Value Engineering Study Report

I-71 Pavement Rehabilitation

Items No. 5-22100, 6-22101, 6-20020

Trimble and Carroll Counties, Kentucky

Workshop Dates: July 14 – 18, 2025

Report Date: January 28, 2026

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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, alternatives and findings should be reevaluated as new information is received.

All costs displayed in the report are based on the best available information at the time of the study and, unless otherwise noted, used the parametric estimates 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 alternatives 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 alternatives 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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Executive Summary

Introduction

This report summarizes the events and results of the virtual VE study conducted by HDR Engineering, Inc. for the Kentucky Transportation Cabinet (KYTC) on I-71 pavement rehabilitation project in Trimble and Carroll Counties, Kentucky (Item No. 5-22100, 6-22101, 6-20020). The VE study consisted of a 5-day workshop that was conducted virtually with a multidisciplinary team on July 14 – 18, 2025.

Baseline Project Overview

KYTC is proposing to address long-term maintenance concerns with this segment of I-71. At the time of the VE Study, the project was in pre-design with limited information on the project scope and design development having been developed. A summary of the project and pre-design work is provided below:

- Mainline limits of project: MP 38.086 (Henry County Line) to MP 53.433 (Gallatin County Line)
- Mainline typical sections within the project limits:
    - 2- 12’ Mainline Travel Lanes, 12’ (10’ Paved) Outside Shoulders, 6’ (3’ Paved) Inside Shoulders, and a Depressed Median
    - Bifurcated 2- 12’ Mainline Travel Lanes, 12’ (10’ Paved) Outside Shoulders, and 6’ (3’ Paved) Inside Shoulders
- All existing pavement is asphalt.
    - Travel Lanes consist of 9” Asphalt on 10” Broken & Seated PCCP on 6” DGA
- KYTC has done pavement repairs as much as 3’ deep. Between Exit 40 and Exit 42 there are several locations where pavement repairs have been completed yearly. During repairs, traffic was closed to 1 lane with observed queueing of 5-7 miles long.

VE Study Objectives and Timing

The primary objective of the VE study was to utilize the VE methodology to analyze the I-71 pavement rehab project in order to accomplish the following:

- Establish/validate the project’s purpose and need
- Objectively evaluate preliminary project alternatives
- Identify and evaluate additional alternatives

To accomplish this, the VE team employed the following:

- Performed pre-workshop sessions with the project team to help define project priorities, constraints, and controlling decisions
- Conducted a thorough review and analysis of the key project issues using a multidiscipline, cross-functional team
- Objectively evaluated preliminary project alternatives using Value Metrics
- Improved the value of the project through innovative measures aimed at improving the functional performance of the project
- Used a “fresh set of eyes” to identify new/innovative approaches focused on providing a balanced multimodal solution
- Evaluated the baseline project and VE Alternatives based upon their ability to satisfy the project’s purpose and need

Value Opportunities / VE Focus points

The items listed below are the drivers, constraints, or issues identified during the VE team’s analysis of the Baseline Concept and considered during this VE study as opportunities to identify possible value enhancements.

- Pavement Rehab Strategies
  - Pavement rehab to achieve minimum pavement life expectancy
  - Additives and Structural Enhancements to Asphalt Structural Section
  - Full-depth pavement rehab (includes exposing to crack and seat concrete layer)
- Maintenance of Traffic (MoT) Strategies
  - Nighttime Lane Closures
  - Full Lane Closures during non-peak / weekday times
  - Temporary Widening and Avoiding Bridges
  - Full Lane(s) Widening and Bridge Widening
- Operational Improvements
  - Additional benefits based on MoT Strategy and reducing throw-away
  - Accommodation / Readiness for future widening

VE Alternatives

The VE team generated 20+ ideas for the project. The concepts that performed the best were further developed by the VE team and resulted in 9 VE Alternatives being developed. The cost and performance trade-offs for each VE alternative are summarized below in Table 1; the developed information about each is included in the Development section of this report.

The Performance Attribute Legend is as follows:

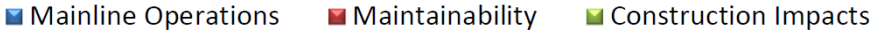
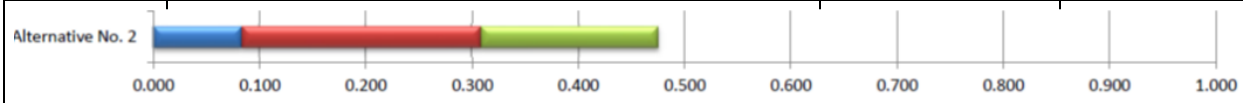
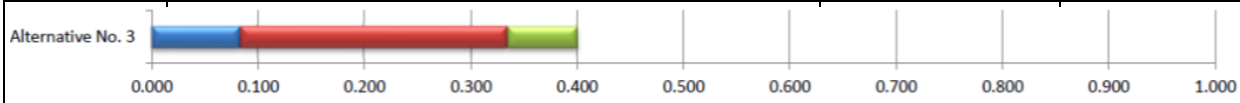
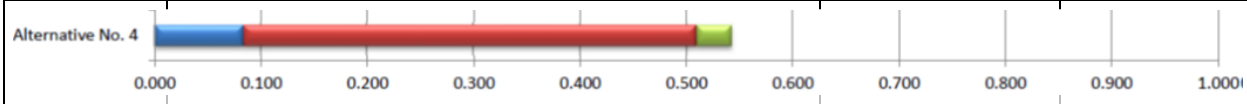
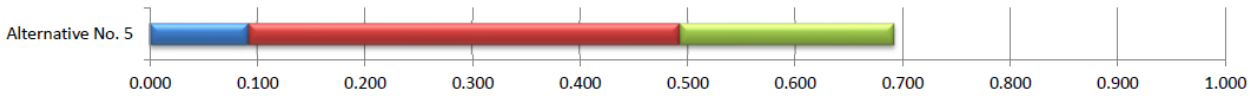
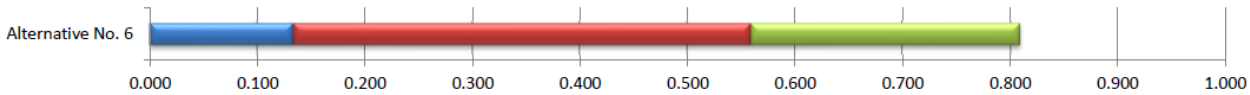
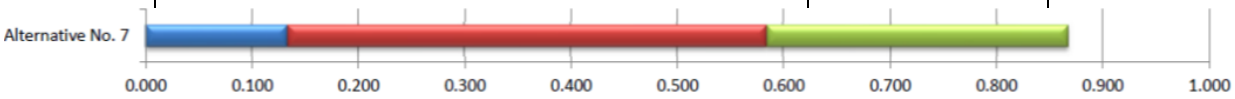
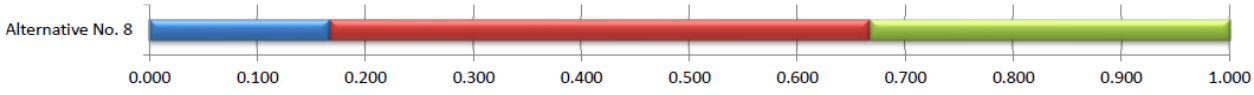
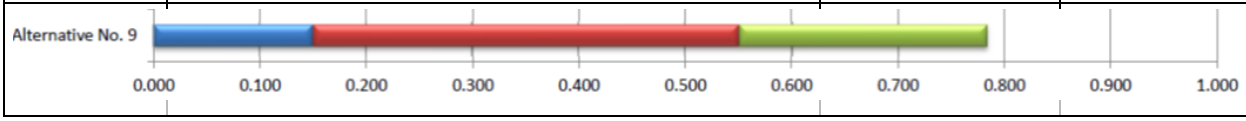


Table 1. Summary of Alternatives

Alt No.	Alternative Title	Total Cost	$/Mile
1	Mill and fill pavement overlay with nighttime closures	$20,900,000	$1,366,013
			
2	Minimum pavement rehab with nighttime closures	$51,400,000	$3,359,477
			
3	Minimum pavement replacement with structural improvements with weekday full lane closures	$51,600,000	$3,372,549
			
4	Full-Depth Pavement Rehab with weekday full lane closures	$95,000,000	$6,209,150
			
5	Full-Depth Pavement Rehab. Provide temporary widening with counterflow.	$79,200,000	$5,176,471
			
6	Full-Depth Pavement Rehab. Provide one lane widening.	$88,400,000	$5,777,778
			
7	Full Depth Pavement Rehab. Provide widening to one side only and widen bridges.	$114,300,000	$7,470,588
			
8	Widen to Six Lanes	$242,600,000	$15,856,209
			
9	Widen to Six Lanes for 6 miles. Nighttime closure with enhanced minimum rehab for remainder.	$100,648,366	Varies
			

VE Alternative Comparative Analysis

Due to the complex nature of the project, the limitations from available pavement to maintain traffic, and the large volume of traffic and trucks, the VE team used the Value Metrics process to evaluate the VE Alternatives from a total value perspective. Different segments, intersections, locations, and other site characteristics throughout the project may all influence the decision of which alternative KYTC should adopt.

It is not the intent of the VE team to recommend one alternative over another but instead highlight a consortium of ideas that may be considered be KYTC and the project team. The performance scores for each alternative were divided by the total cost scores to derive a value index. The value indices for the VE Alternatives are then compared against the value index of the other alternatives and the difference is expressed as a percent (±%) deviation.

Comparing the performance and cost suggests which alternatives are the best options in terms of overall value. The value metrics graph below illustrates each VE Alternative's value profile.

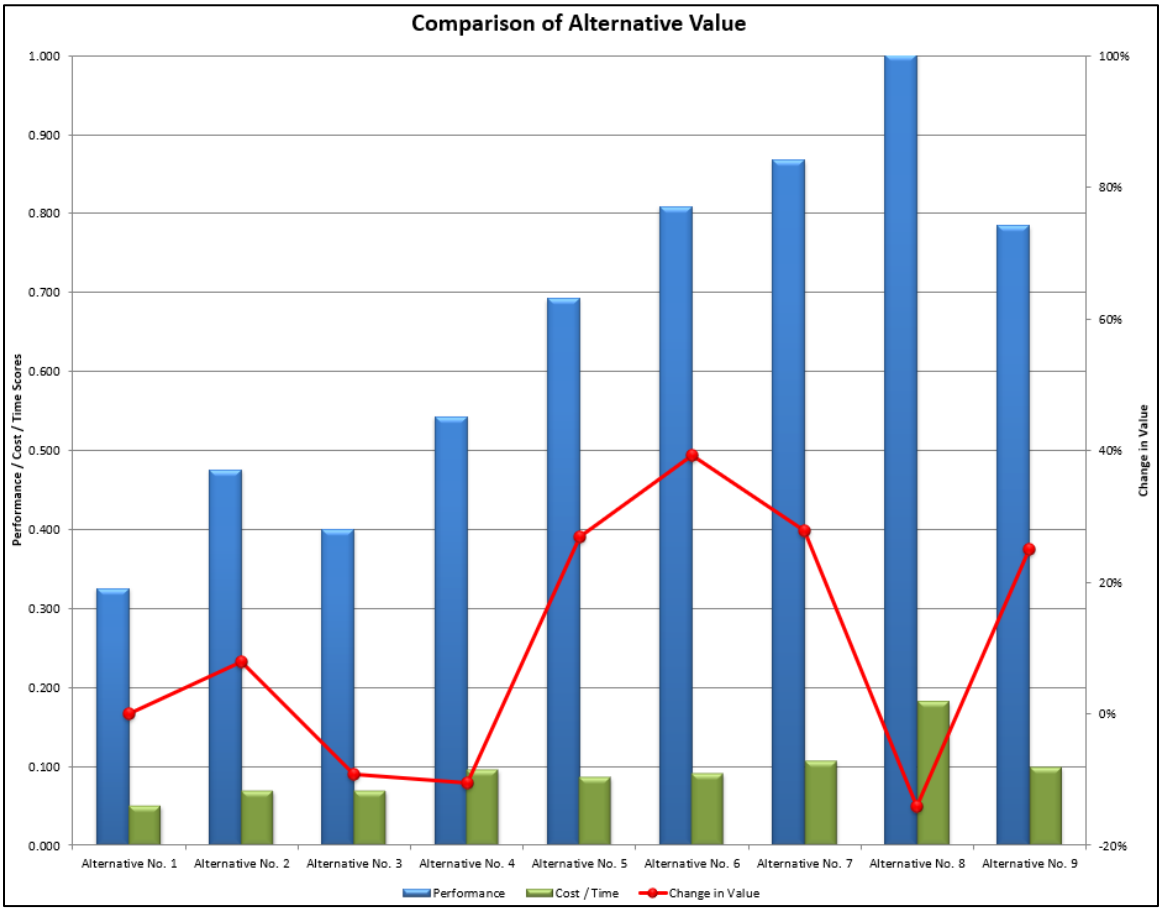


Figure 1: Comparison of Value Chart

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 B for additional details of all workshop attendees.

- Adam Ross, KYTC
- John Oksuz, HDR
- Scott Pennington, HDR
- Jared McCammon, HDR
- Mark Watson, HDR

Acknowledgements

The VE team wishes to express our appreciation to the KYTC project team members and the design team representatives for the excellent support they provided throughout the study. We hope that the alternatives and design considerations provided will assist in the management decisions necessary to move the project forward through the project delivery process.

1 Introduction

This VE report summarizes the events of the virtual VE study conducted for KYTC and facilitated virtually by HDR. The subject of the study was the I-71 pavement rehabilitation project in Trimble and Carroll Counties, Kentucky (Item No. 5-22100, 6-22101, 6-20020). The VE study was conducted on July 14 – 18, 2025 while the project was in preliminary design and scope development.

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:

- Conduct a thorough review and analysis of the key project functions using a multidiscipline, cross-functional team.
- Evaluate the project scope relative to updated budgetary information and project funding scenarios.
- 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 Performance Based Value Engineering

Value Engineering (VE) 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 value engineering can play to improve project performance. To address this issue, a performance based VE approach was used.

The primary objective of any VE study is to improve the value of the project. A simple way to think of value in terms of an equation is shown to the right.

While project costs are fairly easy to quantify and compare through traditional estimating techniques, performance is not so easily quantifiable.

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

The use of performance measures provides the cornerstone of the performance-based VE process by giving a systematic and structured

way of considering the relationship of a project's performance and cost as it relates 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.

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

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

The VE team identified and defined the following performance attributes for this project and then evaluated the VE Alternatives as it pertains to these attributes. The following performance attributes were used throughout the study to identify, evaluate, and document ideas and recommendations:

- Mainline Operations (MO) - An assessment of traffic operations and safety on the main line within the project limits.
- Maintainability (M) - An assessment of the long-term durability, longevity, and maintainability of all roadway elements.
- Construction Impacts (CI) - 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 during construction.

A detailed definition of the performance attributes can be found in the *Project Analysis* section of this report.

2 Information Phase

Limited information on the project and design/scope development was available at the time of the VE Study. The WSP design team 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
Summary of Pre-Design Conference	12/28/2022
I-71 Pavement Rehab Schematic Exhibit	N/A
Google Earth .kmz	N/A
Preliminary Cost Estimates	2/2/2025

2.2 Preliminary Design Development

The following preliminary design development has been completed prior to the VE Study:

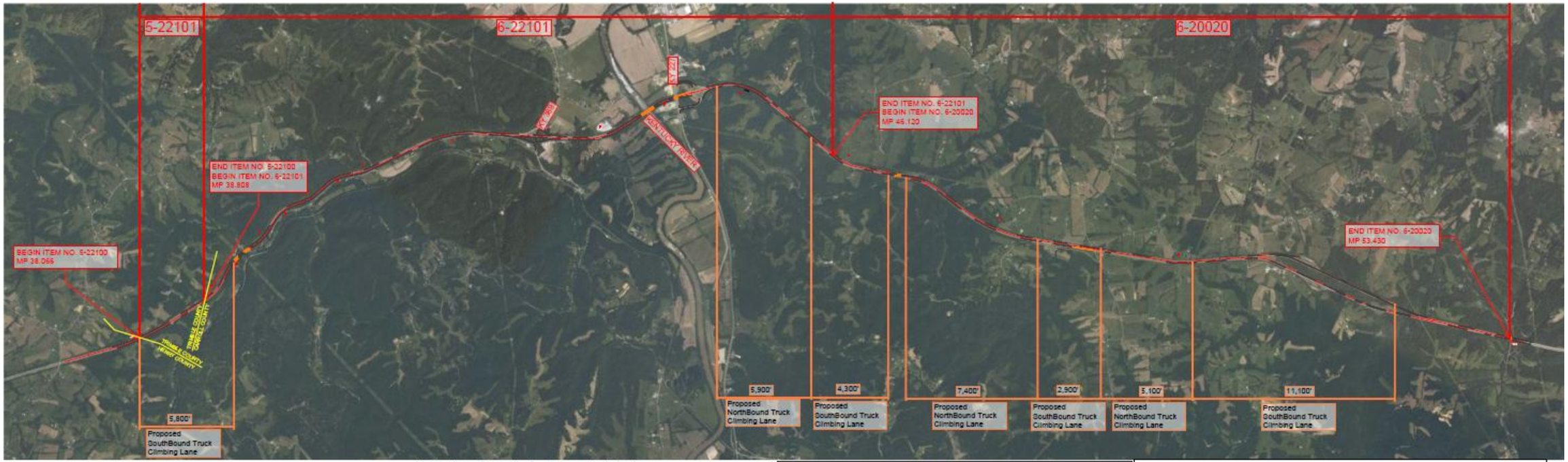
- Download and review of record plans – Mainline and Ramps
- Field reconnaissance and inventory of existing facilities and condition of pavement and roadway elements
- Review of existing geometrics
- Partial review and assessment of crash reports and user costs provided by KYTC
- Preiminary development of the following:
    - Mainline alignment (based on record plans)
    - Existing typical sections
    - Existing pavement designs based on record plan
    - MOT Concepts

2.3 Project History / Information

KYTC is proposing to address long-term maintenance concerns with this segment of I-71. A summary of the project and pre-design work is provided below:

- Mainline limits of project: MP 38.086 (Henry County Line) to MP 53.433 (Gallatin County Line)
- Traffic Data (AADT) for I-71 from KYTC's Traffic Count Reporting System:

  - MP 38.086 to MP 42.802 (Henry County to KY 389 Interchange) – AADT (2021) of 29,817 with 34.59% Trucks
  - MP 42.802 to MP 44.315 (KY 389 Interchange to KY 227 Interchange) – AADT (2021) of 41,573 with 17.15% Trucks
  - MP 44.315 to MP 53.433 (KY 227 Interchange to Gallatin County) – AADT (2021) of 33,859 with 33.76% Trucks
- Mainline typical sections within the project limits:
  - 2- 12’ Mainline Travel Lanes, 12’ (10’ Paved) Outside Shoulders, 6’ (3’ Paved) Inside Shoulders, and a Depressed Median
  - Bifurcated 2- 12’ Mainline Travel Lanes, 12’ (10’ Paved) Outside Shoulders, and 6’ (3’ Paved) Inside Shoulders
- All of the existing pavement is asphalt.
  - Travel Lanes consist of 9” Asphalt on 10” Broken & Seated PCCP on 6” DGA
- KYTC has done pavement repairs as much as 3’ deep. Between Exit 40 and Exit 42 there are several locations where pavement repairs have been completed yearly. During repairs, traffic was closed to 1 lane with observed queueing of 5-7 miles long.
- Pavement Rehabilitation Strategy –
  - MP 38.806- 46.121 Mainline
    - 1.50” CL4 ASPH SURF 0.38A PG76-22
    - 3.00” CL4 ASPH BASE 1.00D PG76-22
    - 3.00” – 3.25” CL4 ASPH BASE 1.00D PG64-22
    - 3.00” – 3.25” CL4 ASPH BASE 1.00D PG64-22
  - MP 46.121 – 53.433 Mainline
    - 1.50” CL4 ASPH SURF 0.38A PG76-22
    - 3.00” CL4 ASPH BASE 1.00D PG76-22
  - Ramps will be included with a 1.50” mill and overlay
    - 1.50” CL3 APH SURF 0.38A
  - Use regular tack material and joint adhesive.
- Maintenance of Traffic:
  - Multiple MOT strategies have been developed (See Figure below).
  - In order to maintain 2 lanes of traffic, the existing pavement section would need to be widened.

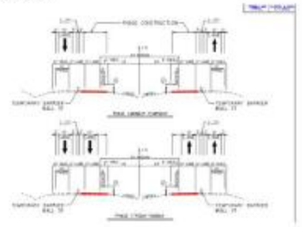


1. Shift down traffic to one-lane per direction.
   a. Estimated Construction Cost: **$54,500,000**
   b. No bridge impacts.
   c. Estimated 2.5 constructions seasons.
   d. Pros:
      i. Easiest Setup.
      ii. Quickest Construction.
   e. Cons:
      i. User costs eliminates this option due to an estimated 16 mile queue length.
      ii. Will have a significant backup.
      iii. District 6 concern: Constraining all traffic to one lane and trucks not being able to maintain/achieve speed due to the roadway grades.

Climbing Lane Add-in option

A. Estimated Added Construction Cost: **$15,300,000**
   a. This could added to options 1, 2, or 3.
      i. Option 1 with Climbing Lanes Estimated Construction Cost: **$69,800,000**
      ii. Option 2 with Climbing Lanes Estimated Construction Cost: **$74,200,000**
      iii. Option 3 with Climbing Lanes Estimated Construction Cost: **$79,700,000**
   b. Adds 4 climbing lanes Southbound and 3 Lanes Northbound. Adds approximately 8.5 miles of climbing lanes.
   c. 23% of Northbound (18,400') and 32% of Southbound (24,100') will have passing lanes
   d. Lanes will be added to inside to avoid right of way impacts.
   e. Passing Lanes are not continued onto bridges.
   f. Assumes that Median in passings lanes will be reduced to 48' with a cable barrier or guardrail system in place.
   g. No bridge impacts.
   h. Adds 1 construction season to the total project length.
   i. Pros:
      i. Would allow construction to be continuous.
      ii. Reduce work required to improve future capacity in areas of climbing lanes.
      iii. Provide passing opportunities in upgrade situation during construction.
   j. Cons:
      i. Could encourage high speeds in climbing lanes during construction.

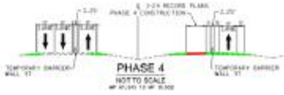
2. Shut down traffic to one lane four days per week and split traffic.
   a. Estimated Construction Cost: **$58,900,000**
   b. Place barrier wall along in the outside lane, 8' from the shoulder. Monday - Thursday. Traffic would be reduce to one lane. Friday - Sunday, Traffic would be split by the barrier.
      i. In order to mitigate the narrow shoulders on the existing bridges, segments could be set up between bridges.
   c. No bridge impacts.
   d. Estimated 3 constructions seasons.
   e. Pros:
      i. Would not require temporary widening.
      ii. 2 lanes of traffic open during busiest time.
      iii. No setup time during week.
      iv. User cost analysis shows no queue greater than one mile Monday - Thursday
   f. Cons:
      i. Barrier wall would need to be relocated multiple times.
      ii. Narrow bridges and interchanges complicate the MOT. Would need to be build in segments to accommodate these.
      iii. Traps motorist in inside lane.
      iv. Construction segments will be short to allow contractor to reopen lanes on Friday.
      v. District 6 concern: Constraining all traffic to one lane and trucks not being able to maintain/achieve speed due to the roadway grades.



3. Shut down traffic to one lane four days per week and move barrier wall.
   a. Estimated Construction Cost: **$64,400,000**
   b. Use a zipper barrier mover to install/uninstall barrier.
   c. No bridge impacts.
   d. Estimated 3 constructions seasons.
   e. Pros:
      i. Would not require temporary widening.
      ii. 2 lanes of traffic open during busiest time.
      iii. User cost analysis shows no queue greater than a mile Monday - Thursday
   f. Cons:
      i. Requires specialized equipment (zipper barrier wall mover).
      ii. Requires moving barrier wall twice a week.
      iii. Narrow bridges and interchanges complicate the MOT. Would need to be built in segments to accommodate these.
      iv. Loses working days to moving the barrier wall.
      v. Construction segments will be short to allow contractor to reopen lanes on Friday.
      vi. District 6 concern: Constraining all traffic to one lane and trucks not being able to maintain/achieve speed due to the roadway grades.

5. Add a lane in one direction.
   a. Estimated Construction Cost: **$122,800,000**
   b. Widening the existing pavement 14.25' would allow all traffic to be shifted to one side.
   c. Would need to complete a traffic analysis to determine which direction is the best to widen.
   d. 5 Bridges Widened
   e. Estimated 4 constructions seasons.
   f. Pros:
      i. Would allow construction to be continuous.
      ii. Reduce work required to improve future capacity of one direction.
   g. Cons:
      i. Only 1 direction improved.

4. Use Counterflow Traffic:
   a. Estimated Construction Cost: **$78,400,000**
   b. A minimum of 39.25' is needed (11' Lanes, 3' Shoulders). Would need to widen existing pavement 3.25'. (Example typical section from I-24 -Christian County)
   c. Would require widening five sets of twin bridges.
      i. Assumed a 3.5' widening of the existing bridges. Actual widening width would be determined during design.
      ii. Alternatively, crossovers could be installed at each bridge. Would need to pave directly adjacent to bridge while shutting traffic down to one lane.
   d. 5 Twin Bridges Widened (10 Total)
   e. Estimated 4 constructions seasons.
   f. Pros:
      i. Would maintain 2 lanes of traffic in each direction.
      ii. Construction could happen continuously.
   g. Cons:
      i. Minimal widening provides no benefit to permanent traffic.



6. Widen to six lanes.
   a. Estimated Construction Cost: **$102,500,000**
   b. 5 Twin Bridges Widened (10 Total)
   c. Estimated 4.5 constructions seasons.
   d. Pros:
      i. Would improve capacity.
      ii. 2 lanes can be maintained at all times.
   e. Cons:
      i. Outside of scope of rehab.

Figure 2. Preliminary MOT Options Exhibit

2.4 Existing Condition Issues

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. In addition to typical requirements such as applicable KYTC standards and design requirements, the following project constraints and controlling decisions were identified:

- Heavy Traffic Volumes and Large Truck Percentage
    - Lane closure causing long back-ups and diversions to local roads not designed to accommodate
- Steep Grades in select areas make it difficult for trucks to climb
- Limitations of Existing Roadway Widths to accommodate additional traffic during construction (not enough existing pavement)
    - Widening required to maintain two lanes
- Five sets of twin structures (concrete)
- Steel structure over KY River
- Existing concrete / subsurface conditions beneath existing pavement is root cause of pavement condition issues and maintenance, however, there are varying levels of pavement condition through different segments
- Annual maintenance activities required to address major pavement failures
- This segment of I-71 is slated for future widening to 6-lane facility

3 Project Analysis

3.1 Existing Condition Issues and Functions

The following issues were identified by the project team and incorporated into the VE team's analysis of the project. The VE team also assigned functions to the issues to better understand how they are impacting the project and what possible measures could be employed to address them.

- Heavy Traffic Volumes / Large Truck Percentage
  - Minimize Impacts
  - Reduce Outage Times
- Steep Grades
  - Minimize Lane Closures
  - Improve Operations
- Existing Roadway Widths
  - Manage Traffic
  - Widen Roadway
- Existing Structures
  - Manage Traffic
  - Widen Bridges
- Varying Levels of Pavement Condition
  - Modify Rehab Strategies to Address Pavement Failures

3.2 Value Metrics

The value metrics process was used as an analysis tool to evaluate the baseline project and the VE alternatives. 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 contributes to the overall functional purpose of a given project.

The basic equation used for calculating value is:

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

In other words, value is equivalent to the relationship of the resources needed to provide a certain level of performance for a given function. Performance is defined as a set of requirements and attributes of a project's scope that are pertinent to the project's purpose

and need. Participant responses are elicited for a series of paired comparisons in which the performance of alternatives are compared, with consideration of the project purpose and need, while taking into account the relative intensity of preference of one criterion over another.

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

3.2.1 Performance Attributes

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

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

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 3 were used throughout the study to identify, evaluate, and document ideas and alternatives.

Table 3. Performance Attributes and Description

Performance Attribute	Description of Attribute	Baseline Concept / Existing Conditions Summary
Main Line Operations	An assessment of traffic operations and safety on the main line within the project limits. Operational considerations include level of service relative to the 20-year traffic projections, as well as geometric considerations such as design speed, sight distance, and lane and shoulder widths.	Two-lane in each direction with depressed median with cable barrier Limited bifurcated section KY River Bridge limited to 24' total width due to drainage grades 25' to 27' total width on other structures Heavy AADT ranging between 30,000 and 40,000 with truck percentages ranging from 20% to 35%. Steep grades leading to slow moving vehicles Acceleration ramp conflicts at Highway 227 / I-71 interchange ramps Headwalls within clear zone(safety headwall or guard rail) Single Slope Barrier Wall Retro fit for the 4 sets of twin bridges to upgrade to current standards.
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.	Existing concrete / subsurface conditions beneath existing asphalt underlying cause of pavement condition issues Expose and rubblelize all existing concrete Variable depth of pavement section in project segments: MP38 - 46 Proposed pavement section (1.5 AC surface, 9" AC base) MP 46 - 53 Proposed pavement section (1.5 AC surface, 3" AC base) Subdrainage clogged / damaged - Rehab/replace Minor erosion repair Replacement of guardrail / impacts to existing cable rail
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.	Maintaining two lanes in each direction to avoid significant delays / back-ups User cost analysis shows reduced impacts for lane closures during weekdays Assuming adding lanes to accommodate lane shifting with alternating sides based on grades Detour routes not available due to lengths and load restrictions for trucks

3.2.2 Performance Attribute Matrix

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

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

Performance Attributes Criteria Matrix						
Paired Comparison						
					Total points	% of Total
Main Line Operations	A	B	C		1.0	16.7%
Maintainability		B	B		3.0	50.1%
Construction Impacts			C		2.0	33.3%
				Total	6.0	100%

Figure 3. Performance Attribute Matrix

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

The primary functions identified by the VE team for the project were to **Improve Maintainability** by **Extending Pavement Life** while **Maintaining Operations** and/or **Reducing Impacts.** Key secondary functions include **Reduce Reflective Cracking, Improve Subsurface Drainage,** and **Improve Operations.**

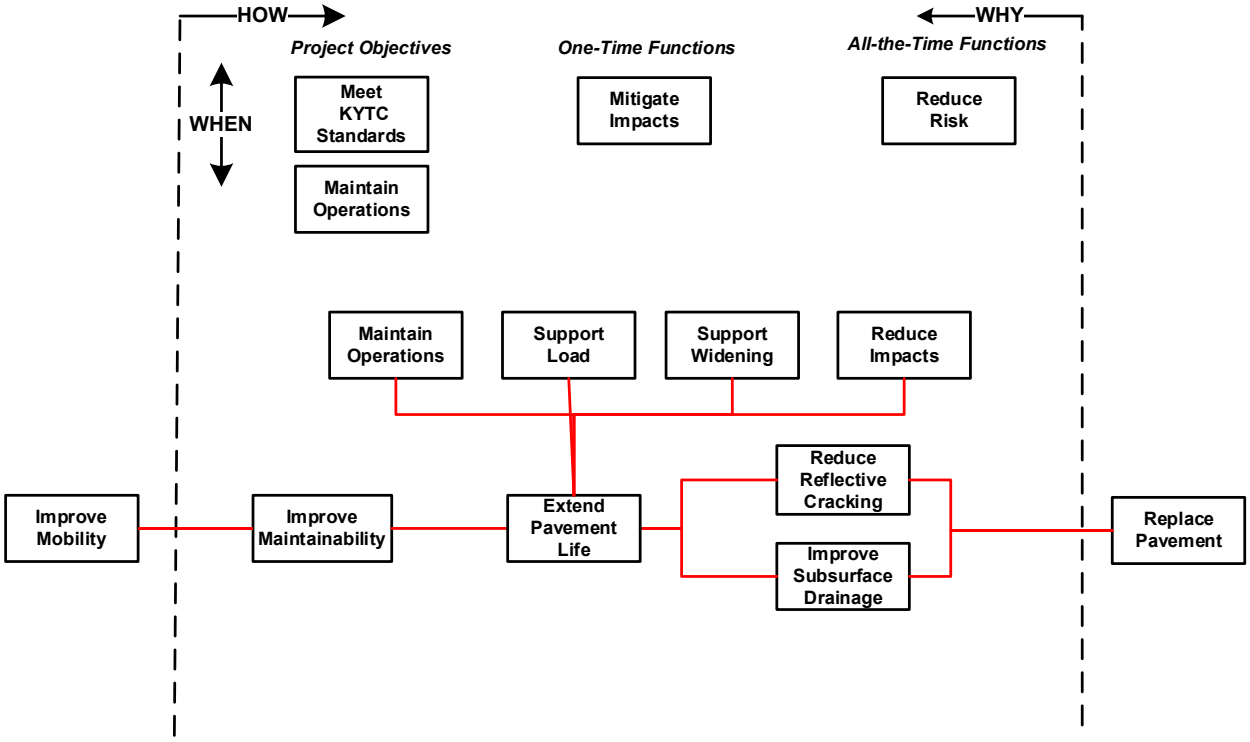
Table 4. Random Function Identification

Project Element	Functions
Project Need (Higher-Order)	Improve Mobility
Project Purpose (Basic)	Improve Maintainability
	Replace Aged Pavement
	Maintain Operations
	Accommodate Future Improvements
	Reduce Impacts
Pavement Structural Section	Support Load
	Accommodate Geotechnical Conditions
	Maintain Existing Pavement
	Support Widening
	Accommodate Existing Condition
	Extend Pavement Life
	Reduce Reflective Cracking
	Improve Subgrade Drainage

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

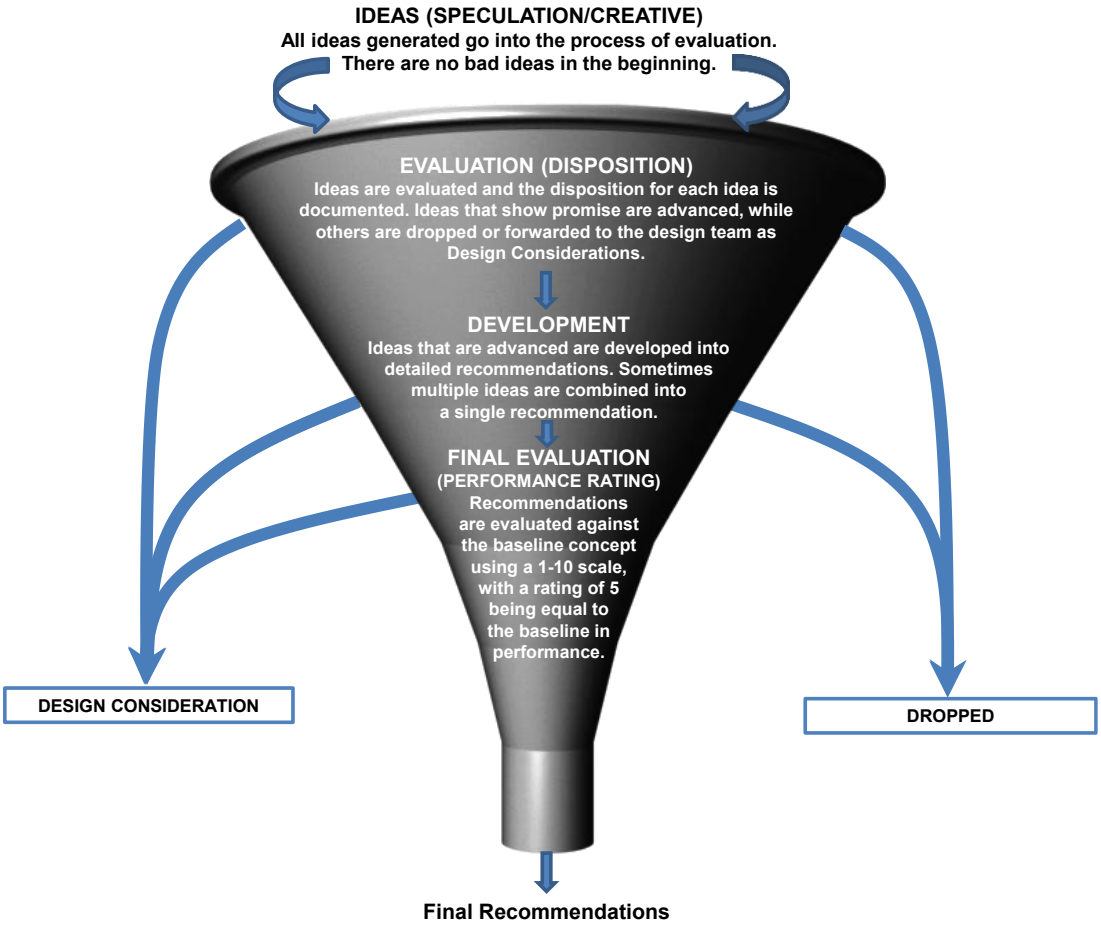
Table 5. Creative Idea List

Idea No.	Description
1	Use stone matrix asphalt to reduce pavement thickness
2	Add Kevlar fibers to asphalt mix
3	Full depth dig out during night closures and overlay (8 year pavement life)
4	Widen a segment to 6-lanes and mill/fill the rest
5	Install geogrid under asphalt
6	Widen to one side to accommodate 4-lanes and replace pavement
7	Widen all bridges to accommodate future 6-lane section
8	Close one direction for extended period and reroute traffic
9	Close one lane in each direction and use reversible lanes with crossovers
10	Limit the distance of closure to a minimum level of delay/back-up
11	Reopen traffic on asphalt base after night closures prior to overlay
12	Construct new bridge in median to accommodate traffic alignment shift
13	Use temporary bridges and widen to median to accommodate traffic shifts
14	Increase mill and overlay depth during night closures
15	Micro-mill segments during night closure and reopen during day, then overlay
16	Widen into median to accommodate traffic except at bridges with temp pavement
17	Widen into median to accommodate traffic except at bridges with permanent pavement
18	Install longitudinal underdrainage systems beneath existing in lieu of full-depth replacement
19	Use full-depth pulverization / reclamation in lieu of crack and seat
20	Use full-depth asphalt replacement section throughout project limits
21	Install asphalt curb or regrade at guardrails to reduce erosion
22	Close one lane and use reversible lanes based on directional traffic volumes

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 alternatives to be forwarded. The figure below 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 based on their relationship to the project's purpose and need.

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.

Once ideas were evaluated, the VE facilitator held a mid-point review with the project team to validate the evaluation results and ensure the ideas moving forward aligned with the goals and objectives of the project.

6.2 Evaluation Summary

All of the ideas that were generated during the Creativity Phase using brainstorming techniques are detailed in the table belowTable 6.

Table 6. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Status
1	Use stone matrix asphalt to reduce pavement thickness	• Reduces maintenance • Reduce pavement thickness	• Added cost	3 – Consider Further
2	Add Kevlar fibers to asphalt mix	• Reduces maintenance • Reduce pavement thickness	• Added cost	3 – Consider Further
3	Full depth dig out during night closures and overlay (8 year pavement life)	• Improved pavement life	• Night work safety issues and traffic management • Traffic impacts due to lane closures	3 – Consider Further
4	Widen a segment to 6-lanes and mill/fill the rest	• Improved operations • Improved MoT during construction	• Added cost	3 – Consider Further
5	Install geogrid under asphalt	• Reduces maintenance • Reduce pavement thickness	• Added cost	3 – Consider Further
6	Widen to one side to accommodate 4-lanes and replace pavement	• Reduced lane closures	• Added lanes may not be optimized for grades / truck climbing	3 – Consider Further
7	Widen all bridges to accommodate future 6-lane section	• Reduced work during future widening	• Added costs	3 – Consider Further
8	Close one direction for extended period and reroute traffic	• Reduced total schedule	• Impacts to local roads • Significant traffic impacts	3 – Consider Further
9	Close one lane in each direction and use reversible lanes with crossovers	• Reduced total schedule	• Driver expectancy • Multiple lane shifts	3 – Consider Further
10	Limit the distance of closure to a minimum level of delay/back-up	• Managed back-ups with reduced distances	• Increased total project schedule	2 – Design Comment
11	Reopen traffic on asphalt base after night closures prior to overlay	• Optimized lane closure time	• Traffic impacts from unimproved roadway	2 – Design Comment

Table 6. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Status
12	Construct new bridge in median to accommodate traffic alignment shift	• Reduced traffic impacts	• Added costs	3 – Consider Further
13	Use temporary bridges and widen to median to accommodate traffic shifts	• Reduced traffic impacts	• Added costs	2 – Design Comment
14	Increase mill and overlay depth during night closures	• Improved pavement life / condition	• Night work safety issues and traffic management • Traffic impacts due to lane closures	3 – Consider Further
15	Micromill segments during night closure and reopen during day, then overlay	• Reduced pavement life	• Reduced traffic impacts due to night work	1 - Dismiss
16	Widen into median to accommodate traffic except at bridges with temp pavement	• Reduced traffic impacts	• Added costs	3 – Consider Further
17	Widen into median to accommodate traffic except at bridges with permanent pavement	• Reduced traffic impacts	• Added costs	3 – Consider Further
18	Install longitudinal underdrainage systems beneath existing in lieu of full-depth replacement	• Improved pavement life	• Increased impacts to existing	2 – Design Comment
19	Use full-depth pulverization / reclamation in lieu of crack and seat	• Improved pavement life	• Increased impacts to existing	2 – Design Comment
20	Use full-depth asphalt replacement section throughout project limits	• Improved pavement life	• Increased impacts	1 - Dismiss
21	Install asphalt curb or regrade at guardrails to reduce erosion	• Reduces maintenance	• None noted	2 – Design Comment
22	Close one lane and use reversible lanes based on directional traffic volumes	• Reduced traffic impacts	• Driver expectancy • Multiple lane shifts	3 – Consider Further

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 VE Alternatives. In many cases, it is possible that one or more ideas were combined to form an overall alternative, which was then evaluated further by the VE team.

In the case of this project, of the 22 ideas that were generated during the Creativity Phase, 10 of those ideas were evaluated high enough to be taken forward, combined, and developed further.

7.1 Individual Alternatives

Based on the evaluation process, individual alternatives were developed. Each alternative consists of a summary of the Pavement Rehab Strategy and MoT Strategy for the alternative concept, a brief narrative that includes Discussion of options for the alternative, Sketches/Photos, Performance Evaluation, and Cost calculations as developed by the VE team.

7.2 Summary of VE Alternatives

The alternatives developed by the VE team are shown in the table below. The table below summarizes each alternative's cost and performance trade-offs as follows:

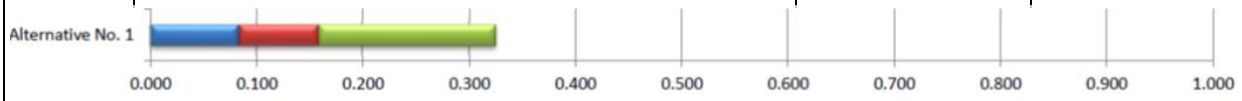
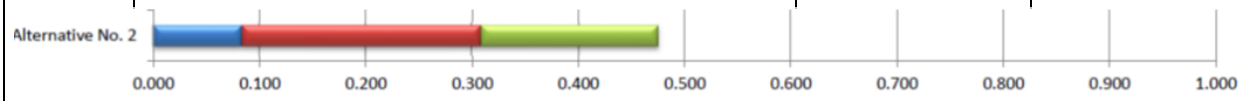
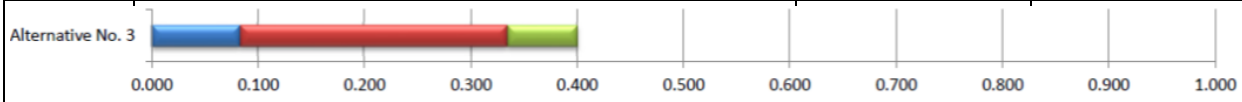
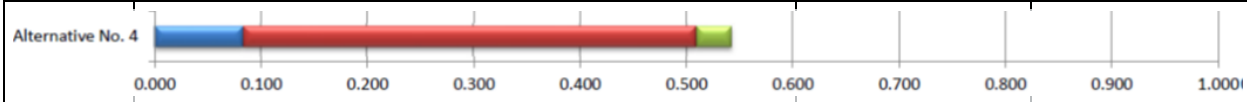
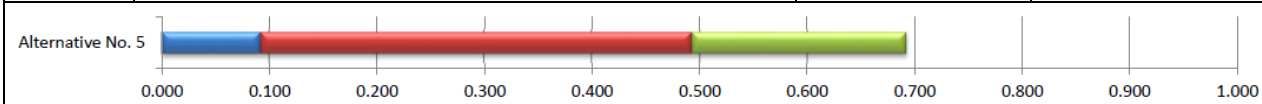
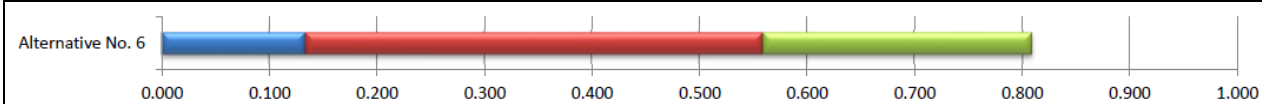
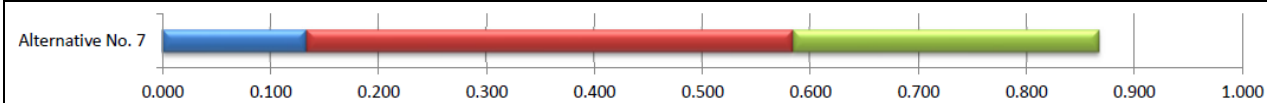
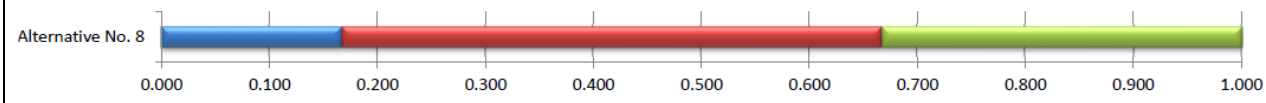
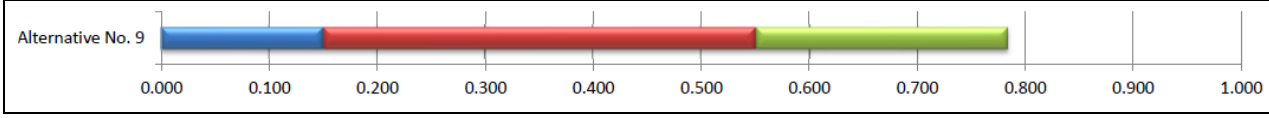
- Total Construction Cost – A preliminary / parametric estimation of the alternative's total construction cost. Costs are conceptual and reflective of the VE team's parametric estimation and represent orders of magnitude costs of the VE alternative.
- Performance – A summary of the performance impacts of the VE alternative in comparison with the baseline concept.

  Performance attributes include the following:

  Mainline Operations Maintainability Construction Impacts

  Refer to the *Project Analysis* section of this report for additional explanation of the performance attributes identified.

Table 7. Summary of Alternatives

Alt No.	Alternative Title	Total Cost	$/Mile
1	Mill and fill pavement overlay with nighttime closures	$20,900,000	$1,366,013
			
2	Minimum pavement rehab with nighttime closures	$51,400,000	$3,359,477
			
3	Minimum pavement replacement with structural improvements with weekday full lane closures	$51,600,000	$3,372,549
			
4	Full-Depth Pavement Rehab with weekday full lane closures	$95,000,000	$6,209,150
			
5	Full-Depth Pavement Rehab. Provide temporary widening with counterflow.	$79,200,000	$5,176,471
			
6	Full-Depth Pavement Rehab. Provide one lane widening.	$88,400,000	$5,777,778
			
7	Full Depth Pavement Rehab. Provide widening to one side only and widen bridges.	$114,300,000	$7,470,588
			
8	Widen to Six Lanes	$242,600,000	$15,856,209
			
9	Widen to Six Lanes for 6 miles. Nighttime closure with enhanced minimum rehab for remainder.	$100,648,366	Varies
			

VE ALTERNATIVE 1
Mill and fill pavement overlay with nighttime closures

Description of MOT Concept:

This repair concept would fall in line with a "typical" KYTC interstate rehab project. Initial base failure repair followed by the mill and fill of 1.5" of asphalt surface would be performed under nightly lane closures during non-peak traffic periods.

Description of Pavement Rehab Concept:

In lieu of more extensive pavement repairs, the pavement would be rehabilitated as a "typical" interstate resurfacing project. Initially, full-depth pavement base failures would be performed at specific areas of deteriorating pavement under nightly lane closures. Once repairs have been performed, a mill and fill of 1.5" of asphalt surface would take place nightly under lane closures during non-peak traffic periods.

Discussion:

With the noted issues related to maintaining two lanes of traffic during the duration of construction, a "typical" interstate rehab performed under nightly closures would reduce costs and interferences with traffic during daily peak periods of travel. Initial base failure repairs could be focused on key areas where the pavement has deteriorated significantly. Though a 1.5" surface overlay may not reach the long-term life desired by the agency, a significant cost savings would be realized with the reduction of material for the permanent pavement, elimination of temporary measures (widened bridges, widened pavements, temporary barrier wall, etc.) and the shortened construction schedule (likely one construction season). In addition to the cost savings, the following safety improvements may be realized:

- No daytime lane closures when traffic backups are more significant
- One construction season in lieu of multiple construction seasons with MOT in place
- Elimination of temporary measures in other alternatives:
    - Lesser clear zones (temp barrier walls in place, traffic shifted closer to guardrail/cable rail/bridge rails, etc.)
    - Multiple crossovers
    - MOT/shifted traffic in place over winter shutdown periods – Winter maintenance
    - Elimination of traffic outside normal lanes of traffic (not multiple traffic shifts)
    - Less interference with entrance and exit ramps
- Construction will follow a continuous process, no segmented construction

With the originally proposed alternatives, the construction timeline ranges from 2.5 to 4.5 construction seasons. This proposed method could be completed in one construction season. If this method shaves a couple of years off of the desired life expectancy of the project, a follow up rehab project could be performed in another single construction season which would still be less time than the multiple construction seasons proposed with the originals (spaced apart but less overall traffic impacts).

VE ALTERNATIVE 1
Mill and fill pavement overlay with nighttime closures

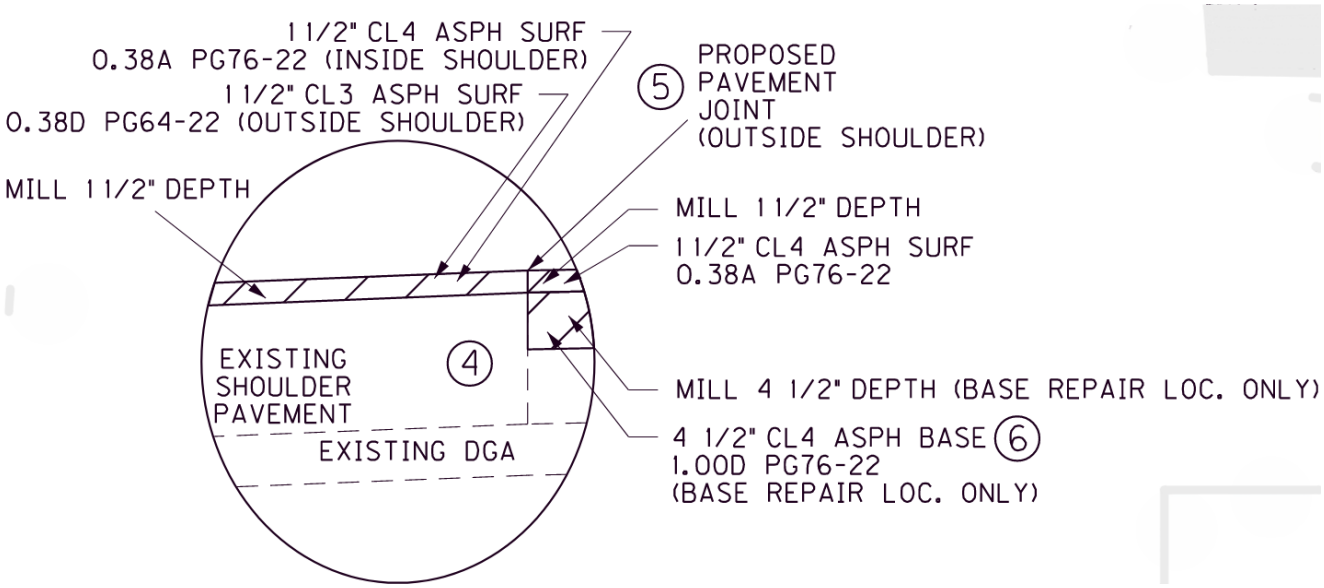
Performance Assessment:

Attributes and Rating Rationale
Mainline Operations Limited additional operational improvements as the original configuration will remain. No temporary pavement or bridge widening.
Maintainability It is expected this method may shave two to three years off of the desired life of the final project. All deteriorated areas may not be addressed full depth, but spot base failure repairs may be performed at the worst areas to minimize future repairs.
Construction Impacts Work will only be performed during nightly lane closures outside peak traffic periods. Traffic will always remain in the normal lanes of traffic. No lane shifts or crossovers. No bridge widening. As work may be completed in a single construction season, no winter maintenance would be required.

VE ALTERNATIVE 1

Mill and fill pavement overlay with nighttime closures

VE Alternative Concept Sketch



Assumptions and Calculations:

Mill and fill 1.5”

Base Failures 5%

No pavement or bridge widening

Milling and Texturing - Assume $2.89/SY

VE ALTERNATIVE 1

Mill and fill pavement overlay with nighttime closures

Initial Cost Estimate

Item	Unit	Amount	Unit Price	Cost
1.5" Pavement ML	SY	412,000	$14	$5,768,000
1.5" Pavement Shoulder	SY	412,000	$12	$4,944,000
Full Depth ML	SY	20,000	$126	$2,520,000
MOT				$750,000
Drainage & MISC (10%)				$1,398,200
Mob/Demob (4.5%)				$692,109
SubTotal				$16,072,309
Total (30% Contingency)				$20,900,000

VE ALTERNATIVE 2
Minimum pavement rehab with nighttime closures

Description of MOT Concept:

This repair concept would fall in line with a "typical" KYTC interstate rehab project. Initial base failure repair followed by the mill and fill of 3" of asphalt base and 1.5" of asphalt surface would be performed under nightly lane closures during non-peak traffic period times.

Description of Pavement Rehab Concept:

In lieu of full-depth pavement repairs, the pavement would be rehabilitated as a "typical" interstate resurfacing project which would include a lift of asphalt base. Initially, full-depth pavement base failures would be performed at specific areas of deteriorating pavement under nightly lane closures. Once repairs have been performed, a mill and fill of 3" of asphalt base and 1.5" of asphalt surface would take place nightly under lane closures during non-peak traffic periods.

Discussion:

With the noted issues related to maintaining two lanes of traffic during the duration of construction, a "typical" interstate rehab performed under nightly closures would reduce costs and interferences with traffic during daily peak periods of travel. Initial base failure repairs could be focused on key areas where the pavement has deteriorated significantly. Though a 4.5" asphalt base/surface overlay may not reach the exact long-term life desired by the agency with a full-depth repair, a significant cost savings would be realized with the reduction of material for the permanent pavement, elimination of temporary measures (widened bridges, widened pavements, temporary barrier wall, etc.) and the shortened construction schedule (likely one construction season). In addition to the cost savings, the following safety improvements may be realized:

- No daytime lane closures when traffic backups are more significant
- One construction season in lieu of multiple construction seasons with MOT in place
- Elimination of temporary measures in other alternatives:
    - Lesser clear zones (temp barrier walls in place, traffic shifted closer to guardrail/cable rail/bridge rails, etc.)
    - Multiple crossovers
    - MOT/shifted traffic in place over winter shutdown periods – Winter maintenance
    - Elimination of traffic outside normal lanes of traffic (not multiple traffic shifts)
    - Less interference w/ entrance and exit ramps
- Construction will follow a continuous process, no segmented construction

With the originally proposed alternatives, the construction timeline ranges from 2.5 to 4.5 construction seasons. This proposed method could be completed in one construction season. If this method shaves a couple of years off of the desired life expectancy of the project, a follow up rehab project could be performed in another single construction season which would still be less time than the multiple construction seasons proposed with the originals (spaced apart but less overall traffic impacts).

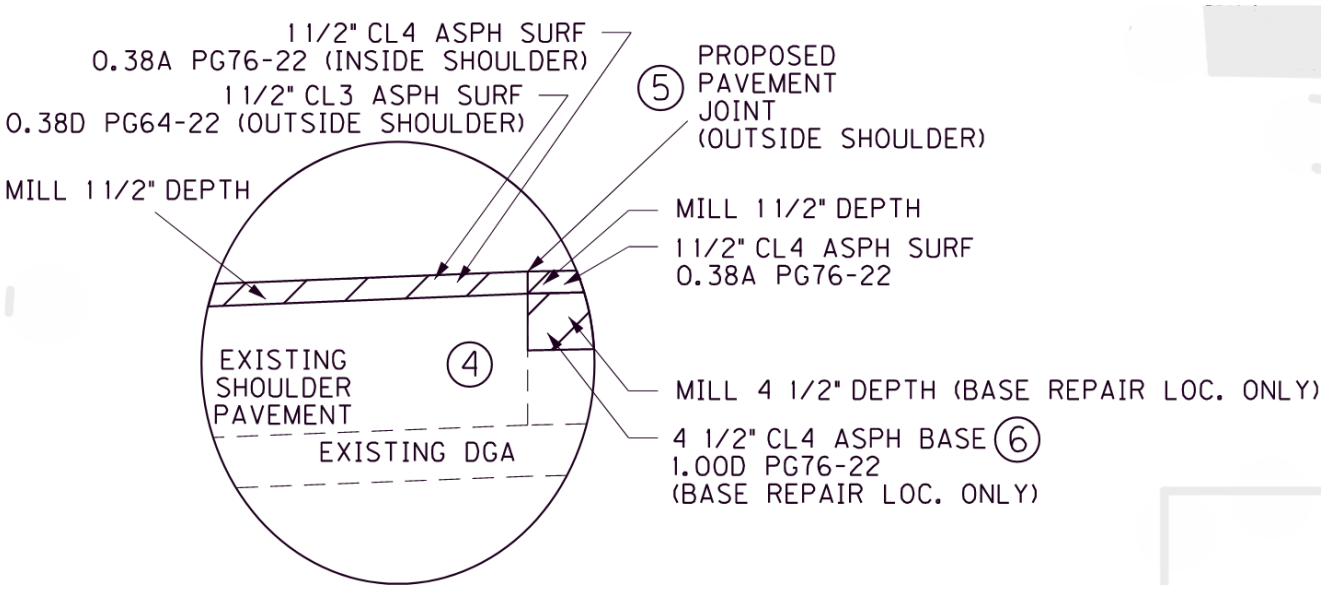
With this method, it is assumed the milling and installation of 4.5" of asphalt pavement will take place nightly. If there are concerns about a lift of surface being installed on a new lift of base in the same night, the asphalt surface could be installed the following night if KYTC will allow traffic to operate adjacent to a 1.5" lip.

VE ALTERNATIVE 2
Minimum pavement rehab with nighttime closures

Performance Assessment:

Attributes and Rating Rationale
Mainline Operations Limited additional operational improvements as the original configuration will remain. No temporary pavement or bridge widening.
Maintainability It is expected this method may not reach the desired life expectancy of the original design with a full-depth pavement repair, though it should be close. All deteriorated areas may not be addressed full depth but spot base failure repairs may be performed at the worst areas to minimize future repairs.
Construction Impacts Work will only be performed during nightly lane closures outside peak traffic periods. Traffic will always remain in the normal lanes of traffic. No lane shifts or crossovers. No bridge widening. As work may be completed in a single construction season, no winter maintenance would be required.

VE Alternative Concept Sketch



VE ALTERNATIVE 2
Minimum pavement rehab with nighttime closures

Assumptions and Calculations:

Mill and fill 4.5”

Base Failures 5%

No pavement or bridge widening

No replacement of guardrail or median cable rail

Initial Cost Estimate

Item	Unit	Amount	Unit Price	Cost
4.5" Pavement ML	SY	412,000	$40	$16,480,000
4.5" Pavement Shoulder	SY	412,000	$35	$14,420,000
Full Depth ML	SY	20,000	$126	$2,520,000
MOT				$1,000,000
Drainage & MISC (10%)				$3,442,000
Mob/Demob (4.5%)				$1,703,790
SubTotal				$39,565,790
Total (30% Contingency)				$51,400,000

VE ALTERNATIVE 3

Minimum pavement replacement with structural improvements and weekday full lane closures

Description of MOT Concept: Closure of one lane of traffic on 7:00 PM Sunday to 6:00 AM Friday.

Description of Pavement Rehab Concept: Pavement design consists of milling 4-4.5” of existing pavement and replacing with 3” Asphalt Base and 1.5” Asphalt Surface.

Discussion: Two options on what lane(s) could be closed were considered along with an additional closure time. Option #1 would close only one direction at a time and allow for a longer work zone. Option #2 would close one lane each direction with a shorter work zone. Option# 3 would allow Saturday night closures in addition to Sunday night to Friday morning closures.

Working in only one direction will allow for a longer work zone, allowing the contractor enhanced productivity with less personnel and equipment transporting. It will provide a better product with less construction joints in the pavement, limit most traffic delays to the side under construction and provide an unobstructed travel direction for emergency vehicles.

Working on both sides with a lane closed in each direction will require a shorter work zone, shortening the delay for each direction and allow material delivery trucks to make easier U-turns on the project.

Based on the traffic analysis it appears that night closures on Saturdays and Sundays would not greatly impact traffic. This closure would be limited to prep work, non-mainline pavement, and/or finish work.

To speed the construction of the asphalt pavement, traffic could be allowed to run on the asphalt base and on milled surfaces. This will allow for longer work zones and the asphalt plant will not have to switch mixes during the process as often. Cooling operations would not be required to cure the base layer to install surface before opening to traffic. By allowing traffic on milled (or micro-milled) surfaces, the contractor can use Saturday nights to prep some of the area in advance of full operations beginning on Sunday night.

The basic pavement rehab could be enhanced with several options to increase durability and/or decrease lane closure time. The VE team considered several options for pavement durability and a couple for speeding up construction. To increase durability the pavement design could use one or a combination of the following: Stone Matrix Asphalt Mix, Aramid Fibers, or a Paving Grid/Fabric. To speed construction traffic could be allowed to run on a milled surface or a base layer for a limited time frame.

Stone matrix asphalt is often used on routes with large amounts of truck traffic to provide rut resistance and durability. The gap graded SMA mix allows more stone-to-stone contact than normal asphalt mixes, providing a more robust and stronger pavement. We recommend it be used for the base course and the surface course.

Aramid fibers add tensile strength to asphalt mixes and reduces the cracking and rutting. They have been used on several projects over old concrete pavement to resist reflective cracking and rutting. The VE team recommends aramid fibers be added to the top base and surface courses. The fibers are added directly into the asphalt mix at the asphalt plant. This will add about $8-10/ton to the cost of the project.

Paving grids and fabrics add a strong tensile layer between pavement layers. The products can be a solid grid material, a woven geotextile fabric or as a composite of both. They have been

used on some projects over existing concrete pavements to resist reflective cracking and rutting. The VE team recommends placing the grid/fabric on the top of the existing pavement before placing the asphalt base. A small scratch course could be used if the existing pavement is badly pitted or overly rough. Proper installation is needed to ensure full strength of the material. The cost of grid or fabric is about $6 per square yard.

Use of one or a combination of these ideas should increase the life of the asphalt, compared to traditional asphalt mixtures. Each item should extend the life of pavements for approximately 2 years and a combination of at least two of them should provide 4 years of extended life.

Performance Assessment:

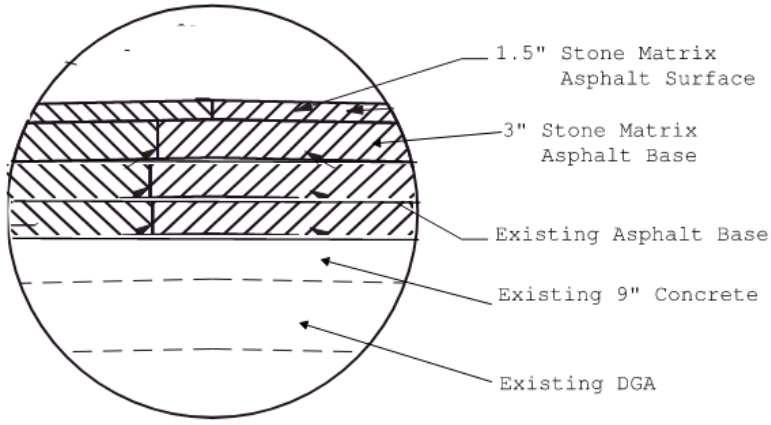
Attributes and Rating Rationale
Mainline Operations This alternative will provide no additional operations as the typical section will remain the same with 2 12' travel lanes, shoulders and a depressed median. The pavement would be more durable and less susceptible to rutting, potholes and cracking than existing if one or more of the innovative ideas is used.
Maintainability This alternative would provide some relief from the yearly maintenance currently required by replacing the top two layers of asphalt. The length of the relief period will depend on the asphalt pavement design used. The use of one or more innovative materials will extend the pavement life at least an additional 3-4 years.
Construction Impacts Require a lane closure with options to speed up construction with some innovative products and use of all available time. Will require a lot of planning and coordination from the contractor and district construction and public relations staff.

VE ALTERNATIVE 3

Minimum pavement replacement with structural improvements and weekday full lane closures

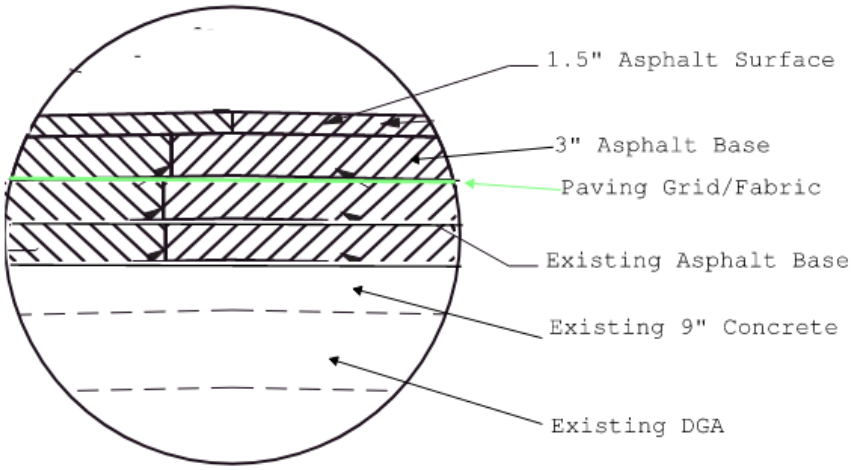
VE Alternative Concept Sketch

Assumptions and Calculations: No lane reductions from Friday 6:00 AM to Saturday 8:00PM and from Sunday 6:00 AM to 7:00 PM.



VE ALTERNATIVE 3

Minimum pavement replacement with structural improvements and weekday full lane closures

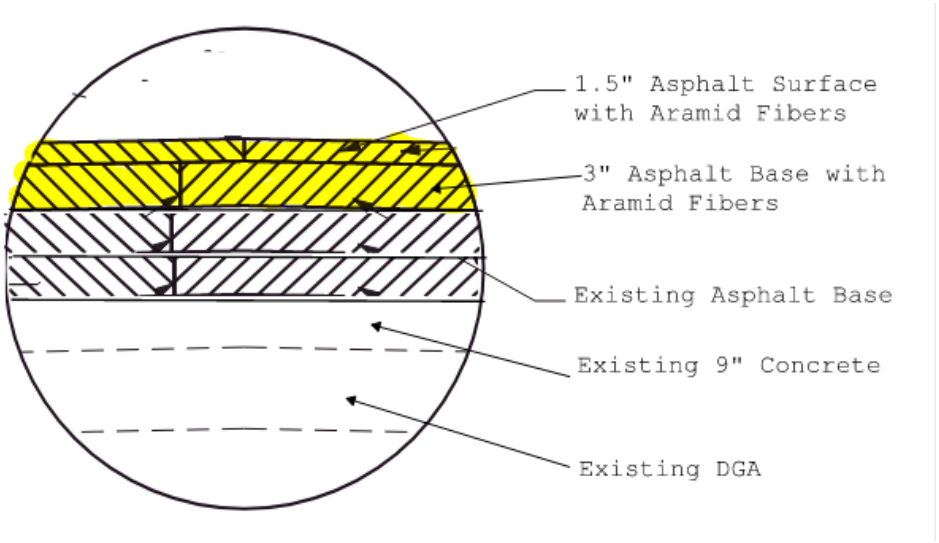


VE ALTERNATIVE 3

Minimum pavement replacement with structural improvements and weekday full lane closures

VE ALTERNATIVE 3

Minimum pavement replacement with structural improvements and weekday full lane closures



Assumptions and Calculations:

No pavement or bridge widening

No replacement of guardrail or median cable rail

Initial Cost Estimates

Option 1 – All Pavement Enhancements

Item	Unit	Amount	Unit Price	Cost
4.5" Pavement ML	SY	412,000	$40	$16,480,000
4.5" Pavement Shoulder	SY	274,600	$35	$9,611,000
Aramid Fiber	SY	412,000	$4	$1,648,000
SMA	SY	412,000	$8	$3,296,000
Grid/fabric	SY	412,000	$6	$2,472,000
MOT	LS	1	$1,000,000	$1,000,000
Drainage & MISC (10%)				$3,450,700
Mob/Demob (4.5%)				$1,708,097
SubTotal				$39,665,797
Total (30% Contingency)				$51,600,000

Option 2 – Aramid Fiber Pavement Enhancement

Item	Unit	Amount	Unit Price	Cost
4.5" Pavement ML	SY	412,000	$40	$16,480,000
4.5" Pavement Shoulder	SY	274,600	$35	$9,611,000
Aramid Fiber	SY	412,000	$4	$1,648,000
SMA	SY	0	$8	$0
Grid/fabric	SY	0	$6	$0
MOT	LS	1	$1,000,000	$1,000,000
Drainage & MISC (10%)				$2,873,900
Mob/Demob (4.5%)				$1,422,581
SubTotal				$33,035,481
Total (30% Contingency)				$42,900,000

Option 3 – Stone Matrix Asphalt Pavement Enhancement

Item	Unit	Amount	Unit Price	Cost
4.5" Pavement ML	SY	412,000	$40	$16,480,000
4.5" Pavement Shoulder	SY	274,600	$35	$9,611,000
Aramid Fiber	SY	0	$4	$0
SMA	SY	412,000	$8	$3,296,000
Grid/fabric	SY	0	$6	$0
MOT	LS	1	$1,000,000	$1,000,000
Drainage & MISC (10%)				$3,038,700
Mob/Demob (4.5%)				$1,504,157
SubTotal				$34,929,857
Total (30% Contingency)				$45,400,000

Option 4 - Geogrid / Fabric Underlayment Pavement Enhancement

Item	Unit	Amount	Unit Price	Cost
4.5" Pavement ML	SY	412,000	$40	$16,480,000
4.5" Pavement Shoulder	SY	274,600	$35	$9,611,000
Aramid Fiber	SY	0	$4	$0
SMA	SY	0	$8	$0
Grid/fabric	SY	412,000	$6	$2,472,000
MOT	LS	1	$1,000,000	$1,000,000
Drainage & MISC (10%)				$2,956,300
Mob/Demob (4.5%)				$1,463,369
SubTotal				$33,982,669
Total (30% Contingency)				$44,200,000

VE ALTERNATIVE 4
Full-Depth Pavement Rehab with weekday full lane closures

Description of MOT Concept: Closure of one lane of traffic in one or both directions. Two alternative closure plans: closure of one lane from Sunday evening to Friday morning, or closure to one lane with no time restrictions.

Description of Pavement Rehab Concept: Full depth asphalt replacement with breaking and seating the existing concrete pavement.

Discussion: The amount of time required to remove all the asphalt, break and seat the concrete and then place the required asphalt thickness will necessitate a lane closure to remain in place for long periods of time. Impacts to traffic can be minimized by limiting closures to one side at a time and for set lengths based on grade of the roadway.

Alternatively, very short sections that can be completely removed and replaced during the time frame of Sunday evening to Friday morning can be used. This will reduce the overall pavement life due to several construction joints being installed due to the short sections. Allowing traffic to run on micro-milled surfaces and on asphalt base layers for short durations would assist in limiting the closure times to Sunday evening through Friday morning by allowing the contractor to mill off the surface in advance and open to traffic on base. The asphalt surface layer could then be added once a larger section was available with lane closures limited to nighttime or during normal daytime restrictions.

Due to the steep grades of several sections of this project, the VE team suggests limiting the total length of closures to smaller sections to reduce traffic impacts. Smaller construction sections allow traffic to return to normal speed sooner, reducing the total backup. Closure length restrictions should be based on steepness of the roadway. Flatter sections could be longer while steeper sections need to be shorter.

A concrete barrier wall will be required to protect traffic from the large drop off between lanes. This can be left in place with the longer lane closure operation but will have to be removed with the limited lane closure to allow traffic to use both lanes safely.

The basic pavement rehab involves completely removing the existing asphalt from one lane, breaking and seating the existing concrete pavement and then placing the required 10.5” asphalt pavement section (9” Base and 1.5” Surface). This can be enhanced with several options to increase durability. The VE team considered three innovations to use for increasing pavement strength and life: Stone Matrix Asphalt Mix, Aramid Fibers, or a Paving Grid/Fabric.

Stone matrix asphalt is often used on routes with large amounts of truck traffic to provide rut resistance and durability. The gap graded SMA mix allows more stone-to-stone contact than normal asphalt mixes, providing a more robust and stronger pavement. The VE team recommends it be used for all of the base courses and the surface course. Use of SMA could allow for a slightly thinner pavement section with use of two 4” layers of Base. This will offset the additional cost of the SMA but will require some wedging at the bridges.

Aramid fibers add tensile strength to asphalt mixes and reduces the cracking and rutting. They have been used on several projects over old concrete pavement to resist reflective cracking and rutting. The VE team recommends aramid fibers be added to the top base and surface courses. The fibers are added directly into the asphalt mix at the asphalt plant. This will add about $8-10/ton to the cost of the project.

Paving grids and fabrics add a strong tensile layer between pavement layers. The products can be a solid grid material, a woven geotextile fabric or as a composite of both. They have been

used on some projects over existing concrete pavements to resist reflective cracking and rutting. The Ve team recommends placing the grid/fabric on a leveling course placed on the concrete and between the top two layers of base. Proper installation is needed to ensure full strength of the material. The cost of grid or fabric is about $6 per square yard.

Use of one or a combination of these ideas should increase the life of the asphalt, compared to traditional asphalt mixtures. Each item should extend the life of pavements for approximately 3 years and a combination of at least two of them should provide 5-6 years of extended life.

Performance Assessment:

Attributes and Rating Rationale
Mainline Operations This alternative maintains the mainline operations with 2 12' lanes each direction with normal shoulders and a depressed median. Pavement design is the most robust for long life with minimal amounts of routine maintenance required. This provides an adequate pavement for any potential widening projects, with only the possibility of overlaying the pavement to match new project grading or replacement of the surface layer.
Maintainability Maintainability is enhanced with breaking the concrete allowing for more drainage of the subsurface layers and reducing the potential for reflective cracking. Use of SMA, Aramid Fibers, and/or paving grids/fabrics will add strength and life to the pavement while reducing the possibility of reflective cracking even more. This alternative should limit maintenance activities to minor pavement preservation actions such as crack sealing and spot repairs for 14-16 years before need to replace the surface layer.
Construction Impacts Long term lane closures with deep pavement construction and need to break and seat the concrete. Will require concrete barrier wall between traffic and work area where other options could use barrels. This will be the largest impact to traffic of all alternates. This could potentially be completed during 1 construction season. Limiting the work zone to short sections would allow for closure to be limited to Sunday evening-Friday morning. Length of the work section should be based on the grade of the roadway being constructed. This will require concrete barrier wall to be set and removed each week and will add several construction joints into the pavement. Allowing traffic to run on asphalt base and milled surfaces would assist in making this a more viable option. Use of SMA might allow for thinner pavement section with only 2 layers of asphalt base, speeding construction and offsetting the cost of the SMA over conventional asphalt. Adjustments would need to be made at the bridges.

Assumptions and Calculations:

Mill and fill 1.5”

Base Failures 5%

No pavement or bridge widening

No replacement of guardrail or median cable rail

Initial Cost Estimate

Item	Unit	Amount	Unit Price	Cost
10.5" Pavement ML	SY	412,000.00	$91	$37,492,000
10.5" Pavement Shoulder	SY	274,600.00	$59	$16,201,400
Aramid Fiber	SY	412,000.00	$4	$1,648,000
SMA	SY	412,000.00	$16	$6,592,000
Temp Barrier	LF	17,500.00	$35	$612,500
MOT	LS	1.00		$1,000,000
Bridges	SF			$0
Drainage & MISC (10%)				$6,354,590
Mob/Demob (4.5%)				$3,145,522
SubTotal				$73,046,012
Total (30% Contingency)				$95,000,000

VE ALTERNATIVE 5
Full-Depth Pavement Rehab. Provide temporary widening with counterflow.

Description of MOT Concept:

This option would add 3.25’ of pavement width to the inside of the existing pavement. One lane of SB traffic would be diverted into a counterflow configuration from NB traffic with temporary barrier separation. Once SB pavement rehab is completed, one lane of NB traffic will be diverted to counterflow with the SB traffic. Crossovers would be installed at each bridge to avoid the need to widen them.

Description of Pavement Rehab Concept:

The pavement rehab strategy for MP 38.806- 46.121 would be to provide a full depth pavement rehab including rubbleizing the underlying concrete with 9” of Asphalt Base and 1.5” of Asphalt Surfacing. The pavement rehab strategy for MP 46.121 – 53.433 would be milling and replacement of 3” of Asphalt Base and 1.5” of Asphalt Surfacing.

Discussion:

This alternative is similar to Option 4 of the initial MOT options that were considered. The example typical section is from I-24 in Christian County. Bridge widening is not included in this Alternative but could be an option to avoid the number of crossovers required. Using the crossovers and not widening the bridges results in small segments that would need to remain as existing during construction and rehabbed as a separate phase. These are relatively small segments that should be able to be completed with temporary nighttime lane closures.

VE ALTERNATIVE 5

Full-Depth Pavement Rehab. Provide temporary widening with counterflow.

Performance Assessment:

Attributes and Rating Rationale
Mainline Operations This alternative provides limited additional operational improvements in the final configuration of 2- 12' Mainline Travel Lanes and a Depressed Median like the existing conditions. The temporary pavement provided would be converted into slightly widened shoulders providing approximately 3' additional. No widening of bridges is assumed.
Maintainability The resulting pavement section should provide a long-term solution with full depth AC replacement and cracking/seating of the concrete. Pavement rehab work is limited to a single lane area which may require additional joints to be installed. The drainage improvements may be less continuous and more difficult to install given the piecemeal nature of the pavement rehab limited to one lane only.
Construction Impacts The alternative provides two lanes of traffic in each direction. There may be some temporary lane closures required at the crossovers and transition locations, but these should be able to be completed with nighttime closures or very temporary lane closures. The counterflow configuration includes barrier separation, but it may lead to driver confusion / unease. Additionally, there is less separation of construction from traffic (but still includes barrier separation). Pavement rehab work is limited to a single lane at a time, thus the total project schedule may be longer. Transition locations at the bridges not completed with the main rehab will need to be completed with nighttime closures.

Assumptions and Calculations:

Assumes no bridge widening

Assumes moving temporary barrier for each phase for a total of 4 times

Assumes all of the guardrail on the inside shoulders, half of the guardrail on the outside shoulders, and all of the median cable rail will be replaced due to widening and crossovers.

VE ALTERNATIVE 5

Full-Depth Pavement Rehab. Provide temporary widening with counterflow.

Initial Cost Estimate

	Unit	Amount	Unit Price	Cost
4.5" Pavement ML	SY	208,512.00	$40	$8,340,480
4.5" Pavement Shoulder	SY	85,810.00	$35	$3,003,350
10.5" Pavement ML	SY	229,095.00	$91	$20,847,645
10.5" Pavement Shoulder	SY	94,280.00	$59	$5,562,520
Full Depth ML	SY	0.00	$126	$0
Full Depth Shoulder	SY	72,029.33	$88	$6,364,692
Temp Barrier	LF	81,033.00	$35	$2,836,155
Move Temp Barrier	LF	81,033.00	$8	$648,264
MOT				$1,000,000
Guardrail	LF	65,674.00	$35	$2,298,590
Cable Rail	LF	69,945.00	$30	$2,098,350
Bridges	SF			$0
Drainage & MISC (10%)				$5,300,005
Mob/Demob (4.5%)				$2,623,502
SubTotal				$60,923,553
Total (30% Contingency)				$79,200,000

VE ALTERNATIVE 6
Full-Depth Pavement Rehab. Provide one lane widening.

Description of MOT Concept:

This concept will widen the existing pavement into the median by 14.25', alternating the side of the interstate that the widening will occur on (either NB or SB). This provides enough pavement width to maintain four travel lanes during construction (two in each direction) on one side of the interstate to allow full-depth pavement reconstruction to occur on the other side. A temporary barrier wall will separate the traffic directions with a minimal 1' shoulder between the lane line and the barrier. The exception to this scheme is that traffic directions will split at bridge locations so that there is no widening of bridges. After the bridges, all lanes will again transition to one side of the interstate.

The location of the widening will alternate between the NB and SB directions to provide the widening where it will be most beneficial in the final condition, which correlates to the proposed truck climbing lanes. In areas where the need for the truck climbing lane shifts from NB to SB (and vice versa), then a pavement crossover will be constructed – shifting all four lanes of traffic together to the other side. This alternative will have perhaps the most median crossovers of all alternatives because of the alternating sides and the splits to avoid widening bridges.

After the initial sections of pavement are replaced, the concept will be mirrored to replace the rest of the pavement sections. Smaller phases of construction will be necessary to construct bridge approach pavement, thought to be possible during night operations to minimize traffic disruptions.

Description of Pavement Rehab Concept:

This concept provides a full-depth pavement replacement from MP 38.806 to MP 46.121. All existing asphalt will be removed. It is proposed to then break and seat all existing concrete pavement underneath to crack the existing concrete slabs into smaller sections that will prevent or delay reflective cracking. The existing concrete and base will be compacted. Underdrains will be constructed along the pavement edge and at strategic locations in all sags and dips in the roadway profile.

An additional improvement concept would be to place a geogrid layer on top of the broken concrete before placing asphalt. This would provide additional reflective crack mitigation and an extended pavement life and structural capacity. It may also allow KYTC to use a lesser asphalt pavement section when placing the geogrid, though that option has not been explored.

The pavement rehab concept for MP 46.121- MP 53.433 will only mill and replace 3" of asphalt base and 1.5" of asphalt surface. The existing pavement in this section is in better condition, and issues with the underlying concrete will not be addressed except perhaps adding/replacing underdrains at locations that are identified in the field to be problematic.

The proposed pavement section will provide a total of 10.5" of asphalt (9" base, 1.5" surface).

Discussion:

This concept is a combination of the original "Option 5" and "Climbing Lane Add-in Option". A new permanent lane will be constructed for the proposed condition. The pavement widening on alternating sides of the interstate maintains four lanes of traffic during construction while placing the widened pavement where it will be most impactful in the long-term for truck climbing lanes, until a six-lane roadway can be constructed. It also keeps costs lower by not requiring bridge

widening. Pavement in crossover locations can be removed after construction and lanes tapered according to standard rates.

The existing condition has a cable median barrier that runs the length of the project, with the exception of the bifurcated section near the north end of the project. Any lane widening or crossovers to the other side would impact these barriers. It is also assumed that they would be disturbed during construction for access reasons and to allow full-depth pavement replacement and underdrain construction. Therefore, the assumption is that all cable median barriers will need to be replaced for all alternatives that provide widening or crossovers. The barrier switches back and forth between sides, so the proposed locations will be on the same side of the interstate that it currently exists. The same is true for existing guardrail, in that it will all be replaced for the length of the project.

This alternative could also consider options for different pavement sections presented in other alternatives that may use structural enhancements that would allow a lesser pavement thickness while matching the pavement strength and lifespan such as geogrid, stone matrix asphalt, or fiber additives. Additionally, other pavement rehabilitation approaches such as Full-Depth Reclamation (though the concrete layer complicates it) or a full-depth pavement that removes the existing concrete completely could be explored further.

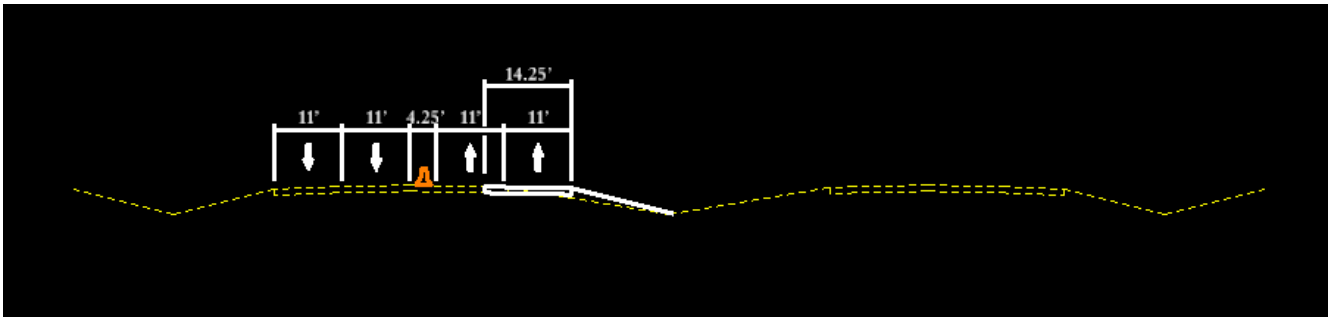
Performance Assessment:

Attributes and Rating Rationale
Mainline Operations This alternative will improve mainline operations in the final configuration by constructing lanes that will remain as truck climbing lanes in steep grade sections.
Maintainability This alternative will provide one of the best quality pavement sections, by eliminating longitudinal joints by allowing the full width of the roadway to be constructed at one time. Drainage improvements will also be easier to construct since the full side can be constructed at one time instead of having to maintain a lane and use phased construction.
Construction Impacts This alternative will likely require the most pavement crossovers of all the concepts considered. However, the barrier wall can remain in one location until all the initial sections of pavement are replaced. The traffic flow should be simple to understand for the traveling public by keeping all lanes of traffic together, with limited split traffic only at bridges. Separate construction phases would be necessary, perhaps during night construction, for reconstructing bridge approach pavement.

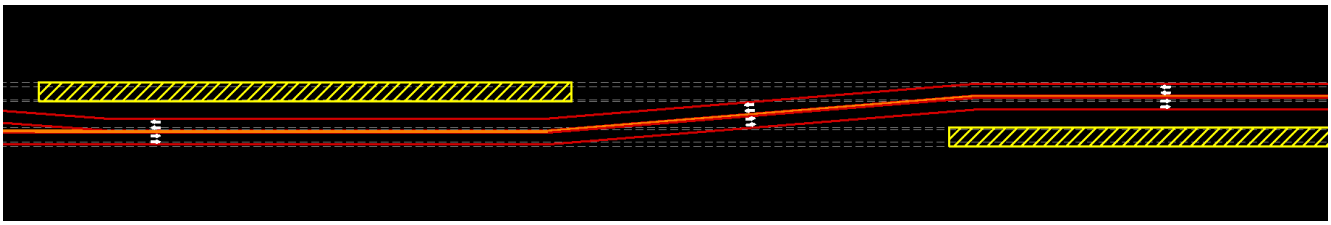
VE ALTERNATIVE 6

Full-Depth Pavement Rehab. Provide one lane widening.

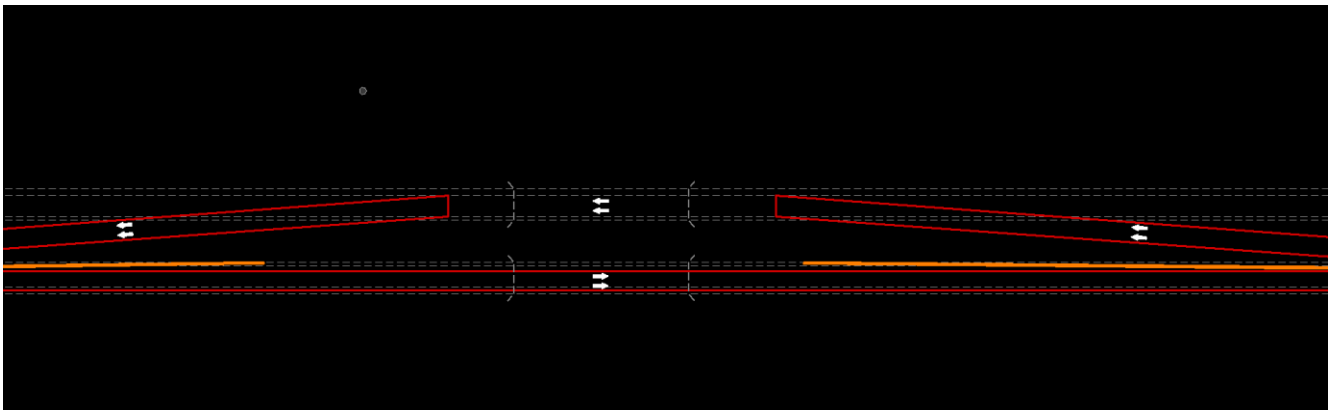
VE Alternative Concept Sketches



Typical Section: 4-lane MOT



4-Lane Crossover MOT



Split Traffic at Bridges

Assumptions and Calculations:

Plan sketches to show schematic only, not to scale. For lane shifts, assume L/2, where L=WS.

W=~60', S=55mph, L=3300'. Shift taper length = 1650'. The design team may determine a lesser taper length by selecting a lower speed or other practical factors. A short taper length would provide a larger construction work area.

Assumes no bridge widening

Assumes moving temporary barrier for each phase for a total of 4 times

Assumes all of the guardrail on the inside shoulders, half of the guardrail on the outside shoulders, and all of the median cable rail will be replaced due to widening and crossovers.

VE ALTERNATIVE 6

Full-Depth Pavement Rehab. Provide one lane widening.

Initial Cost Estimate

	Unit	Amount	Unit Price	Cost
SB 4.5" Pavement ML	SY	102,258	$40	$4,090,325
SB 4.5" Pavement Shoulder	SY	59,651	$35	$2,087,770
NB 4.5" Pavement ML	SY	102,258	$40	$4,090,325
NB 4.5" Pavement Shoulder	SY	42,608	$35	$1,491,264
SB 10.5" Pavement ML	SY	109,350	$91	$9,950,818
SB 10.5" Pavement Shoulder	SY	63,787	$59	$3,763,451
NB 10.5" Pavement ML	SY	109,350	$91	$9,950,818
NB 10.5" Pavement Shoulder	SY	45,562	$59	$2,688,179
NB 10.5" Pavement Widening	SY	125,642	$91	$11,433,433
Temp Crossover Pavement	SY	91,667	$59	$5,408,333
Temp Barrier	LF	76,584	$35	$2,680,437
Move Temp Barrier	LF	153,168	$8	$1,225,343
MOT	LS	1		$1,200,000
Guardrail	LF	65,673.00	$35	$2,298,555
Cable Rail	LF	69,945.00	$30	$2,098,350
Bridge Retrofits/Widening	SF			$0
MISC (1%)	LS			$644,574
Mob/Demob (4.5%)	LS			$2,929,589
SubTotal				$68,031,566
Total (30% Contigency)				$88,400,000

VE ALTERNATIVE 7
Full Depth Pavement Rehab. Provide widening to one side only and widen bridges.

Description of MOT Concept:

This concept differs from VE Alternative 6 by widening the pavement on one side only (either NB or SB) by 14.25' into the median. This provides enough pavement width to maintain four travel lanes (two in each direction) on one side of the interstate, allowing full-depth pavement reconstruction to occur on the other side. A temporary barrier wall will separate the traffic directions with a minimal 1' shoulder between the lane line and the barrier. The pavement would be constructed to permanent pavement specs to remain after construction, accomplishing half of the ultimate build six-lane option.

Initial discussions by the VE team suggest widening would be in the SB direction, though further evaluation of traffic, topography and other factors would be necessary to determine the best solution.

There would be three main MOT phases: Phase 1 would have four lanes of traffic together on one side (SB side, for example) for the length of the project. This allows the pavement in the NB direction to be completely reconstructed. Phase 2 would shift two lanes back to the NB direction to the newly constructed pavement to allow rehabbing the first half of the SB side. Then phase 3 shifts SB traffic to the reconstructed half to allow reconstruction of the rest of the pavement. In final configuration, 3 lanes would remain in the SB direction and 2 lanes in the NB direction.

There are five bridges that would first have to be widened sufficiently to accommodate four lanes of traffic and a 4.25' buffer with barrier median and shoulders. The existing steel bridge over the Kentucky River is ~24' wide and the other four range from 29.9'-wide curb-to-curb. This alternative assumed widening the concrete bridges by 15' and the KY River bridge by 17'.

Description of Pavement Rehab Concept:

This concept follows the initial recommendation for pavement rehab based on the current pavement condition. Part of the rehab will be full-depth and part will be partial-depth. Full-depth pavement replacement will be from MP 38.806 to MP 46.121. All existing asphalt will be removed. It is proposed to then break and seat all existing concrete pavement underneath to crack the existing concrete slabs into smaller sections that will prevent or delay reflective cracking. The existing concrete and base will be compacted. Underdrains will be constructed along the pavement edge and at strategic locations in all sags and dips in the roadway profile. The proposed pavement section will provide a total of 10.5" of asphalt (9" base, 1.5" surface).

An additional improvement could be to place a geogrid layer on top of the broken concrete before placing asphalt. This would provide additional reflective crack mitigation, an extended pavement life, and structural capacity. It may also allow KYTC to use a lesser asphalt pavement section when placing the geogrid, though that option has not been explored.

The pavement rehab concept for MP 46.121- MP 53.433 will only mill and replace 3" of asphalt base and 1.5" of asphalt surface. The existing pavement in this section is in better condition and issues with the underlying concrete will not be addressed except perhaps adding/replacing underdrains at locations that area identified in the field to be problematic.

VE ALTERNATIVE 7

Full Depth Pavement Rehab. Provide widening to one side only and widen bridges.

Discussion:

This alternative is like VE Alternative 6 but improves traffic flow by eliminating median crossovers. However, this requires the additional significant cost of widening bridges, and the extra lane provided in the final configuration is not in the optimized location for all truck climbing lanes. A significant factor for this alternative is that it achieves half of the ultimate six-lane build scenario that KYTC plans for the corridor. The exact width of widening may vary, though 14.25' was assumed for sketches and costs.

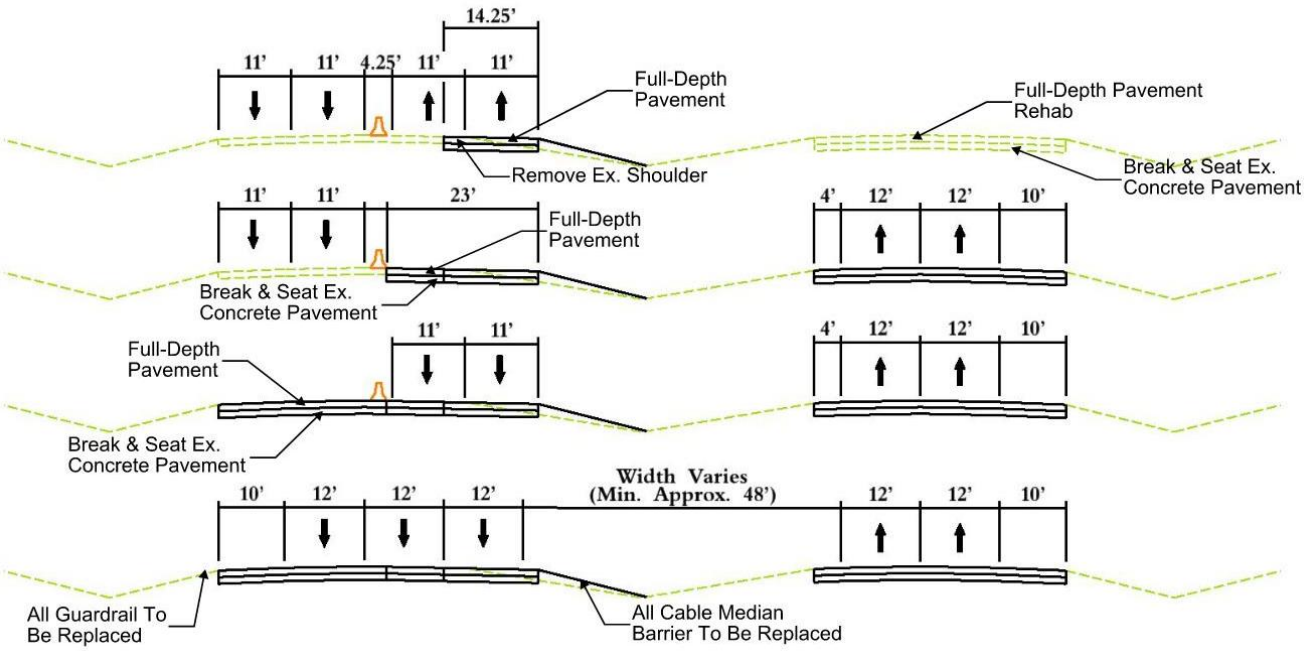
Performance Assessment:

Attributes and Rating Rationale
Mainline Operations Mainline operations are improved in the final configuration by constructing pavement that will remain as an additional travel lane for the length of the project in one direction, including all the bridges in that direction. This will improve capacity, particularly in truck climbing lane sections.
Maintainability This alternative will provide the best quality pavement sections, by eliminating longitudinal joints by allowing the full width of the roadway to be constructed at one time. Drainage improvements will also be easier to construct since the full side can be constructed at one time instead of having to maintain a lane and use phased construction.
Construction Impacts This alternative will maintain four lanes of traffic during construction and likely provide the shortest traffic delays by also eliminating median crossovers. Traffic delays will still occur in construction during peak traffic periods by having a reduced speed limit, reduced-width travel lanes, and steep roadway grades.

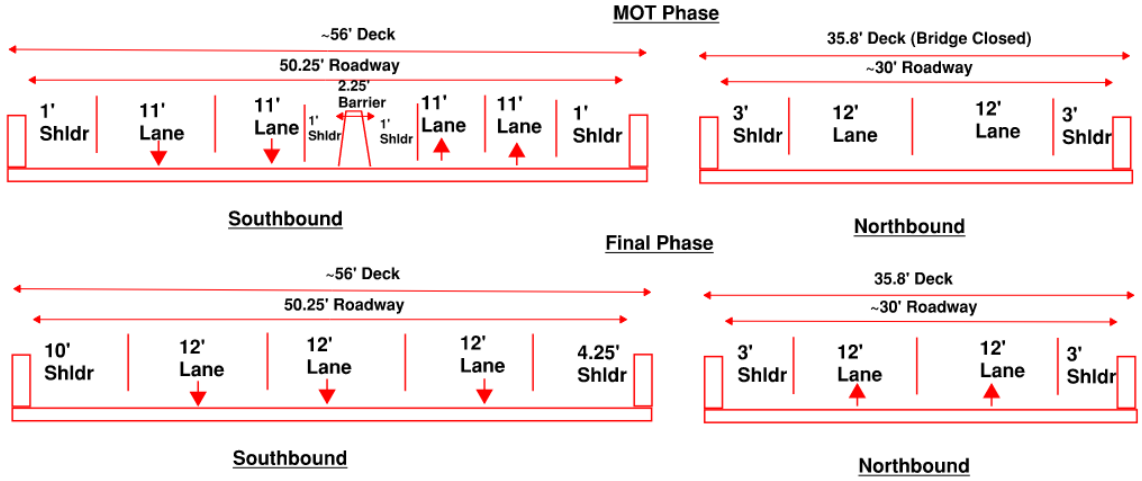
VE ALTERNATIVE 7

Full Depth Pavement Rehab. Provide widening to one side only and widen bridges.

VE Alternative Concept Sketch



Possible Construction Phases



Assumptions and Calculations:

The total width of existing pavement available is assumed and may vary, so the widening width may need to be adjusted.

Assumes all guardrail on the SB direction and all median cable rail will be replaced due to widening and crossovers.

VE ALTERNATIVE 7

Full Depth Pavement Rehab. Provide widening to one side only and widen bridges.

The additional travel lane in the final condition can be in either direction. Further traffic analysis is needed to decide on the optimal direction.

In the section with only partial-depth pavement rehab, the same MOT scheme would be used, but the lesser pavement section used (except for the widening).

All bridges on the widened side will need to be widened. The existing concrete bridge width is ~30'. Cost estimate based on a 50.25' bridge width total. This will provide 4 lanes of travel during construction and will provide three 12' travel lanes in the final condition. This alternative assumed widening the concrete bridges by 20.25' and the KY River bridge by 25.25'.

Initial Cost Estimate

VE Alt 7 - Widen all on one side				
	Unit	Amount	Unit Price	Cost
SB 4.5" Pavement ML	SY	102,258	$40	$4,090,325
SB 4.5" Pavement Shoulder	SY	59,651	$35	$2,087,770
NB 4.5" Pavement ML	SY	102,258	$40	$4,090,325
NB 4.5" Pavement Shoulder	SY	42,608	$35	$1,491,264
SB 10.5" Pavement ML	SY	109,350	$91	$9,950,818
SB 10.5" Pavement Shoulder	SY	63,787	$59	$3,763,451
NB 10.5" Pavement ML	SY	109,350	$91	$9,950,818
NB 10.5" Pavement Shoulder	SY	45,562	$59	$2,688,179
NB 10.5" Pavement Widening	SY	125,642	$91	$11,433,433
Temp Crossover Pavement	SY	20,000	$59	$1,180,000
Temp Barrier	LF	76,584	$35	$2,680,437
Move Temp Barrier	LF	84,242	$8	$673,938
MOT	LS			$800,000
Guardrail	LF	47,375.00	$35	$1,658,125
Cable Rail	LF	69,945.00	$30	$2,098,350
Bridge Widening - KY River	SF	19,417	$800	$15,533,800
Bridge Widening - Concrete	SF	20,250	$450	$9,112,500
MISC (1%)	LS			$832,835
Mob/Demob (4.5%)	LS			$3,785,237
SubTotal				$87,901,608
Total (30% Contigency)				$114,300,000

Description of MOT Concept:

This alternative differs from VE Alternatives 6 and 7 by widening the pavement on both the northbound and southbound sides by one mainline lane and a shoulder. By adding two new lanes to I-71, this option enables the closure of two lanes at a time for full-depth and partial-depth pavement reconstruction while maintaining four travel lanes (two in each direction). The new lanes will be constructed to current permanent pavement specifications and will remain in place after construction is complete.

A phased construction approach will be implemented. First, two new lanes will be constructed in the median, outside the existing roadway limits, so current traffic will not be disrupted. Next, two lanes in either the northbound or southbound direction will be closed to allow for full-depth and partial-depth pavement repairs, as well as erosion improvements, with traffic temporarily shifted onto the new lanes.

At bridge locations, a new structure will be constructed between each of the existing twin bridges. Once completed, either northbound or southbound traffic will be shifted onto the new bridge, allowing for repairs on the existing structures, including full and partial-depth pavement reconstruction and replacement of existing bridge rails with current standard rails. In the final stage, the new bridge deck will be connected to the existing bridge decks and will remain in place after construction is complete.

Description of Pavement Rehab Concept:

Similar to VE Alternatives 6 and 7, this alternative includes full-depth pavement replacement from MP 38.086 to MP 46.121 and partial-depth replacement from MP 46.121 to MP 53.433. In the full-depth section, all existing asphalt will be removed and replaced with 9 inches of asphalt base and 1.5 inches of surface. In the partial-depth section, only 3 inches of asphalt base and 1.5 inches of surface will be milled and replaced, as the existing pavement is in relatively good condition. This alternative also allows traffic to be shifted onto the newly constructed lanes, enabling the installation of new underdrains and the replacement of existing underdrains throughout the length of the project.

Discussion:

Widening I-71 into the median by adding two lanes to the existing four-lane highway provides the following benefits:

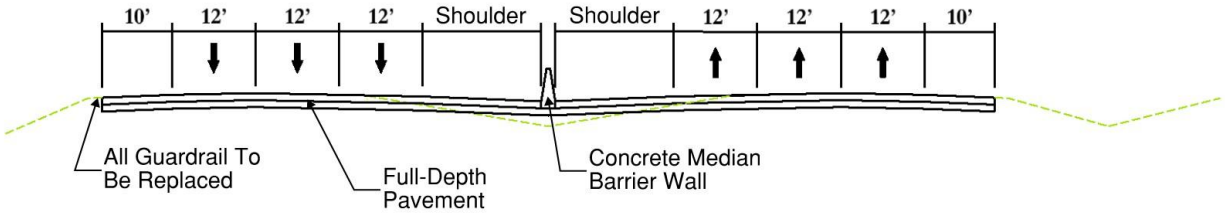
1. This option allows for two-way traffic in each direction during construction, which is important because I-71 is a major highway with high ADT and ADTT.
2. It enables both full-depth and partial-depth repairs on the existing highway and provides opportunities for significant erosion improvements.
3. The highway's capacity will be increased to accommodate more traffic, aligning with the long-term goals for I-71.
4. Safety will be improved for both construction crews and motorists during construction, as well as after the work is completed.
5. The life expectancy of the highway will be greater than that of all other options, due to more in-depth repairs and the addition of new roadway and structures.

VE ALTERNATIVE 8
Widen to Six Lanes

Performance Assessment:

Attributes and Rating Rationale
Mainline Operations • Safest option, as the existing traffic layout will remain unchanged during most of the construction. The majority of the work will occur outside of the existing roadway. • Traffic disruption will be minimal, which is important given the highway's high ADT and ADTT. • This segment of I-71 will match the traffic layout of I-71 north of the intersection with KY 35. • The capacity of the highway will be increased to accommodate more traffic. • Bridges will have safety shoulders and standard rails, which will improve safety and bridge inspection ratings.
Maintainability • Easiest to maintain, considering that we are introducing new roadways and structures and performing more in-depth repairs on the existing highway. • This option allows for significant erosion control improvements.
Construction Impacts • Minimal to no construction impacts, with two lanes of traffic in each direction active at all times.

VE Alternative Concept Sketch



Assumptions and Calculations:

Assume all guardrail will be replaced due to widening and crossovers.

Assume center concrete median barrier will be installed in non-bifurcated sections.

All bridges will need to be widened on the inside for the additional lanes and shoulders.

Initial Cost Estimate

Widen to 6 - Lanes				
	Unit	Amount	Unit Price	Cost
SB 4.5" Pavement ML	SY	102,048.69	$40	$4,081,948
SB 4.5" Pavement Shoulder	SY	42,520.29	$35	$1,488,210
NB 4.5" Pavement ML	SY	102,048.69	$40	$4,081,948
NB 4.5" Pavement Shoulde	SY	42,520.29	$35	$1,488,210
SB 10.5" Pavement ML	SY	108,665.07	$91	$9,888,521
SB 10.5" Pavement Shoulde	SY	45,277.11	$59	$2,671,350
NB 10.5" Pavement ML	SY	108,665.07	$91	$9,888,521
NB 10.5" Pavement Should	SY	45,277.11	$59	$2,671,350
Full Depth ML	SY	210,713.76	$126	$26,549,934
Full Depth Shoulder	SY	175,594.80	$88	$15,515,996
Bridge Retrofits	SF	16,441.63	$100	$1,644,163
Temp Barrier	LF	78,017.66	$35	$2,730,618
Move Temp Barrier	LF	78,017.66	$8	$624,141
MOT	LS	1.00		$1,000,000
Guardrail	LF	116,000.00	$35	$4,060,000
Concrete barrier median	LF	69,945.00	$150	$10,491,750
KY River Bridge Widening	SF	41,526.00	$800	$33,220,800
4 Twin Bridge Widenings	SF	67,257.00	$450	$30,265,650
Drainage & MISC (10%)	LS			$16,236,311
Mob/Demob (4.5%)	LS			$8,036,974
SubTotal				$186,636,394
Total (30% Contingency)				$242,600,000

VE ALTERNATIVE 9

Widen to Six Lanes for 6 miles. Nighttime closure with enhanced minimum rehab for remainder.

Description of MOT Concept:

This alternative is a hybrid combination of VE Alternatives 2, 3, and 8.

The roadway will be widened on both the northbound and southbound sides by one mainline lane and a shoulder for approximately 5.5 miles. This would be similar to what is proposed in VE Alternative 8.

By adding two new lanes to I-71, this option enables the closure of two lanes at a time for full-depth and partial-depth pavement reconstruction while maintaining four travel lanes (two in each direction). The new lanes will be constructed to current permanent pavement specifications and will remain in place after construction is complete.

Description of Pavement Rehab Concept:

The remainder of the project not widened to the 6-lane section would consist of digging out initial base failures followed by the mill and fill of 3” of asphalt base and 1.5” of asphalt surface. This would be performed under nightly lane closures during non-peak traffic period times and is similar to what is proposed in VE Alternative 2.

The basic pavement rehab could be enhanced with several options to increase durability and/or decrease lane closure time. The VE team considered several options for pavement durability and a couple for speeding up construction. To increase durability the pavement design could use one or a combination of the following: Stone Matrix Asphalt Mix, Aramid Fibers, or a Paving Grid/Fabric. To speed construction traffic could be allowed to run on a milled surface or a base layer for a limited time frame.

Discussion:

Widening I-71 into the median by adding two lanes to the existing four-lane highway provides the following benefits to the extent that available funds can support:

1. This option allows for two-way traffic in each direction during construction, which is important because I-71 is a major highway with high ADT and ADTT.
2. It enables both full-depth and partial-depth repairs on the existing highway and provides opportunities for significant erosion improvements.
3. The highway’s capacity will be increased to accommodate more traffic, aligning with the long-term goals for I-71.
4. Safety will be improved for both construction crews and motorists during construction, as well as after the work is completed.
5. The life expectancy of the highway will be greater than that of all other options, due to more in-depth repairs and the addition of new roadway and structures.

VE ALTERNATIVE 9

Widen to Six Lanes for 6 miles. Nighttime closure with enhanced minimum rehab for remainder.

Performance Assessment:

Attributes and Rating Rationale
Mainline Operations Six-lane section (~5.5 miles): • Safest option, as the existing traffic layout will remain unchanged during most of the construction. The majority of the work will occur outside of the existing roadway. • Traffic disruption will be minimal, which is important given the highway's high ADT and ADTT. • This segment of I-71 will match the traffic layout of I-71 north of the intersection with KY 35. • The capacity of the highway will be increased to accommodate more traffic. • Bridges will have safety shoulders and standard rails, which will improve safety and bridge inspection ratings. Remainder Section: This segment would have no additional operations as the typical section will remain the same with 2 12' travel lanes, shoulders and a depressed median. The pavement would be more durable and less susceptible to rutting, potholes and cracking than existing if one or more of the innovative ideas is uses.
Maintainability Six-lane section (~5.5 miles): • Easiest to maintain, considering that we are introducing new roadways and structures and performing more in-depth repairs on the existing highway. • This option allows for significant erosion control improvements. Remainder Section: This alternative would provide some relief from the yearly maintenance currently required by replacing the top two layers of asphalt. The length of the relief period will depend on the asphalt pavement design used. The use of one or more innovative materials will extend the pavement life at least an additional 3-4 years.
Construction Impacts Six-lane section (~5.5 miles): • Minimal to no construction impacts, with two lanes of traffic in each direction active at all times. Remainder Section: Work will only be performed during nightly lane closures outside peak traffic periods. Traffic will always remain in the normal lanes of traffic. No lane shifts or crossovers.

Initial Cost Estimate

The construction costs for this alternative is dependent upon assumed available funding for the project of $100 million. The objective is to maximize the amount of 6-lane section provided (assume 5.5 miles) with enough funding leftover for the enhanced pavement rehab under night closures.

7.3 Additional Design Considerations

The VE team generated the following design suggestions for the project design team's consideration. These items represent ideas that were generated during the Creative Phase of the VE study, but were not chosen for development as VE alternatives. However, they may provide additional value improvement for the project in the form of additional design development options or document clarifications.

Table 8. Design Considerations

Comment No.	Description
DC-1	Reopen traffic on asphalt base after night closures prior to overlay
DC-2	Use temporary bridges and widen to median to accommodate traffic shifts
DC-3	Install longitudinal underdrainage systems beneath existing in lieu of full-depth replacement
DC-4	Use full-depth pulverization / reclamation in lieu of crack and seat
DC-5	Limit the distance of closure to a minimum level of delay/back-up
DC-6	Install asphalt curb or regrade at guardrails to reduce erosion

8 VE Alternative Comparative Analysis

VE studies result in the development of a number of alternatives to a baseline concept.

8.1 Compare Performance of VE Alternatives

The VE team considered the combined effect of all the Performance Attributes in determining a cumulative performance score for each alternative. Total baseline performance was calculated by multiplying an attribute's weight (which was established previously and described in the Project Analysis section) by its rating. The following rating scale was used to evaluate the performance of the VE Alternatives.

Table 9. Performance Rating Scale Definitions

Rating	**Performance Attribute** Rating **Scale**
10	Ideal. Highest level of functional performance for the respective attribute.
9	Mostly Ideal
8	Somewhat Ideal
7	Preferred with some potential performance limitations
6	Acceptable with some additional benefit
5	Acceptable
4	Mostly Acceptable with some minor reductions.
3	Somewhat Acceptable
2	Less than preferred, but with some potential benefit above minimum performance.
1	Very unpreferred and minimal level of performance.
0	Unacceptable. Does not meet minimum criteria for functional performance.

The VE Alternatives were evaluated across all three of the performance attributes and a performance rating was assigned to each as summarized in the table below.

Table 10: Performance Attribute Ratings

Attribute	Attribute Weight	Alternative	Performance Rating	Total Performance
Mainline Traffic Operations	16.7	1	5	83.5
		2	5	83.5
		3	5	83.5
		4	5	83.5
		5	5.5	91.9
		6	8	133.6
		7	8	133.6
		8	10	167.0
		9	9	150.3
Maintainability	50.1	1	1.5	75.2
		2	4.5	225.5
		3	5	250.5
		4	8.5	425.9
		5	8	400.8
		6	8.5	425.9
		7	9	450.9
		8	10	500.1
		9	8	400.8
Temporary Construction Impacts	33.3	1	5	166.5
		2	5	166.5
		3	2	66.6
		4	1	33.3
		5	6	199.8
		6	7.5	249.8
		7	8.5	283.1
		8	10	333.0
		9	7	233.1

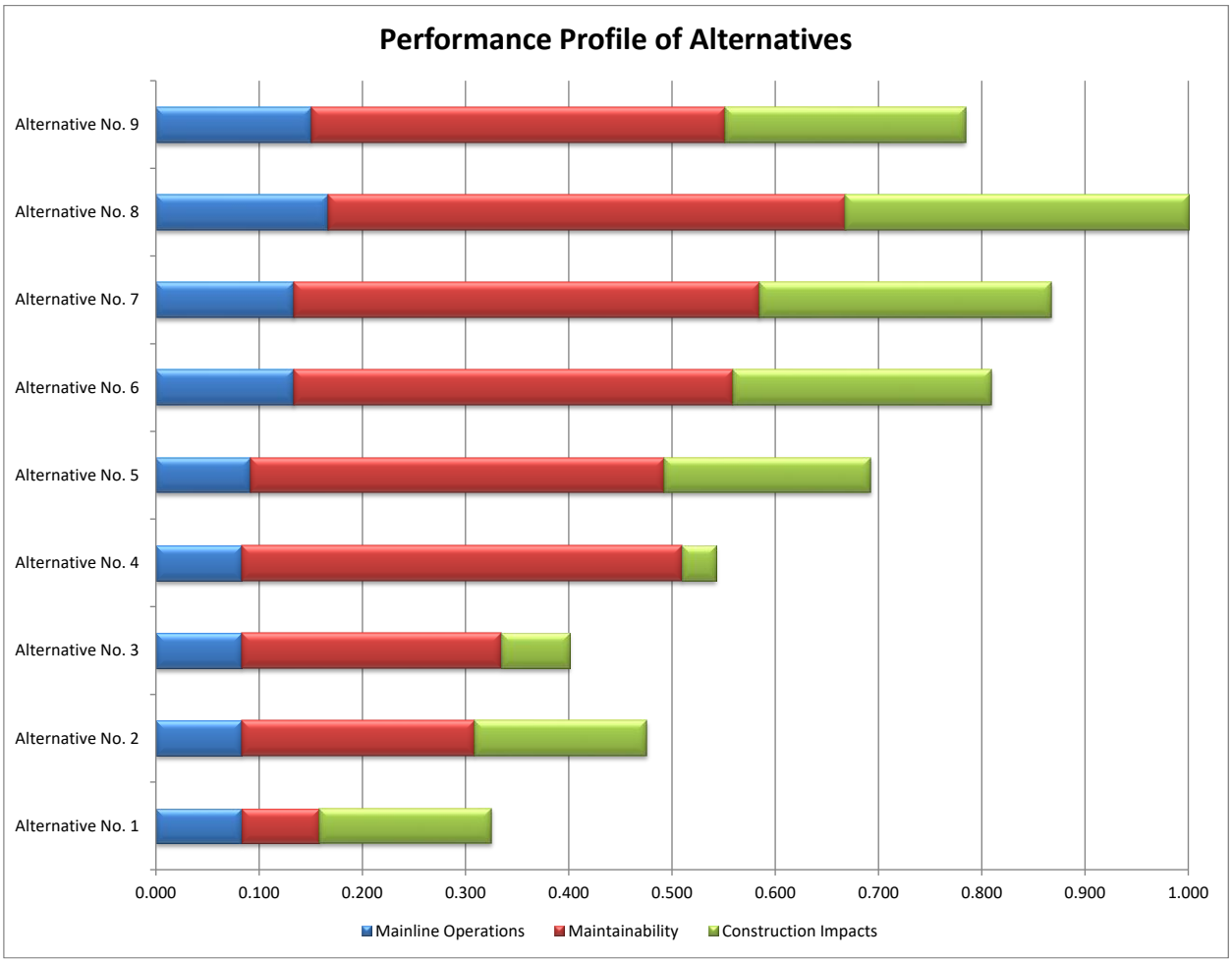


Figure 6: Performance Profile of Value Strategies

8.2 Rating Rationale for VE Alternatives

The rating rationale for the performance of the VE Alternatives is provided in the Individual Alternative Write-ups in Section 7 of this report.

8.3 Compare Cost

The cost elements were compared and normalized for the VE Alternatives using the following table. The table illustrates how the cost scores were derived. In this comparison, a lower score is desirable as the project will benefit from lower costs. The VE team used high level parametric estimating to develop total costs for each VE Alternative as documented in their individual write-ups.

Table 11: Cost Comparisons

VE Alternatives	Total Cost	Normalized Cost Score
Alt 1 - Mill and fill pavement overlay with nighttime closures	$20,900,000	0.025
Alt 2 - Minimum pavement rehab with nighttime closures	$51,400,000	0.061
Alt 3 - Minimum pavement replacement with structural improvements with weekday full lane closures	$51,600,000	0.061
Alt 4 - Full-Depth Pavement Rehab with weekday full lane closures	$95,000,000	0.113
Alt 5 - Full-Depth Pavement Rehab. Provide temporary widening with counterflow.	$79,200,000	0.094
Alt 6 - Full-Depth Pavement Rehab. Provide one lane widening.	$88,400,000	0.105
Alt 7 - Full Depth Pavement Rehab. Provide widening to one side only and widen bridges.	$114,300,000	0.135
Alt 8 - Widen to Six Lanes	$242,600,000	0.287
Alt 9 - Widen to Six Lanes for 6 miles. Nighttime closure with enhanced minimum rehab for remainder.	$100,648,366	0.119
TOTAL		1.000

8.4 Compare Value

Once relative scores for performance and cost have been derived, the next step is to synthesize a value index for the comparison of their overall value. This is achieved by applying the following algorithm for value:

- V = Value
- f = Function
- P = Performance
- C = Cost
- t = Time
- α = Risk

$$V_f(P,C,t)_{total} = \frac{\sum_{n=1}^{\infty} P_n \cdot \alpha}{\sum_{n=1}^{\infty}[(C_n \cdot \alpha) + (t_n \cdot \alpha)]}$$

A Value Matrix was prepared which facilitated the comparison of the alternatives by organizing and summarizing this data into a tabular format. The performance scores for each alternative were divided by the total cost scores to derive a value index. The value indices for the VE Alternatives are then compared against the value index of the other alternatives and the difference is expressed as a percent (±%) deviation.

Table 12: Value Matrix

VE Alternatives	Performance Score	Cost Score	Value Index	Change in Value
Alt 1 - Mill and fill pavement overlay with nighttime closures	325	0.025	6.395	0%
Alt 2 - Minimum pavement rehab with nighttime closures	475	0.061	6.900	8%
Alt 3 - Minimum pavement replacement with structural improvements with weekday full lane closures	401	0.061	5.803	-9%
Alt 4 - Full-Depth Pavement Rehab with weekday full lane closures	543	0.113	5.728	-10%
Alt 5 - Full-Depth Pavement Rehab. Provide temporary widening with counterflow.	692	0.094	8.110	27%
Alt 6 - Full-Depth Pavement Rehab. Provide one lane widening.	809	0.105	8.909	39%
Alt 7 - Full Depth Pavement Rehab. Provide widening to one side only and widen bridges.	868	0.135	8.171	28%
Alt 8 - Widen to Six Lanes	1000	0.287	5.495	-14%
Alt 9 - Widen to Six Lanes for 6 miles. Nighttime closure with enhanced minimum rehab for remainder.	784	0.119	7.995	25%

Understanding the relationship of cost, performance, and value is essential in evaluating the VE study results. Comparing the performance and cost suggests which alternatives are the best options in terms of overall value. The value metrics graph below illustrates each VE Alternative's value profile.

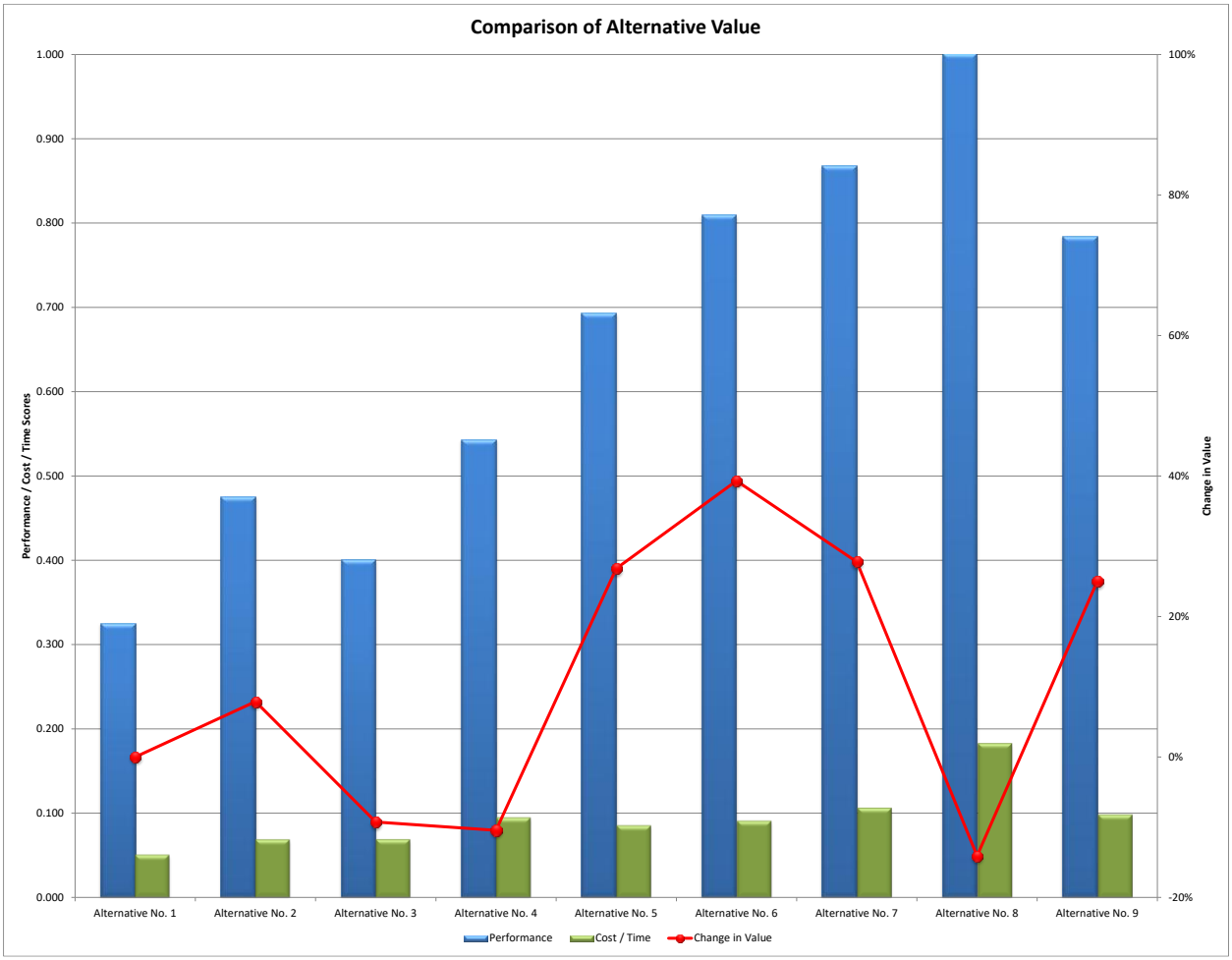


Figure 7: Comparison of Value Chart

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.

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.

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 alternatives 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.
2. Establish the hierarchy and impact of these attributes on the project.
3. Establish the baseline of the current project performance by evaluating and rating the effectiveness of the current design concepts.
4. Identify the change in performance of alternative project concepts generated by the study.

5. 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

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	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.

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 designs 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.

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 alternatives on total project value.

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

- % Performance Improvement = Δ Performance VE Strategy/Total Performance Original Concept
- Value Index = Total Performance/Total Cost
- % Value Improvement = ΔValue Index VE Strategy/Value Index Original Concept.

Appendix B. VE Workshop Agenda and Attendees

Day 1	July 14, 2025 Objective for the day: Learn about VE and the project	
9:00 AM (EDT)	**Workshop Kick-off Meeting** • Study kickoff • Team introductions • Workshop objectives	**All Audiences:** Project owner, management, stakeholders, designers, etc.
9:15 AM *Information Phase*	**VE Process Overview** • An instructional presentation on the principles of value Engineering and their application to the project	**VE Facilitator**
9:30 AM *Information Phase*	**Project Overview** • Goals and objectives of the project • Key project drivers, decisions, and constraints • Project Scope / Design Overview • Project challenges and VE focus areas • Areas for discussion: ○ Roadway Design ○ Traffic Analysis ○ Structures ○ Drainage/Hydraulics ○ Utilities ○ Environmental Conditions ○ Staging/Phasing	**Project Team/ Designer**
11:00 AM	**Break**	
11:15 AM	**Project Issues and Concerns**	**KYTC/Designer**
11:30 AM	**Define and Prioritize Performance Attributes**	**All Audiences**
12:00 AM	**Risk Assessment & Risk Register Updates**	**All Audiences**
Noon	**Lunch**	
1:00 PM	**VE Project Engineering and Documentation Review** • Review Available Project Documents • Review Project schedule, including construction phasing/sequencing, work windows • Cost Estimate / Cost Model Review and contingency assumptions • Preliminary List of Project Issues and Value Opportunities	**VE Team**
2:00 PM	**Value Metrics and Baseline Performance Rating** • Rate performance attributes of baseline project **Risk Assessment & Risk Register** • Assign probabilities and impact ratings to risks **Discuss Project Issues and Value Opportunities**	**VE Team**
5:00 PM	**Adjourn for the day**	

Day 2	**July 15, 2025** **Objective for the day: Function Engineering, Brainstorming Ideas, and Evaluation**	
8:00 AM *Function Phase*	**Function Analysis** • Random Function Identification • Build / Review FAST diagram	**VE Team**
9:00 AM *Creative Phase*	**Brainstorming Ideas** • Brainstorm alternative ways to perform key functions	**VE Team**
Noon	**Lunch**	
1:00 PM *Evaluation Phase*	**Evaluation of Ideas** • Score/Rate ideas based on predetermined criteria	**VE Team**
5:00 PM	**Adjourn for the day**	
Day 3	**July 16, 2025** **Objective for the day: Midpoint Review and Begin Developing**	
8:00 AM	**Develop Ideas into VE Alternatives** • Select ideas to develop further into Alternatives • Individual/team assignments • Review VE Alternative Development Process	**VE Team**
9:00 AM	**Midpoint Review**	**KYTC / Designer Reps**

10:00 AM
Development Phase
	Develop Ideas into Recommendations
	• Individual/team assignments
	• Development of recommendations:
	  ○ Test design feasibility
	  ○ Design Engineering
	  ○ Technical narratives
	  ○ Further discussion on advantages and disadvantages
	  ○ Cost Estimating
		VE Team (offline individual assignments)

5:00 PM	**Adjourn for the day**	
Day 4	**July 17, 2025** **Objective for the day: Continue Development of VE Alternatives**	
8:00 AM *Development Phase*	**Continue Development of recommendations:** • Technical narratives • Drawings/Sketches • Cost Estimating	**VE Team**
1:00 PM *Development Phase*	**VE Team Review of VE Alternative Development** • Peer review of recommendations • Outbrief Presentation Preparation/Review	**VE Team**
5:00 PM	**Adjourn**	

Day 5	**July 18, 2025** **Objective for the day: Outbrief Presentation of Draft VE Study Results**	
8:00 AM *Presentation Phase*	**Strategies and Value Metrics** • Development of VE Strategies (combination of Alternatives) • Evaluate performance and cost of VE strategies	**VE Team**
10:00 AM	**Presentation of VE Findings** • Team presents VE Study Results and Value Proposals • Questions and answers	**All Audiences:** Project owner, management, stakeholders, designers, etc.
12:00 PM	**Adjourn**	

Appendix C. Closing Presentation

Appendix D. VE Implementation Approval Form

VE Alternative Implementation Summary

VE Alternatives	Total Cost	Preliminary Decision (Accept or Reject)	Decision Rationale
Alt 1 - Mill and fill pavement overlay with nighttime closures	$20,900,000		
Alt 2 - Minimum pavement rehab with nighttime closures	$51,400,000		
Alt 3 - Minimum pavement replacement with structural improvements with weekday full lane closures	$51,600,000		
Alt 4 - Full-Depth Pavement Rehab with weekday full lane closures	$95,000,000		
Alt 5 - Full-Depth Pavement Rehab. Provide temporary widening with counterflow.	$79,200,000		
Alt 6 - Full-Depth Pavement Rehab. Provide one lane widening.	$88,400,000		
Alt 7 - Full Depth Pavement Rehab. Provide widening to one side only and widen bridges.	$114,300,000		
Alt 8 - Widen to Six Lanes	$242,600,000		
Alt 9 - Widen to Six Lanes for 6 miles. Nighttime closure with enhanced minimum rehab for remainder.	$100,648,366		