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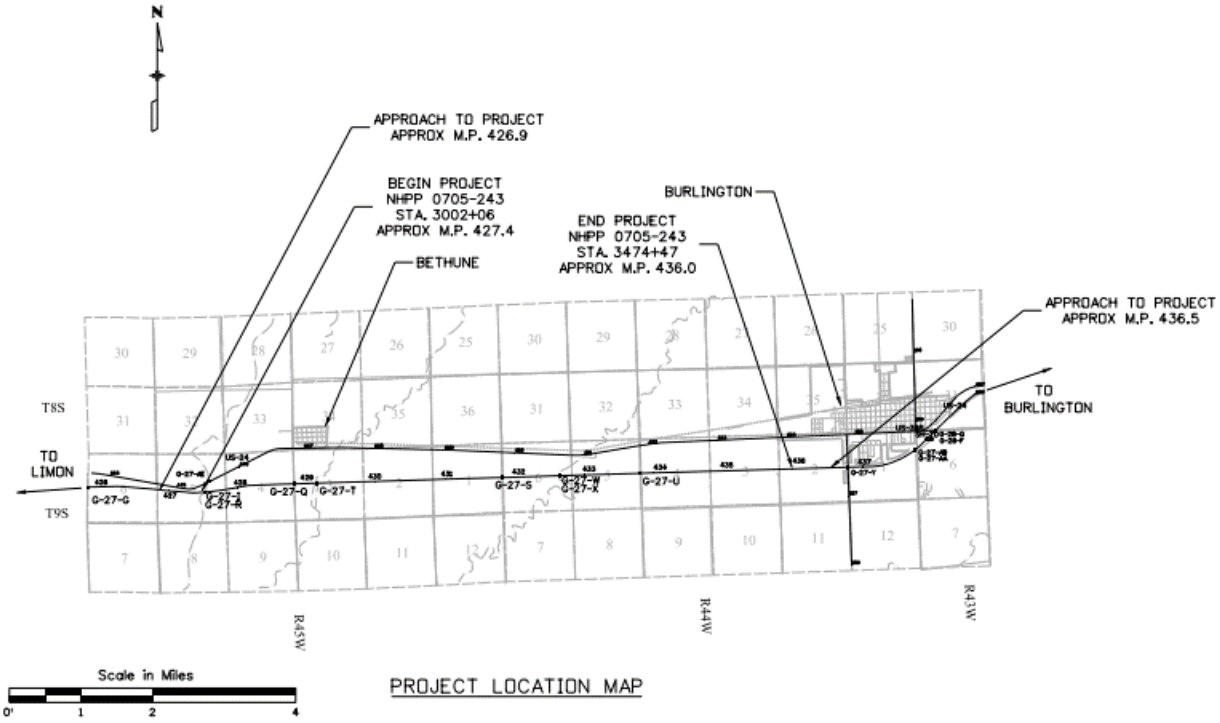
22462 I-70 Bethune Pavement Reconstruction Project

Final Value Engineering Report



PROJECT LOCATION MAP

Prepared For:

COLORADO
Department of Transportation

Date: **January 2020**

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1. Executive Summary

1.1 Introduction

AECOM was retained to undertake a 4-day Value Engineering (VE) Study for the 22462 I-70 Bethune East and West Pavement Reconstruction Project. The project cost estimate is $47.99M based on the Colorado Department of Transportation (CDOT) Preliminary Detail Cost Estimate.

The Value Engineering Study was undertaken based on the scope of work and the SAVE International Value Engineering Methodology, which includes three stages: (1) Pre-Workshop; (2) Workshop; and, (3) Post-Workshop. The workshop portion of the VE Study followed the six-phase VE Job Plan consisting of: (1) Information Phase; (2) Function Analysis Phase; (3) Creative Phase; (4) Evaluation Phase; (5) Development Phase; and, (6) Presentation Phase. A detailed description of the VE Study process is provided in **Section 5** of this report. The Information Phase was held on July 8th, 2019, in Limon, CO. The VE Workshop was held from July 16th to July 18th, 2019 at AECOM's office in Greenwood Village, CO. The VE Results Presentation was held on the morning of July 19th, 2019 at AECOM office in Greenwood Village, CO.

The Pareto Cost Models developed during the Pre-Workshop Stage are provided in **Appendix A**. The results of the Function Analysis Phase are provided in **Appendix B**. Ideas generated and evaluated during the Creative Phase and the Evaluation Phase are provided in **Appendix C**. **Appendix D** provides the Pre-Workshop Pavement Analysis undertaken by the VE Team's pavement subject matter expert.

1.2 Overview of the Project

CDOT Project Code 22462 on I-70 east and west of Bethune begins at approximate milepost (MP) 427.4 and continues east for 8.9 miles ending at MP 436.3 on Interstate 70 (**Figure 1**). The existing roadway pavement is highly distressed hot mixed asphalt (HMA). The roadway condition is worse in the westbound direction compared to the eastbound direction.

The current design consists of milling off the existing 6.5" of HMA followed by 8" rubblization of the existing concrete pavement along with full-depth reclamation of the 4-foot inside shoulder and 10-foot outside shoulder. The current design also includes the placement of edge drains along the outside shoulder that will daylight at intervals of 200-400 ft. Further information on the base case design is provided in **Section 3** of this report.

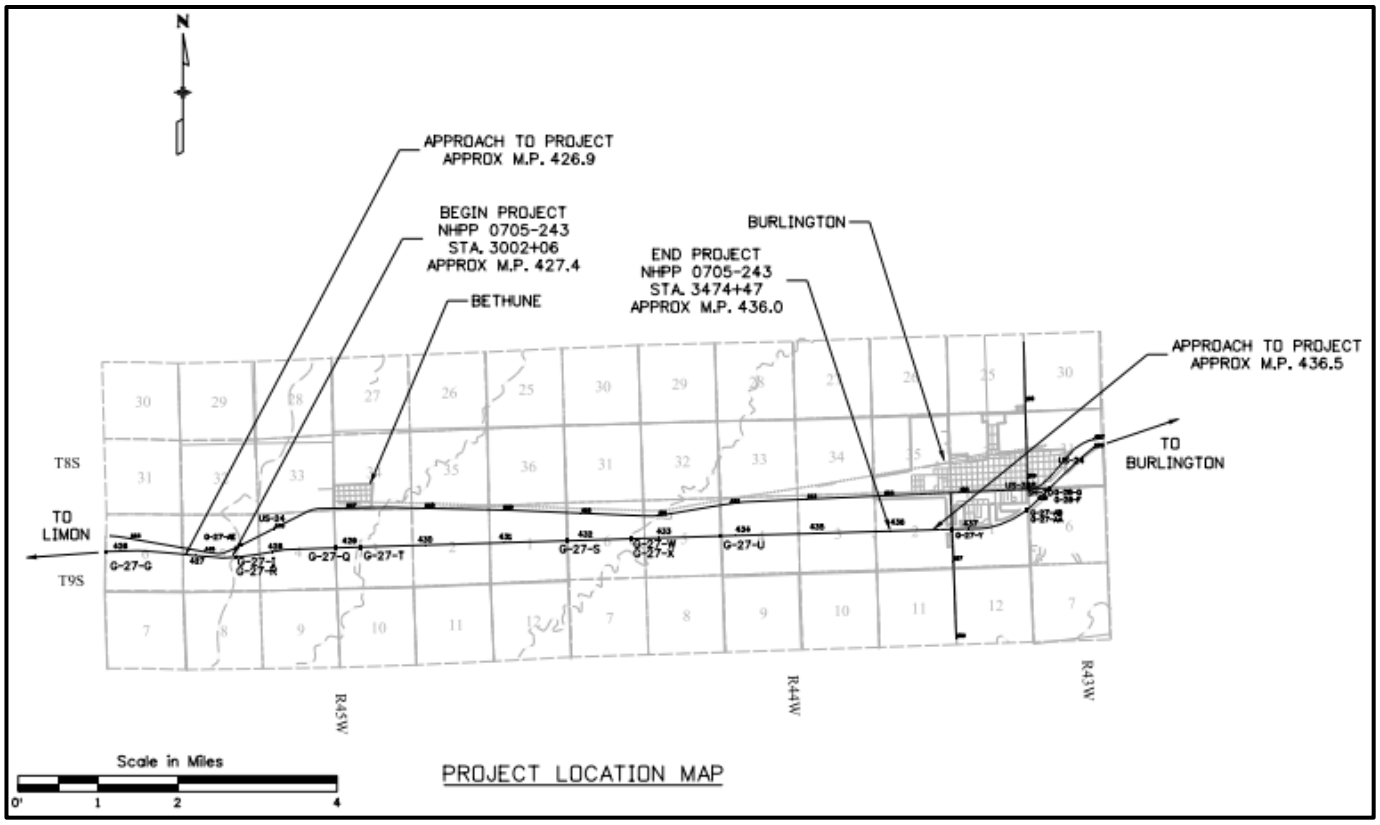


Figure 1: 22462 I-70 Bethune East and West Pavement Rehabilitation Project Study

1.3 Value Engineering (VE) Team

A multi-disciplinary team of subject matter experts was assembled for this assignment. **Table 1** provides the VE Team and Resource Team members.

Table 1: VE Team and Resource Team Members

Name	Discipline	Company	Team
Tammy Dow, CVS	Certified Value Specialist	AECOM	VE
Steve McQuilkin, PE	Senior Engineer/Project Manager	AECOM	VE
Jay Goldbaun, PE	Senior Pavement Design Engineer	RockSol	VE
Mike Heugh, PE	MOT/Traffic Engineer	AECOM	VE
Travis Miller, PE	Limon Resident Engineer	CDOT	Resource
James Miller, PE	Project Manager	CDOT	Resource
Karl Larson	Construction and Design	CDOT	Resource
Michael Hines, EPST II	Design	CDOT	Resource

1.4 Objectives of the VE Study

The goals and objectives of the VE Study were discussed during the Information Phase of the VE Workshop and include:

- Review the 60% Design with respect to cost-effectiveness, function and the ability to meet project objectives
- To provide VE Proposals and Design Comments to increase project value through innovative ideas that improve functionality, improve schedule, improve constructability, and/or capital cost avoidance while maintaining quality and functionality

1.5 Highlights of the VE Study

During the Creative Phase, the VE Team brainstormed ways to improve value in the project, generating **39** creative ideas. The results of VE Study are presented in **11** VE Proposals, which are individual alternatives for elements of the project. These VE Proposals are documented in **Section 4** of this report and were developed from selected creative ideas as discussed in **Section 5**. In addition, there are **11** Design Comments for which definitive VE Proposals could not be made or quantified at the time of the VE Study.

Table 2 presents a summary of the ideas developed into VE Proposals and Design Comments, with cost implications, where applicable. The cost estimates for the VE Proposals were developed consistent to the cost estimate parameters used in the CDOT Preliminary Detail Cost Estimate. Based on discussions with CDOT staff, a 30 % mark-up (5.5% for mobilization, 5% for minor cost revisions (MCR) and 18.66% for Construction Engineering for a total of 29.16%, which was rounded up to 30%), was used.

In **Table 2**, only the ideas developed as VE Proposals and Design Comments are provided. The complete list of creative ideas and their evaluation is provided in the Summary of Creative Ideas and Evaluation Table in **Appendix C** of this report.

Table 2: Summary of VE Proposals and Design Comments

VE Proposal or Design Comment No.	Idea No.	Description	Cost Savings (Additional Costs)
VE-1	4	Eliminate edge drains	$1,726,538
VE-2	5	Optimize the typical sections	$7,505,121
VE-3	7	Reduce the number of dowel bars for the shoulders	$62,234
VE-4	9	Offset the ramp alignments for Bethune	($627,144)
VE-5	12	Eliminate concrete box culverts extensions	$609,198
VE-6	19	Accelerate schedule	($1,234,769)
VE-7	24	Use higher strength concrete	$4,889,507
VE-8	28	Use millings generated on project for subbase material	$927,793
VE-9	34	Reuse unsuitable material for shouldering	$846,300
VE-10	36	Reduce concrete thickness by using shorter panels	$4,697,434

VE Proposal or Design Comment No.	Idea No.	Description	Cost Savings (Additional Costs)
VE-11	39	Optimize the PCCP thickness and reduce the amount of concrete needed by milling the existing HMA to adjust the cross slope	$8,784,613
DC-1	3	Confirm the unit costs for the TRM	-
DC-2	10	Use State Highway 24 as a temporary detour for ramp closures	-
DC-3	18	Allow temporary on and off ramp for construction vehicles close to center of the project	-
DC-4	23	Use innovative to CDOT concrete mixtures	-
DC-5	26	Improve channelizing devices	-
DC-6	27	Use portable rumble strips during construction	-
DC-7	29	Modify density requirements for top 6" of shoulders	-
DC-8	32	Use thin white topping	-
DC-9	33	Reduce initial International Roughness Index (IRI) to 70 to achieve smoother pavement and reduce pavement thickness	-
DC-10	37	Undertake Falling Weight Deflectometer (FWD) analysis	-
DC-11	38	Undertake Ground Penetrating Radar (GPR) analysis	-

1.6 Comments on the Preliminary Detail Cost Estimate

During the VE Study, the VE Team reviewed the Preliminary Detail Cost Estimate. They noted that the following cost items were not included in the Preliminary Detail Cost Estimate:

- 32,000 CY of unsuitable material, which is approximately $864,000
- Dowel bars in the shoulders, which is approximately $62,234
- Culvert extensions, which is approximately $716,513

Therefore, a total of approximately $1,642,747 of additional costs should be added to the Preliminary Detail Cost Estimate. The VE Team recommends that these costs be further reviewed and evaluated prior to inclusion in the Preliminary Detail Cost Estimate.

Based on data from the CDOT Cost Planner Tool and a recent cost estimate for the I-70 at Genoa Project using the same PCCP thickness, the VE Team updated the unit cost of the 9.5-inch PCCP for this project to $48.00 per square yard. Therefore, this change should be made in the Preliminary Detail Cost Estimate.

1.7 Disclaimer

A 4-day VE Study was performed for the I-70 Bethune Project. VE Studies are working sessions for the purpose of developing and proposing alternative ideas for projects. As such, the VE Proposals and Design Comments were developed with the resources available and within the

timeframe of the 4-day workshop and are based on the information provided to the VE Team at the time of the workshop.

The VE Proposals and Design Comments are conceptual in nature and are not intended as final designs. Feasibility and final design development of any VE Proposals and Design Comments presented herein, should they be accepted, remain the responsibility of CDOT as detailed feasibility of the VE Proposals could not be undertaken at the time of the VE Study due to technical and time limitations. Discussions with respect to the viability of the VE Proposals will need to be undertaken by CDOT. VE Team members will not sign or seal any VE Proposals and Design Comments contained in this report as certifiable engineering or architectural designs.

The cost estimates prepared for this VE Study were developed solely for the purpose of comparing the costs of VE Proposals to the functional equivalent in the base case. The VE Team had limited time and resources to prepare cost estimates for each VE Proposal. Therefore, these cost estimates are not recommended to be used for budgeting or construction purposes. CDOT should more accurately quantify any saving/additional costs of the VE Proposals they accept.

The VE Team takes no responsibility for the implementation of the VE Proposals relative to CDOT design standards, etc. The VE Team does not guarantee the potential monetary savings.

2. Implementation Action

2.1 Introduction

Table 3 presents a summary of the ideas developed into VE Proposals and Design Comments. A complete list of the creative ideas and their evaluation is provided in the Summary of Creative Ideas and Evaluation Table in **Appendix C**. All ideas in the **Appendix C** table with a "Carried Forward (CF)" are listed in **Table 3** below as VE Proposals. All ideas in **Appendix C** table with a "Design Comment (DC)" are listed below as Design Comments.

Table 3 contains CDOTs disposition for each VE Proposal and Design Comment. The following legend was used to document the VE Proposals and Design Comments dispositions:

- A = Accepted
- AM = Accepted with Modifications
- FS = Tabled for Further Study
- R = Reject

Table 3 also provides the total maximum potential cost savings of the accepted VE Proposals. Based on their review of the VE Proposals, CDOT noted the following:

"With all of the ideas generated in the Value Engineering Study, we have selected to obtain pieces of individual ideas to create a modified VE-11 (accept modified). This will keep the main components of VE-11, which includes elimination of the side drains, full depth reclamation, rubbilization, and aggregate base course, but add new elements including cold in-place recycle and HMA followed by a thin white topping of 7.5 inch instead of the proposed 8 inch in the VE study. This would actually increase the cost by approximately $1,749,381 but would be a huge benefit in construction time, ease of constructability and future maintenance, which in the long run would be a possible cost savings."

Table 3: VE Proposals and Design Comments Summary and Disposition Table

VE Proposal or Design Comment No.	Idea No.	Description	Cost Savings (Additional Costs)	Accepted Maximum Potential Cost Savings	Disposition	Comments
VE-1	4	Eliminate edge drains	$1,726,538		AM	See VE-11 Savings included in VE-11
VE-2	5	Optimize the typical sections	$7,505,121		R	See VE-11
VE-3	7	Reduce the number of dowel bars for the shoulders	$62,234		FS	Standard currently show dowel bars in shoulders
VE-4	9	Offset the ramp alignments for Bethune	($627,144)		R	Cost/ ROW concerns
VE-5	12	Eliminate concrete box culverts extensions	$609,198		R	Safety
VE-6	19	Accelerate schedule	($1,234,769)		FS	With the new typical section, would not allow adequate time for acc. sched.
VE-7	24	Use higher strength concrete	$4,889,507		R	Data based on current project Contractors are having trouble meeting criteria on 650psi Flexural Strength
VE-8	28	Use millings generated on project for subbase material	$927,793		R	
VE-9	34	Reuse unsuitable material for shouldering	$846,300	$605,101	A	Savings decrease with less reconstruction areas
VE-10	36	Reduce concrete thickness by using shorter panels	$4,697,434	3,858,555	AM	New typical section (VE-11) will have 6’x10’ panels
VE-11	39	Optimize the PCCP thickness and reduce the amount of concrete needed by milling the existing HMA to adjust the cross slope	$8,784,613	($1,749,381)	AM	Accepted modifying typical section with an added layer of CIPR to eliminate void failure due to pavement rocking forward to backward

VE Proposal or Design Comment No.	Idea No.	Description	Cost Savings (Additional Costs)	Accepted Maximum Potential Cost Savings	Disposition	Comments
						(See Section 4.5 VE Summary in Report)
		Total Maximum Potential Cost Savings		**$2,714,275**		
DC-1	3	Confirm the unit costs for the TRM	-	-	A	
DC-2	10	Use State Highway 24 as a temporary detour for ramp closures	-	-	Already use	
DC-3	18	Allow temporary on and off ramp for construction vehicles close to center of the project	-	-	Already use	
DC-4	23	Use innovative to CDOT concrete mixtures	-	-	FS	
DC-5	26	Improve channelizing devices	-	-	FS	
DC-6	27	Use portable rumble strips during construction	-	-	A	
DC-7	29	Modify density requirements for top 6" of shoulders	-	-	A	
DC-8	32	Use thin white topping	-	-	FS	
DC-9	33	Reduce initial International Roughness Index (IRI) to 70 to achieve smoother pavement and reduce pavement thickness	-	-	R	
DC-10	37	Undertake Falling Weight Deflectometer (FWD) analysis	-	-	FS	

VE Proposal or Design Comment No.	Idea No.	Description	Cost Savings (Additional Costs)	Accepted Maximum Potential Cost Savings	Disposition	Comments
DC-11	38	Undertake Ground Penetrating Radar (GPR) analysis	-	-	FS	

3. Project Overview

3.1 Project Description

CDOT Project Code 22462 on I-70 east and west of Bethune begins at approximate MP 427.4 and continues east for 8.9 miles ending at MP 436.3 on Interstate 70 (**Figure 2**). The current annual daily traffic (ADT) for this stretch of roadway is 10,000 vehicles with 27.6% of those vehicles being trucks. This is a 4-lane roadway. There are 2 lanes with a 4' median shoulder and a 10' outside shoulder making for a total roadway width of 38' in each direction of travel. There are 6 vertically restricted areas within the project limits, 3 overpasses and 3 structures at grade in each direction of travel. The terrain in this area is relatively flat with gently rolling hills and plains.

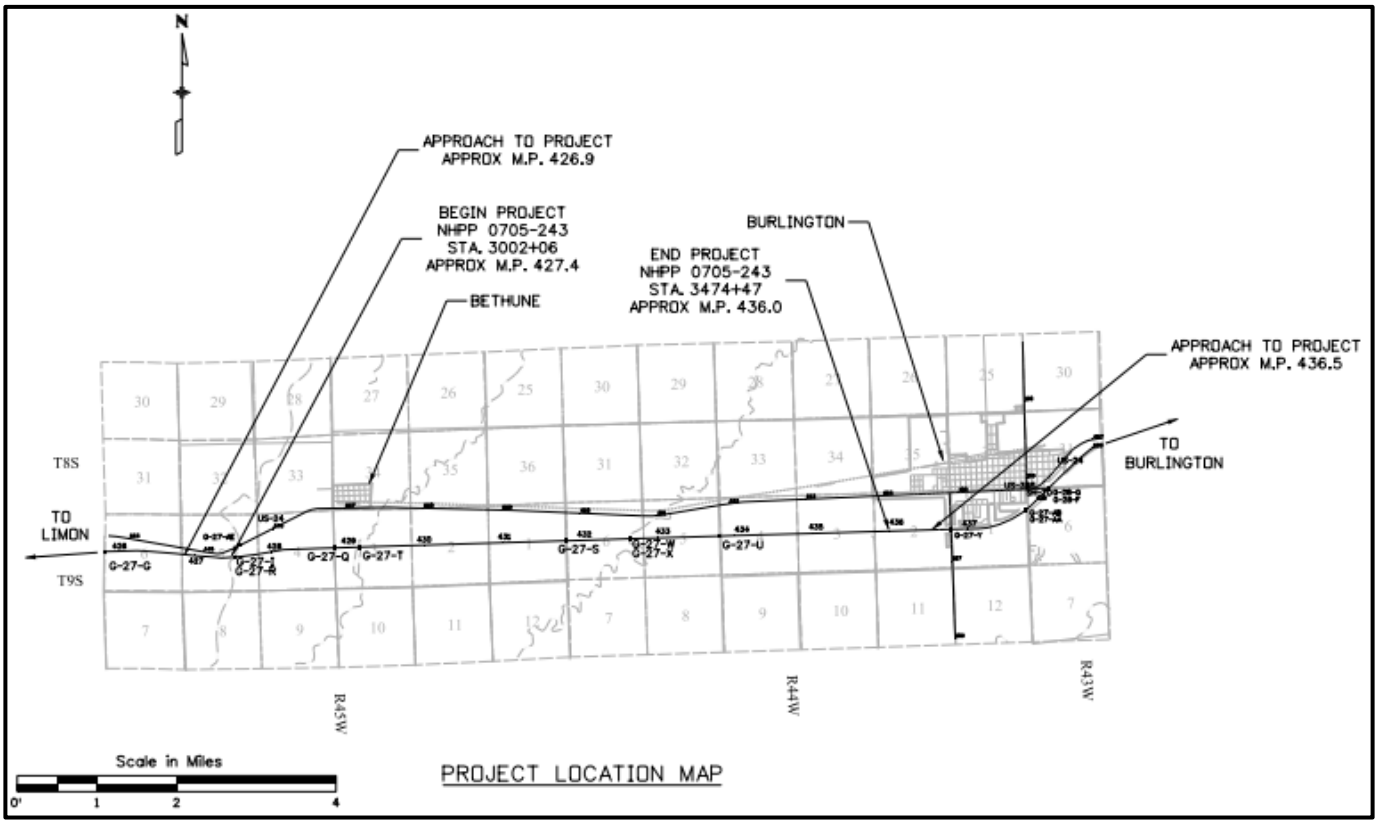


Figure 2: 22462 I-70 Bethune East and West Pavement Rehabilitation Project Study

3.2 Existing Roadway Characteristics

The existing roadway pavement is highly distressed HMA. The westbound direction is in worse condition than the eastbound direction. Under the HMA in the driving lanes is concrete pavement with HMA shoulders. From the core data, there is about 6.5 inches of HMA with a fabric layer roughly 5 to 6-inches below the surface and approximately 8-inches of concrete pavement for both the westbound and eastbound direction. Underneath the concrete, there appears to be about 4 inches of an ABC layer. and then sandy clay subgrade soil.

3.3 Base Case Design

The current design being used is rotomilling about 6.5” of the existing HMA surface to expose the PCCP followed with 8” rubblization of the existing concrete pavement. Full-depth reclamation of the shoulders with edge drains in the outside shoulder that will daylight at intervals of 200-400 ft is also proposed. Once this pre-overlay work is accomplished, this design is for 4 inches of ABC placed over the rubblized PCCP and reclaimed shoulders followed by 9.5 inches of concrete pavement resulting in a net gain of 7 inches in elevation. The vertically restricted areas have a separate design that would eliminate the rubblization and in return have crushed rock to meet the existing grades. Typical sections are provided in **Figure 3, Figure 4** and **Figure 5**.

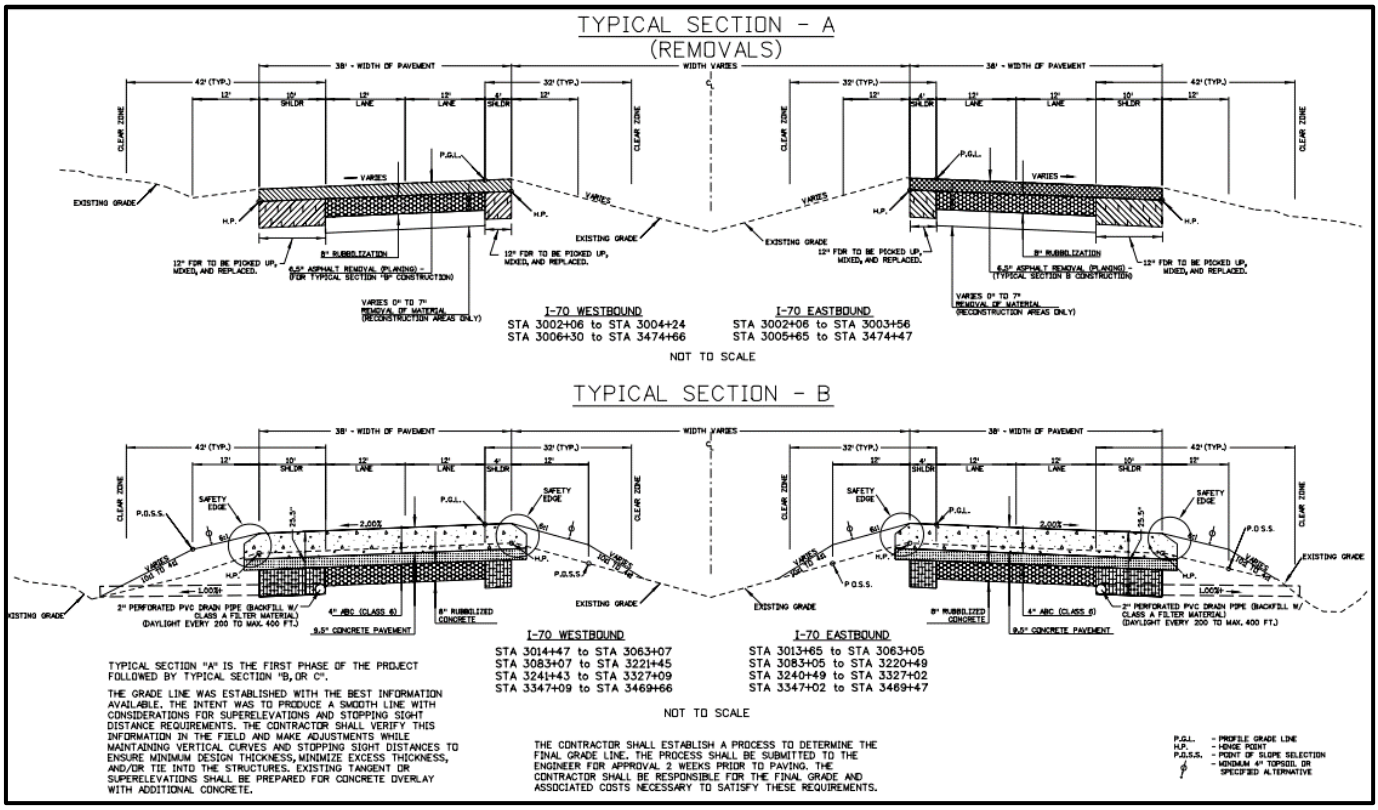


Figure 3: Typical Cross-Sections

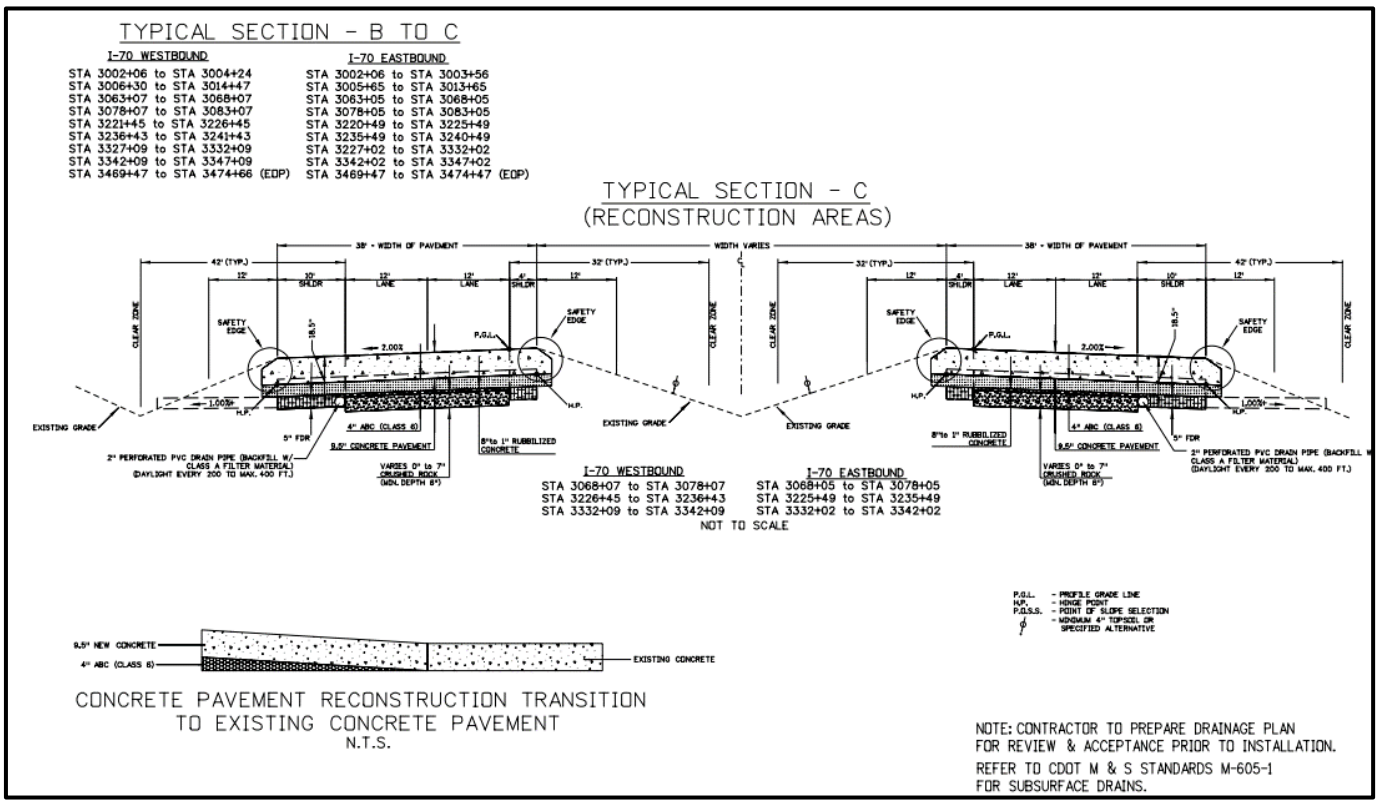


Figure 4: Typical Cross-Section

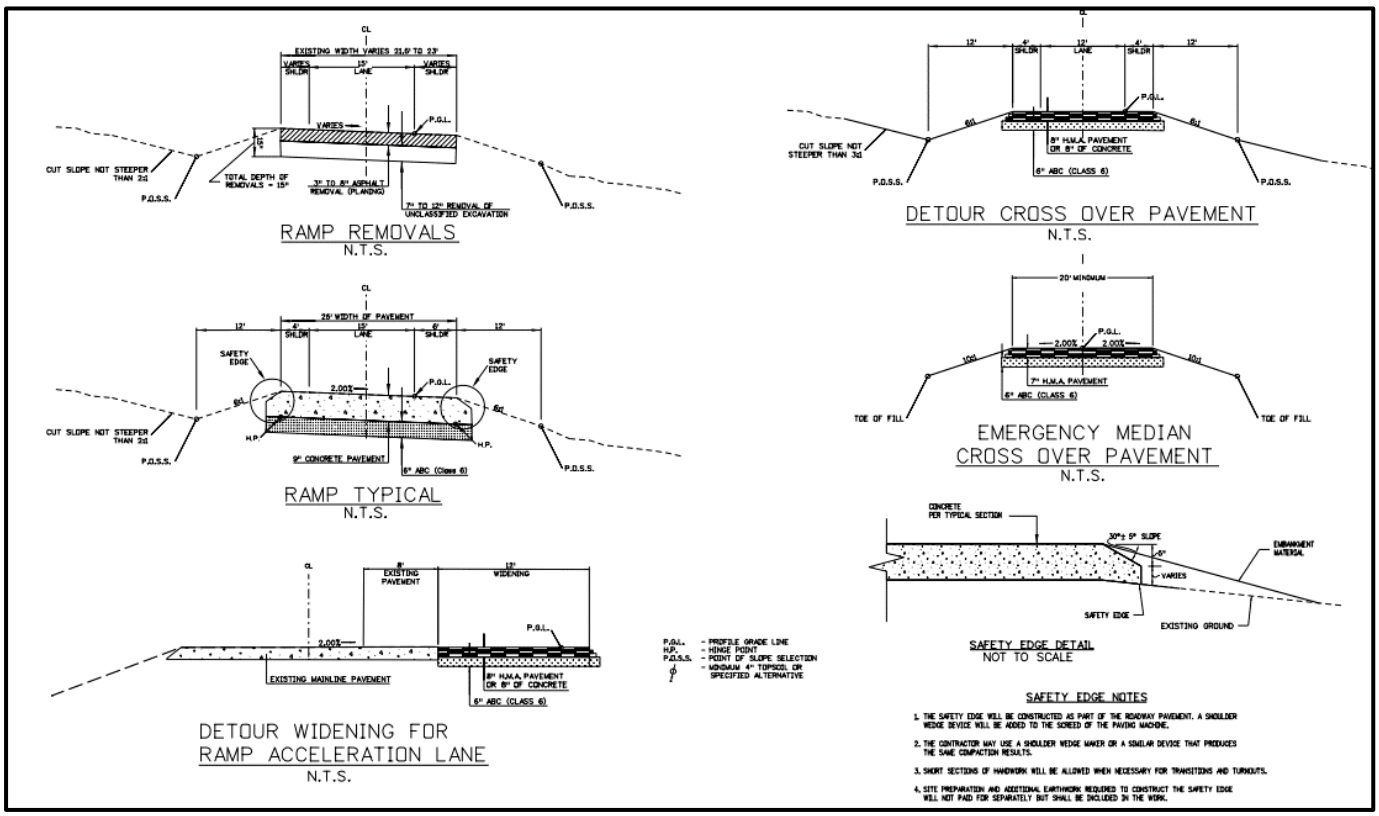


Figure 5: Typical Cross-Section

4. VE Proposals and Design Comments

4.1 Information

During the Creative Phase, the VE Team brainstormed ways to improve value in the project, generating **39** creative ideas. As a result of the Evaluation Phase, **22** ideas were considered to have potential for cost savings and/or value improvement. These ideas were developed further by the VE Team and resulted in **11** VE Proposals and **11** Design Comments for consideration by CDOT going forward.

4.2 Organization of VE Proposals and Design Comments

This section contains the complete documentation of all VE Proposals and Design Comments that have resulted from the VE Study. The ideas from which the VE Proposals and Design Comments began are provided. The complete list of creative ideas and their evaluation is provided in the Summary of Creative Ideas and Evaluation Table provided in **Appendix C** of this report.

Each VE Proposal is documented by a separate write-up that includes:

- a description of both the original design and proposed change
- a list of advantages and disadvantages
- sketches, where appropriate
- calculations
- cost estimate for both the original design and proposed change

Each Design Comment is documented by a separate write-up that includes:

- a description of both the original design and proposed change
- a list of advantages and disadvantages
- sketches, where appropriate

Value Engineering Studies are working sessions for the purpose of developing and proposing alternative ideas for the project. As such, the results and the VE Proposals and Design Comments were developed with the resources available and within the timeframe of the 4-day workshop and are based on the information provided to the VE Team at the time of the workshop. The VE Proposals are conceptual in nature and are not intended as final design. Detailed feasibility and final design development of any VE Proposals and Design Comments, should they be accepted, remain the responsibility of CDOT. VE Team members will not sign or seal any VE Proposals and Design Comments contained in this report as certifiable engineering or architectural design.

The cost estimates for the VE Proposals were developed consistent to the cost estimate parameters used in the CDOT Preliminary Detail Cost Estimate provided to the VE Team. Based on discussions with CDOT staff, a 30 % mark-up (5.5% for mobilization, 5% for MCR and 18.66% for Construction Engineering for a total of 29.16%, which was rounded up to 30%.), was applied to all of the VE costs. The cost estimates prepared for this VE Study were developed solely for comparing the costs of VE Proposals to the functional equivalent in the CDOT Preliminary Detail Cost Estimate. The VE Team has limited time and resources to prepare cost estimates for each VE Proposal. Therefore, these cost estimates are not recommended to be used for budgeting or

construction purposes. CDOT should more accurately quantify any savings/additional costs resulting from acceptance of the VE Proposals.

4.3 Acceptance of VE Proposals and Design Comments

This report includes VE Proposals and Design Comments that could enhance the value of this project. These VE Proposals and Design Comments should be evaluated individually as they require additional design, cost estimating and/or evaluation prior to implementation. Consideration should be given to the areas within a VE Proposal and Design Comment that are acceptable and implement those parts only. Any VE Proposal and Design Comment can be accepted in whole or in part.

The VE Proposals and Design Comments were developed based on the information provided to the VE Team prior to and during the workshop. As the design proceeds, new information may become available and this information should be evaluated for potential impacts to the VE Proposals and Design Comments.

4.4 VE Proposals

The **11** VE Proposals developed by the VE Team are presented in this section. They are listed in the order in which they are provided in **Table 2**. The cost estimates for the VE Proposals were developed consistent to the cost estimate parameters used in the CDOT Preliminary Detail Cost Estimate provided to the VE Team.

The VE Proposals and Design Comments are conceptual in nature and are not intended as final designs. Feasibility and final design development of any VE Proposals should they be accepted, remain the responsibility of CDOT as detailed feasibility of the VE Proposals could not be undertaken at the time of the VE Study due to technical and time limitations. Discussions with respect to the viability of the VE Proposals will need to be undertaken by CDOT with the project stakeholders.

4.5 VE Summary

Based on their review of the VE Proposals, CDOT noted the following:

“With all of the ideas generated in the Value Engineering Study, we have selected to obtain pieces of individual ideas to create a modified VE-11 (accept modified). This will keep the main components of VE-11, which includes elimination of the side drains, full depth reclamation, rubbilization, and aggregate base course, but add new elements including cold in-place recycle and HMA followed by a thin white topping of 7.5 inch instead of the proposed 8 inch in the VE study. This would actually increase the cost by approximately $1,749,381 but would be a huge benefit in construction time, ease of constructability and future maintenance, which in the long run would be a possible cost savings.”

The CDOT Accepted Modified Cost Estimates are also provided in the applicable VE Proposals.

VE PROPOSAL VE-1	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 4** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Eliminate edge drains**	**Page No.: 1 of 3**

VE-1: Idea 4: Eliminate edge drains

ORIGINAL DESIGN:
The original design shows an edge drain under the right shoulder adjacent to either rubblized concrete or crushed rock for approximately 100,962 LF. The drain is shown to be daylighted every 200', with a max of 400'. The intent of the drain is to remove water from the roadway prism.

PROPOSED DESIGN:
The proposed design would eliminate the edge drain.

ADVANTAGES:
- Reduces costs
- Reduces schedule
- Easier to construct
- Reduces future maintenance

DISADVANTAGES:
- Potential to trap water under the concrete

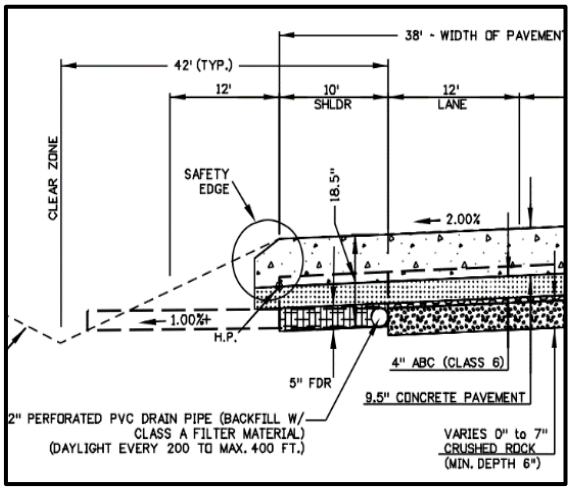
DISCUSSION/JUSTIFICATION:
By removing the edge drain from the original design, it would reduce cost by eliminating this pay item altogether, could reduce schedule, and will make the project easier to construct by not having to install and backfill the pipe. Given that the typical section calls to daylight the pipe every 200'-400', there is a large potential for time savings. Since annual rainfall is less than 10" per year the probability of trapping water under the concrete is minimal. There is no indication that the water table is within 10 feet of the surface.

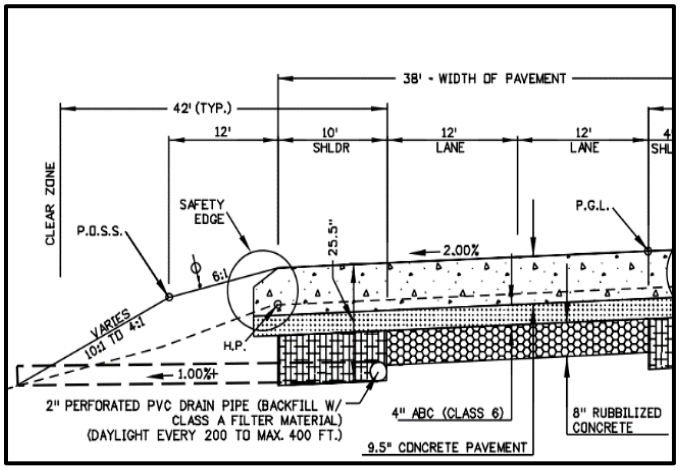
Edge drains are not recommended because the pavement design model adjusts the modulus of the soil based on rainfall and the permeability of the soil. Edge drains are not recommended since the past performance of the existing pavement has been good without edge drains. Since the existing HMA has a very low erodibility index, edge drains are not recommended. However, edge drains could be used only in low points to reduce the potential for ponding in these low-lying areas. Historically, there were no signs of high-water table or water problems reported by maintenance staff. The installation of edge drains will require periodic maintenance to remove debris. A V-ditch with appropriate slopes off both shoulders is a possible method to help transmit water without an edge drain.

	Construction Costs
Base Case Design	$1,726,538
Proposed Design	$0
Estimated Cost Savings	**$1,726,538**

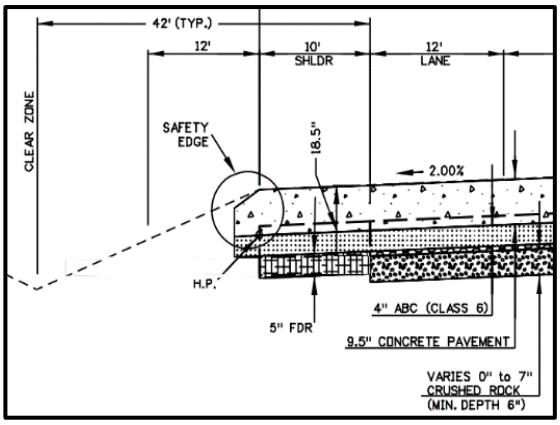
VE PROPOSAL VE-1	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 4** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Eliminate edge drains**	**Page No.: 2 of 3**

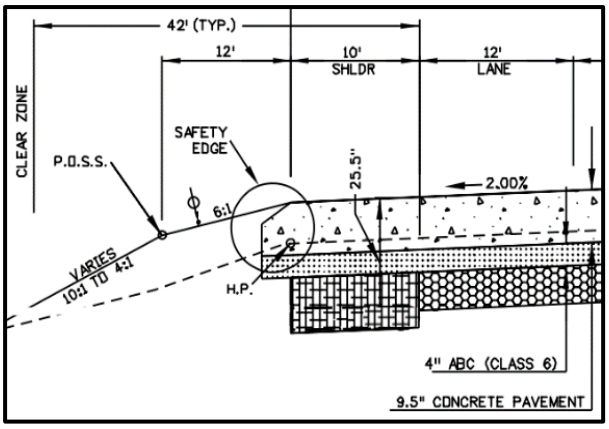
ORIGINAL DESIGN SKETCH:





PROPOSED CHANGE SKETCH:





ASSUMPTIONS AND CALCULATIONS:

It was assumed that the entire quantity for “Pipe Edge Drain” is removed from the project. Material to fill the void was already accounted for in the original design estimate.

VE PROPOSAL VE-1	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 4** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Eliminate edge drains**	**Page No.: 3 of 3**

Construction Item		Current Design			Proposed Design		
Item	**Units**	**No. of Units**	**Cost / Unit**	**Total**	**No. of Units**	**Cost / Unit**	**Total**
605-82100 Pipe Edge Drain	LF	100,962	$13	$1,312,506			
605-84100 Subsurface Drain Outlet Structure	EA	312	$50	$15,600			
Subtotal				$1,328,106			$0
Mark-Up	30%			1.30			1.30
Total				**$1,726,538**			**$0**
						Net Cost Avoidance	**$1,726,538**

VE PROPOSAL VE-2	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 5** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Optimize the typical sections**	**Page No.: 1 of 5**

VE-2: Idea 5: Optimize the typical sections

ORIGINAL DESIGN:
The current design shows Class-P PCCP being installed, per specifications. The original design includes milling off all the existing HMA, full depth reclamation of the shoulders, rubbilize the existing PCCP, add edge drains along the shoulder with outlet structures, add 4 inches of aggregate base course, and place 9.5 inches of PCCP on the mainline of Interstate 70.

PROPOSED DESIGN:
Based on CDOT's 2020 Pavement Design Manual, the VE Team re-evaluated the pavement design and no longer recommends removing all the existing HMA, rubbilizing the existing PCCP, full-depth reclamation of the shoulders or adding edge drains. The VE Team recommends an 8.5" PCCP overlay of the existing pavement to meet the minimum requirements.

ADVANTAGES:
- Potential to reduce costs
- Potential to accelerates schedule
- Easier to construct
- Easier to maintain

DISADVANTAGES:
- Potential to reduce service life due to an increase in transverse cracking
- Redesign required

DISCUSSION/JUSTIFICATION:
Some cracks in the HMA appear to be reflecting through from the underlying PCCP. One benefit of placing PCCP over the HMA is to mitigate reflective cracking from underlying layers. The performance of US 40/287 corridor from Limon to the Oklahoma border has not shown reflective cracking to be an issue.

The 6.5 inches of HMA over the 1960's era PCCP reduces the amount of water below the PCCP which helps to mitigate any pumping of fines through the cracks in PCCP. The HMA over the PCCP helps disperse the point load on the PCCP thereby reducing the possibility of faulting. The load transfer efficiency of the existing PCCP is not known without further investigation of the existing roadway.

Once the existing 6.5 inches of HMA is milled off, the current design requires full-depth reclamation of the 4-foot and 10-foot shoulders along with rubbilization of the existing 8 inches of PCCP. The full-depth reclamation of the 4-foot shoulder is not a typical width for this type of work in Colorado. This would require special equipment for the reclamation and compaction processes.

VE PROPOSAL VE-2	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 5** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Optimize the typical sections**	**Page No.: 2 of 5**

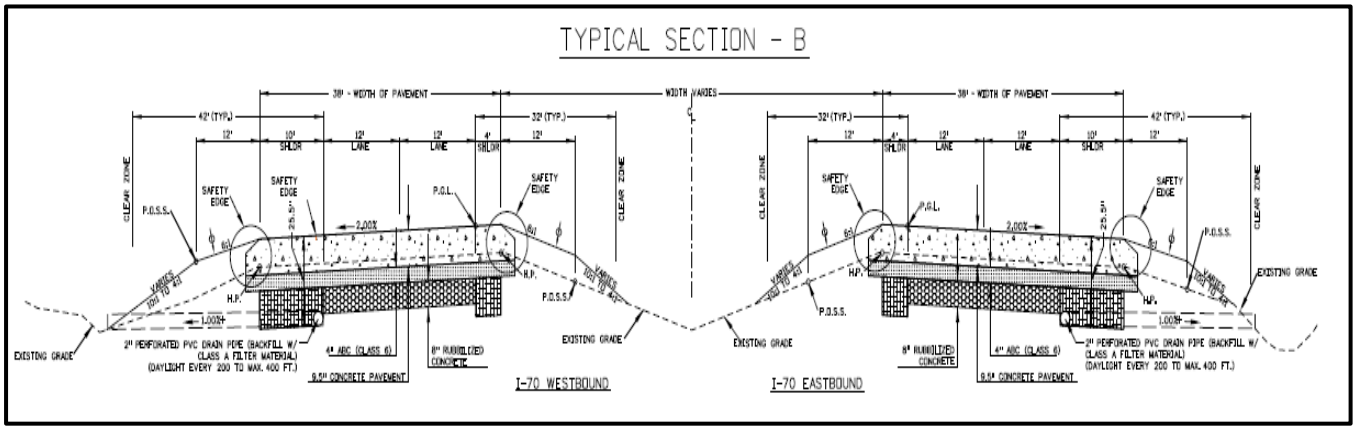
The baseline concept shows Class-P PCCP being installed, per specifications, at thicknesses of 9.5" throughout the project. Based on the current design standards, 8.5 inches of concrete will meet the guidelines. A thinner section of concrete would accelerate the Contractor's schedule by reducing the amount of pre-overlay repair work in the original design. Since this design is one inch thinner than the original design, it is estimated that the transverse cracking will increase by about 1.5 percent.

DISCUSSION OF RISK IMPACTS:

The proposed design has the potential to increase the amount of transverse cracking thus reducing service life compared to the base case design. However, the proposed design meets the 27-year distress threshold as per CDOT 2020 Pavement Design Manual. It would also require time and costs to redesign what is currently shown in the plans.

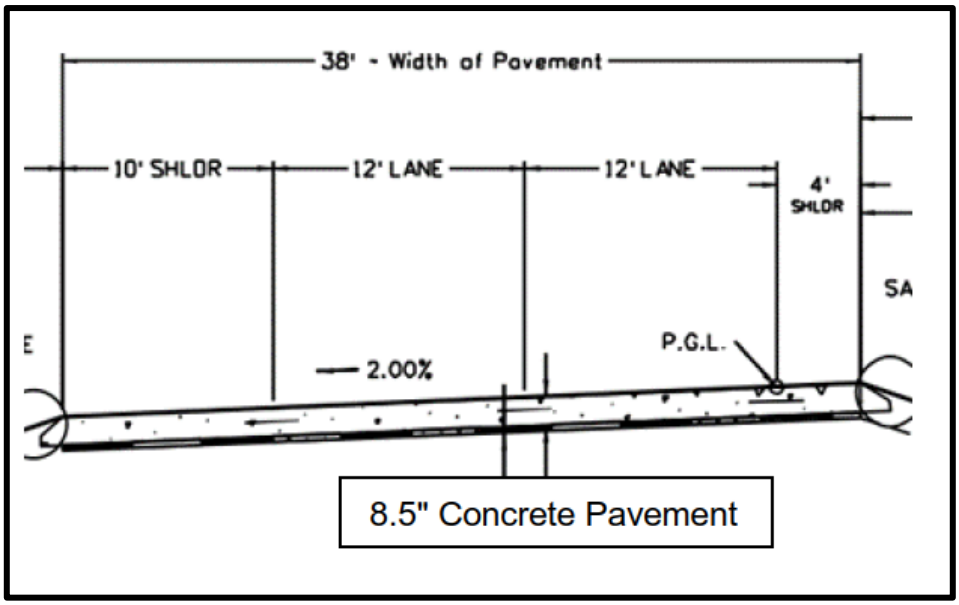
	Construction Costs
Base Case Design	$32,451,829
Proposed Design	$24,946,708
Estimated Cost Saving	**$7,505,121**

ORIGINAL DESIGN SKETCH:



VE PROPOSAL VE-2	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 5** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Optimize the typical sections**	**Page No.: 3 of 5**

PROPOSED CHANGE SKETCH:



ASSUMPTIONS AND CALCULATIONS:
A total paving quantity of 400,122 square yards of mainline paving has been estimated for this project.

Based on data from the CDOT Cost Planner Tool and a recent cost estimate for the I-70 at Genoa Project using the same PCCP thickness, the VE Team updated the unit cost of the 9.5-inch PCCP for this project to $48.00 per square yard.

8.5-inch PCCP = $43.00 *provided by CDOT Cost Estimating 7/16/19 does not include the cross-slope correction.

Depth of adjusting the cross-slope = 0.020 – 0.015 = 0.005 x 38’ wide = 0.19’ x 12 inches = 2.28 inches

Area of additional concrete = 0.5 x (38’ x (2.28/12)) = 3.61 ft^2 / 9 = 0.4011 yd^2

Volume of concrete furnished by the Contractor needs to adjust cross-slope = 0.4011 yd^2 x (8.5 miles x 5,280 feet x 2 directions / 3) = 12,001 yd^3 x 1.10 for irregularities in the surface = 10,910 yd^3

Based on the estimated unit cost of $48.00/ yd^2 for 9.5” PCCP the furnished concrete cost is 9.5 inches / 36 inches = 0.2639 yards thick. Therefore, $48.00/0.2639 = $181.90 / yd^3

VE PROPOSAL VE-2	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 5** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Optimize the typical sections**	**Page No.: 4 of 5**

JPCP_over_AC_Bethune Project (wide slabs)(650 psi)

File Name: C:\Users\goldbaum\Desktop\Bethune Project\JPCP_over_AC_Bethune Project (wide slabs)(650 psi).dgpx

Design Inputs

Design Life: 30 years
Design Type: JPCP_JPCP

Existing construction: May, 2006
Pavement construction: July, 2021
Traffic opening: October, 2021

Climate Data Sources (Lat/Lon): 39.245, -102.284

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 3 Flex Lawson	8.5
Flexible	Default asphalt concrete	6.5
Sandwich/Fractured	Existing JPCP	8.0
NonStabilized	Crushed stone	4.0
Subgrade	A-6	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.25
Slab width (ft)	13.0 (w)

Traffic

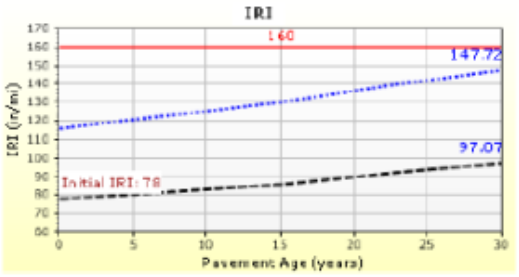
Age (year)	Heavy Trucks (cumulative)
2021 (initial)	2,830
2036 (15 years)	7,594,870
2051 (30 years)	16,677,900

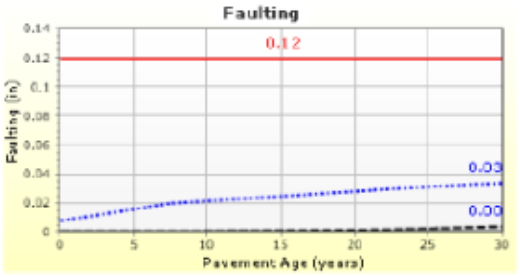
Design Outputs

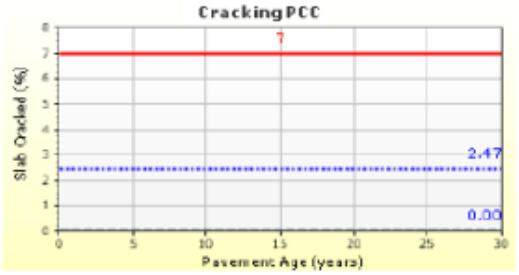
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	147.72	95.00	97.95	Pass
Mean joint faulting (in)	0.12	0.03	95.00	100.00	Pass
JPCP transverse cracking (percent slabs)	7.00	2.47	95.00	100.00	Pass

Distress Charts







Threshold Value ····· @ Specified Reliability - - - @ 50% Reliability

Report generated on: 8/7/2019 3:07 PM
Version: 2.3.1+66
Created by: on: 10/3/2011 12:00 AM
Approved by: on: 10/3/2011 12:00 AM
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VE PROPOSAL VE-2	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 5** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Optimize the typical sections**	**Page No.: 5 of 5**

Construction Item		Current Design			Proposed Design		
Item	**Units**	**No. of Units**	**Cost / Unit**	**Total**	**No. of Units**	**Cost / Unit**	**Total**
202-00240 Removal of Asphalt Mat (Planing)	Yd^2	400,122	$5.25	$2,100,641			
412-18010 Rubblization of Concrete Pavement	Yd^2	210,891	$3.00	$632,673			
310-00608 Full Depth Reclamation (0-8)	Yd^2	146,356	$2.50	$365,890			
605-82100 Pipe Edge Drains	LF	100,962	$13.00	$1,312,506			
605-84100 Drain Outlet Structures	EA	312	$50.00	$15,600			
304-06007 Aggregate Base Course (Class 6)	Yd^3	44,326	$30.00	$1,329,780			
412-00950 Concrete Pavement (9.5”)	Yd^2	400,122	$48.00	$19,205,856			
412-00850 Concrete Pavement (8.5”)	Yd^2				400,122	$43.00	$17,205,246
412-00000 Furnish Concrete Pavement	CY				10,910	$181.90	$1,984,529
Subtotal				$24,962,946			$19,189,775
Mark-Up	30%			1.30			1.30
Total				**$32,451,829**			**$24,946,708**
						Net Cost Avoidance	**$7,505,121**

VE PROPOSAL VE-3	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 7** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Reduce the number of dowel bars for the shoulders**	**Page No.: 1 of 2**

VE-3: Idea 7: Reduce the number of dowel bars for the shoulders

ORIGINAL DESIGN:
Based upon the FIR minutes dated Feb. 20, 2019, the original design requires dowel bars in the transverse joint for the 10' shoulder spaced at 12-inch intervals to alleviate faulting between the shoulder and the outside lane.

PROPOSED DESIGN:
Remove the recommended dowel bars from the shoulders

ADVANTAGES:
- Reduces costs

DISADVANTAGES:
- None identified

DISCUSSION/JUSTIFICATION:
Adding dowel bars to the shoulder is not required since the current CDOT M-Standard do not require dowel bars in the shoulder when the shoulder is not a future driving lane. The Pavement M-E Design Manual does not evaluate the potential cracks in a shoulder. The current PCCP shoulders on I-70 are performing well without dowel bars. It was mentioned that the dowel bars are recommended to alleviate the faulting between the lane and shoulder. Historically, tie bars and aggregate interlock perform well on CDOT projects when different substrates are encountered. Since very little traffic would be using the shoulder, aggregate interlock performs well to minimize faulting in the transverse joints.

	Construction Costs
Base Case Design	$62,234
Proposed Design	$0
Estimated Cost Saving	**$62,234**

ASSUMPTIONS AND CALCULATIONS:
Assuming that each additional dowel bar costs $1.00 per bar. Due to the 13-foot-wide driving lane, the width of the shoulder is 9 feet. Assuming that the bars would be placed 12 inches apart and 6 inches in from the edges of the shoulder. Therefore, eight bars would be placed in each transverse joint for the shoulder.

Number of transverse joints = 8.5 miles x 5,280 feet = 44,880 linear feet / 15 feet per transverse joint = 2,992 joints x 2 directions = 5,984 transverse joints

5,984 transverse joints x 8 dowel bars per joint = 47,872 dowel bars

VE PROPOSAL VE-3

PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 7** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Reduce the number of dowel bars for the shoulders**	**Page No.: 2 of 2**

Construction Item		Current Design			Proposed Design		
Item	**Units**	**Qty**	**Unit $**	**Total**	**Qty**	**Unit $**	**Total**
Shoulder Dowel Bars	each	47,872	1	$47,872			$0
Subtotal				$47,872			$0
Mark-up				1.30			1.30
Total				**$62,234**			**$0**
						Net Cost Avoidance	**$62,234**

VE PROPOSAL VE-4	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 9** **Date: July 16th, 2019**
DESCRIPTION OF VE PROPOSAL: **Offset the ramp alignments for Bethune**	**Page No.: 1 of 4**

VE-4: Idea 9: Offset the ramp alignments for Bethune

ORIGINAL DESIGN:
Ramps at the Bethune interchange are currently planned to be reconstructed in their present location (i.e. no changes in alignment or profile). Pavement structure will be 9" of PCCP over 6" of ABC. To construct the ramps, it will be necessary to either close the ramps temporarily and detour traffic, or to construct the ramps one half at a time. The ramps will be used by both general traffic and construction traffic during construction which introduces the potential for accidents and conflicts.

PROPOSED DESIGN:
The proposed idea is to construct a new ramp parallel to, and alongside the existing ramp (see construction phasing sketches). Traffic would utilize the existing ramp while the new ramp is constructed. Once the new ramp is constructed, traffic would be shifted to the new ramp and the existing ramp could be utilized for construction traffic only. At the completion of construction, the existing ramps would be taken out of service and obliterated.

ADVANTAGES:
- Ramps would remain open continuously during construction
- Simplifies the construction phasing of the ramps
- Reduces the construction duration
- Reduces the potential for conflicts between general traffic and construction traffic
- Eliminates a construction joint – potential to reduce future maintenance

DISADVANTAGES:
- Potential right-of-way (ROW) impacts – may require 3:1 side slope and/or guardrail to keep toes of slopes within ROW
- Increased project cost

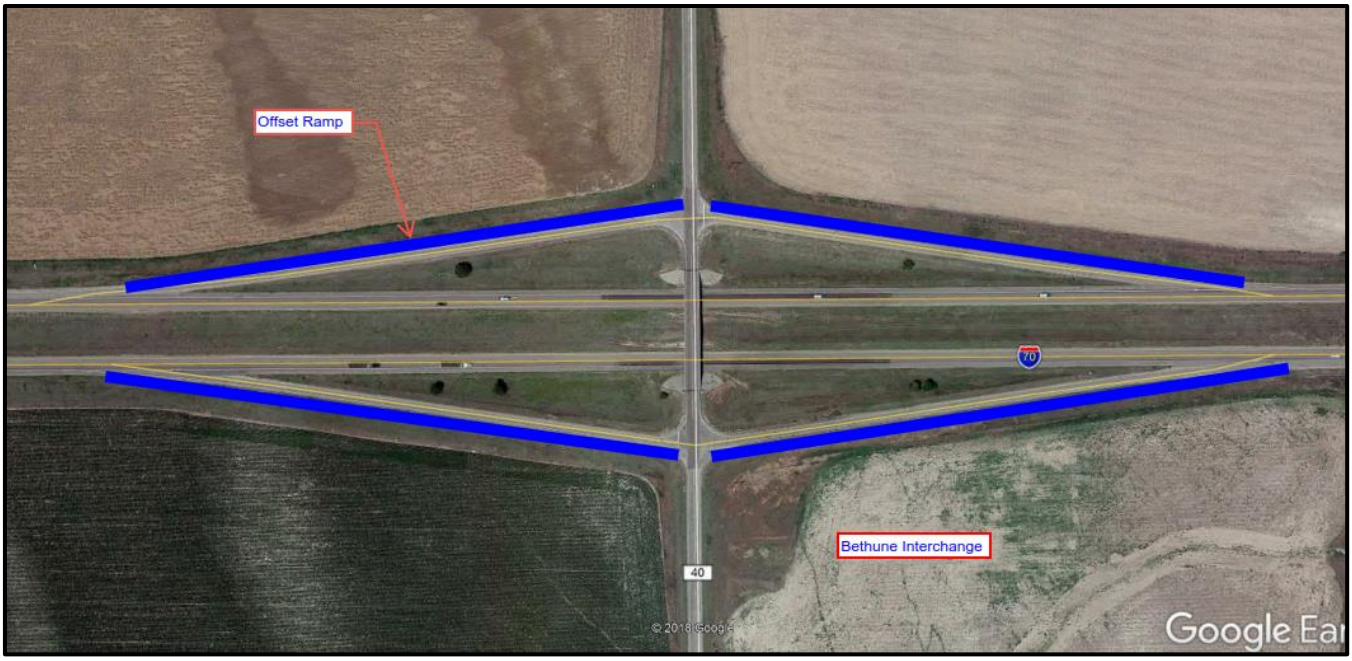
DISCUSSION/JUSTIFICATION:
This idea would simplify the phasing of the interchange ramps, would allow construction traffic to fully utilize the existing ramps, and would reduce the potential for general traffic – construction traffic conflicts. This idea could be implemented on a ramp-by-ramp basis depending upon a number of factors including existing ramp traffic volumes. It could be implemented on any or all of the 4 interchange ramps.

DISCUSSION OF RISK IMPACTS:
The VE Team does not anticipate any added risks related to this idea. Possibly a reduction in risk related to separation of general traffic and construction traffic.

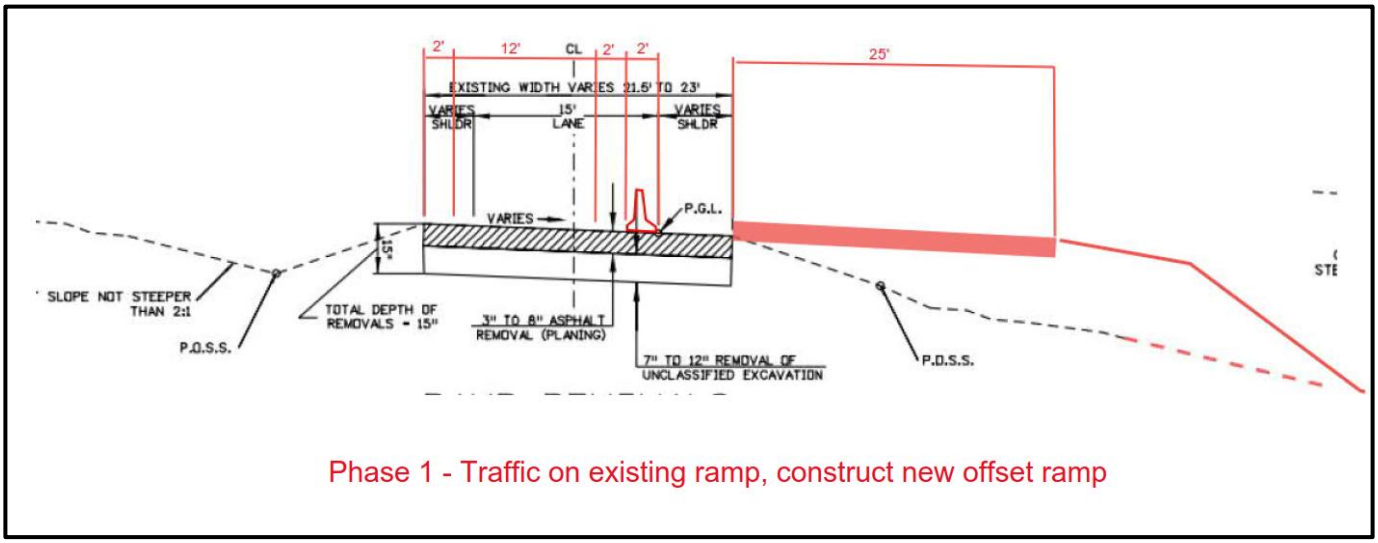
VE PROPOSAL VE-4	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 9** **Date: July 16th, 2019**
DESCRIPTION OF VE PROPOSAL: **Offset the ramp alignments for Bethune**	**Page No.: 2 of 4**

	Construction Costs
Base Case Design	$0
Proposed Design	$156,786 per ramp * 4 ramps
Estimated Additional Costs	**$627,144**

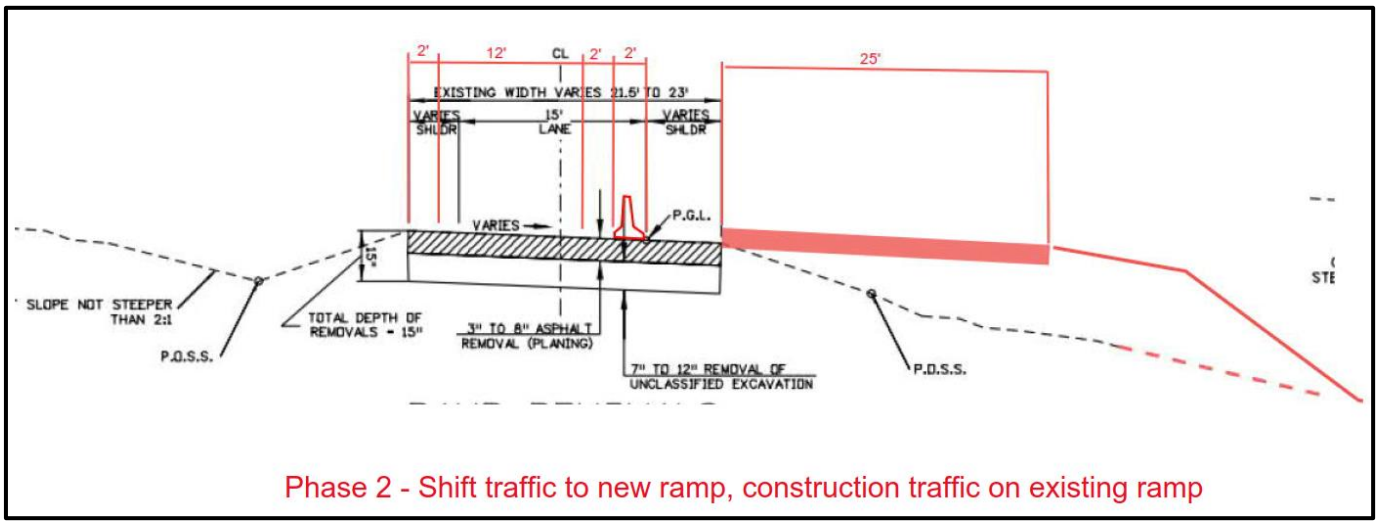
PROPOSED CHANGE SKETCH:



VE PROPOSAL VE-4	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 9** **Date: July 16th, 2019**
DESCRIPTION OF VE PROPOSAL: **Offset the ramp alignments for Bethune**	**Page No.: 3 of 4**

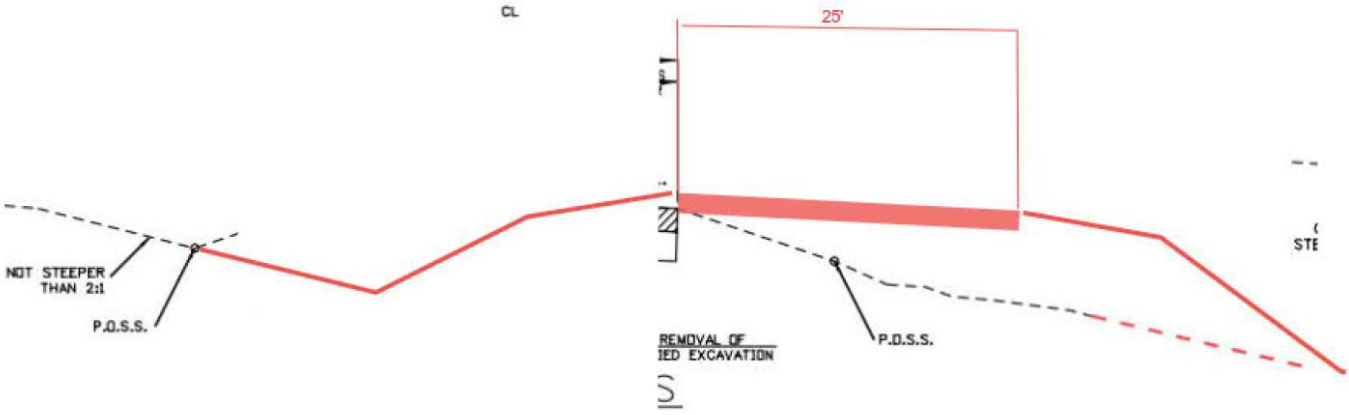


Phase 1 - Traffic on existing ramp, construct new offset ramp



Phase 2 - Shift traffic to new ramp, construction traffic on existing ramp

VE PROPOSAL VE-4	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 9** **Date: July 16th, 2019**
DESCRIPTION OF VE PROPOSAL: **Offset the ramp alignments for Bethune**	**Page No.: 4 of 4**



Phase 3 - Obliterate existing ramp

ASSUMPTIONS AND CALCULATIONS:
Unit costs are based upon Project Code #22462 I-70 Bethune FIR cost estimate and Project Code #21878 Arriba Bid tabs. Assume pavement costs for offset alignment will be the same as for the base case design. Added a 25% contingency to cover minor items blading, seeding, etc. Some items including signing, striping, delineators, etc. will be the same under the base case alternative. Costs for proposed idea do not include any credits back for traffic control.

Construction Item		Current Design			Proposed Design		
Item	**Units**	**Qty**	**Unit $**	**Total**	**Qty**	**Unit $**	**Total**
203 Embankment Material (CIP)	CY			$0	6,013	$9.5	$57,124
630 Concrete Barrier (Temp)	LF			$0	1,230	$32	$39,360
`Contingencies (25%)				$0			$24,121
Subtotal				$0			$120,605
Mark-up				1.30			1.30
Total				**$0**			**$156,786**
						Net Cost Increase	**$156,786 per ramp**

VE PROPOSAL VE-5	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 12** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Eliminate concrete box culverts extensions**	**Page No.: 1 of 4**

VE-5: Idea 12: Eliminate concrete box culverts extensions

ORIGINAL DESIGN:
The current design proposes to extend the concrete box culverts (CBC's) in order to reduce the safety risk as both of the structures are located within the estimated clear zone of 42'. Extending the CBC's out past the clear zone would eliminate guardrail for these areas and reduce the risk of possible accidents due to the hazardous structures being within the roadway clear zone. The following extensions are proposed with the current design:

- Extend the existing culvert G-27-T 18' to the north side of WB I-70 and 23' to the south side of EB I-70
- Extend existing CBC's G-27-X & G-27-W, 11' to the north side of WB I-70 and 19' to the south side of EB I-70. These two box culverts would also be extended across the median so that they form a continuous structure to eliminate the open section at the median.

PROPOSED DESIGN:
Eliminate all of the CBC extensions including the median closing of CBC G-27-X and G-27W and replacing the existing guardrail at all locations to bring it up to standard.

ADVANTAGES:

- Reduces cost of the project

DISADVANTAGES:

- Maintains existing hazard
- Maintenance issues related to guardrail

DISCUSSION/JUSTIFICATION:
The concept centers around evaluating cost effectiveness to potentially reduce the long-term safety concerns associated with a roadside hazard (CBC's and guardrail) within the clear zone. Extending the CBC's beyond the clear zone to eliminate a roadside hazard, as well as eliminating the guardrail in the area would be considered a safety improvement and would reduce the future exposure for accidents in the area.

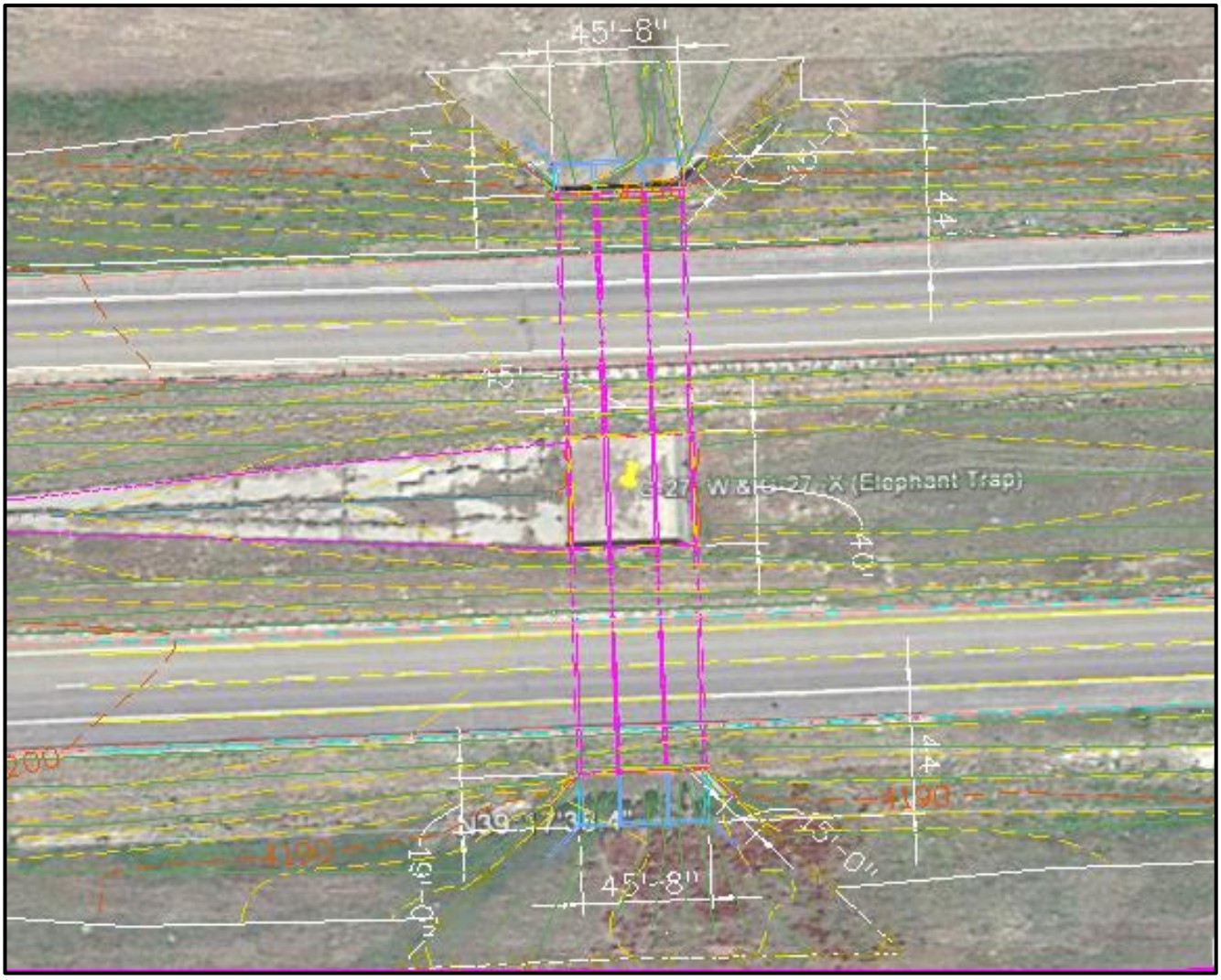
DISCUSSION OF RISK IMPACTS:
Maintaining the existing hazards (CBC's and guardrail) could have possible safety related impacts in the future. Keeping the original design of extending the CBC's would predominantly reduce future safety risks and exposure and adding guardrail would require more future maintenance.

	Construction Costs
Base Case Design	$716,513
Proposed Design	$107,315
Estimated Cost Saving	**$609,198**

VE PROPOSAL VE-5	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 12** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Eliminate concrete box culverts extensions**	**Page No.: 2 of 4**

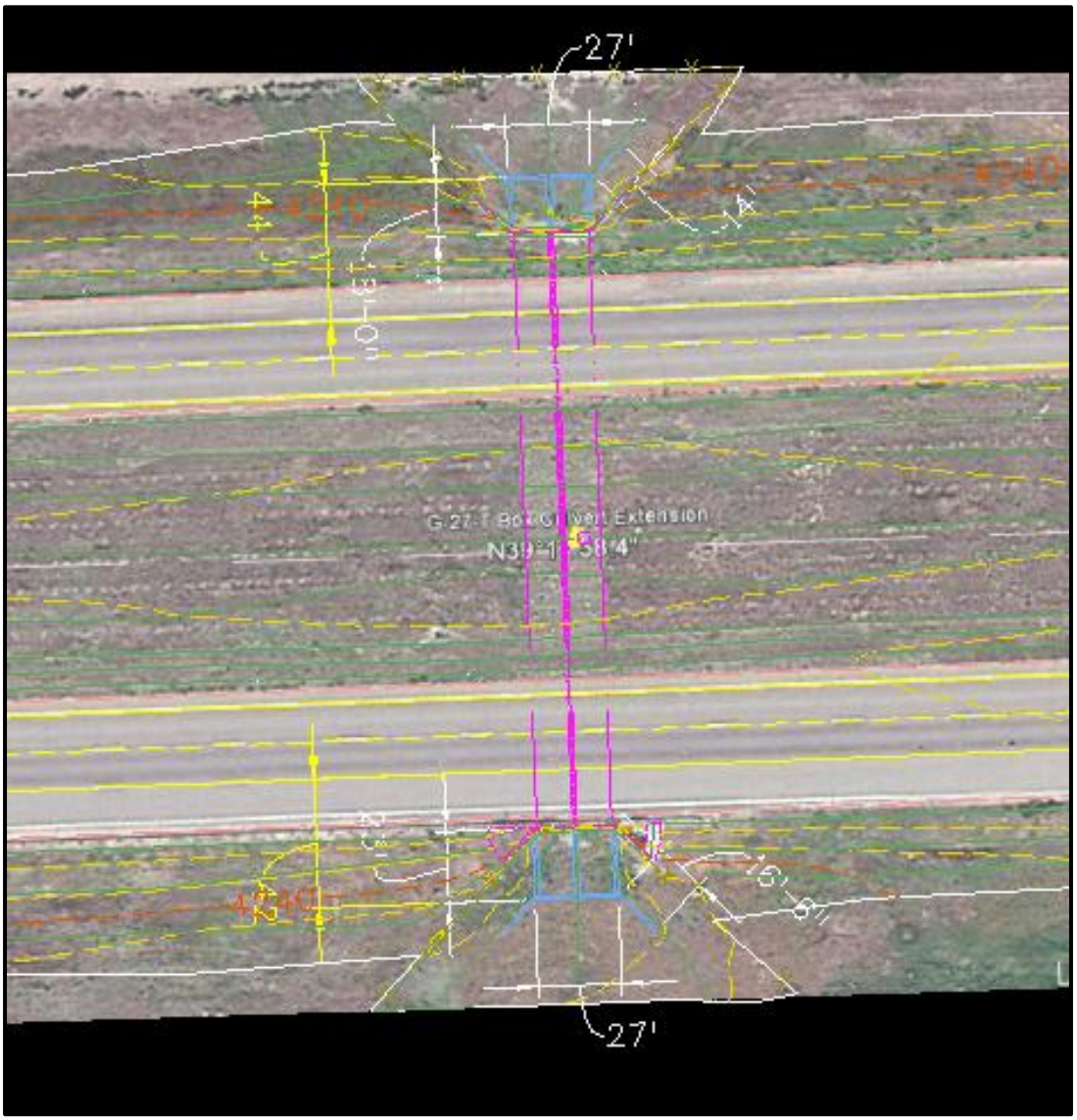
ORIGINAL DESIGN SKETCH:

Structure G-27-X&W Current Proposed Design:



VE PROPOSAL VE-5	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 12** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Eliminate concrete box culverts extensions**	**Page No.: 3 of 4**

Structure G-27-T Current Proposed Design:



PROPOSED CHANGE SKETCH:
Roadway would remain the same without the CBC extensions, but with new guardrail

VE PROPOSAL VE-5	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 12** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Eliminate concrete box culverts extensions**	**Page No.: 4 of 4**

ASSUMPTIONS AND CALCULATIONS:

Construction Item		Current Design			Proposed Design		
Item	Units	No. of Units	Cost / Unit	Total	No. of Units	Cost / Unit	Total
G-27-X&W							
Remove Portions Present Structure	SY	47	$300.00	$14,100.00	0		
Unclassified Excavation	CY	57	$23.00	$1,311.00			
Embankment Material (CIP)	CY	205	$22.00	$4,510.00			
Concrete Class D (Box Culvert)	CY	260	$975.00	$253,500.00			
Reinf Steel (Epoxy)	LB	31,389	$1.60	$50,222.40			
Guardrail Type 3 (6-3 Post Spacing)	LF				1,925	$22.00	$42,350.00
End Anchorage Type 3D	EA				4	$2,000.00	$8,000.00
End Anchor (Flared)	EA				4	$2,500.00	$10,000.00
TOTAL G-27-W&X				**$323,643.40**			**$60,350.00**
G-27-T							
Remove Portions Present Structure	SY	47	$300.00	$14,100.00	0		
Unclassified Excavation	CY	45	$23.00	$1,035.00			
Embankment Material (CIP)	CY	205	$22.00	$4,510.00			
Concrete Class D (Box Culvert)	CY	166	$975.00	$161,850.00			
Reinf Steel (Epoxy)	LB	28,766	$1.60	$46,025.60			
Guardrail Type 3 (6-3 Post Spacing)	LF				600	$22.00	$13,200.00
End Anchorage Type 3D	EA				2	$2,000.00	$4,000.00
End Anchor (Flared)	EA				2	$2,500.00	$5,000.00
TOTAL G-27-T				**$227,520.60**			**$22,200.00**
Subtotal				$551,164			$82,550
Mark-Up	0			$165,349			$24,765
Total				**$716,513**			**$107,315**
						Net Cost Avoidance	**$609,198**

VE PROPOSAL VE-6	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 19** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Accelerate schedule**	**Page No.: 1 of 2**

VE-6: Idea 19: Accelerate schedule

ORIGINAL DESIGN:
The construction schedule for this project would be calculated based on previous interstate 70 projects with similar bid items. The I-70 Bethune project is 8.9 miles in length. The Contractor averages 1 mile per 20 working days (working day = 10-HR). The project would then take 178 working days to complete. The current CDOT specifications do not allow work on weekends, nights, or holidays unless otherwise approved by the Engineer. The typical working days in one month is 21 days. With the 21 working days/month this project would take 8.5 months to complete. A construction season for an interstate project is from March 15th to October 31st (7.5 months). Therefore, the project would need to utilize two construction seasons to be completed.

PROPOSED DESIGN:
The proposed design is to accelerate the construction schedule so that the project is completed in one construction season instead of two by using incentives/disincentives and a must finish before date specification. This means that CDOT would allow the Contractor to work six days per week instead of five days per week to accelerate their schedule.

ADVANTAGES:
- Reduces the length of the construction schedule
- Reduces the time that the traveling public is impacted by the project
- Allows the contractor to work on another project for the next construction season
- Less maintenance during the construction phase on the head to head traffic side
- Less exposure of the construction staff to the traveling public

DISADVANTAGES:
- Increases costs
- Hard to get enough staff for the Contractor's laborers and truck drivers
- Working approximately 60 hours per week may cause lower quality due to tired workers
- Increases potential for claims

DISCUSSION/JUSTIFICATION:
The advantage of accelerating the project schedule is that it would allow the project to be completed in one construction season instead of two. To construct full width concrete paving in one direction of the interstate the traffic must be moved to the opposite side of the interstate and put into a head-to-head configuration. By accelerating the project schedule and completing all items in one construction season it would cut off 1 month of the head-to-head configuration for the traveling public on the interstate. It would also allow the Contractor and construction staff to work on another project during the second construction season.

VE PROPOSAL VE-6	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 19** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Accelerate schedule**	**Page No.: 2 of 2**

DISCUSSION OF RISK IMPACTS:

The largest risk for accelerating the project schedule is having a Contractor that can provide the staffing and truck drivers to put in the longer hours and work weeks. There is a federal requirement to have traffic out of head-to-head configuration on Interstate 70 by November 1. This poses another potential risk of the Contractor failing to meet the accelerated schedule, thus having traffic in the head-to-head configuration past the November 1 deadline. FHWA and CDOT do not want head-to-head traffic on the interstate after October 31st due to the chances of snow and bad weather which could increase risk of severe accidents.

	Construction Costs
Base Case Design	-
Proposed Design	$1,234,769
Estimated Additional Cost	**$1,234,769**

ASSUMPTIONS AND CALCULATIONS:

It is our understanding that the labor rates on transportation projects are dependent upon a number of factors including location, type of project etc. Therefore, the labor rates for transportation projects have been found to vary between 20 and 50 percent. Using this information, the average of 35% was used.

		hours/day	day/month	hr/month	Total HR to complete project	Total months to complete project	overtime hr/week	
current	5 day/week	10	21	210	1780	8.5	10	
proposed	6 day/week	10	25	250	1780	7.1	20	
					178 days @10 hr/day = 1,780 hours	Additional overtime/week	10	
						Additional overtime/month	40	
						Additional overtime for proposal	285	time and a half extra hours 142.40 Additional cost for overtime **$1,234,768.82**

Total construction project cost	35% = Labor of total cost	Total HR to complete	dollar/hr for entire labor cost
$44,098,886.58	$15,434,610.30	1780	$8,671.13

VE PROPOSAL VE-7	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 24** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Use high strength concrete**	**Page No.: 1 of 3**

VE-7: Idea 24: Use high strength concrete

ORIGINAL DESIGN:
Original design is based on 9.5 inches overlay with a 28-day flexural strength of 650 psi.

PROPOSED DESIGN:
Proposed 8.00 inches overlay with a 28-day flexural strength of 750 psi.

ADVANTAGES:
- Reduce thickness by 1.5 inches
- Reduces costs
- Reduces schedule

DISADVANTAGES:
- Will require a higher level of process control monitoring and testing by the Contractor

DISCUSSION/JUSTIFICATION:
Most Class P concrete can meet the higher flexural strength with no adjustments to their current mix designs. In the past, Contractors have suggested using a higher flexural strength as a Value Engineering Proposal.

DISCUSSION OF RISK IMPACTS:
Achieving this target flexural strength may affect the Contractor's quality level and may impact the incentive/disincentive for flexural strength. If this requirement were to be implemented by CDOT, the Contractors would need time to evaluate their current quality levels for each mix design and make the appropriate modifications. The specifications for the laboratory mix design would need to be modified. The incentive/disincentive program as well as the project specifications would need to be modified.

	Construction Costs
Base Case Design	$24,967,613
Proposed Design	$20,078,106
Estimated Cost Saving	**$4,889,507**

VE PROPOSAL VE-7	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 24** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Use high strength concrete**	**Page No.: 2 of 3**

New_JPCP_R-4 Design (750)

File Name: C:\Users\gokdbaum\Desktop\Bethune Project\New_JPCP_R-4 Design (750).dgpx

Design Inputs

Design Life: 30 years
Design Type: JPCP

Existing construction: -
Pavement construction: March, 2021
Traffic opening: August, 2021

Climate Data Sources (Lat/Lon): 39.245, -102.284

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 3 Flex Lawson	8.0
NonStabilized	Crushed gravel	4.0
NonStabilized	Rubbilized PCCP	8.0
NonStabilized	Crushed gravel	4.0
Subgrade	A-6	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.25
Slab width (ft)	13.0 (w)

Traffic

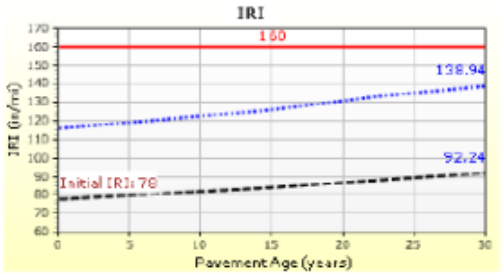
Age (year)	Heavy Trucks (cumulative)
2021 (initial)	2,830
2036 (15 years)	7,594,870
2051 (30 years)	16,677,900

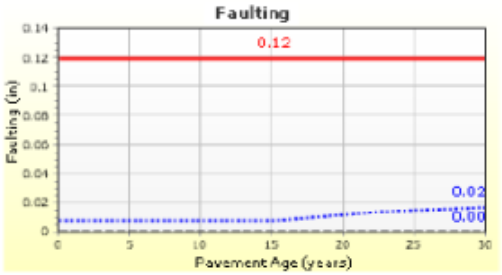
Design Outputs

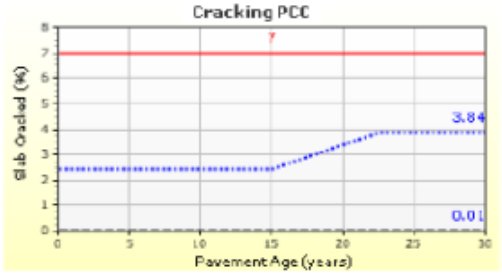
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	138.94	95.00	99.15	Pass
Mean joint faulting (in)	0.12	0.02	95.00	100.00	Pass
JPCP transverse cracking (percent slabs)	7.00	3.84	95.00	99.86	Pass

Distress Charts







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Version: 2.3.1+66
Created by: on: 8/5/2016 12:00 AM
Approved by: on: 8/5/2016 12:00 AM
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VE PROPOSAL VE-7	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 24** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Use high strength concrete**	**Page No.: 3 of 3**

ASSUMPTIONS AND CALCULATIONS:

Assumed that the base case design was not modified and that the only change was to the required flexural strength. Assumed no additional cementitious materials will be needed. Assumed one additional Process Control Tester will be needed to monitor the materials. Based on the CDOT Cost Planner Tool, 8.00-inch PCCP will cost $38.50 per square yard for this project.

Based on data from the CDOT Cost Planner Tool and a recent cost estimate for the I-70 at Genoa project using the same PCCP thickness, the VE Team updated the unit cost of the 9.5-inch PCCP for this project to $48.00 per square yard.

Construction Item		Current Design			Proposed Design		
Item	**Units**	**No. of Units**	**Cost / Unit**	**Total**	**No. of Units**	**Cost / Unit**	**Total**
412-00950 Concrete Pavement (9.5”)	Yd²	400,122	$48	$19,205,856			
412-00825 Concrete Pavement (8.00”)	Yd²				400,122	$38.50	$15,404,697
Process Control Tester	Hour				1,600	$25	$40,000
Subtotal				$19,205,856			$15,444,697
Mark-Up	30%			1.30			1.30
Total				**$24,967,613**			**$20,078,106**
						Net Cost Avoidance	**$4,889,507**

VE PROPOSAL VE-8	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 28** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Use millings generated on project for subbase material**	**Page No.: 1 of 5**

VE-8: Idea 28: Use millings generated on project for subbase material

ORIGINAL DESIGN:
The current design has millings generated from the project being hauled off of the project. The millings are not reused on the project with the current design. The current design also proposes using Crushed Rock in the reconstruction areas in the eastbound and westbound directions.

PROPOSED DESIGN:
Use a portion of the millings generated on this project in place of the Crushed Rock material in the reconstruction areas where there are vertical restrictions. There are 3 overpass areas and a set of sister bridges that are vertically restricted areas on this project.

ADVANTAGES:
- Reduces costs
- Reduces schedule
- Eliminates some trucking

DISADVANTAGES:
- Potential for long term creep
- Potential compaction issues

DISCUSSION/JUSTIFICATION:
Reusing a portion of the millings generated on the project in place of the Crushed Rock material currently required for the reconstruction areas in both eastbound and westbound directions where there are vertical restrictions would be a cost savings. The schedule would also be reduced in that there would not need to be any Crushed Rock material required to be trucked in and stockpiled.

DISCUSSION OF RISK IMPACTS:
Reusing a portion of the millings generated on the project in place of the Crushed Rock material currently required for the reconstruction areas in both eastbound and westbound directions where there are vertical restrictions could have the potential to trap water. The material being milled might not produce a sufficient enough gradation to allow water to properly drain through it. The milling material might also pose the risk of being able to reach the desired compaction if it were to have an insufficient gradation.

	Construction Costs
Base Case Design	$1,476,783
Proposed Design	$548,990
Estimated Cost Saving	**$927,793**

VE PROPOSAL VE-8	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 28** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Use millings generated on project for subbase material**	**Page No.: 2 of 5**

ASSUMPTIONS AND CALCULATIONS:

Based off the current design for the typical section in the reconstruction areas it shows 7" of Crushed Rock as the subgrade. It was assumed that the Crushed Rock would be classified as ABC (Class 4) (see table below) but paid for as ABC (Special)/CY.

Table 703-2
CLASSIFICATION FOR AGGREGATE BASE COURSE

Sieve Size	Mass Percent Passing Square Mesh Sieves						
	LL not greater than 35			LL not greater than 30			
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
150mm (6")			100				
100mm (4")		100					
75mm (3")		95-100					
60mm (2 ½")	100						
50mm (2")	95-100			100			
37.5mm (2")				90-100	100		
25mm (1")					95-100	100	100
19mm (3/4")				50-90		95	
4.75mm (#4)	30-65			30-50	30-70	30-65	
2.36mm (#8)						25-55	20-85
75 µm (#200)	3-15	3-15	20 max	3-12	3-15	3-12	5-15
NOTE: Class 3 material shall consist of bank or pit run material.							

VE PROPOSAL VE-8	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 28** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Use millings generated on project for subbase material**	**Page No.: 3 of 5**

Current Tabulation of quantities for Unsuitable Material:

TABULATION OF SURFACING

STATION / LOCATION	202-00241 REMOVAL OF ASPHALT MAT (PLANING) SY				203-00050 REMOVAL OF UNSUITABLE MATERIAL CY				NOTES
	Wid (FT.)	THK (IN.)	PLAN	AS CONST.	Wid (FT.)	THK (FT.)	PLAN	AS CONST.	
MAINLINE	**WESTBOUND**								
3002+06 - 3004+24					38	2	614		WB Mainline (Reconstruct Area)
3004+24 3006+30	Structure G-27-I								
3006+30 3014+47					38	2	2,300		WB Mainline (Reconstruct Area)
3014+47 - 3063+07	38	6.5	20,520						WB Mainline
3063+07 - 3083+07					38	2	5,630		WB Mainline (Reconstruct Area)
3083+07 - 3221+45	38	6.5	58,427						WB Mainline
3221+45 - 3241+43					38	2	5,624		WB Mainline (Reconstruct Area)
3241+43 - 3327+09	38	6.5	36,168						WB Mainline
3327+09 - 3347+09					38	2	5,630		WB Mainline (Reconstruct Area)
3347+09 - 3469+47	38	6.5	51,672						WB Mainline
3469+47 - 3474+66					38	2	1,461		WB Mainline (Transition to EOP)
WB ON RAMP									
3047+63 - 3062+30	VAR	6.5	1,351						Accel & Gore Area (From Model)
WB OFF RAMP									
3062+30 - 3082+50	VAR	6.5	626						Decel & Gore Area (From Model)
MAINLINE	**EASTBOUND**								
3002+06 - 3003+56					38	2	422		EB Mainline
3003+56 3005+65	Structure G-27-R								
3005+65 3013+65					38	2	2,252		EB Mainline (Reconstruct Area)
3013+65 - 3063+05	38	6.5	20,858						EB Mainline
3063+05 - 3083+05					38	2	5,630		EB Mainline (Reconstruct Area)
3083+05 - 3220+49	38	6.5	58,030						EB Mainline
3220+49 - 3240+49					38	2	5,630		EB Mainline (Reconstruct Area)
3240+49 - 3327+02	38	6.5	36,535						EB Mainline
3327+02 - 3347+02					38	2	5,630		EB Mainline (Reconstruct Area)
3347+02 - 3469+47	38	6.5	51,701						EB Mainline
3469+47 - 3474+47					38	2	1,407		EB Mainline (Transition to EOP)
EB OFF RAMP									
3054+49 - 3063+59	VAR	6.5	752						Decel & Gore Area (From Model)
EB ON RAMP									
3062+30 - 3082+50	VAR	6.5	1,575						Accel & Gore Area (From Model)
SUB-TOTALS			338,215				42,230		
5% IRREGULARITIES									
PROJECT TOTAL			**338,215**				**42,230**		

VE PROPOSAL VE-8	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 28** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Use millings generated on project for subbase material**	**Page No.: 4 of 5**

Cost data from 2018 for Item:

COLORADO DEPARTMENT OF TRANSPORTATION 10:52 Thursday, February 28, 2019 221
ITEM UNIT COSTS BY PROJECTS -- 2018 COST DATA

PROJECT NUMBER	ITEM NUMBER/	ITEM DESCRIPTION/ PROJECT LOCATION	DATE LET	UNIT/ QUANTITY	ENGR. EST.	AVERAGE BID	AWARDED BID
==========	304-09014	ABC (Spec)		Ton			
ER007A-026		PR SH-7 FLOOD (PH II),EP - JC	03/01/18	3,955.00	40.00	33.10	33.00
STA007A-025		SH-7 NON FLOOD, SHO (PH II),E					
NHPP1602-166		US 160 JCT 172 TO BAYFIELD RE	03/08/18	4,505.00	23.00	32.16	28.00
		WEIGHTED AVERAGE FOR THE FIRST QUARTER		13,565.00	32.47	31.81	24.94
FBR0502-081		US 50, MP 190.4 Near Sargents	04/19/18	54.00	40.00	75.40	17.60
		WEIGHTED AVERAGE FOR THE SECOND QUARTER		54.00	40.00	75.40	17.60
NHPP4912-007		US 491 MP 36.15 - MP 53.74	11/15/18	7,270.00	30.00	43.82	37.64
STR112A-001		SH 112 FROM US 285 TO SH 17	12/06/18	5,269.00	25.00	25.29	22.36
STR1591-001		SH 159 SAN LUIS TO FT GARLAND	12/13/18	5,512.00	22.00	26.77	22.00
		WEIGHTED AVERAGE FOR THE FOURTH QUARTER		18,051.00	26.10	31.56	28.40
		WEIGHTED AVERAGE FOR THE YEAR		31,670.00	28.85	31.87	26.90

The design plans show a total of 338,215 SY of Removal of Asphalt (Planing) with a depth of 6".

338,215 SY x 9 SF/SY = 3,043,935 SF 3,043,935 SF x 0.5' (depth) = 1,521,968 CF

1,521,968 CF / 27 CF/CY = 56,369.17 CY

The design plans show a total of 42,230 SY of Removal of Unsuitable Material. Based off the above calculated quantity, there is more than enough millings generated from the project to fulfill the need for the replacement of the Removal of Unsuitable Material with millings in lieu of the Crushed Rock.

42,230 SY x $26.90 CY (ABC (Special) = $1,135,987.00

It is estimated that a bid price of $10.00 / CY from projects with similar quantities for Embankment (CIP) would be used for the use of the millings generated from the project.

42,230 SY x $10.00 CY Embankment (CIP) = $422,300.00

(ABC (Special) = $1,135,987.00 - $422,300.00 Embankment (CIP) CY = $713,687

To place the asphalt millings is included in 203-00060.

VE PROPOSAL VE-8	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 28** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Use millings generated on project for subbase material**	**Page No.: 5 of 5**

Construction Item		Current Design			Proposed Design		
Item	**Units**	**No. of Units**	**Cost / Unit**	**Total**	**No. of Units**	**Cost / Unit**	**Total**
304-09014 ABC (Special)	CY	42,230	$26.90	$1,135,987			
203-00060 Embankment (CIP)					42,230	$10	$422,300
Subtotal				$1,135,987			$422,300
Mark-Up	30%			$340,796			$126,690
Total				**$1,476,783**			**$548,990**
						Net Cost Avoidance	**$927,793**

VE PROPOSAL VE-9	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 34** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Reuse unsuitable material for shouldering**	**Page No.: 1 of 2**

VE-9: Idea 34: Reuse unsuitable material for shouldering

ORIGINAL DESIGN:
Current specification Section 203.06 states that unsuitable materials that are determined to be detrimental to the roadway or embankment shall be removed to the depths and extents directed by the Engineer.

203.06

(c) *Unsuitable Material*. Unsuitable materials encountered in the subgrade, roadway, or embankment foundation that are determined to be detrimental to the roadway or embankment shall be removed to the depth and extents directed by the Engineer. The excavated area shall be backfilled to the finished graded section with approved material. Materials that contain organics or that cannot be dried or moisture conditioned, then compacted to the required density shall be disposed of and shall not be reused as embankment fill. Materials that don't contain organics and that can be dried or moisture conditioned and compacted to the required density may be reused as embankment fill as approved by the Engineer.

PROPOSED DESIGN:
Rewrite the specification to allow the unsuitable material to be used for shouldering embankment as a project special provision.

ADVANTAGES:
- Cost savings of not having to haul the material off the project
- Cost savings in less embankment material
- Reduces truck traffic on roads

DISADVANTAGES:
- Time required for drying
- Potential for errant vehicles/trucks to get stuck if they venture off the paved surface

DISCUSSION/JUSTIFICATION:
Currently, the project is estimated to have about 42,000 CY of unsuitable material and will need to import 62,175 CY of embankment material. If 2/3 of the embankment material could be eliminated, the project would not only save on the cost of the embankment, but it allows the Contractor more freedom of where they can get their embankment from (finding a site that has 20,000 CY's instead of 60,000 CY's) which could save in hauling time and cost. This will also eliminate the cost of hauling the unsuitable material off the project. The current shouldering material along most CDOT highways in this area use clay soils found on this project. Note: This idea could be used in conjunction with Idea #9 where additional fill would be required to build the embankments for the new offset ramp alignments.

VE PROPOSAL VE-9	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 34** **Date: July 17th, 2019**
DESCRIPTION OF VE PROPOSAL: **Reuse unsuitable material for shouldering**	**Page No.: 2 of 2**

DISCUSSION OF RISK IMPACTS:

If the unsuitable material takes a considerable time to dry, this could affect the construction schedule in delays. There is a potential for errant vehicles and trucks to get stuck in the soft unsuitable material if they were to drive off of the paved surface. However, this condition is not different from today's condition where vehicles could get stuck during inclement weather or wet conditions.

	Construction Costs
Base Case Design	$2,242,061
Proposed Design	$1,395,761
Estimated Cost Saving	**$846,300**

ASSUMPTIONS AND CALCULATIONS:

Assumed the quantity of unsuitable material is about 42,000 CY

Construction Item		**Current Design**			**Proposed Design**		
Item	**Units**	**No. of Units**	**Cost / Unit**	**Total**	**No. of Units**	**Cost / Unit**	**Total**
Embankment Material (CIP)	CY	62,175	$9.5	$590,662.50	20,175	$9.5	$191,662.50
Unsuitable Material	CY	42,000	$27	$1,134,000	42,000	$21	$882,000
Subtotal				$1,724,663			$1,073,663
Mark-Up	30%			1.30			1.30
Total				**$2,242,061**			**$1,395,761**
						Net Cost Avoidance	**$846,300**

CDOT Accepted Modified Cost Estimate

Construction Item		**Current Design**			**Proposed Design**		
Item	**Units**	**Qty**	**Unit $**	**Total**	**Qty**	**Unit $**	**Total**
203 Embankment Material (CIP)	CY	62,175	$9.5	$590,663	84,380	$10	$801,610
630 Concrete Barrier (Temp)	LF	42,000	$27	$1,134,000	21,790	$21	$457,590
Subtotal				$1,724,663			$1,259,200
Mark-up				1.3			1.30
Total				**$2,242,061**			**$1,636,960**
						Net Cost Avoidance	**$605,101**

VE PROPOSAL VE-10	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 36** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Reduce concrete thickness by using shorter panels**	**Page No.: 1 of 4**

VE-10: Idea 36: Reduce concrete thickness by using shorter panels

ORIGINAL DESIGN:
The current design shows Class-P PCCP being installed, per specifications with transverse joints at 15-foot intervals.

PROPOSED DESIGN:
Based on CDOT's 2020 Pavement Design Manual, the VE Team re-evaluated the pavement design with 12-foot panel lengths.

ADVANTAGES:
- Potential to reduce the amount of transverse cracks
- Potential to extend service life
- Reduces the overlay thickness of concrete to 8.00"
- Reduces costs

DISADVANTAGES:
- Increases the potential for the Contractor to misplace the transverse joints
- Increases the number of transverse joints
- Increases the linear feet of sawing and sealing transverse joints
- Increases the number dowel bars
- Over time there is the potential for incompressible materials to fill a transverse crack and break the PCCP
- Increases maintenance efforts to clean and reseal the joints

DISCUSSION/JUSTIFICATION:
The shorter panel length will create less warping and curling in the panel. The tractor portion of a Class 9 vehicle will span the shorter length thereby implying less stress on a panel. The 12-foot panel length may eliminate random cracking in the pavement. The recommendation to keep the panel dimensions as square as possible would be achieved. Transverse cracking would be minimized. The time required to add the dowel bars along with sawing and sealing the additional joints is offset by the reduced thickness.

DISCUSSION OF RISK IMPACTS:
It would require time and costs to redesign what is currently shown in the plans. It would increase the future maintenance cost to clean and reseal the joints.

	Construction Costs
Base Case Design	$24,967,613
Proposed Design	$20,270,179
Estimated Cost Saving	**$4,697,434**

VE PROPOSAL VE-10	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 36** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Reduce concrete thickness by using shorter panels**	**Page No.: 2 of 4**

New_JPCP_R-4 Design (12 Foot Panels)

File Name: C:\Users\goldbaum\Desktop\Bethune Project\New_JPCP_R-4 Design (12 Foot Panels).dgpx

Design Inputs

Design Life: 30 years
Design Type: JPCP

Existing construction: -
Pavement construction: March, 2021
Traffic opening: August, 2021

Climate Data Sources (Lat/Lon): 39.245, -102.284

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 3 Flex Lawson	8.0
NonStabilized	Crushed gravel	4.0
NonStabilized	Rubbilized PCCP	8.0
NonStabilized	Crushed gravel	4.0
Subgrade	A-6	Semi-infinite

Joint Design:	
Joint spacing (ft)	12.0
Dowel diameter (in)	1.25
Slab width (ft)	12.0 (w)

Traffic

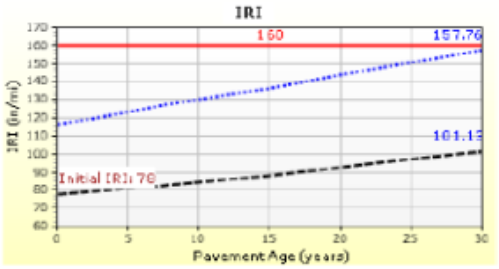
Age (year)	Heavy Trucks (cumulative)
2021 (initial)	2,830
2036 (15 years)	7,594,870
2051 (30 years)	16,677,900

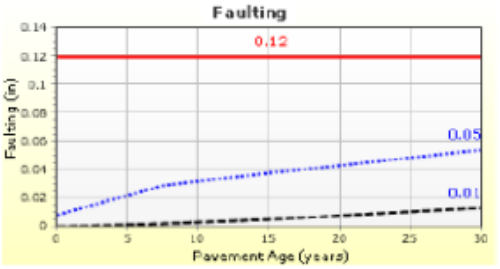
Design Outputs

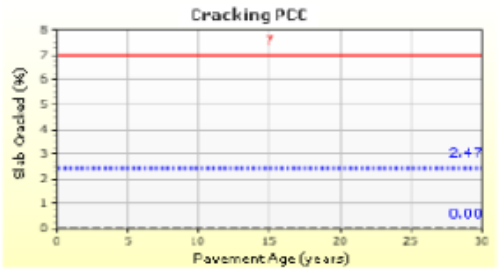
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	157.76	95.00	95.64	Pass
Mean joint faulting (in)	0.12	0.05	95.00	100.00	Pass
JPCP transverse cracking (percent slabs)	7.00	2.47	95.00	100.00	Pass

Distress Charts







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Approved by: on: 8/5/2016 12:00 AM
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VE PROPOSAL VE-10	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 36** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Reduce concrete thickness by using shorter panels**	**Page No.: 3 of 4**

ASSUMPTIONS AND CALCULATIONS:

Assumed that the base case design was not modified and that the only change was to the length of the panels. This design does not include the information from Idea 5. Using a total paving quantity of 400,122 square yards for this project. Use the updated cost estimate developed for this project for the 9.5-inch PCCP and the unit cost from CDOT's Cost Planner Tool for the 8.00-inch PCCP. Does not include cost of potentially reduced embankment material.

Dowel bars cost $1.00 each.

The cost of sawing and sealing transverse joints is $2.75 per linear foot.

Total number of transverse joints @ 15-foot long panels = (8.5 miles x 5,280' x 2 directions) /15' = 5,984 joints

Total number of transverse joints @ 12-foot long panels = (8.5 miles x 5,280 x 2 directions) /12' = 7,480 joints

Total additional linear feet = (7,480 – 5,984) x 38 feet wide = 56,848 feet

Total additional dowel bars = (7,480 – 5,984) x 21 dowel bars per joint = 31,416 bars

Construction Item		Current Design			Proposed Design		
Item	**Units**	**No. of Units**	**Cost / Unit**	**Total**	**No. of Units**	**Cost / Unit**	**Total**
412-00950 Concrete Pavement (9.5")	Yd^2	400,122	$48	$19,205,856			$0
412-00800 Concrete Pavement (8.00")	Yd^2				400,122	$38.50	$15,404,697
Dowel Bars	each				31,416	$1	$31,416
Sawing joints	Ln Ft				56,848	$2.75	$156,332
Subtotal				$19,205,856			$15,592,445
Mark-Up	30%			1.30			1.30
Total				**$24,967,613**			**$20,270,179**
						Net Cost Avoidance	**$4,697,434**

VE PROPOSAL VE-10	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 36** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Reduce concrete thickness by using shorter panels**	**Page No.: 4 of 4**

CDOT Accepted Modified Cost Estimate

Construction Item		Current Design			Proposed Design		
Item	**Units**	**Qty**	**Unit $**	**Total**	**Qty**	**Unit $**	**Total**
412-00950 Concrete Pavement (9.5")	Yd²	400,122	$48	$19,205,856			$0
412-00800 Concrete Pavement (7.50")	Yd²			$0	400,122	$38.50	$15,404,697
Dowel Bars	each			$0	105,732	$5	$528,660
Sawing joints	Ln Ft			$0	121,752	$2.5	$304,380
Subtotal				$19,205,856			$16,237,737
Mark-up				1.30			1.30
Total				**$24,967,613**			**$21,109,058**
						Net Cost Avoidance	**$3,858,555**

VE PROPOSAL VE-11	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 39** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Optimize the PCCP thickness and reduce the amount of concrete needed by milling the existing HMA to adjust the cross slope**	**Page No.: 1 of 6**

VE-11: Idea 39: Optimize the PCCP thickness and reduce the amount of concrete needed by milling the existing HMA to adjust the cross slope

ORIGINAL DESIGN:
The current design shows Class-P PCCP being installed, per specifications. The original design includes milling off all the existing HMA, full-depth reclamation of the shoulders, rubbilizing the existing PCCP, adding edge drains along the outside shoulder with outlet structures, adding 4 inches of aggregate base course, and placing 9.5 inches of PCCP on the mainline of Interstate 70.

PROPOSED DESIGN:
Based on CDOT's 2020 Pavement Design Manual, the VE Team re-evaluated the pavement design and no longer recommends removing all the existing HMA, rubbilizing the existing PCCP, full-depth reclamation of the shoulders or adding edge drains.

During our site visit on July 9th, the VE Team noticed some locations where the cross-slope seemed to be at 0.015. Other locations had multiple thin overlays; however, they were only in the driving lanes. It is recommended to mill the cross-slope to the 0.020 specification by feathering the milling from zero inches at the control point to a minimum required depth to develop a 0.020 cross-slope. Recommend milling the cross-slope to 0.020 and then placing the 8.5" PCCP overlay to meet the minimum requirements.

ADVANTAGES:
- Potential to reduce costs
- Potential to minimize elevation gain

DISADVANTAGES:
- May delay the project in order to get a more accurate survey

DISCUSSION/JUSTIFICATION:
Once the existing 6.5 inches of HMA is milled off, the current design requires full-depth reclamation of the 4-foot and 10-foot shoulders along with rubbilization of the existing 8 inches of PCCP. The full-depth reclamation of the 4-foot shoulder is not a typical width for this type of work in Colorado. This would require special equipment for the reclamation and compaction process.

Based on the current thickness of the HMA, milling the cross-slope will not impact the minimum HMA thickness needed to support the PCCP. The 2018 CDOT Pavement Management Data indicated that the maximum rut depth was 1.94 inches. Milling the cross-slope will remove approximately 1.1 inches from the left wheel path and approximately 1.6 inches from the right wheel path. Since 2018, maintenance forces have placed numerous thin-lift overlays to address the ruts in HMA. The Contractor would need to fill any remaining ruts with PCCP.

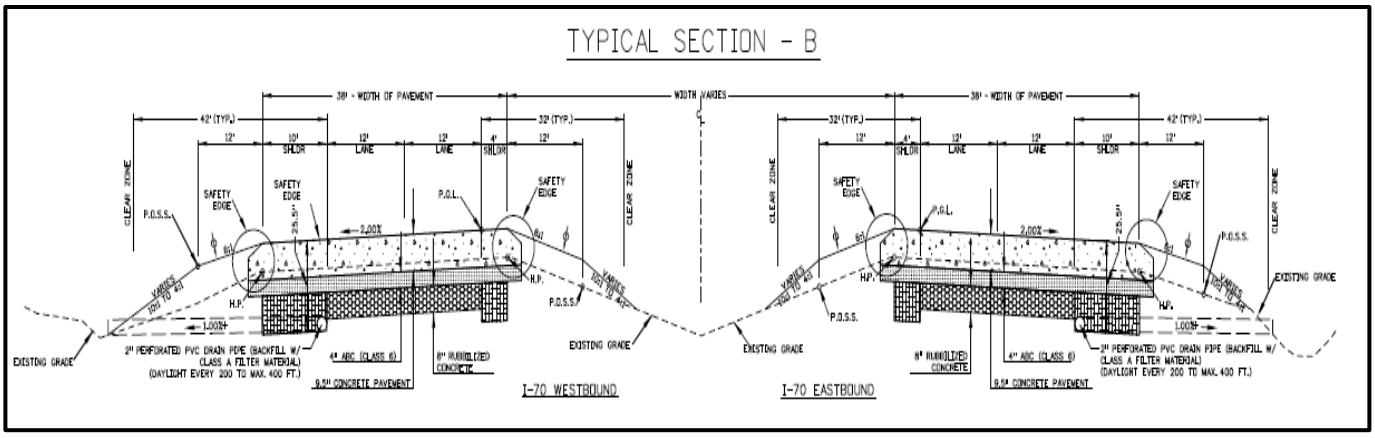
VE PROPOSAL VE-11	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 39** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Optimize the PCCP thickness and reduce the amount of concrete needed by milling the existing HMA to adjust the cross slope**	**Page No.: 2 of 6**

Only milling required sections of the existing HMA could accelerate the Contractor's schedule and minimize the Contractor's risk of placing additional concrete to meet the required cross-slope. Based on the current design standards, 8.5 inches of concrete will meet the guidelines. A thinner section of concrete would accelerate the Contractor's schedule by reducing the amount of pre-overlay repair work found in the original design. Since PCCP is typically paid for by the square yard, additional concrete needed to fill the remaining ruts would not be paid for separately but included in the work.

DISCUSSION OF RISK IMPACTS:
It would require time to redesign what is currently shown in the plans.

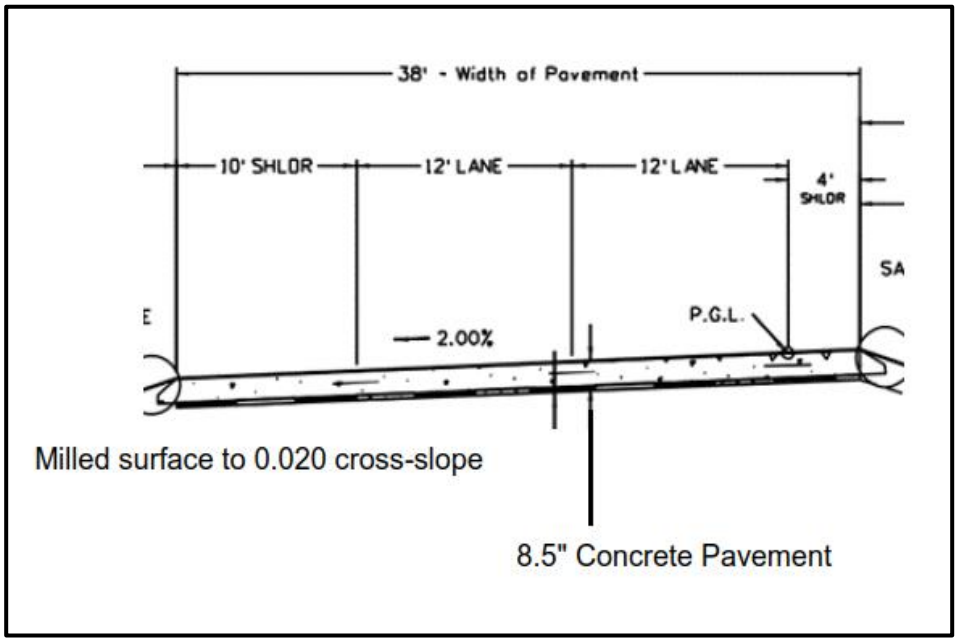
	Construction Costs
Base Case Design	$32,451,829
Proposed Design	$23,667,216
Estimated Cost Saving	**$8,784,613**

ORIGINAL DESIGN SKETCH:



VE PROPOSAL VE-11	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 39** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Optimize the PCCP thickness and reduce the amount of concrete needed by milling the existing HMA to adjust the cross slope**	**Page No.: 3 of 6**

PROPOSED CHANGE SKETCH:



VE PROPOSAL VE-11	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 39** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Optimize the PCCP thickness and reduce the amount of concrete needed by milling the existing HMA to adjust the cross slope**	**Page No.: 4 of 6**

JPCP_over_AC_Bethune Project (wide slabs)(650 psi)milling HMA

File Name: C:\Users\goldbaum\Desktop\Bethune Project\JPCP_over_AC_Bethune Project (wide slabs)(650 psi)milling HMA.dgpx

Design Inputs

Design Life: 30 years
Design Type: JPCP_JPCP

Existing construction: May, 2006
Pavement construction: July, 2021
Traffic opening: October, 2021

Climate Data Sources (Lat/Lon): 39.245, -102.284

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 3 Flex Lawson	8.5
Flexible	Default asphalt concrete	4.0
Sandwich/Fractured	Existing JPCP	8.0
NonStabilized	Crushed gravel	4.0
Subgrade	A-6	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.25
Slab width (ft)	13.0 (w)

Traffic

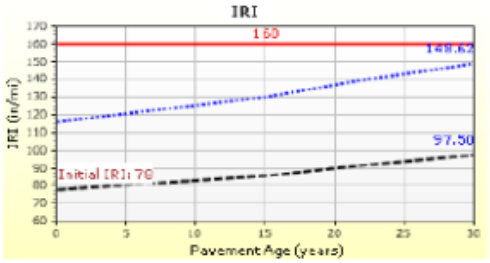
Age (year)	Heavy Trucks (cumulative)
2021 (initial)	2,830
2036 (15 years)	7,594,870
2051 (30 years)	16,677,900

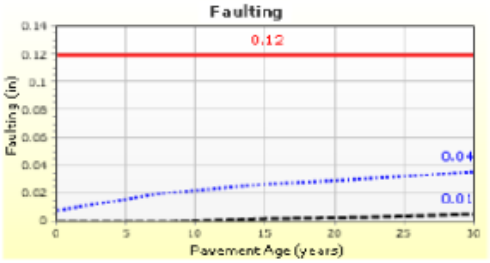
Design Outputs

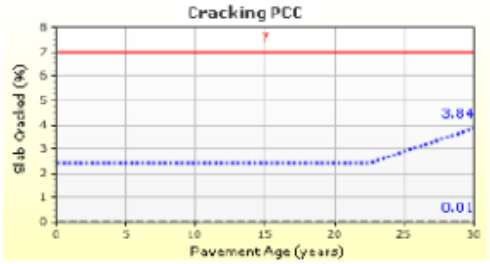
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	148.62	95.00	97.78	Pass
Mean joint faulting (in)	0.12	0.04	95.00	100.00	Pass
JPCP transverse cracking (percent slabs)	7.00	3.84	95.00	99.86	Pass

Distress Charts







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Page 1 of 16

VE PROPOSAL VE-11	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 39** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Optimize the PCCP thickness and reduce the amount of concrete needed by milling the existing HMA to adjust the cross slope**	**Page No.: 5 of 6**

ASSUMPTIONS AND CALCULATIONS:

Estimating that milling the cross-slope will cost $2.50/yd^2. It is assumed that the Contractor would have corrected the cross-slope in PCCP.

Depth of milling = 0.020 – 0.015 = 0.005 x 38’ wide = 0.19’ x 12 inches = 2.28 inches

Construction Item		Current Design			Proposed Design		
Item	**Units**	**No. of Units**	**Cost / Unit**	**Total**	**No. of Units**	**Cost / Unit**	**Total**
202-00240 Removal of Asphalt Mat (Planing)	Yd²	400,122	$5.25	$2,100,641			
412-18010 Rubblization of Concrete Pavement	Yd²	210,891	$3.00	$632,673			
310-00608 Full Depth Reclamation (0-8)	Yd²	146,356	$2.50	$365,890			
605-82100 Pipe Edge Drains	LF	100,962	$13.00	$1,312,506			
605-84100 Drain Outlet Structures	EA	312	$50.00	$15,600			
304-06007 Aggregate Base Course (Class 6)	Yd³	44,326	$30.00	$1,329,780			
412-00950 Concrete Pavement (9.5”)	Yd²	400,122	$48.00	$19,205,856			
412-00850 Concrete Pavement (8.5”)	Yd²				400,122	$43.00	$17,205,246
202-00240 Removal of Asphalt Mat (Planing)	Yd²				400,122	$2.50	$1,000,305
Subtotal				$24,962,946			$18,205,551
Mark-Up	30%			1.30			1.30
Total				**$32,451,829**			**$23,667,216**
						Net Cost Avoidance	**$8,784,613**

VE PROPOSAL VE-11

PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 39** **Date: July 23rd, 2019**
DESCRIPTION OF VE PROPOSAL: **Optimize the PCCP thickness and reduce the amount of concrete needed by milling the existing HMA to adjust the cross slope**	**Page No.: 6 of 6**

Construction Item		Current Design			Proposed Design		
Item	**Units**	**Qty**	**Unit $**	**Total**	**Qty**	**Unit $**	**Total**
202-00240 Removal of Asphalt Mat (Planning)	Yd²	400,122	$5.25	$2,100,641	371,984	$5.25	$1,952,916
412-18010 Rubberization of Concrete Pavement	Yd²	210,891	$3.00	$632,673		$3.00	$0
310-00608 Full Depth Reclamation (0-8)	Yd²	146,356	$2.50	$365,890		$2.50	$0
605-82100 Pipe Edge Drains	LF	100,962	$13.00	$1,312,506		$13.00	$0
605-84100 Drain Outlet Structures	EA	312	$50.00	$15,600		$50.00	$0
304-06007 Aggregate Base Course (Class 6)	Yd³	44,326	$30.00	$1,329,780	6,059	$30.00	$181,770
412-00950 Concrete Pavement (9.5”)	Yd²	400,122	$48.00	$19,205,856		$48.00	$0
412-00850 Concrete Pavement (7.5”)	Yd²			,	390,583	$40.00	$15,623,320
406-09500 Cold Bituminous Pavement (recycle)	Ton				69,817	$16.00	$1,117,072
307-00000 Hydrated Lime	Ton				1,745	$258.00	$450,210
403-34751 HMA (SX)(75)(PG 64-28)	Ton				46,986	$120.00	$5,638,320
411-90040 Recycling Agent	Gal				498,237	$2.19	$1,091,139
411-10253 Emulisified Asphalt (CSS-1H)	Gal				24,411	$4.00	$97,644
411-10255 Emulisified Asphalt (Slow Setting)	Gal				19,529	$8.00	$156,232
Subtotal				$24,962,946			$26,308,623
Mark-up				1.30			1.30
Total				**$32,451,829**			**$34,201,210**
						Net Cost Increase	**$1,749,381**

4.6 Design Comments

The **11** Design Comments developed by the VE Team are presented in this section. They are listed in the order in which they are provided in **Table 2**. Design Comments are ideas that in the opinion of the VE Team were good ideas, but for any number of reasons were not selected for development as VE Proposals. Design Comments can be notes to CDOT, a documentation of various thoughts that came up during the course of the VE Study, a reference to possible problems, suggested items that might need further study, or questions that CDOT might want to explore.

DESIGN COMMENT DC-1	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 3** **Date: July 16th, 2019**
DESCRIPTION OF VE PROPOSAL: **Confirm the unit costs for the TRM**	**Page No.: 1 of 1**

DC-1: Idea 3: Confirm the unit costs for the TRM

ORIGINAL DESIGN:
The original unit price was listed at $250/SY at 2,400 SY the total price came in at $600,000

PROPOSED DESIGN:
Verify that that unit price is correct to eliminate any errors in the plans. After looking in the 2018 cost data book, it appears the correct unit price should be around $5.00. This corrected unit price was calculated to be around $12,000. This is a $588,000 difference.

ADVANTAGES:
- Eliminated the wrong unit price

DISADVANTAGES:
- None

DISCUSSION/JUSTIFICATION:
This will eliminate an error in the plan set which effects the project estimate.

DESIGN COMMENT DC-2	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 10** **Date: July 16th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Use State Highway 24 as a temporary detour for ramp closures**	**Page No.: 1 of 3**

DC-2: Idea 10: Use State Highway 24 as a temporary detour for ramp closures

ORIGINAL DESIGN:
The original design will construct each of the 4 interchange ramps in place, constructing the new pavement one-half at a time while maintaining traffic on the other half of the ramp. The original designs will also construct 8 temporary ramp cross-overs for paving mainline I-70, to allow ramps to remain open at all times.

PROPOSED DESIGN:
The proposed design would allow the Contractor to close one ramp at a time for a short duration (i.e. one week or over a long weekend) to allow the Contractor to construct the full width pavement on either the ramp or mainline. Local traffic would be temporarily detoured to US 24 along the north of I-70. I-70 thru traffic would remain on I-70 and would not be impacted by the detour.

ADVANTAGES:
- Reduces number of construction phases
- Reduces schedule
- Separates construction traffic from general public traffic
- Eliminates construction joint on ramp
- Potential to reduce maintenance
- Eliminates 4 temporary ramp cross-overs

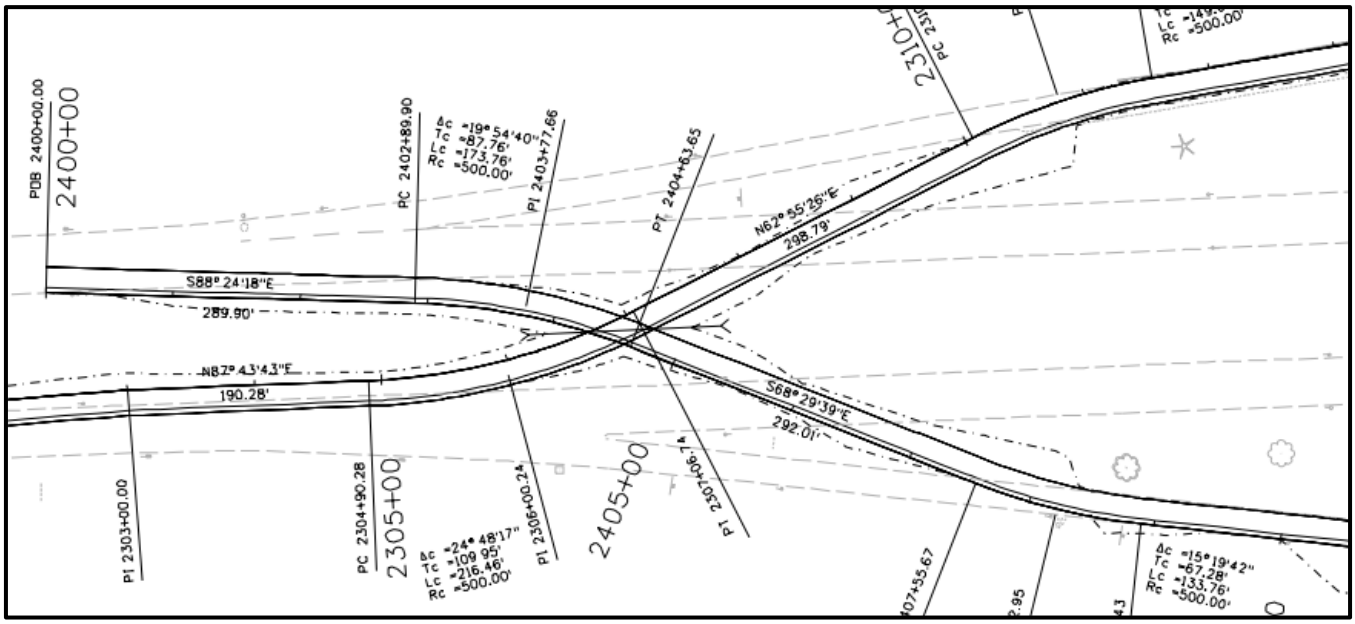
DISADVANTAGES:
- Inconvenience to the traveling public
- Potential to reduce the service life of US 24

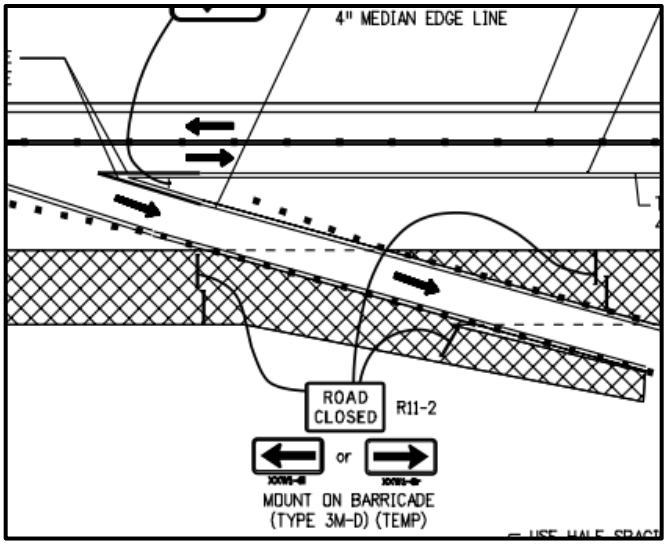
DISCUSSION/JUSTIFICATION:
This would allow the Contractor to construct each ramp full width without the need to maintain and shift traffic. This should provide improved quality of the pavement construction, protect workers within the construction zone and reduce the potential for vehicle conflicts with construction traffic. It would also eliminate the need for the 2nd temporary ramp crossover to pave the mainline in its entirety, thus saving on detour pavement costs.

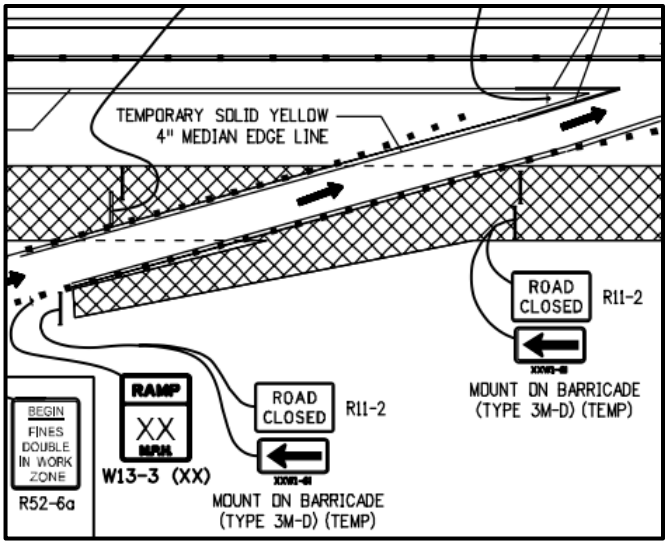
DISCUSSION OF RISK IMPACTS
There is an inconvenience to the traveling public by detouring entering/exiting vehicles from the highway to US 24. Not only is the detour route longer in length but the posted speed limits are lower as well. Vehicles would likely experience turning delay at the intersections along the detour route, as well as additional conflict points with existing accesses on US 24. Existing volumes along the detour route are likely very low. There is also a potential risk of damage to US 24 due to increased traffic.

DESIGN COMMENT DC-2	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 10** **Date: July 16th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Use State Highway 24 as a temporary detour for ramp closures**	**Page No.: 2 of 3**

ORIGINAL DESIGN SKETCH:







DESIGN COMMENT DC-2	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 10** **Date: July 16th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Use State Highway 24 as a temporary detour for ramp closures**	**Page No.: 3 of 3**

PROPOSED CHANGE SKETCH:

DESIGN COMMENT DC-3	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 18** **Date: July 16th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Allow a temporary on and off ramp for construction vehicles close to center of project**	**Page No.: 1 of 2**

DC-3: Idea 18: Allow a temporary on and off ramp for construction vehicles close to center of project

ORIGINAL DESIGN:
This project currently has no phasing plans to incorporate as to where the Contractor can place their concrete plant. It is up to the Contractor to find a land owner who will lease property to the Contractor to set up their plant.

PROPOSED DESIGN:
It was suggested that if possible CDOT would allow temporary ramps to be built at county road overpasses over I-70 near the center of the project.

ADVANTAGES:
- May reduce costs and schedule
- Moves construction traffic away from travelling public
- Keeps heavy loads off of other roads

DISADVANTAGES:
- Potential to limit Contractor plant placement

DISCUSSION/JUSTIFICATION:
This would reduce construction traffic mixing in with the traveling public and would eliminate concrete haul trucks having to share on/off ramps with the traveling public at the existing on/off ramps to I-70 at Genoa and Bovina. There may be a potential for cost saving for traffic control devices, flagging and Traffic Control Management but also an increase in materials for the building and removal of the ramps. Quantifying the estimated quantities for the temporary ramp or how much savings there would be for traffic control items cannot be calculated due unknown field conditions.

DISCUSSION OF RISK IMPACTS:
The Contractor may not be able to negotiate a reasonable price with a landowner to lease the land near this location or may get a cheaper price from other landowners in the area.

DESIGN COMMENT DC-3	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 18** **Date: July 16th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Allow a temporary on and off ramp for construction vehicles close to center of project**	**Page No.: 2 of 2**

PROPOSED CHANGE SKETCH:

DESIGN COMMENT DC-4	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 23** **Date: July 16th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Use innovative to CDOT concrete mixtures**	**Page No.: 1 of 1**

DC-4: Idea 23: Use innovative to CDOT concrete mixtures

ORIGINAL DESIGN:
A CDOT standard Class-P Portland Cement Concrete Pavement for 9.5".

PROPOSED DESIGN:
The proposed change is to use innovative to CDOT concrete mixtures. A specific mixture is not being identified but would be outside of CDOT standard specifications for concrete mixtures.

ADVANTAGES:
- Potential to reduce cost
- Potential to compress schedule

DISADVANTAGES:
- Unfamiliarity to CDOT staff (designers, inspectors, etc.)
- Unfamiliarity to Contractors
- Potential to expand schedule

DISCUSSION/JUSTIFICATION:
There are numerous different types of mixtures, some of which include newer technologies. These different types of mixtures would not meet CDOT standard specification for mixture type but would still meet all other specifications, when applicable. When not applicable, they would meet the intent of current CDOT specifications. By using a different mixture, there is a potential to reduce the cost of concrete by potentially having a lower unit cost and/or lower quantity. Also, depending on the characteristics or the mixture, there is a potential that the concrete can be placed and cured quicker, thus compressing the schedule for this activity.

DISCUSSION OF RISK IMPACTS:
By using an innovative to CDOT concrete mixture, there is a risk of unfamiliarity to CDOT staff (designers, inspectors, etc.), as well as with contractors bidding on the project. While there is potential for unfamiliarity, it would not be impossible to find someone(s) with familiarity. Once a specific innovative to CDOT concrete mixture is identified, the potential cost savings might outweigh the risk of unfamiliarity. Additional special provisions would likely need to be developed.

DESIGN COMMENT DC-5	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 26** **Date: July 16th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Improve channelizing devices**	**Page No.: 1 of 2**

DC-5: Idea 26: Improve channelizing devices

ORIGINAL DESIGN:
Currently the proposed design is based on CDOT standard S-630-1, Case No. 25. The traffic control plan shows “channelizing devices (fixed)”. On a similar project located on I-70 near the Bethune Project, temporary flexible delineators are being used when traffic is in a head-to-head configuration and it assumed that the same will be used on the Bethune Project.

PROPOSED DESIGN:
It is proposed to improve the fixed channelizing devices when traffic is in a head-to-head configuration. A specific type of device is not being identified, but the proposed device is assumed to be more rigid than temporary flexible delineators and/or affixed better. Additional specification for tensile strength of adhesion material is recommended.

ADVANTAGES:
- Reduces the number of devices knocked over and become a roadway hazard
- Reduces the maintenance of these devices through the work zone

DISADVANTAGES:
- Potential cost increase
- Probable increase in roadway width when in head-to-head configuration
- Limits access to opposite direction of travel

DISCUSSION/JUSTIFICATION
Based on discussions with CDOT staff and field observations of the similar, adjacent project, the flexible delineators are not staying upright as installed. It is difficult to adhere the temporary flexible delineators to the asphalt pavement with the size of base that is being used on the adjacent project. When not in place as installed, the device can become a roadway hazard and requires a maintenance crew to remove and reinstall. Given that this needs to be done near live-traffic, worker and driver safety is critical.

DISCUSSION OF RISK IMPACTS
Using an improved channelizing device would potentially reduce the number of flexible delineators not staying upright, by either using a larger base on the flexible delineator or using a more rigid device. The issues of the delineators becoming roadway hazards and the need to maintain these devices would be reduced. More rigid devices like temporary barrier or drums will likely cost more, potentially require additional roadway width when in place and could limit access to the opposite direction of travel. The limitations on access could be an issue for emergency responders, for example.

DESIGN COMMENT DC-5	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 26** **Date: July 16th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Improve channelizing devices**	**Page No.: 2 of 2**

ORIGINAL DESIGN SKETCH: (Assumed original channelizing device)

PROPOSED CHANGE SKETCH: Below are examples of other devices.

DESIGN COMMENT DC-6	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 27** **Date: July 17th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Use portable rumble strips during construction**	**Page No.: 1 of 2**

DC-6: Idea 27: Use portable rumble strips during construction

ORIGINAL DESIGN
This project currently has no item for portable rumble strips.

PROPOSED DESIGN:
It was suggested that the item for portable rumble strips may be added to the project to enhance the traveling public awareness of entering a work zone.

ADVANTAGES
- Alerts drivers of pattern changes

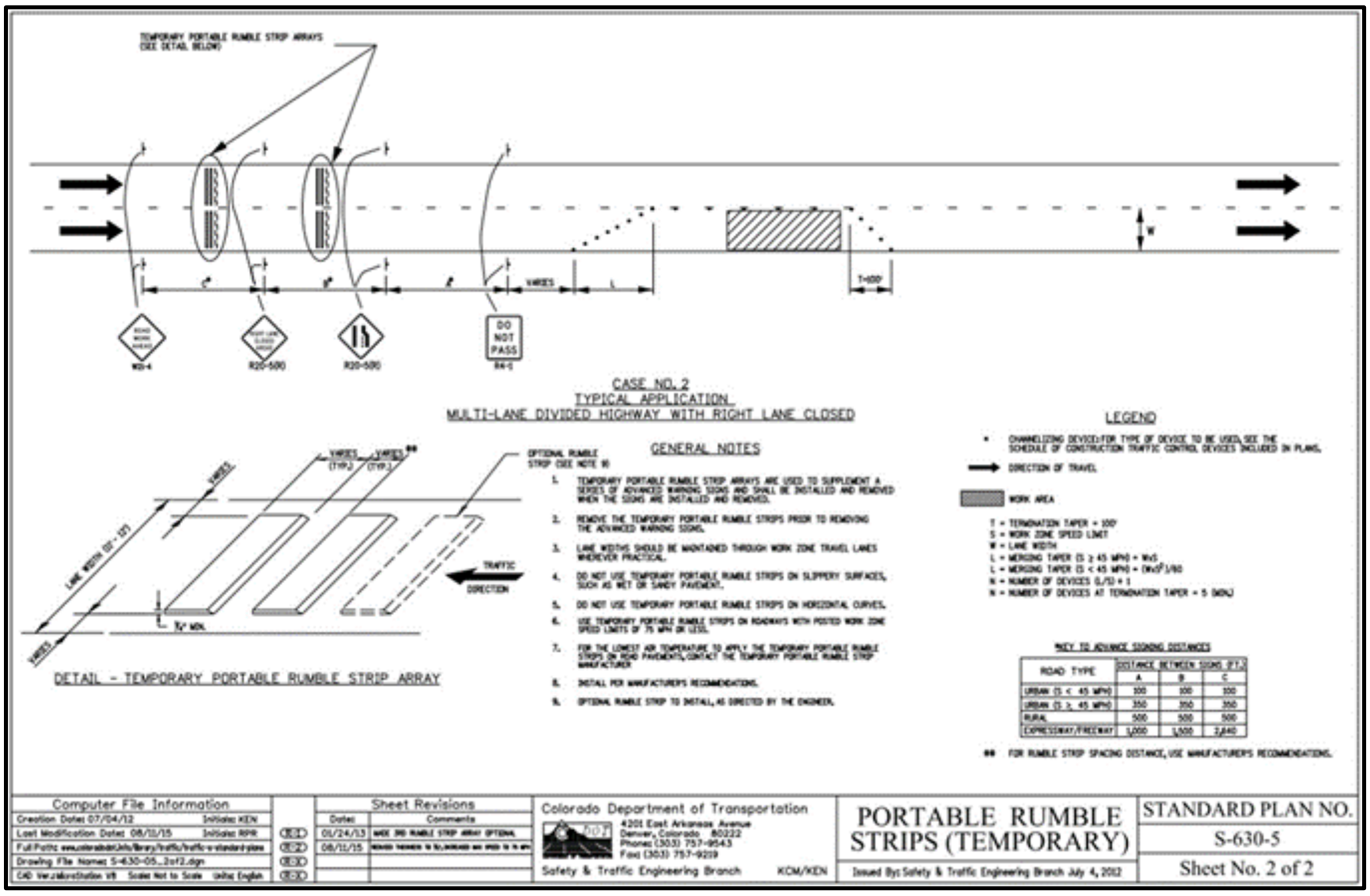
DISADVANTAGES:
- Increases cost and maintenance

DISCUSSION/JUSTIFICATION:
By adding the item Portable Rumble Strips, it may help to alert drivers of pattern changes and enhance the traveling public awareness of entering a work zone.

DISCUSSION OF RISK IMPACTS:
By adding the item Portable Rumble Strips, it may cause impacts to the traveling public if maintenance of this item needs to be addressed.

DESIGN COMMENT DC-6	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 27** **Date: July 17th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Use portable rumble strips during construction**	**Page No.: 2 of 2**

PROPOSED CHANGE SKETCH:



DESIGN COMMENT DC-7	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 29** **Date: July 17th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Modify density requirement for the top 6" of shoulders**	**Page No.: 1 of 1**

DC-7: Idea 29: Modify density requirement for the top 6" of embankment

ORIGINAL DESIGN:
The original design requires the Contractor to compact all of the installed embankment. The top six inches of embankment that is used to shoulder the new pavement also requires the seeding Contractor to rip and place their seed mixture.

PROPOSED DESIGN:
The proposed design would require the Contractor to still compact all the embankment except the top six inches that receives seeding.

ADVANTAGES:
- Time and cost savings

DISADVANTAGES:
- Contractor may not place the correct amount of embankment for the top six inches

DISCUSSION/JUSTIFICATION:
The proposal eliminates the double work of compacting and then ripping up the compacted embankment back to its uncompacted state for the top six inches.

DISCUSSION OF RISK IMPACTS:
Small chance of the Contractor not placing enough embankment to end up flush with the top of pavement.

DESIGN COMMENT DC-8	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 32** **Date: July 17th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Use thin white topping**	**Page No.: 1 of 1**

DC-8: Idea 32: Use thin white topping

ORIGINAL DESIGN:
The current design is based on CDOT's Pavement Mechanistic-Empirical Design which allows the designer to analyze a PCCP overlay of asphalt down to 7 inches.

PROPOSED DESIGN:
Use CDOT's Thin White topping spreadsheet to evaluate a potential pavement thickness below 7 inches.

ADVANTAGES:
- Reduces thickness
- Eliminates the need for dowel bars
- Reduced construction time
- Substantial cost savings
- Less impact to the public
- Profile raise maybe an advantage

DISADVANTAGES:
- Increases the number of joints
- Increases sawing and sealing of joints
- May cause a reduced service life due to the 6' by 6' panels
- Need additional data to determine if this is feasible

DISCUSSION/JUSTIFICATION:
A minimum asphalt thickness of 3 inches (after cold planning or other remedial work) is recommended. Sound evaluation of the existing pavement conditions for overlay option is recommended. In 2012, CDOT placed 6 inches of PCCP over the HMA on I-70 East of Mack. Currently, the thin white topping is performing well. Since 2006, CDOT has placed approximately 200,000 square yards of thin white topping.

DESIGN COMMENT DC-9	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 33** **Date: July 17th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Reduce initial International Roughness Index (IRI) to 70 to achieve smoother pavement and reduce pavement thickness**	**Page No.: 1 of 1**

DC-9: Idea 33: Reduce initial International Roughness Index (IRI) to 70 to achieve smoother pavement and reduce pavement thickness

ORIGINAL DESIGN:
The 2019 CDOT Pavement Mechanistic-Empirical Design (PMED) recommends the initial International Roughness Index (IRI) of 76 inches per mile for all newly constructed PCCP.

PROPOSED DESIGN:
The proposed initial IRI of 70 inches per mile is recommended as the PMED input.

ADVANTAGES:
- Reduces thickness
- Substantial cost savings
- Smoother pavement through greater IRI criteria
- More durable pavement
- Less maintenance

DISADVANTAGES:
- Potential risk to the Contractor for not achieving the targeted IRI
- May increase the amount of diamond grinding
- May cause the Contractor to reduce production
- Contractor's risk to not obtain the full quality and performance incentives
- May require the Project Engineer to revert to the original design

DISCUSSION/JUSTIFICATION:
Since implementation of this Design Comment results in pavement thickness reduction, a more stringent QA/QC plan should be in place to assure achieving the goals and objectives of the design. The Contractor should have a back-up plan presented prior to the pre-pave to revisit design criteria or method of placement in case favorable results are not achieved.

DESIGN COMMENT DC-10	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 37** **Date: July 17th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Use Falling Weight Deflectometer (FWD) Analysis**	**Page No.: 1 of 1**

DC-10: Idea 37: Use Falling Weight Deflectometer (FWD) Analysis

ORIGINAL DESIGN:
The design was based on thickness data from cores and subgrade samples obtained at an interval of about 2,000 feet in each direction.

PROPOSED DESIGN:
Use the Falling Weight Deflectometer (FWD) data at an interval of about 500 feet in each direction.

ADVANTAGES:
- May reduce thickness
- Evaluates the condition of the existing roadway at a greater interval
- Can determine the in-situ strength of the asphalt and subgrade material

DISADVANTAGES:
- May increase the time to design the project
- May require the design team to take additional cores to validate the data
- FWD data may have high standard error of the estimated strength

DISCUSSION/JUSTIFICATION:
A sound evaluation of the existing pavement condition at a higher frequency is recommended due to the various levels of distress noted in the pavement. FWD data can be used to determine the overlay thickness.

DESIGN COMMENT DC-11	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 38** **Date: July 17th, 2019**
DESCRIPTION OF DESIGN COMMENT: **Undertake Ground Penetrating Radar (GPR) analysis**	**Page No.: 1 of 1**

DC-11: Idea 38: Undertake Ground Penetrating Radar (GPR) analysis

ORIGINAL DESIGN:
The design was based on thickness data from cores and subgrade samples obtained at an interval of about 2,000 feet in each direction.

PROPOSED DESIGN:
Use the Ground Penetrating Radar (GPR) in each wheel path in each direction.

ADVANTAGES:
- May reduce thickness
- Continuously evaluates the condition of the existing roadway and subgrade
- Data can be obtained at highway speeds

DISADVANTAGES:
- May increase the time to design the project
- May require the design team to take additional cores to validate the data
- Ground penetrating radar needs a highly skilled technician to interpret the data

DISCUSSION/JUSTIFICATION:
A sound evaluation of the existing pavement condition at a higher frequency is recommended due to the various levels of distress noted in the existing pavement. GPR data can be used to determine the condition of the existing asphalt, if water is present near the surface, and if any of the underlying PCCP was removed.

4.7 Dropped During Development

The following VE Proposal was dropped during the Development Phase due to the reasons indicated.

DROPPED DURING DEVELOPMENT	
PROJECT: 22462 I-70 Bethune East and West Pavement Reconstruction Project	**Idea No.: 20** **Date: July 16th, 2019**
DESCRIPTION OF IDEA: **Use asphalt instead of concrete**	**Page No.: 1 of 1**

ORIGINAL DESIGN:
The current Life Cycle Cost Analysis (LCCA) compared 9.5 inches of Class-P PCCP to 10 inches of HMA.

PROPOSED DESIGN:
Based on Chapter 13 of CDOT's 2020 Pavement Design Manual, the VE Team re-evaluated the LCCA.

ADVANTAGES:
- Reduces the comments from the Asphalt Pavement Association and the local chapter of the American Concrete Pavement Association
- Potential to advertise the project on time
- Improves the accuracy of the LCCA
- May reduce initial cost
- May allow for construction under traffic

DISADVANTAGES:
- May require the project to be re-designed
- Potential to delay the advertisement of the project
- Higher future maintenance cost

DISCUSSION/JUSTIFICATION:
The LCCA should follow the CDOT approved guidelines shown in the current version of CDOT's Pavement Design Manual.

DISCUSSION OF RISK IMPACTS:
It would require time to re-run the LCCA. It may delay the project in order to get comments from industry representatives.

Base Case LCCA	Most cost-effective alternative shown was PCCP by 22%
Proposed LCCA	Most cost-effective alternative determined was PCCP by 9.5%

ASSUMPTIONS AND CALCULATIONS:
The LCCA will use the preliminary cost estimate developed for this project.

Using Idea 39, the LCCA indicated that the 8.5-inch PCCP alternative was more cost-effective by 24.3 percent as compared to 4 inches of grading S (100) 76-28 and 4 inches of grading S (100) 64-22 HMA.

5. Value Engineering Process

5.1 Introduction

AECOM was retained to undertake a 4-day Value Engineering (VE) Study for the 22462 I-70 Bethune East and West Pavement Reconstruction Project. The project cost estimate is $47.99M based on the Colorado Department of Transportation (CDOT) Preliminary Detail Cost Estimate.

Value Engineering is a systematic process, performed by a multi-disciplinary team to analyze the functions of a project to satisfy users' needs while improving value. The VE Team identifies critical project functions and evaluates how those functions are proposed to be met in the base case design. Alternative ways are considered to achieve the equivalent functions while increasing the value of the project. The focus of a VE Study is on increasing value rather than simply reducing costs.

The Value Engineering Study was undertaken based on the scope of work and the SAVE International Value Engineering Methodology, which includes three stages: (1) Pre-Workshop; (2) Workshop; and, (3) Post-Workshop, as outlined in the following sections. **Figure 6** illustrates the activities undertaken in each stage of the VE Job Plan.

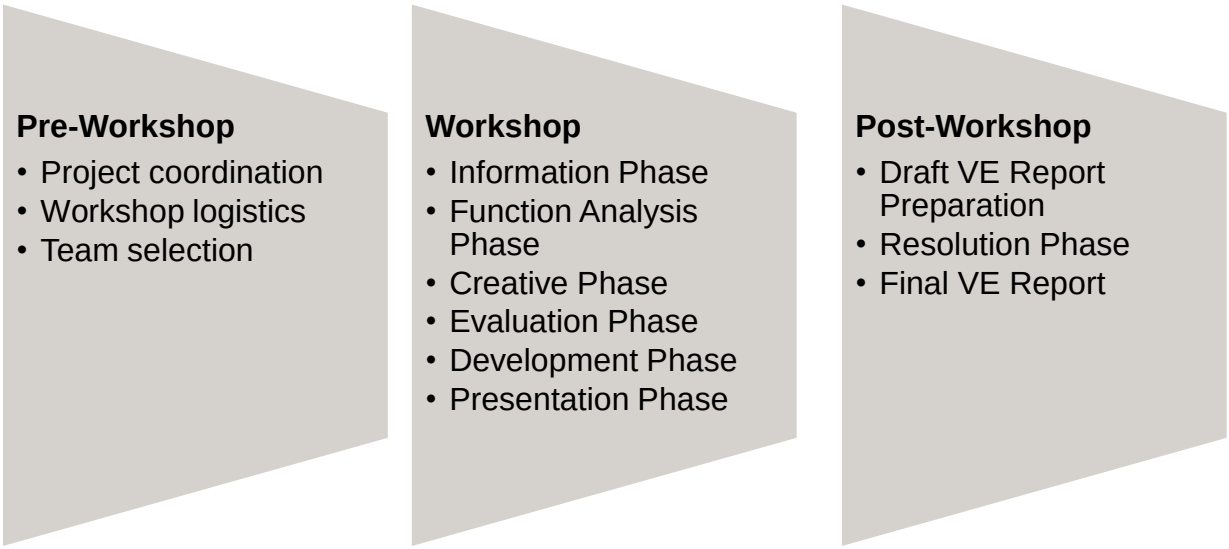


Figure 6: VE Job Plan

5.2 Pre-Workshop Activities

In the Pre-Workshop Stage, the workshop logistics were determined (i.e. location, dates, agenda); team members were identified and invited to participate in the workshop; the venue and travel arrangements were finalized; the base case information was gathered and compiled; the base

case information as well as the agenda was distributed to the team prior to the workshop; and, all required information for the completion of the workshop was gathered / completed (i.e. materials, workshop spreadsheets, etc.). The following is a list of the project documents that were provided to the VE Team for use during the workshop:

- Preliminary Detail Cost Estimate, CDOT, July 2, 2019
- 60% Design Drawings, FIR, CDOT, Feb. 14, 2019
- Draft Resurfacing Recommendation, SA22462, I-70 East of Bethune, CDOT
- Special Provisions, CDOT

During the Pre-Workshop Stage, Pareto Cost Models were generated. Pareto's Law of Distribution states that 80% of the project costs are found in 20% of the project elements. The Pareto Cost Model is developed to:

- Organize the costs to be understood effectively
- Identify major costs elements
- Help focus the VE Team efforts on project elements with the most potential for value improvement

The Pareto Cost Models developed are included in **Appendix A.**

During the Pre-Workshop Stage, the VE Team Pavement Engineer analyzed the pavement management data for this project dating back to 1998. This information was used to understand the distresses over time and the performance of the rehabilitation historically stored on this project. This information is provided in **Appendix D**.

5.3 Workshop

During the workshop portion of the VE Study, the Job Plan is followed. The Job Plan is an organized approach for finding alternatives to improve value. The workshop follows an agenda which details the Job Plan and utilizes a multi-disciplinary team to arrive ultimately at the VE Team alternatives for implementation.

The Information Phase was held on July 8th, 2019, in Limon, CO. The VE Workshop was held from July 16th to July 18th, 2019 at AECOM's office in Greenwood Village, CO. The VE Results presentation was held on the morning of July 19th, 2019 at AECOM office in Greenwood Village, CO.

The Value Engineering Study was undertaken based on the scope of work and the SAVE International Value Engineering Methodology, which includes the following six (6) phases as illustrated in **Figure 7**. These six (6) key steps are described in the following subsections.

Figure 7: Six Phase VE Job Plan

5.3.1 Information Phase

The purpose of this phase is for the VE Team to obtain a thorough understanding of the project's objectives, design, controlling decisions, issues, and constraints by reviewing the project's documents, drawings, and cost estimate. After introductions, the Value Engineering Team Leader gave a kick-off presentation. The purpose of the kick-off presentation was to provide an overview of the Value Engineering Methodology in order for all VE Team members to understand the process to be followed during the VE Workshop.

After the kick-off presentation, the design team presented the project to the VE Team. During the presentation, the goals and objectives of the VE Study were discussed and include:

- Review the 60% Design with respect to cost-effectiveness, function and the ability to meet project objectives
- To provide VE Proposals and Design Comments to increase project value through innovative ideas that improve functionality, improve schedule, improve constructability, and/or capital cost avoidance while maintaining quality and functionality

After the presentation of the base case design, the VE Team and the CDOT design team undertook a site visit. The site visit was invaluable as it provided the VE Team with further understanding of the project (**Figure 8**). During the site visit, the VE Team reviewed the Arriba Project construction site, which is a similar project to the Bethune Project.

Figure 8: Site Visit

5.3.2 Function Analysis Phase

Function Analysis transforms the project elements into functions. A function is an expression of what something needs to do without defining how it should be done. Functions are defined in verb-noun statements to reduce the needs of the project to their most elemental level. Identifying the functions of the project provided the VE Team with an understanding of the functions required for the project. Once the functions were identified, the VE Team developed a Function Analysis System Technique (FAST) Diagram. The results of the Function Analysis Phase, as well as further information on the development of the FAST Diagram, are provided in **Appendix B**.

5.3.3 Creative Phase

A VE Team's diverse background most often enhances the creative portion of the VE Workshop, and this VE Workshop was no exception. The facilitator's intent was to create an atmosphere in which team members would be willing to think creatively and "outside the box."

During the Creative Phase, the VE Team brainstormed ways to improve value in the project. A positive environment was maintained during the brainstorming session. This phase of the study was conducted as a free flow of ideas session where no idea was a bad idea and no explanations were sought or allowed. The VE Team was looking for quantity and association of ideas that would improve the value in the project. The more ideas generated, the more likely a "breakthrough" idea would be identified that would improve value.

Many of the ideas brought forth in the Creative Phase were a result of work done in the Information Phase and in the Function Analysis Phase. The resulting list of ideas was evaluated during the Evaluation Phase. A complete list of the creative ideas is provided in the Summary of Creative Ideas and Evaluation Table provided in **Appendix C**.

5.3.4 Evaluation Phase

The purpose of this phase is to evaluate the ideas generated during the Creative Phase. The VE Team critically viewed each of the ideas generated during the Creative Phase of the workshop to determine whether the ideas were likely to improve the value of the project.

After the VE Team listed the advantages and disadvantages for each of the ideas, each idea was evaluated in terms of its potential impact to performance, cost, time, and risk. Once each idea was fully evaluated, it was given a total rating number based on a scale of 1 to 7.

Ideas rated 4 to 7 were developed further. The VE Team reviewed each of the ideas scoring 4 to 7 to determine which ideas could be developed as VE Proposals. The ideas where cost impacts could not be determined were developed as Design Comments. A "Carried Forward" (CF) scoring was given to VE Proposals. A "Design Comment" (DC) score was given to the ideas that the VE Team thought had potential to improve value but did not have the information or time to fully explore the idea. Only ideas that scored a "CF" or "DC" were evaluated further during the Development Phase. The results of the Evaluation Phase are provided in the Summary of Creative Ideas and Evaluation Tables provided in **Appendix C**.

5.3.5 Development Phase

VE Team members were assigned the CF and DC ideas to develop into VE Proposals or Design Comments based on their areas of expertise. The developer was instructed to use the entire team as a resource in the development of the idea. VE Proposals and Design Comments were developed as far as time and resources would allow during the VE Workshop.

Each VE Proposal included a summary of the base case design, a description of the suggested change, a list of advantages and disadvantages of the VE Proposal compared to the base case design, a brief narrative comparing the base case design with the VE Proposal, and a comparison of the costs associated with the base case design relative to the proposed change. Sketches of the base case and proposed design were also provided, if applicable. Design Comments were also developed to the same level of detail as the VE Proposals, but no costs were estimated. The completed VE Proposals and Design Comments are provided in **Section 4** of this report.

5.3.6 Presentation Phase

The VE Study results were presented to the CDOT staff on the morning of July 19th, 2019. In addition to the VE Team, the presentation attendees from CDOT included:

- Travis Miller, PE, Limon Resident Engineer
- Rhianna Poss, P.E., Genoa Project Manager
- Karl Larson, CEPM I, Construction and Design
- James Miller, PE, Bethune Project Manager
- Michael Hines, EPST II, Design
- Corey Stewart, PE III North Program Engineer
- Keith Sheaffer, PE III South Program Engineer
- Gary DeWitt, PE II Region 4 Materials Engineer
- Steven Heimmer, PE I

5.4 Post-Workshop Activities

The Post-Workshop activities for this project included:

- **Draft VE Report:** Prepare and submit the Draft VE Report, which provides a complete documentation of the VE Study
- **Resolution Phase:** CDOT reviewed and determined the disposition of all VE Proposals and Design Comments
- **Final VE Report:** Finalization of the Draft VE Report based on the comments received

Appendix A Pareto Cost Model

A.1 Pareto Cost Model

Pareto Cost Models are used to understand where the majority of the project resources are being allocated. Pareto's Law of Distribution states that 80% of the project costs are found in 20% of the project items. A Pareto Cost Model is developed to:

- Organize the costs in order for them to be understood effectively
- Identify where the major costs are to be found
- Help focus the Value Engineering Team efforts on project elements with the most potential for value improvement

Table 4 and **Figure 9** provide the Pareto Cost Model for Overall Project Summary developed using the Biddable Items in the CDOT Preliminary Detail Cost Estimate provided to the VE Team. The items highlighted in yellow illustrate where 80% of the costs are in the project.

Table 4: Pareto Cost Model Table – Overall Project Summary (Biddable)

Items	Cost	% of Project	Total %
Roadway	$35,418,507	96.4%	96.4%
G-27-R	$557,757	1.5%	98.0%
G-27-I	$532,902	1.5%	99.4%
Construction Engineering	$102,000	0.3%	99.7%
G-27-T	$89,544	0.2%	99.9%
G-27-W	$12,160	0.0%	100.0%
G-27-X	$12,160	0.0%	100.0%
	$36,725,029	**100.0%**	

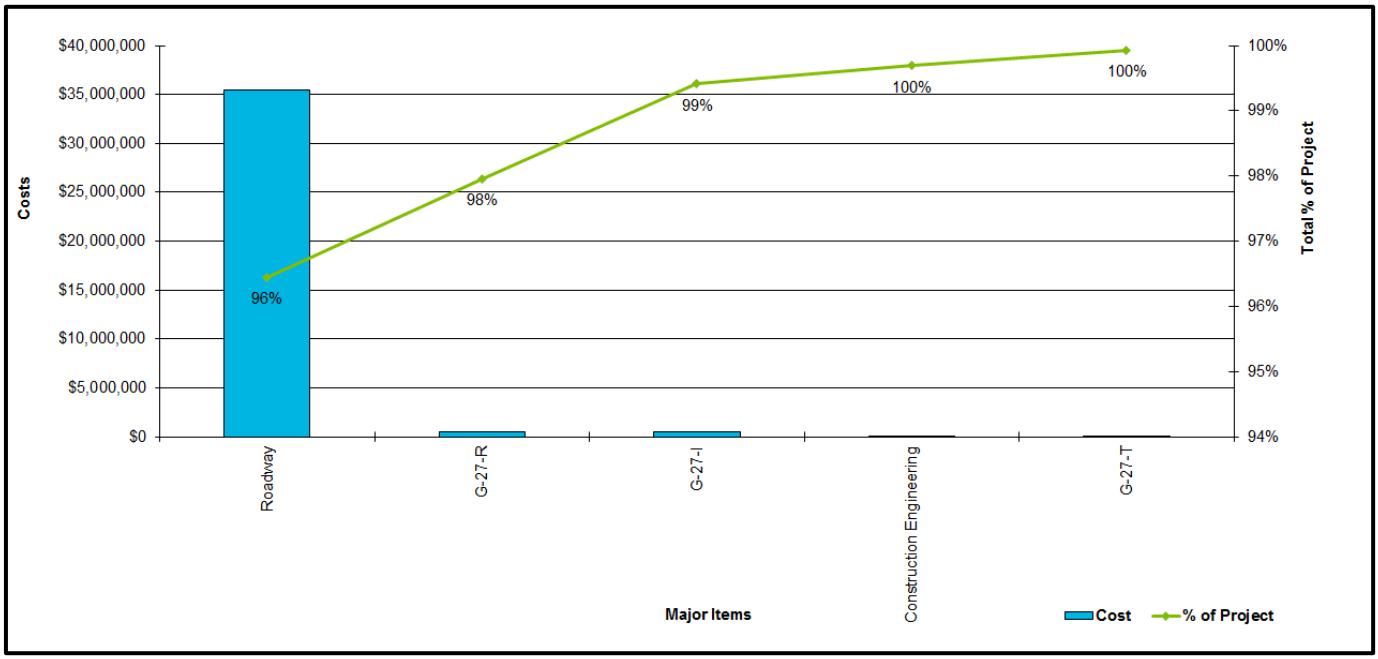


Figure 9: Pareto Cost Model Figure – Overall Project Summary (Biddable)

Table 5 and **Figure 10** provide the Pareto Cost Model for the Biddable Roadway Items developed using the CDOT Preliminary Detail Cost Estimate provided to the VE Team. The items highlighted in yellow illustrate where 80% of the costs are in the project for the roadway. Note: The Biddable Roadway costs do not include all forced Account (F/A) and mobilization costs.

Table 5: Pareto Cost Model – Roadway (Biddable)

Items	Cost	% of Project	Total %
Concrete Pavement (9-1/2-inch)	$19,205,856	61.3%	61.3%
Removal of Asphalt (Planing)	$2,148,757	6.9%	68.2%
Aggregate Base Course (Class 6)	$1,485,570	4.7%	72.9%
Pipe Edge Drain	$1,312,506	4.2%	77.1%
Detour Pavement	$1,287,060	4.1%	81.2%
Items less than $100,000	$1,166,945	3.7%	84.9%
Rubblization of Concrete Pavement (Crack and Seat)	$632,673	2.0%	87.0%
Turf Reinforcement Mat (Class 2)	$600,000	1.9%	88.9%
Embankment Material (Complete in Place)	$590,663	1.9%	90.8%
Concrete Pavement (9-inch)	$458,235	1.5%	92.2%
Concrete Safety Edge	$376,270	1.2%	93.4%
Full Depth Reclamation of Hot Mix asphalt Pavement (0-8")	$365,890	1.2%	94.6%
Unsuitable Material	$270,000	0.9%	95.5%
Preformed Plastic Pavement Marking (Type II) (Inlaid)	$266,430	0.9%	96.3%

Construction Surveying	$250,000	0.8%	97.1%
Bonded Fiber Matrix	$213,750	0.7%	97.8%
Spray-on Mulch Blanket	$164,640	0.5%	98.3%
Removal of Asphalt	$159,270	0.5%	98.8%
Guiderail Type 3 (6-3 Post Spacing)	$140,250	0.4%	99.3%
Detour Drainage Pipe (Class 0)	$126,000	0.4%	99.7%
Compost (Mechanically Applied)	$104,000	0.3%	100.0%
	$31,324,764	**100.0%**	

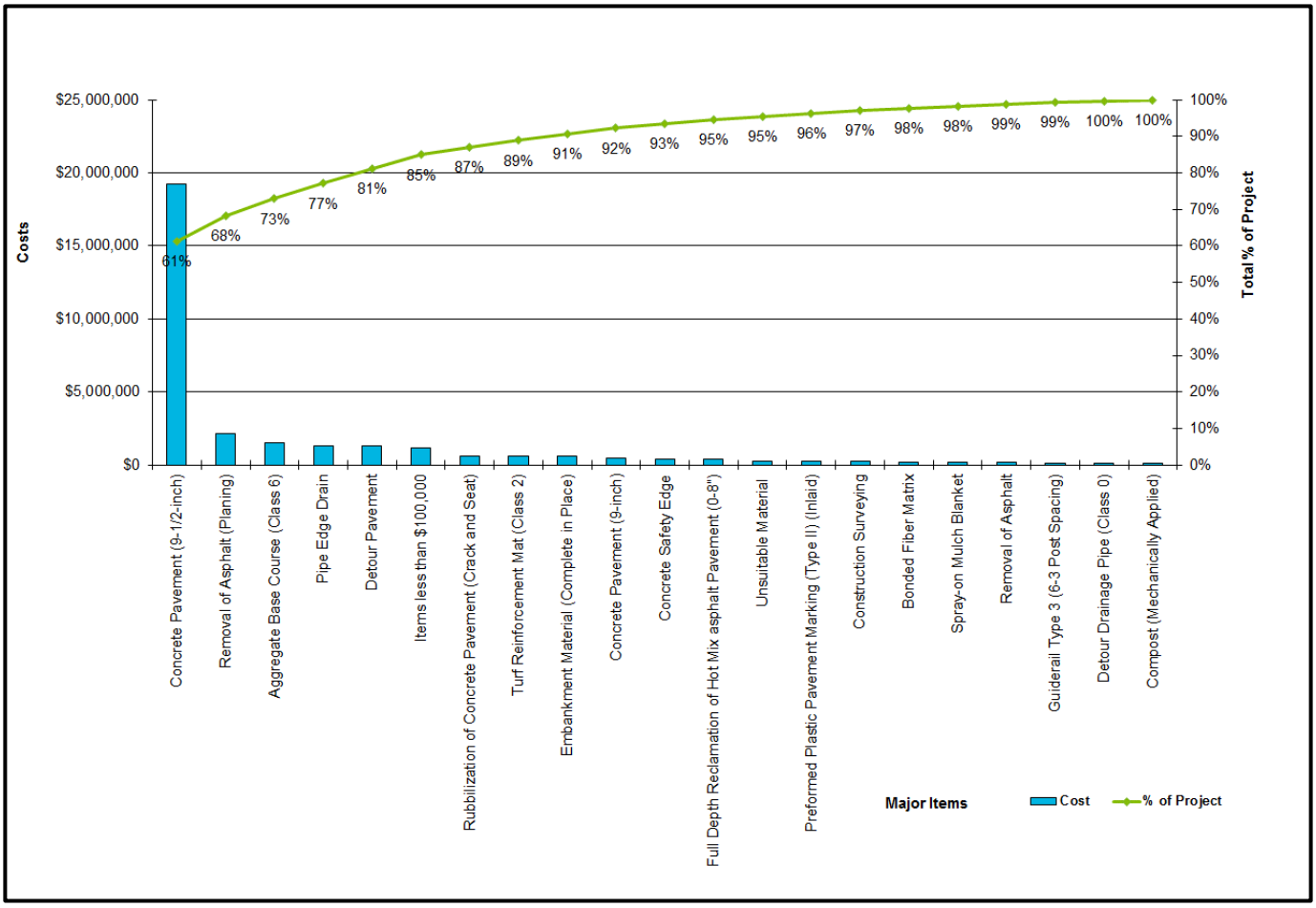


Figure 10: Pareto Cost Model – Roadway (Biddable)

Appendix B Function Analysis

B.1 Function Analysis

Function Analysis was undertaken by the VE Team to develop an understanding of the functions that the project must achieve to satisfy the owner. A function is an expression of what something needs to do without defining how it should be done. Functions are defined in active verb / measurable noun statements to reduce the needs of the project to their most elemental level. Identifying the functions of the major project elements allows alternative solutions to be generated to accomplish those functions. **Table 6** provides the functions of the project identified by the VE Team.

Table 6: Project Functions

Element	Functions	Functions
Overall Project	Improve Safety Move Vehicles Efficiently Increase Rideability Reduce Maintenance Increase Service Life Extend Structure Life Maintain Vertical Clearance Reconstruct Ramps Widen Ramps Replace Signage Maintain Traffic Improve Illumination	Improve Drainage Improve Skid Resistance Improve Cross-Slope Meet Standards Improve Recovery Area Improve Emergency Turnarounds Reduce Accidents Improve Lane Delineation Verify Quality Stabilize Existing Subbase Reduce Distresses Expedite SWMP Permit Closure

B.2 Function Analysis System Technique (FAST) Diagram

The Function Analysis System Technique (FAST) Diagram shown in **Figure 11** graphically illustrates the functions in logical order. A function diagram organizes the identified functions into the "How-Why" logic model. Proper arrangement and relationship of the functions in the function diagram can be confirmed with the How-Why logic test as follows:

- Ask the question of any function, "**How** do I verb-noun?" The answer should be the function to the immediate **right**.
- Ask the question "**Why** do I verb-noun?" The answer should be the function to the immediate **left** (i.e., "so that I can verb-noun?").
- A function that does not pass the How-Why test is either described improperly or is in the wrong place. The answer must make sense.

The farther you proceed from left to right in the diagram, the more precise you become. Conversely, the farther you proceed from right to left, the more general you become. It is important to understand that the position of functions in a functional diagram in no way represents the chronological order of events. The intent of the FAST Diagram is to help the VE Team consider the logic of how and why something is done, as well as the importance and relevance of each function.

Some of the functions listed in **Table 6** may not be included in the FAST Diagram because they were not considered critical functions when the diagram was created. In addition, some of the critical functions in the FAST Diagram are not listed above because they were not identified until the diagram was created.

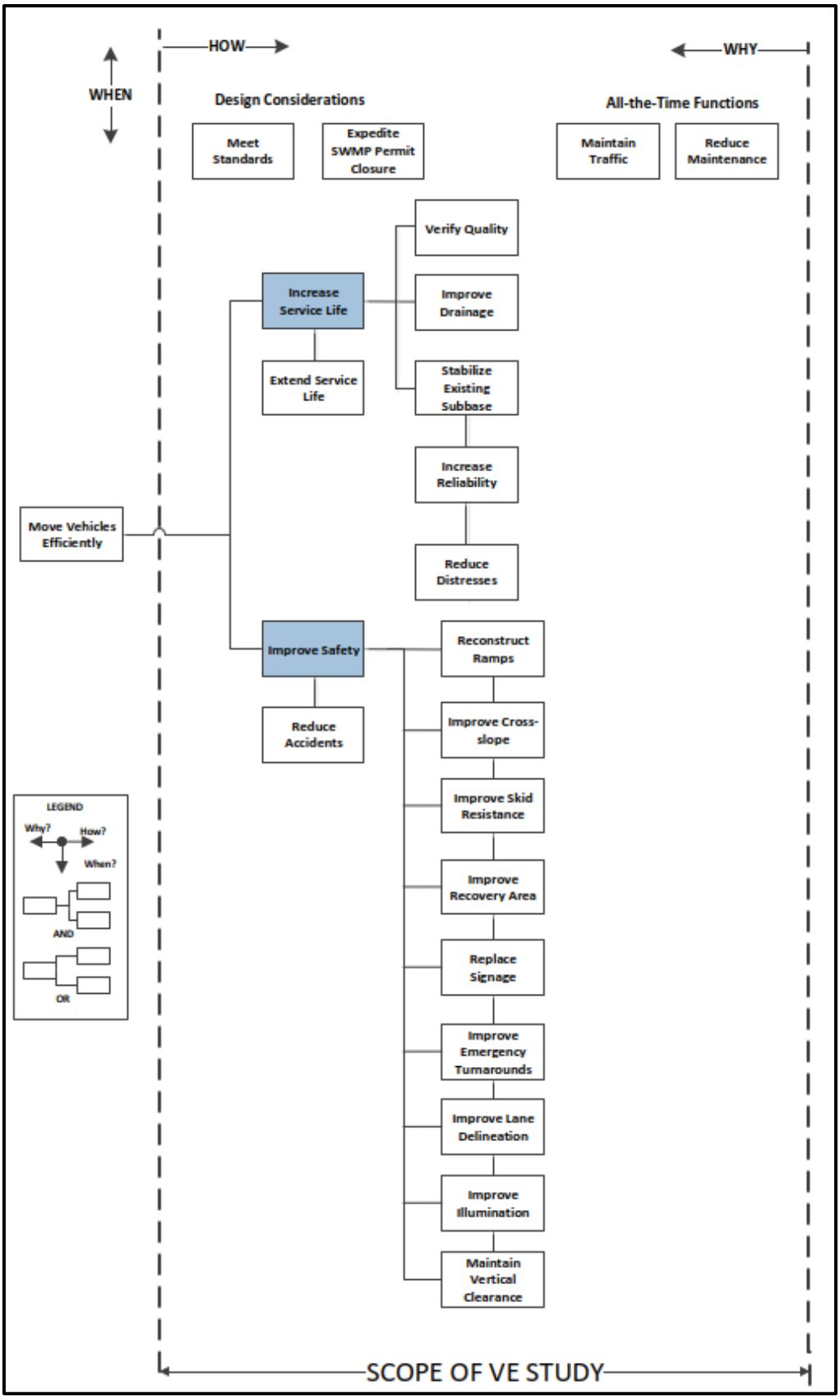


Figure 11: FAST Diagram

Appendix C Creative Phase and Evaluation Table

C.1 Creative Phase and Evaluation Table

During the Creative Phase of the VE Study, the VE Team was encouraged to offer any and all ideas, including “wild ideas” or “out of the box” ideas, to perform the intended functions of the project. A positive environment for brainstorming was maintained at all times, reserving all judgment of the ideas until the Evaluation Phase so that all VE Team members would be comfortable offering thoughts and ideas. The VE Team was looking for quantity and association of ideas. The more ideas generated, the more likely a “breakthrough” idea would be identified with significant value implications.

During the Evaluation Phase, the VE Team critically viewed each of the ideas generated during the Creative Phase of the workshop to determine whether the ideas were likely to improve the value of the project. After the VE Team listed the advantages and disadvantages for each of the ideas, each idea was evaluated in terms of its potential impact to performance, cost, time, and risk. Once each idea was fully evaluated, it was given a total rating number. This is based on a scale of 1 to 7, as indicated by the following rating index:

7 = Major Value Improvement	These ratings represent the subjective opinion of the VE Team regarding the potential benefits of the concepts in order to prioritize them for development.
6 = Moderate Value Improvement	
5 = Minor Value Improvement	
4 = Possible Value Improvement	
3 = Minor Value Degradation	Concept results in a minor cost or performance improvement at the expense of the other.
2 = Moderate Value Degradation	Concept reduces cost but creates an unacceptable degradation to performance.
1 = Major Value Degradation	Concept is not technically feasible or does not meet project need and purpose.

Ideas rated 4 to 7 were developed further. The VE Team reviewed each of the ideas scoring 4 to 7 to determine which ideas could be developed as VE Proposals. The ideas where cost impacts could not be determined were developed as Design Comments. **Table 7** provides the results of the Creative Phase and Evaluation Phase. Ideas scoring 4 to 7 which were developed as VE Proposals are indicated as “Carried Forward (CF)”. Design Comments are indicated as “DC”. The following legend was used by the VE Team to determine which ideas to develop as VE Proposals and Design Comments generated during the Creative Phase:

- CF: Carried Forward = Idea to be developed into a VE Proposal
- DC: Design Comment = Idea to be developed into a Design Comment
- NCF: Not Carried Forward = Idea rejected by the VE Team
- W: With = Idea is being developed with another idea
- DDD: Dropped During Development = Idea was determined to not be feasible
- ABD: Already Being Done = Idea is already being done in the base case design

Table 7: Creative Ideas and Evaluation Table

Idea No.	Description	Advantages	Disadvantages	Evaluation Ranking	VE Team Action
1	Eliminate rubblization of the concrete	Reduces schedule; Reduces costs; Increases strength of subbase; Eliminates edge drains; Eliminates ABC requirement; Eliminates milling	Increases shouldering embankment; Redesign required	7	with Idea 5
2	Eliminate Full Depth Reclamation (FDR) on the shoulders	Reduces schedule; Reduces costs; Easier to construct	Redesign required; Different structural strength in shoulder versus driving lanes; Potential to increase ponding under the shoulder	5	with Idea 5
3	Confirm the unit costs for the TRM	Improves project estimate	None identified	6	DC
4	Eliminates edge drains	Reduces schedule; Reduces costs; Easier to construct	Potential to trap water under the concrete	5	CF
5	Optimize the typical sections	Reduces costs; Improves constructability; Reduces schedule; Potential to use available materials	Redesign required; Potential to increase distresses; Potential to increase future maintenance costs	7	CF
6	Optimize vertical profile by lowering the current design	Reduces costs; Potential to reduce schedule; Potential to reduce pipe length; Reduces seeding requirements	Redesign required	4	with Idea 5
7	Reduce the number of dowel bars for the shoulders	Reduces costs	Possible increase in distresses	4	CF
8	Optimize concrete thickness for the mainline	Reduces costs; Reduces schedule; Reduces gain in elevation	Redesign required; Potential to reduce service life	6	with Idea 5
9	Offset the ramp alignments for Bethune	Ramps would remain open during construction; Reduces phasing; Reduces schedule; Separates construction and general public traffic; Eliminates construction joints; Potential to reduce maintenance	Increases costs; Potential right-of-way impacts	5	CF

Idea No.	Description	Advantages	Disadvantages	Evaluation Ranking	VE Team Action
10	Use State Highway 24 as a temporary detour for ramp closures	Reduces phasing; Reduces schedule; Separates construction and general public traffic; Eliminates construction joints; Potential to reduce maintenance	Inconvenience to travelling public; Potential to reduce the service life of State Highway 24	5	DC
11	Do nothing	Reduces costs	Does not address the purpose and need of the project	1	NCF
12	Eliminate concrete box culverts extensions	Reduces costs	Maintains existing hazard	5	CF
13	Half width typical paving for each direction	Removes head-to-head traffic during construction; Eliminates some detour pavement	Mix of drivers and construction personnel; Increases costs; Increases schedule; Harder to construct; Construction joint in the middle of the road	3	NCF
14	Do not extend the box culverts	Reduces costs	Guardrail is required	3	NCF
15	Optimize asphalt milling	Reduces schedule; May not impact destabilized HMA	Thicker concrete; Meeting cross-slope	4	with Idea 5
16	Detour traffic onto State Highway 24 and construct WB and EB lanes without head to head traffic	Potential to reduce costs; Eliminates head-to-head traffic; Eliminates cross-overs; Reduces schedule; Eliminates traffic control requirements for head-to-head	Additional asphalt required for State Highway 24; Mixing highway and local traffic; Unknown roadway and traffic infrastructure within communities; Inconvenience to Interstate traffic; Guardrail improvements would be required	3	NCF
17	Consider allowing the Contractor to place their plant in the median	Reduces schedule; Easier access for construction vehicles; Removes negotiating with land owners for plant	Guardrail required for plant area; Potentially not enough space to stockpile materials	4	ABD

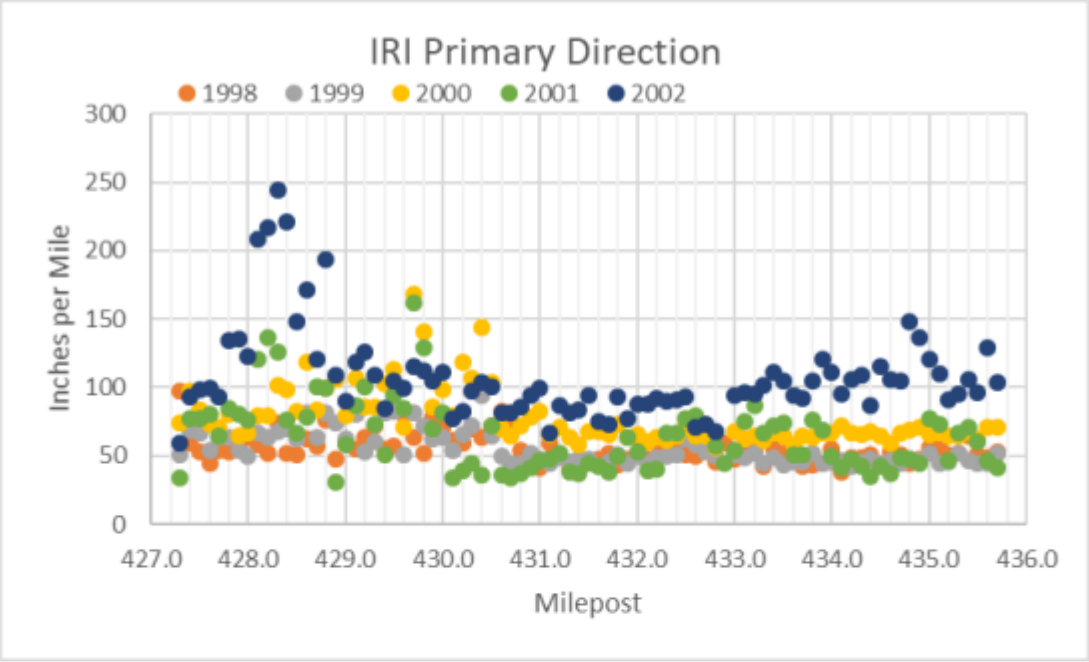
Idea No.	Description	Advantages	Disadvantages	Evaluation Ranking	VE Team Action
18	Allow temporary on and off ramp for construction vehicles close to center of the project	Reduces costs and schedule; Moves construction traffic away from travelling public; Keeps heavy trucks off of other roads	Potential to limit Contractor plant placement	5	DC
19	Accelerate schedule	Reduces schedule; Less inconvenience to the travelling public	Potential to increase costs; Increase potential for claims	4	CF
20	Use asphalt instead of concrete	Potential reduction in initial costs; Allows construction under traffic; Smoother than concrete	Higher maintenance costs; Potential reduction in service life	4	DDD
21	Cold in place recycling	Stabilizes the subgrade; Reusing materials; Does not impact subgrade	Potential increase in cost and schedule	4	with Idea 20
22	Use hot mixed asphalt (HMA) leveling course	Smoother surface; Removes ruts; Potentially reduces schedule	Compaction in the ruts is difficult to achieve; Increases shouldering quantities	5	with Idea 5
23	Use innovative to CDOT concrete mixtures	Potential to reduce costs	Unknown to CDOT and potentially unknown to Contractors	4	DC
24	Use higher strength concrete	Reduces thickness; Reduces schedule	Potential to increase costs	4	CF
25	Eliminate R value for the shoulders outside roadway prism	Reduces costs; Potential to reduce schedule	High variability in material	6	ABD
26	Improve channelizing devices	Reduces number of devices knocked over: Reduces maintenance	Increases cost; Additional width may be required	4	DC
27	Use portable rumble strips during construction	Alerts drivers of pattern changes	Increases cost and maintenance	4	DC
28	Use millings generated on project for subbase material	Reduces costs; Reduces schedule	Potential to trap water	5	CF

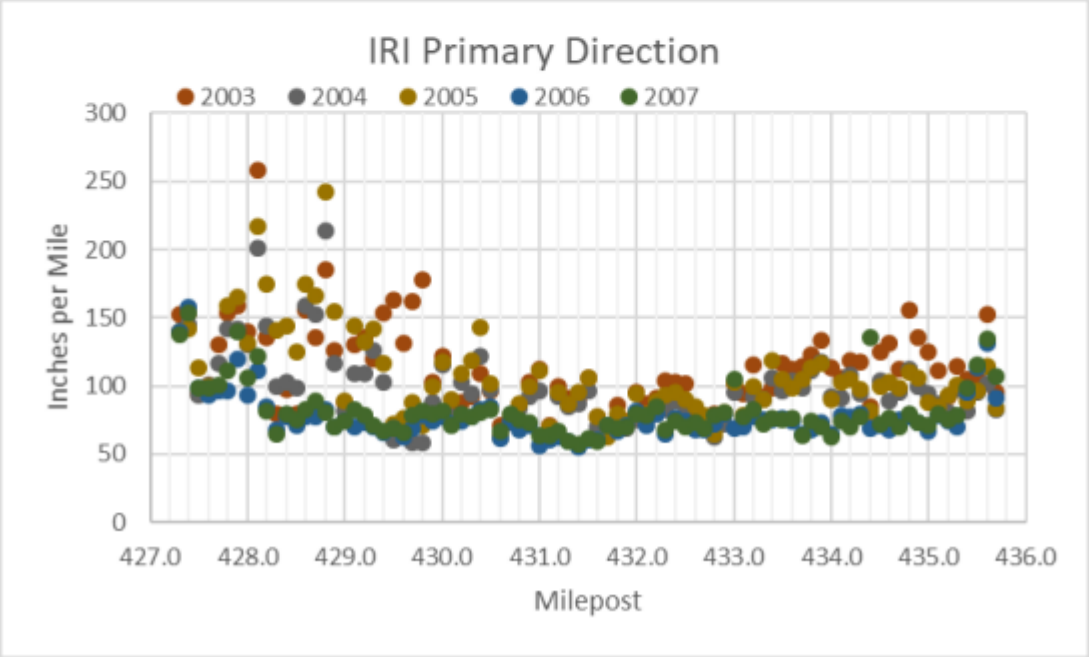
Idea No.	Description	Advantages	Disadvantages	Evaluation Ranking	VE Team Action
29	Modify density requirements for top 6" of shoulders	Easier to seed; Reduces schedule; Reduces costs	Possible settlement issues	5	DC
30	Use incentive / disincentive for early completion with variances allowed on hours and days of operation	Reduces schedule; Reduces impacts to travelling public	Potential to increase costs; Additional CDOT staff required; Not common in this area; Potential for increase in claims	3	NCF
31	Use precast concrete panels for mainline at the ramps	Reduces schedule; Reduces impacts to travelling public	Increases costs	3	NCF
32	Use thin white topping	Reduces costs; Reduces schedule	Increases joints and sawing; Increases maintenance	4	DC
33	Reduce initial International Roughness Index (IRI) to 70 to achieve smoother pavement and reduce pavement thickness	Reduces thickness; Reduces schedule	Potential for more diamond grinding	4	DC
34	Reuse unsuitable material for shouldering	Reduces costs; Reduces schedule	Time required for drying	4	CF
35	Use millings from asphalt in concrete as an aggregate	Reduce material; Reduces costs	Potential for lower flexural strength	3	NCF
36	Reduce concrete thickness by using shorter panels	Potential to reduce thickness; Potential to reduce costs	Increases sawing and dowel bars	4	CF
37	Undertake Falling Weight Deflectometer (FWD) analysis	Potential to reduce costs; Allows other design options	Potential scheduling issues	4	DC

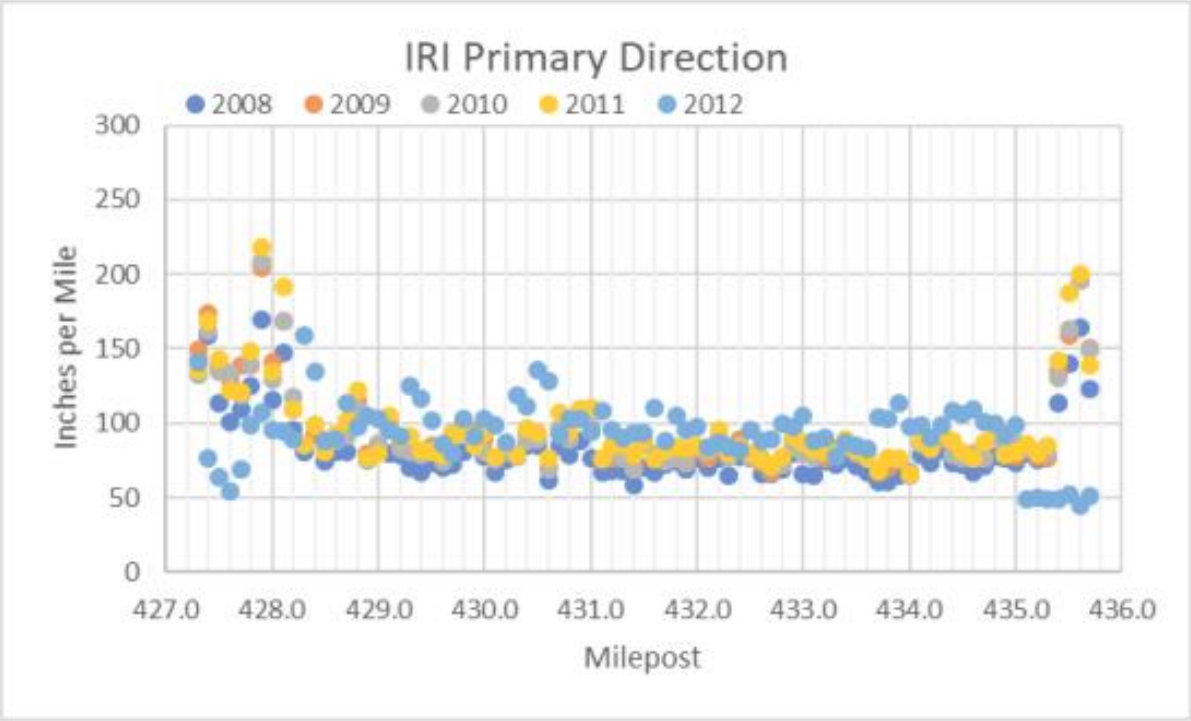
Idea No.	Description	Advantages	Disadvantages	Evaluation Ranking	VE Team Action
38	Undertake Ground Penetrating Radar (GPR) analysis	Potential to reduce costs; Allows other design options	Potential scheduling issues	4	DC
39	Optimize the PCCP thickness and reduce the amount of concrete needed by milling the existing HMA to adjust the cross slope	Reduces costs; Improves constructability; Reduces schedule; Potential to use available materials	Redesign required; Potential to increase distresses; Potential to increase future maintenance costs	7	CF

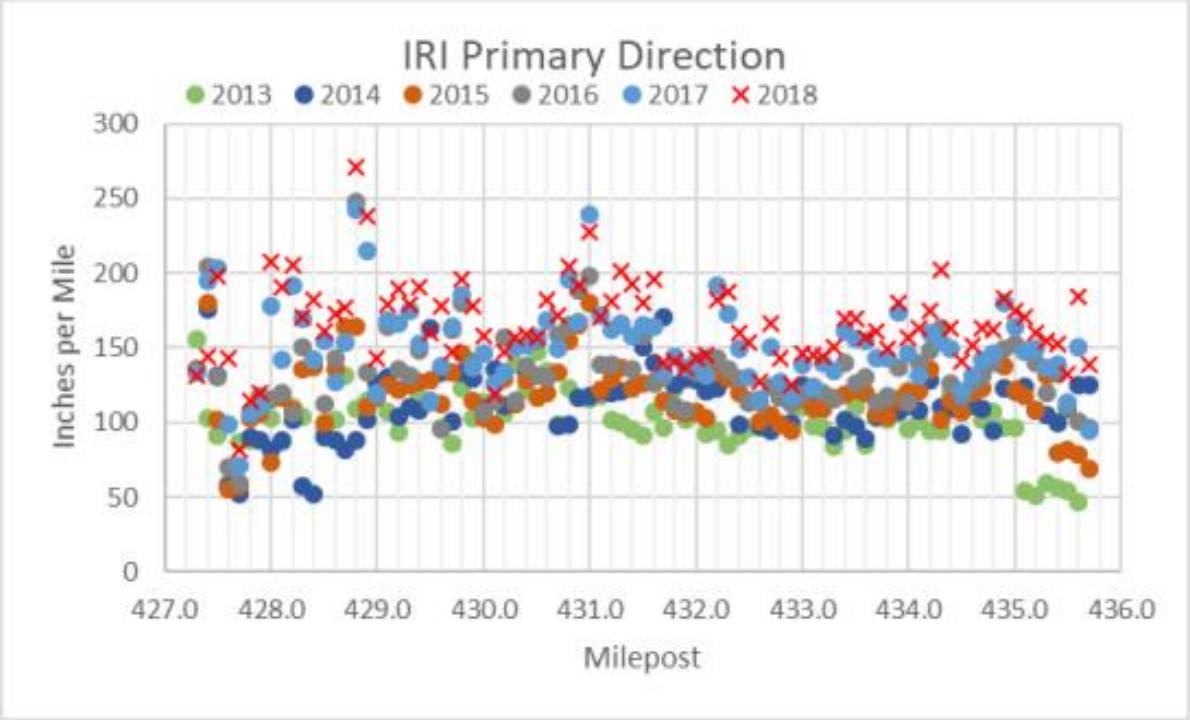
Appendix D Pre-Workshop Pavement Analysis

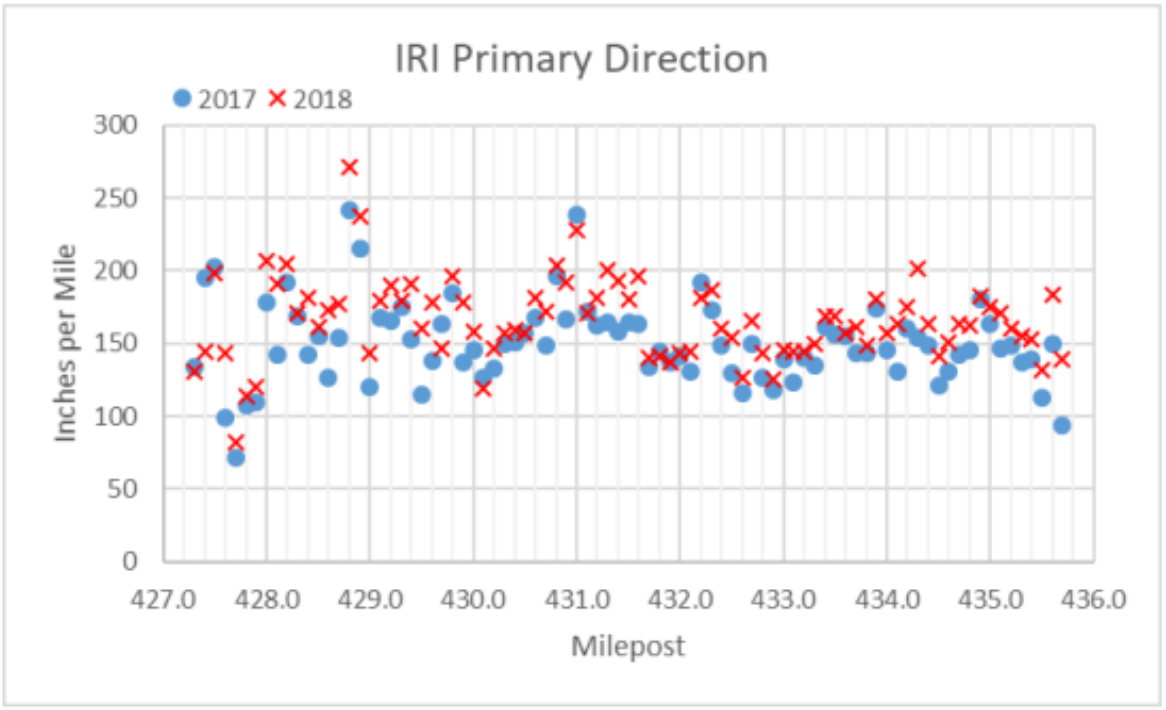
Summary of Pavement Management Data for the I-70 Project at Bethune

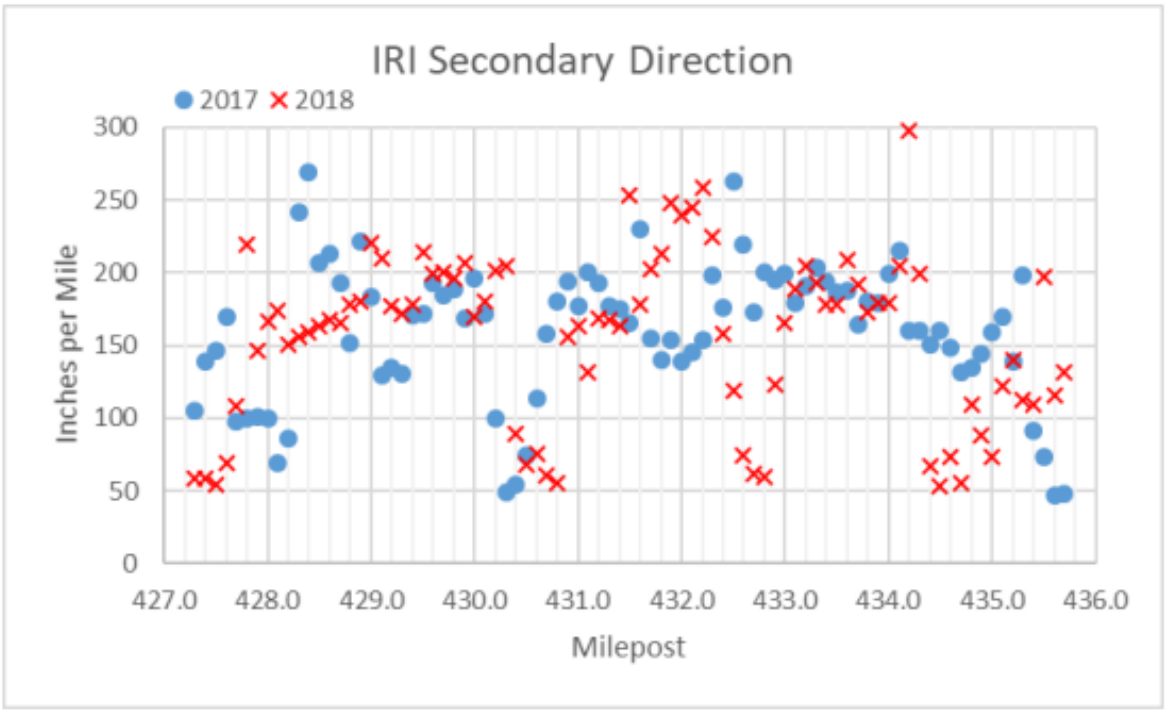


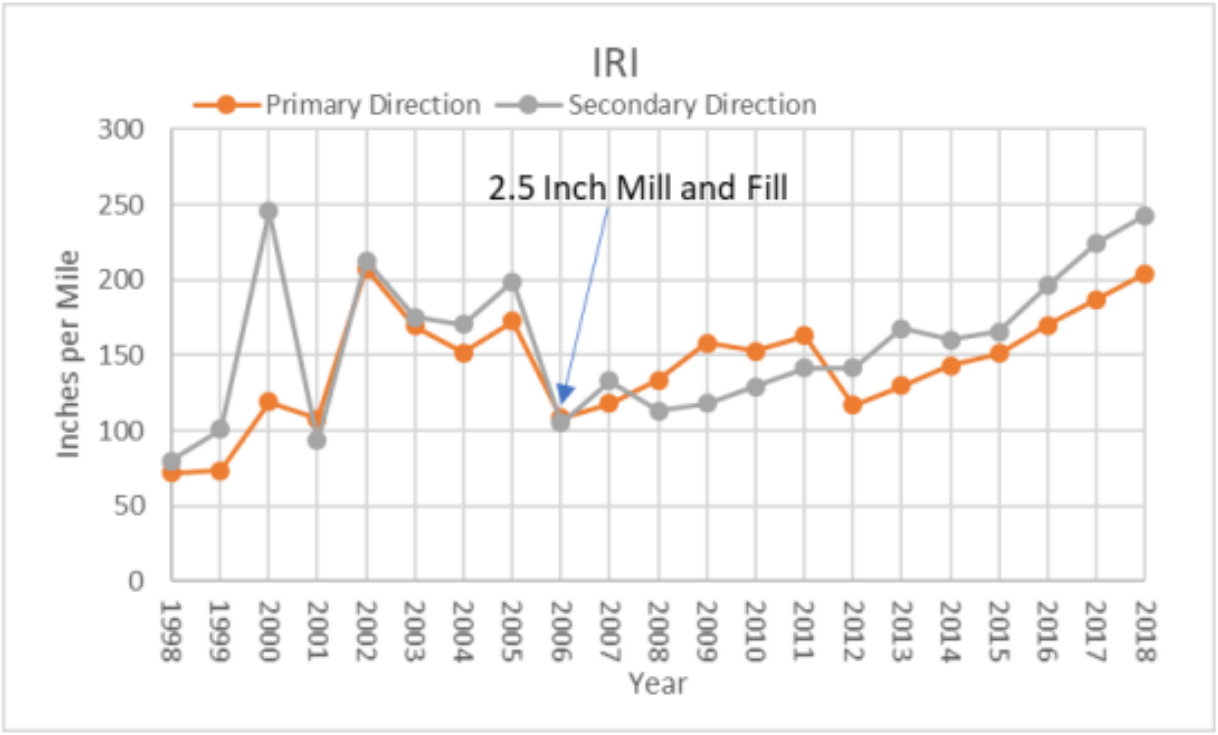


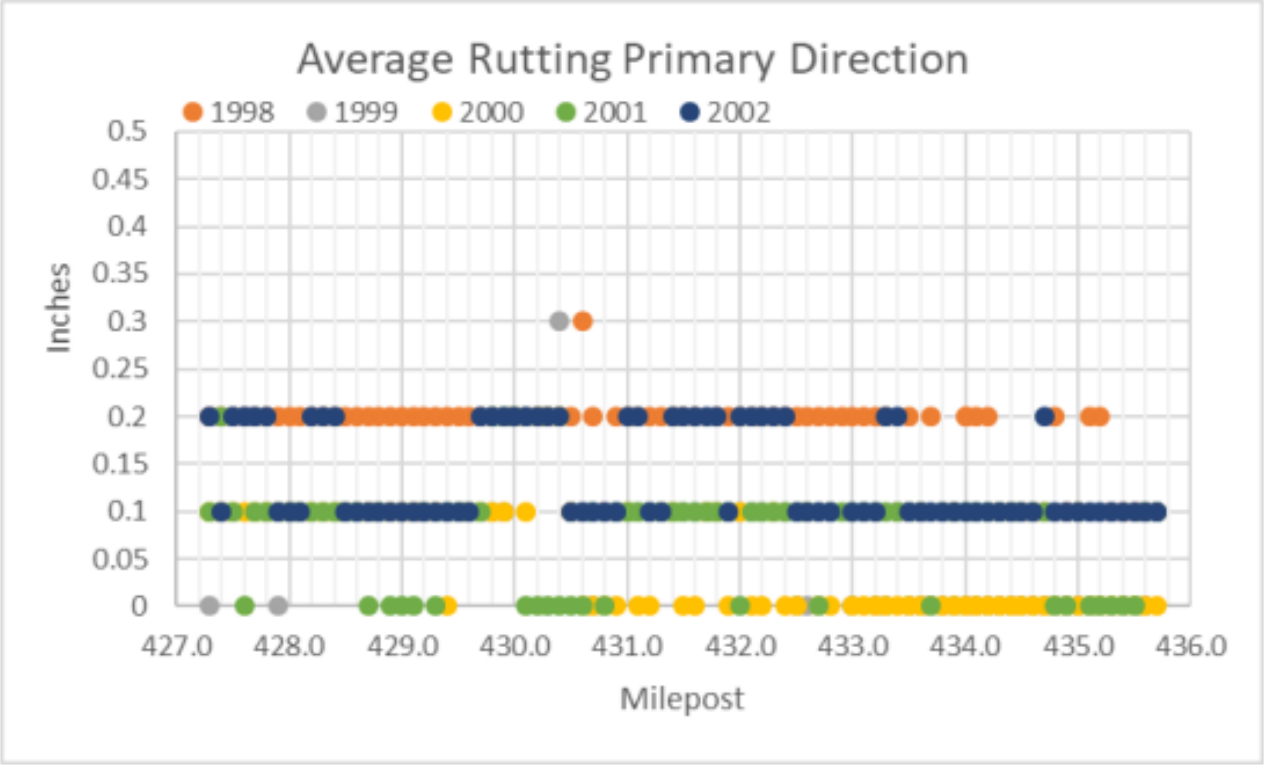

IRI Primary Direction
2008
2009
2010
2011
2012
Inches per Mile
300
250
200
150
100
50
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

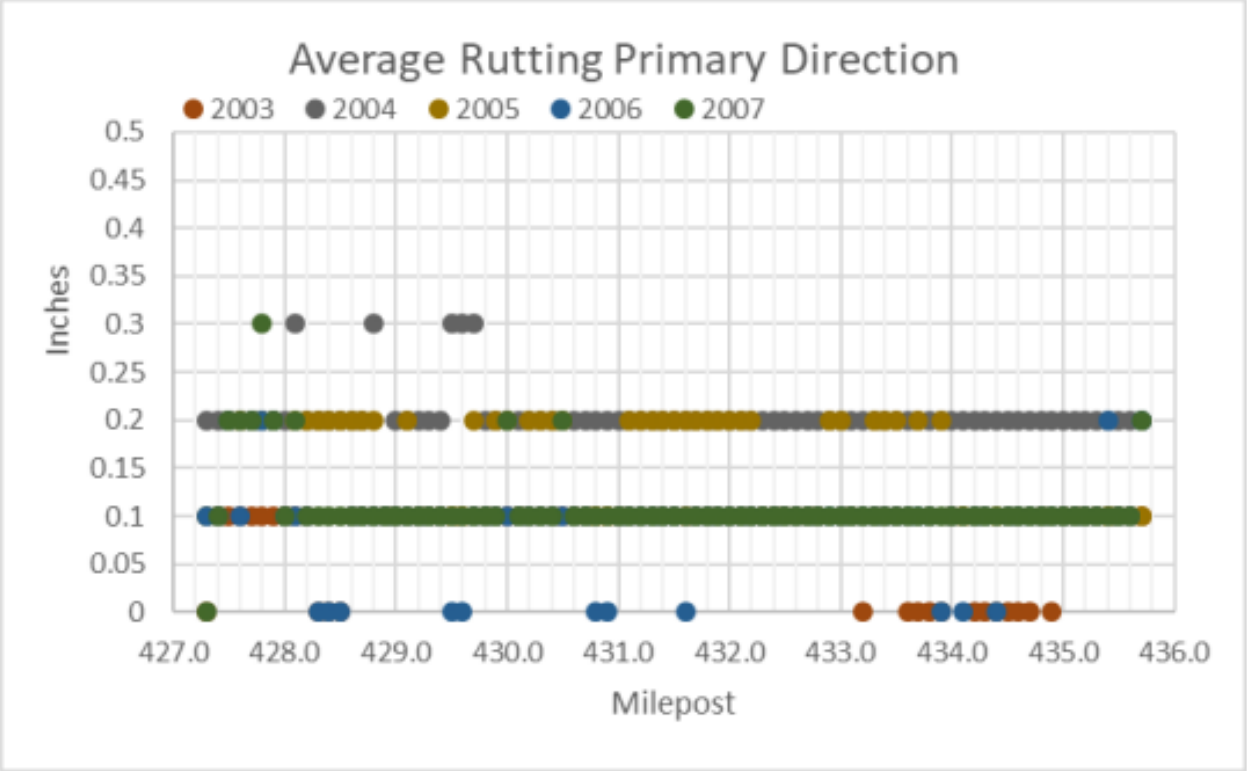

IRI Primary Direction
2013
2014
2015
2016
2017
2018
Inches per Mile
300
250
200
150
100
50
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

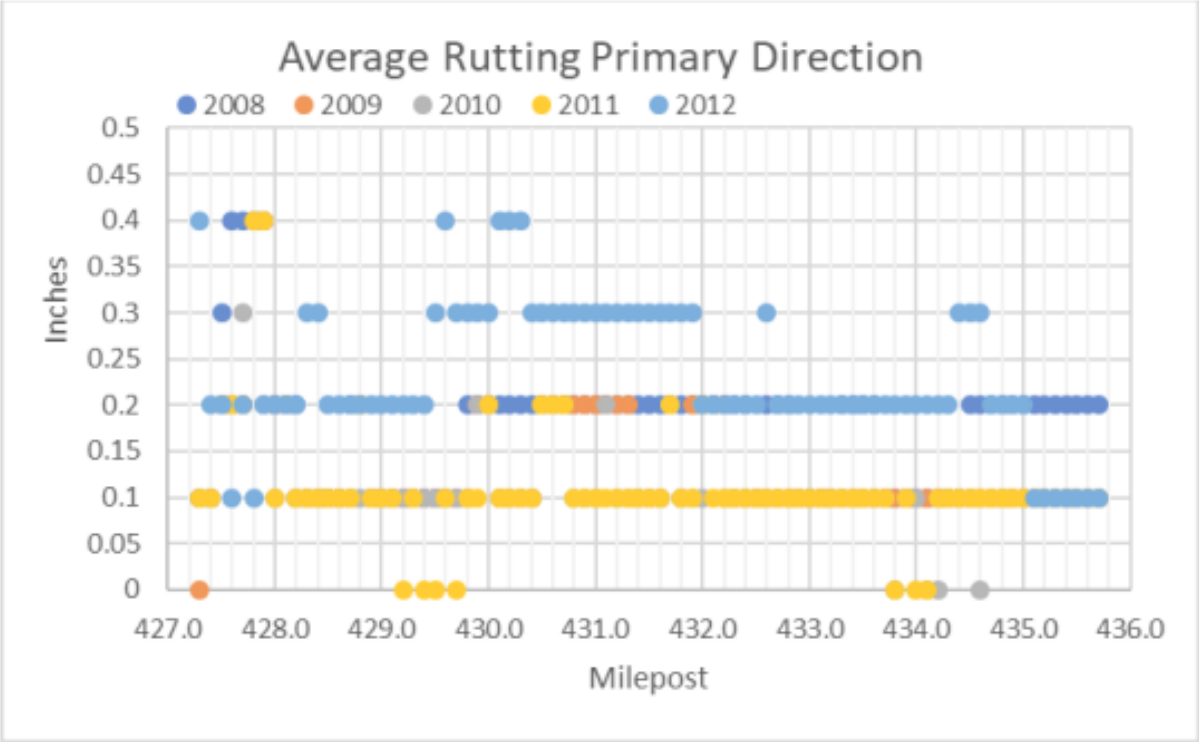

IRI Primary Direction
2017
2018
Inches per Mile
300
250
200
150
100
50
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

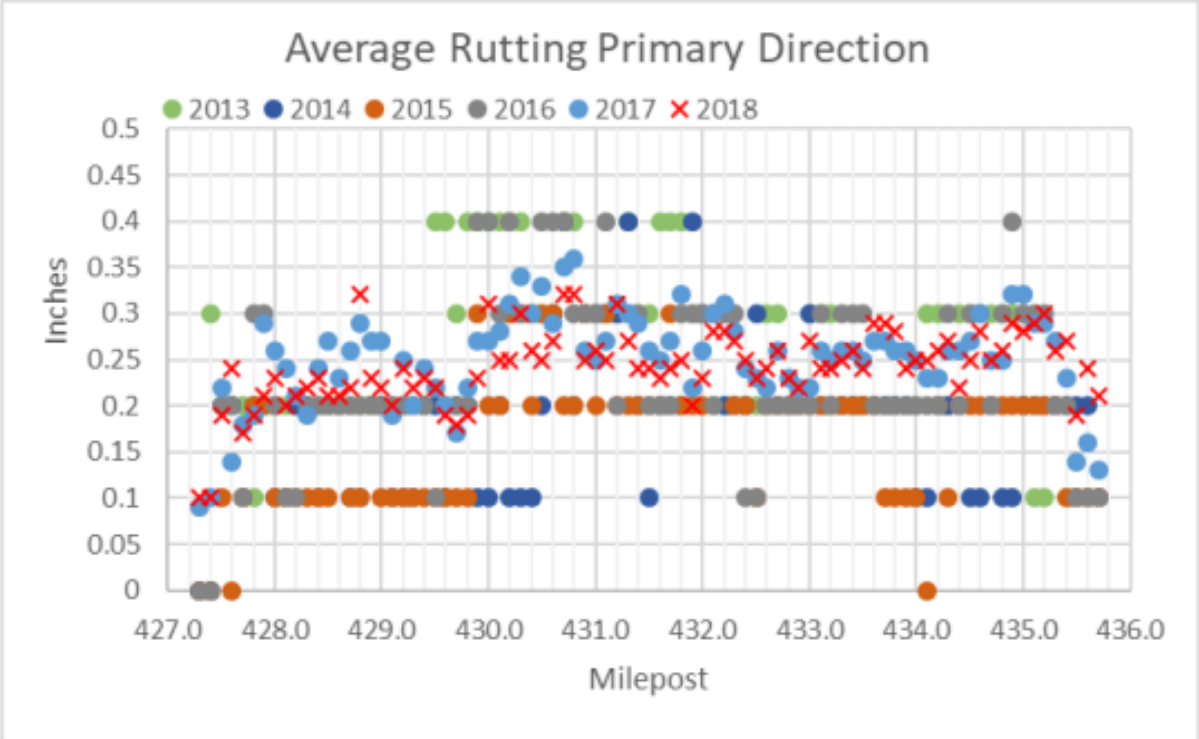

IRI Secondary Direction
2017
2018
Inches per Mile
300
250
200
150
100
50
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

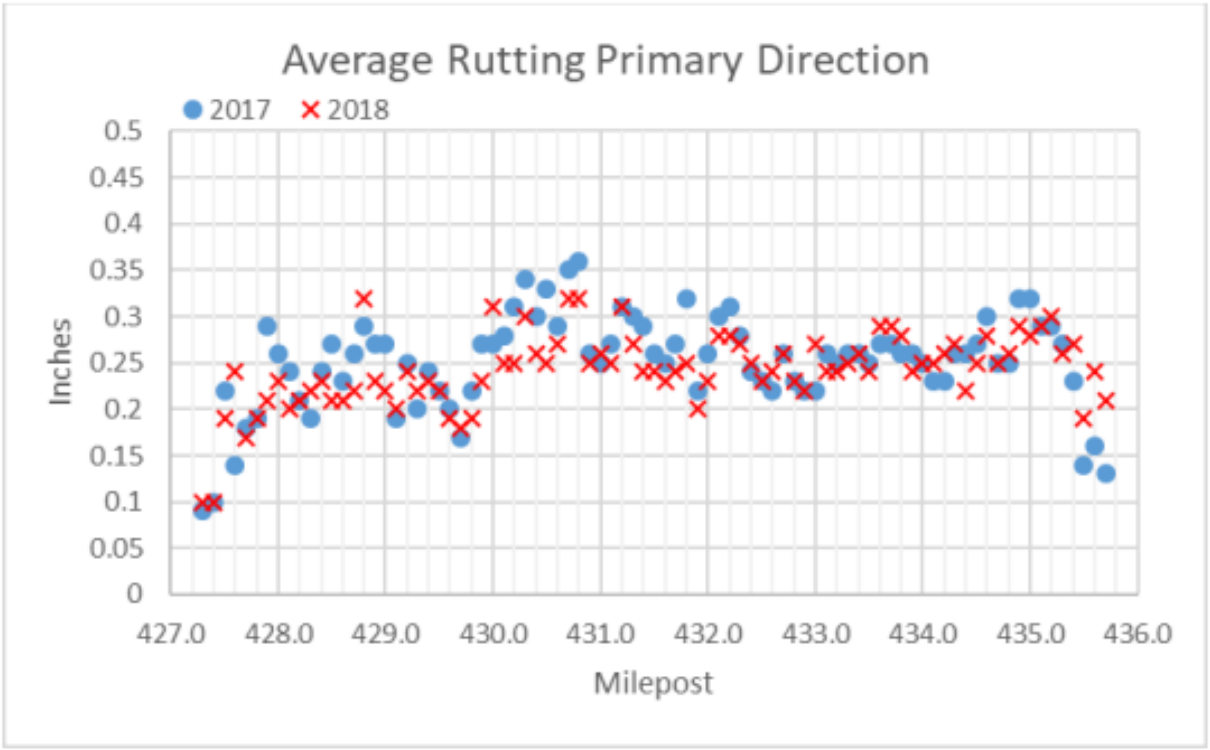

IRI
Primary Direction
Secondary Direction
2.5 Inch Mill and Fill
Inches per Mile
300
250
200
150
100
50
0
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year

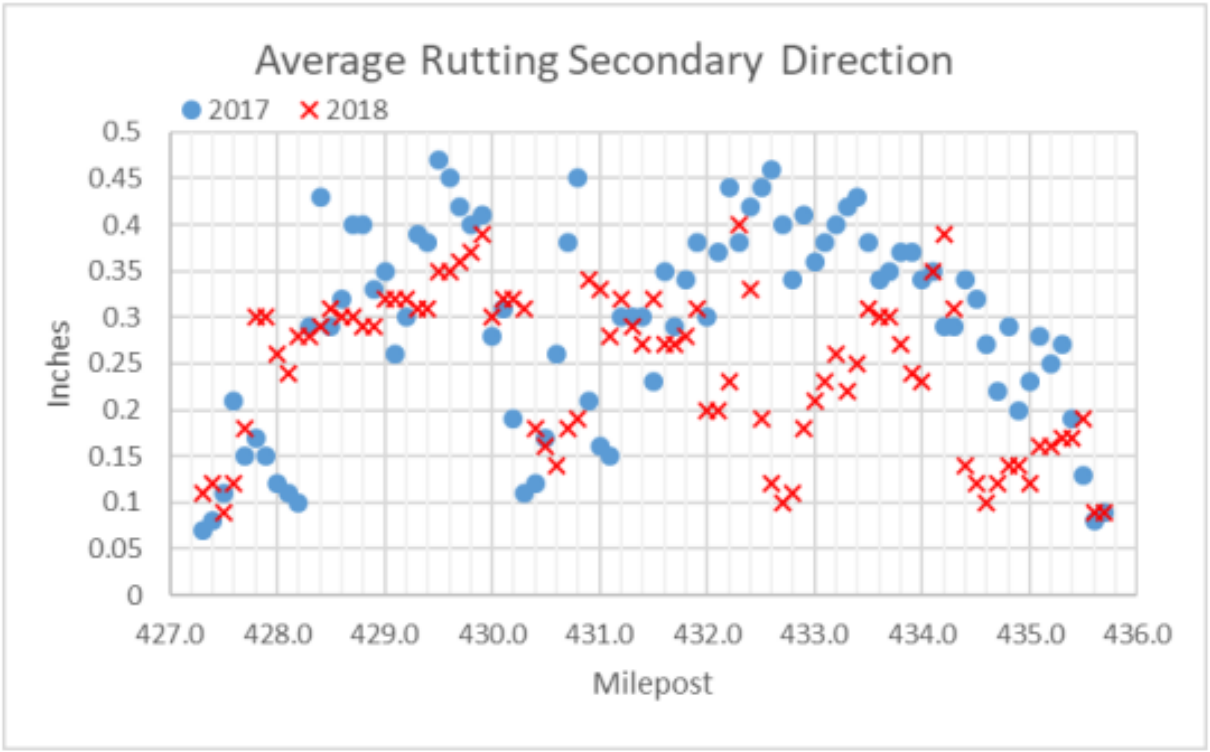

Average Rutting Primary Direction
1998
1999
2000
2001
2002
Inches
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

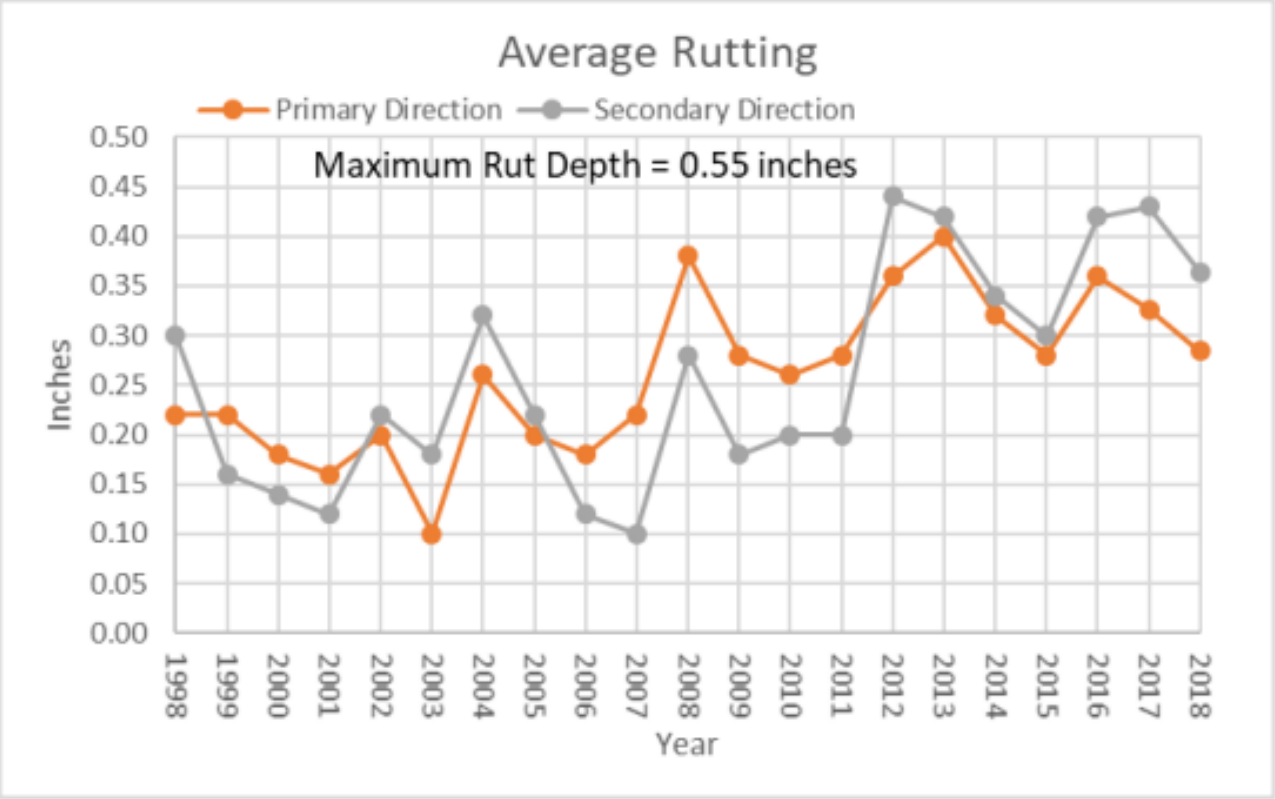

Average Rutting Primary Direction
2003
2004
2005
2006
2007
Inches
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

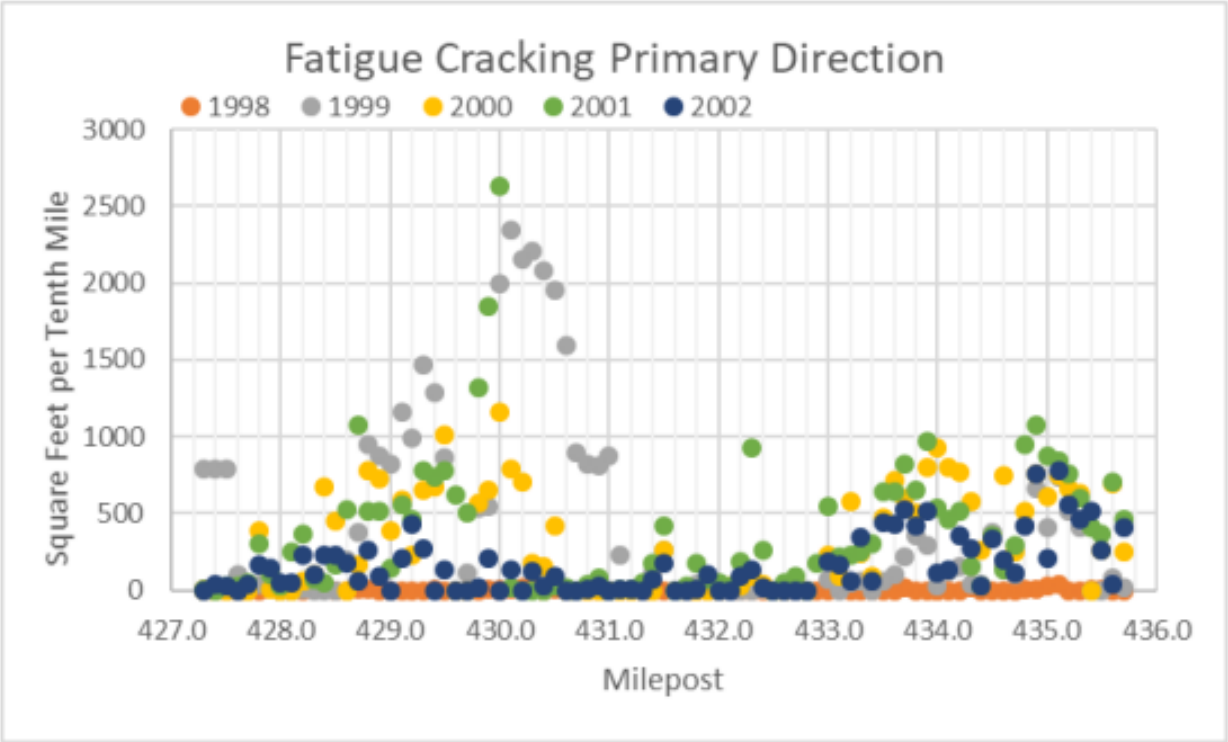

Average Rutting Primary Direction
2008
2009
2010
2011
2012
Inches
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

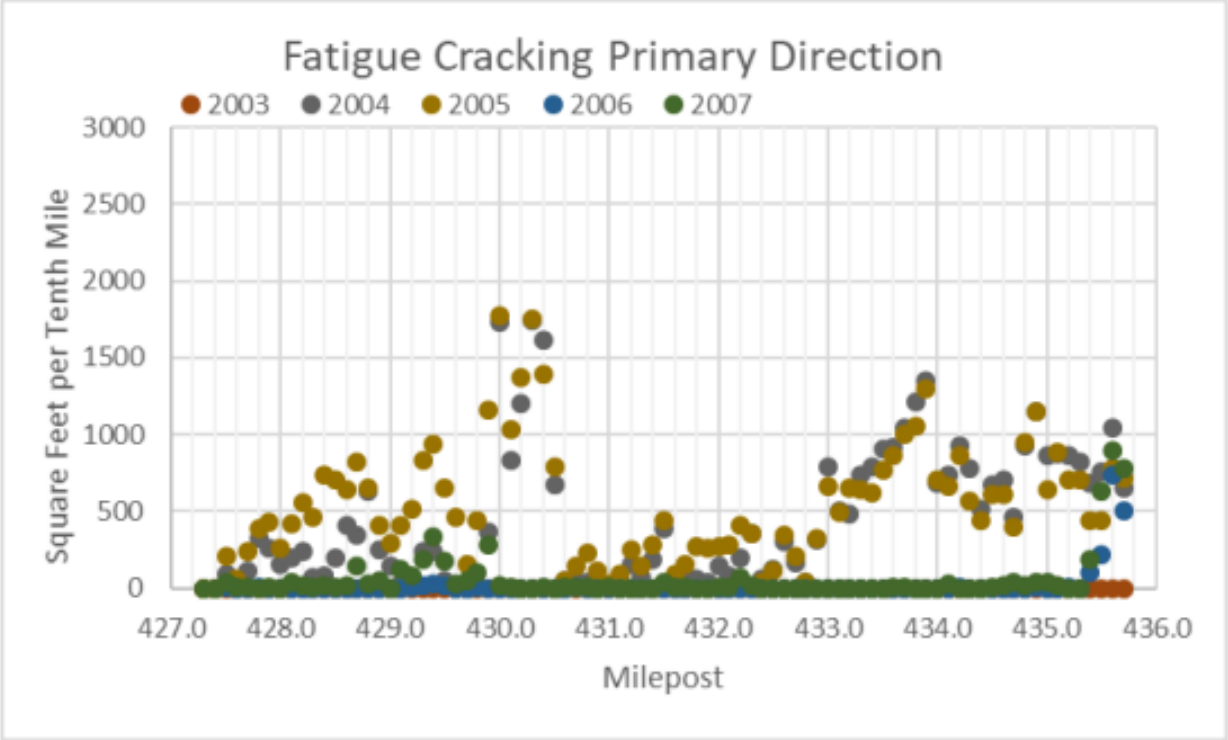

Average Rutting Primary Direction
2013
2014
2015
2016
2017
2018
Inches
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

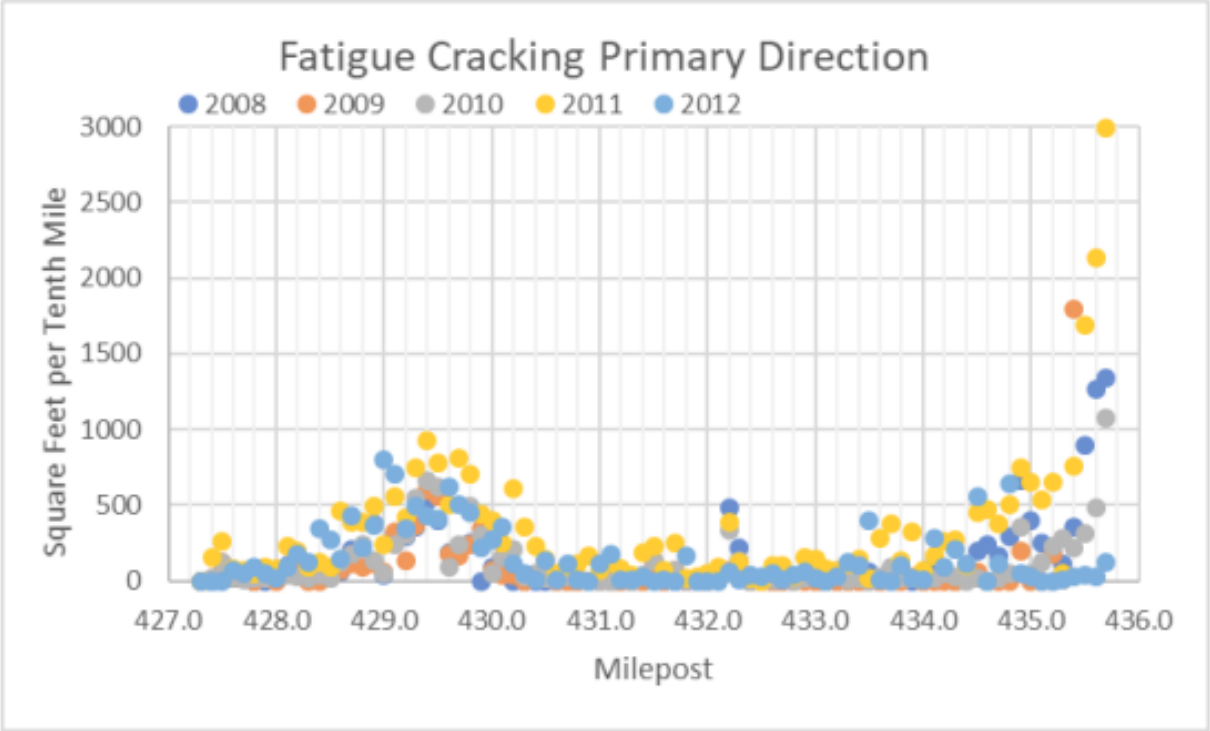

Average Rutting Primary Direction
2017
2018
Inches
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

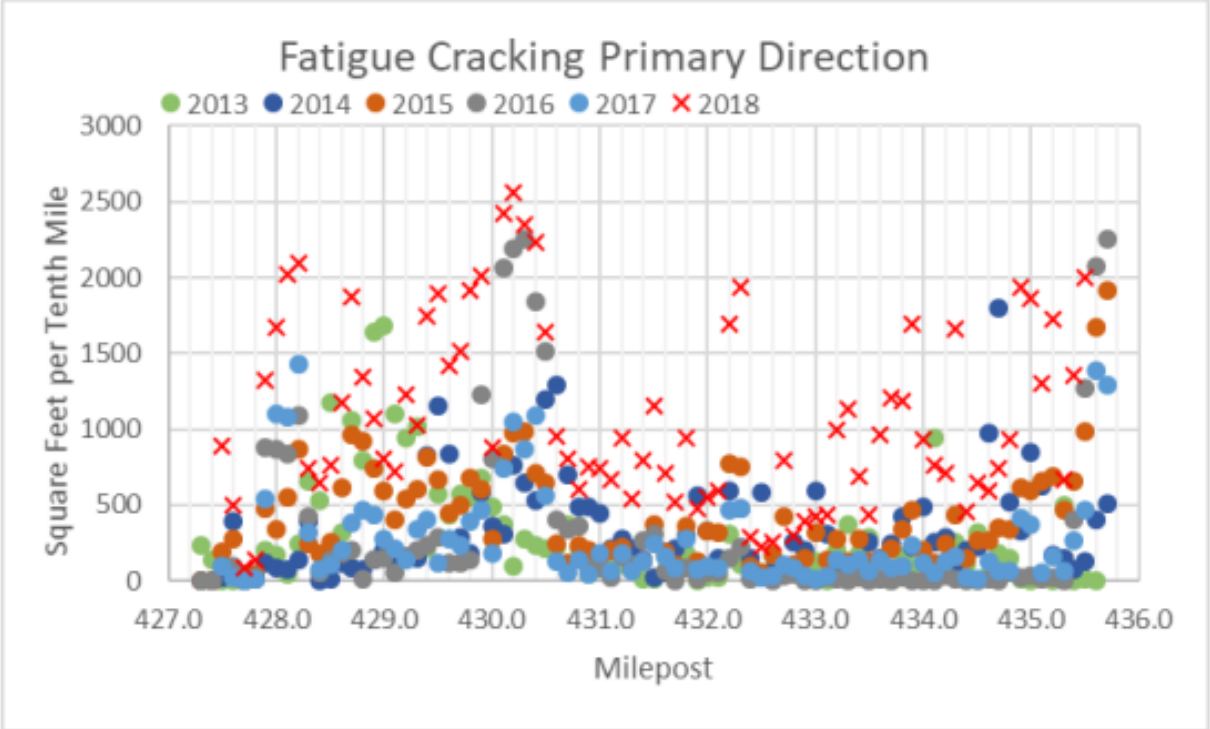

Average Rutting Secondary Direction
2017
2018
Inches
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

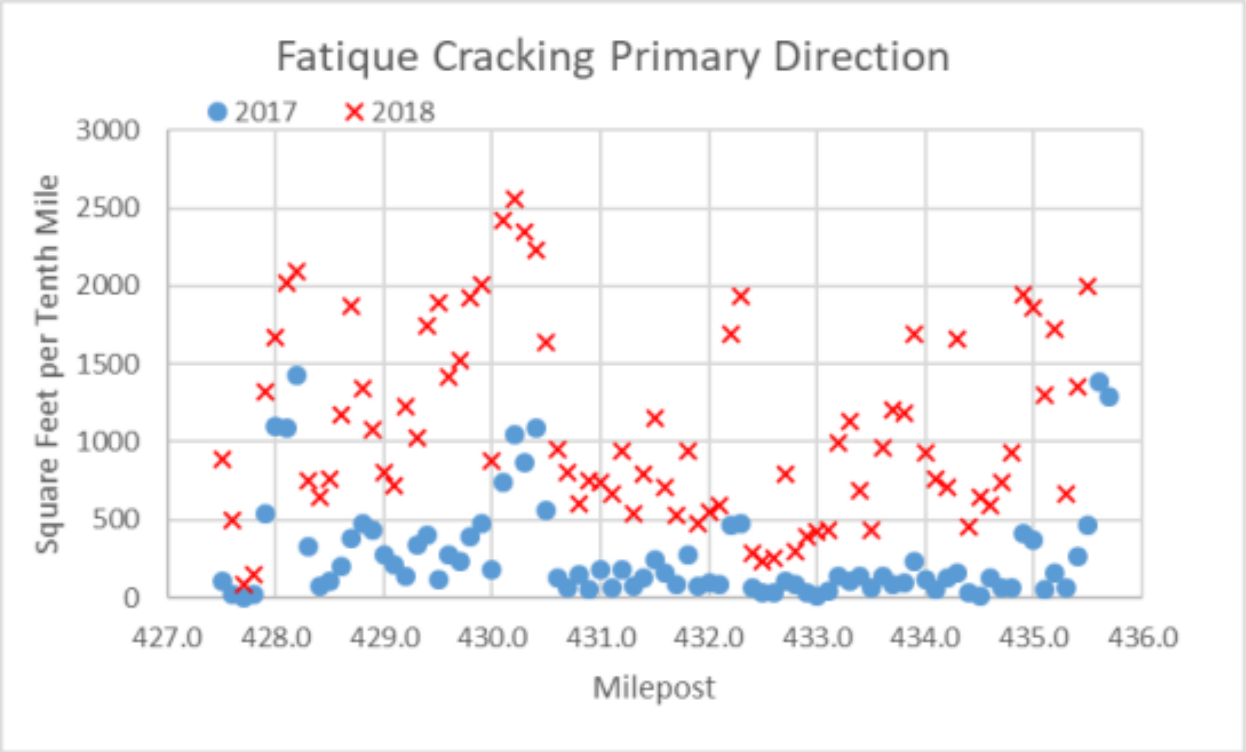

Average Rutting
Primary Direction
Secondary Direction
Maximum Rut Depth = 0.55 inches
Inches
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year

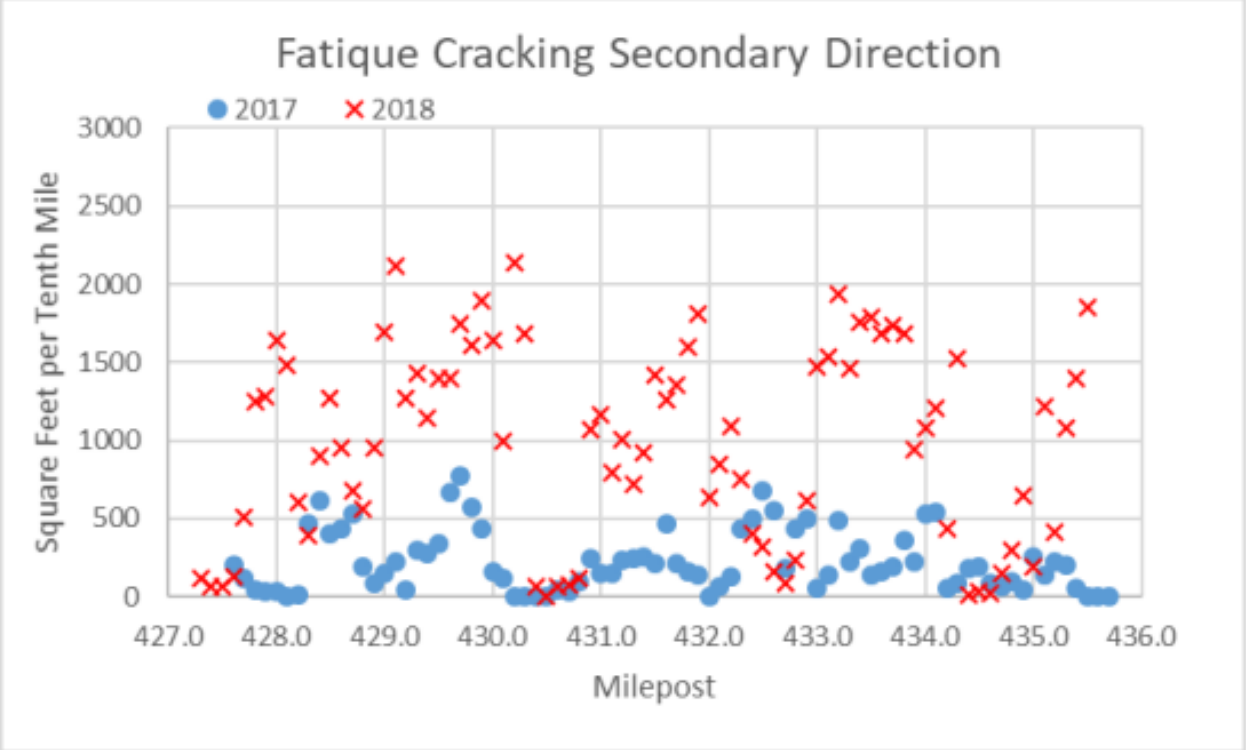

Fatigue Cracking Primary Direction
1998
1999
2000
2001
2002
Square Feet per Tenth Mile
3000
2500
2000
1500
1000
500
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

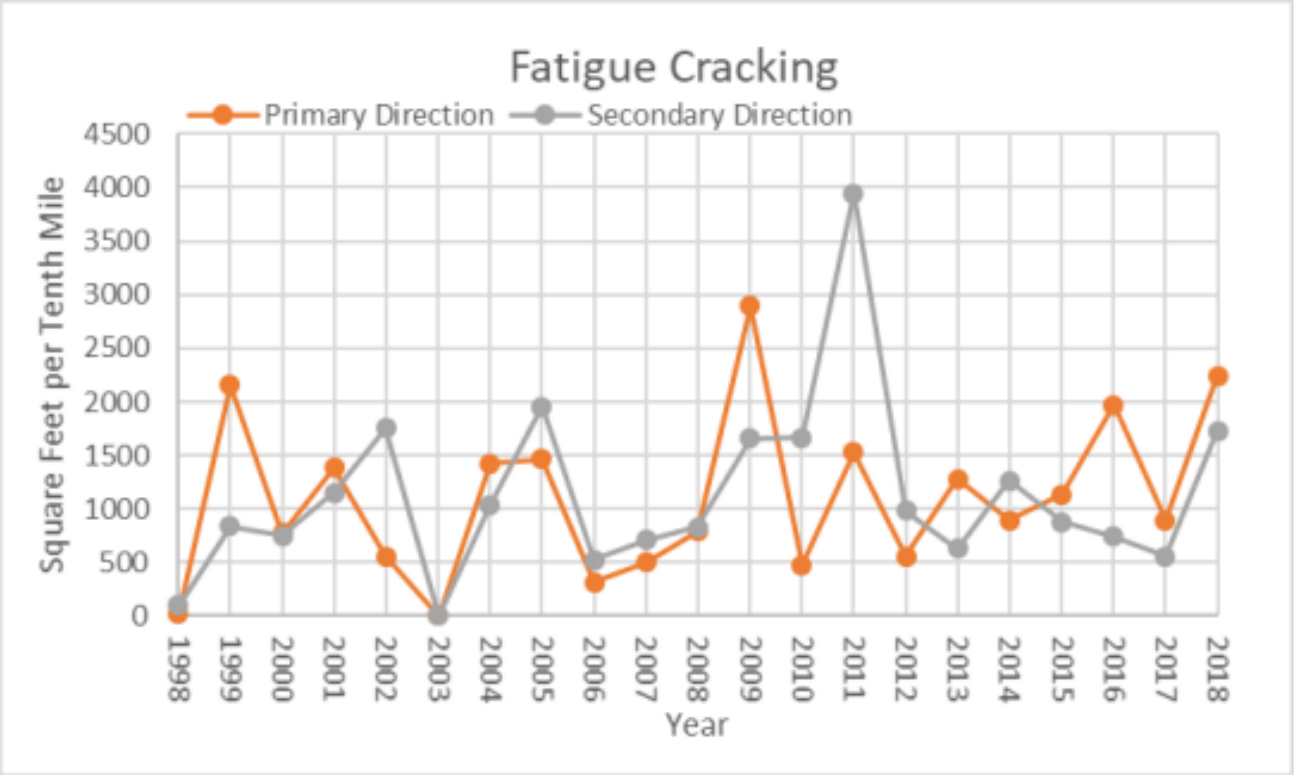

Fatigue Cracking Primary Direction
2003
2004
2005
2006
2007
Square Feet per Tenth Mile
3000
2500
2000
1500
1000
500
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

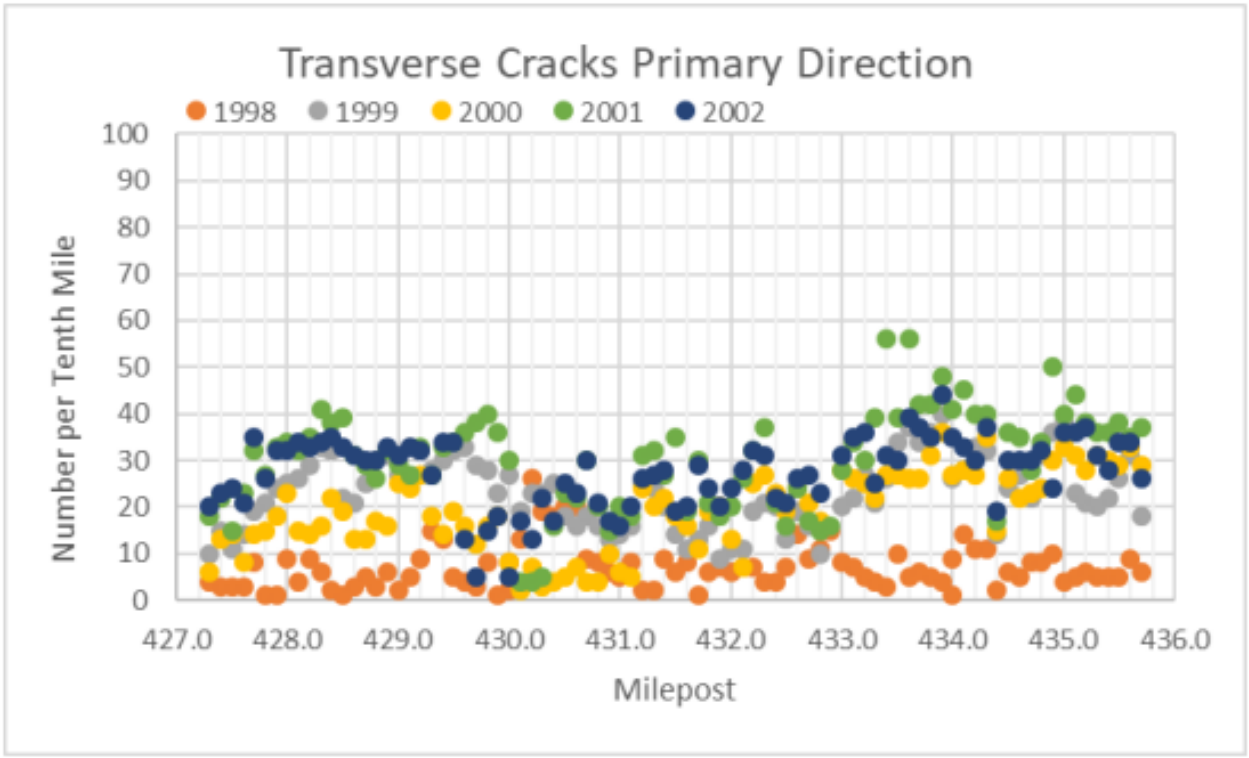

Fatigue Cracking Primary Direction
2008
2009
2010
2011
2012
Square Feet per Tenth Mile
3000
2500
2000
1500
1000
500
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

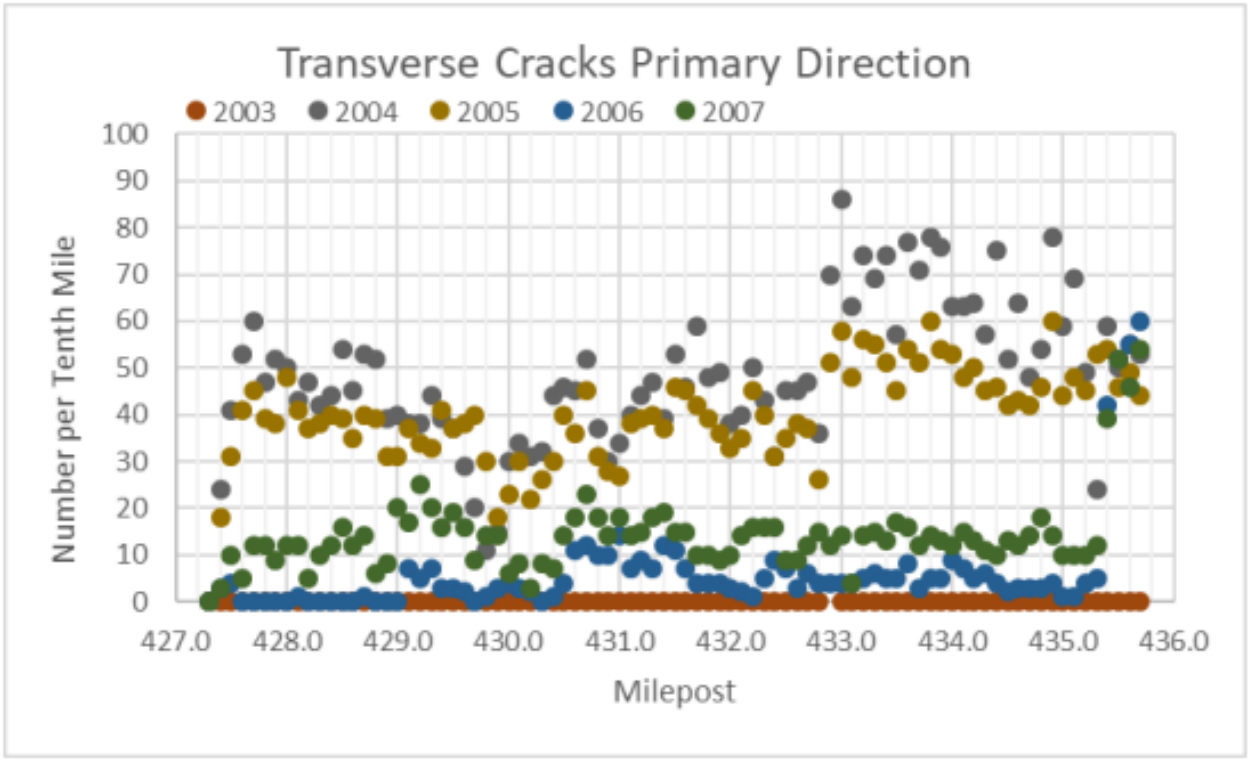

Fatigue Cracking Primary Direction
2013
2014
2015
2016
2017
2018
Square Feet per Tenth Mile
3000
2500
2000
1500
1000
500
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

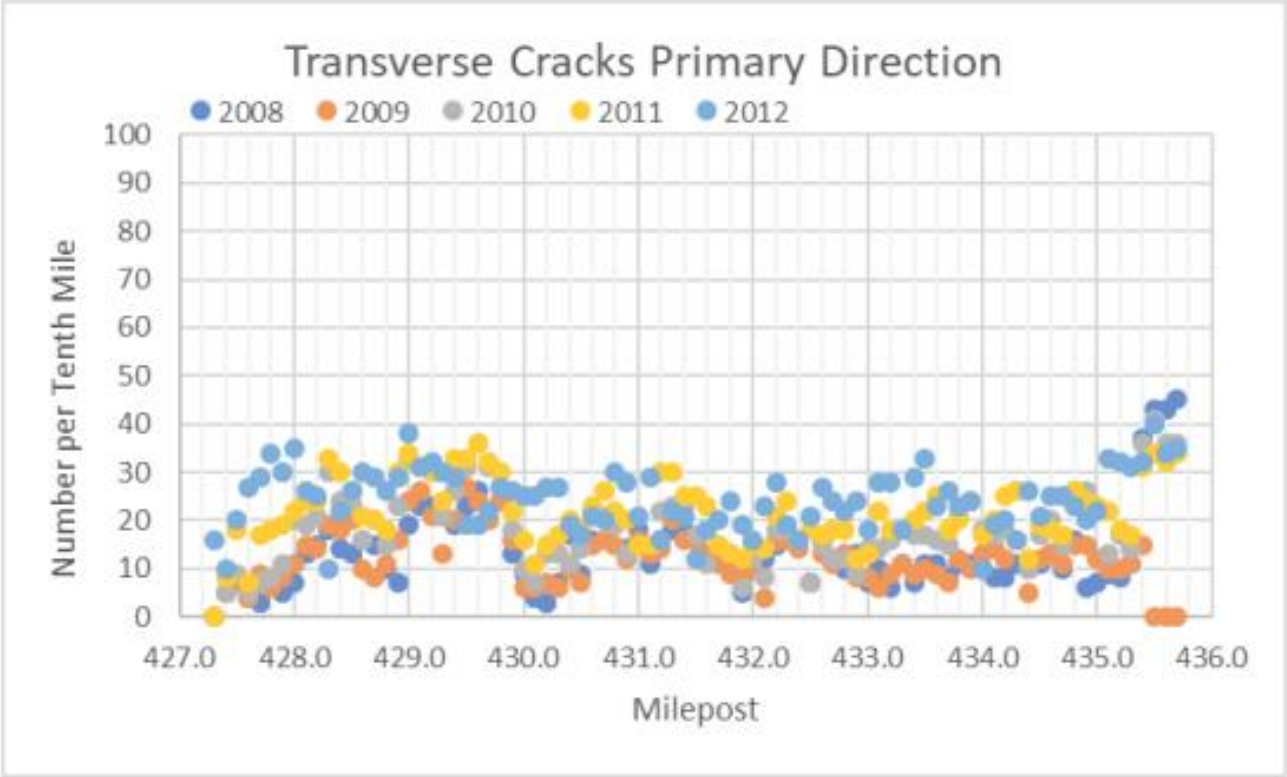

Fatique Cracking Primary Direction
2017
2018
Square Feet per Tenth Mile
3000
2500
2000
1500
1000
500
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

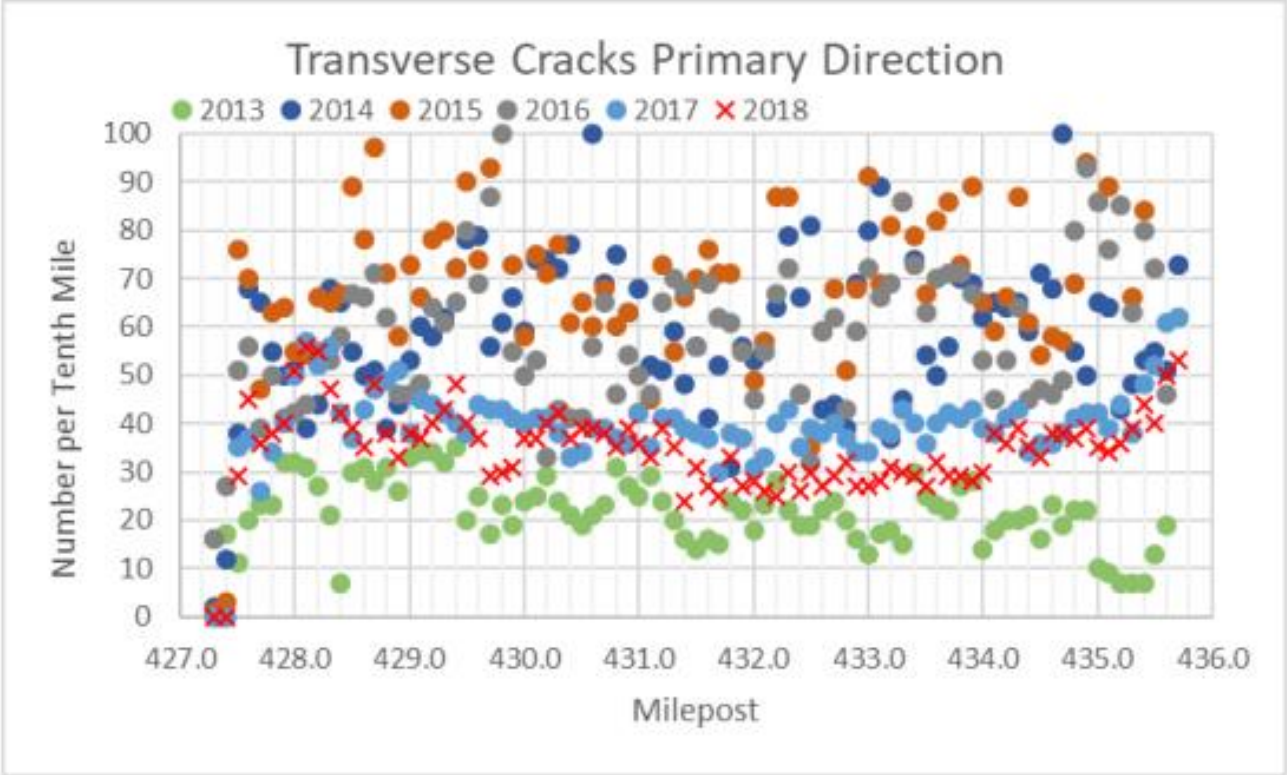

Fatique Cracking Secondary Direction
2017
2018
Square Feet per Tenth Mile
3000
2500
2000
1500
1000
500
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

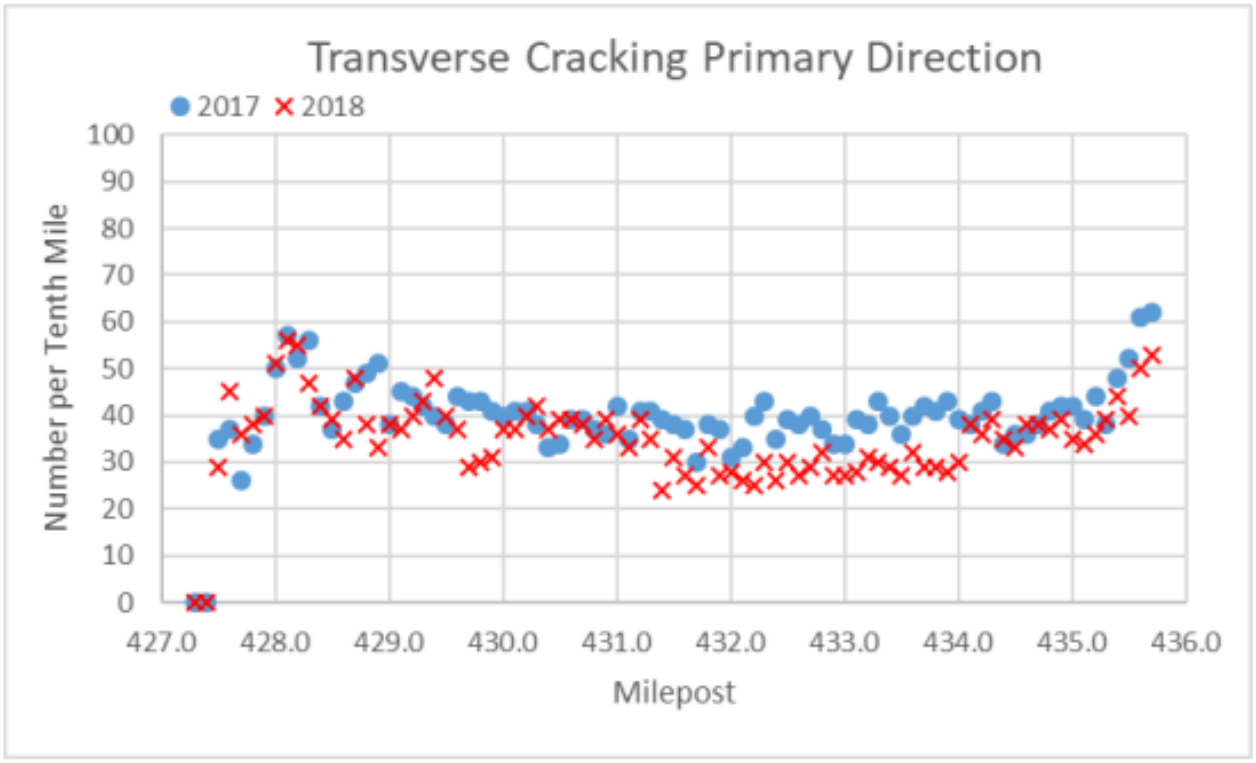

Fatigue Cracking
Primary Direction
Secondary Direction
Square Feet per Tenth Mile
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year

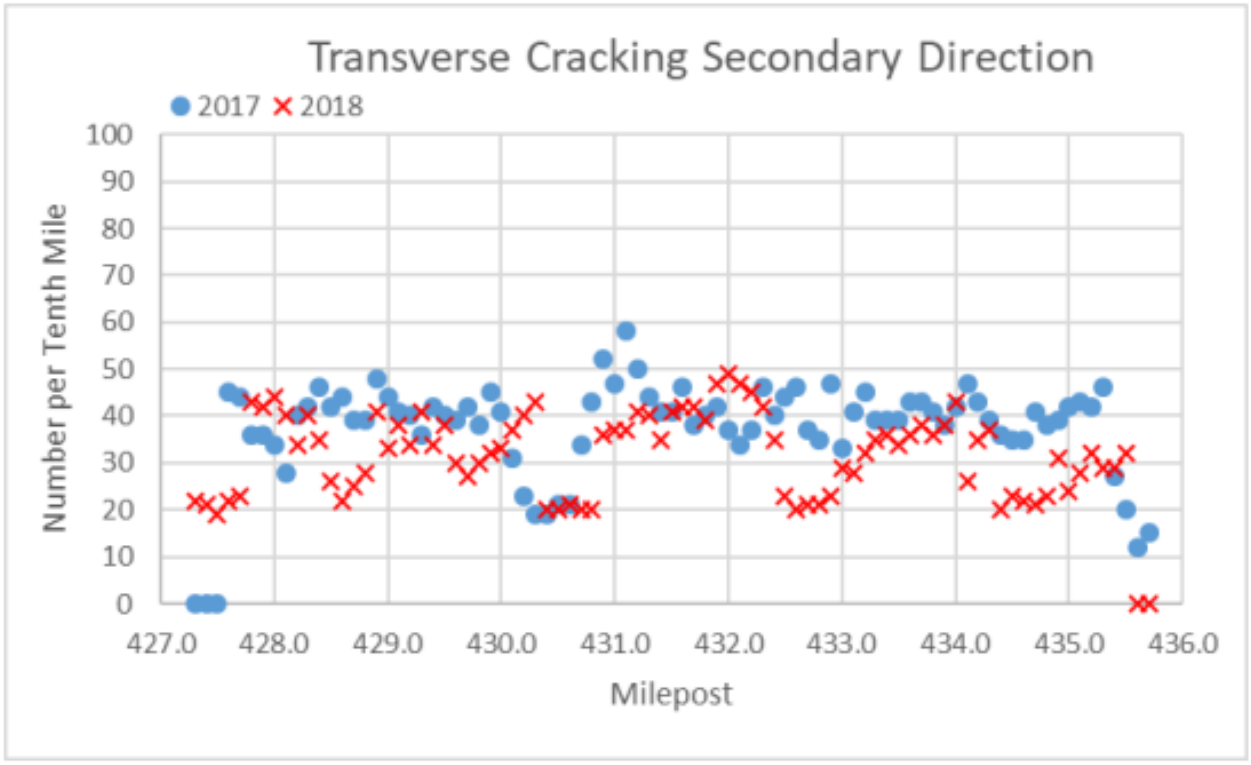

Transverse Cracks Primary Direction
1998
1999
2000
2001
2002
Number per Tenth Mile
100
90
80
70
60
50
40
30
20
10
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

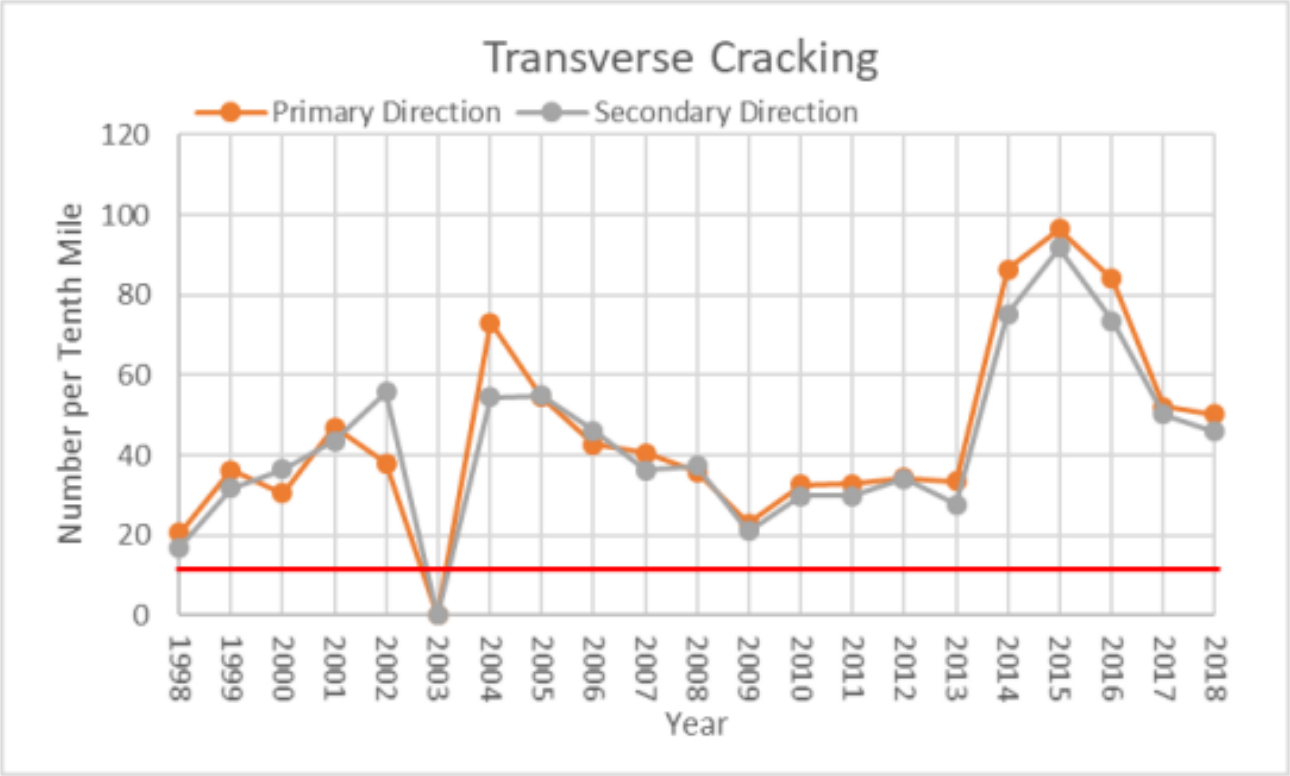

Transverse Cracks Primary Direction
2003
2004
2005
2006
2007
Number per Tenth Mile
100
90
80
70
60
50
40
30
20
10
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

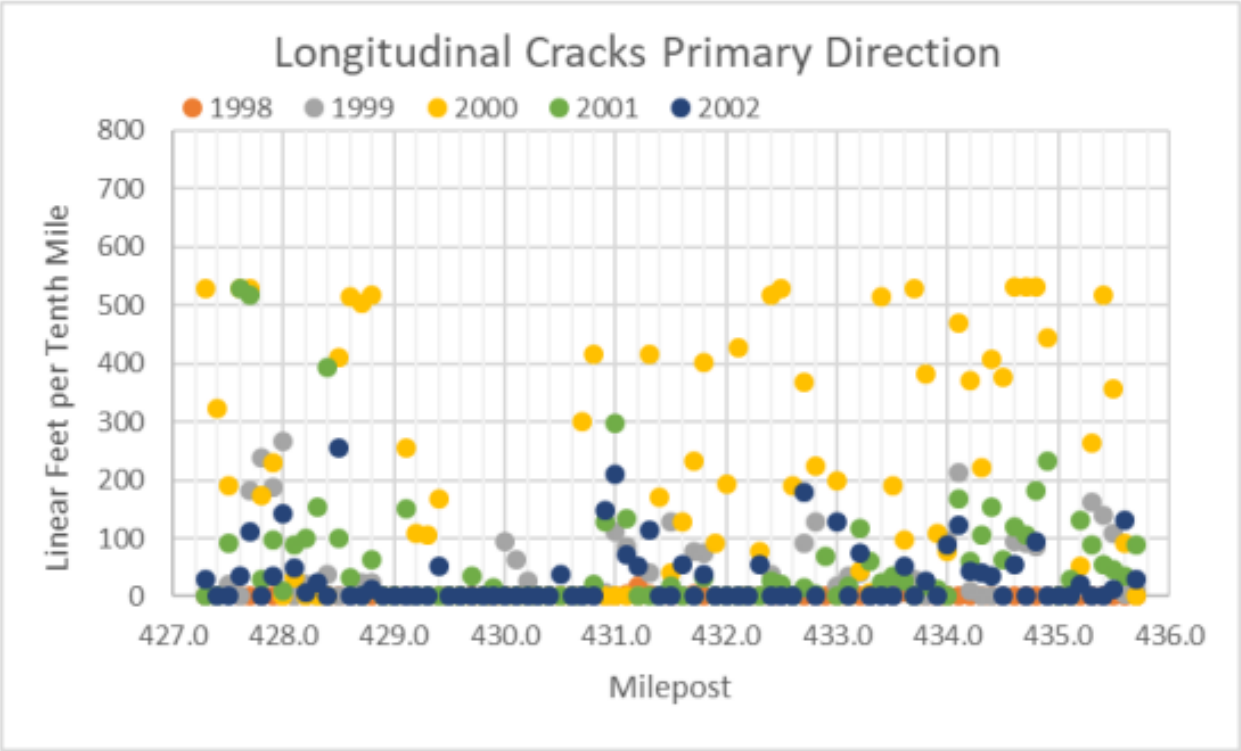

Transverse Cracks Primary Direction
2008
2009
2010
2011
2012
Number per Tenth Mile
100
90
80
70
60
50
40
30
20
10
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

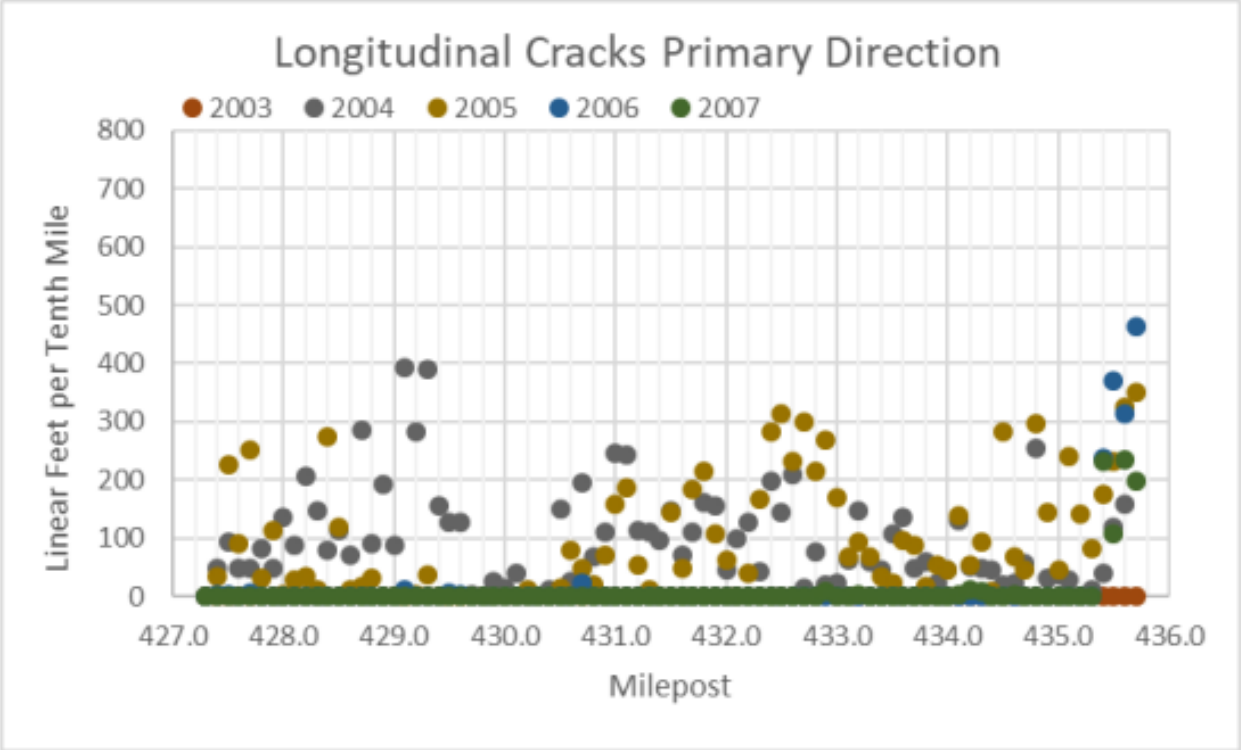

Transverse Cracks Primary Direction
2013
2014
2015
2016
2017
2018
Number per Tenth Mile
100
90
80
70
60
50
40
30
20
10
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

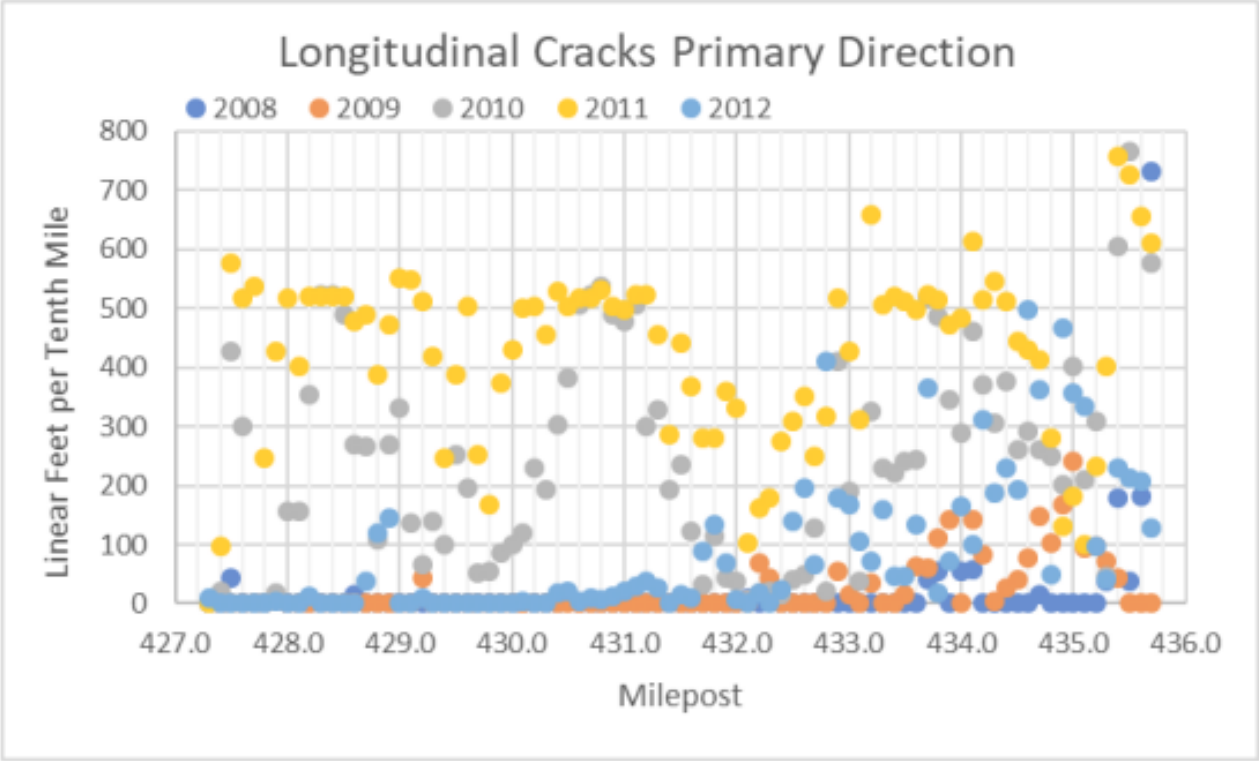

Transverse Cracking Primary Direction
2017
2018
Number per Tenth Mile
100
90
80
70
60
50
40
30
20
10
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

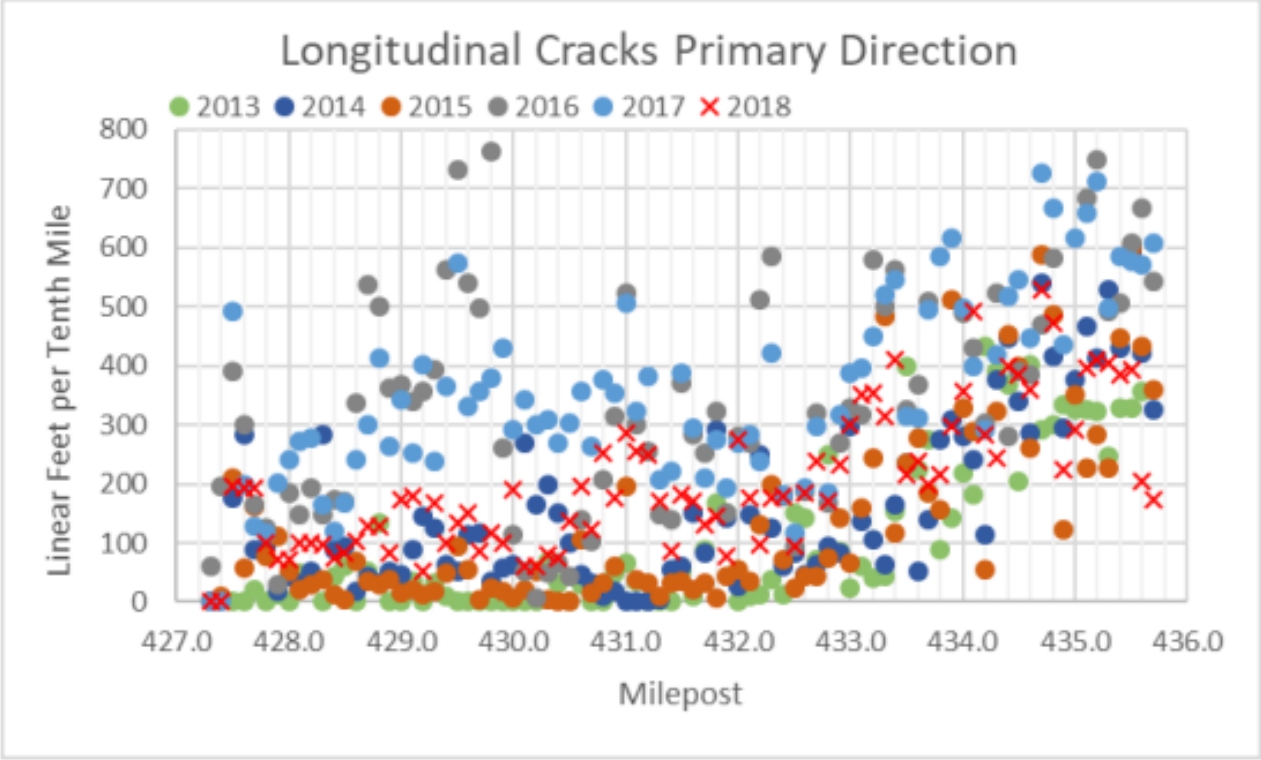

Transverse Cracking Secondary Direction
2017
2018
Number per Tenth Mile
100
90
80
70
60
50
40
30
20
10
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

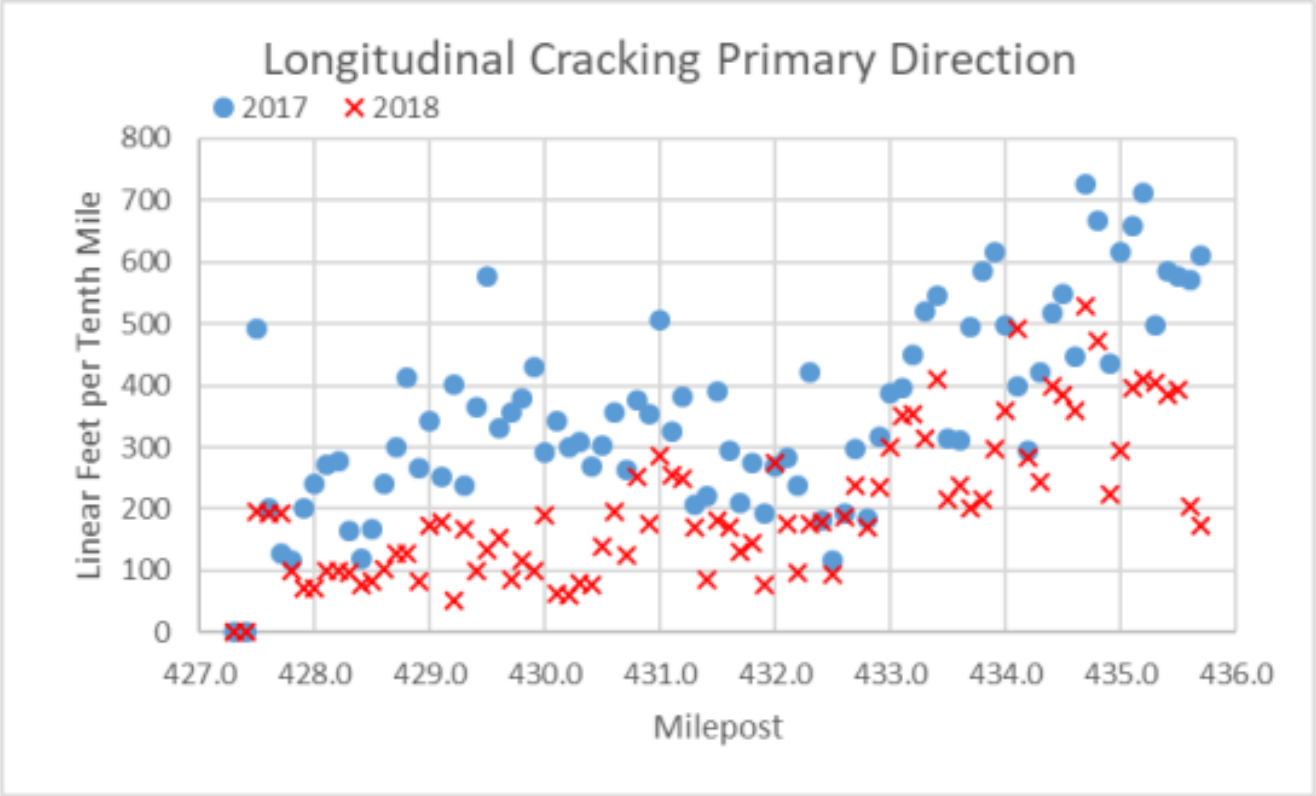

Transverse Cracking
Primary Direction
Secondary Direction
Number per Tenth Mile
120
100
80
60
40
20
0
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year

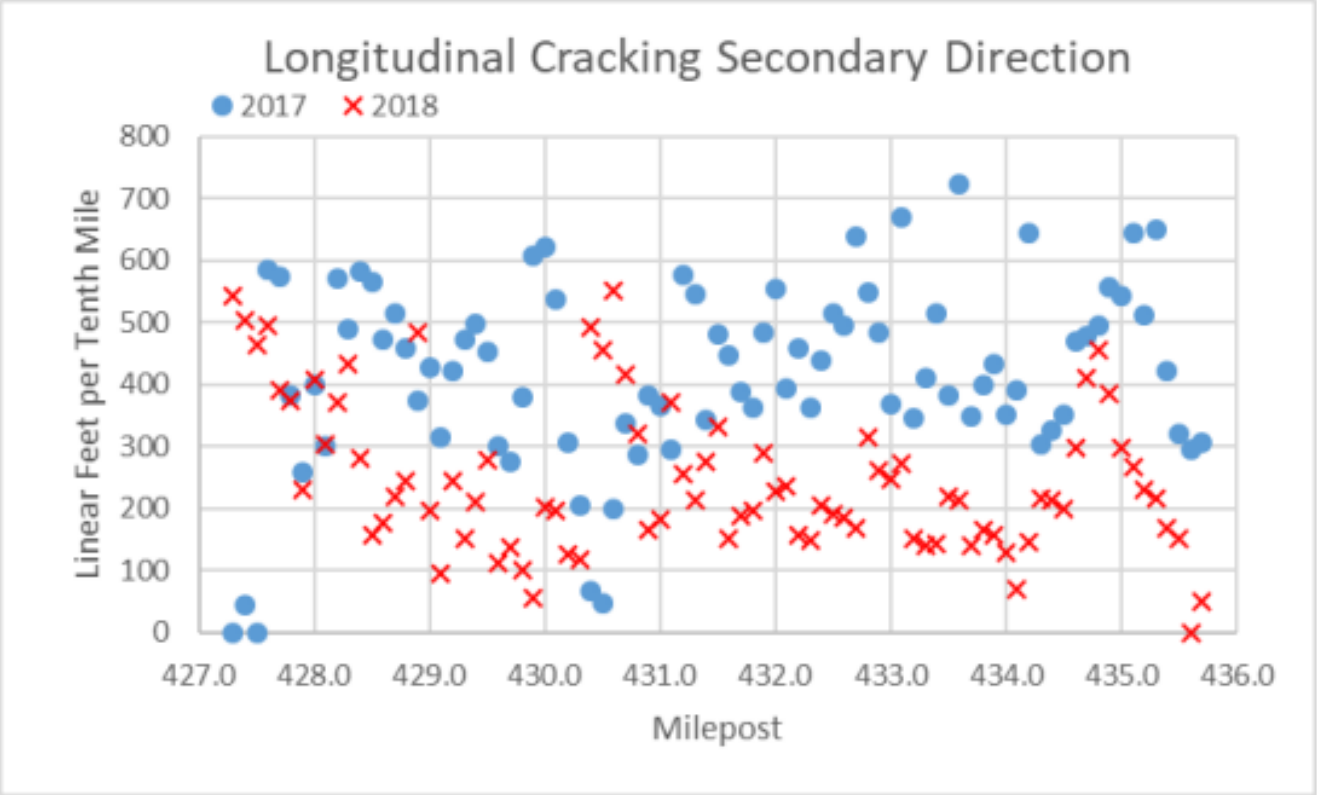

Longitudinal Cracks Primary Direction
1998
1999
2000
2001
2002
Linear Feet per Tenth Mile
800
700
600
500
400
300
200
100
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost

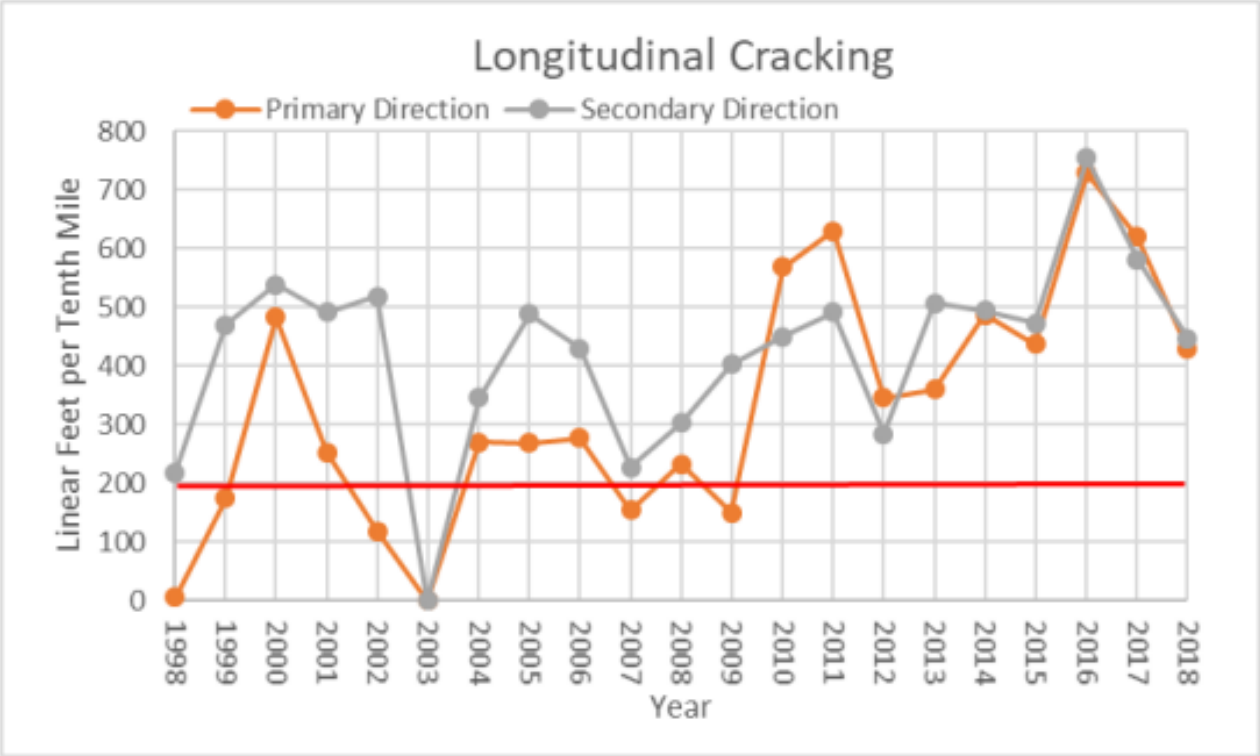

Longitudinal Cracks Primary Direction
2003
2004
2005
2006
2007
Linear Feet per Tenth Mile
800
700
600
500
400
300
200
100
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost


Longitudinal Cracks Primary Direction
2008
2009
2010
2011
2012
Linear Feet per Tenth Mile
800
700
600
500
400
300
200
100
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost


Longitudinal Cracks Primary Direction
2013
2014
2015
2016
2017
2018
Linear Feet per Tenth Mile
800
700
600
500
400
300
200
100
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost


Longitudinal Cracking Primary Direction
2017
2018
Linear Feet per Tenth Mile
800
700
600
500
400
300
200
100
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost


Longitudinal Cracking Secondary Direction
2017
2018
Linear Feet per Tenth Mile
800
700
600
500
400
300
200
100
0
427.0
428.0
429.0
430.0
431.0
432.0
433.0
434.0
435.0
436.0
Milepost


Longitudinal Cracking
Primary Direction
Secondary Direction
Linear Feet per Tenth Mile
800
700
600
500
400
300
200
100
0
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year