FINAL Value Engineering Study Report

I-65 from Mile Point 123.18 to Mile Point 127.57– Pavement Improvement Project – # 5-22069

Jefferson County, Kentucky

Kentucky Transportation Cabinet, District 5

May 6-10, 2024

Prepared by:

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Disclaimer

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

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

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

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

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Acronyms and Abbreviations

ATCS	Adaptive Traffic Control System
CCTV	closed circuit television
CD	collector distributor
CEMP	Categorical Exclusion for minor projects
CIP	cast in place
CMGC	Construction Manager / General Contractor
CVS	Certified Value Specialist
CY	cubic yard
DDI	diverging diamond interchange
DGA	dense-graded aggregate
DMS	dynamic message sign
FAST	Function Analysis System Technique
FHWA	Federal Highway Administration
GRS	geosynthetic reinforcement soil
IMR	Interchange Modification Report
ITS	Intelligent Traffic System
KY	Kentucky
KYTC	Kentucky Transportation Cabinet
LF	linear feet
LOS	level of service
MOT	maintenance of traffic
MP	mile point
MSE	mechanically stabilized earth
MVDS	microwave vehicle detection sensor
OBG	optional base group
SF	square feet
SY	square yard
TSM&O	Traffic System Management and Operation
VE	Value Engineering
VMA	Value Methodology Associate

Executive Summary

Introduction

This report summarizes the events and results of the semi-virtual VE study conducted by HDR Engineering, Inc. for the Kentucky Transportation Cabinet's on the I-65 from Mile Point 123.18 to Mile Point 127.57– Pavement Improvement Project – # 5-22069 in Jefferson County, Kentucky. The VE study consisted of a 4-day workshop that was conducted with a multidisciplinary team May 6-10, 2024 at KYTC state office building in Frankfort, KY for the first two days of the study followed by a virtual team for the remainder of the week using Microsoft Teams.

Project Overview

The purpose of the project is to improve the pavement for the project limits.

At the time of the VE study, the total cost of the project, including design, construction, right-of-way, utilities, and construction engineering was estimated at $73 million.

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 I-65 from Mile Point 123.18 to Mile Point 127.57– Pavement Improvement Project – # 5-22069.
- Conduct a thorough review and analysis of the key project functions using an independent, multidiscipline, cross-functional team.
- Improve the value of the project through innovative measures aimed at improving the performance while reducing costs of the project.

VE Recommendations

The VE team generated 38 ideas for the project. These concepts were compared against assumed baseline elements discussed in the information phase and developed by the project team. The concepts that resulted in improved performance were further developed by the VE team and resulted in 9 recommendations (Table 1).

Table 1. Summary of Recommendations

#	Recommendation Title	Cost Savings/ (Cost Added) ($M)	Performance Improvement (%)
1	Construct Ramps First and Sync Traffic Control Plans	$0.00	+39%
2	Use Robust Asphalt Pavement Design	$17.64	+92%
3	Conduct Traffic Control Plans Operational Analysis	($0.05)	+6%
4	Reconstruct Drainage	($15.07)	+3%
5	Crossover Traffic to One Side and Switch Over	$6.40	+44%
6	Include Bridge Rehabilitation Scope	$0.48	+11%
7	Use Smart Work Zone Strategies	($1.95)	+9%

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

1—Construct Ramps First and Sync Traffic Control Plans with I-65 Central Corridor Project – Anticipating concurrent construction with the Central Corridor project, this recommendation is to coordinate and sync MOT schemes between the projects, incorporating ramp construction timing, to preclude potential conflicts.

2—Use Robust Asphalt Pavement Design – The VE Team recommends an asphalt pavement that protects a modified base with improved drainage for greater life expectancy.

3—Conduct Traffic Control Plans Operational Analysis – With variability expected hourly in required lanes to meet capacity needs during construction, this recommendation is to perform detailed traffic analysis to fine tune lane closures to best serve users.

4—Reconstruct Drainage – The VE team recommends reconstructing drainage from MP 123.9 northward, removing existing infrastructure between the inside lanes, to improve the resiliency of the facility and to lower lifetime maintenance costs.

5—Crossover Traffic to One Side and Switch Over – Taking advantage of shoulder widths and traffic peaks expected daily during construction, the recommendation looks to maintain 3 to 4 lanes for peak-hour traffic movements during construction.

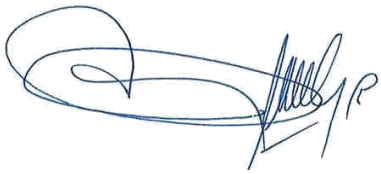
6—Include Bridge Rehab Scope – The VE team recommends incorporating near-future bridge needs into the scope for work within the project limits to reduce overall construction impacts.

7—Use Smart Work Zone Strategies – Looking beyond standard specifications, this recommendation is to improve operations during construction with the strategic use of temporary work zone systems.

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 VE study conducted for the KYTC and facilitated both in person and virtually by HDR using Microsoft Teams. The subject of the study was I-65 from Mile Point 123.18 to Mile Point 127.57– Pavement Improvement Project – # 5-22069. The VE study was conducted May 6-10, 2024 before the project was in the 30 percent to 35 percent design phase.

1.1 Scope of VE Study

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

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

- Verify or improve on the various concepts for the identified section of the I-65 from Mile Point 123.18 to Mile Point 127.57– Pavement Improvement Project – # 5-22069.
- Conduct a thorough review and analysis of the key project functions using a multidiscipline, cross-functional team.
- Improve the value of the project through innovative measures aimed at improving the performance while reducing costs of the project.

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

1.2 VE Team Members

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

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

- Chris Kuntz, PE, HDR
- Kevin Gearlds, PE, HDR
- Wendy Southworth, PE, KYTC
- Jose Theiler, PE, CVS, HDR
- Kevin Walker, PE, HDR
- Chad Wallace, PE, HDR

2 Information Phase

The VE team received the documentation and drawings from the project design team as shown in Table 2. 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 2 lists the project documents provided to the VE team for use during the study.

Table 2. Information Provided to the VE Team

Document/Drawing/Schematic	Document Date
05-22069 CEMP Jefferson County.pdf	10/31/2022
pj05651_I-65_soil_profile_1390+00_to_2180+00.pdf	5/1/1954
pj09255_I-65_thru_I-265_interchange.pdf	6/15/1983
pj09253_I-65_thru_KY_1065_interchange.pdf	6/29/1984
pj09261_ky_1065.pdf	Post 1979
5-22069_jefferson_I-65_project_limits.kmz	4/30/2024
pj09257_ky_1065.pdf	10/15/1979
2022-09-13_pre-design_meeting_summary_i65_5-22069.pdf	9/13/2022
pj10167_ky_1065.pdf	10/15/1979
2023_09_22_5-22069_Jefferson_County_I-65_preliminary_estimate_asphalt_alt.pdf	9/22/2023
5-22069_I-65_Jefferson_JI.pdf	4/6/2023
5-22069_jefferson_I-65_project_limits.pdf	2/21/2024
R-022-1978.pdf	June 1978
Bullitt County I-65 MP 107-127 Pavement Thickness Investigation.pdf	3/13/2019
5-22069_asph_alt.xlsx	5/3/2024

2.2 Project History / Information / Location

The project team developed a comprehensive understanding of the existing conditions after becoming familiar with the information provided to the team and the project team's introduction presentation and walkthrough.

The purpose of the project is to improve pavement condition along this segment of highway by replacing existing 11" concrete pavement with asphalt pavement. The project begins at Mile Point (MP) 123.18 near the Bullitt County and Jefferson County Line and continues north along I-65 into Jefferson County for nearly 4.4 miles to MP 127.57. The project includes the full-directional interchange with I-265 and the KY 1065 / "Outer Loop" interchange. The project is in the vicinity of a major shipping center, which contribute to the high percentage of trucks along the route.

The lane capacity varies from 3, 12-ft lanes per direction at the southern terminus of the project (with 10' interior and exterior shoulders, depressed grass median, and cable median barrier) for the first three quarters of a mile transitioning to 4, 12-ft lanes per direction. Here the depressed median and cable barrier shift to a concrete median barrier with drainage originally designed to be carried longitudinally by a subsurface pipe below the median barrier. The route proceeding north then widens to 6, 12-ft lanes per direction near the I-265 interchange with similar median treatments plus ramps, auxiliary lanes and CD roads relative to the two interchanges served by the route.

The existing condition of the facility is needing pavement improvements as the concrete pavement has been in place over 40 years but is experiencing severe cracking prevalent throughout the project limits. Expansive soils are understood be along portions of the project area and may have contributed to some of the degradation the pavement has experienced. Pavement degradation has persisted to the point where making spot repairs within the project limits are expected to exceed costs of a complete rebuild of the existing lanes. Conditions of subsurface median drains may have been compromised given the drainage concerns expressed during the information section, including settling differentials between outside lanes and shoulders referenced in recent core sample analysis.

The route carries a truck percentage that varies from 13 to 21 percent trucks.

Figure 1. Project Location

2.3 Proposed Improvements

Proposed improvements discussed during the information session look to consider a full depth removal and replacement of the existing pavement. Currently, concrete and asphalt are under consideration. Ramps at interchanges are also needing replacement and are considered part of the scope. Bridge needs in the project limits are not currently being considered part of the scope at the beginning of this study.

2.4 Constraints and Controlling Decisions

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

- No ROW will be added for the project.
- 55 mph construction speed zone expected.

2.5 Project Observations

The first day of the 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 key project issues, project drivers, and observations identified during this session:

- Asphalt favored by district leadership in the field for the project relative to desire for minimal user impacts and shorter construction and maintenance windows.
- Design leadership expressed a strong desire to retain shoulders and median barrier for the proposed project. This is understood to be in effort to lessen the cost and duration of construction of the improved facility.
- Echelon pavement may be able to minimize joints in asphalt pavement if used but could impact constructability.
- Cost estimates were developed using information from the Bullitt County project currently under construction to the south of this project.
- Existing facility:
    - Original project was let in 1980.
    - As-builts reveal use of DGA for the subbase of the existing pavement verses current tendency toward crushed stone base due to better drainage.
    - Median inlets appear to be widely spaced and not quickly noticeable.
    - It is understood that stormwater was seen jetting upward between pavement slabs in some instances.
    - Pavement is 11” thick. Shoulders are 6” thick.
    - Condition of 40+ year concrete pavement is less than expected, potentially due to clay soils affecting drainage.
    - Perforated, 4”-pipe drainage system is at inside shoulders.
    - Carries a varied percentage of 13 to 21 percent trucks.

  - Signalization at KY 1065 interchange at upper ends of ramps
  - A depressed median is used for the first three quarters of a mile at the south end of the project area.
- Maintenance of Traffic
  - Ramps may need to be addressed first / early to adequately meet the MOT needs of this and the Central Corridor project concurrently, especially if the other project has full detours for those proposed bridge replacements.
  - Coordination between the projects may be necessary.
  - Two lanes per direction must be maintained, and it is expected that no more than 50 percent of the lanes can be closed during construction.
- High-friction surface course, typically an expensive application, was applied to the ramps and may be indicative of wrecks on the ramps.
- Schedule:
  - Project's schedule is expected to take two construction seasons and would ideally be let prior to 2025 construction season.
  - Design could take 6-8 months to complete, depending on the surface type, and longer if grading modifications are needed.
  - Asphalt may not be able to be installed from November to March if used for the project.

2.6 Project Schedule

The project is still conceptual having not entered design yet; however, it could be near final design by the end of the calendar year. The conceptual schedule is expected to last two construction seasons.

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 3**. For a detailed estimate please see **Appendix D.**

Table 3. Cost Estimate – Baseline Concept

Cost Item	Cost	Percent of Total	Cumulative Percentage
Pavement	$43,872,405.27	63.3%	63%
Pavement Removal	$14,697,852.00	21.2%	84%
Earthwork	$3,533,130.00	5.1%	90%
Mobilization	$3,230,054.78	4.7%	94%
Contingency	$2,071,602.00	3.0%	97%
MOT	$1,096,350.80	1.6%	99%
Pavement Marking	$582,126.10	0.8%	100%
Guardrail	$177,773.70	0.3%	100%

Curb & Gutter	$39,006.91	0.1%	100%
Demo	$12,788.87	0.0%	100%
Erosion Control	$2,040.17	0.0%	100%
Total	$69,315,130.60		

3 Project Analysis

3.1 VE Focus Points and Observations

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

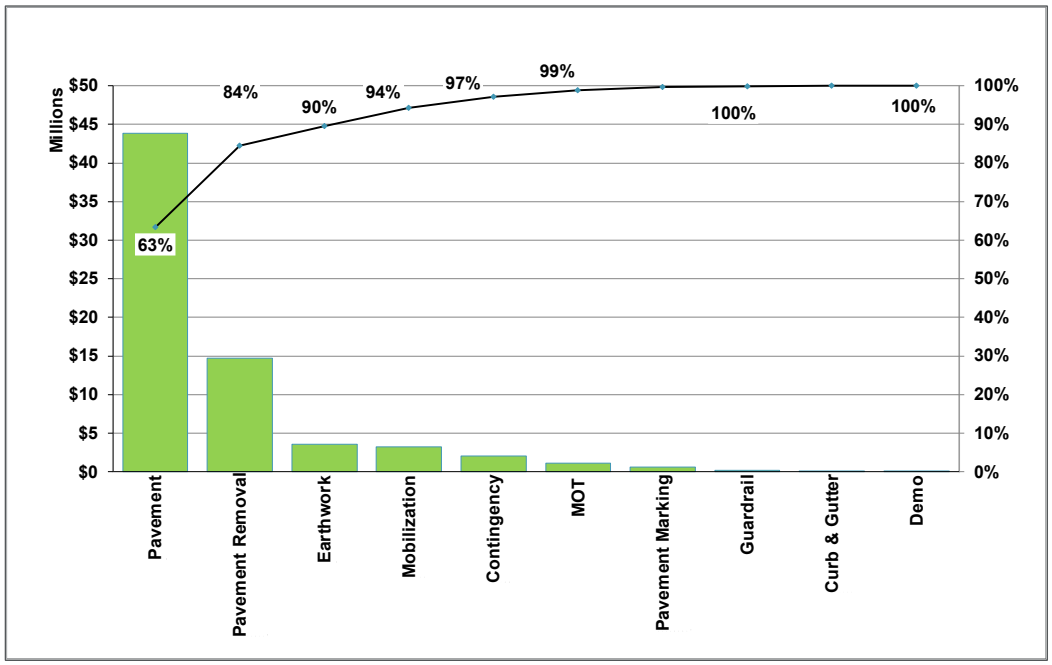
- Improve pavement to incorporate resiliency and reduce maintenance
- Review drainage needs
- Review MOT needs relative to concurrent projects

3.2 Cost Model

The VE facilitator prepared a cost model from the cost estimate, which was provided by the project team. The model was organized to identify major construction elements or trade categories, the design team's estimated costs, and the percent of total project cost for the significant cost items (Figure 2).

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

Figure 2. Cost Model



3.3 Value Metrics

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

The basic equation used for calculating value is:

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

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

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

3.3.1 Performance Requirements

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

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

3.3.2 Performance Attributes

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

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

criteria. In contrast, a performance attribute might be project schedule, which means that a wide range of alternatives could be acceptable that had different durations.

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. The performance attributes shown in Table 4 were used throughout the study to identify, evaluate, and document ideas and recommendations. The baseline evaluation criteria can be found in Table 4, and the performance measures for each recommendation can be found in Section 7.3, Individual Recommendations.

Table 4. Performance Attributes and Description

Performance Attribute	Description of Attribute	Baseline Concept
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 pavement Retain shoulders and not reconstruct drainage
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.	Maintain 2 lanes of traffic Standard MOT to construct one lane at a time Undetermined staging locations Restricted work Nov-1 / Mar-31 Directional Traffic 60/40 Speed limit: 55 MPH I-65 bridge project to the north- MOT conflicts
Project Schedule	An assessment of the total project delivery as measured from the time of the VE Study to completion of construction.	Design: 8 to 12 months from NTP Letting: Winter 2025 Construction duration: 2 seasons
Risk	An assessment of risk events and uncertainties impacting cost and schedule of the project.	Pavement failure if drainage is not reconstructed I-65 bridge project may delay project completion by 1 to 2 seasons

3.3.3 Performance Attribute Matrix

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

These attributes were compared in pairs Figure 3, 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. Attributes were later revaluated to establish a better consensus in the paired comparison. These scores were then used to calculate the value of each recommendation during the VE team’s performance evaluation scoring (Section 6).

Figure 3. Performance Attribute Matrix

Paired Comparison						Total points	% of Total
Maintainability	A	A	A	A		4.0	40%
Construction Impacts		B	B/C	B		2.5	25%
Project Schedule			C	C		2.5	25%
Risk				D		1.0	10%
					Total	10.0	100%

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

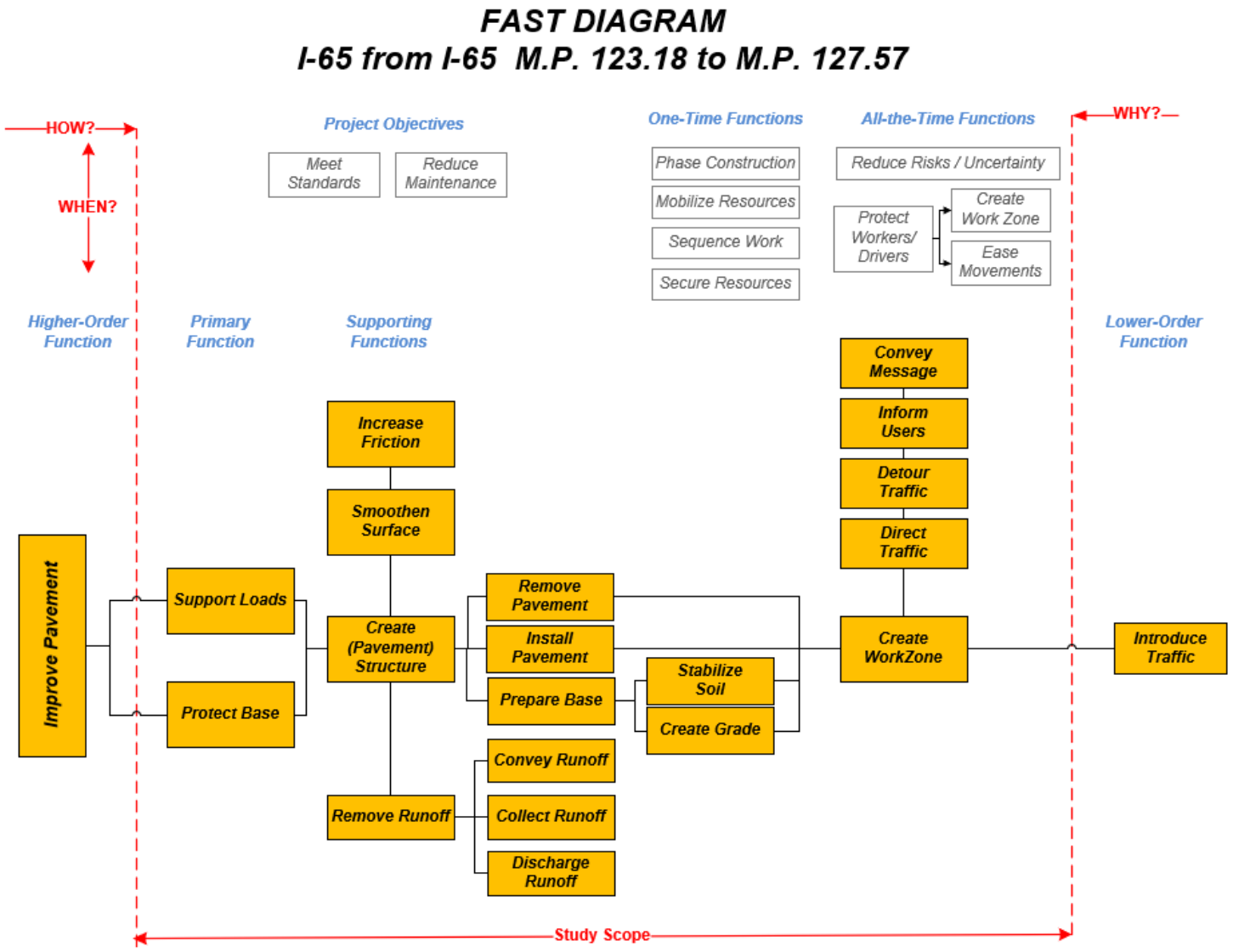
Table 5. Random Function Identification

Project Element	Functions
Project	Implement Design Improve Pavement Introduce Traffic Meet Standards Minimize Maintenance
Pavement	Support Loads Create (Pavement) Structure Increase Friction Install Pavement Protect Base Create (Rideable) Surface Smoothen Surface
MOT	Create Work Zone Remove Pavement Sequence Work
Contingency	Reduce Risks/Uncertainty
Demolition	Create Space
Intelligent Traffic System (ITS)	Collect Data Convey Message Detour Traffic Direct Traffic Inform Users
Drainage	Collect Runoff Convey Runoff Discharge Runoff Remove Runoff
Clearing & Grubbing	Prepare Site
Earthwork	Stabilize Soil
Erosion Control	Reduce Erosion
Mobilization	Deploy Resources
Structures	Support Loads

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

Figure 4. FAST Diagram



5 Creativity Phase

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

Table 6. Creative Idea List

Idea No.	Description
Function: Create WorkZone	
7	Use crossovers to shift traffic to one side
9	Replace one lane at a time
10	Use collector distributors (CD roads) for detours
12	Shut down I-65 / close everything
16	Identify potential staging and wasting locations (KYTC, county, city, etc.) to include in specs for contract (see KY 61 / I-265 interchange)
24	Use smart work zones (queue loops, smart cones, traffic counters, etc.)
31	Detour local traffic to KY 61 / Preston Highway
Function: Implement Design	
20	Use design build
21	Use CMGC
22	Combine I-65 projects into one project
23	Use progressive design build
Function: Support Loads	
1	Use crack & seat rehab method / overlay with asphalt
2	Use modified pavement design
3	Replace damaged slabs / seal joints
4	Use concrete pavement
5	Use geotextile reinforcement to improve stability of soil
6	Use concrete overlay with bond breaker and geotextile
25	Use dense grade wedge
Function: Sequence Work	
11	Build interior lanes first (with median and shoulders if required)
19	Use milestone incentives / disincentives

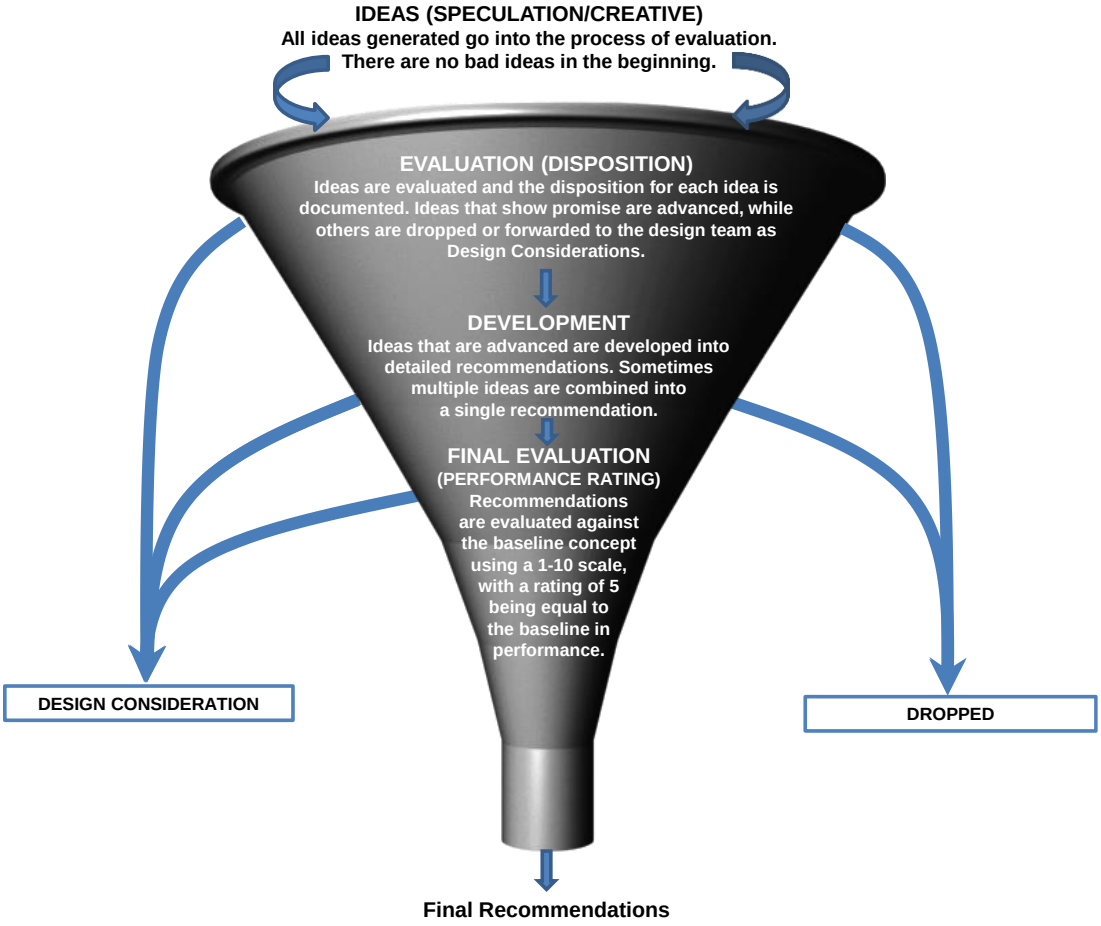
Table 6. Creative Idea List

Idea No.	Description
Function: Mitigate Risks	
14	Coordinate and sync MOT schemas between this and other projects
15	Construct ramps first
Function: Improve Pavement	
13	Incorporate bridge needs
18	Salvage inside shoulders and barriers in place
26	Use proof roll technique - cement stabilizer
27	Use chemical stabilizing techniques in the pavement design
28	Use OGFC or some form friction course
29	Use cement treated aggregate (6-8" typical)
Function: Protect Base	
36	Use a drainage blanket over existing pavement to convey water
Function: Remove Runoff	
8	Reconstruct drainage
30	Use minimum mowing strip at shoulder edge to minimize runoff pooling
34	Use French drains at shoulders
35	Use trench drains at shoulders
37	For three-lane section, grade lanes to flow to the outside away from the median
38	For four-lane section, change cross slope entirely to the outside and change two outside lanes from 2.5 percent to 3 percent where feasible
Function: Remove Pavement	
17	Recycle concrete and asphalt on site
32	Borrow resources (trucks and manpower) to operate leased machinery for crushing concrete
33	Incentivize contractor to use existing concrete on site.

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

Figure 5. VE Process Information Flow



6.1 Evaluation Process

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

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

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

3 = Advance for further development

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

1 = Poor Opportunity/dropped from further development

0 = Unacceptable impact/fatal flaw

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

Table 7. Idea Summary Evaluation Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
Function: Create Workzone					
7	Use crossovers to shift traffic to one side	• Improves constructability • Improves workzone safety • Improves mobilization/demobilization • Shortens scheduling needs	• May require shoulders be reinforced • Entrance / Exit points must be managed • Driver expectation • May require the zipper median for 6 lane to accommodate additional traffic for the 4th lane	*3*	
9	Replace one lane at a time	• Reduces user delays	• Baseline is very similar • Increases mobilization / demobilization • Increases cost • Lengthens schedule • Introduces more conflict by splitting traffic • May increase accidents • May increase queue recovery delays	*3*	*run simulation model for the different lane closure configurations*
10	Use collector distributors (CD roads) for detours	• Improves operations during construction • Relieves congestion in the workzone	• Increases driver confusion • Introduces conflicts • Splits traffic • Negatively impacts ramp operations • May require modifications to wall • May require shoulder reinforcement	*2*	
12	Shut down I-65 / close everything	• Reduce schedule	• Not feasible	*0*	

Ranking Scale:
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

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from further development

Table 7. Idea Summary Evaluation Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
16	Identify potential staging and wasting locations (KYTC, county, city, etc.) to include in specs for contract (see KY 61 / I-265 interchange)	• Reduces risk to the contractor • May reduce costs to the project • No additional right-of-way required	• May require reevaluation of the environmental approval	*2*	
24	Use smart work zones (queue loops, smart cones, traffic counters, etc.)	• Improves operations during construction • Improves communication to users • Improves safety • Gives real-time information to make decisions • May be helpful with the potential of both this and the CMGC project being both ongoing together.	• May require dedicated resources for the project to monitor and manage the system.	*3*	
31	Detour local traffic to KY 61 / Preston Highway	• Increases lane capacity during construction • Reduces number of vehicles in the working zones	• Access of to route via temporary ramp would be required • Additional traffic control would be required	*0*	

Ranking Scale: 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

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from further development

Table 7. Idea Summary Evaluation Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
Function: Implement Design					
20	Use design build	• Improves maintenance of traffic • May improve schedule • May improve MOT • May improve innovation for delivery • May improve the schema for MOT interaction with CMGC project	• Additional work required upfront for the preparation • Funding required upfront • May require budget amendment if fiscal years are modified • May increase costs • May not be the right project for design build	*2*	
21	Use CMGC	• Share risk with contractor • MOT becomes more reasonable and effective • Betters communication between contractor and KYTC	• May increase costs • Competition may be limited • Contractors may not be available • Internal resources to manage the project may not be available	*2*	
22	Combine I-65 projects into one project	• MOT scheme will be better than that of two contractors combined	• CMGC project may also be under procurement already and the change in scope may not be likely • May approach the major project threshold	*1*	
23	Use progressive design build	• Share risk with contractor • MOT becomes more reasonable and effective • Betters communication between contractor and KYTC	• May increase costs • Competition may be limited • Contractors may not be available • Internal resources to manage the project may not be available	*1*	

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Table 7. Idea Summary Evaluation Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
Function: Improve Pavement					
13	Incorporate bridge needs	• Reduces user delays • Reduces traffic interruptions • Reduces costs (MOT)	• Increases contract amount • Reprioritization of bridge funding • Timing of design of bridge project and this project may not match • Requires coordination • May delay letting	*3*	
18	Salvage inside shoulders and barriers in place	• May reduce capital costs	• Does not address root cause of the pavement failure • Reduces the longevity of the facility • May increase costs with installation of cross drains throughout the project • Underdrains will not work properly	*1*	*Constructability and feasibility to keep water from getting in the base would render the fix short lived*
26	Use proof roll technique - cement stabilizer	• Reduces schedule	• May be means and methods • May lose performance	*2*	*May be used in the specs as an alternative method*
27	Use chemical stabilizing techniques in the pavement design	• Stabilizes soil • Reduces maintenance • Improves pavement life	• Increases cost • May take longer to construct • May complicate construction	*3*	*Combine 2,5, 27, 29, 36*

Ranking Scale: 3 = Advance for further development
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Table 7. Idea Summary Evaluation Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
28	Use OGFC or some form of friction course	• Improves friction • Reduces spray • Improves visibility during rain event • Reduces stop distance	• Increases cost • May take longer to construct	*1*	
29	Use cement treated aggregate (6-8" typical)	• Stabilizes soil • Reduces maintenance • Improves pavement life	• Increases cost • May take longer to construct • May complicate construction	*3*	*Combine 2,5, 27, 29, 36*
Function: Mitigate Risks					
14	Coordinate and sync MOT schemas between this and other projects	• Will prevent complete shutdown • Improve operations during construction • Will reduce user delay costs	• Requires coordination and communication • May delay one of the projects	*3*	*combine 14,15* *Consider incentives / disincentives idea 19*
15	Construct ramps first	• Will support the MOT of the CMGC project to the north • May delay the project if not done	• Construction could impact top surface after built • May require rework at end of project • May increase cost • Behind the CMGC project when it needs to be in front	*3*	*combine 14,15* *May require change in CMGC scope to include the reconstruction of the ramps for this project*
Function: Protect Base					
36	Use a drainage blanket over existing pavement to convey water	• Protects pavement base • Conveys infiltrated runoff • Extend pavement life • Reduces maintenance	• Increases cost • May require regrading	*3*	*Combine 2,5, 27, 29, 36*

Ranking Scale: 3 = Advance for further development
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1 = Poor opportunity/dropped from further development
0 = Unacceptable impact/fatal flaw

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= Dropped from further development

Table 7. Idea Summary Evaluation Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
Function: Remove Pavement					
17	Recycle concrete and asphalt on site	• May reduce project cost • Environmentally friendly	• Means and methods may dictate • KYTC may not have the resources available • May introduce risk to the contractor	*2*	*may require borrowed resources from another district and the leasing of equipment may require more coordination Combine 32, 17*
32	Borrow resources (trucks and manpower) to operate leased machinery for crushing concrete	• May be able to be used by local staff as applicable resource	• May not be practical or economical • May not have the required resources available	*2*	*Combine 17, 32*
33	Incentivize contractor to use existing concrete on site.	• Environmentally friendly • May be cost effective	• Will increase cost for incentive • May not realize possible economies • May not have full utilization with some still needing to be disposed	*2*	
Function: Remove Runoff					
8	Reconstruct drainage	• Addresses root cause of poor pavement conditions • Lower maintenance costs in future • Improve resiliency and life of facility	• Increases costs • More time to construct • Shoulders and median barrier will need to be removed • Increased time and cost relative to design and installation of MASH compliant barrier expected to be required for the replacement	*3*	

Ranking Scale: 3 = Advance for further development
2 = Design consideration; include as a comment or consideration for design team
1 = Poor opportunity/dropped from further development
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= Dropped from further development

Table 7. Idea Summary Evaluation Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
30	Use minimum mowing strip at shoulder edge to minimize runoff pooling	• Improves operations after construction	• Outside scope of work	*2*	*good practice for long-term maintenance*
34	Use French drains at shoulders	• May be used as a drainage alternative if the shoulders remain	• May not work effectively • Maintenance long-term not feasible	*1*	
Function: Remove Runoff					
35	Use trench drains at shoulders	• May reduce of spread onto the main lanes • Improve drainage	• Requires a closed drainage system • Increases costs • Increases maintenance	*1*	
37	For three-lane section, grade lanes to flow to the outside away from the median	• Reduces risk of drainage failure • May avoid reconstruction of the inside shoulder	• May not fully address the root cause of failure • May increase costs with overbuild • Will require grade changes	*1*	
38	For four-lane section, change cross slope entirely to the outside and change two outside lanes from 2.5 percent to 3 percent where feasible	• Reduces risk of drainage failure • May avoid reconstruction of the inside shoulder	• May not fully address the root cause of failure • May increase costs with overbuild • Will require grade changes	*1*	
Function: Sequence Work					
11	Build interior lanes first (with median and shoulders if required)	• Reduces conflicts • May improve phasing • Improves traffic flow • Offers contractor more space at the beginning for constructability • Proven method	• May be baseline	*2*	

Ranking Scale: 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

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= Dropped from further development

Table 7. Idea Summary Evaluation Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
19	Use milestone incentives / disincentives	• Motivation to contractor for efficiency • May improve quality • May reduce construction time	• Increases costs for incentives • Requires that they be enforced • May not effectively reduce overall construction time	*2*	*Combine 14,15* *May be useful for advancing the ramps*
Function: Support Loads					
1	Use crack & seat rehab method / overlay with asphalt	• Improves schedule • Reduces / eliminates pavement removal cost • Reduces cost of materials (base aggregate)	• May require drainage improvements (drainage blanket) • Reduces life expectancy • Cannot stabilize soils to meet load bearing capacity	*1*	*Originally moved to development but later validated baseline design*
2	Use modified pavement design	• Improve resiliency • Improve long-term performance • Reduce maintenance costs	• May increase capital costs • May increase schedule •	*3*	*Combine 2,5, 27, 29, 36*
3	Replace damaged slabs / seal joints	• May reduce costs	• Proven more costly by design team •	*0*	
4	Use concrete pavement	• Improved longevity • Reduces maintenance	• Rideability may be less than alternative • Reduces comfort • More expensive • Longer scheduling • More complex construction	*1*	*Originally moved to development but later validated baseline design*

Ranking Scale:
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

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from further development

Table 7. Idea Summary Evaluation Table

Idea #	Description	Advantages	Disadvantages	Rating	Comments
5	Use geotextile reinforcement to improve stability of soil	• Improves stability of the entire structure • Decreases amount of work required to subbase • Substitute for other subgrade improvements such as chemical stabilization	• May increase cost • May require special skill for installation	*3*	*Combine 2,5, 27, 29, 36*
6	Use concrete overlay with bond breaker and geotextile	• Quicker since excavation of disposal may not be required	• Rocking slabs are not addressed with this application • Drainage still needs to be addressed since the subbase was compromised • Issues at bridges • Grade concerns are problematic • Reduces the life compared to replacement	*2*	
25	Use dense grade wedge	•	• Duplicate	*1*	

Ranking Scale: 3 = Advance for further development
2 = Design consideration; include as a comment or consideration for design team
1 = Poor opportunity/dropped from further development
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7 Development Phase

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

In the case of this project, of the 38 ideas that were generated during the Creativity Phase, 14 of those ideas were evaluated high enough to be taken forward, combined, and developed further. Some of the ideas were deemed more appropriate as a design consideration for the project team, rather than developed into a VE recommendation (Section 7.5). For the Development Phase, narratives, drawings, calculations, and cost estimates were prepared for each recommendation.

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

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

7.1 Summary of Recommendations

Table 8 is a summary of all recommendations generated and their cost impact to the project.

The recommendations developed by the VE team are shown in Table 8. The table summarizes each recommendation's cost impact and performance improvement. The recommendations are organized by category based on the project feature/project location or aspect of the project being addressed. Each recommendation received a unique idea code during the Evaluation Phase based on the project function being considered by the idea.

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 8 is based on the following:

- Improved Performance – A qualitative assessment of key performance attributes.
- 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 8. Summary of Recommendations

#	Recommendation Title	Cost Savings/ (Cost Added) ($M)	Value Improvement (%)
1	Construct Ramps First and Sync Traffic Control Plans	$0.00	+39%
2	Use Robust Asphalt Pavement Design	$17.64	+92%
3	Conduct Traffic Control Plans Operational Analysis	($0.05)	+6%
4	Reconstruct Drainage	($15.07)	+3%
5	Crossover Traffic to One Side and Switch Over	$6.40	+44%
6	Include Bridge Rehabilitation Scope	$0.48	+11%
7	Use Smart Work Zone Strategies	($1.95)	+9%

7.1.1 FHWA Functional Benefit Criteria

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

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

7.2 Value Engineering Recommendation Approval

The resolution or disposition of recommendations is based on the information in this report and is independent of the proceeding of the VE study. HDR has no participation, direct or

indirect, in such decisions. The VE Recommendation Approval form shown in Appendix B is intended to aid the project manager in tracking and informing the state Value Engineer in annual reporting of VE activities to FHWA. Resolution and disposition of recommendations contained in Appendix B are pending.

7.3 Individual Recommendations

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

VE RECOMMENDATION NO. 1: CONSTRUCT RAMPS FIRST AND SYNC TRAFFIC CONTROL PLANS WITH I-65 CENTRAL CORRIDOR PROJECT	Idea No(s). 14, 15

Baseline Concept

Construct the project one lane at a time with a traditional traffic control scheme with no consideration for each project's individual needs. The ramps would traditionally be constructed last.

Recommendation Concept

Coordinate and sync MOT schemes between this and the CMGC project farther north. Phase the construction work such that the ramps of the major intersecting roadways are constructed first to minimize conficts betweeen the two contracts and provide efficiency with the global MOT plan.

Advantages	Disadvantages
• Will prevent complete shutdown • Improve operations during construction • Will reduce user delay costs • Will support the MOT of the CMGC project to the the north • May delay the project if not done	• Requires coordination and communication • May delay one of the projects • Construction could impact top surface after built • May require rework at end of project • May increase cost • Behind the CMGC project when it needs to be in front

Cost Summary	Construction	Right-of-way	Total
Baseline Concept			
Recommendation Concept			
Cost Avoidance/(Added Value)	Not assessed		Not assessed

FHWA Function Benefit

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

VE RECOMMENDATION NO. 1: CONSTRUCT RAMPS FIRST AND SYNC TRAFFIC CONTROL PLANS WITH I-65 CENTRAL CORRIDOR PROJECT	Idea No(s). 14, 15

Discussion/Sketches/Photos/Calculations

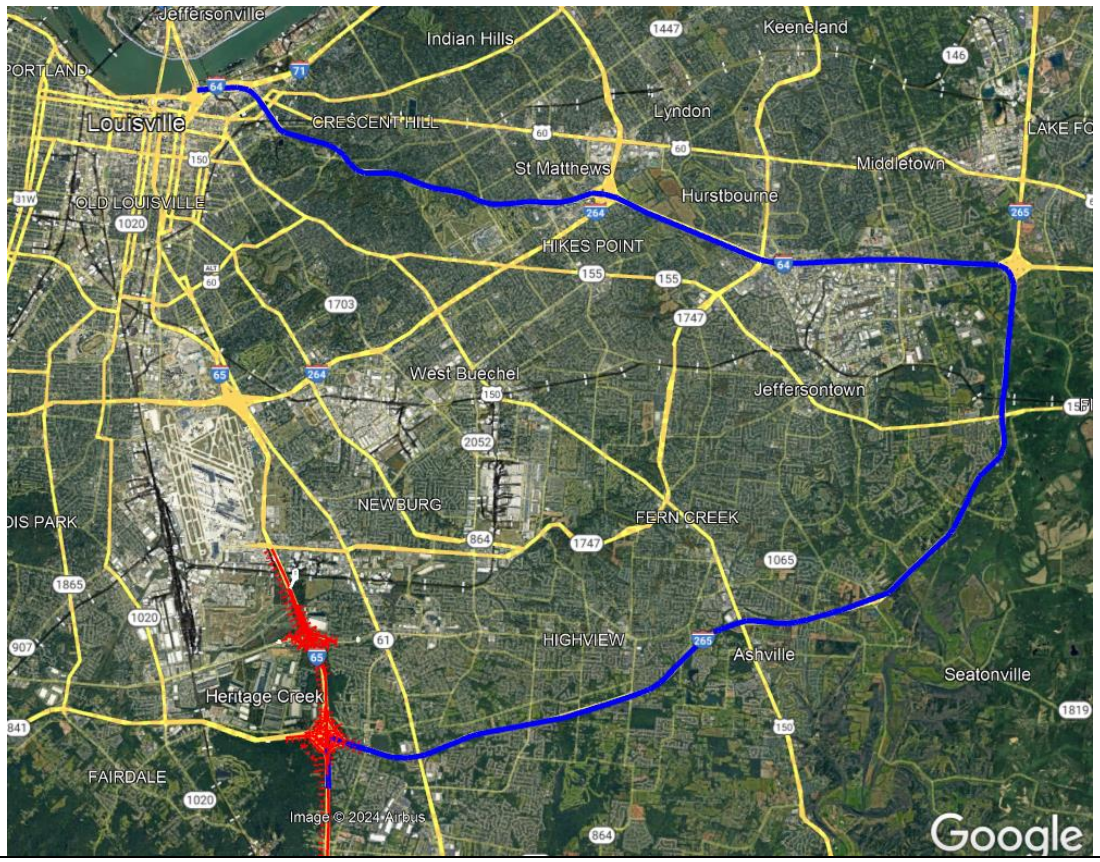
Technical Discussion/Sketches

KYTC has already initiated and awarded a CMGC project in partnership with Kiewit to reconstruct/rehab several bridges on I-65 north of this project in the downtown area of Louisville. This CMGC project will replace a minimum of 3 bridges on the northern part of this corridor, and may involve up to 18 bridges total, with the nearest of these being less than four miles from the northern termini of the pavement replacement project. It will be imperative that the traffic control schemes be compatible to maintain traffic for both projects in a safe and efficient manner.

In a normal construction phasing/sequence, the ramps for approaches would be constructed late in the project to avoid damaging newly constructed ramps with routine construction traffic. However, I-65 southbound traffic of the northern project would likely be re-routed to the I-265 loop to construct up to 18 bridges along the I-65 corridor. This means that 4 ramps on the southern project would not be available for construction until the bridges to the north are finished, roughly 3 or more years. The unavailability of the ramps would delay this pavement replacement project construction beyond its expected completion. Therefore, the VE team recommends syncing the traffic control schemes of both I-65 projects.

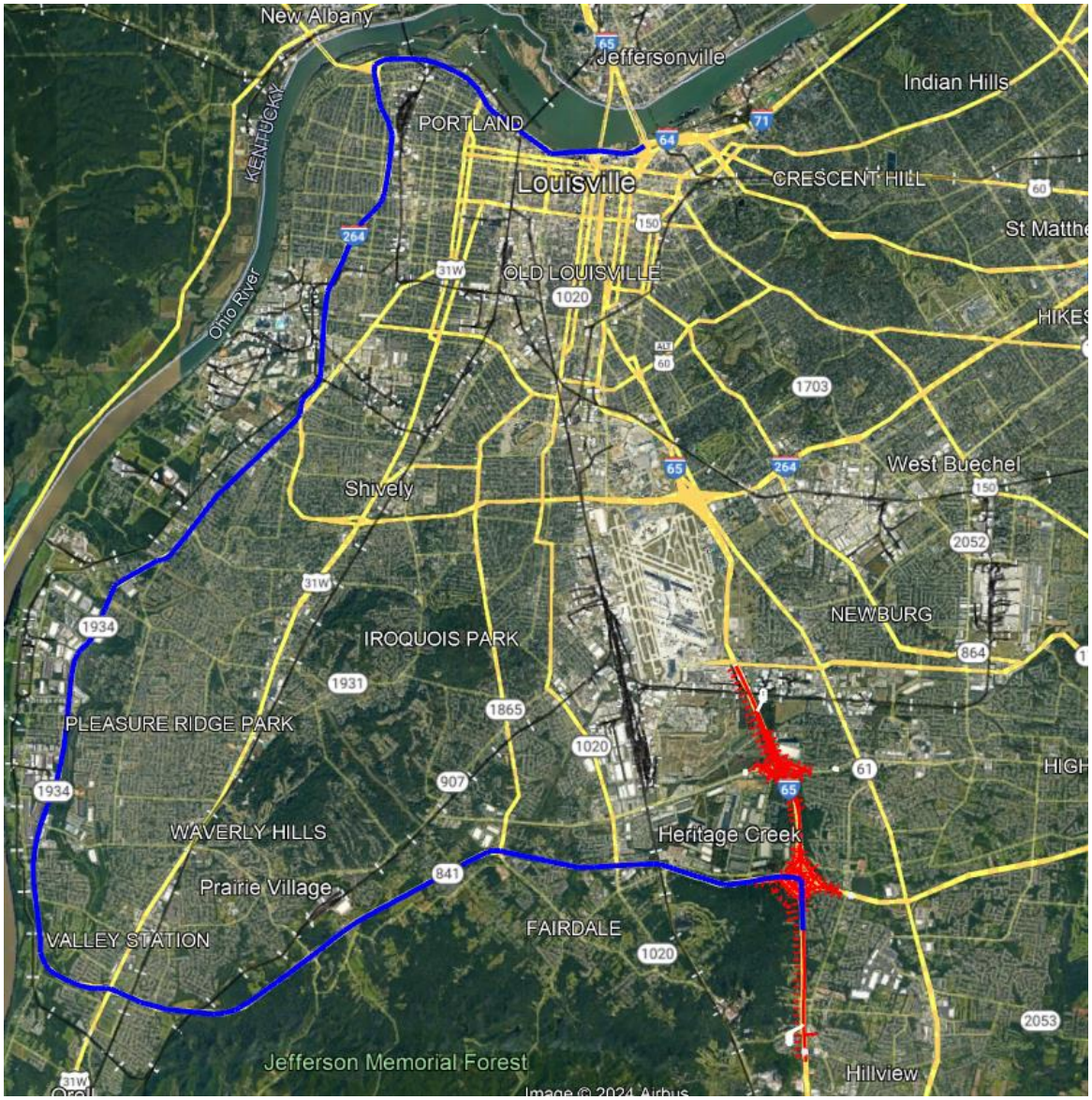
Assumptions/Calculations

Assume the CMGC project traffic control scheme will close I-65 for periods of time while building the new bridges. Traffic will be diverted onto I-64, I-265 & I-264 which will greatly impact traffic traveling through this project.



VE RECOMMENDATION NO. 1: CONSTRUCT RAMPS FIRST AND SYNC TRAFFIC CONTROL PLANS WITH I-65 CENTRAL CORRIDOR PROJECT	Idea No(s). 14, 15

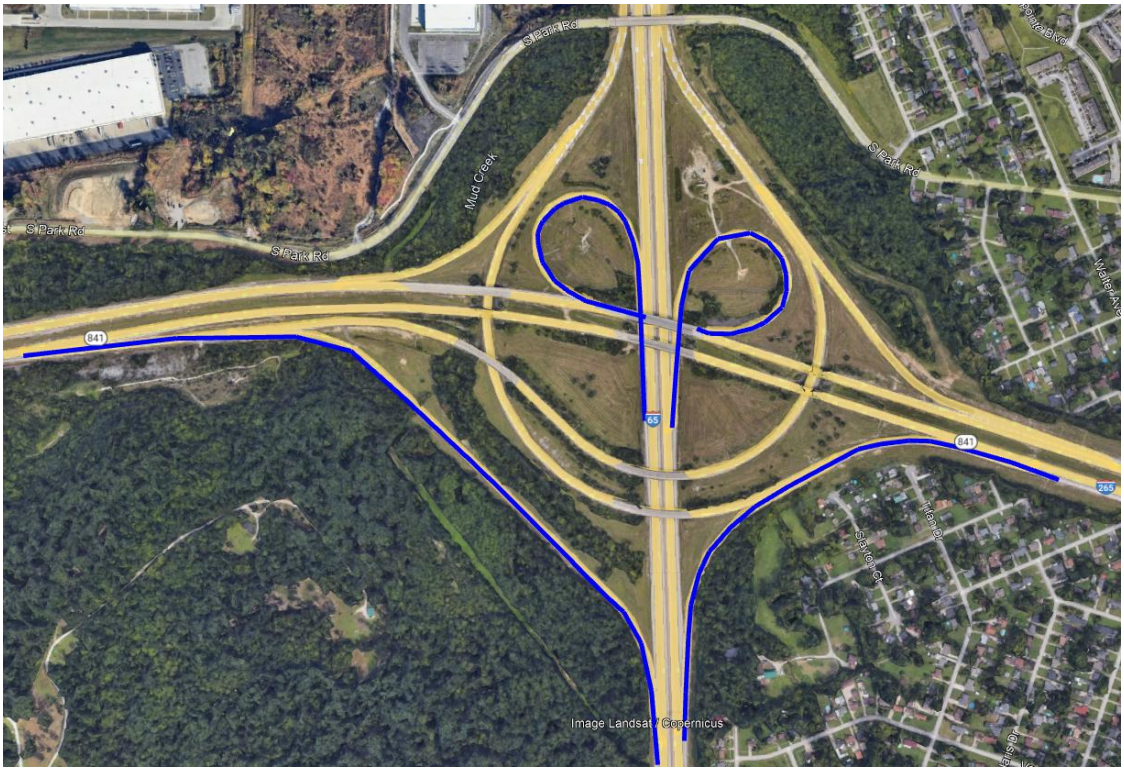
I 65 Eastern bypass option



I 65 West detour option

VE RECOMMENDATION NO. 1: CONSTRUCT RAMPS FIRST AND SYNC TRAFFIC CONTROL PLANS WITH I-65 CENTRAL CORRIDOR PROJECT	Idea No(s). 14, 15

Below is a representation of the impacted ramps by the two detours into the southern project:



Ramps to be constructed

While the cost of reconstructing the ramps would not change, the delays to the southern project could be significant, at a significant cost due to escalation and overhead costs to the contractor.

By constructing the ramps first, these delays would be minimized. To prevent or address construction damage to the ramps, the final lift of asphalt could be done at the end of the project.

VE RECOMMENDATION NO. 1: CONSTRUCT RAMPS FIRST AND SYNC TRAFFIC CONTROL PLANS WITH I-65 CENTRAL CORRIDOR PROJECT	Idea No(s). 14, 15

VE RECOMMENDATION NO. 1	IDEA NO.		
Construct Ramps First and Sync Traffic Control Plans			
PERFORMANCE MEASURES	***Performance***	***Baseline***	***Recommendation***
Attributes and Rating Rationale for Recommendation			
Maintainability	***Rating***	**5**	**5**
No change	***Weight***	**40.0**	
	Contribution	**200**	**200**
Construction Impacts	***Rating***	**5**	**9**
Supports northern project detours Avoids traffic gridlock during construction	***Weight***	**25.0**	
	Contribution	**125**	**225**
Project Schedule	***Rating***	**5**	**8**
May increase construction duration if ramps are done last waiting on the other project to finish Will delay end of construction if MOT schemes are not synced	***Weight***	**25.0**	
	Contribution	**125**	**200**
Risk	***Rating***	**5**	**7**
Reduces risk of delays if MOTs are not in sync	***Weight***	**10.0**	
	Contribution	**50**	**70**
Total Performance		**500**	**695**
Net Change in Performance			**39%**

VE RECOMMENDATION NO. 2: USE ROBUST ASPHALT PAVEMENT DESIGN	Idea No(s). 2, 5, 27, 29, 36

Baseline Concept

Remove the existing concrete pavement and reconstruct with typical asphalt design.

Recommendation Concept

The VE team recommends using a robust pavement design, including stabilization techniques such as use of geotextile reinforcement, chemical stabilization, and the use of cement treated aggregate. To improve drainage and protect the base from water infiltration, the use of a drainage blanket over existing pavement may be practical and extend life of the pavement.

Advantages	Disadvantages
• Improve resilliancy • Improve long-term performance • Reduce maintenance costs • Improves stability of the entire structure • Decreases amount of work required to subbase • Substitute for other subgrade improvements such as chemical stabilization	• May increase capital costs • May increase schedule • May require special skill for installation

Cost Summary	Construction	Right-of-way	Total
Baseline Concept	$50,454,835		$50,454,835
Recommendation Concept	$32,813,673		$32,813,673
Cost Avoidance/(Added Value)	$17,641,162		$17,641,162

FHWA Function Benefit

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

VE RECOMMENDATION NO. 2: USE ROBUST ASPHALT PAVEMENT DESIGN	Idea No(s). 2, 5, 27, 29, 36

Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

This recommendation considered several asphalt pavement design scenarios. Each scenario considered chemical stabilization, geogrid, and drainage blankets.

Assumptions:

Traffic information was obtained from the HIS website where the available data throughout the project limits was evaluated. The segment from mile points 121.6 to 123.2 nearest the south end of the project has the highest Truck AADT percentage (20.9 percent) and was selected as a basis of design.

Soils information utilized in pavement designs was obtained from the geotechnical report prepared by Fuller, Mossbarger, Scott, & May dated June 1978. Based on the soils data presented in the report a CBR value of 4 was selected.

The pavement designs were prepared using the KYTC Web-based Pavement Design Application.

The pavement designs presented were developed with the assumption that maintenance of traffic configurations can be developed to accommodate the construction.

The existing mainline pavement consists of 11 inches of PCC over 6 inches of DGA with 12 inches of Cement Stabilized Subgrade. The existing shoulder pavement consists of 9 inches of PCC over full depth DGA.

After consideration of the different pavement design alternatives analyzed, the VE team recommends the reconstruction of travel lanes and shoulders using asphalt pavement with a drainage blanket over a chemical stabilized DGA.

Asphalt Pavement Designs:

Asphalt Reconstruction with Cement Stabilized Roadbed: Total Reconstruction with cement stabilized roadbed. Requires completely removing the existing pavement and DGA materials and reconstructing the roadbed.

Driving Lane Material Selection

Thickness	Item Code	Description	Unit Price
1.5	00342	CL4 ASPH SURF 0.38A PG76-22	90.58
		Polish-resistant type A is correct.	
3	00219	CL4 ASPH BASE 1.00D PG76-22	62.66
3	00217	CL4 ASPH BASE 1.00D PG64-22	66.05
3.5	00217	CL4 ASPH BASE 1.00D PG64-22	66.05
0	0	None	0
6	00003	CRUSHED STONE BASE	24.74
8	00008	CEMENT STABILIZED ROADBED	2.5
	02542	CEMENT	150

VE RECOMMENDATION NO. 2: USE ROBUST ASPHALT PAVEMENT DESIGN

Idea No(s). 2, 5, 27, 29, 36

Shoulder Material Selection

Thickness	Item Code	Description	Unit Price
1.5	00388	CL3 ASPH SURF 0.38B PG64-22	83.25
3	00214	CL3 ASPH BASE 1.00D PG64-22	92.24
0	0	None	
0	0	None	
0	0	None	0
12.5	00003	CRUSHED STONE BASE	24.74
8	00008	CEMENT STABILIZED ROADBED	2.5
	02542	CEMENT	150

LIFE CYCLE COST ANALYSIS*

Maximum Asphalt Design

FLEXIBLE PAVEMENT

Design CBR 4 Design MR

ONE OR TWO DIRECTIONS:	1	11	in. ASPHALT PAVEMENT
ANALYSIS PERIOD (YEARS):	40	0	in. DRAINAGE BLANKET
CONSTRUCTION YEAR:		6	in. Aggregate Base
MAINT.OF TRAFFIC($/MILE):	10000 Init. Const.	1	MILES (LENGTH OF PROJECT)
COST on MAINT.OF TRAFFIC:	$10,000.00 Init. Const.	5000	Rehabilitation
Analysis DATE:	2024-05-08	$5,000.00	Rehabilitation

*NOTE - These analyses compare only the pavement types and Maintenance of Traffic. They are not total project costs.

ECONOMIC ANALYSIS **Maximum Asphalt Design**

YEAR		INTEREST	P/F	COST	PW
0	PW OF INITIAL CONSTRUCTION	4	1.00	$379,445.26	$379,445.26
10	PW OF REHABILITATION	4	0.68	$72,128.86	$48,727.68
20	PW OF REHABILITATION	4	0.46	$72,128.86	$32,918.67
30	PW OF REHABILITATION	4	0.31	$72,128.86	$22,238.68
40	PW OF SALVAGE	4	0.21	$165,461.12	

* Salvage Values are considered equivalent and are currently not included in Life Cycle Cost Analysis

PW OF Maximum Asphalt Design $483,330.28

Asphalt pavement with Geogrid: Total reconstruction with asphalt pavement and incorporating geogrid. Requires completely removing the existing pavement and DGA materials and reconstruction.

Driving Lane Material Selection

Thickness	Item Code	Description	Unit Price
1.5	00342	CL4 ASPH SURF 0.38A PG76-22	90.58
		Polish-resistant type A is correct.	
3	00219	CL4 ASPH BASE 1.00D PG76-22	62.66
3	00217	CL4 ASPH BASE 1.00D PG64-22	66.05
3.5	00217	CL4 ASPH BASE 1.00D PG64-22	66.05
0	0	None	0
6	00003	CRUSHED STONE BASE	24.74
6	00003	CRUSHED STONE BASE	24.74
	00005	GEOGRID REINFORCEMENT FOR SUBGRADE	2.12
	02602	FABRIC-GEOTEXTILE CLASS 1	1.45

VE RECOMMENDATION NO. 2: USE ROBUST ASPHALT PAVEMENT DESIGN

Idea No(s). 2, 5, 27, 29, 36

Shoulder Material Selection

Thickness	Item Code	Description	Unit Price
1.5	00388	CL3 ASPH SURF 0.38B PG64-22	83.25
3	00214	CL3 ASPH BASE 1.00D PG64-22	92.24
0	0	None	0.00
0	0	None	0.00
0	0	None	0
12.5	00003	CRUSHED STONE BASE	24.74
6	00003	CRUSHED STONE BASE	24.74
	00005	GEOGRID REINFORCEMENT FOR SUBGRADE	2.12
	02602	FABRIC-GEOTEXTILE CLASS 1	1.45

LIFE CYCLE COST ANALYSIS*

Maximum Asphalt Design

FLEXIBLE PAVEMENT

Design CBR 4 Design MR

ONE OR TWO DIRECTIONS: 1
ANALYSIS PERIOD (YEARS): 40
CONSTRUCTION YEAR:
MAINT.OF TRAFFIC($/MILE): 10000 Init. Const.
COST on MAINT.OF TRAFFIC: $10,000.00 Init. Const.
Analysis DATE: 2024-05-08

11 in. ASPHALT PAVEMENT
0 in. DRAINAGE BLANKET
6 in. Aggregate Base
1 MILES (LENGTH OF PROJECT)
5000 Rehabilitation
$5,000.00 Rehabilitation

*NOTE - These analyses compare only the pavement types and Maintenance of Traffic. They are not total project costs.

ECONOMIC ANALYSIS **Maximum Asphalt Design**

YEAR		INTEREST	P/F	COST	PW
0	PW OF INITIAL CONSTRUCTION	4	1.00	$447,071.52	$447,071.52
10	PW OF REHABILITATION	4	0.68	$72,128.86	$48,727.68
20	PW OF REHABILITATION	4	0.46	$72,128.86	$32,918.67
30	PW OF REHABILITATION	4	0.31	$72,128.86	$22,238.68
40	PW OF SALVAGE	4	0.21	$165,461.12	

* Salvage Values are considered equivalent and are currently not included in Life Cycle Cost Analysis

PW OF Maximum Asphalt Design $550,956.54

Asphalt Pavement with Cement Stabilized Roadbed and a Drainage Blanket. Requires completely removing the existing pavement and DGA materials and reconstructing the roadbed.

Driving Lane Material Selection

Thickness	Item Code	Description	Unit Price
1.5	00342	CL4 ASPH SURF 0.38A PG76-22	90.58
		Polish-resistant type A is correct.	
3.5	00219	CL4 ASPH BASE 1.00D PG76-22	62.66
4	00217	CL4 ASPH BASE 1.00D PG64-22	66.05
	0	None	0.00
4	00018	DRAINAGE BLANKET-TYPE II-ASPH	48.00
6	00001	DGA BASE	27.41
8	00008	CEMENT STABILIZED ROADBED	2.5
	02542	CEMENT	150

VE RECOMMENDATION NO. 2: USE ROBUST ASPHALT PAVEMENT DESIGN

Idea No(s). 2, 5, 27, 29, 36

Shoulder Material Selection

Thickness	Item Code	Description	Unit Price
1.5	00388	CL3 ASPH SURF 0.38B PG64-22	83.25
3.5	00214	CL3 ASPH BASE 1.00D PG64-22	92.24
0	0	None	0.00
0	0	None	0.00
0	0	None	0
14	00001	DGA BASE	27.41
8	00008	CEMENT STABILIZED ROADBED	2.5
	02542	CEMENT	150

LIFE CYCLE COST ANALYSIS*

Maximum Asphalt Design

FLEXIBLE PAVEMENT

Design CBR 4 **Design MR**

ONE OR TWO DIRECTIONS:	1	9	in. ASPHALT PAVEMENT
ANALYSIS PERIOD (YEARS):	40	4	in. DRAINAGE BLANKET
CONSTRUCTION YEAR:		6	in. Aggregate Base
		1	MILES (LENGTH OF PROJECT)
MAINT.OF TRAFFIC($/MILE):	10000 Init. Const.	5000	Rehabilitation
COST on MAINT.OF TRAFFIC:	$10,000.00 Init. Const.	$5,000.00	Rehabilitation
Analysis DATE:	2024-05-08		

*NOTE - These analyses compare only the pavement types and Maintenance of Traffic. They are not total project costs.

ECONOMIC ANALYSIS **Maximum Asphalt Design**

YEAR		INTEREST	P/F	COST	PW
0	PW OF INITIAL CONSTRUCTION	4	1.00	$421,918.28	$421,918.28
10	PW OF REHABILITATION	4	0.68	$72,128.86	$48,727.68
20	PW OF REHABILITATION	4	0.46	$72,128.86	$32,918.67
30	PW OF REHABILITATION	4	0.31	$72,128.86	$22,238.68
40	PW OF SALVAGE	4	0.21	$200,685.06	

* Salvage Values are considered equivalent and are currently not included in Life Cycle Cost Analysis

PW OF Maximum Asphalt Design $525,803.30

Asphalt Pavement with a Drainage Blanket and Chemical Stabilized DGA. Requires removal of the existing concrete pavement and treats the existing DGA material with cement.

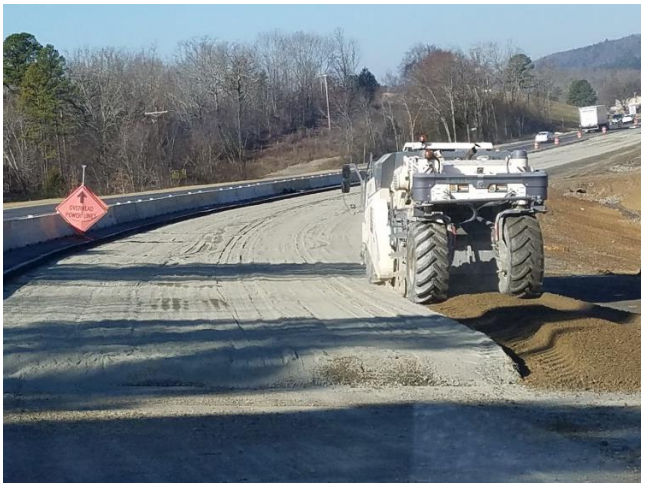
Driving Lane Material Selection

Thickness	Item Code	Description	Unit Price
1.5	00342	CL4 ASPH SURF 0.38A PG76-22	90.58
		Polish-resistant type A is correct.	
3.5	00219	CL4 ASPH BASE 1.00D PG76-22	62.66
4	00217	CL4 ASPH BASE 1.00D PG64-22	66.05
	0	None	0.00
4	00018	DRAINAGE BLANKET-TYPE II-ASPH	48.00
8	00008	CEMENT STABILIZED ROADBED	2.5
	02542	CEMENT	150

Shoulder Material Selection

Thickness	Item Code	Description	Unit Price
1.5	00388	CL3 ASPH SURF 0.38B PG64-22	83.25
3.5	00214	CL3 ASPH BASE 1.00D PG64-22	92.24
0	0	None	0.00
0	0	None	0.00
0	0	None	0
8	00008	CEMENT STABILIZED ROADBED	2.5
	02542	CEMENT	150

VE RECOMMENDATION NO. 2: USE ROBUST ASPHALT PAVEMENT DESIGN	Idea No(s). 2, 5, 27, 29, 36



LIFE CYCLE COST ANALYSIS*

Maximum Asphalt Design

FLEXIBLE PAVEMENT

ONE OR TWO DIRECTIONS:	1			
ANALYSIS PERIOD (YEARS):	40			
CONSTRUCTION YEAR:				
MAINT.OF TRAFFIC($/MILE):	10000	Init. Const.	5000	Rehabilitation
COST on MAINT.OF TRAFFIC:	$10,000.00	Init. Const.	$5,000.00	Rehabilitation
Analysis DATE:	2024-05-08			

Design CBR	4	Design MR	
	9		in. ASPHALT PAVEMENT
	4		in. DRAINAGE BLANKET
	6		in. Aggregate Base
	1		MILES (LENGTH OF PROJECT)

*NOTE - These analyses compare only the pavement types and Maintenance of Traffic. They are not total project costs.

ECONOMIC ANALYSIS **Maximum Asphalt Design**

YEAR		INTEREST	P/F	COST	PW
0	PW OF INITIAL CONSTRUCTION	4	1.00	$421,918.28	$355,339.41
10	PW OF REHABILITATION	4	0.68	$72,128.86	$48,727.68
20	PW OF REHABILITATION	4	0.46	$72,128.86	$32,918.67
30	PW OF REHABILITATION	4	0.31	$72,128.86	$22,238.68
40	PW OF SALVAGE	4	0.21	$200,685.06	

* Salvage Values are considered equivalent and are currently not included in Life Cycle Cost Analysis

PW OF Maximum Asphalt Design $459,224.41

The comparison with the baseline design is shown below:

The VE Team converted the total cost of pavement in the baseline concept estimate to replace the total concrete removal area, then converting to lane mile by using a 12’ lane.

Lane miles calculation	565,302 SY	7040 SY/LM	80.30 LM
Asphalt Cost per LM	$43,873,088	80.30 LM	$546,374.40

Total lane-miles to be reconstructed: 80.3 LM

Calculations per lane mile done using the KYTC software includes MOT, which was removed from the calculations in the table below.

VE RECOMMENDATION NO. 2: USE ROBUST ASPHALT PAVEMENT DESIGN	Idea No(s). 2, 5, 27, 29, 36

VE Study Cost Calculations

KYTC - I-65 in Jefferson Co (5-22069)

		Baseline Concept			VE Recommended Concept		
Component	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
Baseline Pavement	LM	80.3	$ 546,375.00	$ 43,873,913			$ -
Asphalt w/ drainage blanket over Chemical Stabilized DGA, includes shoulders	LM			$ -	80.3	$ 355,339.00	$ 28,533,722
				$ -		$ -	$ -
				$ -		$ -	$ -
Subtotal Construction				*$ 43,873,913*			*$ 28,533,722*
Mark-Up (MOT, Mob., PE, CEI)	15%			$ 6,580,922	13%		$ 4,279,951
Total Construction				**$ 50,454,835**			**$ 32,813,673**
Utility Costs				$ -		$ -	$ -
Right of Way Costs				$ -		$ -	$ -
TOTAL CAPITAL COST				***$ 50,454,835***			***$ 32,813,673***
COST CAPITAL SAVINGS / (VALUE ADDED)							**$ 17,641,162**

VE RECOMMENDATION NO. 2: USE ROBUST ASPHALT PAVEMENT DESIGN

Idea No(s). 2, 5, 27, 29, 36

VE RECOMMENDATION NO. 2	IDEA NO.		
Use Robust Asphalt Pavement Design			
PERFORMANCE MEASURES	*Performance*	*Baseline*	*Recommendation*
Attributes and Rating Rationale for Recommendation			
Maintainability	*Rating*	5	8
Improves stability of sub-base/soils Improves base protection (drainage blanket) Reduces risk of runoff infiltration May extend rehab life cycle	*Weight*	40.0	
	Contribution	200	320
Construction Impacts	*Rating*	5	6
Reduces length of time impacting users Reduces user delay costs	*Weight*	25.0	
	Contribution	125	150
Project Schedule	*Rating*	5	7
Reduces excavation Reduces laydown times Avoids regrading	*Weight*	25.0	
	Contribution	125	175
Risk	*Rating*	5	7
Reduces risk of failure using blanket	*Weight*	10.0	
	Contribution	50	70
Total Performance		500	715
Net Change in Performance			43%

VE RECOMMENDATION NO. 3: CONDUCT TRAFFIC CONTROL PLANS OPERATIONAL ANALYSIS	Idea No(s). 9

Baseline Concept

Reconstruct I-65 by utilizing lane closures, with two lanes of traffic open at all times.

Recommendation Concept

Conduct an in-depth traffic control operational analyis to determine the appropriate lane closures that can be utilized through each section of the project.

Advantages	Disadvantages
• Reduces user delays	• Baseline is very similar • Increases mob / demob • Increases cost • Lengthens schedule • Introduces more conflict by splitting traffic • May increase accidents • May increase queue recovery delays

Cost Summary	Construction	Engineering	Total
Baseline Concept		$0	$0
Recommendation Concept		$50,000	$50,000
Cost Avoidance/(Added Value)		($50,000)	($50,000)

FHWA Function Benefit

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

VE RECOMMENDATION NO. 3: CONDUCT TRAFFIC CONTROL PLANS OPERATIONAL ANALYSIS	Idea No(s). 9

Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

A basic queue analysis was performed using available traffic count data and Highway Capacity Software. This analysis recommends maintaining three through lanes south of I-265 and four through lanes north of I-265. The initial assessment of traffic delays and queue lengths shows that maintaining 2 lanes of traffic in the 3-lane and 4-lane sections is unattainable, causing undesirable conditions.

Main findings of the analysis show:

- North of I-265
  - Projected 2025 Volumes: AADT = 148,000 vpd; DHV = 7,950 vph in peak direction
  - **6 Lane to 2 Lane**: **Over Capacity**; d/c = 2.00; Queue after 1 Hour = 7+ miles
  - **6 Lane to 3 Lane**: **Over Capacity**; d/c = 1.26; Queue after 1 Hour = 4+ miles
  - **6 Lane to 4 Lane**: **Stable**, d/c = 0.94; **No Queuing**
- South of I-265
  - Projected 2025 Volumes: AADT = 114,500 vpd; DHV = 5,325 vph in peak direction
  - **4 Lane to 2 Lane**: **Over Capacity**; d/c = 1.36; Queue after 1 Hour = 5+ miles
  - **4 Lane to 3 Lane**: **Stable**, d/c = 0.90; **No Queuing**
  - **3 Lane to 2 Lane**: **Over Capacity**; d/c = 1.34; Queue after 1 Hour = 10+ miles

While these numbers offer a general idea of the issues with lane closures as currently proposed, the VE team recommends performing a more detailed traffic analysis to determine the number of through lanes needed during construction phasing. This analysis should include the impacts from the traffic entering and exiting the system at the interchange ramps located throughout the project. An hourly analysis should be done to determine system performance outside of the peak hours. The amount of local traffic diverting to other routes during construction should also be estimated during this analysis.

VE RECOMMENDATION NO. 3: CONDUCT TRAFFIC CONTROL PLANS OPERATIONAL ANALYSIS	Idea No(s). 9

Assumptions/Calculations

Assume a senior traffic engineer will need approximately 2 weeks to build traffic model links and perform analysis and detail recommendations based on the results, totaling $50,000 approximately.

KYTC Streetlight data subscription can be utilized so that additional traffic counts will not need to be done.

VE RECOMMENDATION NO. 3	IDEA NO.		
Conduct Traffic Control Plans Operational Analysis			
PERFORMANCE MEASURES	*Performance*	*Baseline*	*Recommendation*
Attributes and Rating Rationale for Recommendation			
Maintainability	*Rating*	5	5
No change	*Weight*	40.0	
	Contribution	200	200
Construction Impacts	*Rating*	5	6
Establishes number of lanes to be maintaned opened Reduces user delay costs	*Weight*	25.0	
	Contribution	125	150
Project Schedule	*Rating*	5	5
No change	*Weight*	25.0	
	Contribution	125	125
Risk	*Rating*	5	5.5
Helps with traffic patterns and possible detours from other proje	*Weight*	10.0	
	Contribution	50	55
Total Performance		500	530
Net Change in Performance			6%

VE RECOMMENDATION NO. 4: RECONSTRUCT DRAINAGE	Idea No(s). 8

Baseline Concept

The current roadway configuration includes a Type 14 Barrier Wall with curb inlets for roadway surface drainage. Barrier wall currently exists within the project limits from Milepoint 123.9 to Milepoint 127.57. The existing barrier wall is 32” tall.

Recommendation Concept

This recommendation includes the reconstruction of the drainage from MP 123.9 to MP 127.57 by removing the existing barrier wall and drainage structures within the inside shoulder and replacing the barrier with a MASH compliant barrier wall which is 56” tall since this wall will likely have sign structures and/or lighting pedestals. Further, this recommendation will incorporate the appropriate drainage structure to ensure that any water does not infiltrate the subgrade and further impact the integrity of the new pavement.

Advantages	Disadvantages
• Addresses root cause of poor pavement conditions • Lower maintenance costs in future • Improve resiliency and life of facility	• Increases costs • More time to construct • Shoulders and median barrier will need to be removed • Increased time and cost relative to design and installation of MASH complient barrier that may be required for the replacement

Cost Summary	Construction	Right-of-way	Total
Baseline Concept	$-		$-
Recommendation Concept	$15,069,054		$15,069,054
Cost Avoidance/(Added Value)	$(15,069,054)		$(15,069,054)

FHWA Function Benefit

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

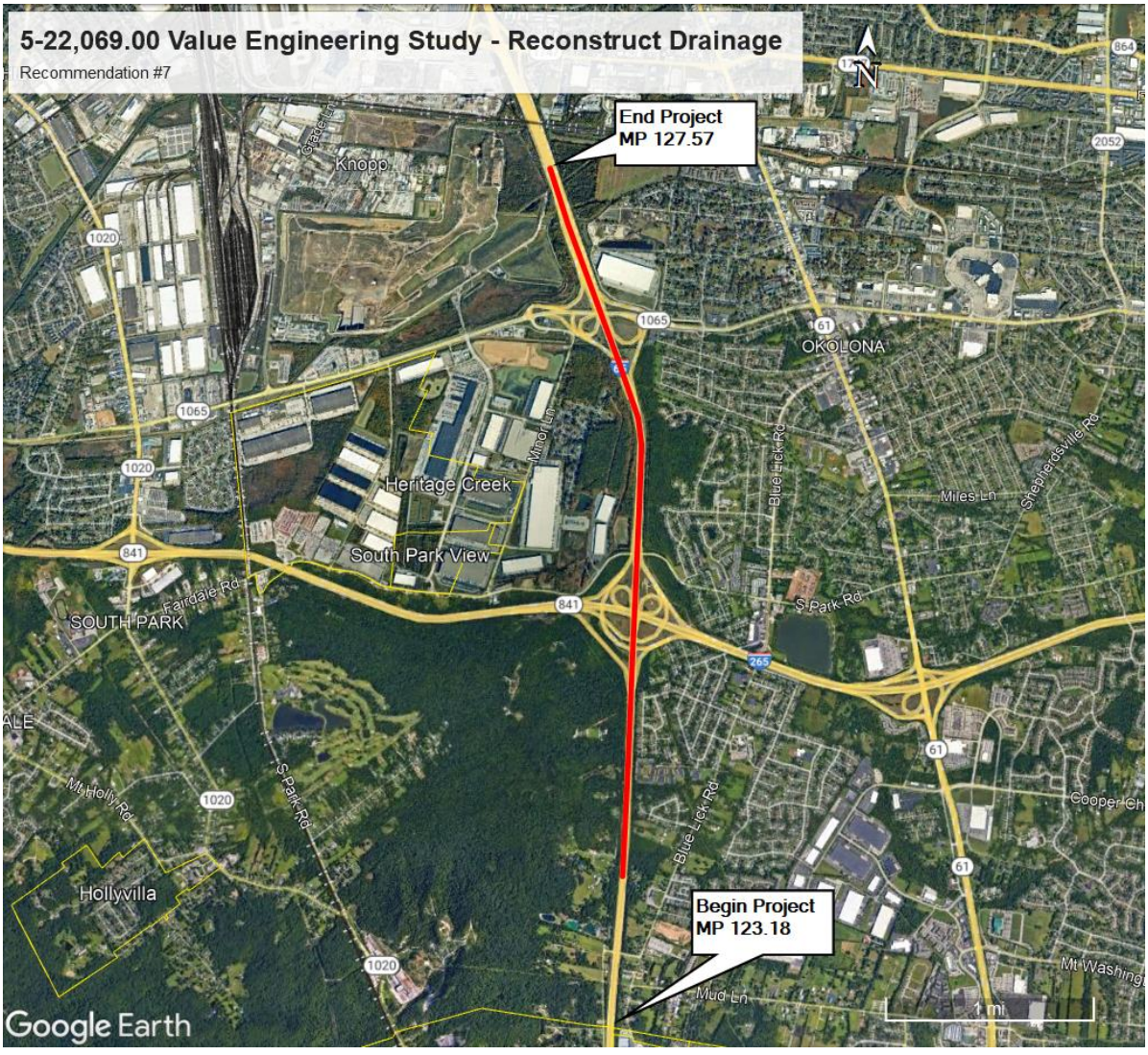
VE RECOMMENDATION NO. 4: RECONSTRUCT DRAINAGE	Idea No(s). 8

Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

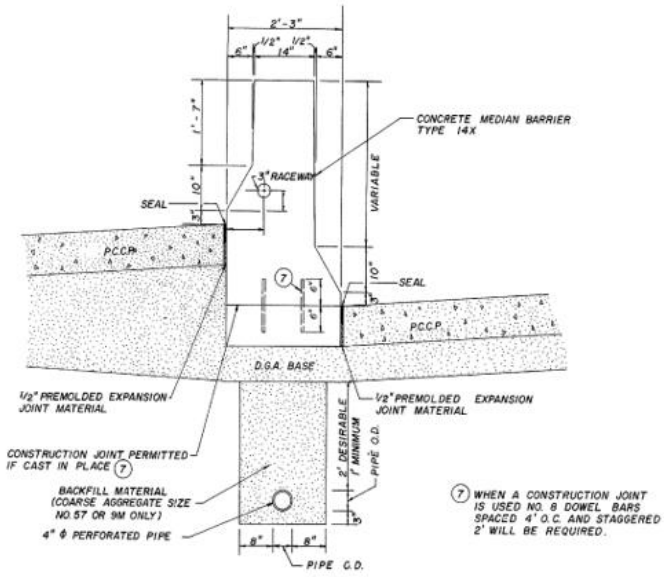
During the analysis phase of the project, the VE team concluded that the root cause of the pavement failure is mainly due to pavement base deterioration because water is infiltrating the pavement base and causing the existing concrete pavement to fail at the joints. This deterioration is caused by underdrain issues. While preserving the shoulders and the median barrier seem feasible, the VE team believes that not addressing the drainage issues will cause the pavement to fail in a very short time. Thus, addressing drainage issues is primary to this project, which the baseline design does not address.

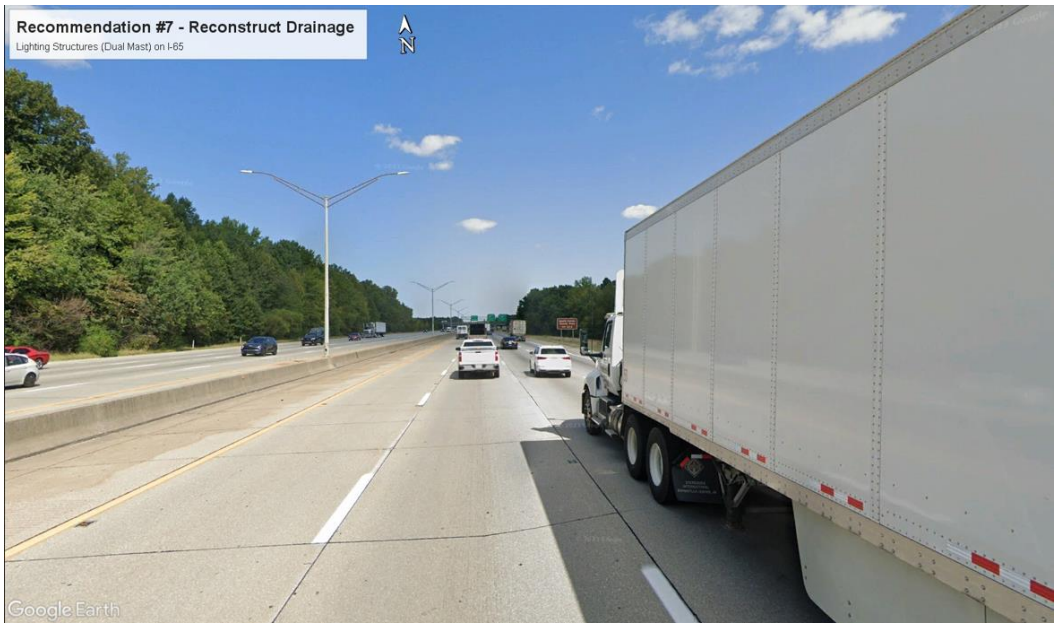
Therefore, the objective of this recommendation is to remove the existing barrier wall and inside shoulder from MP 123.9 to MP 127.57 as shown in the graphic below and to reconstruct the drainage system and effectively protect the pavement base. It is anticipated that this work will be completed with the closure of the inside lane and inside shoulders in both the southbound and northbound directions on I-65.



VE RECOMMENDATION NO. 4: RECONSTRUCT DRAINAGE	Idea No(s). 8

Existing Barrier Wall with Drainage



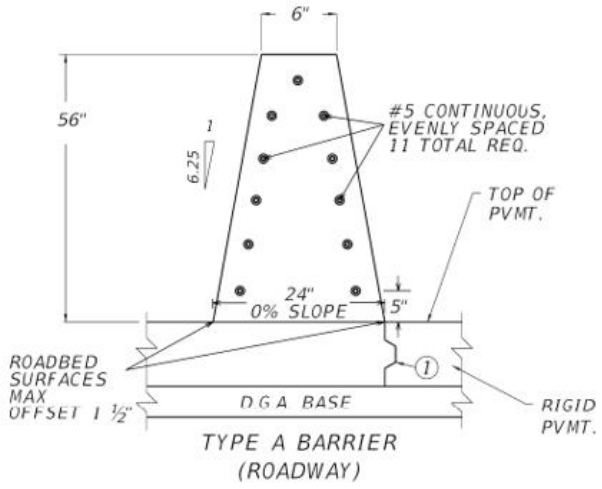


Assumptions/Calculations

When calculating the cost for this recommendation, it was assumed that although there are several different possible solutions to replacing the pavement, the baseline pavement design was used for the replacement of the shoulder pavement. It was also assumed that the barrier wall will be a 56” tall (MASH Test Level 3 hardware) since there will be sign structures and lighting pedestals on the wall. The sign structures and lighting (dual and single mast) assumed to be removed and reinstalled with conduit added through the barrier wall for the lighting.

VE RECOMMENDATION NO. 4: RECONSTRUCT DRAINAGE	Idea No(s). 8

Proposed Barrier Wall



VE Study Cost Calculations

KYTC - I-65 in Jefferson Co (5-22069)

		Baseline Concept			VE Recommended Concept		
Component	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
Barrier Wall	LF	0	$ 301.00	$ -	19,377	$ 301.00	$ 5,832,477
Drainage	LF	0	$ 56.00	$ -	19377	$ 56.00	$ 1,085,112
Paved Shoulder (Full Depth)	LF	0	$ 125.00	$ -	38754	$ 125.00	$ 4,844,250
Remove Existing Barrier Wall	LF	0	$ 17.00	$ -	19377	$ 17.00	$ 329,409
Remove Existing Shoulder	SY	0	$ 28.50	$ -	3950	$ 28.50	$ 112,575
Remove and Reset Crash Cushion	EA	0	$ 6,000.00	$ -	1	$ 6,000.00	$ 6,000
Lighting	LF	0	$ 36.00	$ -	15840	$ 36.00	$ 570,240
Overhead signs (Remove and Reset)	EA	0	$ 35,945.00	$ -	9	$ 35,945.00	$ 323,505
				$ -		$ -	$ -
Subtotal Construction				$ -			$ *13,103,568*
Mark-Up (MOT, Mob., PE, CEI)	15%			$ -			$ 1,965,486
Total Construction				**$ -**			**$ 15,069,054**
Utility Costs				$ -		$ -	$ -
Right of Way Costs				$ -		$ -	$ -
TOTAL CAPITAL COST				***$ -***			***$ 15,069,054***
COST CAPITAL SAVINGS / (VALUE ADDED)							**$ (15,069,054)**

VE RECOMMENDATION NO. 4: RECONSTRUCT DRAINAGE	Idea No(s). 8

VE RECOMMENDATION NO. 4	IDEA NO.		
Reconstruct Drainage			
PERFORMANCE MEASURES / **Attributes and Rating Rationale for Recommendation**	***Performance***	***Baseline***	***Recommendation***
Maintainability Significantly improves life of the pavement structure Removes infiltrated runoff much faster Improves effectiveness of drainage system Solves the root cause of pavement failure	***Rating***	**5**	**9**
	Weight	**40.0**	
	Contribution	**200**	**360**
Construction Impacts Complicates sequencing Increases number of phases Reduces available space for MOT	***Rating***	**5**	**4**
	Weight	**25.0**	
	Contribution	**125**	**100**
Project Schedule Takes longer to construct More scope to construct Adds excavation in the median	***Rating***	**5**	**3**
	Weight	**25.0**	
	Contribution	**125**	**75**
Risk Reduces risk of pavement failure Improves drainage	***Rating***	**5**	**9**
	Weight	**10.0**	
	Contribution	**50**	**90**
Total Performance		**500**	**625**
Net Change in Performance			**25%**

VE RECOMMENDATION NO. 5: CROSSOVER TRAFFIC TO ONE SIDE AND SWITCH OVER	Idea No(s). 7

Baseline Concept

Reconstruct I-65 by utilizing lane closures, with two lanes of traffic open at all times.

Recommendation Concept

Use crossovers to shift traffic to one side. Utilize existing 11” concrete shoulder to maintain 3 or 4 lanes of traffic in each direction.

Advantages	Disadvantages
• Improves constructability • Improves workzone safety • Improves mobilization/demolization • Shortens scheduling needs	• Entrance / Exit points must be managed • Driver expectation • May require the zipper median for 6 lane to accommodate addition traffic for the 4th lane

Cost Summary	Construction	Time-Related Savings	Total
Baseline Concept	$70,919,528	$2,758,921	$73,678,449
Recommendation Concept	$67,274,689	$-	$67,274,689
Cost Avoidance/(Added Value)	$3,644,839	$2,758,921	$6,403,760

FHWA Function Benefit

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

VE RECOMMENDATION NO. 5: CROSSOVER TRAFFIC TO ONE SIDE AND SWITCH OVER	Idea No(s). 7

Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

The objective of this recommendation is to potentially lower the cost of major construction items and reduce overall contract time by shifting all traffic to one side of the interstate to allow for complete reconstruction on the opposite side. This will reduce traffic conflicts during construction and allow the contractor full access to one complete side of the project. This recommendation will also allow for less complicated construction methods for major pavement items to be constructed, as well as chemical stabilization and pavement drainage systems to be completed.

A basic queue analysis was performed using available traffic count data and Highway Capacity Software. This analysis recommends maintaining three through lanes south of I-265 and four through lanes north of I-265.

This option will require the construction of temporary crossovers at the north and south ends of the project limits. In the three-lane depressed median section, three lanes should be maintained in the peak direction of traffic utilizing a movable zipper median system. Temporary mainline pavement widening (4') and temporary shoulder widening (2') will be needed. The cable barrier median will need to be reset after construction is complete.

In the four-lane section, three lanes of traffic can be maintained in both directions. Temporary mainline pavement widening (2') and temporary shoulder widening (2') will be needed.

At the north end of the project, the barrier wall will need to be removed to allow for construction of the crossover and then replaced after construction is completed and the crossover is removed.

In the six-lane section, four lanes of traffic can be maintained in both directions. Temporary mainline pavement widening (1') and temporary shoulder widening (2') will be needed.

Assumptions/Calculations

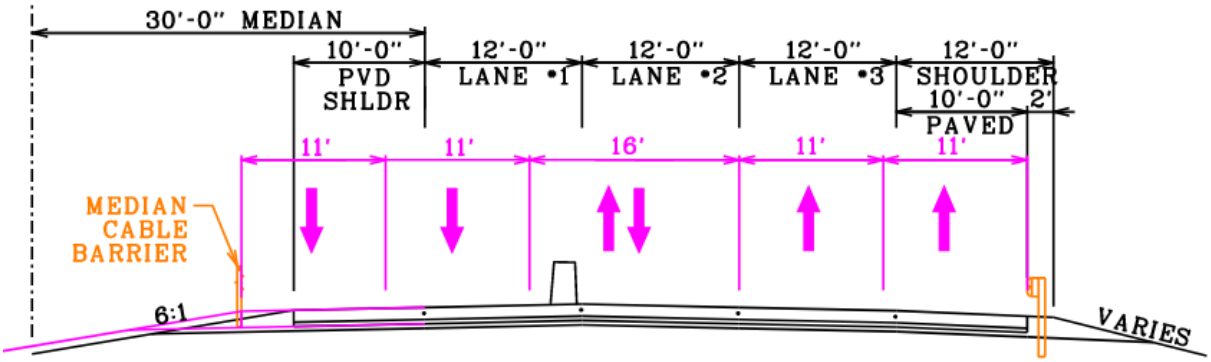
The base cost utilized average unit bid prices. Based on other pavement rehab projects in the area, a 10 percent savings for the major paving items was assumed.

Reversible Zipper Barrier cost estimate - $0.8M/mile per year to have the fabricator supply the machine, barrier and operator. A two-year construction time frame was assumed.

Main findings:

- North of I-265
  - Projected 2025 Volumes: AADT = 148,000 vpd; DHV = 7,950 vph in peak direction
  - **6 Lane to 2 Lane**: **Over Capacity**; d/c = 2.00; Queue after 1 Hour = 7+ miles
  - **6 Lane to 3 Lane**: **Over Capacity**; d/c = 1.26; Queue after 1 Hour = 4+ miles
  - **6 Lane to 4 Lane**: **Stable**, d/c = 0.94; **No Queuing**
- South of I-265
  - Projected 2025 Volumes: AADT = 114,500 vpd; DHV = 5,325 vph in peak direction
  - **4 Lane to 2 Lane**: **Over Capacity**; d/c = 1.36; Queue after 1 Hour = 5+ miles
  - **4 Lane to 3 Lane**: **Stable**, d/c = 0.90; **No Queuing**
  - **3 Lane to 2 Lane**: **Over Capacity**; d/c = 1.34; Queue after 1 Hour = 10+ miles

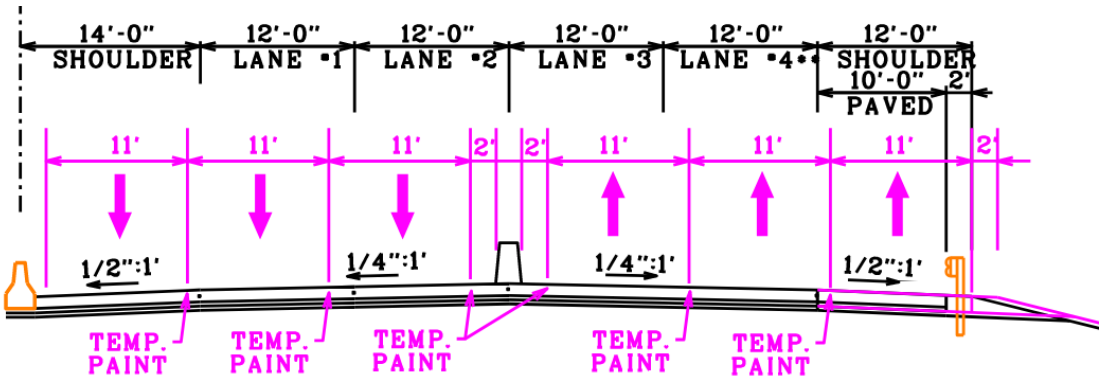
VE RECOMMENDATION NO. 5: CROSSOVER TRAFFIC TO ONE SIDE AND SWITCH OVER	Idea No(s). 7



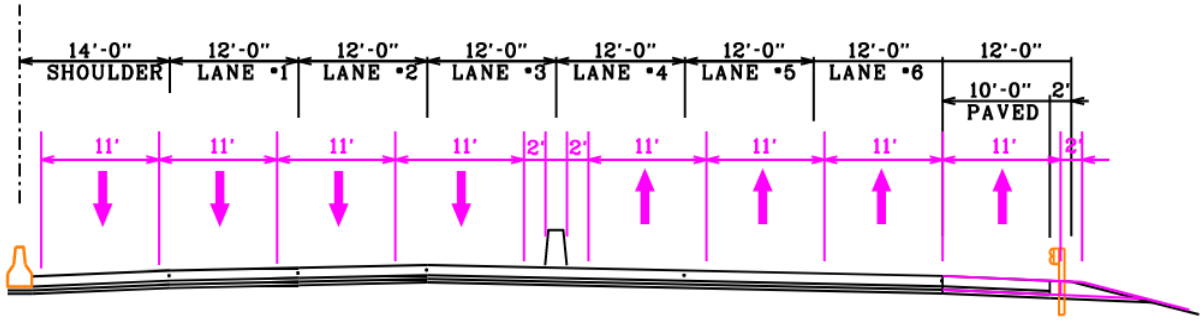
I-65 CONSTRUCTION
3-LANE SECTION - DEPRESSED MEDIAN
ZIPPER BARRIER

Michigan I-75 Zipper barrier example

VE RECOMMENDATION NO. 5: CROSSOVER TRAFFIC TO ONE SIDE AND SWITCH OVER	Idea No(s). 7



PHASE III - I-65 CONSTRUCTION
4-LANE LANE SECTION - BARRIER WALL



I-65 CONSTRUCTION
6-LANE LANE SECTION - BARRIER WALL

The VE team believes that a 2-season construction duration is very aggressive and it's likely that it will take 36 months to construct with a traditional construction phasing. By giving the contractor the entire width of one side of the roadway, there will be significant time savings as well. The VE team estimated a reduction in schedule duration of 3 to 6 months. Based on typical design-bid-build construction and an inflation factor of 5.7 percent, the cost avoidance due to time savings is calculated as follows:

	Baseline Concept						
SCHEDULE IMPACTS	**Start Date**	**Construction Duration (months)**	**Finish Date**	**Amount**	**Contracting Method**	**Overhead/ Mo** (PE, CN, CEI)	**Inflationary Value**
Construction	7/1/2025	24.00	6/27/2027	$ 69,315,000	Design Bid Bu	$ 231,050	$ 8,954,000
CEI	7/1/2025		7/27/2027	$ 5,545,200		$ 115,525	$ 716,000

VE RECOMMENDATION NO. 5: CROSSOVER TRAFFIC TO ONE SIDE AND SWITCH OVER	Idea No(s). 7

Recommended Concept		
Time Savings (Mo)	**OVH Savings**	**Inflationary Savings**
4.5	$ 1,039,725	$ 824,000
4.5	$ 519,863	$ 650,000

Inflationary Calculations					
i(%)	**Escalation Multiplier**	**Base Escalating**	**Days/Mo**	**Escalation Multiplier**	**Recom. Escalating**
5.7%	1.1292	25.8	30.25	1.1173	23.57

Total Savings (YOE)	**$ 3,033,588**
Total Savings (PDC)	**$ 2,758,921**

VE Study Life-Cycle Costs Calculations

KYTC - I-65 in Jefferson Co (5-22069)

		Baseline Concept				VE Recommended Concept		
Component	**Unit**	**Quantity**	**Cost/Unit**	**Total**		**Quantity**	**Cost/Unit**	**Total**
Crushed Stone Base	TON	221611	$ 25.80	$ 5,717,564		221611	$ 23.22	$ 5,145,807.42
Asph Base	TON	316580	$ 100.00	$31,658,000		316580	$ 90.00	$ 28,492,200
CI 4 Asph Surface	TON	46637	$ 130.00	$ 6,062,810		46637	$ 117.00	$ 5,456,529
Remove PCC pavement	SQ YD	565302	$ 26.00	$14,697,852		565302	$ 23.40	$ 13,228,067
Roadway Exc	CU YD	117771	$ 30.00	$ 3,533,130		117771	$ 27.00	$ 3,179,817
				$ -			$ -	$ -
Crossover	EA	0	$ 250,000.00	$ -		2	$ 250,000.00	$ 500,000
Zipper median	MI	0	$ -	$ -		1.35	$ 1,600,000.00	$ 2,160,000
Barrier Wall	FT	0		$ -		1500	$ 150.00	$ 225,000
Median Cable Barrier	FT	0		$ -		1500	$ 25.00	$ 37,500
Remove Barrier wall	FT	0		$ -		1500	$ 50.00	$ 75,000
				$ -			$ -	$ -
				$ -			$ -	$ -
Subtotal Construction				$61,669,356				$ 58,499,920
Mark-Up (MOT, Mob., PE,	15%			$ 9,250,172				$ 8,774,769
Total Construction				**$70,919,528**				**$ 67,274,689**
Utility Costs				$ -			$ -	$ -
Time Savings				$ 2,758,921			$ -	$ -
TOTAL CAPITAL COST				**$73,678,449**				**$ 67,274,689**
COST CAPITAL SAVINGS / (VALUE ADDED)								**$ 6,403,760**

VE RECOMMENDATION NO. 5: CROSSOVER TRAFFIC TO ONE SIDE AND SWITCH OVER

Idea No(s). 7

VE RECOMMENDATION NO. 5	IDEA NO.		
Crossover Traffic to One Side and Switch Over			
PERFORMANCE MEASURES / **Attributes and Rating Rationale for Recommendation**	***Performance***	***Baseline***	***Recommendation***
Maintainability No change	***Rating***	5	5
	Weight	40.0	
	Contribution	200	200
Construction Impacts Greatly reduce mobilization & demobilization Reduces impacts to local traffic	***Rating***	5	8
	Weight	25.0	
	Contribution	125	200
Project Schedule Reduces construction phases Reduces project duration	***Rating***	5	8
	Weight	25.0	
	Contribution	125	200
Risk Reduces risk of MOT conflicts with norther section Maintains traffic without major delays	***Rating***	5	5.5
	Weight	10.0	
	Contribution	50	55
Total Performance		500	655
Net Change in Performance			31%

VE RECOMMENDATION NO. 6: INCLUDE BRIDGE REHAB SCOPE	Idea No(s). 13

Baseline Concept

Bridge rehabilitation scope is not part of this project.

Recommendation Concept

This recommendation includes the incorporation of the bridge needs within the project limits and coordinating those needs with this project.

Advantages	Disadvantages
• Reduces user delays • Reduces traffic interruptions • Reduces costs (MOT and Mobilization)	• Increases contract amount • Reprioritization of bridge funding • Timing of design of bridge project and this project may not match • Requires coordination • May delay letting

Cost Summary	Construction	Right-of-way	Total
Baseline Concept	$16,594,446		$16,594,446
Recommendation Concept	$16,112,303		$16,112,303
Cost Avoidance/(Added Value)	$482,143		$482,143

FHWA Function Benefit

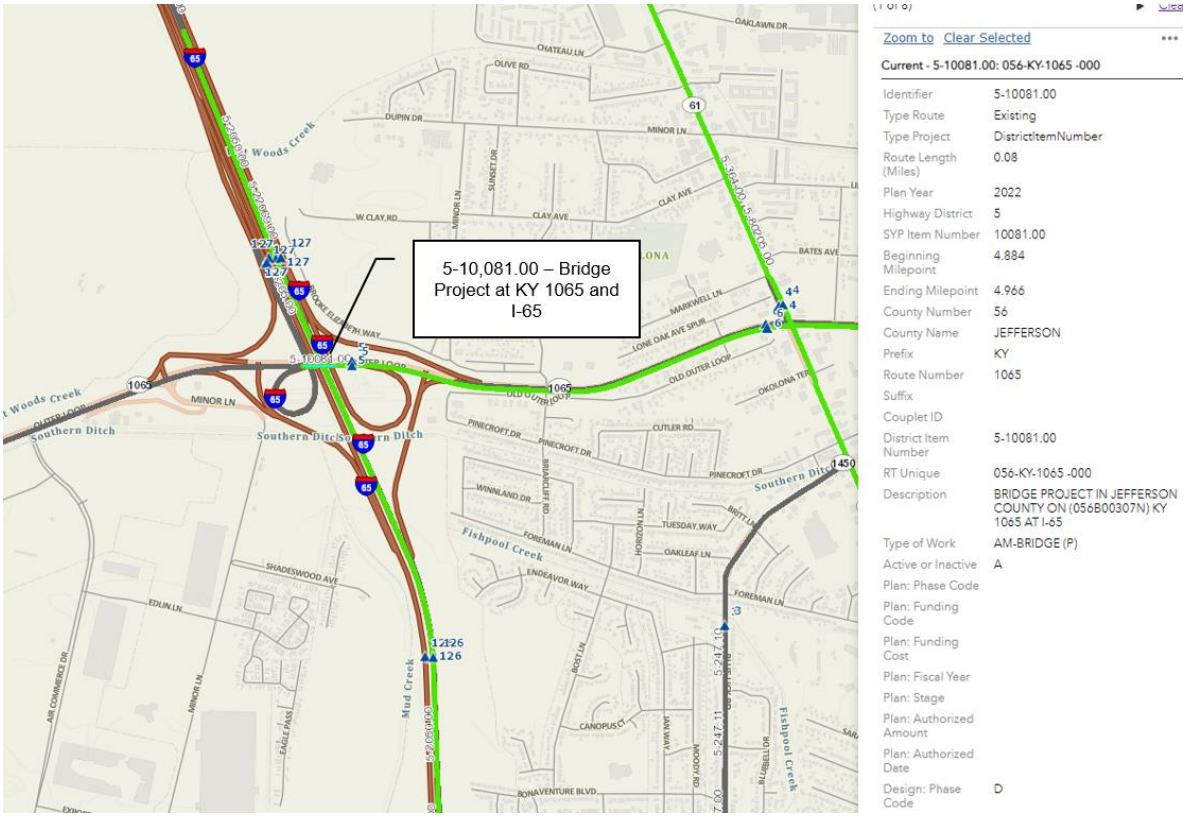
Safety	*Operations*	*Environment*	*Construction*	*Right-of-way*
	✓		✓	

VE RECOMMENDATION NO. 6: INCLUDE BRIDGE REHAB SCOPE	Idea No(s). 13

Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

There is one project, 5-10,081.00 - Bridge project in Jefferson County on KY 1065 at I-65 (056B00307N) that currently has construction funding allocated in FY 2027. If this bridge project's construction can coincide with the roadway project's, a cost sharing could be assumed for the mobilization and demobilization costs for the two projects.



Assumptions/Calculations

An assumption that both the 5-22,069 roadway project and the 5-10,081 bridge project will let in the same contract and share the mobilization and demobilization costs. The estimated cost for the Bridge project is $14,430,000, therefore assumed 3 percent cost for mobilization and demobilization for the project.

VE RECOMMENDATION NO. 6: INCLUDE BRIDGE REHAB SCOPE	Idea No(s). 13

VE Study Cost Calculations

KYTC - I-65 in Jefferson Co (5-22069)

		Baseline Concept			VE Recommended Concept		
Component	Unit	Qty	Cost/Unit	Total	Qty	Cost/Unit	Total
Bridge under 5-10.081	LS	1	$ 14,430,000	$ 14,430,000	1	$ 14,430,000	$ 14,430,000
				$ -		$ -	$ -
Subtotal Construction				*$ 14,430,000*			*$ 14,430,000*
Mark-Up (MOT, Mob., PE, CEI)	15%			$ 2,164,446	12%		$ 1,682,303
Total Construction				**$ 16,594,446**			**$ 16,112,303**
TOTAL CAPITAL COST				***$ 16,594,446***			***$ 16,112,303***
COST CAPITAL SAVINGS / (VALUE ADDED)							**$ 482,143**

VE RECOMMENDATION NO. 6	IDEA NO.		
Include Bridge Rehabilitation Scope			
PERFORMANCE MEASURES / **Attributes and Rating Rationale for Recommendation**	***Performance***	***Baseline***	***Recommendation***
Maintainability No change	***Rating***	**5**	**5**
	Weight	**40.0**	
	Contribution	**200**	**200**
Construction Impacts Impacts users once in lieu of multiple times	***Rating***	**5**	**7**
	Weight	**25.0**	
	Contribution	**125**	**175**
Project Schedule May increase project schedule Reduce overall construction time of both projects	***Rating***	**5**	**5**
	Weight	**25.0**	
	Contribution	**125**	**125**
Risk No change	***Rating***	**5**	**5**
	Weight	**10.0**	
	Contribution	**50**	**50**
Total Performance		**500**	**550**
Net Change in Performance			**10%**

VE RECOMMENDATION NO. 7: USE SMART WORK ZONE STRATEGIES	Idea No(s). 24

Baseline Concept

The current design does not consider “Smart Work Zone” strategies. Standard specs call for the use of temporary variable message signs (VMS) at the start and end of the project construction

Recommendation Concept

Use smart work zones strategies beyond standard specifications, including temporary queue detection system, temporary construction equipment alert system, temporary travel time system and temporary incident detection and surveillance system.

Advantages	Disadvantages
• Improves operations during construction • Improves communication to users • May redirect traffic and reduce conflicts • Gives real-time information for users early decisions • Improves detour performance of traffic from the northern project	• May require dedicated resources for the project to monitor and manage the system. • Increases cost

Cost Summary	Construction	Right-of-way	Total
Baseline Concept	$-		$-
Recommendation Concept	$1,952,671		$1,952,671
Cost Avoidance/(Added Value)	$(1,952,671)		$(1,952,671)

FHWA Function Benefit

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

VE RECOMMENDATION NO. 7: USE SMART WORK ZONE STRATEGIES	Idea No(s). 24

Discussion/Sketches/Photos/Calculations

Technical Discussion/Sketches

Standard specifications use variable messaging signs (VMS) installed at key locations of the project. The VE team recommends the use of strategies beyond standard specifications, to include:

Temporary Queue Detection System

System that continuously monitors traffic on the approaches to and within construction work zones to detect slowed or stopped traffic. This information is then presented to approaching motorists so they can make informed decisions. A system includes at least 1 sensor every 1mile, 1 PCMS every sensor, and an operating system.

Temporary Construction Equipment Alert System

System that delivers immediate information to motorists about construction vehicles and equipment that are entering the highway from a work zone. A system includes at least 1 sensor and at least 1 Warning device.

Temporary Travel Time System

System that continuously monitors travel times through a work zone, and then presents this information to approaching motorists so they can make informed decisions. A system includes at least 2 sensors at either end of the segment if using Bluetooth, 2 PCMS and an operating system.

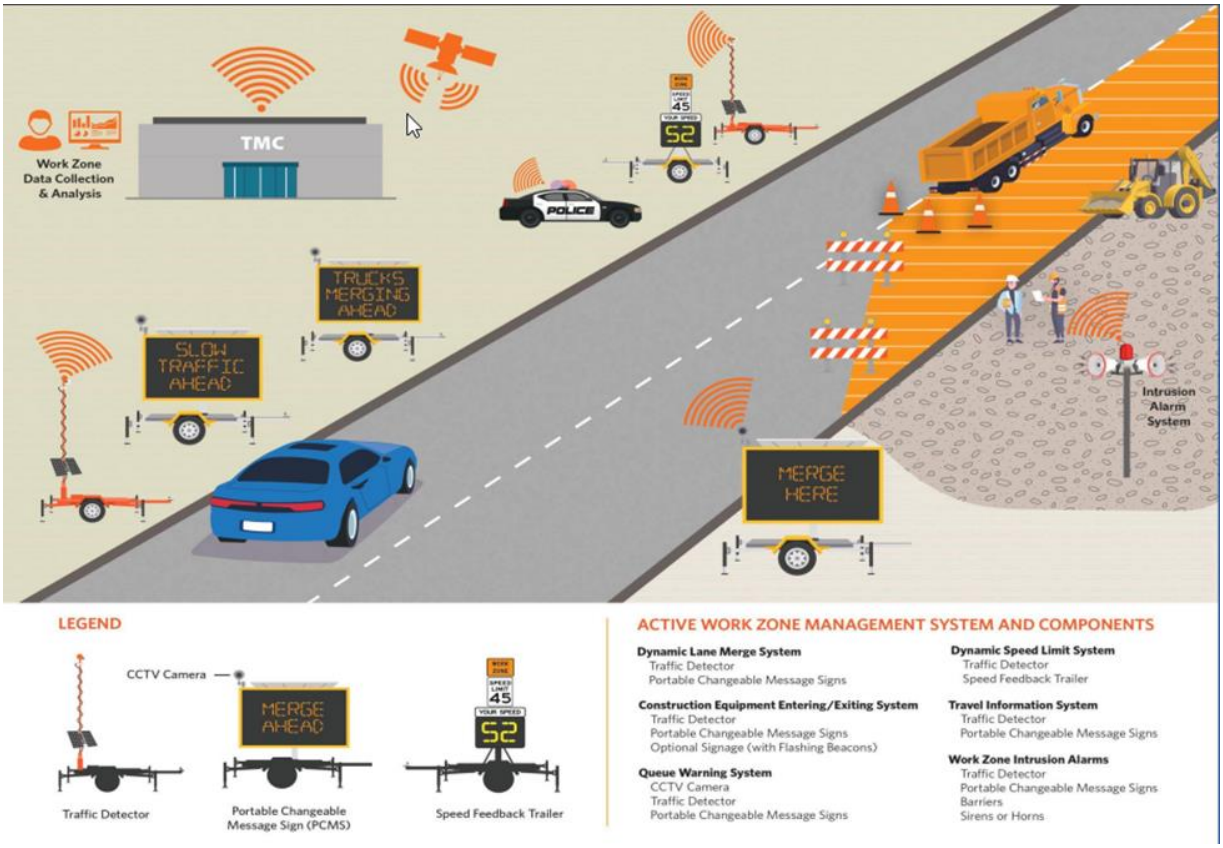
Temporary Incident Detection and Surveillance System

System that uses sensors and/or video to detect crashes and other incident conditions within a work zone and then communicates that information to a local TMC and/or to emergency response agencies. The alerts are then confirmed remotely using live streaming video, snapshots, or on-site personnel. This System can be used to provide critical information to responders who help them decide exactly what equipment to bring, how best to approach the incident, and any additional precautions that might be needed to protect themselves and the public. A system includes at least 1 sensor every 1 mile, at least 1 video imaging system and a data streaming system.

The VE team also recommends using the existing VMS system and dedicated personnel at the Louisville TRIMARC Traffic Management Center (TMC) to monitor and actively manage traffic during the construction of this project.

Below is a typical smart work zone set up depicting all systems and their interaction.

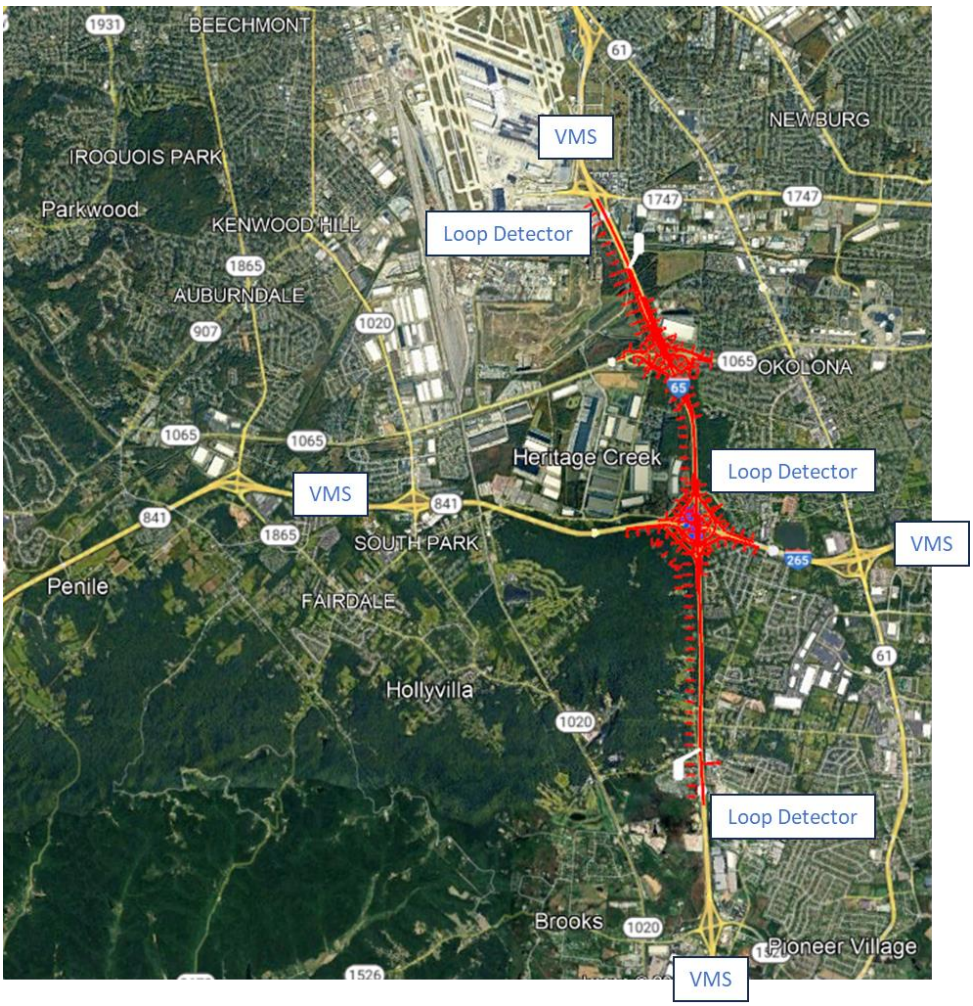
VE RECOMMENDATION NO. 7: USE SMART WORK ZONE STRATEGIES	Idea No(s). 24



Assumptions/Calculations

Below is a sketch of possible equipment and their locations.

VE RECOMMENDATION NO. 7: USE SMART WORK ZONE STRATEGIES	Idea No(s). 24



The costs were obtained from a similar system used in Texas for the TXDOT.

VE RECOMMENDATION NO. 7: USE SMART WORK ZONE STRATEGIES	Idea No(s). 24

VE Study Cost Calculations

KYTC - I-65 in Jefferson Co (5-22069)

		Baseline Concept			VE Recommended Concept		
Component	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
Queue Loop Detector	EA	0	$ 60	$ -	3	$ 60	$ 180
Queue Loop Detector Assembly	EA	0	$ 1,600	$ -	3	$ 1,600	$ 4,800
Power Supply	EA	0	$ 16,000	$ -	3	$ 16,000	$ 48,000
Temporary Movable VMS	EA	0		$ -	4	$ -	$ -
Travel Time System	EA	0	$ 800,000	$ -	1	$ 800,000	$ 800,000
Temporary Incident Detection and Surveillance System			$ 800,000	$ -	1	$ 800,000	$ 800,000
Temporary Construction Alert System	EA	0	$ 45,000	$ -	1	$ 45,000	$ 45,000
				$ -		$ -	$ -
Subtotal Construction				*$ -*			*$ 1,697,980*
Mark-Up (MOT, Mob., PE, CEI)	15%			$ -			$ 254,691
Total Construction				**$ -**			**$ 1,952,671**
Utility Costs				$ -		$ -	$ -
Right of Way Costs				$ -		$ -	$ -
TOTAL CAPITAL COST				***$ -***			***$ 1,952,671***
COST CAPITAL SAVINGS / (VALUE ADDED)							**$ (1,952,671)**

VE RECOMMENDATION NO. 7: USE SMART WORK ZONE STRATEGIES

Idea No(s). 24

VE RECOMMENDATION NO. 7	IDEA NO.		
Use Work Zone Strategies			
PERFORMANCE MEASURES / **Attributes and Rating Rationale for Recommendation**	***Performance***	***Baseline***	***Recommendation***
Maintainability No change	***Rating***	**5**	**5**
	Weight	**40.0**	
	Contribution	**200**	**200**
Construction Impacts Improves operations during construction Real time information for users to make early decision Clears incidents faster Proactive traffic management versus reactive May reduce traffic volumes by detouring traffic	***Rating***	**5**	**7**
	Weight	**25.0**	
	Contribution	**125**	**175**
Project Schedule No change	***Rating***	**5**	**5**
	Weight	**25.0**	
	Contribution	**125**	**125**
Risk Improves operations during construction Improves detour operations of adjacent job	***Rating***	**5**	**6**
	Weight	**10.0**	
	Contribution	**50**	**60**
Total Performance		**500**	**560**
Net Change in Performance			**12%**

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 9 shows the criteria used to evaluate the performance of the alternative concepts relative to the baseline concept.

Table 9. 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 10) 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 suggest which recommendations are potentially as good as, or better than, the baseline concept, in terms of overall value. Comparison at the value index level suggest which recommendations represent the best function or provide 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 in Section 7.3.

Table 10. Performance Matrix

Attribute	Attribute Weight	Concept	Performance Rating	Total Performance
Maintainability	40.0	Baseline	5	200.0
		1	5	200.0
		2	8	320.0
		3	5	200.0
		4	9	360.0
		5	5	200.0
		6	5	200.0
		7	5	200.0
Construction Impacts	25.0	Baseline	5	125.0
		1	9	225.0
		2	6	150.0
		3	6	150.0
		4	4	100.0
		5	8	200.0
		6	7	175.0
		7	7	175.0
Project Schedule	25.0	Baseline	5	125.0
		1	8	200.0
		2	7	175.0
		3	5	125.0
		4	3	75.0
		5	8	200.0
		6	5	125.0
		7	5	125.0
Risk	10.0	Baseline	5	50.0
		1	7	70.0
		2	7	70.0
		3	5.5	55.0
		4	9	90.0
		5	5.5	55.0
		6	5	50.0
		7	6	60.0

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 11. Value Index

	Recommendations	Performance (P)	% Change Performance	Cost (C) $ millions	Cost Change $M	% Change Cost	Value Index	% Value Improvement
	Baseline	500	---	$69.3	---	---	7.21	---
1	Construct Ramps First and Sync Traffic Control Plans	695	+39.0%	$69.3	$0.00	0.0%	10.03	+39%
2	Use Robust Asphalt Pavement Design	715	+43.0%	$51.7	($17.64)	-25.5%	13.84	+92%
3	Conduct Traffic Control Plans Operational Analysis	530	+6.0%	$69.4	$0.05	+0.1%	7.64	+6%
4	Reconstruct Drainage	625	+25.0%	$84.4	$15.07	+21.7%	7.41	+3%
5	Crossover Traffic to One Side and Switch Over	655	+31.0%	$62.9	($6.40)	-9.2%	10.41	+44%
6	Include Bridge Rehabilitation Scope	550	+10.0%	$68.8	($0.48)	-0.7%	7.99	+11%
7	Use Smart Work Zone Strategies	560	+12.0%	$71.3	$1.95	+2.8%	7.86	+9%

7.5 Design Considerations

The VE team generated the following design suggestions for the project design team's consideration. These items represent ideas that are general in nature and are listed below in Table 12. One idea was initially brought forward as a recommendation; however, after further evaluation, the VE team felt it should be presented to the design team for further investigation and design. The write-up for this design consideration can be found following the recommendations in Section 7.3.

Table 12. Design Considerations

Idea No.	Description
6	Use concrete overlay with bond breaker and geotextile
10	Use collector distributors (CD roads) for detours
11	Build interior lanes first (with median and shoulders if required)
16	Identify potential staging and wasting locations (KYTC, county, city, etc.) to include in specs for contract (see KY 61 / I-265 interchange)
17	Recycle concrete and asphalt on site
19	Use milestone incentives / disincentives
20	Use design build
21	Use CMGC
26	Use proof roll technique - cement stabilizer
30	Use minimum mowing strip at shoulder edge to minimize runoff pooling
32	Borrow resources (trucks and manpower) to operate leased machinery for crushing concrete
33	Incentivize contractor to use existing concrete on site.

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.

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

Pre-VE Study

Preparation Phase - 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 the information gathered prior to the VE study is given to the team members for their use.

Workshop 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.

Creativity – 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 VE 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.

Post-Study

Implementation Phase - The project team is then charged with reviewing the report and may hold a Disposition Meeting with management and other stakeholders, to determine which recommendations will be implemented in the design. The project team then tracks their implementation into the plans.

Performance-Based Value Engineering

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 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 related to improving project performance. Project costs are relatively easy to quantify and compare through traditional estimating techniques. Performance is not so easily quantifiable.

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

Performance-based VE yields the following benefits:

- Builds consensus among project stakeholders (especially those holding conflicting views)
- Develops a better understanding of a project's goals and objectives
- Develops a baseline understanding of how the project is meeting performance goals and objectives
- Identifies areas where project performance can be improved through the VE process
- Develops a better understanding of a VE alternative's effect on project performance
- Develops an understanding of the relationship between performance and cost in determining value
- Uses value as the true measurement for the basis of selecting the right project or design concept
- Provides decision-makers with a means of comparing costs and performance (i.e., costs vs. benefits) in a way that can assist them in making better decisions.

Methodology

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

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

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

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

Assumptions

Before embarking on the details of this methodology, some assumptions need to be identified. The methodology described in the following steps assumes the project functions are well established. Project functions are defined as what the project delivers to its users and stakeholders; a good reference for the project functions can be found in the environmental document's purpose and need statement. Project functions are generally well defined prior to the start of the VE study. If 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. Most 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
- Project Schedule

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.
Project Schedule	An assessment of the total project delivery as measured from the time of the VE study to completion of construction.

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

An example of this exercise is shown below.

PERFORMANCE ATTRIBUTE MATRIX

[Project Name]

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

Without emphasis on preference

A = A is of greater importance

A/B = A and B are of equal importance

For the example project above, the project owner, design team, and stakeholders determined that Main Line Operations, followed by Environmental, gave the greatest improvement relative to the projects purpose and need, while Construction Impacts and Project Schedule gave the least improvement.

Step 3 – Establish the Performance Baseline for the Original Design

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

Evaluation of Baseline Project		
Standard Performance Attribute	**Description of Attribute**	**Baseline Design Rating Rational**
Main Line Operations	An assessment of traffic operations and safety on the project. Operational considerations include level of service relative to the 20-year traffic projections as well as geometric considerations such as design speed, sight distance, lane widths, and shoulder widths.	Design Speed - __ MPH Bridge – __' Lanes, __' shoulders Roadway - __' Lanes, __' shoulders Bridge ___ Loading
Local Operations	An assessment of traffic operations and safety on the local roadway infrastructure. Operational considerations include level of service relative to the 20-year traffic projections; geometric considerations such as design speed, sight distance, lane widths; bicycle and pedestrian operations and access.	Revisions will need to be made to the existing streets and private approaches due to vertical alignment
Maintainability	An assessment of the long-term maintainability of the transportation facility(s). Maintenance considerations include the overall durability, longevity, and maintainability of pavement 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
Project Schedule	An assessment of the total project delivery from the time as measured from the time of the study to completion of construction.	Advertisement date ____ Construction start of ____ 26-month overall construction duration

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 the potential for value improvement. As discussed in Step 3, the baseline is given a rating of 5. The following ratings were used to evaluate the performance of the alternative concepts relative to the baseline concept.

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

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

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

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

- % Performance Improvement = ∆ Performance VE Strategy/Total Performance Original Concept

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	85.2
		3	4.5	63.9
Environmental Impacts	16.6	Baseline	5	83.0
		1	6.5	107.9
		2	5	83.0
		3	4.5	74.7
Construction Impacts	14.2	Baseline	5	71.0
		1	4	56.8
		2	6	85.2
		3	5	71.0
Project Schedule	11.9	Baseline	5	59.5
		1	5	59.5
		2	5	59.5
		3	5	59.5

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

The following is an example of a Value Matrix worksheet.

Recommendation Summary

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

Appendix B. VE Recommendation Approval Form

Project: I-65 from Mile Point 123.18 to Mile Point 127.57– Pavement Improvement Project – # 5-22069
VE Study Date: May 6-10, 2024

Recommendation		Approved Y/N	FHWA Functional Benefit					Estimated Cost Avoidance or (Cost Added)	Justification
			Safety	Operations	Environment	Construction	Right-of-way		
1	Construct Ramps First and Sync Traffic Control Plans					✓		$0.00	
2	Use Robust Asphalt Pavement Design			✓		✓		$17.64	
3	Conduct Traffic Control Plans Operational Analysis		✓			✓		($0.05)	
4	Reconstruct Drainage			✓				($15.07)	
5	Crossover Traffic to One Side and Switch Over		✓			✓		$6.40	
6	Include Bridge Rehabilitation Scope			✓		✓		$0.48	
7	Use Smart Work Zone Strategies		✓			✓		($1.95)	
TOTALS								$4.93	

Justification for the value engineering workshop recommendations **not** approved or implemented is provided in the table above.

The completed VE Recommendation Approval form, including justification for any recommendations not approved or modified, will be sent to the State Value Engineering Coordinator/Manager by October 1 of each year so the results can be included in the annual Value Engineering Report to FHWA.

Signature – Project Manager

Date

Name (please print)

FHWA Functional Benefit Criteria

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

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

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

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

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

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

Appendix C. VE Study Memo, Agenda, and Attendees

Memo

Date:	Tuesday, April 30, 2024
Project:	KYTC I-65 from M.P. 123.18 to M.P. 127.57 (Item No. 5-22069)
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 for working together.

If you have any questions, please contact Jose Theiler, at 561-386-3879 (jose.theiler@hdrinc.com),

VE Study Dates and Location

The VE study will be held In-Person on May 6-8, 2024 – 8:00 to 5:00 Local Time and May 10, 8:00 to 12:00 virtually using MS-Teams.

On Location **May 6-8**:	Virtually **May 10**:
200 Mero Street Frankfort, KY 40622 Conference Room 110	**Microsoft Teams** Need help? **Join the meeting now** Meeting ID: 294 595 138 081 Passcode: VMF47G **Dial-in by phone** +1 402-513-9026,,438582953# United States, Omaha (833) 255-2803,,438582953# United States (Toll-free) Find a local number Phone conference ID: 438 582 953#

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 to 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. We will use MS Teams as a holding place for conversations, notes, documentation, etc. Follow the link (I-65 Jefferson Co.) to make sure you have access and become familiar with the site.

b. 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. Please minimize disruptions by muting your phone or asking for a break.

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

d. Dress code. I want everyone to be comfortable. Please dress appropriately (business casual).

e. A laptop is required for the workshop. We will develop recommendations using Word and Excel templates 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 eight-phase VE job plan in analyzing the project. This process is recommended by SAVE International® and AASHTO, and is composed of the following phases:

Preparation Phase: The project PM, the State Value Engineer and the CVS meet to work out logistics, establish goals and objectives, and establish constraints.

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 Value Engineering 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 VE Team with any specific project constraint and commitments.
  - Q&A – Presenters answers questions from the VE Team
- Risk Assessment: the VE team leader will ask for key risks that may impact cost and schedule of the project. This information will help the VE Team 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 Team Leader/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,

- Reviews 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.

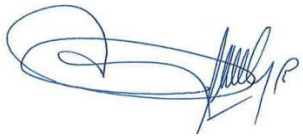
Development Phase – Those concepts that ranked highest in the evaluation are further developed into VE recommendations. Recommendation narratives, further qualify advantages and disadvantages, drawings, calculations, and lifecycle cost analysis will be prepared for each recommendation.

Presentation Phase – On the last day of the study, the VE team presents their finding during an oral presentation to the District management and the designer. Following the workshop, a written report prepared by the facilitator, summarizes the study, its findings and recommendations.

Implementation Phase – This phase is done by the project team, management and other key stakeholders using the electronic Form 2502, when disposition of recommendations are decided and later implemented into design.

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®
Principal - East Region
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, May 6, 2024 Objective for the day: Learn about VE and the Project	
8:00 *Information Phase*	• **Meet & Greet** • **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*	**Risk Elicitation**	**All audiences facilitated by** Jose Theiler, PE, CVS
10:30 *Information Phase*	**Define/Review Performance Attributes**	**All audiences facilitated by** Jose Theiler, PE, CVS
11:00 *Information Phase*	**Project Documentation Review** • Site visit observations • Review plans/schematics, cross sections, typical sections, traffic control plans, construction constraints	**VE team facilitated by** Jose Theiler, PE, CVS
12:00	**Lunch**	
01:00 *Function Analysis Phase*	**Function Analysis** • Review project cost model • Define key project functions using “verb + noun” expressions **Build a FAST diagram**	
3:00	**Break**	
03:15 *Function Analysis Phase*	**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**
05:00	**Adjourn**	

Day 2	Tuesday, May 7, 2024 Objective for the day: Function Analysis, Brainstorming Ideas, Evaluate Ideas	
08:00 *Function Analysis Phase*	**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
9:00	**Break**	
9:15 *Creative Phase*	**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
12:00	**Lunch**	
01:00 *Creative Phase*	**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
03:00	**Break**	

03:15
Evaluation 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
		VE team facilitated by
		Jose Theiler, PE, CVS

05:00	**Adjourn**	

Day 3	Wednesday, May 8, 2024 Objective for the day: Evaluate Ideas and Begin Developing	
08:00 *Evaluation Phase*	**Check-in periodically** • Technical write-up • Sketches • Life cycle cost estimate	**VE team facilitated by** Jose Theiler, PE, CVS
12:00	**Lunch**	
1:00 *Evaluation Phase*	**Check-in periodically** • Technical write-up • Sketches • Life cycle cost estimate	**VE team facilitated by** Jose Theiler, PE, CVS
03:00 *Development Phase*	**Finalize recommendations** • Peer review of recommendations	**VE team facilitated by** Jose Theiler, PE, CVS
04:00 *Development Phase*	**Evaluate performance attributes of recommendations**	**VE team facilitated by** Jose Theiler, PE, CVS
05:00 PM	**Adjourn**	

Day 4	Friday, May 10, 2024 Objective for the day: Deliver Close-out Presentation	
8:00 *Presentation Phase*	**Finalize Close-out Presentation** • Team rehearsal	**VE team facilitated by** Jose Theiler, PE, CVS
10:30 *Presentation Phase*	**Presentation / Out-brief of VE Findings** • Team presents recommendations to management • Questions and answers	**All audiences:** Project owner, management, stakeholders, designers, etc.
	Adjourn	

VE Study Attendees
I-65 from M.P. 123.18 to M.P. 127.57 (5-22069)

May 2024					NAME	ORGANIZATION – POSITION/DISCIPLINE	EMAIL	PHONE
6	7	8	9	10				
✓	✓	☎	☎	☎	Gearlds, Kevin	HDR – Construction	Kevin.Gearlds@hdrinc.com	859-230-0497
✓				☎	Johannes, Andre A	KYTC – Project Manager	Andre.Johannes@ky.gov	502-564-3280
✓	✓	☎	☎	☎	Kuntz, Chris	HDR – SME	Chris.Kuntz@hdrinc.com	270-538-1527
✓				☎	Mills, Ross	KYTC – Project Manager	Ross.Mills@ky.gov	502-564-3280
✓	✓	☎	☎	☎	Southworth, Wendy L	KYTC – VE Coordinator	Wendy.Southworth@ky.gov	502-564-3280
✓	✓	☎	☎	☎	Theiler, Jose	HDR – CVS VE Facilitator	jose.theiler@hdrinc.com	561.386.3879
✓	✓	☎	☎	☎	Walker, Kevin	HDR – Pavement	Kevin.Walker@hdrinc.com	270-538-1534
✓	✓	☎	☎	☎	Wallace, Chad	HDR – VMA Team Assistant	chad.wallace@hdrinc.com	601-673-7238
✓				☎	Brad Frazier	KYTC – Highway Design – D7	Brad.Frazier@ky.gov	502-564-3280
✓				☎	Blake Nelson	KYTC – District 5 – Proj Delivery & Preservation	blake.nelson@ky.gov	502-751-8374
☎				☎	Jason Bricker	Stantec – Design Team	jason.bricker@stantec.com	
✓				☎	Glenn Hardin	Stantec – Design Team	glenn.hardin@stantec.com	
				☎	Matt Bullock	KYTC – District 5 – Chief District Engineer	matt.bullock@ky.gov	502-210-5485
				☎	Tim Layson	KYTC – Director of Highway Design	tim.layson@ky.gov	502-564-3280

Appendix D. Project Estimate

Item Description	Category	Quantity	Unit Price	Extension
DGA BASE	Pavement	1734	$ 44.17	$ 76,582.20
CRUSHED STONE BASE	Pavement	221611	$ 25.80	$ 5,718,315.06
CRUSHED AGGREGATE SIZE NO 2	Pavement	100	$ 73.04	$ 7,304.04
ASPHALT SEAL AGGREGATE	Pavement	1059	$ 80.57	$ 85,323.01
ASPHALT SEAL COAT	Pavement	127	$ 711.29	$ 90,334.16
LEVELING & WEDGING PG64-22	Pavement	50	$ 90.73	$ 4,536.72
CL4 ASPH BASE 1.50D PG64-22	Pavement	98940	$ 100.00	$ 9,894,000.00
CL3 ASPH BASE 1.00D PG64-22	Pavement	63734	$ 100.00	$ 6,373,400.00
CL4 ASPH BASE 1.00D PG64-22	Pavement	76953	$ 100.00	$ 7,695,300.00
CL4 ASPH BASE 1.00D PG76-22	Pavement	76953	$ 100.00	$ 7,695,300.00
CL4 ASPH SURF 0.38A PG76-22	Pavement	46637	$ 130.00	$ 6,062,810.00
REMOVE CURB	Demo	2036	$ 6.28	$ 12,788.87
DELINEATOR FOR GUARDRAIL MONO DIRECTIONAL WHITE	Guardrail	28	$ 12.56	$ 351.72
REMOVE PCC PAVEMENT	Pavement Removal	565302	$ 26.00	$ 14,697,852.00
ROADWAY EXCAVATION	Earthwork	117771	$ 30.00	$ 3,533,130.00
GUARDRAIL END TREATMENT TYPE 1	Guardrail	18	$ 3,510.29	$ 63,185.25
GUARDRAIL END TREATMENT TYPE 2A	Guardrail	9	$ 1,097.21	$ 9,874.89
REMOVE GUARDRAIL	Guardrail	2512.5	$ 2.76	$ 6,930.93
REMOVE & RESET GUARDRAIL	Guardrail	1442.5	$ 16.80	$ 24,237.95
CHANNEL LINING CLASS III	Erosion Control	22	$ 92.73	$ 2,040.17
TEMPORARY SIGNS	MOT	5000	$ 9.54	$ 47,675.65
MAINTAIN & CONTROL TRAFFIC	MOT	1	$ 1,000,000.00	$ 1,000,000.00
PORTABLE CHANGEABLE MESSAGE SIGN	MOT	6	$ 3,600.42	$ 21,602.53
ARROW PANEL	MOT	4	$ 1,208.01	$ 4,832.03
FLEXIBLE DELINEATOR POST-M/W	pavement marking	758	$ 54.37	$ 41,210.10
FLEXIBLE DELINEATOR POST-M/Y	pavement marking	641	$ 55.00	$ 35,255.00
STEEL POST MILE MARKERS	pavement marking	8	$ 343.62	$ 2,748.95
PAVE STRIPING-TEMP PAINT-6 IN	pavement marking	417564	$ 0.21	$ 86,936.82
PAVE STRIPING-THERMO-6 IN W	pavement marking	148638	$ 1.05	$ 156,542.57
PAVE STRIPING-THERMO-6 IN Y	pavement marking	96984	$ 1.06	$ 103,222.98
PAVE STRIPING-THERMO-12 IN W	pavement marking	24327	$ 2.28	$ 55,465.56
PAVE MARKING-THERMO STOP BAR-12IN	pavement marking	48	$ 9.92	$ 476.27
INLAID PAVEMENT MARKER-B W/R	pavement marking	2761	$ 27.55	$ 76,054.37
FUEL ADJUSTMENT	Contingency	646932	$ 1.00	$ 646,932.00
ASPHALT ADJUSTMENT	Contingency	1424670	$ 1.00	$ 1,424,670.00
JOINT ADHESIVE	Pavement	246000	$ 0.32	$ 78,346.08
OBJECT MARKER TY 3	pavement marking	19	$ 52.25	$ 992.68
SHOULDER RUMBLE STRIPS-SAWED	Pavement	192411	$ 0.11	$ 20,262.80
LAW ENFORCEMENT OFFICER	MOT	300	$ 74.14	$ 22,240.59
G/R STEEL W BEAM-S FACE (7 FT POST)	Guardrail	1937.5	$ 37.78	$ 73,192.96
CONCRETE WEDGE CURB	Curb & Gutter	2036	$ 19.16	$ 39,006.91
PAVE MARK THERMO CHEVRON	pavement marking	4364	$ 5.32	$ 23,220.80
PAVE MOUNT INFRARED TEMP EQUIPMENT	Mobilization	18860976	$ 0.01	$ 245,192.69
ASPHALT MATERIAL FOR TACK NON-TRACKING	Pavement	536	$ 131.70	$ 70,591.20
MOBILIZATION	Mobilization	1	$ 1,989,908.06	$ 1,989,908.06
DEMOBILIZATION	Mobilization	1	$ 994,954.03	$ 994,954.03
				$ 69,315,130.60

Appendix E. Performance Criteria Rating

Criteria	Definition	Rating Scale	Unit of Measure/Quantification	Base Evaluation
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.	10		
		9	Very low maintenance	
		8		
		7	Similar maintenance to the existing facility when it was in like new condition	
		6		
		5	Similar maintenance to the existing facility in existing condition	
		4		
		3	Maintainability is significantly increased over the existing facility when it was in like new condition	
		2		
		1		
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.	10	No impacts	
		9	Minor impacts (i.e., noise, vibration, dust, or visual, requiring limited mitigation effort)	
		8		
		7	Minor impacts (i.e., minor traffic delays, occasional temporary nighttime lane closures, etc.)	
		6	Ramp closures of up to 30 days with acceptable detours	
		5	Moderate impacts (i.e., noise, vibration, dust, or visual, requiring significant mitigation efforts and/or inconveniences to the public)	
		4	Moderate impacts (i.e., multiple minor traffic delays, lengthy detours for ramp closures up to 45 days, extended temporary night closures, etc.)	
		3	Major impacts (i.e., noise, vibration, dust, or visual, requiring substantial mitigation efforts and/or inconveniences to the public with lengthy detours for ramp closures up to 60 days	
		2	Major impacts (i.e., noise, vibration, dust, or visual, requiring substantial mitigation efforts and/or inconveniences to the public with lengthy detours for ramp closures up to 90 days	

Criteria	Definition	Rating Scale	Unit of Measure/Quantification	Base Evaluation
		1	Major impacts (i.e., noise, vibration, dust, or visual, requiring substantial mitigation efforts and/or inconveniences to the public with lengthy detours for ramp closures up to 120 days	
Schedule	An assessment of whether the schedule of the project, from the time of the study through open to traffic, is conservative or has no remaining positive float and activities are already critical. Consideration should be given to whether the project is a critical component of program of projects or a corridor and its implementation may impact the network operations performance.	10	No dependencies and ample positive float	
		9		
		8	Moderate float available	
		7		
		6	Little (under 30 days) or no float remaining	
		5		
		4	Project is super critical. Other projects depend on the implementation of this project	
		3		
		2	Significant risks threaten the ability to deliver the project on time, schedule is too aggressive and is unlikely to be met.	
		1	Network Operations are severely threatened if project is not delivered on time. Commitments are broken.	
Risk	.	10		
		9		
		8		
		7		
		6		
		5		
		4		
		3		
		2		
		1		

Appendix F. Closing Presentation

KENTUCKY TRANSPORTATION CABINET

1

VALUE ENGINEERING STUDY

I-65 – Station 1772+99.59 (M.P. 123.18) to 2004+97.74 (M.P. 127.57) May 6-10, 2024

KENTUCKY TRANSPORTATION CABINET

HDR

2

VE Team

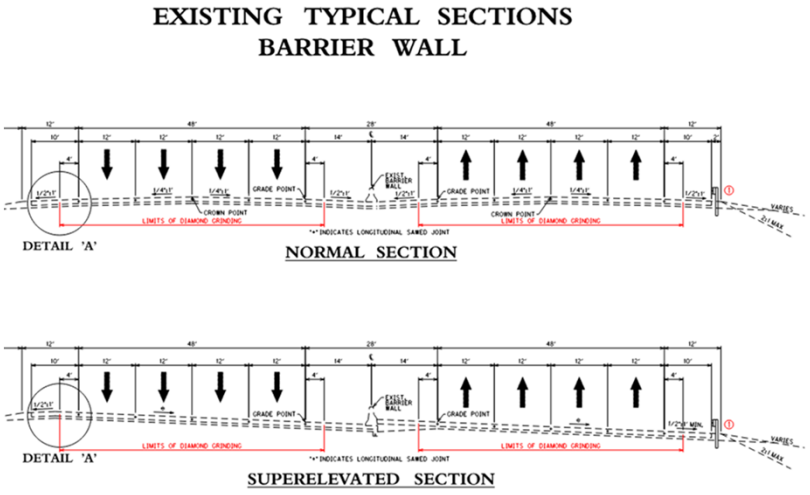
- Kevin Gearlds, PE, HDR
- Chris Kuntz, PE, HDR
- Wendy Southworth, PE, KYTC
- Jose Theiler, PE, CVS, HDR
- Kevin Walker, PE, HDR
- Chad Wallace, PE, HDR

3

Project Information

Existing Facility

- Six 12-ft lanes for first 1.2 miles with drainage to grassed median ditch
- Eight 12-ft lanes through north of I-265, full depth paved inside and outside shoulders
- Twelve 12-ft lanes barrier separated for the remainder of the project, full depth inside and outside shoulders
- Sloped 28-ft barrier-divided median
- 11-in concrete pavement over DGA
- Poor pavement condition



4

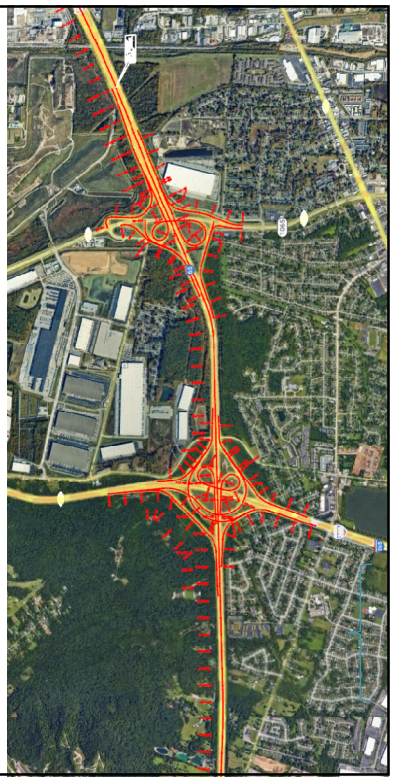
Project Information

Limits I-65 – Station 1772+99.59 (M.P. 123.18)
to 2004+97.74 (M.P. 127.57)

Project Length 4.4 miles

Proposed Facility

- Reconstruct through lanes and ramps with asphalt pavement
- Asphalt pavement design assumed similar to adjacent project
- No capacity improvements
- No changes to alignment
- Preserve median barrier and shoulders
- Preserve drainage



5

Objective of the VE study

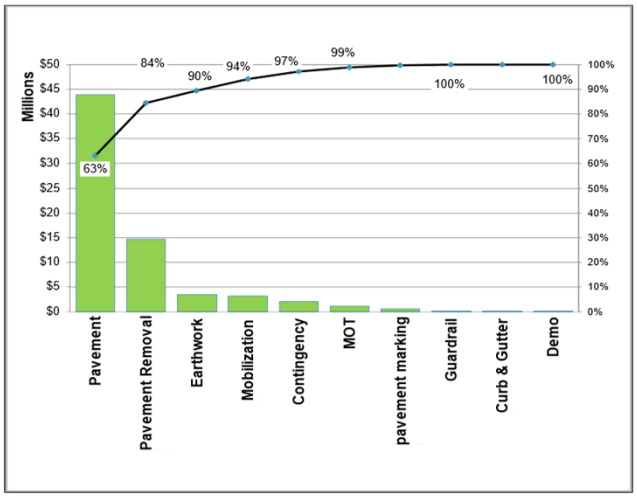
The objective of the VE team is to **validate or improve** on the various concepts for the I-65 project, through the application of the VE job plan.

"Achieve essential functions at lowest life-cycle cost consistent with required performance, quality, reliability, and safety"

6

Cost Model

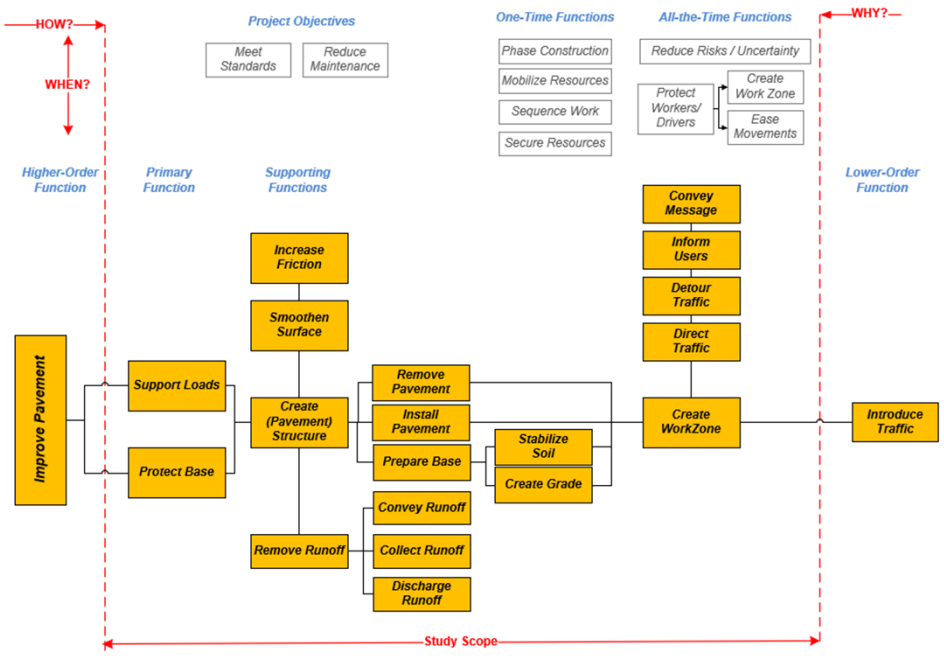
Description	Amount
Pavement	$ 43,872,405.27
Pavement Removal	$ 14,697,852.00
Earthwork	$ 3,533,130.00
Mobilization	$ 3,230,054.78
Contingency	$ 2,071,602.00
MOT	$ 1,096,350.80
pavement marking	$ 582,126.10
Guardrail	$ 177,773.70
Curb & Gutter	$ 39,006.91
Demo	$ 12,788.87
Erosion Control	$ 2,040.17
Total Cost	**$ 69,315,130.60**



7

Function Analysis System Technique (FAST) Diagram

FAST DIAGRAM
I-65 from I-65 M.P. 123.18 to M.P. 127.57



8

Evaluation Process – Tier 1

Idea No.	Description	
2	Use modified pavement design	
	Advantages	**Disadvantages**
	• Improve resiliency • Improve long-term performance • Reduce costs	• May increase costs • May increase schedule
	Rating:	***Justification/Comments/Disposition:***
	3	*Brought forward as Recommendation No. 2*

0-Unacceptable Impact / Fatal Flaw

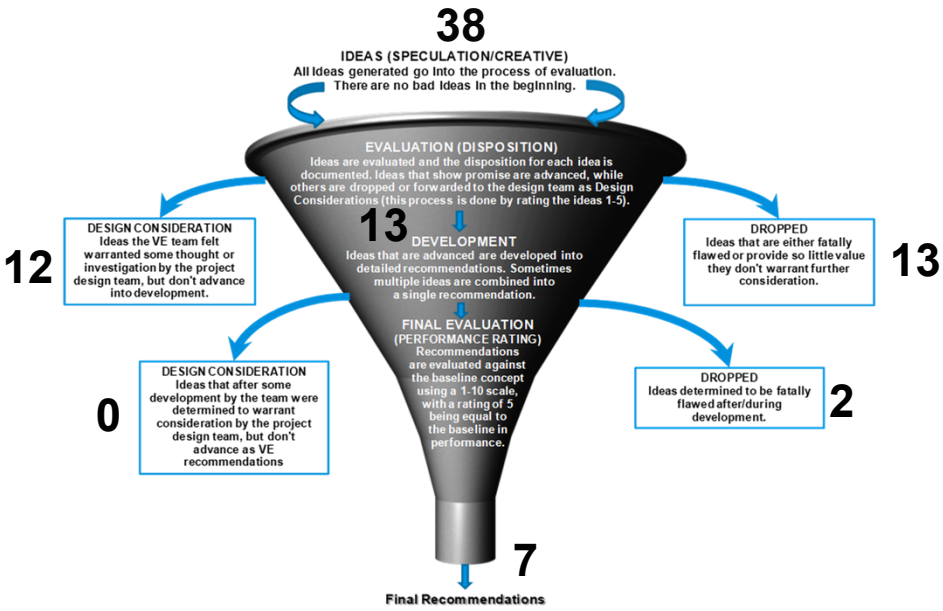
1-Poor Opportunity

2-Good idea for design team to pursue

3-Good Opportunity

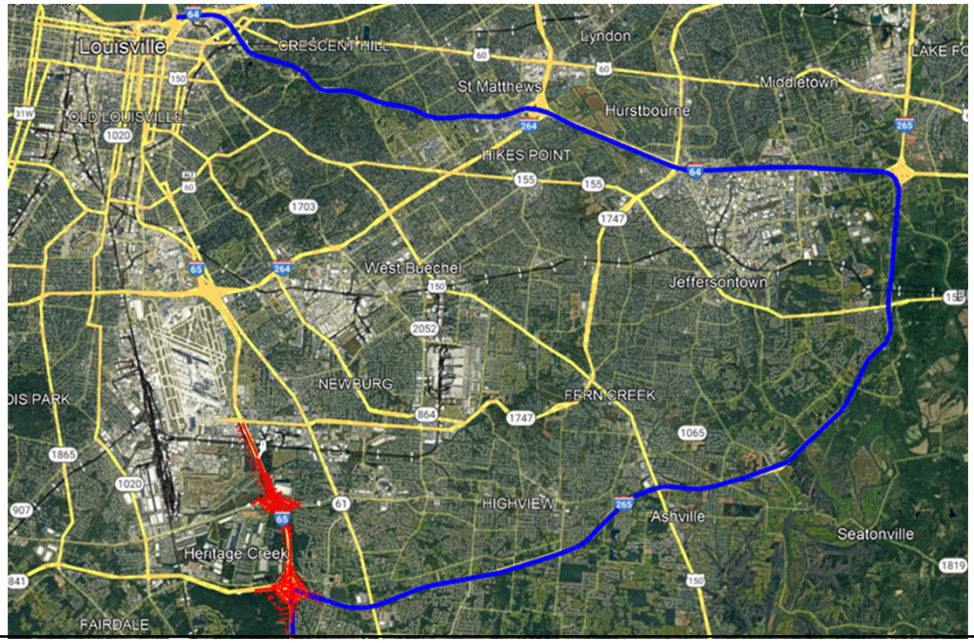
9

Evaluation Process – Tiered Approach



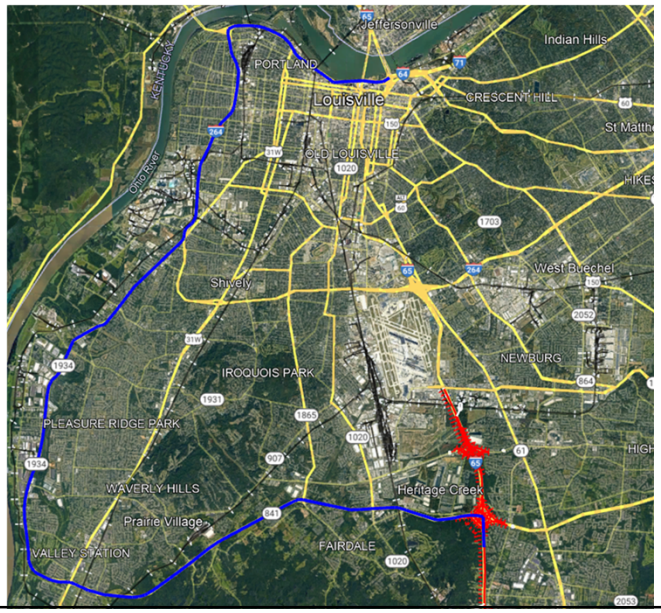
10

Construct Ramps First and Sync Traffic Control Plans with I-65 Central Corridor Project



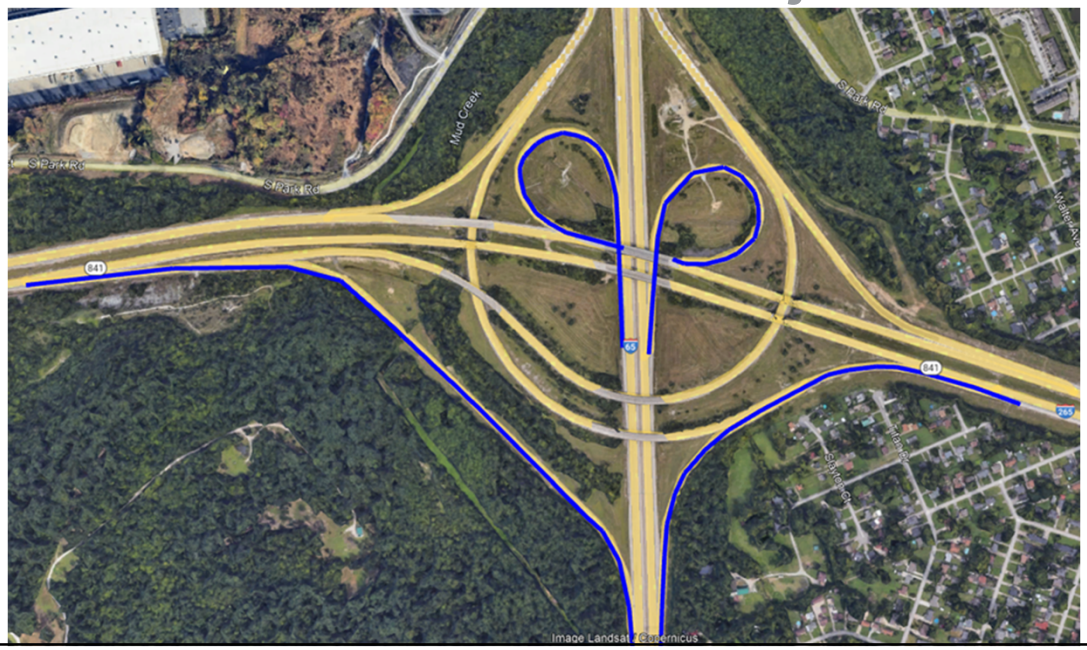
11

Construct Ramps First and Sync Traffic Control Plans with I-65 Central Corridor Project



12

Construct Ramps First and Sync Traffic Control Plans with I-65 Central Corridor Project



13

Use Robust Asphalt Pavement Design

14

Use Robust Asphalt Pavement Design

Driving Lane Material Selection

Thickness	Item Code	Description
1.5	00342	CL4 ASPH SURF 0.38A PG76-22
		Polish-resistant type A is correct.
3.5	00219	CL4 ASPH BASE 1.00D PG76-22
4	00217	CL4 ASPH BASE 1.00D PG64-22
	0	None
4	00018	DRAINAGE BLANKET-TYPE II-ASPH
6	00001	DGA BASE
8	00008	CEMENT STABILIZED ROADBED
	02542	CEMENT

15

Use Robust Asphalt Pavement Design

LIFE CYCLE COST ANALYSIS*

Maximum Asphalt Design

FLEXIBLE PAVEMENT

ONE OR TWO DIRECTIONS: 1

ANALYSIS PERIOD (YEARS): 40

CONSTRUCTION YEAR:

MAINT.OF TRAFFIC($/MILE): 10000 Init. Const.

COST on MAINT.OF TRAFFIC: $10,000.00 Init. Const.

Analysis DATE: 2024-05-08

Design CBR 4 Design MR

9 in. ASPHALT PAVEMENT

4 in. DRAINAGE BLANKET

6 in. Aggregate Base

1 MILES (LENGTH OF PROJECT)

5000 Rehabilitation

$5,000.00 Rehabilitation

'E - These analyses compare only the pavement types and Maintenance of Traffic. They are not total project costs.

NOMIC ANALYSIS Maximum Asphalt Design

EAR		INTEREST	P/F	COST	PW
0	PW OF INITIAL CONSTRUCTION	4	1.00	$421,918.28	$355,339.41
10	PW OF REHABILITATION	4	0.68	$72,128.86	$48,727.68
20	PW OF REHABILITATION	4	0.46	$72,128.86	$32,918.67
30	PW OF REHABILITATION	4	0.31	$72,128.86	$22,238.68
40	PW OF SALVAGE	4	0.21	$200,685.06	

vage Values are considered equivalent and are currently not included in Life Cycle Cost Analysis

PW OF Maximum Asphalt Design $459,224.41

Lane miles calculation	565,302 SY	7040 SY/LM	80.30 LM
Asphalt Cost per LM	$43,873,088	80.30 LM	$546,374.40

16

Conduct Traffic Control Plans Operational Analysis

17

Conduct Traffic Control Plans Operational Analysis

Main findings of the analysis show:

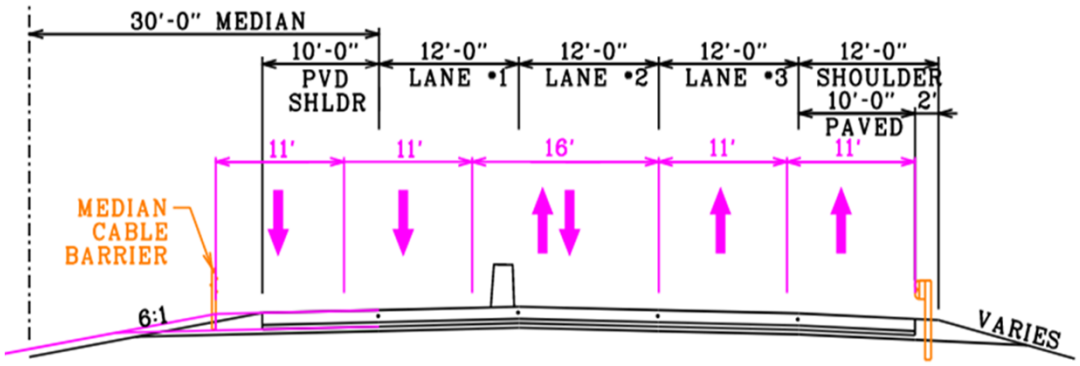
- North of I-265
  - Projected 2025 Volumes: AADT = 148,000 vpd; DHV = 7,950 vph in peak direction
  - **6 Lane to 2 Lane**: **Over Capacity**; d/c = 2.00; Queue after 1 Hour = 7+ miles
  - **6 Lane to 3 Lane**: **Over Capacity**; d/c = 1.26; Queue after 1 Hour = 4+ miles
  - **6 Lane to 4 Lane**: **Stable**, d/c = 0.94; **No Queuing**
- South of I-265
  - Projected 2025 Volumes: AADT = 114,500 vpd; DHV = 5,325 vph in peak direction
  - **4 Lane to 2 Lane**: **Over Capacity**; d/c = 1.36; Queue after 1 Hour = 5+ miles
  - **4 Lane to 3 Lane**: **Stable**, d/c = 0.90; **No Queuing**
  - **3 Lane to 2 Lane**: **Over Capacity**; d/c = 1.34; Queue after 1 Hour = 10+ miles

18

Crossover Traffic to One Side and Switch Over

19

Crossover Traffic to One Side and Switch Over



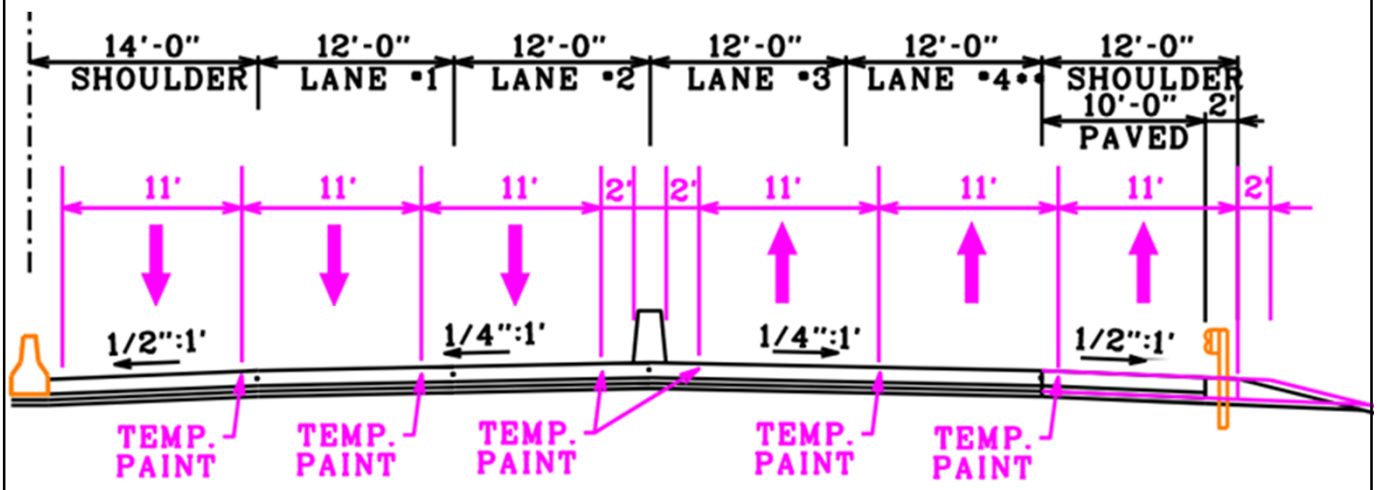
I-65 CONSTRUCTION
3-LANE SECTION - DEPRESSED MEDIAN
ZIPPER BARRIER

20

Crossover Traffic to One Side and Switch Over

21

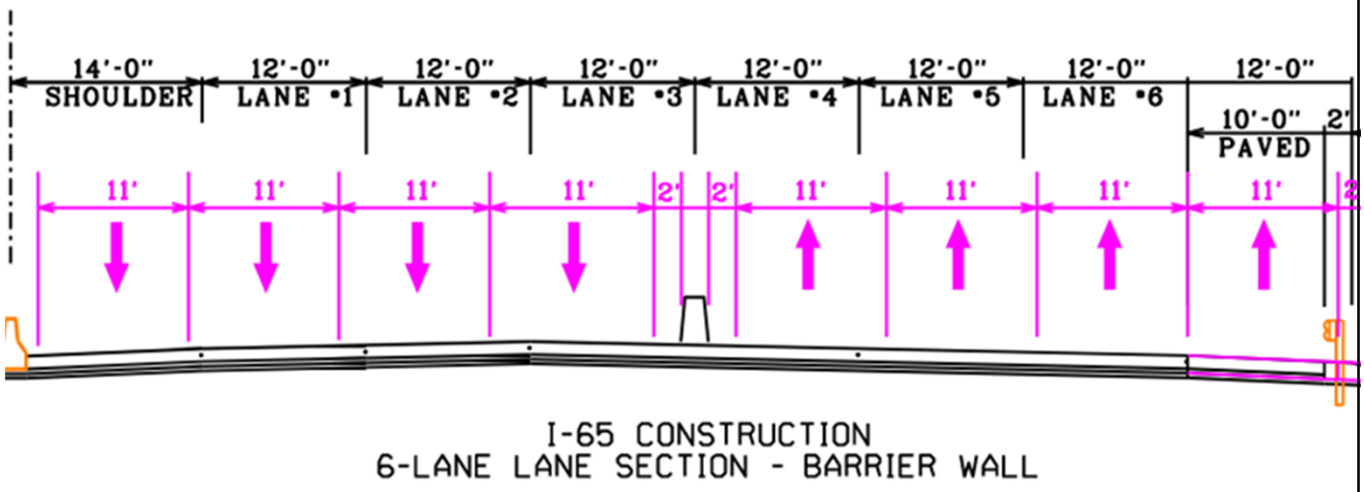
Crossover Traffic to One Side and Switch Over



PHASE III - I-65 CONSTRUCTION
4-LANE LANE SECTION - BARRIER WALL

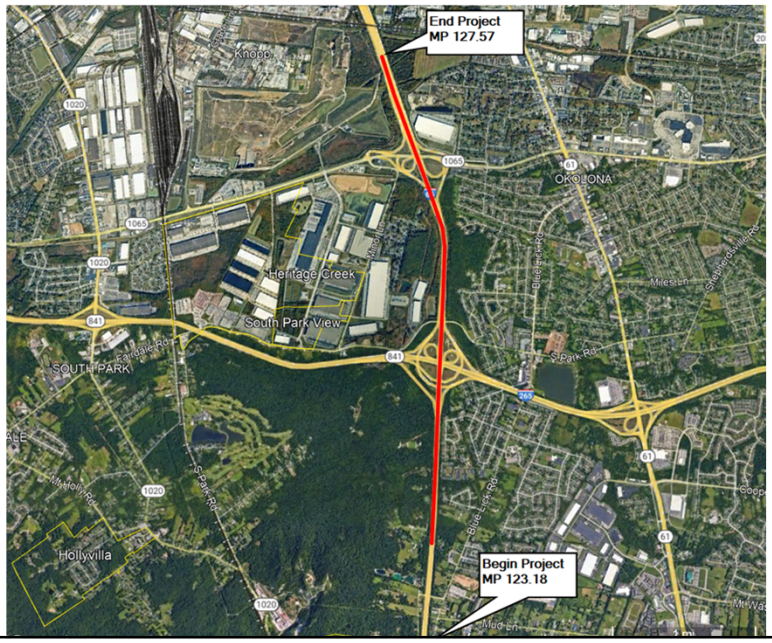
22

Crossover Traffic to One Side and Switch Over



23

Reconstruct Drainage



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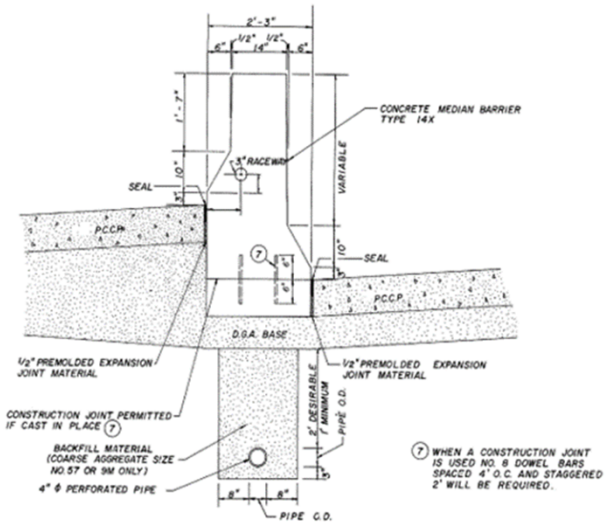
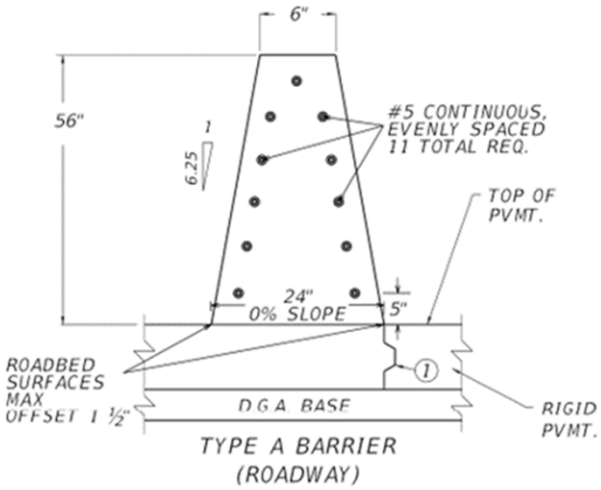
Reconstruct Drainage

Existing Barrier Wall with Drainage



Proposed Barrier Wall



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Reconstruct Drainage

26

Include Bridge Rehab Scope

Current - 5-10081.00: 056-KY-1065 -000

Identifier	5-10081.00
Type Route	Existing
Type Project	DistrictItemNumber
Route Length (Miles)	0.08
Plan Year	2022
Highway District	5
SYP Item Number	10081.00
Beginning Milepoint	4.884
Ending Milepoint	4.966
County Number	56
County Name	JEFFERSON
Prefix	KY
Route Number	1065
Suffix	
Couplet ID	
District Item Number	5-10081.00
RT Unique	056-KY-1065 -000
Description	BRIDGE PROJECT IN JEFFERSON COUNTY ON (056B00307N) KY 1065 AT I-65
Type of Work	AM-BRIDGE (P)
Active or Inactive	A
Plan: Phase Code	
Plan: Funding Code	
Plan: Funding Cost	

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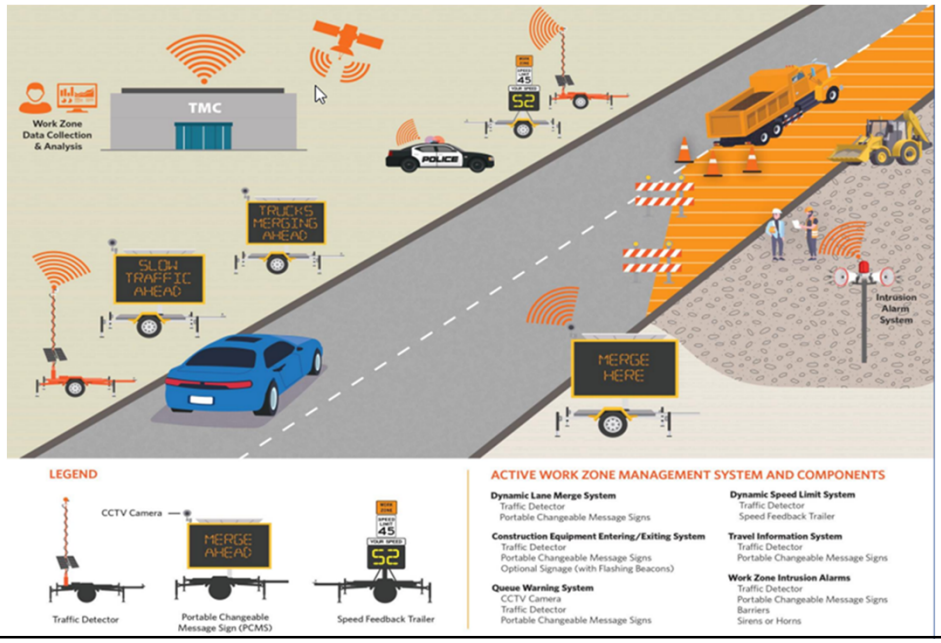
Use Smart Work Zone Strategies



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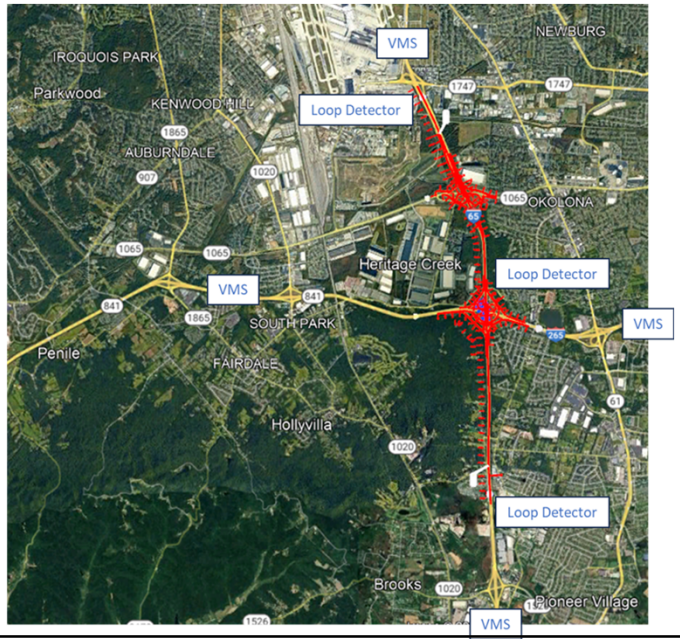
Use Smart Work Zone Strategies



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Design Considerations

Idea #	Idea Description
6	Use concrete overlay with bond breaker and geotextile
10	Use collector distributors (CD roads) for detours
11	Build interior lanes first (with median and shoulders if required)
16	Identify potential staging and wasting locations (KYTC, county, city, etc.) to include in specs for contract (see KY 61 / I-265 interchange)
17	Recycle concrete and asphalt on site
19	Use milestone incentives / disincentives
20	Use design build
21	Use CMGC
26	Use proof roll technique - cement stabilizer
30	Use minimum mowing strip at shoulder edge to minimize runoff pooling
32	Borrow resources (trucks and manpower) to operate leased machinery for crushing concrete
33	Incentivize contractor to use existing concrete on site.

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Evaluation Process – Tier 2

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.

Performance-based VE

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

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Performance Attributes

Evaluation Criteria		
Performance Attribute	**Description**	**Baseline**
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 pavement • Retain shoulders and not reconstruct drainage
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.	• Maintain 2 lanes of traffic • Standard MOT to construct one lane at a time • Undetermined stagging locations • Restricted work Nov-1 / Mar-31 • Directional Traffic 60/40 • Speed limit: 55 MPH • I-65 bridge project to the north- MOT conflicts
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.	• Design: 8 to 12 months from NTP • Letting: Winter 2025 • Construction duration: 2 seasons
Risk	An assessment of risk events and uncertainties impacting cost and schedule of the project.	• Pavement failure if drainage is not reconstructed • I-65 bridge project may delay project completion by 1 to 2 seasons

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Performance Attributes

Performance Attributes Criteria Matrix						
Paired Comparison					Total points	% of Total
Maintainability	A	A	A	A	4.0	40%
Construction Impacts		B	B/C	B	2.5	25%
Project Schedule			C	C	2.5	25%
Risk				D	1.0	10%

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VE Summary

Value Index = Performance / Cost

Value Index								
Recommendations		Performance (P)	% Change Performance	Cost (C) $ millions	Cost Change $ millions	% Change Cost	Value Index	% Value Improvement
	Baseline	500	---	$69.3	---	---	7.21	---
1	Construct Ramps First and Sync Traffic Control Plans	695	+39.0%	$69.3	$0.00	0.0%	10.03	+39%
2	Use Robust Asphalt Pavement Design	715	+43.0%	$51.7	($17.64)	-25.5%	13.84	+92%
3	Conduct Traffic Control Plans Operational Analysis	530	+6.0%	$69.4	$0.05	+0.1%	7.64	+6%
4	Reconstruct Drainage	625	+25.0%	$84.4	$15.07	+21.7%	7.41	+3%
5	Crossover Traffic to One Side and Switch Over	655	+31.0%	$62.9	($6.40)	-9.2%	10.41	+44%
6	Include Bridge Rehabilitation Scope	550	+10.0%	$68.8	($0.48)	-0.7%	7.99	+11%
7	Use Work Zone Strategies	560	+12.0%	$71.3	$1.95	+2.8%	7.86	+9%

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Jose Theiler, PE, CVS®
Chad Wallace, PE

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