lane for traffic turning left onto NB KY 15 would also be incorporated.



This recommendation would eliminate the smaller twin set of bridges at the baseline interchange which would have been used to carry KY 15 traffic over KY 28. The green T intersection would adjust the KY 28 tie-in into KY 15 250 feet to the north. The VE Team recommends this movement because it allows KY 28 to be constructed on a crest of the proposed profile. The thought is by moving KY 28 to this crest, sight distance would be improved since the slope differs on either side. In addition, moving the tie-in to the north would also help avoid the cemetery impacted by the baseline KY 28 tie-in concept. The VE team assessed moving the tie-in 250 feet would not increase additional costs towards excavation and pavement. The grades on the KY 28 extension will meet design standards and should be able to tie into the KY 15 baseline alignment without any substandard grades. In addition, the horizontal curvature on KY 28 extension will help calm traffic speeds for vehicles approaching the stop-controlled, at-grade intersection with KY 15.

For eastbound KY 28 traffic turning northbound onto KY 15, the recommendation calls for a separate channelized acceleration lane 800 feet long plus taper, which would then tie into the

VE RECOMMENDATION NO. 2: USE AT-GRADE INTERSECTION AT KY 28	Idea Nos. 20,28,49

baseline KY 15 alignment. This will keep traffic separated until turning traffic reaches optimal speed to join free flow NB KY 15 traffic.

The VE Team would note, while this recommendation would increase conflict points. The Safety Performance for Intersection Control Evaluation (SPICE) tool suggests this at-grade Minor Road Stop intersection predicts 0.81 total crashes/year and 0.28 Fatal and Injury crashes/year

As part of the development of this VE Recommendation, the VE team investigated using an R-cut for EB KY 28 to NB KY 15, however, upon further analysis the geometry does not work at this location.

Assumptions/Calculations

Excavation:

Baseline Concept – 6,550,000 cubic yards x $4.00 per cubic yard = $26,200,000

Recommendation Concept – 5,950,000 cubic yards x $4.00 per cubic yard = $23,800,000

The recommendation concept would roughly subtract 600,000 cubic yards of excavation from the project with the removal of the Tight Diamond Interchange for a cost savings of $2,400,000. The VE Team would note it appears the quantities for excavation and earthwork may have been underestimated. This includes the quantities dealing with the approaches, ramps, and entrances to the Tight Diamond Interchange. We tried to keep this in mind, but also stay in the realm of possible cost savings. So, there is potential that cost savings could be either higher or lower with what the VE Team went with.

Structures:

Baseline Concept – 15,036 square feet x $200 per square foot = $3,007,200

Recommendation Concept – 0 square feet x $200.00 per square foot = $0.00

Removing the set of twin bridges carrying KY 15 traffic over KY 28 would have a cost savings of $3,007,200.

The baseline concept includes a culvert under KY 28, the recommended VE concept also includes a similar size culvert, but in a slightly different location.

Additional:

Baseline Concept for Tight Diamond Interchange pavement – 11,889 square yards x $50.00 per square yard = $594,450.

Recommendation Concept for at-grade intersection pavement – 3,869 square yards x $50.00 per square yard = $193,333.

The VE Team is assuming a similar amount of right-of-way might be needed for the recommended concept. It was our thought even if less right-of-way was going to be needed, it would be negligible.

Lifecycle cost assumptions:

Assume $10,000/year in inspection and minor repairs and one re-decking of bridges at 40 years (75-year life is assumed)

VE RECOMMENDATION NO. 2: USE AT-GRADE INTERSECTION AT KY 28	Idea Nos. 20,28,49

VE Study Life-Cycle Costs Calculations

VE Recommendation 2

		Baseline Concept				VE Recommended Concept		
Component	**Unit**	**Quantity**	**Cost/Unit**	**Total**		**Quantity**	**Cost/Unit**	**Total**
Roadway Excavation	CU YD	600,000	$4.00	$ 2,400,000		-	$ 4.00	$ -
208+63 Bridge	SQ FT	15,036	$200.00	$ 3,007,200		-	$ 200.00	$ -
Diamond Interchange Pavement	SY	11889	$ 50.00	$ 594,450		3,867	$ 50.00	$ 193,333
				$ -			$ -	$ -
Subtotal Construction				*$6,001,650*				*$193,333*
Mark-Up (MOT, Mob., PE, CEI)	25%			$1,500,413				$48,333
Total Construction				**$7,502,063**				**$241,667**
Monetized Time Savings								$0
Right of Way Costs				$0				$0
TOTAL CAPITAL COST				***$7,502,063***				***$241,667***
COST CAPITAL SAVINGS / (VALUE ADDED)								**$7,260,396**

Life Cycle Cost Analysis

Life Cycle Period	75	Years				**Baseline Concept**	**Alternative Concept**
Discount Rate	3.6%	https://www.whitehouse.gov/wp-content/uploads/2018/12/M-19-05.pdf					
A. Initial Costs						$ 7,502,063	$ 241,667
B. Annual Costs					**Total Capital Cost Savings / (Value Added)**		***$ 7,260,395.83***
1. Annual Maintenance:	$10,000 per bridge pair per year					$ 10,000	
2. Annual Energy:							
3. Other:							
					Total Annual Costs:	$ 10,000	$ -
					Present Value Factor (P/A):	73.9834	73.9834
					Present Value of Annual Costs:	$ 739,834	$ -

C. Single Future Expenditures	**Amount**	**Year**	**PV Factor**	**Present Value**	**Present Value**
Re-decking	$ 751,800.00	40	0.2430	$ 182,689	
			1.0000		$ -
			1.0000	$ -	
			1.0000		$ -
			1.0000	$ -	
			1.0000		$ -
			1.0000	$ -	
			1.0000		$ -
Residual Value		40	0.2430	$ -	$ -
			Present Value of Future Single Expenditures and Residual Value:	$ 922,523	$ -
D. TOTAL PRESENT VALUE COST (A+B+C)				$ 8,424,586	$ 241,667
TOTAL LIFE CYCLE SAVINGS / (VALUE ADDED):					$ 8,182,919

VE RECOMMENDATION NO. 2: USE AT-GRADE INTERSECTION AT KY 28	Idea Nos. 20,28,49

VE RECOMMENDATION NO. 2	IDEA NOS.		
Use At-Grade Intersection at KY 28	20,28,49		
PERFORMANCE MEASURES / **Attributes and Rating Rationale for Recommendation**	***Performance***	***Baseline***	***Recommendation***
Main Line Operations	***Rating***	**5**	**4.75**
Conflict points added (low volume left turn NB) Eliminates grade separation	***Weight***	**23.8**	
	Contribution	**119**	**113.1**
Local Operations	***Rating***	**5**	**4.5**
Intersection operations less functional than interchange Added conflict points	***Weight***	**19.0**	
	Contribution	**95**	**85.5**
Maintainability	***Rating***	**5**	**7**
Eliminates structures to maintain Reduces slope maintenance/cut back on right side Slightly reduces pavement	***Weight***	**23.8**	
	Contribution	**119**	**166.6**
Construction Impacts	***Rating***	**5**	**5**
No change	***Weight***	**7.1**	
	Contribution	**35.5**	**35.5**
Environmental Impacts	***Rating***	**5**	**5.75**
Slightly reduces pavement Reduces impacts to cemetery	***Weight***	**19.0**	
	Contribution	**95**	**109.3**
Project Schedule	***Rating***	**5**	**6**
Eliminating bridges reduces construction duration Simpilfied design may reduce design schedule	***Weight***	**7.1**	
	Contribution	**35.5**	**42.6**
Total Performance		**499**	**553**
Net Change in Performance			**11%**

VE RECOMMENDATION NO. 3: REDUCE TYPICAL SECTION	Idea Nos. 7,10

Baseline Concept

The baseline concept includes a 4-lane typical section with 40-foot depressed median along the new alignment.

Recommendation Concept

The recommended concept includes utilizing a 2+1 typical section along the new alignment.

Advantages	Disadvantages
• Reduces footprint • Reduces earthwork/excavation • Reduces pavement • Reduces structures • Meets operational requirements • Reduces construction schedule • Improves fundability	• Inconsistent with corridor • Reduces separation between opposing traffic • Reduces future flexibility/expansion potential • Has lower performance of mainline operations • Reduces capacity (for passing vehicles)

Cost Summary	Construction	Right-of-way	Lifecycle	Total
Baseline Concept	$68,917,875	$6,748,000	$6,276,363	$81,942,238
Recommendation Concept	$40,930,506	$4,386,200	$4,160,251	$49,476,957
Cost Avoidance/(Added Value)	$27,987,369	$2,361,800	$2,116,112	$32,465,281

FHWA Function Benefit

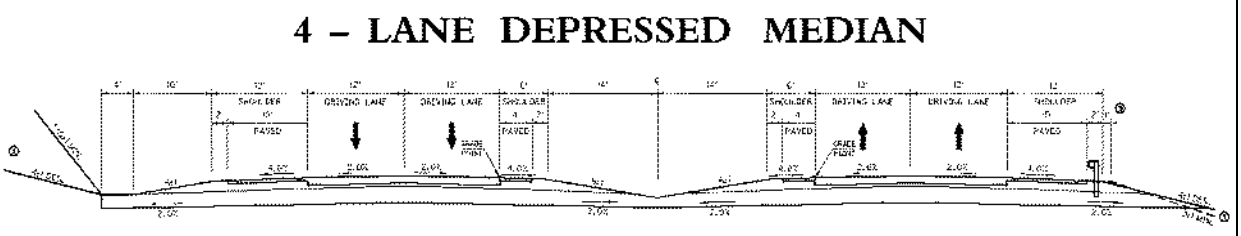
Safety	*Operations*	*Environment*	*Construction*	*Right-of-way*
		✓	✓	✓

VE RECOMMENDATION NO. 3: REDUCE TYPICAL SECTION	Idea Nos. 7,10

Discussion/Sketches/Photos/Calculations

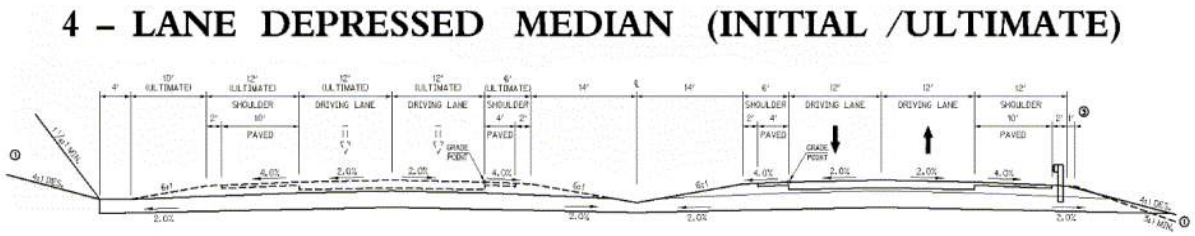
Technical Discussion/Sketches

The baseline concept includes a 4-lane typical section with 40-foot depressed median along the new alignment.

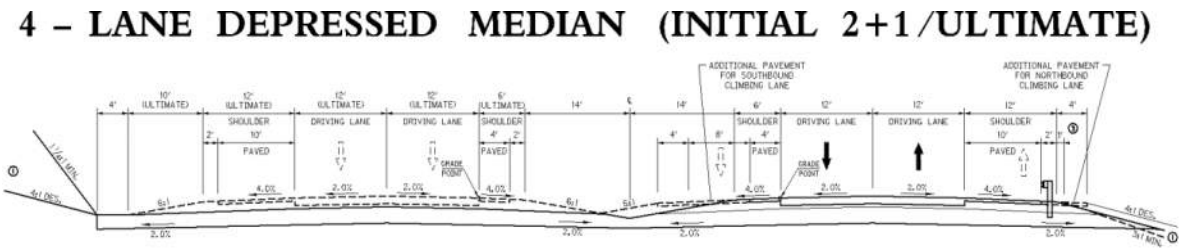


The VE team studied three options to reduce the typical section:

Initial/Ultimate - This option includes constructing the necessary earthwork, excavation and purchasing the necessary right-of-way for the full typical section shown in the figure above, but only paving half the typical section and constructing one of the twin bridges. This constructed section would function as a two-lane section, deferring the cost of the pavement and bridges on the other side of the section for some point in the future.

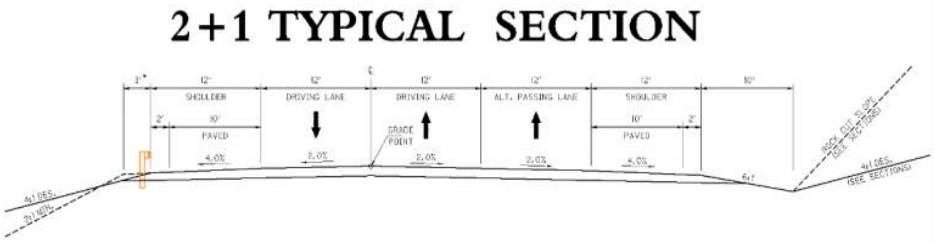


Initial (2+1)/Ultimate - This option includes constructing the necessary earthwork, excavation and purchasing the necessary right-of-way for the full typical section shown in the figure above, but only paving half the typical section and constructing one of the twin bridges. This would function as a 2-lane section with an alternating passing lane. This option would require additional full-depth pavement on the shoulders to accommodate traffic during the initial condition.



VE RECOMMENDATION NO. 3: REDUCE TYPICAL SECTION	Idea Nos. 7,10

2+1 - This option includes reducing the typical section to a 2+1 typical section. This would function as a 2-lane section with an alternating passing lane. This option achieves the project goal of improving congestion and meets the operational requirements of traffic projections. This option reduces the number of bridges from a twin bridge at each grade separate to a single bridge which would reduce future maintenance cost.



Traffic Analysis - Highway Capacity Software was utilized to analyze peak-hour, future traffic operations for the 4-lane typical and the 2+1 typical. Both typical sections were analyzed for the segment of the new alignment that has 5.6% vertical grade. The 4-lane typical has a Volume-to-Capacity Ratio (v/c) of 0.14. The 4-lane typical has capacity for 2,091 passenger cars per hour per lane (pc/h/ln). The calculated flow rate for the 4-lane typical is 286 pc/h/ln. The 2+1 typical has a Demand Capacity of 0.43. The segment capacity for the 2+1 typical is 1300 vehicles per hour. The calculated Directional Demand Flow Rate is 559 vehicles per hour. It was noted that for the single lane direction (downhill grade), due to time spent following, the Vehicle LOS is C. For the two-lane segment with passing lanes, the Vehicle LOS is A.

Recommendation

The initial cost savings for both initial/ultimate options are around $12 million compared to the baseline concept. However, the VE team agreed these options are undesirable since the total cost is not actually decreased but deferred to the future, so these options were not further analyzed. Based on sizable cost savings and acceptable operations, the VE team consequently recommends an ultimate 2+1 typical section.

Assumptions/Calculations

The VE team did not have sufficient information to be able to calculate excavation and earthwork quantities. To determine an approximate cost savings, the VE team utilized a percentage (65%) to approximate the quantities which would decrease because of a reduced typical section width.

Structures - Decrease the sq ft of each bridge by 50% to approximately account for one set of bridges compared to twin bridges.

Twins at Sta 195+62 = 44,688 sq ft x 0.50 = 22,344 sq ft for Single Bridge

Twins at Sta 208+63 = 15,036 sq ft x 0.50 = 7,518 sq ft for Single Bridge

VE RECOMMENDATION NO. 3: REDUCE TYPICAL SECTION

Idea Nos. 7,10

VE Study Costs Calculations

Recommendation 3 - 2+1 Typical Section

Component	Unit	Baseline Concept Quantity	Baseline Concept Cost/Unit	Baseline Concept Total	VE Recommended Concept Quantity	VE Recommended Concept Cost/Unit	VE Recommended Concept Total
Roadway Excavation	CU YD	6550000	$ 4.00	$ 26,200,000.00	4257500	$ 4.00	$ 17,030,000.00
30+55 - 14x10 RCBC	CU FT	68320	$ 32.50	$ 2,220,400.00	44408	$ 32.50	$ 1,443,260.00
195+65 - 14x10 RCBC	CU FT	62160	$ 32.50	$ 2,020,200.00	40404	$ 32.50	$ 1,313,130.00
220+08 - 10x6 RCBC	CU FT	19320	$ 32.50	$ 627,900.00	12558	$ 32.50	$ 408,135.00
195+62 - Bridge*	SQ FT	44688	$ 200.00	$ 8,937,600.00	22344	$ 200.00	$ 4,468,800.00
208+63 - Bridge*	SQ FT	15036	$ 200.00	$ 3,007,200.00	7518	$ 200.00	$ 1,503,600.00
Class 3 Asphalt Surface 0.38B PG 64-22	TON	13300	$ 90.00	$ 1,197,000.00	6650	$ 90.00	$ 598,500.00
Class 3 Asphalt Base 1.00D PG 64-22	TON	70700	$ 80.00	$ 5,656,000.00	35350	$ 80.00	$ 2,828,000.00
Crushed Stone Base	TON	168500	$ 20.00	$ 3,370,000.00	84250	$ 20.00	$ 1,685,000.00
Class 2 Asphalt Surface 0.38D PG 64-22	TON	6600	$ 90.00	$ 594,000.00	3300	$ 90.00	$ 297,000.00
Class 2 Asphalt Base 1.00D PG 64-22	TON	16300	$ 80.00	$ 1,304,000.00	8150	$ 80.00	$ 652,000.00
Class 3 Asphalt Surface 0.38B PG 64-22 (for truck lane)					882	$ 90.00	$ 79,380.00
Class 3 Asphalt Base 1.00D PG 64-22 (for truck lane)					4550	$ 80.00	$ 364,000.00
Crushed Stone Base (for truck lane)					3680	$ 20.00	$ 73,600.00
Subtotal Construction				$ 55,134,300			$ 32,744,405
Mark-Up (MOT, Mob., PE, CEI)	25%			$ 13,783,575			$ 8,186,101
Total Construction				**$ 68,917,875**			**$ 40,930,506**
Monetized Time Savings							$ -
Right of Way Costs				$ 6,748,000			$ 4,386,200
TOTAL CAPITAL COST				**$ 75,665,875**			**$ 45,316,706**
COST CAPITAL SAVINGS / (VALUE ADDED)							**$ 30,349,169**

Life Cycle Cost Analysis

			Baseline Concept	Alternative Concept
Life Cycle Period	40	Years		
Discount Rate	3.6%	https://www.whitehouse.gov/wp-content/uploads/2018/12/M-19-05.pdf		
A. Initial Costs			$ 75,665,875	$ 45,316,706
B. Annual Costs		**Total Capital Cost Savings / (Value Added)**		**$ 30,349,168.75**
1. Annual Maintenance:	Assume $10,000 per year in inspection and minor repairs		$ 10,000	
2. Annual Energy:				
3. Other:				
		Total Annual Costs:	$ 10,000	$ -
		Present Value Factor (P/A):	39.7063	39.7063
		Present Value of Annual Costs:	$ 397,063	$ -

C. Single Future Expenditures	Amount	Year	PV Factor	Present Value	Present Value
First Cycle Resurfacing - Baseline section	$ 3,344,000.00	10	0.7021	$ 2,347,841	
First Cycle Resurfacing - reduced section	$ 2,464,000.00	10	0.7021		$ 1,729,988
Second Cycle Resurfacing - Baseline section	$ 3,344,000.00	20	0.4930	$ 1,648,432	
Second Cycle Resurfacing - reduced section	$ 2,464,000.00	20	0.4930		$ 1,214,634
Third Cycle Resurfacing - Baseline section	$ 3,344,000.00	30	0.3461	$ 1,157,374	
Third Cycle Resurfacing - reduced section	$ 2,464,000.00	30	0.3461		$ 852,802
Redecking Bridges - Baseline Section	$ 2,986,200.00	40	0.2430	$ 725,652	
Redecking Bridges - Reduced Section	$ 1,493,100.00	40	0.2430		$ 362,826
Residual Value		40	0.2430	$ -	$ -
	Present Value of Future Single Expenditures and Residual Value:			$ 6,276,363	$ 4,160,251
D. TOTAL PRESENT VALUE COST (A+B+C)				$ 81,942,238	$ 49,476,957
TOTAL LIFE CYCLE SAVINGS / (VALUE ADDED):					$ 32,465,281

VE RECOMMENDATION NO. 3: REDUCE TYPICAL SECTION	Idea Nos. 7,10

VE RECOMMENDATION NO. 3	IDEA NOS.		
Construct Modified Typical Section	7,10		
PERFORMANCE MEASURES / **Attributes and Rating Rationale for Recommendation**	*Performance*	*Baseline*	*Recommendation*
Main Line Operations	*Rating*	5	4.5
Reduces separation between opposing vehicles Minor section of mainline LOS reduction at peak hour Meets revised traffic demand	*Weight*	23.8	
	Contribution	119	107.1
Local Operations	*Rating*	5	5
No change	*Weight*	19.0	
	Contribution	95	95
Maintainability	*Rating*	5	6
Reduces pavement Reduces bridge Reduces space for maintenance activities	*Weight*	23.8	
	Contribution	119	142.8
Construction Impacts	*Rating*	5	5.5
Reduces rock blasting and vibrations	*Weight*	7.1	
	Contribution	35.5	39.1
Environmental Impacts	*Rating*	5	6
Reduced impervious Reduced footprint Reduced stream impacts	*Weight*	19.0	
	Contribution	95	114
Project Schedule	*Rating*	5	5
Reduces construction duration, less pavement and bridges May require environmental reevaluation	*Weight*	7.1	
	Contribution	35.5	35.5
Total Performance		499	534
Net Change in Performance			7%

VE RECOMMENDATION NO. 4: UPGRADE EXISTING KY 15 ALIGNMENT IN LIEU OF CONSTRUCTING THE BASELINE ALTERNATIVE	Idea No. 44

Baseline Concept

Proposed cross country KY 15 alignment utilizing 4-lane typical section with 40-foot median width.

Recommendation Concept

Provide consistant typical section (2+1) along existing alignment and implement other operational improvements.

Advantages	Disadvantages
• Reduces earthwork • Reduces cost • Reduces bridges • May reduce right-of-way impacts • Realign curves for 55 MPH design speed • Addresses hot spots at intersections • Fundable project that alleviates safety and traffic congestion concerns	• May increase right-of-way impacts along existing KY 15 • Public opposition • Inconsistent with corridor (roadway section) - Note: section to the south has 25,000 ADT and small urban setting • Reduces capacity - compared to 4-lane typical • Reduces separation between opposing traffic

Cost Summary	Construction	Right-of-way	Utilities	Lifecycle	Total
Baseline Concept	$68,905,800	$6,748,000	$2,160,000	$45,559,941	$123,373,741
Recommended Concept	$10,482,944	$2,000,000	$1,000,000	$3,831,869	$17,341,814
Cost Avoidance/ (Added Value)	$58,422,856	$4,748,000	$1,160,000	$41,728,072	$106,058,928

FHWA Function Benefit

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

VE RECOMMENDATION NO. 4: UPGRADE EXISTING KY 15 ALIGNMENT IN LIEU OF CONSTRUCTING THE BASELINE ALTERNATIVE	Idea No. 44

Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

Existing Information:

The existing typical along KY 15 varies from 2 lanes to 4 lanes, some sections with 2' paved shoulders and some with 10' paved shoulders. There is a two-way-left-turn lane at some locations and also locations of left turn lanes turning into an added lane. The existing route has an AADT of 10,140 with 2041 Future Build Year of 11,210 AADT. This section of KY 15 experienced 115 total crashes, 37 injury crashes, and 4 fatal crashes between 2016 and 2020. It was noted that 37% of the crashes occur during wet / snowy pavement conditions. 27% of the crashes occur during night hours.

Proposed Improvements:

- Implement a consistent typical section (2+1) along the project route. Exhibits and information at the workshop show inconsistent typical section in this stretch of road. . The route would be resurfaced and restriped. The asphalt surface with a polish resistance aggregate will be used to improve the pavement friction. Design Memo 04-13 recommends a shared four-lane facility (2+1) be considered as the ultimate design for roadways having a design year volume of 15,000 ADT or less.
- Realign curves to meet a minimum 55 mph design speed. There are three curves that do not meet current standards for 55 mph and are recommended for realignment. Crash Modification Factor (CMF) calculations for Rural – Principal Arterial Roads result in CMF's ranging from 0.78 to 0.86 for Fatal and Injury Crashes (22% reduction in KABC crashes).
- A review of the crash data reveals several "hot spots" at a few of the approaches that warrant special attention for safety measures and access management. One location is at the KY 1067 intersection with the gas station on one quadrant. Another location is at the Entertainment Drive approach.
- With the high percent of crashes occurring during nighttime conditions, lighting is an improvement option that is recommended along the corridor. CMF for Principal Arterial is 0.74 and may result in a reduction of 26% of night time crashes at intersections.

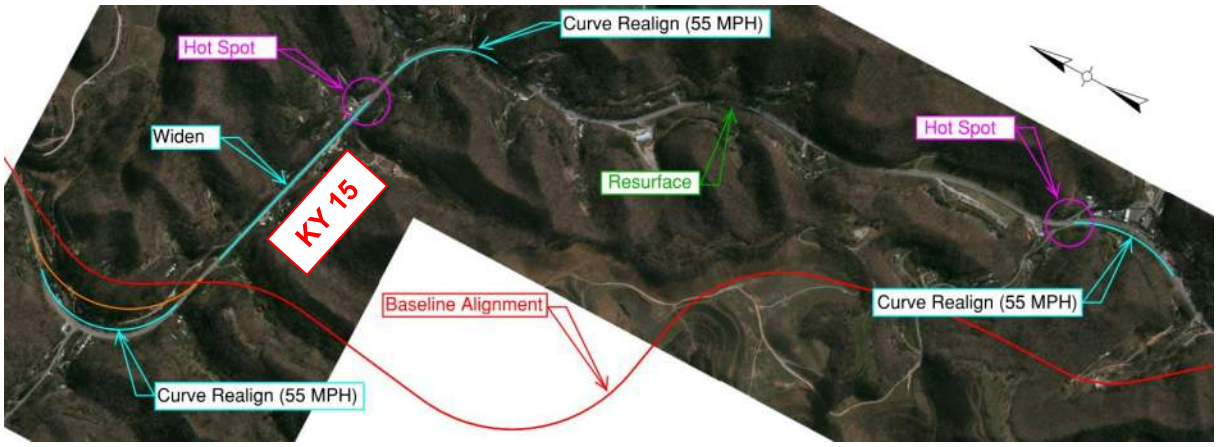
Construction:

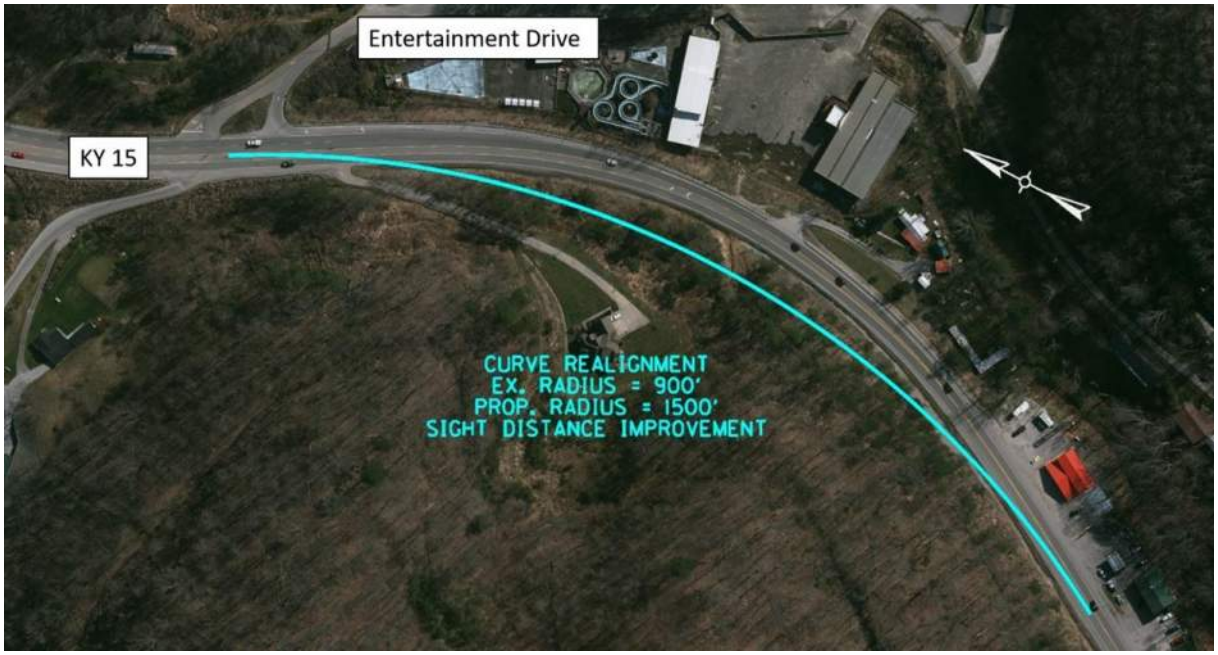
Consideration of existing utilities and additional R/W will dictate construction in this area. For purposes of this VE Study we will assume additional width to the existing cut slopes. Construction is generally accomplished by moving traffic to the outside shoulder and maintaining two-way traffic with temporary barrier wall placed along the cut shoulder to separate traffic from the excavation work taking place.

Substandard curves will be brought to current standards and may again require utility relocations and additional R/W. Construction should be straightforward as traffic will be maintained along current alignment with measures such as temporary barrier wall installed to provide separation between those traveling and workers.

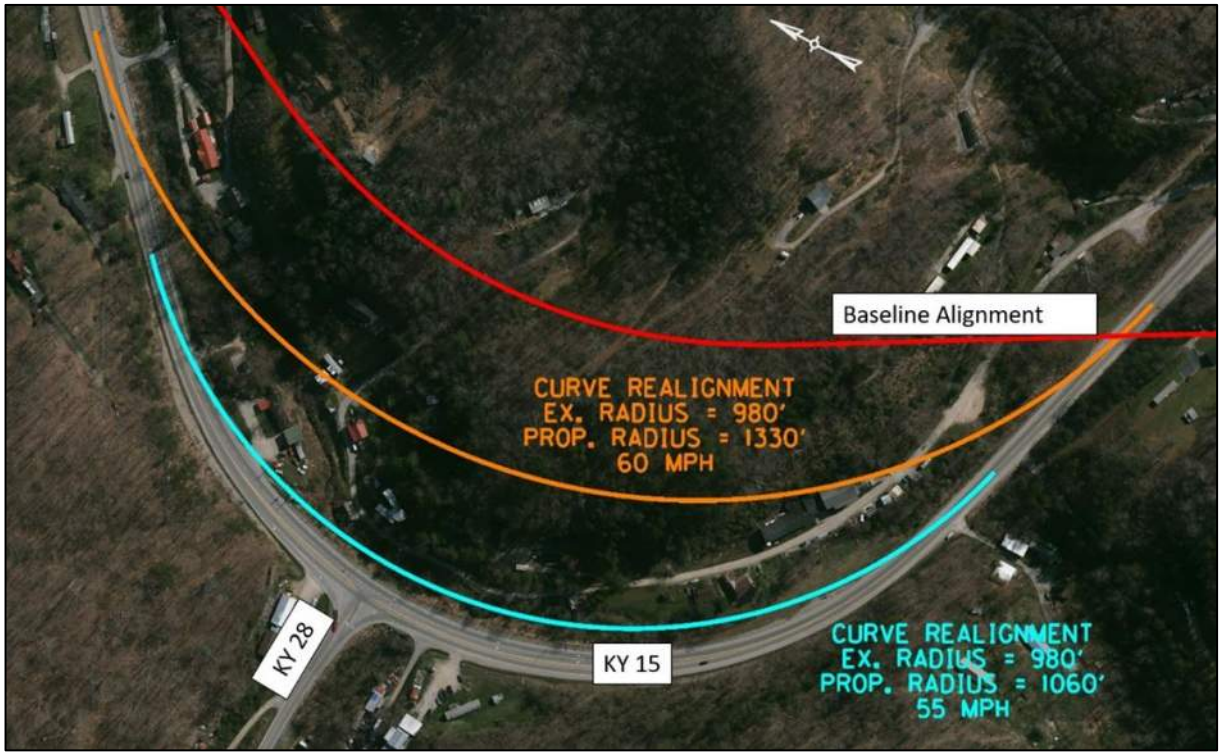
For other areas along the route (particularly along the minor approaches), crash data and traffic will be analyzed and mitigation plans developed to further enhance safety. Resurfacing, restriping and additional safety measures (turn lanes, truck lanes) and intersection improvements will be placed as dictated.

VE RECOMMENDATION NO. 4: UPGRADE EXISTING KY 15 ALIGNMENT IN LIEU OF CONSTRUCTING THE BASELINE ALTERNATIVE	Idea No. 44





VE RECOMMENDATION NO. 4: UPGRADE EXISTING KY 15 ALIGNMENT IN LIEU OF CONSTRUCTING THE BASELINE ALTERNATIVE	Idea No. 44



Assumptions/Calculations

- For the purpose of cost calculations, average unit prices were compared to those used by the design team for the baseline estimate. In this case prices per ton were converted to price per SY utilizing the same pavement design for full depth widening and curve revisions after areas were estimated. Same unit prices were used to develop a conservative price per SY for milling and resurfacing existing pavement areas at 2".
- Conservative estimates were used for estimating R/W and utility costs for application.
- The team estimated that there will be at least 3 areas that will need lighting at around $100k per location.
- Costs associated with mitigating high crash areas at KY 1067 and Entertainment Drive are included. Enhanced channelization, advance warning systems, high friction surface, and combining approach roads and entrances utilizing frontage roads are a few of the ideas to be considered.

VE RECOMMENDATION NO. 4: UPGRADE EXISTING KY 15 ALIGNMENT IN LIEU OF CONSTRUCTING THE BASELINE ALTERNATIVE

Idea No. 44

VE Study Life-Cycle Costs Calculations

VE Recommendation 4

		Baseline Concept				VE Recommended Concept		
Component	**Unit**	**Quantity**	**Cost/Unit**	**Total**		**Quantity**	**Cost/Unit**	**Total**
Earthwork	CU YD	6550000	$ 4.00	$ 26,200,000		500,000	$ 4.00	$ 2,000,000
Paving	SQ FT	44688	$ 200.00	$ 12,121,000		0	$ 200.00	$ -
Structures	SQ FT	15036	$ 200.00	$ 16,803,640		0	$ 200.00	$ -
New Roadway Construction	SQ YD			$ -		53855	$ 50.00	$ 2,692,756
Resurface Pavement	SQ YD			$ -		159573.33	$ 15.00	$ 2,393,600
Lighting	LS			$ -			$ -	$ 300,000
Access Management / Frontage Roads / Warning Systen	LS			$ -			$ -	$ 1,000,000
				$ -			$ -	$ -
Subtotal Construction				*$ 55,124,640*				*$ 8,386,356*
Mark-Up (MOT, Mob., PE, CEI)	25%			$ 13,781,160				$ 2,096,589
Total Construction				**$ 68,905,800**				**$ 10,482,944**
Monetized Time Savings								$ -
Right of Way Costs				$ 6,748,000				$ 2,000,000
Utility Costs				$ 2,160,000				$ 1,000,000
TOTAL CAPITAL COST				***$ 77,813,800***				***$ 13,482,944***
COST CAPITAL SAVINGS / (VALUE ADDED)								**$ 64,330,856**

Life Cycle Cost Analysis

			Baseline Concept	Alternative Concept
Life Cycle Period	40	Years		
Discount Rate	3.6%	https://www.whitehouse.gov/wp-content/uploads/2018/12/M-19-05.pdf		
A. Initial Costs			$ 77,813,800	$ 13,482,944
B. Annual Costs		**Total Capital Cost Savings / (Value Added)**		***$ 64,330,856***
1. Annual Maintenance:				
2. Annual Energy:		Lighting Electricity	$ -	$ 3,600
3. Other:		Bridge Maintenance	$ 120,000	
		Total Annual Costs:	$ 120,000	$ 3,600
		Present Value Factor (P/A):	39.7063	$ 40
		Present Value of Annual Costs:	$ 4,764,754	$ 142,943

C. Single Future Expenditures	**Amount**	**Year**	**PV Factor**	**Present Value**	**Present Value**
First Cycle Asphalt Resurfacing	$26,470,400	10	0.7021	$ 18,585,016	
First Cycle Concrete Repair	$2,393,600	10	0.7021		$ 1,680,560
Second Cycle Asphalt Resurfacing	$26,470,400	20	0.4930	$ 13,048,644	
Second Cycle Concrete Repair	$2,393,600	20	0.4930		$ 1,179,931
Third Cycle Asphalt Resurfacing	$26,470,400	30	0.3461	$ 9,161,526	
Third Cycle Concrete Repair	$2,393,600	30	0.3461		$ 828,436
Asphalt Reconstruction			1.0000	$ -	
Concrete Reconstruction			1.0000		$ -
Residual Value		40	0.2430	$ -	$ -
		Present Value of Future Single Expenditures and Residual Value:		$ 45,559,941	$ 3,831,869
D. TOTAL PRESENT VALUE COST (A+B+C)				$ 123,373,741	$ 17,314,814
TOTAL LIFE CYCLE SAVINGS / (VALUE ADDED):					$ 106,058,928

VE RECOMMENDATION NO. 4: UPGRADE EXISTING KY 15 ALIGNMENT IN LIEU OF CONSTRUCTING THE BASELINE ALTERNATIVE

Idea No. 44

VE RECOMMENDATION NO. 4	IDEA NO.		
Use Alternative 1 with a Minimized Typical Section with other Operational Improvements	44		
PERFORMANCE MEASURES	*Performance*	*Baseline*	*Recommendation*
Attributes and Rating Rationale for Recommendation			
Main Line Operations	*Rating*	5	3.5
Decreases capacity, decreases separation between opposing vehicles Verticals not addressed Increases conflicts - access Some operational improvements to address conflicts but still in existing alignment	*Weight*	23.8	
	Contribution	119	83.3
Local Operations	*Rating*	5	4
Increasing exposure of local operations to regional traffic (eliminates separation) Old 15 improved safety concerns and access control	*Weight*	19.0	
	Contribution	95	76
Maintainability	*Rating*	5	6.5
Eliminates bridges, significantly reduces pavement - but less space for maintenance	*Weight*	23.8	
	Contribution	119	154.7
Construction Impacts	*Rating*	5	3
Increases utility impacts Increased impacts to MOT and through movements Lane closures will likely be required Nighttime work may affect residents more because they're right on alignment	*Weight*	7.1	
	Contribution	35.5	21.3
Environmental Impacts	*Rating*	5	7.5
Reduces footprint Reduces cemetery impacts Reduces ROW impacts Stream impacts significantly increased at KY 28 curve (channel change)	*Weight*	19.0	
	Contribution	95	142.5
Project Schedule	*Rating*	5	6
Environmental reevaluation may be required Construction duration significantly reduced Simplified design may reduce design schedule May improve funding ability, alternative funding sources	*Weight*	7.1	
	Contribution	35.5	42.6
Total Performance		499	520
Net Change in Performance			4%

VE RECOMMENDATION NO. 5: SHIFT ALIGNMENT WEST OF CEMETERY AND PROVIDE ALTERNATIVE INTERSECTION AT KY 28	Idea Nos. 1,12,16

Baseline Concept

The baseline is grade separated where it crosses existing KY 15 which results in twin bridges carrying the new alignment. As the baseline alignment continues north, it includes a Tight Diamond Interchange at KY 28 with a bridge carrying KY 28 under new KY 15.

Recommendation Concept

Modify the radius of the horizontal curve to shift the alignment to the west of the existing Miller cemetery which will eliminate twin structures at KY 28 under new KY 15, and provide a new at-grade intersection or high green-T interchange at KY 15 and KY 28.

Advantages	Disadvantages
• Reduces impacts to Miller cemetery to the north • Eliminates twin structures at existing KY 15 • Eliminates twin structures at KY 15 and KY 28 • Reduces severity of conflict points • Improves sight distance	• Requires a culvert extension • Increases number of conflict points (Option A) • May require additional features (high friction surface, etc.) to address 6% super elevation • At-grade intersection at bottom of hill (Option A)

Cost Summary	Construction	Right of Way	Lifecycle	Total
Baseline Concept	$48,424,063	$6,748,000	$1,122,715	$56,294,778
Recommendation Concept (Option A)	$42,777,235	$6,748,000	$0	$49,525,235
Cost Avoidance (Option A)	$5,646,827	$0	$1,122,715	$6,769,542
Recommendation Concept (Option B)	$47,640,548	$6,748,000	$326,836	$54,715,384
Cost Avoidance (Option B)	$783,515	$0	$795,879	$1,579,393

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Right-of-way*

Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

The baseline concept realigns KY 15 to the west of existing KY 15 starting right before a horizontal curve near Copperhead Bend and ties back in near Martha Lane by crossing existing KY 15 with a set of twin bridges. The baseline concept continues north and includes a proposed Tight Diamond Interchange for the intersection of KY 15 at KY 28. This includes a proposed intersection which would take the Tight Diamond Interchange into the side of a mountain to the east of existing KY 15, and includes a set of twin bridges carrying KY 15 traffic over KY 28. There is also a small cemetery which would be impacted at the current baseline proposal of the Tight Diamond Interchange. A portion of the baseline concept is shown below:

The VE Team studied shifting the alignment west of cemetery and providing an alternative intersection at KY 28. Two options were studied and are presented on the following pages.

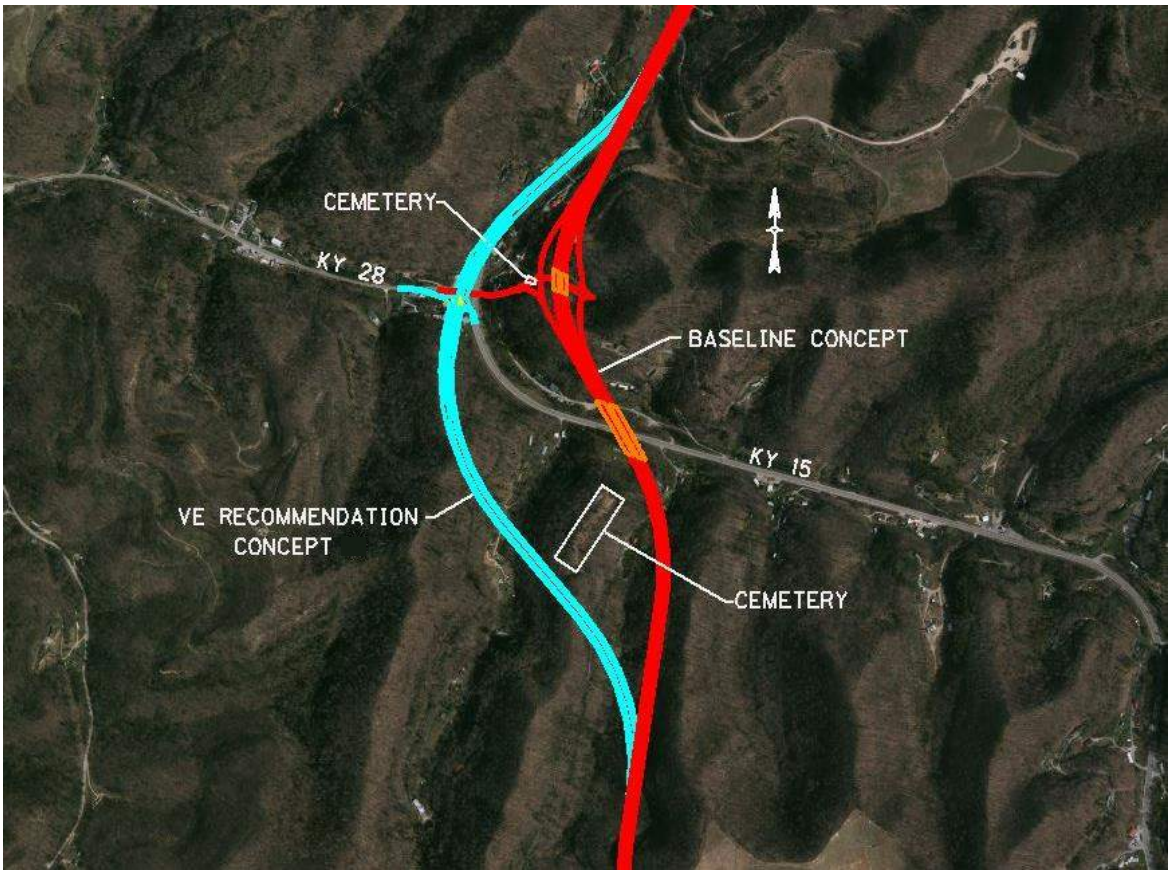
Option A

The recommendation concept would use the majority of the baseline concept's new alignment of KY 15, but would modify the radius of the horizontal curve to shift the alignment to the west of an existing cemetery south of the existing KY 15. This would convert KY 28 and KY 15 to an at-grade 4-legged intersection. This would eliminate the need for the set of twin bridges which are currently needed to cross existing KY 15 near Martha Lane. This recommendation would also

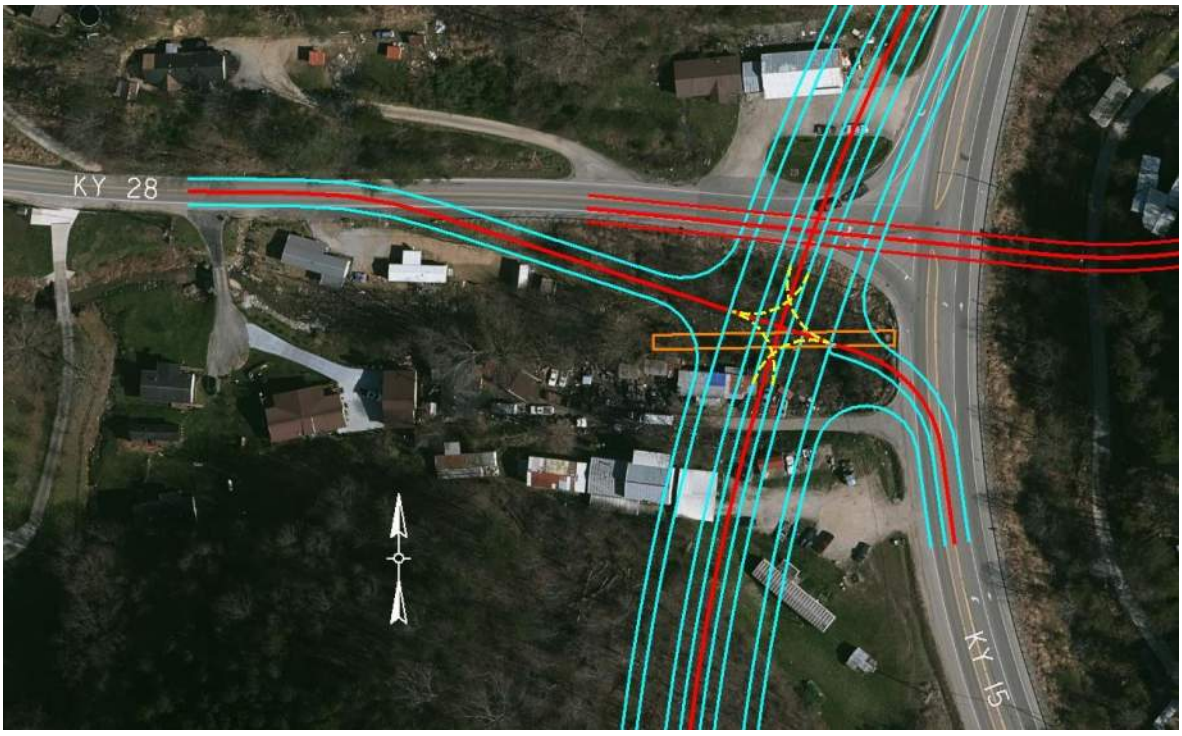
create an at-grade intersection for KY 15 @ KY 28 by moving the intersection back close to where it is on existing alignment. This would eliminate the need for the set of twin bridges carrying KY 15 traffic over KY 28 by removing the Tight Diamond Interchange altogether. Additionally, with the removal of the Tight Diamond Interchange, this would reduce the excavation needed for the mountain located in the Tight Diamond Interchange footprint. The concept also provides acceleration lanes for all turning movements for the approaches onto the mainline by utilizing available median width in an effort to reduce the severity of conflict points. This would also reduce impacts to the Miller cemetery in this project location.

Option A might also require additional features, such as the use of a high friction surface to address 6% super elevation. The VE Team is assuming the modified radius (cyan curve) would be constructed at the correct super elevation. If so, then there might not be a need for the high friction surface. Depending on the grade at the KY 28 tie-in into the 6% super elevation, high friction surface could be used at the KY 28 intersection or the design team could reduce the 6% super elevation by using a high friction surface and increasing the friction factor. The VE Team did not have enough information available regarding the proposed change to the baseline, we were unable to quantify if high friction surface would be needed, but wanted to state it.

Baseline Concept vs. Recommendation Concept for Option A



KY 15 @ KY 28 Intersection for Option A



Option B

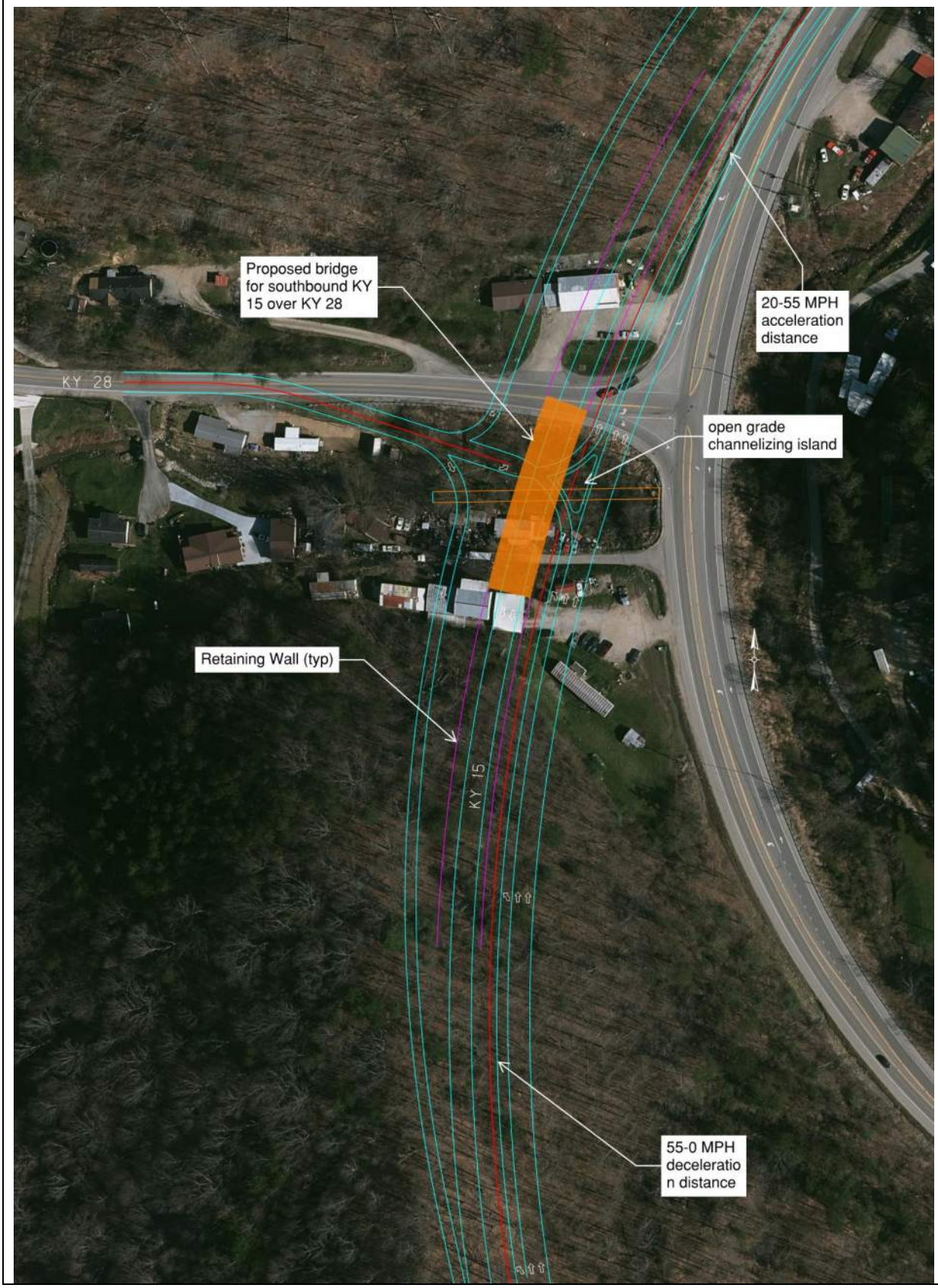
Option B is to provide a continuous high green T-intersection (CHGT) at KY 28 and KY 15. This will provide free flow through movement along the KY 15, with NB KY 15 at grade and SB KY 15 elevated over KY 28. The benefits of a CHGT are as follows:

- Provides uninterrupted flow for all through movements along the arterial
- Reduces conflict points

Southbound entrance and exit ramps are required to maintain connection to KY 28. Retaining walls will also be required to facilitate grade separating the southbound travel lanes. Wall height and length will vary depending on structure depth and vertical profile.

Additional local connections to KY 15 will be required to maintain a T-intersection at KY 15 and KY 28.

Continuous High Green T-Intersection for Option B



Assumptions/Calculations (Option A)

Excavation (Utilizing InRoads)

Baseline Concept – 6,550,000 cubic yards x $4.00 per cubic yard = $26,200,000

Recommendation Concept – 8,350,000 cubic yards x $4.00 per cubic yard = $33,400,000

The recommended concept would add an approximate net total of 3,000,000 cubic yards of excavation. However, with the removal of the Tight Diamond Interchange, roughly 600,000 cubic yards of excavation would be subtracted form that net total. That results in a net increase of 2,400,000 cubic yards for this recommendation. The VE Team observed that the quantities for excavation and earthwork included in the baseline concept cost estimate may have been underestimated. This includes the quantities of the approaches, ramps, and entrances to the Tight Diamond Interchange. Considering the potential uncertainty associated with those quantities, the VE's team recommended concept could result in either higher or lower cost savings.

Structures

Baseline Concept for twin bridges carrying new aligned KY 15 traffic over existing KY 15 – 44,688 square feet x $200 per square foot = $8,937,600.

Baseline Concept for twin bridges carrying KY 15 traffic over KY 28 – 15,036 square feet x $200 per square foot = $3,007,200.

Recommendation Concept – 0 square feet x $200.00 per square foot = $0.00

Removing both sets of twin bridges would have a cost savings of $11,337,600.

Additional

The Recommendation Concept includes a 10x12 culvert extension at KY 28 and KY 15 – 13,747 cubic feet x $32.50 per cubic foot = $446,788.33.

Baseline Concept for Tight Diamond Interchange pavement – 11,889 square yards x $50.00 per square yard = $594,450

Recommendation Concept for at-grade intersection pavement – 7,500 square yards x $50.00 per square yard = $375,000.

The VE Team's assumption is the need for right-of-way stays roughly the same due to the baseline concept and recommendation concept still being on new alignment and redesigning how KY 28 interacts with KY 15.

VE Study Life-Cycle Costs Calculations

VE Recommendation 5 Option A

		Baseline Concept				VE Recommended Concept		
Component	**Unit**	**Quantity**	**Cost/Unit**	**Total**		**Quantity**	**Cost/Unit**	**Total**
Roadway Excavation	CU YD	6550000	$ 4.00	$ 26,200,000		8,350,000	$ 4.00	$ 33,400,000
195+62 Bridge	SQ FT	44688	$ 200.00	$ 8,937,600			$ 200.00	$ -
208+63 Bridge	SQ FT	15036	$ 200.00	$ 3,007,200			$ 200.00	$ -
12x10 Culvert Extension at KY 28 & KY 15	CU FT			$ -		13747	$ 32.50	$ 446,788
Diamond Interchange Pavement	SY	11889	$ 50.00	$ 594,450		7500	$ 50.00	$ 375,000
Subtotal Construction				*$ 38,739,250*				*$ 34,221,788*
Mark-Up (MOT, Mob., PE, CEI)	25%			$ 9,684,813				$ 8,555,447
Total Construction				**$ 48,424,063**				**$ 42,777,235**
Monetized Time Savings								$ -
Right of Way Costs				$ 6,748,000				$ 6,748,000
TOTAL CAPITAL COST				***$ 55,172,063***				***$ 49,525,235***
COST CAPITAL SAVINGS / (VALUE ADDED)								**$ 5,646,827**

Life Cycle Cost Analysis

Life Cycle Period	40	Years					**Baseline Concept**	**Alternative Concept**
Discount Rate	3.6%	https://www.whitehouse.gov/wp-content/uploads/2018/12/M-19-05.pdf						
A. Initial Costs							$ 55,172,063	$ 49,525,235
B. Annual Costs						**Total Capital Cost Savings / (Value Added)**		***$ 5,646,827***
1. Annual Maintenance:	Assume $10,000/year in inspection and minor repairs						$ 10,000	
2. Annual Energy:								
3. Other:								
						Total Annual Costs:	$ 10,000	$ -
						Present Value Factor (P/A):	39.7063	$ 40
						Present Value of Annual Costs:	$ 397,063	$ -
C. Single Future Expenditures			**Amount**		**Year**	**PV Factor**	**Present Value**	**Present Value**
Re-decking bridges			$ 2,986,200.00		40	0.2430	$ 725,652	
						1.0000		$ -
						1.0000	$ -	
						1.0000		$ -
						1.0000	$ -	
						1.0000		$ -
						1.0000	$ -	
						1.0000		$ -
Residual Value					40	0.2430	$ -	$ -
						Present Value of Future Single Expenditures and Residual Value:	$ 1,122,715	$ -
D. TOTAL PRESENT VALUE COST (A+B+C)							$ 56,294,778	$ 49,525,235
TOTAL LIFE CYCLE SAVINGS / (VALUE ADDED):								$ 6,769,542

Assumptions/Calculations (Option B)

Acceleration from 20 mph to 55 mph is used for the acceleration length of the channelized receiving lane.

Lane drop taper rate is 50:1.

Maximum wall height is assumed to be 24 feet

Structures

Bridge is 220'x48'=10560 SF

Retaining Walls:

- Assumed length for each wall is 400'
- Assumed height varies from 22.5' to 8'
- 4x [400'x8+400x(22.5-8)/2] = 24,400 SF

Embankment

The embankment is assumed to require 800' in length on each side of the structure with a maximum embankment height of 22.5 feet (16.5' VC with 8' structure minus 2'for pavement depth)

Embankment (south) is (48'x22.5'x800'/2)/27=16,000 CY

Embankment (north) is (48'x22.5'x800'/2)/27=16,000 CY

Total Embankment = 32,000 CY

Pavement

The northbound and southbound ramp connections to KY 28 is assumed as follows:

- Ramp length is 1,200'each ramp
- Ramp widths is 16' lane, 4' left and 8' right shoulders
- 2 ramps x 1,200'x28'/9=3,733 SY

VE Study Life-Cycle Costs Calculations

VE Recommendation 5 Option B

		Baseline Concept				VE Recommended Concept		
Component	**Unit**	**Quantity**	**Cost/Unit**	**Total**		**Quantity**	**Cost/Unit**	**Total**
Roadway Excavation	CU YD	6550000	$ 4.00	$ 26,200,000		8,382,000	$ 4.00	$ 33,528,000
195+62 Bridge	SQ FT	44688	$ 200.00	$ 8,937,600			$ 200.00	$ -
208+63 Bridge	SQ FT	15036	$ 200.00	$ 3,007,200			$ 200.00	$ -
Bridge over KY 28	SQ FT	0	$ 200.00	$ -		10,560	$ 200.00	$ 2,112,000
Retaining Wall	SQ FT	0	$ 60.00	$ -		24,400	$ 60.00	$ 1,464,000
12x10 Culvert Extension at KY 28 & KY 15	CU FT	0	$ 32.50	$ -		13,747	$ 32.50	$ 446,788
Diamond Interchange Pavement	SY	11889	$ 50.00	$ 594,450		11,233	$ 50.00	$ 561,650
Subtotal Construction				*$ 38,739,250*				*$ 38,112,438*
Mark-Up (MOT, Mob., PE, CEI)	25%			$ 9,684,813				$ 9,528,110
Total Construction				**$ 48,424,063**				**$ 47,640,548**
Monetized Time Savings								$ -
Right of Way Costs				$ 6,748,000				$ 6,748,000
TOTAL CAPITAL COST				***$ 55,172,063***				***$ 54,388,548***
COST CAPITAL SAVINGS / (VALUE ADDED)								**$ 783,515**

Life Cycle Cost Analysis

Life Cycle Period	40	Years				**Baseline**	**Alternative**
Discount Rate	3.6%	https://www.whitehouse.gov/wp-content/uploads/2018/12/M-19-0				**Concept**	**Concept**
A. Initial Costs						$ 55,172,063	$ 54,388,548
B. Annual Costs		**Total Capital Cost Savings / (Value Added)**					***$ 783,515***
1. Annual Maintenance:	Assume $10,000/year in inspection and minor repairs					$ 10,000	$ 5,000
2. Annual Energy:							
3. Other:							
					Total Annual Costs:	$ 10,000	$ 5,000
					Present Value Factor (P/A):	39.7063	$ 40
					Present Value of Annual Costs:	$ 397,063	$ 198,531
C. Single Future Expenditures		**Amount**		**Year**	**PV Factor**	**Present Value**	**Present Value**
Re-decking bridges		$ 2,986,200.00		40	0.2430	$ 725,652	
Redecking new bridge over KY 28		$ 528,000.00		40	0.2430		$ 128,305
					1.0000	$ -	
					1.0000		$ -
					1.0000	$ -	
					1.0000		$ -
					1.0000	$ -	
					1.0000		$ -
Residual Value				40	0.2430	$ -	$ -
					Present Value of Future Single Expenditures and Residual Value:	$ 1,122,715	$ 326,836
D. TOTAL PRESENT VALUE COST (A+B+C)						$ 56,294,778	$ 54,715,384
TOTAL LIFE CYCLE SAVINGS / (VALUE ADDED):							$ 1,579,393

VE RECOMMENDATION NO. 5	IDEA NOS.		
Shift Alignment West of Cemetery and Provide At-Grade Intersection at KY 28	1,12,16		
PERFORMANCE MEASURES	*Performance*	*Baseline*	*Recommendation*
Attributes and Rating Rationale for Recommendation			
Main Line Operations	*Rating*	5	4.75
At-grade intersection increases conflicts (Option A) High T increases conflict points (Option B)	*Weight*	23.8	
	Contribution	119	113.1
Local Operations	*Rating*	5	4.5
Intersection operations slightly less functional than interchange given new traffic counts Added conflict points, severity of conflicts increased (ramps speeds vs mainline) but providing acceleration lanes	*Weight*	19.0	
	Contribution	95	85.5
Maintainability	*Rating*	5	7
Eliminates structures to maintain Reduces slope maintenance/cut back on right side Slightly reduces pavement	*Weight*	23.8	
	Contribution	119	166.6
Construction Impacts	*Rating*	5	5
No change	*Weight*	7.1	
	Contribution	35.5	35.5
Environmental Impacts	*Rating*	5	5
Increases impervious (longer road) but eliminates ramps Reduces impacts to cemetery May reduce relocations Extends RCBC near KY 28	*Weight*	19.0	
	Contribution	95	95
Project Schedule	*Rating*	5	6
Eliminating bridges reduces construction duration Simplified design may reduce design schedule Environmental reevaluation may be required	*Weight*	7.1	
	Contribution	35.5	42.6
Total Performance		499	538
Net Change in Performance			8%

VE RECOMMENDATION NO. 6: SHIFT ACCESS TO KY 28 NORTH OF PROPOSED KY 28 INTERCHANGE	Idea No. 4

Baseline Concept

KY 28 utilizes a Tight Diamond Interchange to access the new proposed KY 15 alignment.

Recommendation Concept

Shift access from KY 28 to KY 15 to the north and maintain freeflow between KY 28 to KY 15.

Advantages	Disadvantages
• Reduces cemetery impacts • Reduces earthwork by shifting to north and out of side of mountain • Eliminates structures at Tight Diamond Interchange • Eliminates interchange ramps • Reduces number of conflict points • Eliminates stop controlled intersections and allows for freeflow traffic movement (Option B)	• Adds smaller twin structures • Eliminates direct EB to SB movements (Option A) • Eliminates direct NB to WB movements (Option A) • Driver expectancy

Cost Summary	Construction	Right-of-way	Total
Baseline Concept	$37,252,056	$6,748,000	$44,000,056
Recommendation Concept	$34,773,722	$6,748,000	$41,521,722
Cost Avoidance/(Added Value)	$2,478,333	$0	$2,478,333

FHWA Function Benefit

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

VE RECOMMENDATION NO. 6: SHIFT ACCESS TO KY 28 NORTH OF PROPOSED KY 28 INTERCHANGE	Idea No. 4

Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

The baseline concept shown below features a Tight Diamond Interchange carved into the mountain side.

VE RECOMMENDATION NO. 6: SHIFT ACCESS TO KY 28 NORTH OF PROPOSED KY 28 INTERCHANGE	Idea No. 4

This recommendation is to relocate the KY 28 and KY 15 intersection to north. KY 28 would free flow onto old KY 15 and then tie into the new alignment approximately 450' to the north of the baseline Tight Diamond Interchange. The free flow movements reduce conflict points compared to the Tight Diamond Interchange.

Option A:

This option provides KY 28 access to KY 15 northbound by utilizing old KY 15 and ramps to the baseline alignment. KY 15 baseline alignment would bridge over the one lane KY 28 ramp. Access to KY 15 southbound utilized old KY 15 and ties in at the southern end of the project.

Option B:

A variant of this recommendation is to accommodate EB KY 28 traffic onto KY 15 southbound and KY 15 NB onto KY 28 westbound with tight loops at the interchange. KY 15 northbound traffic to KY 28 westbound (150 vehicles PM Peak) would utilize a loop ramp off of KY 15 NB and free flow onto old KY 15 and continue on KY 28 WB. WB-62 design vehicle was used to develop the turn radius from KY 15 NB to ensure trucks would be able to maneuver. KY 28 would free flow onto old KY 15 and then tie into the new alignment approximately 450' to the north of the baseline Tight

VE RECOMMENDATION NO. 6: SHIFT ACCESS TO KY 28 NORTH OF PROPOSED KY 28 INTERCHANGE	Idea No. 4

Diamond Interchange. The free flow movements reduce conflict points compared to the Tight Diamond Interchange.

KY 28 eastbound traffic to KY 15 southbound (150 vehicles PM Peak) would utilize a ramp to merge onto KY 15 SB.

KY 28 eastbound traffic to KY 15 northbound (20 vehicles PM Peak) would go under the proposed KY 15 alignment and utilize a ramp to merge onto KY 15 NB.

KY 15 southbound traffic to KY 28 westbound (30 vehicles PM Peak) would utilize a ramp from the proposed KY alignment onto old KY 15 and continue on KY 28 WB.

VE RECOMMENDATION NO. 6: SHIFT ACCESS TO KY 28 NORTH OF PROPOSED KY 28 INTERCHANGE	Idea No. 4

One key advantage of not creating the Tight Diamond Interchange as shown in the baseline is the reduced footprint at the mountain edge, which reduces excavation, reduces relocations and avoids cemetery impacts.

Assumptions/Calculations

It's assumed that, for maintenance purposes, the area of bridges and pavement quantities are similar and differences are negligible between Option A and Option B.

Assume similar ROW and Utility cost with the Baseline.

VE Study Costs Calculations

VE Recommendation 6

		Baseline Concept				VE Recommended Concept		
Component	**Unit**	**Quantity**	**Cost/Unit**	**Total**		**Quantity**	**Cost/Unit**	**Total**
Roadway Excavation	CU YD	6,550,000	$4.00	$ 26,200,000		5,950,000	$4.00	$ 23,800,000
208+63 Bridge	SQ FT	15,036	$200.00	$ 3,007,200		18,236	$200.00	$ 3,647,200
Diamond Interchange Pavement	SY	11889	$ 50.00	$ 594,444		3889	$ 50.00	$ 194,444
Resurface old KY 15	SY			$ -		11822	$ 15.00	$ 177,333
				$ -			$ -	$ -
Subtotal Construction				*$ 29,801,644*				*$ 27,818,978*
Mark-Up (MOT, Mob., PE, CEI)	25%			$ 7,450,411				$ 6,954,744
Total Construction				**$ 37,252,056**				**$ 34,773,722**
Monetized Time Savings								$ -
Right of Way Costs				$ -				$ -
TOTAL CAPITAL COST				***$ 37,252,056***				***$ 34,773,722***
COST CAPITAL SAVINGS / (VALUE ADDED)								**$ 2,478,333**

VE RECOMMENDATION NO. 6: SHIFT ACCESS TO KY 28 NORTH OF PROPOSED KY 28 INTERCHANGE	Idea No. 4

VE RECOMMENDATION NO. 6	IDEA NO.		
Maintain Free-flow from KY 28 to KY 15	4		
PERFORMANCE MEASURES / **Attributes and Rating Rationale for Recommendation**	*Performance*	*Baseline*	*Recommendation*
Main Line Operations	*Rating*	5	5
Reduces number of conflict points Reduces traffic from mainline to local roads	*Weight*	23.8	
	Contribution	119	119
Local Operations	*Rating*	5	4
Increases traffic on local roads from mainline Funnels traffic through old 15 Maintains freeflow from KY 28	*Weight*	19.0	
	Contribution	95	76
Maintainability	*Rating*	5	5
Old 15 may require more maintenance but bridge maintenance is reduced and interchange ramps eliminated	*Weight*	23.8	
	Contribution	119	119
Construction Impacts	*Rating*	5	5.5
Road closures and detours are no longer needed	*Weight*	7.1	
	Contribution	35.5	39.1
Environmental Impacts	*Rating*	5	5.25
Eliminates impacts to cemetery	*Weight*	19.0	
	Contribution	95	99.8
Project Schedule	*Rating*	5	5
Slightly easier to construct	*Weight*	7.1	
	Contribution	35.5	35.5
Total Performance		499	488
Net Change in Performance			-2%

VE RECOMMENDATION NO. 7: USE CONTINUOUS HIGH T AT SOUTHERN SPLIT	Idea No. 19

Baseline Concept

The baseline concept realigns KY 15 to a new cross-country alignment. An at-grade T-intersection is proposed at the southern connection with existing KY 15.

Recommendation Concept

Use a continuous high T at the southern limit of the new alignment.

Advantages	Disadvantages
• Reduces conflicts • Improves operations	• May increase impervious surfaces • Adds structure • Increases maintenance

Cost Summary	Capital	Life Cycle	Total
Baseline Concept	$77,815,000	$0	$77,815,000
Recommendation Concept	$80,890,000	$844,811	$81,734,811
Cost Avoidance/(Added Value)	($3,075,000)	($844,811)	($3,919,811)

FHWA Function Benefit

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

VE RECOMMENDATION NO. 7: USE CONTINUOUS HIGH T AT SOUTHERN SPLIT	Idea No. 19

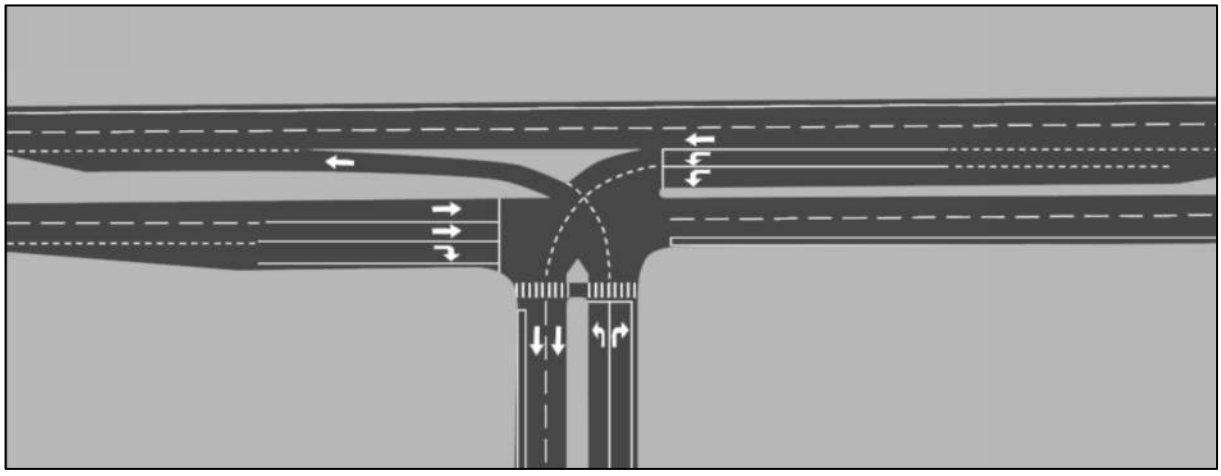
Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

The baseline intersection concept at the new aligned KY 15 and existing KY 15 does not show dedicated left or right turn lanes, nor does it include deceleration and acceleration lanes. It is assumed the baseline intersection will be full access. To reduce conflict points between turning traffic and KY 15 through traffic, NB KY 15 will be elevated over the intersection with existing KY 15. Northbound entrance and exit ramps are required to facilitate northbound access to and from existing KY 15.

This recommendation is to construct a Continuous High Green T-intersection (CHGT), a grade-separated variation of the Continuous Green-T (CGT) intersection design, at the southern intersection of the new aligned KY 15 and existing KY 15.

A Continuous Green T-intersection (CGT) channelizes left-turn movement from the minor street approach onto the main arterial, along with a continuous arterial through movement that occurs at the same time. This results in reducing conflict points and improving overall traffic flow at the intersection. Refer to the KYTC Congestion Toolbox at Continuous Green T | KYTC and the general layout of a CGT below.



To further enhance a CGT, the roadway of the opposing through movement on the mainline can be elevated. This will provide free flow through movement along the mainline, with one direction being at grade and the other being elevated over the minor street. This is referred to as a CHGT since one direction of travel is elevated. The benefits of a CHGT are as follows:

- Provides uninterrupted flow for all through movements along the arterial
- Reduces conflict points

The northbound exit ramp utilizes the existing KY 15 alignment. Below is a figure showing the general layout of the CHGT:

Recommended Continuous High Green T

The CHGT will require some retaining walls adjacent to the southbound left turn lane and the channelized southbound receiving lane from existing KY 15. Wall height and length will vary depending on structure depth and vertical profile.

VE RECOMMENDATION NO. 7: USE CONTINUOUS HIGH T AT SOUTHERN SPLIT	Idea No. 19

Assumptions/Calculations

Acceleration from 20 mph to 55 mph is used for the acceleration length of the channelized receiving lane. Lane drop taper rate is 50:1.

Maximum wall height is assumed to be 24'.

It is assumed the southbound left turn lane (not currently shown in the baseline concept) does not add additional cost to the project. It is also assumed that the northbound entrance ramp costs are negligible. The assumption is the baseline concept will include northbound and southbound deceleration and acceleration lanes.

Bridge is 180'x48'=8,640 SF

The embankment is assumed to require 800' in length on each side of the structure with a maximum embankment height of 22.5' (16.5' VC with 8' structure minus 2' for pavement depth)

Embankment in place is quantified but assumed to be incidental and not a pay item

Embankment (south) is (48'x22.5'x800'/2)/27=16,000 CY

Embankment (north) is (48'x22.5'x800'/2)/27=16,000 CY

Total Embankment = 32,000 CY

Retaining Walls

400' length adjacent to the southbound left turn lane and southbound channelized receiving lane

Height varies from 22.5' to 8'

Retaining Wall = 2x [400'x8+400x(22.5-8)/2] = 12,200 SF

VE RECOMMENDATION NO. 7: USE CONTINUOUS HIGH T AT SOUTHERN SPLIT

Idea No. 19

VE Study Life-Cycle Costs Calculations

VE Recommendation 7

		Baseline Concept				VE Recommended Concept		
Component	**Unit**	**Quantity**	**Cost/Unit**	**Total**		**Quantity**	**Cost/Unit**	**Total**
New Bridge	SQ FT	0	$ 200.00	$ -		8,640	$ 200.00	$ 1,728,000
Retaining Wall	SQ FT	0	$ 60.00	$ -		12,200	$ 60.00	$ 732,000
Subtotal Construction				$ -				$ 2,460,000
Mark-Up (MOT, Mob., PE, CEI)	25%			$ -				$ 615,000
Total Construction				**$ -**				**$ 3,075,000**
Monetized Time Savings								$ -
Right of Way Costs				$ -				$ -
TOTAL CAPITAL COST				**$ -**				**$ 3,075,000**
COST CAPITAL SAVINGS / (VALUE ADDED)								**$ (3,075,000)**

Life Cycle Cost Analysis

			Baseline Concept	Alternative Concept
Life Cycle Period	75	Years		
Discount Rate	3.6%	https://www.whitehouse.gov/wp-content/uploads/2018/12/M-19-05.pdf		
A. Initial Costs			$ -	$ 3,075,000
B. Annual Costs		**Total Capital Cost Savings / (Value Added)**		**$ (3,075,000)**
1. Annual Maintenance:	Bridge inspection and minor repairs, including retaining walls			$ 10,000
2. Annual Energy:				
3. Other:				
		Total Annual Costs:	$ -	$ 10,000
		Present Value Factor (P/A):	73.9834	$ 74
		Present Value of Annual Costs:	$ -	$ 739,834

C. Single Future Expenditures	**Amount**	**Year**	**PV Factor**	**Present Value**	**Present Value**
			1.0000	$ -	
Bridge re-decking	$ 432,000.00	40	0.2430		$ 104,977
			1.0000	$ -	
			1.0000		$ -
			1.0000	$ -	
			1.0000		$ -
			1.0000	$ -	
			1.0000		$ -
Residual Value		40	0.2430	$ -	$ -
		Present Value of Future Single Expenditures and Residual Value:		$ -	$ 844,811
D. TOTAL PRESENT VALUE COST (A+B+C)				$ -	$ 3,919,811
TOTAL LIFE CYCLE SAVINGS / (VALUE ADDED):					$ (3,919,811)

VE RECOMMENDATION NO. 7: USE CONTINUOUS HIGH T AT SOUTHERN SPLIT	Idea No. 19

VE RECOMMENDATION NO. 7	IDEA NO.		
Use Continuous High T at Southern Split	19		
PERFORMANCE MEASURES	*Performance*	*Baseline*	*Recommendation*
Attributes and Rating Rationale for Recommendation			
Main Line Operations	*Rating*	5	5.75
Eliminates NB conflict point SB through movement is horizontally separated	*Weight*	23.8	
	Contribution	119	136.9
Local Operations	*Rating*	5	6
Improves local turning movements from old 15 Reduces conflicts	*Weight*	19.0	
	Contribution	95	114
Maintainability	*Rating*	5	4
Adds a structure and walls to maintain May add acceleration lane (baseline may require also)	*Weight*	23.8	
	Contribution	119	95.2
Construction Impacts	*Rating*	5	5
Bridge constructed offline, no change	*Weight*	7.1	
	Contribution	35.5	35.5
Environmental Impacts	*Rating*	5	5
No change	*Weight*	19.0	
	Contribution	95	95
Project Schedule	*Rating*	5	5
No change	*Weight*	7.1	
	Contribution	35.5	35.5
Total Performance		499	512
Net Change in Performance			3%

7.4 Performance Assessment

As the VE team developed recommendations, the performance of each was compared to the baseline for potential value improvement. For this exercise, the baseline was given a score of 5. Table 12 shows the criteria used to evaluate the performance of the alternative concepts relative to the baseline concept.

Table 12. Performance Attribute Rating Scale

Rating	Performance Attribute Scales
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	*Concepts are equally preferred*
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

7.4.1 Performance Rating

The performance matrix (Table 13) permits the comparison of various recommendations against the baseline concept by organizing the data developed for the performance attributes into a matrix format to yield value indices.

The matrix is essential for understanding the performance and value of the baseline and VE concepts. Comparing the performance suggests which recommendations are potentially as good or better than the baseline concept in terms of overall value. Comparison at the value index level suggests which recommendations have the best functionality or provides the project with the best value.

The performance rating and rationale for each alternative generated by the VE team is located on the individual recommendation forms found in Section 7.3.

Table 13. Performance Matrix

Attribute	Attribute Weight	Concept	Performance Rating	Total Performance
Main Line Operations	23.8	Baseline	5	119.0
		1	5	119.0
		2	4.75	113.1
		3	4.5	107.1
		4	3.5	83.3
		5	4.75	113.1
		6	5	119.0
		7	5.75	136.9
Local Operations	19.0	Baseline	5	95.0
		1	6	114.0
		2	4.5	85.5
		3	5	95.0
		4	4	76.0
		5	4.5	85.5
		6	4	76.0
		7	6	114.0
Maintainability	23.8	Baseline	5	119.0
		1	6	142.8
		2	7	166.6
		3	6	142.8
		4	6.5	154.7
		5	7	166.6
		6	5	119.0
		7	4	95.2
Construction Impacts	7.1	Baseline	5	35.5
		1	4.75	33.7
		2	5	35.5
		3	5.5	39.1
		4	3	21.3
		5	5	35.5
		6	5.5	39.1
		7	5	35.5

Table 13. Performance Matrix

Attribute	Attribute Weight	Concept	Performance Rating	Total Performance
Environmental Impacts	19.0	Baseline	5	95.0
		1	5	95.0
		2	5.75	109.3
		3	6	114.0
		4	7.5	142.5
		5	5	95.0
		6	5.25	99.8
		7	5	95.0
Project Schedule	7.1	Baseline	5	35.5
		1	5	35.5
		2	6	42.6
		3	5	35.5
		4	6	42.6
		5	6	42.6
		6	5	35.5
		7	5	35.5

7.4.2 Compare Value

Understanding the relationship of cost, performance, and value of the project baseline and VE concepts is essential in evaluating VE recommendations. Comparing the performance and cost suggests which recommendations are potentially as good as or better than the project baseline concept in terms of overall value.

Table 14. Value Index

Recommendation	Performance (P)	% Change Performance	Cost (C) $ millions	Cost Change $ millions	% Change Cost	Value Index	% Value Improvement
Baseline	499	---	$123.3	---	---	4.00	---
Shift KY 28 Intersection to the South	540	+8.2%	$118.5	-$4.81	-3.9%	4.60	+13.0%
Use At-Grade Intersection at KY 28	553	+10.7%	$115.1	-$8.18	-6.6%	4.80	+16.7%
Reduce Typical Section	534	+6.9%	$90.9	-$32.46	-26.3%	5.90	+32.2%
Upgrade Existing KY 15 Alignment in lieu of Constructing the Baseline Alternative	520	+4.3%	$17.3	-$106.06	-86.0%	30.10	+86.7%
Shift Alignment West of Cemetery and Provide At-Grade Intersection at KY 28	538	+7.9%	$116.5	-$6.77	-5.5%	4.60	+13.0%
Shift Access to KY 28 North of Proposed KY 28 Interchange	488	-2.1%	$120.8	-$2.48	-2.0%	4.00	0.0%
Use Continuous High T at Southern Split	512	+2.6%	$127.2	+$3.92	+3.2%	4.00	0.0%

7.6 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 15. Additional details can be found in the evaluation form in Section 6.2. The write-ups for three design considerations the VE team wanted to describe further can be found on the following pages.

Table 15. Design Considerations

Idea No.	Description
3	Maintain 1200' between access points throughout corridor
6	Utilize horsecollar interchange at KY 15/KY 28
11	Validate bridge layouts
17	Improve crash hotspot conditions using low cost safety improvements along existing alignment
22	Minimize number of access points
23	Reduce design speed on KY 28 to 35 mph
26	Split level (bifurcation) typical section to reduce earthwork
29	Allow 7% grades (design exception) for short spans with plateaus
30	Reduce pavement section
31	Avoid shaded areas for KY 15/KY 28 intersection/approaches
37	Use an intersection conflict warning system at KY 15/KY 28 intersection
38	Implement DMS at high crash areas
39	Consolidate access points near 1067 before intersecting with KY 15
41	Carry passing lane through 1067/KY 15 intersection
43	Combine Rome Napier Br Rd, Baker Ln, and Grapevine Creek Rd

DESIGN CONSIDERATION NO. 1: OPERATIONAL IMPROVEMENTS ALONG KY BUS-15	Idea No. 41

Baseline Concept

The baseline concept realigns KY 15 to the west, effectively turning existing KY 15 into a business route, or Old KY 15, which will be used for local connectivity and the connection to KY 1067. The realignment will reduce the vehicular traffic along Old KY 15, however, no additional safety or operational improvements are proposed along Old KY 15.

Suggested Concept

Improve crash hotspot conditions using low-cost safety improvements along existing alignment.

Advantages	Disadvantages
• May reduce number of conflicts • May reduce severity of conflicts • Informs users • Addresses root cause of crashes	• Increases cost • May increase maintenance • Access complexity/coordination • Increases impacts during construction • Public opposition

Discussion

The baseline concept diverts the majority of traffic off of Old KY 15, however, the potential for severe crashes at identified hot spots remain. This design consideration is to confirm whether additional safety measures are warranted along Old KY 15. The two locations additional safety measures should be considered are at the intersections of Old KY 15 and KY 1067 and Old KY 15 and Entertainment Drive.

The remaining traffic volumes along Old KY 15 will likely not warrant roadway improvements that require large funds, such as curve widening or additional passing lanes.

KY 1067

The uncontrolled intersection at KY 1067 has a notably high crash rate with the crash types varying. A lack of access management, existing horizontal and vertical geometry of minor approaches, and poor signage can be attributed to the high crash rate. Safety measures to consider at this location include:

- Enhanced signing, advising drivers of minor approaches and vehicles entering or exiting the roadway
- Access management, constructing curb or combining access points where possible to consolidate access points
- Intersection conflict warning signal

Entertainment Drive

The uncontrolled intersection at Entertainment Drive is another location with a notably high crash rate. The vertical grade of minor approaches and Old KY 15 likely contribute to the high crash rate. Safety measures to consider at this location include:

- Improve intersection lighting
- Improve signage along Old KY 15 at the minor approaches
- Improve intersection sight distance by clearing trees and cutting back slopes where possible

The intent of this design consideration is to validate whether additional safety measures are warranted along Old KY 15 once traffic volumes have been reduced.

DESIGN CONSIDERATION NO. 2: MINIMIZE NUMBER OF ACCESS POINTS ALONG KY 15	Idea No. 22

Baseline Concept

Access spacing is planned to be placed approximately every 1200'.

Suggested Concept

Minimize number of access points and median openings.

Advantages	Disadvantages
• Reduces vehicular conflicts from turning and braking • Maintains smooth, uninterrupted traffic flow	• May require some u-turns or extra pavement

Discussion

Many of the current safety problems along the existing corridor are caused by turning or braking vehicles at streets or other access points. This project will reroute most traffic from the existing corridor to address mobility and safety. To protect this large public investment, there should be a goal of providing no access points or median openings except at the interchange. Any access point that may be required (e.g. due to the high ROW cost from landlocking a property) should be built with adequate turning lane storage on the mainline. No future access permits should be issued that would add new access points or require traffic control on the mainline.

DESIGN CONSIDERATION NO. 3: USE AN INTERSECTION CONFLICT WARNING SYSTEM ON KY 28 AT KY 15 INTERSECTION	Idea No. 22

Baseline Concept

Approach roads that tie into KY 15 are controlled by stop condition.

Suggested Concept

Install an Intersection Conflict Warning System (ICWS) at locations with limited sight disance to warn drivers of approaching traffic.

Advantages	Disadvantages
• Informs users • May reduce conflicts and alleviate crashes	• Increases cost • Increases maintenance

Discussion

For the approaches with limited sight distance which could lead to crashes, an Intersection Conflict Warnig System (ICWS) may be utlized to warn drivers of approaching traffic. If alignment remains on existing KY 15, recommended locations of implementation would be at the KY 28 Intersection and the KY 1067 Intersection. This is due to limited sight distance and travel speeds on KY 15 in the downgrade direction.

This page intentionally left blank.

Appendix A

Value Methodology Process

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:

$$Value = \frac{Performanœ}{Cost}$$

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 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		A	5.0	**23.8%**
Local Operations		B		B	B	B/F	5.5	**26.2%**
Maintainability			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 = Δ Performance VE Strategy/Total Performance Original Concept

Value Index = Total Performance/Total Cost (in Millions)

% Value Improvement = ΔValue 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	83
		1	[illegible]	107.[illegible]
		2	[illegible]	83.0
		3	4.[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	11.[illegible]	Baselin[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			

This page intentionally left blank.

Appendix B

VE Recommendation Approval Form

This page intentionally left blank.

Appendix B. VE Recommendation Approval Form

Project: KY 15 north of Hazard
VE Study Date: November 29 - December 3, 2021

	Recommendation	Approved Y/N	FHWA Functional Benefit: Safety	Operations	Environment	Construction	Right-of-Way	VE Team Estimated Construction Cost Avoidance or (Cost Added)	Actual Estimated Construction Cost Avoidance or Cost Added
1	Shift KY 28 Intersection to the South			1			1	$2.59M	
2	Use At-Grade Intersection at KY 28				1			$7.26M	
3	Reduce Typical Section				1	1	1	$27.99M	
4	Upgrade Existing KY 15 Alignment in lieu of Constructing the Baseline Alternative				1		1	$58.42M	
5	Shift Alignment West of Cemetery and Provide At-Grade Intersection at KY 28							$5.65M	
6	Shift Access to KY 28 North of Proposed KY 28 Interchange				1	1		$2.48M	
7	Use Continuous High T at Southern Split		1	1				($3.08M)	
TOTALS			1	2	4	2	3	**Varies**	

.

This page intentionally left blank.

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.

This page intentionally left blank.

Appendix C

VE Study Memo, Agenda, and Attendees

Appendix C. VE Study Memo, Agenda and Attendees

Memo

Date:	February 10, 2022
Project:	KYTC 10-269.20
To:	VE Team Members
From:	Jose Theiler, PE, CVS®
Subject:	Value Engineering Study

Congratulations!!! You have been chosen to participate in this Value Engineering (VE) study because of your expertise and valuable contributions to the project.

This memo is to introduce some of the expectations for the upcoming VE study. I'm looking forward to working with you on this endeavor. My hope is that this memo will provide information about the project and expectations on working together.

If you have any questions, please contact me, Jose Theiler, at 561-386-3879 (cell), or e-mail: jose.theiler@hdrinc.com.

VE Study Dates and Location

The VE study will be held virtually on Monday, November 29, 2021 through Friday, December 03, 2021 using Microsoft Teams as follows:

Join on your computer or mobile app
Click here to join the meeting
Or call in (audio only)
+1 402-513-9026,,212081877# United States, Omaha
(833) 255-2803,,212081877# United States (Toll-free)
Phone Conference ID: 212 081 877#
Find a local number | Reset PIN
Learn More | Meeting options

What to Bring

Be sure to bring your normal tools of the trade (e.g., calculator, laptop computer, scale, etc.). Bring a creative and open mind. VE studies are a lot of work, but if you bring your creativity and sense of humor you will have a good time and a rewarding experience.

Ground Rules

1. A VE study follows a prescribed process that has been proven over many years to produce the best results. This process requires the team members be fully engaged and have an open mind to "step" outside of the box throughout the week.
2. To maintain our schedule and provide the best results to the project team, I ask that we follow some basic ground rules:

a. Virtual Meetings Guidelines: The meeting invitation includes Virtual Meeting Ground Rules to help with the difficulties of virtual meetings; please follow these guidelines.

b. We will use Microsoft Teams as a holding place for conversations, notes, documentation, etc. Follow the link https://teams.microsoft.com/l/team/19%3aqrMR12HJaRkwRJhVt0A-li8EGyLhfpmOVJ8qnnSHU101%40thread.tacv2/conversations?groupId=d6324910-539f-418e-9642-ea050386d612&tenantId=3667e201-cbdc-48b3-9b42-5d2d3f16e2a9 to make sure you have access and become familiar with the site.

c. Please be prepared to attend the entire duration of the workshop. You were selected to assist on this team based on your expertise. If you cannot be in attendance for the entire time, then please notify me prior to the study. When team members leave part way through, or come and go frequently, the VE team can lose its momentum and cohesiveness. We understand that conducting business virtually is different and typical interruptions or noise background is expected at times. Please minimize disruptions by muting your phone or asking for a break.

d. Avoid multitasking during the study. Unless it is information to assist the team, please try to wait until breaks to return phone calls, check on messages, or sort through e-mails.

e. Dress code. I want everyone to be comfortable. Some of us will attend from our homes; please dress appropriately (business casual).

f. A laptop is required for the workshop. We will develop recommendations using templates in Word format and will exchange and share files throughout the workshop.

3. Our success will be evaluated based on the level of contribution that we bring to the project. Remember that the goal of any VE study is to add value to the project; saving money is just a byproduct. We want to make recommendations based on solid engineering judgment that will result in an improved project.

Value Engineering Job Plan

The VE team will employ the six-phase VE job plan in analyzing the project. This process is recommended by SAVE International® and AASHTO, and is composed of the following phases:

Information Phase – The objective of this phase is to obtain a thorough understanding of the project's design criteria and objectives by reviewing the project's documents and drawings, cost estimates, and schedules. Elements include:

- Overview of the VE process
- Understanding of study objectives
- Project Overview and Briefing by the Design team
  - Provide insight on project history, design concepts, environmental issues, etc.
  - Discuss any design concerns and new concepts involved with the project.
  - All appropriate project disciplines should be discussed.
  - Discuss/identify any risks or issues that the VE team should concentrate on.
  - Provide the VE team with any specific project constraints.
  - Q&A – Presenters answers questions from the VE team.

- Risk Elicitation: I will conduct a brief risk elicitation session to identify and quantify the top 10 risks of the project. This information may provide an opportunity for the VE team to develop response strategies in the form of recommendations.

Function Analysis Phase – Identifying each of the key functions of the project is the most important phase of value engineering, as it is the basis for unlocking the creativity of team members. As part of this phase, the team performs the following tasks with the assistance of the VE Facilitator:

- Defines project and risk functions and assigns them to key project components.
- Classifies functions as either "basic" or "secondary."
- Sequence functions to understand their relationships using the Function Analysis System Technique (FAST).
- Establishes performance measures.
- Creates the project's cost model.

Brainstorming/Creative Phase – During this phase the team will employ creative techniques such as team brainstorming to develop a number of alternative concepts that satisfy the project's basic and supporting functions, and mitigate project risks.

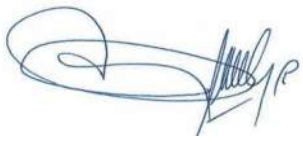
Evaluation Phase – The purpose of this phase is to evaluate the alternative concepts developed by the VE team during the brainstorming sessions. To that purpose, the team discusses advantages and disadvantages, and uses a number of tools to determine the qualitative and quantitative merits of each concept.

Mid-study Review With Management Team: At this point, the VE team holds a meeting with the project team, management, and other stakeholders, to validate the direction of the team and that ideas moving forward to the development phase do not step outside the boundaries set forth by project constraints.

Development Phase – Those concepts that ranked highest in the evaluation are further developed into VE recommendations. Recommendation narratives, additional advantages and disadvantages, drawings, calculations, and life cycle cost analysis are prepared for each recommendation.

Presentation Phase – The VE team presents their findings during an oral presentation to the owner and the project team. Following the workshop, a written report is submitted that summarizes the study, its findings, and recommendations.

I'm looking forward to working with you on this VE study and I really appreciate each of you blocking time out of your busy schedules to participate. Please don't hesitate to call or e-mail me if you have any questions.
Sincerely,



Jose Theiler, PE CVS®
East Region Manager of
Project Risk Management and Value Engineering
HDR Engineering, Inc
440 S. Church Street, Suite 1000
Charlotte, NC 28202-2075
M 561.386.3879
jose.theiler@hdrinc.com

Agenda

Day 1	**Monday, November 29, 2021** **Objective for the day: Learn about VE and the Project**	
8:00	**Connect to Microsoft Teams**	**All audiences** Project owner, PMs, designers, VE team
8:15 *Information Phase*	• **Roll call** • **Study kickoff** • **Review ground rules for virtual meetings** • **VE Process Overview:** an instructional presentation on the principles of value engineering and their application to the project	**All audiences facilitated by** Jose Theiler, PE, CVS
9:00 *Information Phase*	**Project Overview** • Purpose and need of the project • Goals and objectives of the project • Constraints • Basis of design • Virtual site visit • Questions and answers	**All audiences facilitated by** Project team/designer
10:00	**Break**	
10:10 *Information Phase*	Roll call **Risk Update Elicitation**	**All audiences facilitated by** Jose Theiler, PE, CVS
11:00	**Break**	
11:10 *Information Phase*	Roll call **Define/Review Performance Attributes**	**All audiences facilitated by** Jose Theiler, PE, CVS
12:00	**Lunch**	
1:00 *Information Phase*	Roll call **Project Documentation Review** • Site visit observations • 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 team facilitated by** Jose Theiler, PE, CVS
05:00	**Adjourn**	

Day 2	Tuesday, November 30, 2021 Objective for the day: Function Analysis, Brainstorming Ideas, Evaluate Ideas	
8:00 *Information Phase*	**Connect to Microsoft Teams** • Roll call • Day 1 Recap	**VE team facilitated by** Jose Theiler, PE, CVS
08:15 *Function Analysis Phase*	**Function Analysis** • Review project cost model • Define key project functions using “verb + noun” expressions • Build a FAST diagram	**VE team facilitated by** Jose Theiler, PE, CVS
10:00	**Break**	
10:15 *Creative Phase*	Roll call **Creative Phase** • Brainstorm alternative ways to perform key functions • Brainstorm ways to improve value of key functions	**VE team facilitated by** Jose Theiler, PE, CVS
12:00	**Lunch**	
01:00 *Creative Phase*	Roll call **Creative Phase continues** • Brainstorm alternative ways to perform key functions • Brainstorm ways to improve value of key functions	**VE team facilitated by** Jose Theiler, PE, CVS
03:00	**Break**	
03:15 *Creative Phase*	Roll call **Evaluate Ideas** • Discuss advantages and disadvantages for each idea • Score ideas based on predetermined criteria to develop further into recommendations	**VE team facilitated by** Jose Theiler, PE, CVS
05:00	**Adjourn**	

Day 3	Wednesday, December 01, 2021 Objective for the day: Evaluate Ideas and Begin Developing	
8:00 *Information Phase*	**Connect to Microsoft Teams** Roll call	**VE team facilitated by** Jose Theiler, PE, CVS
08:05 *Creative Phase*	**Evaluate Ideas continues** • Discuss advantages and disadvantages for each idea • Score ideas based on predetermined criteria to develop further into recommendations	**VE team facilitated by** Jose Theiler, PE, CVS
10:00	**Break**	
10:15 *Creative Phase*	Roll call **Evaluate Ideas continues** • Discuss advantages and disadvantages for each idea • Score ideas based on predetermined criteria to develop further into recommendations	**VE team facilitated by** Jose Theiler, PE, CVS
11:30	**Lunch**	

01:00	Roll call **Mid-point review**	**Facilitator, Value Engineer, PMs, Managers**

02:00
Development Phase
	Develop Ideas into Recommendations
	• Individual/team assignments
	• Development of recommendations:
	  ○ Test design feasibility
	  ○ Design analysis
	  ○ Technical narratives
	  ○ Further discussion on advantages and disadvantages
	  ○ Cost analysis (life cycle cost comparison)
		VE team facilitated by Jose Theiler, PE, CVS

05:00 PM	**Adjourn**	

Day 4	**Thursday, December 02, 2021** **Objective for the day: Continue Development of Recommendations and Draft the Close-out Presentation**	
8:00 *Information Phase*	**Connect to Microsoft Teams** Roll call	**VE team facilitated by** Jose Theiler, PE, CVS
8:05 *Development Phase*	**Check-in every hour** • Technical write-up • Sketches • Life cycle cost estimate	**VE team facilitated by** Jose Theiler, PE, CVS
11:30	**Lunch**	
01:00 *Development Phase*	**Check-in every hour** • Technical write-up • Sketches • Life cycle cost estimate	**VE team facilitated by** Jose Theiler, PE, CVS
03:30 *Development Phase*	**Finalize recommendations** Peer review of recommendations	**VE team facilitated by** Jose Theiler, PE, CVS
05:00	**Adjourn**	

Day 5	**Friday, December 03, 2021** **Objective for the day: Deliver Close-out Presentation**	
8:00 *Presentation Phase*	**Connect to Microsoft Teams** Roll call	**VE team facilitated by** Jose Theiler, PE, CVS
8:05 *Presentation Phase*	**Evaluate performance attributes of recommendations**	**VE team facilitated by** Jose Theiler, PE, CVS
10:30	**Break**	
10:45 *Presentation Phase*	**Finalize Close-out Presentation** • Team rehearsal	**VE team facilitated by** Jose Theiler, PE, CVS
12:00	**Lunch**	

1:00 *Presentation Phase*	**Presentation of VE Findings** • Team presents recommendations to management • Questions and answers	**All audiences:** Project owner, management, stakeholders, designers, etc.
	Adjourn	

VE Study Attendees
Kentucky Transportation Cabinet 10-269.20

Nov		Dec 2021			NAME	ORGANIZATION – POSITION/DISCIPLINE	EMAIL	PHONE
29	30	1	2	3				
✓	✓	✓	✓	✓	Adams, Tim	HDR – Construction	tim.adams@hdrinc.com	859.317.3103
✓	✓	✓	✓	✓	Albrecht, Erica	HDR – Structures	erica.albrecht@hdrinc.com	
✓	✓	✓	✓	✓	Bernhard, Rachel	HDR, VMA – VE Team Assistant	rachel.bernhard@hdrinc.com	360.259.0787
✓	✓	✓	✓	✓	Brown, Andrew	Palmer – Traffic/Safety	abrown@palmernet.com	
✓					Buckner, Aaron	FHWA – D10 Transportation Specialist	aaron.buckner@dot.gov	
✓					Desmond, Amanda	KYTC – D05 Location Engineer	amanda.desmond@ky.gov	
✓	✓	✓	✓	✓	Harrod, Justin	KYTC – VE Coordinator	justin.harrod@ky.gov	502.395.0401
✓	✓	✓	✓	✓	Hume, Will	HDR – Traffic/Innovative Interchanges	will.hume@hdrinc.com	971.645.0993
				✓	Jiang, Min	KYTC – D10		
✓				✓	Layson, Tim	KYTC – Director of Highway Design	tim.layson@ky.gov	
				✓	Moore, John	KYTC – Director of Planning		
✓				✓	Mosley, Joey	HMB – Project Manager	jmosley@hmbpe.com	606.671.0775
✓				✓	Sipes, Matt	HMB – Planning	msipes@hmbpe.com	502.695.9800
✓				✓	Skaggs, Aric	KYTC – D10 Project Manager	aric.skaggs@ky.gov	502.764.0047

VE Study Attendees
Kentucky Transportation Cabinet 10-269.20

Nov		Dec 2021			NAME	ORGANIZATION – POSITION/DISCIPLINE	EMAIL	PHONE
29	30	1	2	3				
				✓	Stewart, Katy	KYTC – D10 and D7 Construction	katy.steward@ky.gov	
✓	✓	✓	✓	✓	Sweger, Brent	KYTC – Quality Assurance Manager	brent.sweger@ky.gov	
✓	✓	✓	✓	✓	Theiler, Jose	HDR, CVS – VE Facilitator	jose.theiler@hdrinc.com	561.386.3879
✓	✓	✓	✓	✓	Thompson, Travis	HDR – Project Manager	travis.alan.thompson@hdrinc.com	
✓					Vaughan, Eileen	FHWA – Transportation Engineer		
✓	✓	✓	✓	✓	Young, Clint	HMB – Roadway	cyoung@hmbpe.com	

Appendix D

Project Estimate

Appendix D. Project Estimate

SECTION G - COST ESTIMATE			
HMB	Alt. 4 - Off Existing 4 Lanes with a Flush Median		
Item	**Quanity**	**Unit**	**Amount**
EarthWork			
Roadway Excavation	5,680,000	CU YD	$ 22,720,000
Roadway Embankment	5,910,000	CU YD	
Paving			
Asphalt Surface	21,300	TON	$ 1,870,000
Asphalt Base	98,600	TON	$ 7,888,000
Crushed Stone Base	146,400	TON	$ 2,928,000
Structures			
Culverts	143,560		$ 4,656,640
Bridges	59,724		$ 11,944,800
Cont. (25%)			$ 13,002,000
Construction Total			**$ 65,010,000**
Right of Way			
Approximate Net ROW Purchased	195	ACRES	$ 292,500
Residendtial Relocations	54	Each	$ 5,400,000
Business Relocations	4	Each	$ 1,000,000
Right of Way Total			**$ 6,692,500**
Utlity Costs			**$ 2,160,000**
Project Total			**$ 73,863,000**