# Value Engineering Study Report
# I-70 Arriba

Colorado Department of Transportation
District 4
I-70 Arriba to Flagler, Colorado

September 2017
Study Dates: Sept 26 – Sept 28, 2017

Prepared By:

COLORADO
DEPARTMENT OF
TRANSPORTATION

JACOBS

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# 1.0
# EXECUTIVE SUMMARY

# 1.0 EXECUTIVE SUMMARY

## 1.1 INTRODUCTION

Jacobs was commissioned by the Colorado Department of Transportation (CDOT) to perform a 3-day Value Engineering (VE) Study for the I-70 Arriba Pavement Rehabilitation project located to the East and West of Arriba, Colorado. Jacobs provided the facilitation for the VE study.

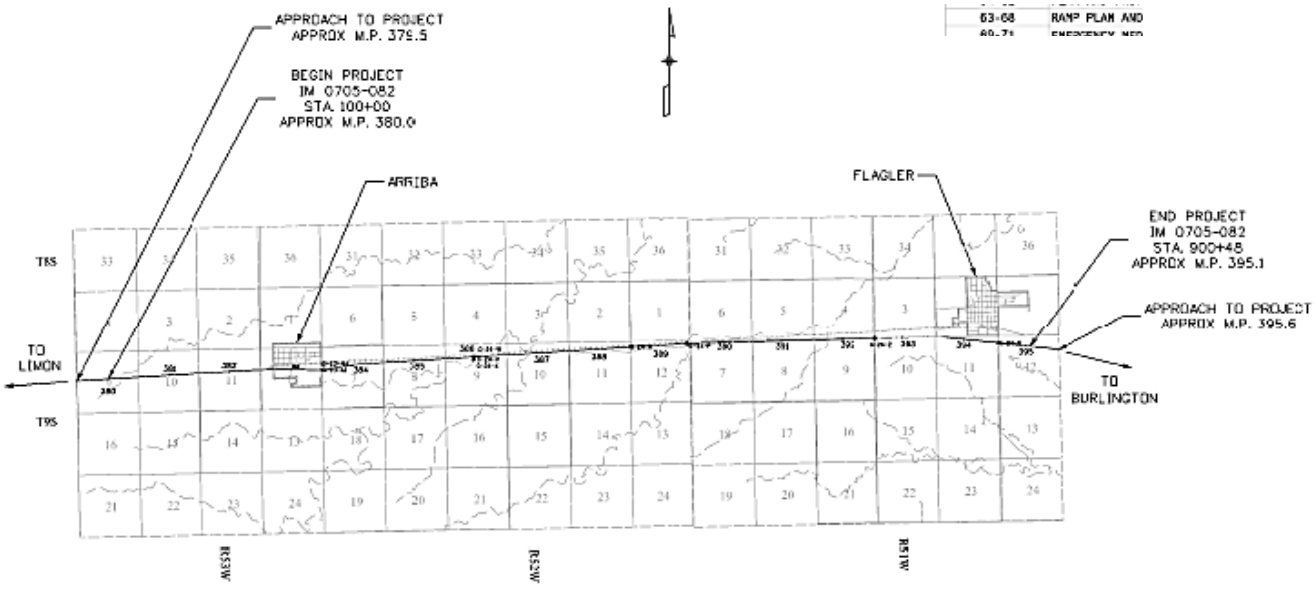
The VE Team concentrated their efforts on opportunities for value improvement and focused on the functional aspects of the project. This report documents the results of the VE study effort, and the processes and procedures followed during the study session. Proposals and design suggestions from the VE study are described in more detail in Section 2, and Section 3 includes information on the project cost.

Four appendices complete the report, as follows:

- Appendix A: Discusses Value Engineering methods and procedures used, and include the names and disciplines of the team members.
- Appendix B: Provides a list of documents furnished to the study team, project function identification, and the meeting minutes of the CDOT presentation of a project overview for the VE Team, and selected pages from the 2017 FIR plan set (30% to 60%)
- Appendix C: Includes a listing of all the ideas generated during Brainstorming and the results of the Idea Evaluation process.
- Appendix D: Includes the meeting minutes of the VE presentation.

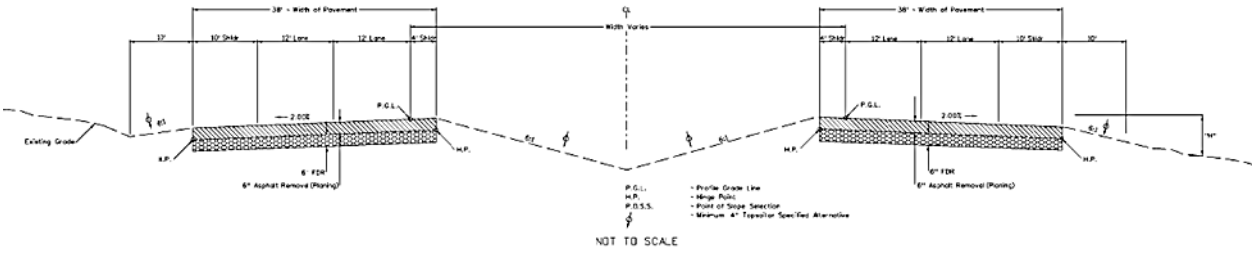
## 1.2 PROJECT DESCRIPTION and PURPOSE

The Colorado Department of Transportation (CDOT) is proposing to replace the pavement on I-70 to the east and west of Arriba between Sta. 100+00 (approx. MP 380.0) Sta. 900+48 (approx. MP 395.1) near Flagler, and within Lincoln and Kit Carson Counties, Colorado. This 15.1 mile long segment of I-70 was repaved with a new 2-1/2” asphaltic layer approximately four years ago. However, that pavement and the underlying layers have badly deteriorated in the four years since the re-pavement, especially in the westbound lanes. The deterioration has resulted in excessive maintenance as it is now necessary to continually repair the road surface and if left uncorrected driving conditions could become a safety hazard.




**Project Vicinity Map**

The majority of the I-70 roadways, including the segments abutting this project, are constructed as concrete pavement. The intent for this project is to remove all existing asphaltic pavement and replace it with concrete pavement. The underlying layers will also be reconstructed to the extent deemed necessary based upon pavement and subbase borings and interpretation thereof. The majority of pavement failure is related to water being retained under the pavement.




**Typical Highway Cross Section**

There are two bridges where clearance is an issue. For those two bridges the roadway subgrade will be lowered beginning about 500-feet from the bridge structure so that the required overhead clearance can be obtained.

For the reconstruction of the highway, traffic on the existing four-lane divided highway will be diverted over to one side of the divided highway using one-lane in each direction. Because of the length of the project and spanning across two interchanges, two cross-overs will be constructed as part of the project. This project is anticipated to be constructed in phases having two-segments in each direction to reduce the length of one-lane traffic in each direction.

During the construction staging, the concrete pavement will be required to have obtained 3,000 psi strength before traffic will be allowed on the new pavement.

## 1.3 CURRENT DESIGN INFORMATION

The project intent is to have the Final Office Review (90% design status) to be completed by the end of October 2017 and the Shelf Date for the design (100% design status) by December 2017. No date has been established yet for when the project will be bid and constructed, as funds are not fully available; the project will be bid as funding permits.

## 1.4 COST INFORMATION

The September 19, 2017 estimated construction cost estimate based upon the 2017 design documents is $79.3 million. This project construction budget is $85 million. A more complete discussion of the estimated project cost, markups and the cost models are included in Section 3 of this report.

## 1.5 SUMMARY OF VE RECOMMENDATIONS

Due to length and scope of this 15.1 mile rehabilitation project, the VE Team primarily concentrated on alternatives that would modify or reduce the pavement section or the detour and cross-over section and geometrics.

The table on the following page summarizes the VE proposals and presents costs with respect to construction issues. The VE Team identifies that some selected proposals will have life-cycle or Operational & Maintenance (O&M) savings, but in most cases life-cycle cost benefits were minimal and/or were not readily quantifiable during the VE timeframe provided. The potential O&M savings were therefore not tabulated.

The list of recommendations includes the FHWA designated functional benefit categories, shown parenthetically in each of the descriptions, as they apply. The FHWA designations consist of: Safety (S), Operations (OP), Environmental (E), Construction (C), or Other (O).

The VE recommended proposals have been estimated using the project estimate as the basis for pricing. If all recommended VE proposals are accepted and implemented together, then the overall potential cost savings would be reduced based upon the overlap of the concepts and impacts to the roadway and pavement sections. A list of all VE proposals is included in Section 2.0, and “Recommended Value Engineering Proposals” are summarized on the following page.

**Recommended Value Engineering Proposals**

| Idea# | Description | Recommended | Potential Savings | Max Potential Savings |
|---|---|---|---|---|
| 1 | Interchange Ramp Crossover – Right in Right Out – Two way ramp. (OP) | Y | $985,000 | |
| 1A | Interchange Ramp Crossover – Low Speed Crossovers. (OP) | Y | $802,000 | |
| 2 | Use taper style off-ramps versus parallel for temporary detour. (OP) | Y | $1,030,000 | $1,030,000 |
| 4 | Use 13 foot slab width to allow thinner slab. (C ) | Y | $15,034,000 | $3,000,000 |
| 6 | Use thinner concrete section for outside shoulders. (C ) | Y | $1,780,000 | $1,417,000 |
| 7 | Reduce width of detour crossover from 20 feet to 16 feet. (C ) | Y | $263,000 | $200,000 |
| 8 | Reduce detour pavement section from 8” HMA plus 6” ABC to 6” HMA and 6” ABC. (C ) | Y | $525,905 | $342,000 |
| **Total Maximum Potential Savings** | | | | **$5,989,000** |

Notes:

1) VE Ideas 1, 1A and 2 are recommended but are related and only one alternative can move forward; the VE team recommends VE#2.
2) The Maximum potential savings is a reduction of the potential savings as a result if all VE items were implemented.

# 2.0
# VE STUDY ITEMS AND RECOMMENDATIONS

## 2.0 VE PROPOSALS AND DESIGN CONSIDERATIONS

VE PROPOSALS

On the following pages each VE proposal is described individually, and as applicable each proposal includes a description of the relevant aspects of the current design, a description of the VE proposal, advantages and disadvantages an estimate, and additional text and information necessary to convey the concept.

All VE proposals that moved forward from the "Idea Generation" phase are contained within this section. For this particular study, the VE team determined which of the VE proposals were recommended for further consideration. A "Summary of VE Proposal Implementation Recommendations" is shown below. The potential savings for each proposal is indicated in the table with the maximum potential savings recognized if all VE items are considered. Some VE items are not mutually exclusive so the combined cost savings (maximum potential savings) reflects the overall reduced savings. Refer to the individual discussion in each of the proposals for more information.

### Summary of VE Proposal Implementation Recommendations

| Idea# | Description | Recommended | Potential Savings | Max Potential Savings |
|---|---|---|---|---|
| 1 | Interchange Ramp Crossover – Right in Right Out – Two way ramp. | Y | $985,000 | |
| 1A | Interchange Ramp Crossover – Low Speed Crossovers. | Y | $802,000 | |
| 2 | Use taper style off-ramps versus parallel for temporary detour | Y | $1,030,000 | $1,030,000 |
| 3 | Use taper style off-ramps versus parallel for permanent | N | - | |
| 4 | Use 13 foot slab width to allow thinner slab | Y | $15,034,000 | $3,000,000 |
| 5 | Use asphalt shoulders | N | - | |
| 6 | Use thinner concrete section for outside shoulders | Y | $1,780,000 | $1,417,000 |
| 7 | Reduce width of detour crossover from 20 feet to 16 feet. | Y | $263,000 | $200,000 |
| 8 | Reduce detour pavement section from 8" HMA plus 6" ABC to 6" HMA and 6" ABC. | Y | $525,905 | $342,000 |
| 9 | Issue west bound reconstruction as a separate contract if funding is limited. | Design Consideration | - | |
| 10 | Remove six inches of ABC in detour (full depth asphalt). | See Idea #8 | $517,139 | |

## Summary of VE Proposal Implementation Recommendations

| Idea# | Description | Recommended | Potential Savings | Max Potential Savings |
|---|---|---|---|---|
| 11 | Require WB construction as first construction phase. | See Idea #9 | - | |
| 12 | For EB lanes only use unbonded white topping | N | - | |
| 13 | For EB lanes only use bonded white topping | N | - | |
| 14 | Remove unstable soil to limits necessary, for reconstruction of base. | Design Consideration | - | |
| 15 | Use PCCP over existing HMA. | See Idea #12 &13 | - | |
| | **Maximum Potential Savings:** | | | **$5,989,000** |

| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#1** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-# 1 Proposal:** Interchange Ramp Crossover – Right in Right Out – Two way ramps

**Current Design:**
- Requires standard ramp cross overs be built for the off and on ramp on each side of the interchange.
- Will require short term ramp crossovers be built to construct and fill in gaps on mainline where ramp crossovers pass over mainline.
- Above will be completed once for WB, and once for EB construction.

Required at both Arriba and Flagler interchanges.

**Description of VE Alternative #1:**

This idea isolates impacted ramp cross over construction to less area by utilizing a two-way ramp, ending in a T-intersection with a right-in and right-out configuration.

The proposed idea constructs acceleration and deceleration lanes along the existing pavement in the median, minimizing cross overs and earthwork. Cross overs will only be required over a 300-foot area, and will handle both the long term and short term crossover needs.

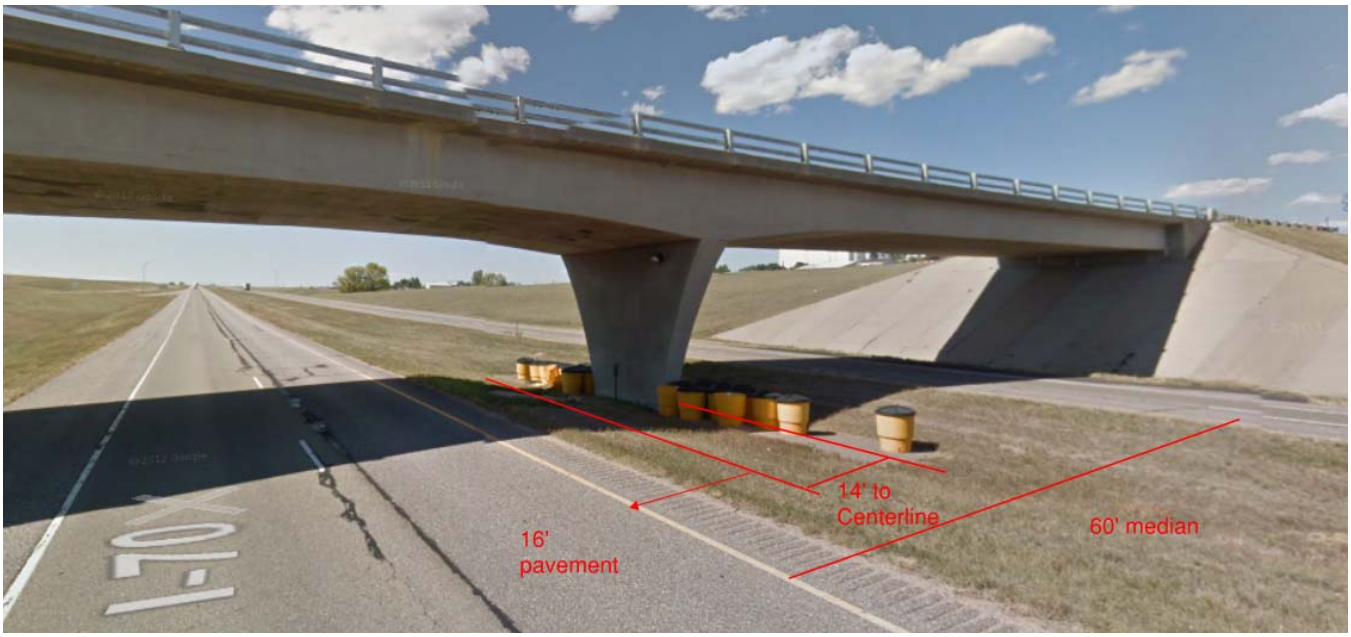
Design will require that acceleration and deceleration lanes be built to accommodate 0-55 mph speed transition

Proposed design reduces both the Square Yards of Detour Pavement (which is the pay item), and reduces the earthwork which would be built into the cost of the pay item. The estimate considers the reduced earthwork required by reducing the SY cost by 5%.

**Advantages:**
1. Reduce detour pavement
2. Reduce embankment
3. Construction time savings –
    a. Switching between standard crossover and short term crossover requires less work.
    b. Two ramp gores can be built during mainline construction.
4. Avoid filling over mainline

**Disadvantages:**
1. Configuration different than normal expectations – Normal ramp access configurations.
2. Reduced speeds with essentially stop conditions at ramp gores – Acceleration and Deceleration take place after crossover.
3. Requires longer acceleration lane
4. Less desirable for trucks
5. U-turn movement for trucks
6. On the Flagler interchange where the median is only 60’ instead of 120’, the alignment will be tighter. See following detail.

## Arriba Median Restrictions




| Cost Summary | | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | $0.00 | $2,241,107 | $2,241,107 |
| Proposed | $0.00 | $1,256,000 | $1,256,000 |
| Savings | $0.00 | $985,107 | $985,107 |

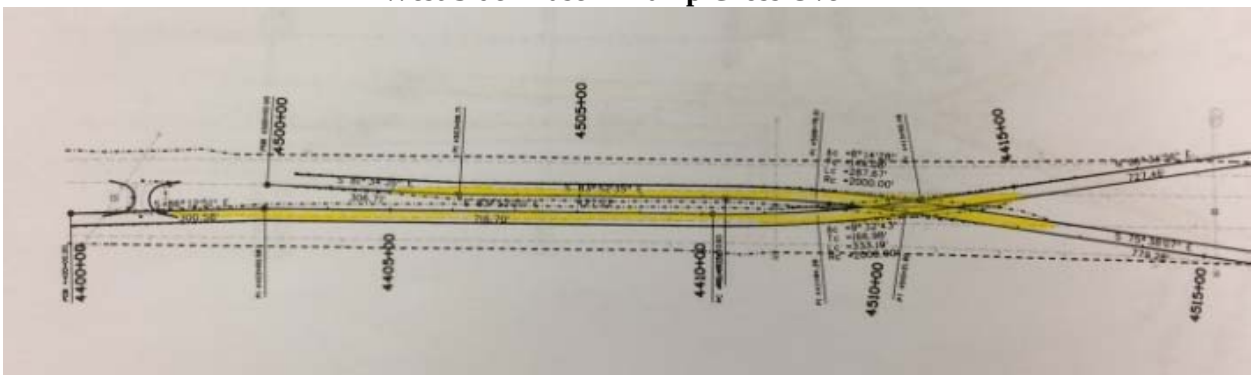
**Recommendation/Discussion:**

The VE Team recommends using this Alternative or Alternative 1A:

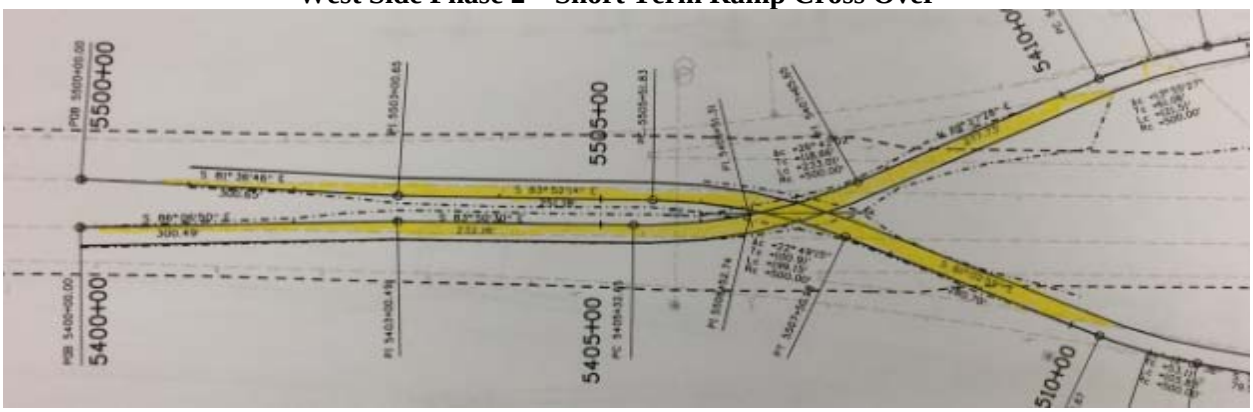
- Close proximity of long term and short term connection
- Allows construction of half of ramps and gores during long term construction phase
- Since Phase 1 construction builds gore, Phase 2 can utilize this pavement for crossover.
- Disadvantage
  - 0-55 and u-turn movement for trucks.
  - Flagler – Minimum median widths
- Cost Savings
  - Reduced SY cost by 5% for reduction in earthwork
  - See summarized overall savings – 56% of original cost

**Original Concept Sketch:**

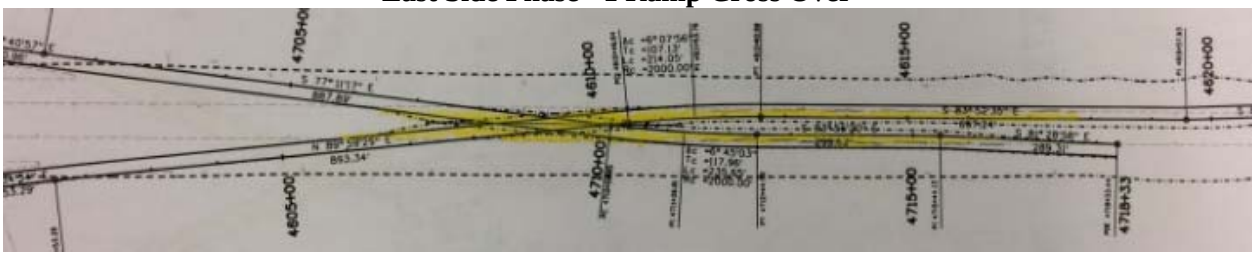
**West Side Phase 1- Ramp Cross Over**



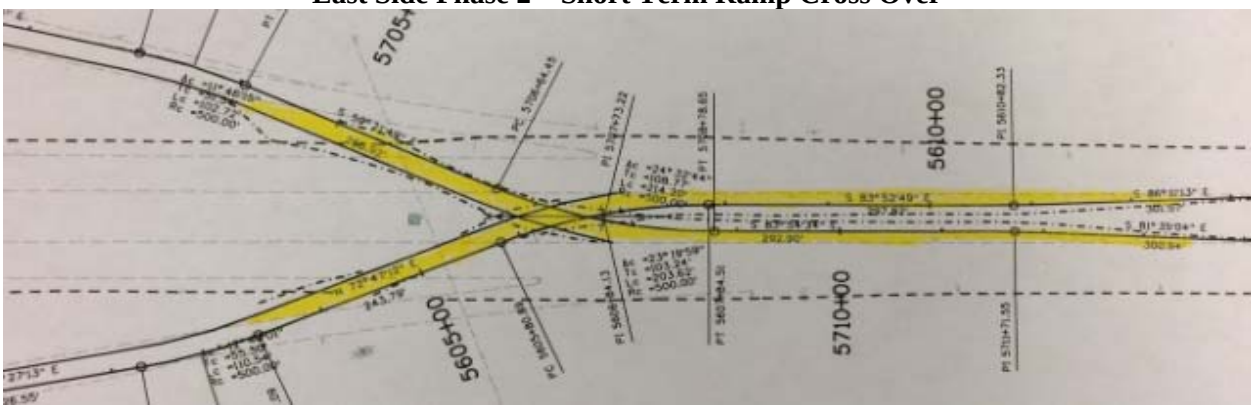
**West Side Phase 2 – Short Term Ramp Cross Over**



**East Side Phase - 1 Ramp Cross Over**



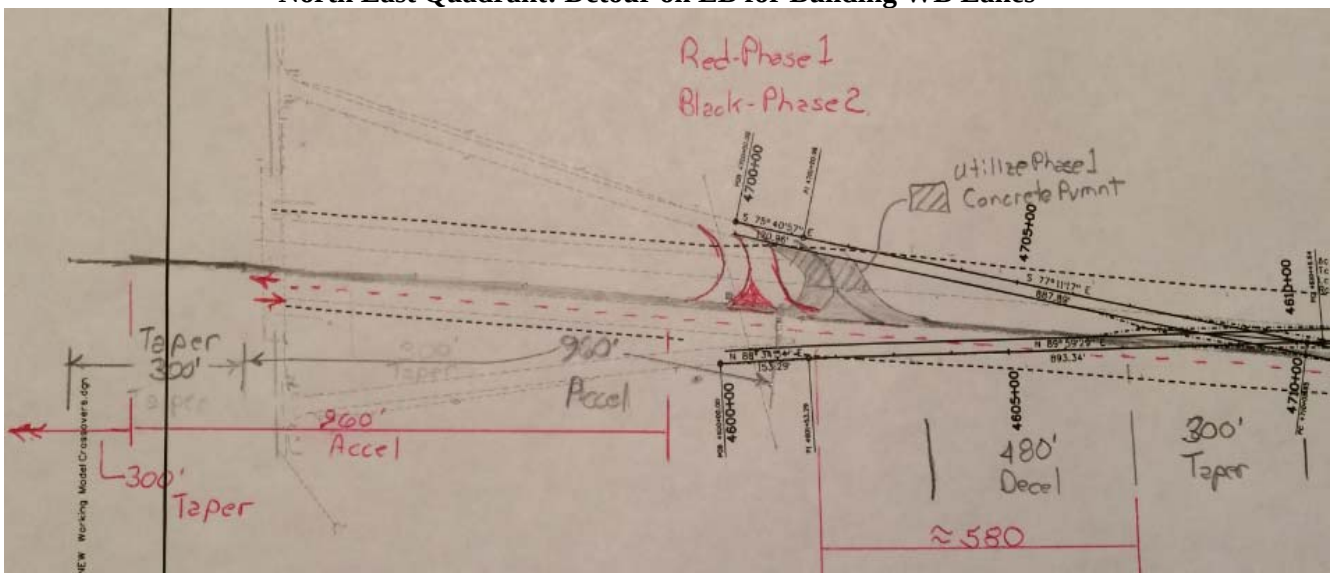
**East Side Phase 2 – Short Term Ramp Cross Over**



| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#1** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE Proposal Sketch:**

**North East Quadrant: Detour on EB for Building WB Lanes**



# *COST WORKSHEET*

**Proposal No:** VE-#1

**Idea No:** VE-#1

| Item | Qty | Unit | Original Estimate | | New Estimate | |
|---|---|---|---|---|---|---|
| | | | Cost | Total | Cost | Total |
| **Current Design** | | | | | | |
| Detour Pavement | | | | | | |
| Flagler | 13,671 | SY | $ 60 | $ 820,260 | | |
| Arriba | 14,583 | SY | $ 60 | $ 874,980 | | |
| **Proposed Design** | | | | | | |
| Detour Pavement (North Side) (Flagler) | | | | | | |
| 12' (960 + 250 + 580) / 9 | 2,387 | SY | | | $57.00 | $ 136,059 |
| (12' / 2) (300 +300) / 9 for tapers | 400 | SY | | | $57.00 | $ 22,800 |
| (105+105+45+75) * 24 wide / 9 | 880 | SY | | | $57.00 | $ 50,160 |
| Detour Pavement (South Side) (Flagler) | 3,667 | SY | | | $57.00 | $ 209,019 |
| | | | | | | $ - |
| Detour Pavement (North Side) (Arriba) | 3,667 | SY | | | $57.00 | $ 209,019 |
| Note - Median 120' instead of 60' | | | | | | $ - |
| Add 60 * 150 / 9 | 1,000 | SY | | | $57.00 | $ 57,000 |
| Detour Pavement (South Side) (Arriba) | 4,667 | SY | | | $57.00 | $ 266,019 |
| | | | | | | $ - |
| | | | | | | $ - |
| *Markup =32.2% ( includes Mobilization | | | | | | |
| Const.Engr and Minor Contract Rev.) | | | | | | |
| Total: | | | | $ 1,695,240 | | $ 950,076 |
| *Markup | 32.2% | | | $ 545,867 | | $ 305,924 |
| Totals | | | | $ 2,241,107 | | $ 1,256,000 |
| | | | | $ (1,256,000) | | |
| **Difference :** | | | | **$ 985,107** | | |

COLORADO DEPARTMENT OF TRANSPORTATION

**CDOT**

I-70 Arriba: East and West
Arriba, CO

By: DV Date: 9/27/17 Page: 5 of 5

| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#1A** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-# 1A Proposal:** Interchange Ramp Crossover – Low Speed Crossovers

**Current Design:**

Requires standard ramp cross overs be built for the off and on ramp on each side of the interchange.

- Will require short term ramp crossovers be built to construct and fill in gaps on mainline where ramp crossovers pass over mainline.
- Above will be completed once for WB, and once for EB construction.

Required at both Arriba and Flagler interchanges.

**Description of VE Alternative #1A:**

This idea isolates the impacted ramp cross over construction to less area, by utilizing low speed ramp cross overs at gore connections with I-70.

The proposed idea constructs accel and decel lanes along the existing pavement in the median, minimizing cross overs and earthwork. Cross overs will only be required over a 300 to 400-foot area, and will handle both the long-term and short-term crossover needs.

Design does require accel and decel lanes be built to accommodate 10-55 mph speed transition.

Unlike VE #1; VE #1A utilizes all current ramp access and directional movements.

Proposed design reduces both the Square Yards of Detour Pavement (which is the pay item), and reduces the earthwork which would be built into the cost of the pay item. The estimate does not consider reduced earthwork that is built into the overall unit cost; this could result in an additional 5% cost reduction.

During Phase 1

- Construct Mainline and Ramp Pavement to Gore except in area of cross over
- Utilize this pavement during Phase 2

**Advantages:**

1. Reduces detour pavement
2. Reduces embankment required
3. Construction time savings –
    a. Switching between standard crossover and short-term crossover requires less work.
4. Avoid filling over constructed mainline during 2nd phase movements
5. Advantages over VE #1
    a. Normal expected ramp and highway access.
    b. Avoids temporary lane widening in median under bridge.

**Disadvantages:**

1. Configuration different than normal expectations – Normal ramp access configurations.
2. Reduced speeds with essentially stop conditions at ramp gores – Acceleration and Deceleration take place after crossover.
3. Requires longer acceleration lane
4. Less desirable for trucks – although better than VE #1

| Cost Summary | | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | $0.00 | $2,241,107 | $2,241,107 |
| Proposed | $0.00 | $1,438,659 | $1,438,659 |
| Savings | $0.00 | $802,449 | $802,449 |

**Recommendation/Discussion:**

The VE Team recommends this Alternative or alternative VE #1

Advantages over VE #1

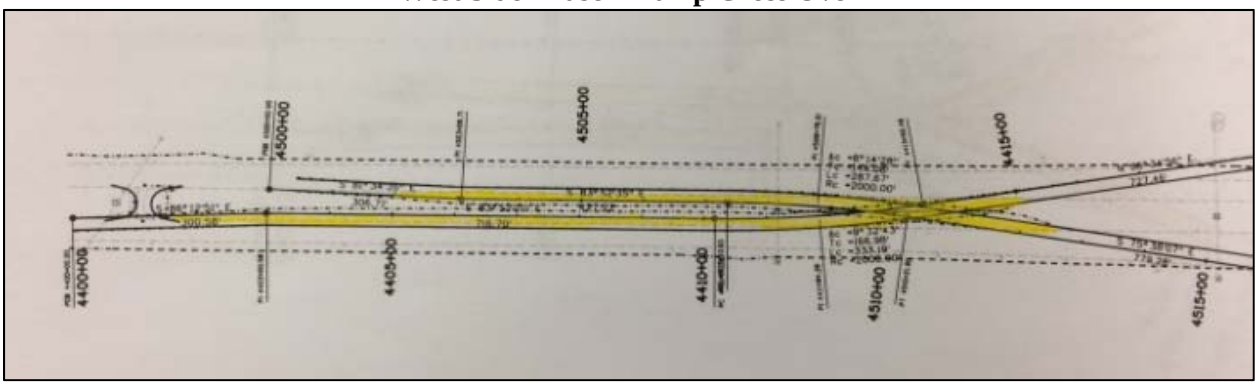
- Normal expected ramp and highway access
- Avoids temporary lane widening in median under bridge.
- Beginning speed closer to 10 mph instead of 0 mph

Cost Savings

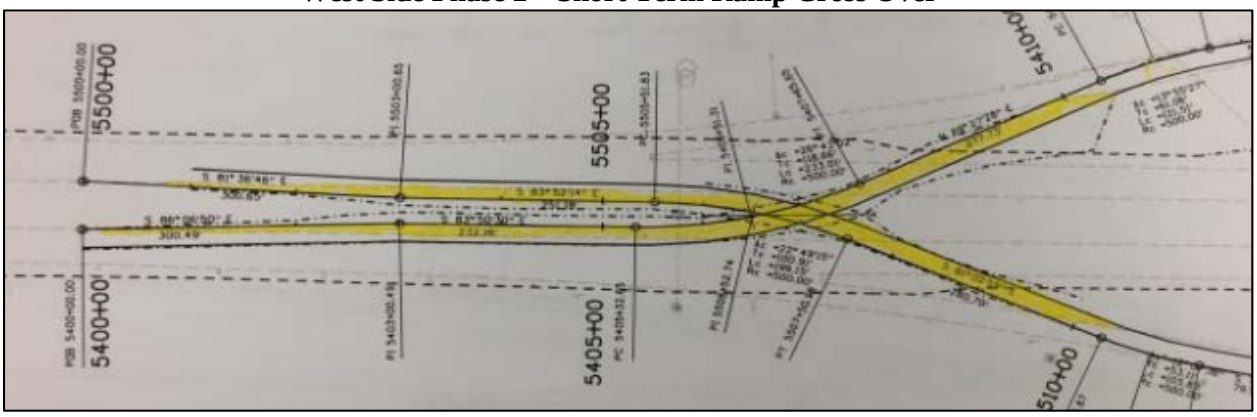
- Reduced SY cost by 5% for reduction in earthwork
- See summarized overall savings – 64% of original cost

**Original Concept Sketch:**

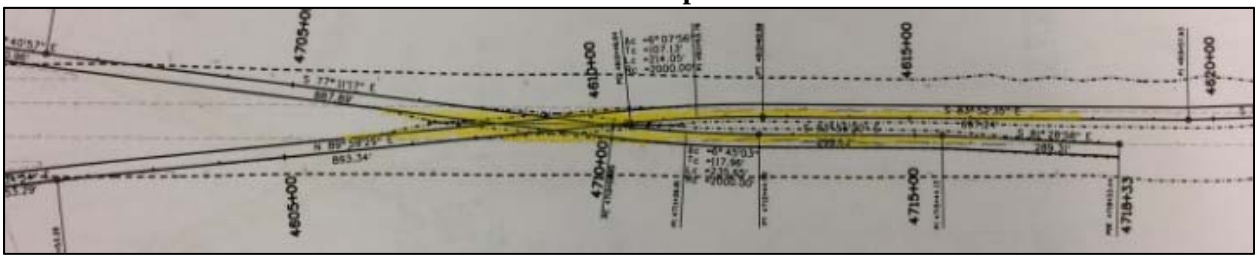
**West Side Phase 1 Ramp Cross Over**



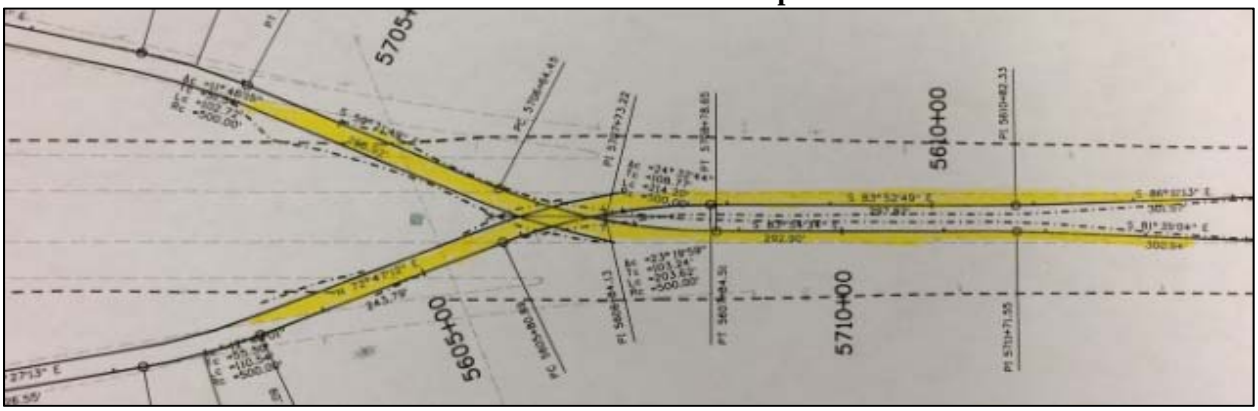

**West Side Phase 2 – Short Term Ramp Cross Over**




**East Side Phase 1 Ramp Cross Over**

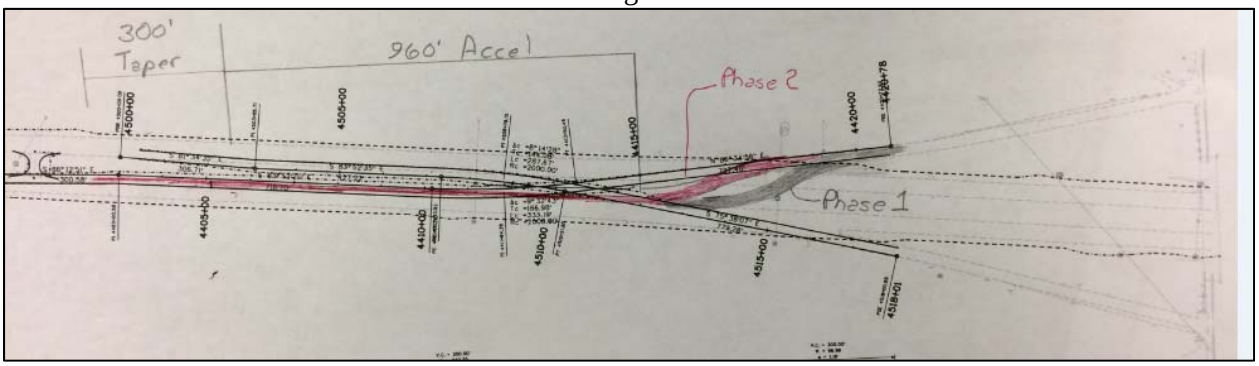


**East Side Phase 2 – Short Term Ramp Cross Over**

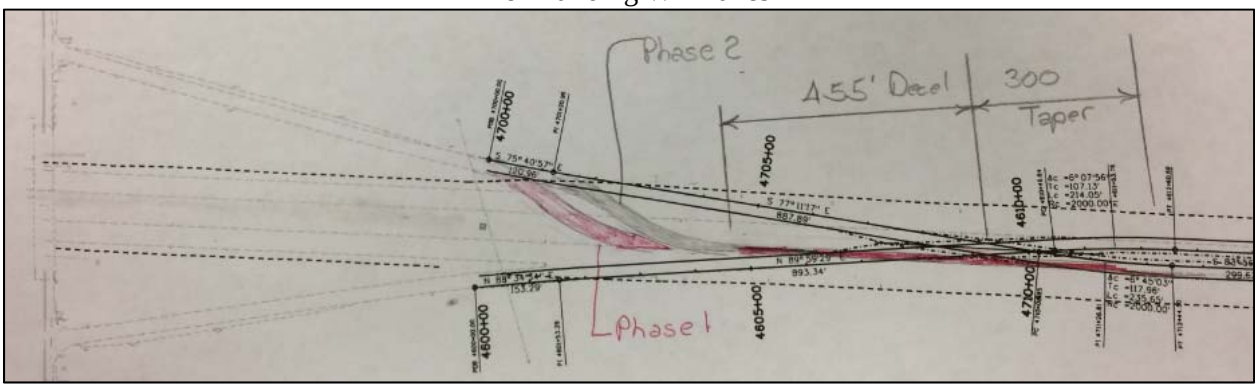



**VE Proposal Sketch:**

Decel Lane to NE Ramp
For Building WB Lanes




Accel Lane off NW Ramp
For Building WB Lanes



# *COST WORKSHEET*

**Proposal No:** VE-#1A

**Idea No:** VE-#1A

| Item | Qty | Unit | Original Estimate | | New Estimate | |
|---|---|---|---|---|---|---|
| | | | Cost | Total | Cost | Total |
| Current Design | | | | | | |
| Detour Pavement | | | | | | |
| Flagler | 13,671 | SY | $ 60 | $ 820,260 | | |
| Arriba | 14,583 | SY | $ 60 | $ 874,980 | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Proposed Design | | | | | | |
| Detour Pavement (Decel - WB) (Flagler) | | | | | | |
| 12' (455 + 125) / 9 | 773 | SY | | | $57.00 | $ 44,061 |
| (12' / 2) (300) / 9 | 200 | SY | | | $57.00 | $ 11,400 |
| 20 * 300 / 9 | 667 | SY | | | $57.00 | $ 38,019 |
| Phase 2 - 100 * 20 / 9 | 222 | SY | | | $57.00 | $ 12,654 |
| | | | | | | |
| Detour Pavement (Decel - EB) (Flagler) | 1,862 | SY | | | $57.00 | $ 106,134 |
| | | | | | | $ - |
| Detour Pavement (Accel - WB) (Flagler) | | | | | | $ - |
| 12' (960 + 140) / 9 | 1,467 | SY | | | $57.00 | $ 83,619 |
| (12' / 2) (300) / 9 | 200 | SY | | | $57.00 | $ 11,400 |
| 20 * 270 / 9 | 600 | SY | | | $57.00 | $ 34,200 |
| Phase 2 - 110 * 20 / 9 | 244 | SY | | | $57.00 | $ 13,908 |
| | | | | | | |
| Detour Pavement (Accel - EB Side) (Flagler) | 2,511 | SY | | | $57.00 | $ 143,127 |
| | | | | | | |
| Detour Pavement (Decel - WB) (Arriba) | 1,862 | SY | | | $57.00 | $ 106,134 |
| Extra median 2 * (90 * 20 / 9) | 400 | SY | | | $57.00 | $ 22,800 |
| Detour Pavement (Decel - EB) (Arriba) | 1,862 | SY | | | $57.00 | $ 106,134 |
| Extra median 2 * (90 * 20 / 9) | 400 | SY | | | $57.00 | $ 22,800 |
| Detour Pavement (Accel - WB) (Arriba) | 2,511 | SY | | | $57.00 | $ 143,127 |
| Extra median 2 * (90 * 20 / 9) | 400 | SY | | | $57.00 | $ 22,800 |
| Detour Pavement (Accel - EB Side) (Arriba) | 2,511 | SY | | | $57.00 | $ 143,127 |
| Extra median 2 * (90 * 20 / 9) | 400 | SY | | | $57.00 | $ 22,800 |
| | | | | | | |
| *Markup =32.2% ( includes Mobilization | | | | | | |
| Const.Engr and Minor Contract Rev.) | | | | | | |
| | | | | | | |
| Total: | | | | $ 1,695,240 | | $ 1,088,244 |
| *Markup | 32.2% | | | $ 545,867 | | $ 350,415 |
| Totals | | | | $ 2,241,107 | | $ 1,438,659 |
| | | | | $ (1,438,659) | | |
| **Difference :** | | | | **$ 802,449** | | |

COLORADO DEPARTMENT OF TRANSPORTATION

**CDOT**

I-70 Arriba: East and West
Arriba, CO

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| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#2** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-#2 Proposal:**
Use taper style off-ramps versus parallel for all eight temporary off ramp detours.

**Current Design:**
The current FIR plans show a parallel type of off-ramp design. Temporary off-ramp designed at 35mph (500-foot radius) assumed.

**Description of VE Alternative #2:**
Use taper style off-ramps versus parallel for temporary off-ramp detours. During construction the work zone speed limit and off-ramp radius design speed was assumed to be 55 mph and 35 mph, respectively. Based upon CDOT and AASHTO criteria the deceleration lane length is 350-feet. When compared to a parallel type of off-ramp, a taper style off-ramp with a 5-degree divergence angle can be constructed with 45% less temporary (detour) pavement.

This reduction can be achieved over the eight temporary ramp locations: CCO2 thru CCO5 and CCO8 thru CCO11

Use of temporary taper type of on-ramps was considered earlier in design and eliminated. VE# 2 is a standalone alternative, and not compatible with VE #1 and #1A

**Advantages:**

1. Less detour pavement
2. Save cost
3. Compatible with current design
4. Accommodates 35mph exit ramp speed.

**Disadvantages:**

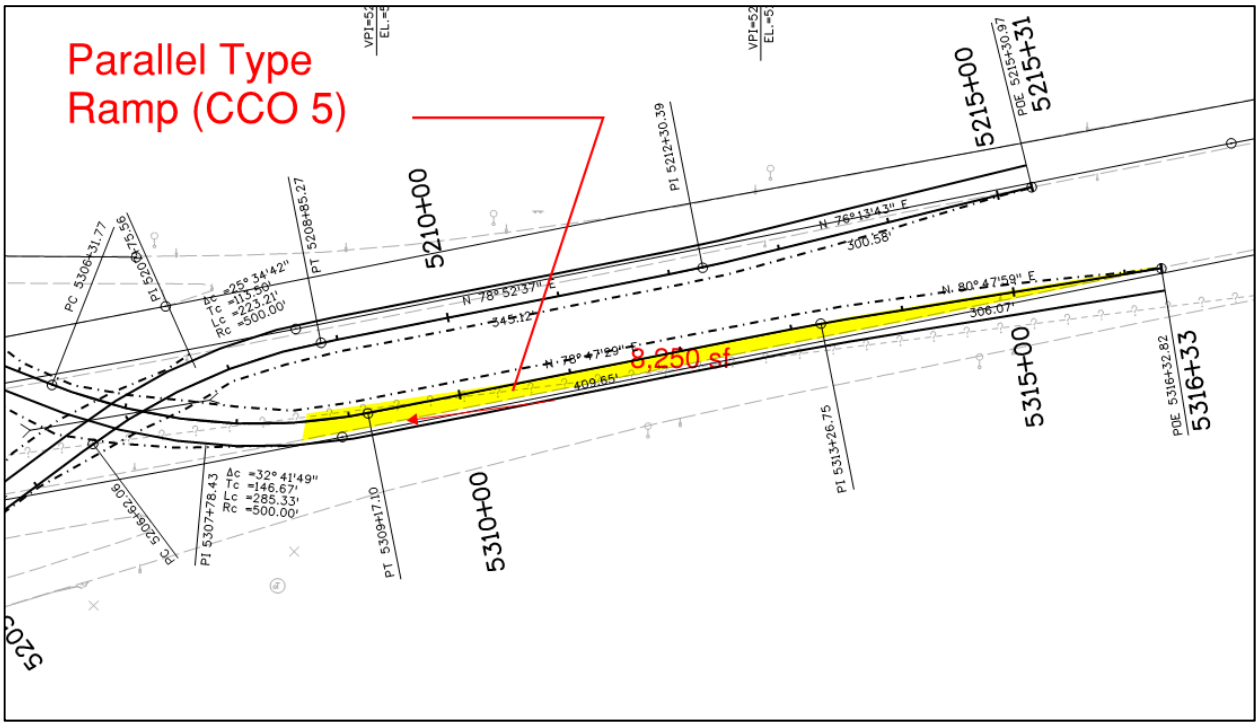
1. None

| Cost Summary | | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | | $2,303,453 | $2,303,453 |
| Proposed | | $1,275,694 | $1,275,694 |
| Savings | | $1,027,759 | $1,027,759 |

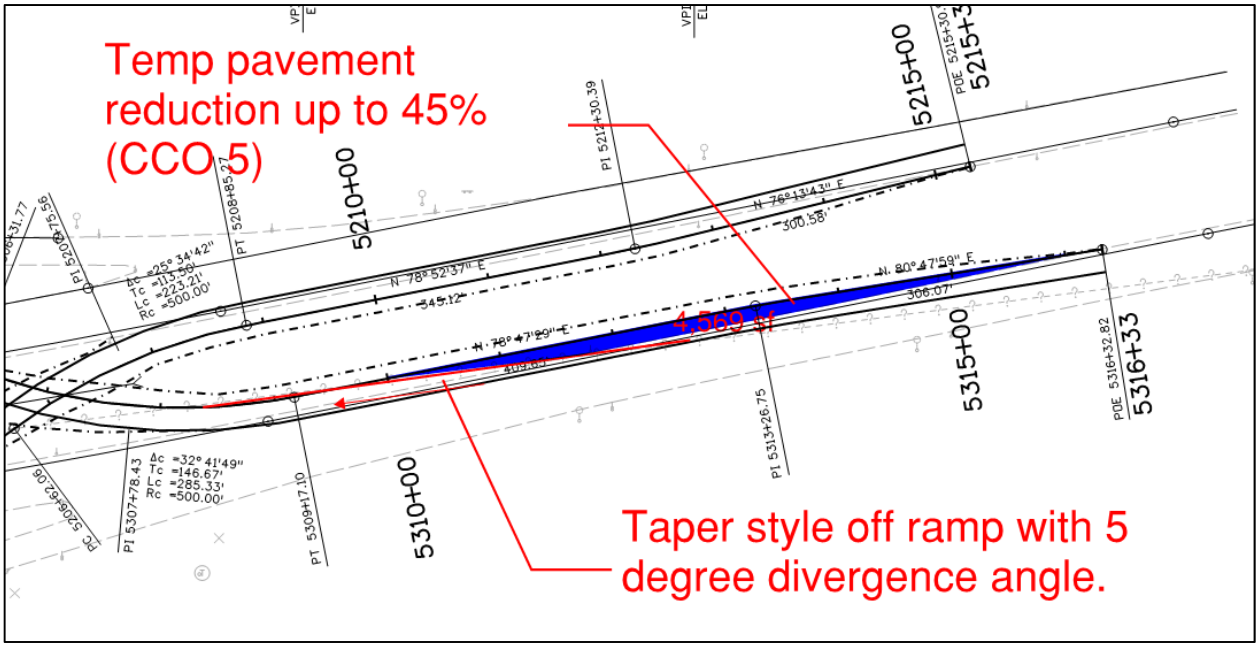
**Recommendation/Discussion:**

The VE Team recommends this Alternative

**Original Concept Sketch:**




**VE Proposal Sketch:**



# *COST WORKSHEET*

**Proposal No:** VE-#2

**Idea No:** VE-#2

| Item | Qty | Unit | Original Estimate | | New Estimate | |
|---|---|---|---|---|---|---|
| | | | Cost | Total | Cost | Total |
| Idea #2 reduces detour pavement to | | | | | | |
| 16-feet on mainline | | | | | | |
| 8 ramp locations: CC02,CC03,CC04,CC05,CC08,CC09,CC010,CC011, | | | | | | |
| | | | | | | |
| Current Design | | | | | | |
| Detour Pavement | | | | | | |
| Detour Pavement-temp parallel ramp (pg 76) | 29,040 | SY | $ 60 | $ 1,742,400 | | |
| (3,630 SY per each location | | | | | | |
| equals a total of 29,040 SY for 8 locations) | | | | | | |
| Proposed Design | | | | | | |
| Detour Pavement | | | | | | |
| Detour Pavement-temp taper ramp (pg 76) | 16,082.88 | SY | $ 60 | | $ 60 | $ 964,973 |
| (2,010.36 SY per each location | | | | | | |
| equals a total of 16,082.88 SY for 8 locations) | | | | | | |
| *Markup =32.2% ( includes Mobilization | | | | | | |
| Const.Engr and Minor Contract Rev.) | | | | | | |
| Total: | | | | $ 1,742,400 | | $ 964,973 |
| *Markup | 32.2% | | | $ 561,053 | | $ 310,721 |
| Totals | | | | $ 2,303,453 | | $ 1,275,694 |
| | | | | $ (1,275,694) | | |
| **Difference :** | | | | **$ 1,027,759** | | |

COLORADO DEPARTMENT OF TRANSPORTATION

**CDOT**

I-70 Arriba: East and West
Arriba, CO

By: LC | Date: 9/27/17 | Page: 3 of 3

| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#3** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-# 3 Proposal:**
Use taper style off-ramps at the interchanges versus parallel ramps, for the permanent ramps.

**Current Design:**
The current FIR plans show an overlay for all permanent ramp connections.

**Description of VE Alternative #3:**
Verify ramp types at interchanges. Consider the use of taper style off-ramps for all the off-ramps. Taper type off- ramps can be constructed with less permanent material, when compared to parallel type ramps. Review of plans could not determine the ramp type at each interchange.

Note: during field visit and additional discussion with CDOT staff during the study; revealed that the design intent it to use taper style ramps. The concept was not clear in the current plan set, but will be updated for clarity in the upcoming submittal.

**Advantages:**

1. Less permanent pavement
2. Save cost

**Disadvantages:**

1. None

| Cost Summary | | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | | N/A | N/A |
| Proposed | | N/A | N/A |
| Savings | | N/A | N/A |

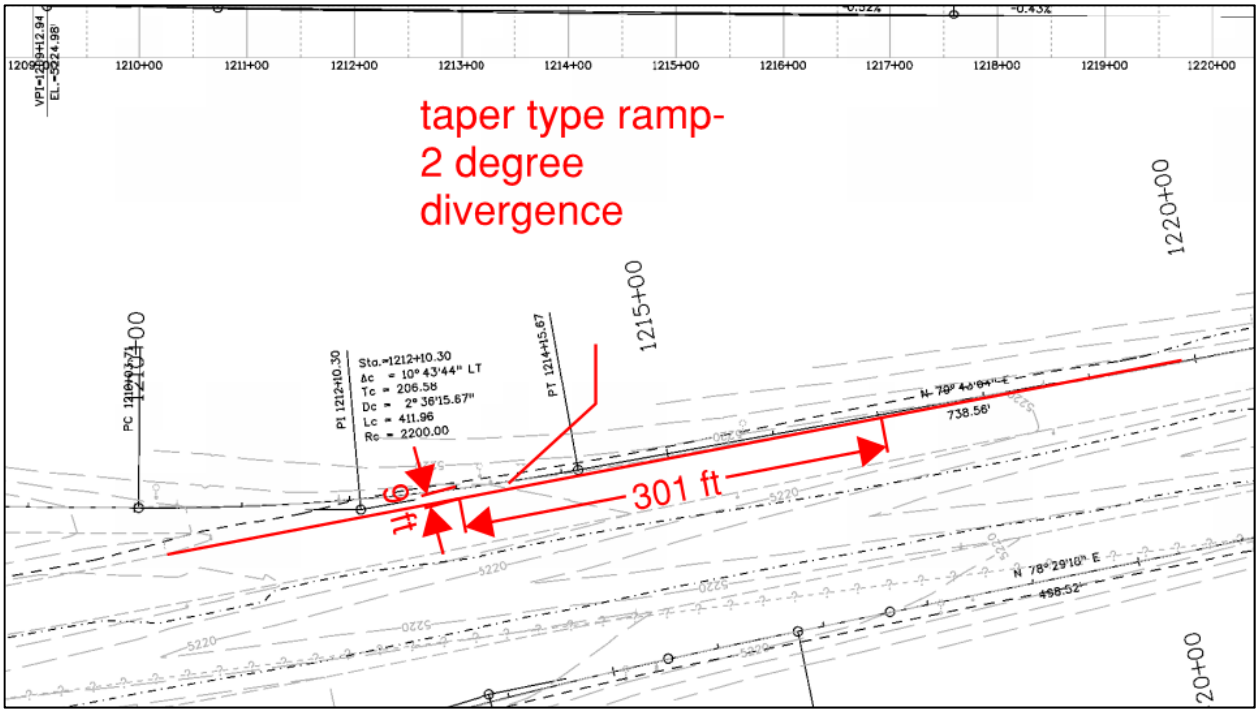
No cost savings recognized for this VE item.

**Recommendation/Discussion:**

The VE Team recommends this Alternative, but after conversations with CDOT and field measurements this concept is currently intended to be incorporated and the current cost estimate reflects this concept. Recommend to provide additional information in Plan set for this concept.

| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#3** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**Sketch:**



| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#04** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-# Proposal:**
Use 13-foot width PCCP slab to allow for a thinner concrete slab section

**Current Design:**
Current design indicates placing a 12-inch of PCCP over 6-inch of Full Depth Reclaimed (FDR) material, using 12-foot wide slabs for the travel lanes, with a 4-foot wide and 10-foot wide shoulder slabs on either side.

**Description of VE Alternative #04:**
This VE alternative proposes to widen the slab to 13-feet which will allow the PCCP slab thickness to be decreased to an 8.5 inch slab (using 1.25-inch dowel bars), placed over 6-inches of FDR. The shoulder slabs would be adjusted to 3-feet and 9-feet on either side.

**Advantages:**

1. Significantly lowers the construction cost of PCCP.
2. Lowers the top of new road surface 3.5 inches, reducing the amount of earthwork required along shoulders

**Disadvantages:**
1. Past experience at CDOT is that 8-inch slabs have not performed adequately over time with the high truck volumes experienced by I-70 in this area.

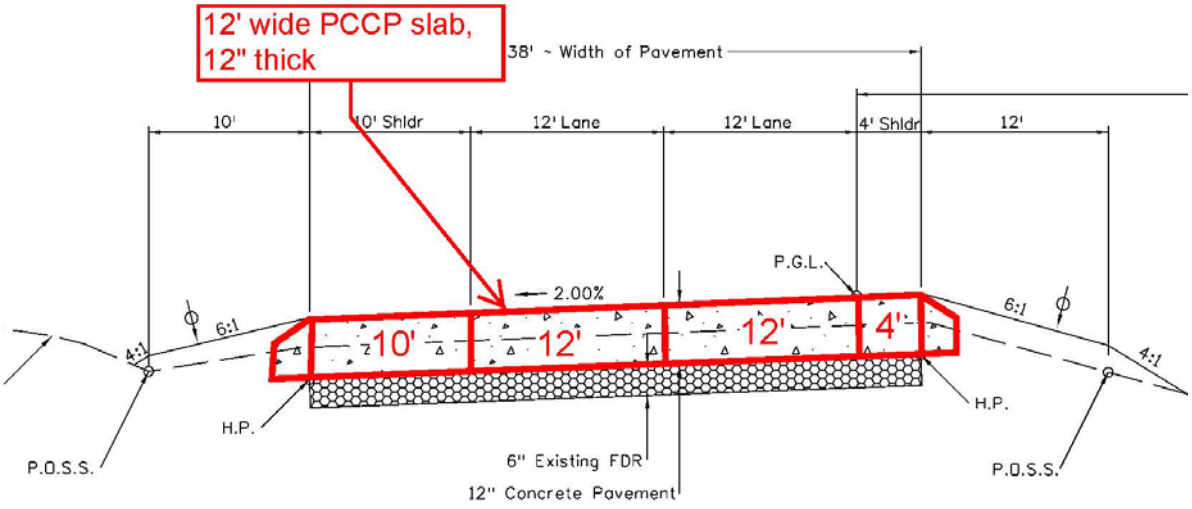
| **Cost Summary** | | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | | $39,091,085 | $39,091,085 |
| Proposed | | $27,719,133 | $27,719,133 |
| *Savings** | | *$15,033,721* | *$15,033,721** |

**The VE Team recommendation is to go with a smaller reduction in PCCP, assume 20% of savings using a slab width reduced by only 1-inch ($3M)*

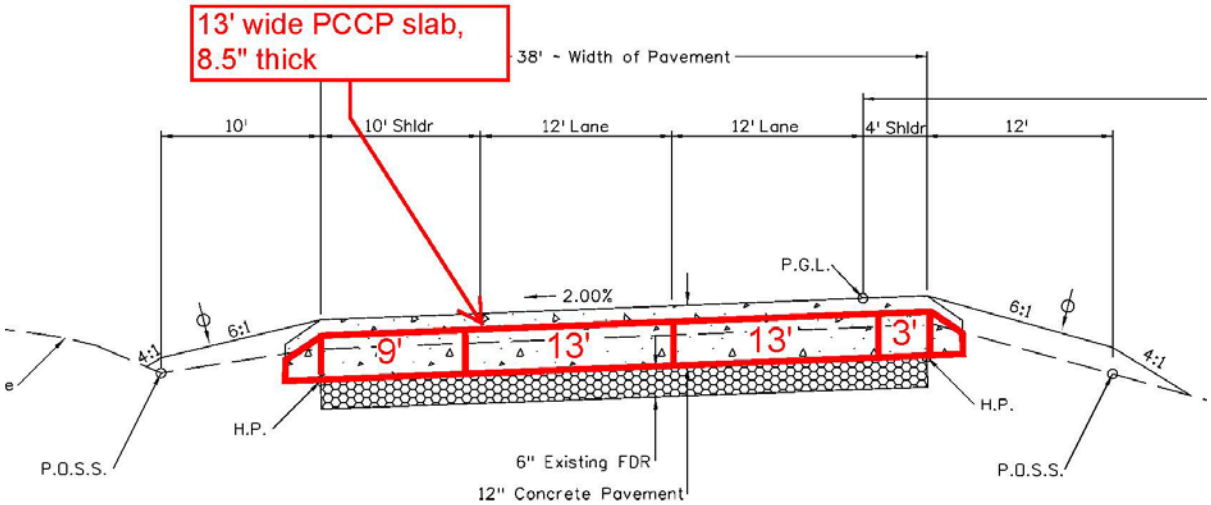
**Recommendation/Discussion:**

The VE Team recommends the reduction of slab thickness using a wider slab. However, the VE team does not recommend going to an 8.5-inch slab. The VE Team recommends that further investigation be performed for this alternative, and the design team should considered using a 13-foot or 14-foot slab, with a thickness between 10 and 12-inch.

**Original Concept Sketch:**




**VE Proposal Sketch:**




- The VE team does not recommend the 8.5-inch thick slab, but recommends the design team consider a reduces slab thickness with the wider slab

# *COST WORKSHEET*

**Proposal No:** VE-#04

**Idea No:**

| Item | Qty | Unit | Original Estimate | | New Estimate | |
|---|---|---|---|---|---|---|
| | | | Cost | Total | Cost | Total |
| Current Design | | | | | | |
| 12" PCCP with 1.5" Dowel Bars | 710,747 | YD | $ 55 | $ 39,091,085 | | |
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| Proposed Design | | | | | | |
| | | | | | | |
| 8.5" PCCP with 1.25" Dowel Bars | 710,747 | YD | | | $ 39 | $ 27,719,133 |
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| *Markup =32.2% ( includes Mobilization | | | | | | |
| Const.Engr and Minor Contract Rev.) | | | | | | |
| | | | | | | |
| Total: | | | | $ 39,091,085 | | $ 27,719,133 |
| *Markup | 32.2% | | | $ 12,587,329 | | $ 8,925,561 |
| Totals | | | | $ 51,678,414 | | $ 36,644,694 |
| | | | | $ (36,644,694) | | |
| **Difference :** | | | | **$ 15,033,721** | | |

COLORADO DEPARTMENT OF TRANSPORTATION

**CDOT**

I-70 Arriba: East and West
Arriba, CO

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| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-06** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-# 06 Proposal:** Use thinner concrete section for outside shoulders

**Current Design:** Pavement thickness for the two driving lanes is 12-inches thick and is continued across the shoulders (inside and outside).

**Description of VE Alternative (Idea #06):** Since the outside shoulder is primarily used for emergency parking it would not need to be designed to carry the same live loads as the travel lanes. A 25% reduction in loading could be applied to the design of the outside shoulders (consistent with other agencies). This reduction in traffic loading would result in a reduced concrete shoulder section from 12-inches to 8-inches.

**Advantages:**

1. Reduction in thickness will reduces overall quantity of concrete required and corresponding cost savings.

**Disadvantages:**

1. Contractor will most likely need to do an additional paving and grading operation to place the shoulder separate from the driving lanes (4-inches higher).
2. Possible differential settlement between shoulder and driving lanes due to different thickness.

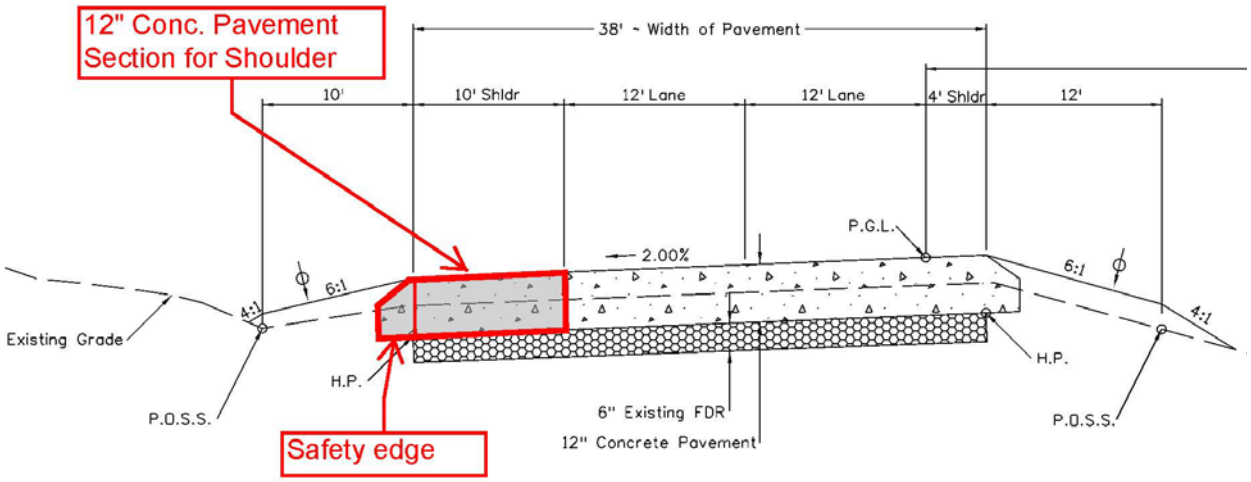
| Cost Summary | | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | $0 | $6,773,766 | $6,773,766 |
| Proposed | $0 | $5,002,110 | $5,002,110 |
| Savings* | $0 | $1,771,656 | $1,771,656 |

- *If this VE concept is combined with VE proposal #4, then the cost savings would be reduced by approximately 20%, which results in a savings of $1,417,325*

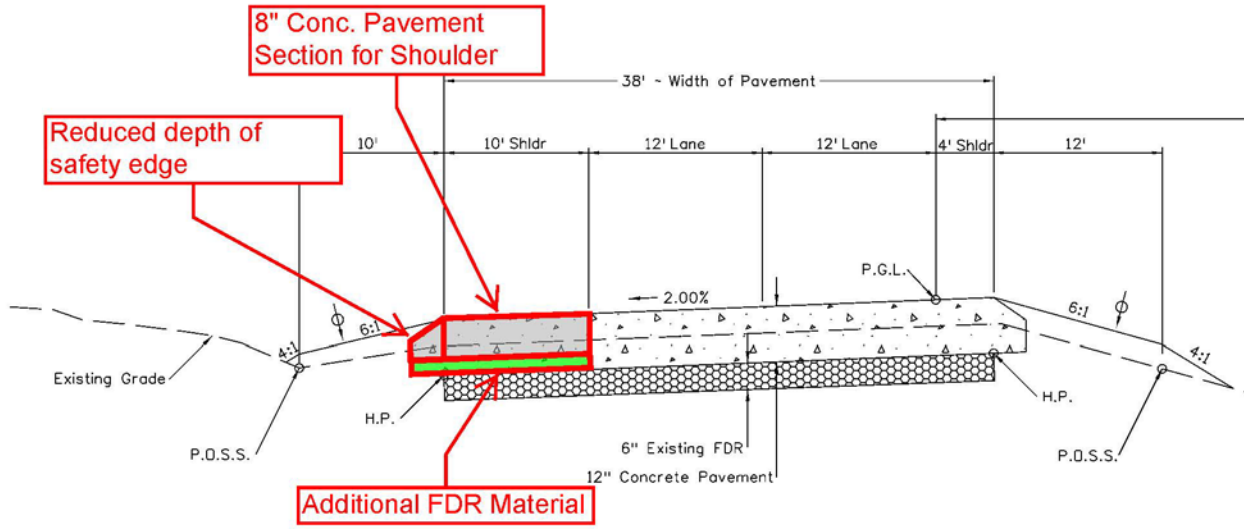
**Recommendation/Discussion:**

The VE Team recommends this Alternative for further consideration.

**Original Concept Sketch:**




**VE Proposal Sketch:**



# *COST WORKSHEET*

**Proposal No:** VE-#06

**Idea No:**

| Item | Qty | Unit | Original Estimate | | New Estimate | |
|---|---|---|---|---|---|---|
| | | | Cost | Total | Cost | Total |
| Current Design | | | | | | |
| | | | | | | |
| Concrete shoulder: 10" thick | 84,942.22 | SY | $55/SY | $4,891,822.22 | | |
| ABC Class 6 (Detour) | 6,630.16 | CY | $35/CY | $232,055.60 | | |
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| Proposed Design | | | | | | |
| Concrete shoulder 8" | 84,942.22 | SY | | | $40/SY | $3,551,688.80 |
| Delete ABC Class 6 (Detour) | 6,630.16 | | | | $35/CY | $232,055.60 |
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| *Markup =32.2% ( includes Mobilization | | | | | | |
| Const.Engr and Minor Contract Rev.) | | | | | | |
| | | | | | | |
| Total: | | | | $ 5,123,878 | | $ 3,783,744 |
| *Markup | 32.2% | | | $ 1,649,889 | | $ 1,218,366 |
| Totals | | | | $ 6,773,766 | | $ 5,002,110 |
| | | | | $ (5,002,110) | | |
| **Difference :** | | | | **$ 1,771,656** | | |

COLORADO DEPARTMENT OF TRANSPORTATION

**CDOT**

I-70 Arriba: East and West
Arriba, CO

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| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#7** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-# Proposal:**
Reduce width of detour crossovers (mainline and ramps) from 20-feet to 16-feet.

**Current Design:**
The current FIR plans show a 20-foot wide detour for mainline and ramp crossovers.

**Description of VE Alternative #7:**
Consider using 16-foot detour (12-foot lane, with two 2-foot shoulders)

**Advantages:**

1. Reduce detour pavement
2. Less embankment

**Disadvantages:**

1. Stalled vehicle safety – cannot pass a stalled if temp barrier is used

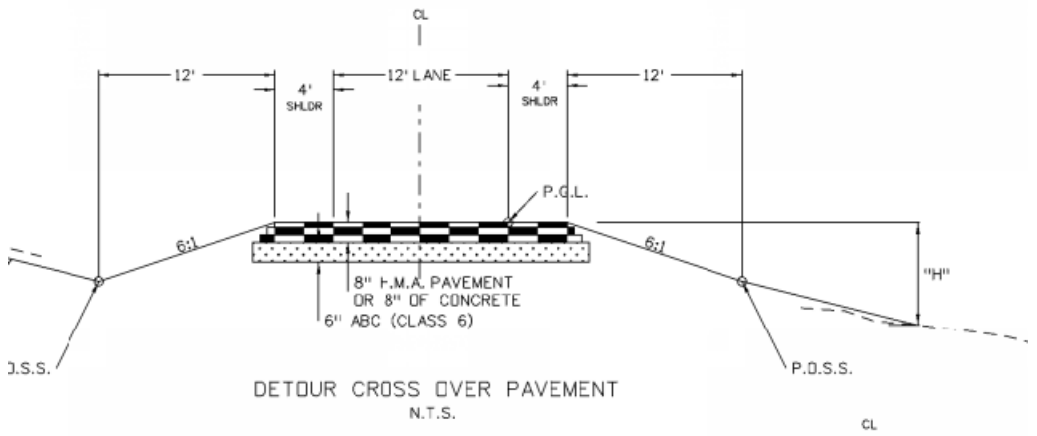
| Cost Summary | | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | | $3,155,429 | $3,155,429 |
| Proposed | | $2,892,721 | $2,892,721 |
| *Savings** | | *$ 262,708* | *$ 262,708* |

- *Recommended VE Savings will be reduced to approximately $200,000 with the implementation of VE alternatives #1A or 2.*

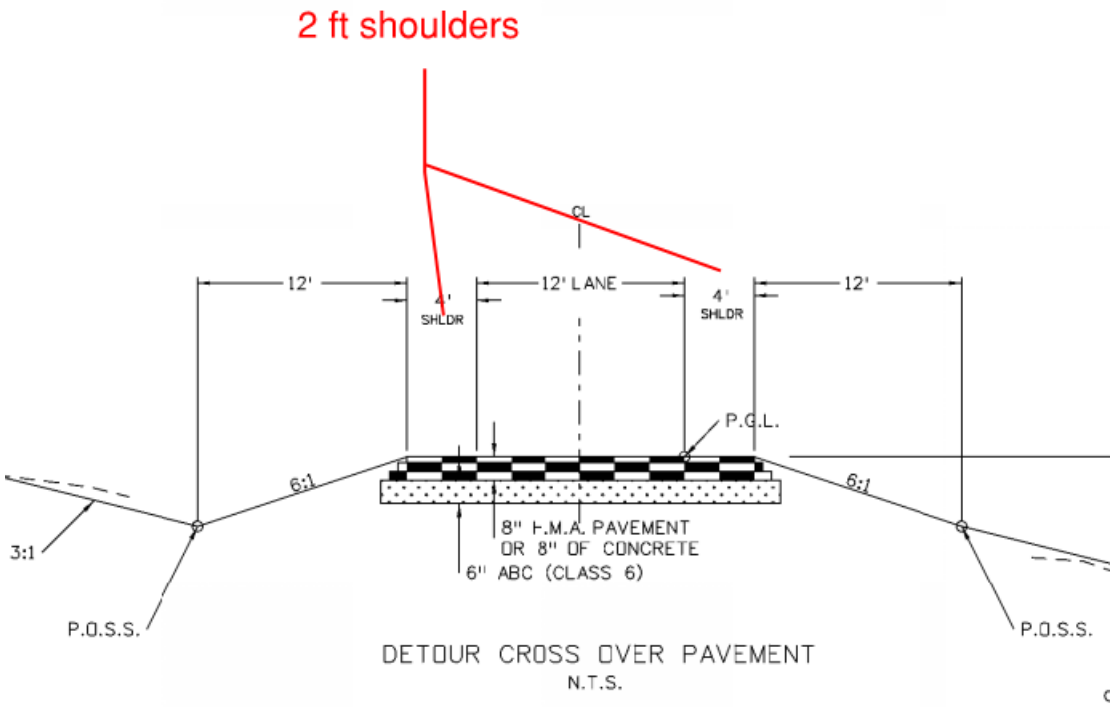
**Recommendation/Discussion:**

The VE Team recommends this Alternative.

**Original Concept Sketch:**




**VE Proposal Sketch:**



# *COST WORKSHEET*

**Proposal No:** VE-#7

**Idea No:**

| Item | Qty | Unit | Original Estimate | | New Estimate | |
|---|---|---|---|---|---|---|
| | | | Cost | Total | Cost | Total |
| Current Design | | | | | | |
| | | | | | | |
| Detour Pavement | 39781 | SY | $60.00 | $ 2,386,860 | | |
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| Proposed Design | | | | | | |
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| Detour Pavement | 36469 | SY | $60.00 | | | $ 2,188,140 |
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| *Markup =32.2% ( includes Mobilization | | | | | | |
| Const.Engr and Minor Contract Rev.) | | | | | | |
| | | | | | | |
| Total: | | | | $ 2,386,860 | | $ 2,188,140 |
| *Markup | 32.2% | | | $ 768,569 | | $ 704,581 |
| Totals | | | | $ 3,155,429 | | $ 2,892,721 |
| | | | | $ (2,892,721) | | |
| **Difference :** | | | | **$ 262,708** | | |

COLORADO DEPARTMENT OF TRANSPORTATION

**CDOT**

I-70 Arriba: East and West
Arriba, CO

By: LC Date: 9/27/17 Page: 3 of 3

| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#8** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-# 08 Proposal:** Reduce detour pavement section from 8” HMA plus 6” ABC to 7” HMA and 6” ABC.

**Current Design:**
Current Detour section is 8” of HMA over 6” of ABC (Class 6).

**Description of VE Alternative #08:**
Using Darwin 3.1 Pavement Design software the detour section can be reduced to 7” HMA or 7” of PCCP over 6” of ABC.

**Advantages:**

1. Reducing in thickness reduces quantity of HMA or concrete required and corresponding cost savings.

**Disadvantages:**

1. Possible reduction in reliability and maintenance of detour under traffic

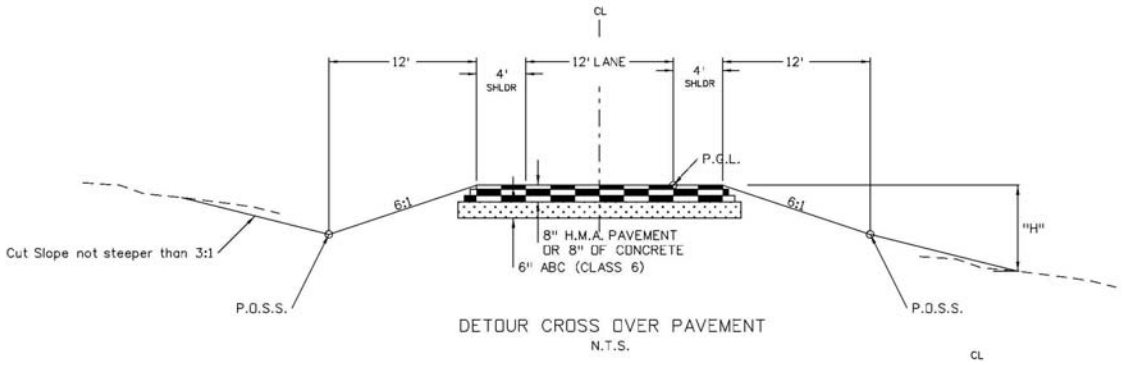
| Cost Summary | | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | | $3,155,429 | $3,155,429 |
| Proposed | | $2,629,524 | $2,629,524 |
| *Savings** | | *$525,905* | *$525,905* |

** VE Cost Savings would reduce by approximately 35% to $341,828 (as estimated by VE team), if implemented with VE alternatives 1A or 2 and 7.*

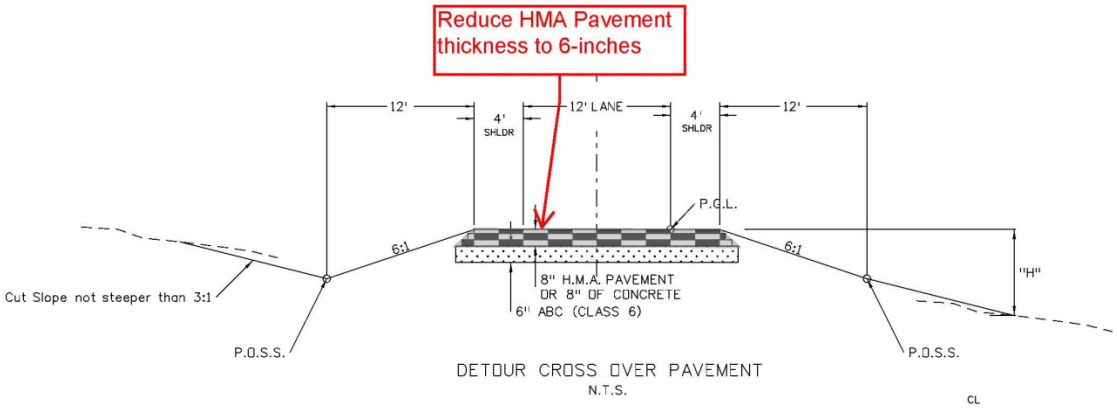
**Recommendation/Discussion:**

The VE Team recommends this Alternative for further consideration.

## Original Concept Sketch:




## VE Proposal Sketch:



# *COST WORKSHEET*

**Proposal No:** VE-#8

**Idea No:**

| Item | Qty | Unit | Original Estimate | | New Estimate | |
|---|---|---|---|---|---|---|
| | | | Cost | Total | Cost | Total |
| Current Design | | | | | | |
| | | | | | | |
| Detour pavement section from 8" HMA | 39,781 | SY | **$60/SY** | $2,386,860 | | |
| plus 6" ABC | | | | | | |
| Proposed Design | | | | | | |
| | | | | | | |
| Reduce detour pavement section to 6" HMA | 39,781 | SY | | | **$50/SY** | $1,989,050 |
| over 6" ABC | | | | | | |
| *Markup =32.2% ( includes Mobilization | | | | | | |
| Const.Engr and Minor Contract Rev.) | | | | | | |
| Total: | | | | $ 2,386,860 | | $ 1,989,050 |
| *Markup | 32.2% | | | $ 768,569 | | $ 640,474 |
| Totals | | | | $ 3,155,429 | | $ 2,629,524 |
| | | | | $ (2,629,524) | | |
| **Difference :** | | | | **$ 525,905** | | |

COLORADO DEPARTMENT OF TRANSPORTATION

**CDOT**

I-70 Arriba: East and West
Arriba, CO

By: RG | Date: 9/27/17 | Page: 3 of 3

| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-9** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-#9 Proposal:**
Issue west bound reconstruction as a separate contract if funding is limited.

**Current Design:**
The intent is to issue the reconstruction of I-70 as a single project.

**Description of VE Alternative #9:**

The VE team concurs with the intent to issue the entire project as a single contract. However, if funding becomes limited it would be more beneficial to issue the reconstruction of the westbound lanes first as a single contract. The westbound work should be the first contract as the westbound lanes are in a more deteriorated condition.

**Advantages:**

1. Address more deteriorated lane first as the condition is more critical.
2. Reduce maintenance which would otherwise be required if the westbound lanes are not rehabilitated.

**Disadvantages:**

1. Impacts to cross over areas will occur twice; will need to reconstruct if just doing one side at a time.

**Recommendation/Discussion:**

The VE Team recommends this Alternative only if funding is limited.

| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#10** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-# 10 Proposal:** Remove six inches of ABC in detour (full depth asphalt).

**Current Design:**
Current Detour section is 8" of HMA over 6" of ABC (Class 6).

**Description of VE Alternative #10:**
Using Darwin 3.1 Pavement Design software the detour section can be reduced to 7" HMA or 7" of PCCP without requiring any ABC (Class 6).

**Advantages:**

1. Eliminating ABC (Class 6) will reduce construction costs.

**Disadvantages:**

1. Potential reduction in reliability and increase in maintenance of detour section under traffic

| Cost Summary | | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | | $3,462,206 | $3,462,206 |
| Proposed | | $2,945,067 | $2,945,067 |
| *Savings** | | *$517,139* | *$517,139* |

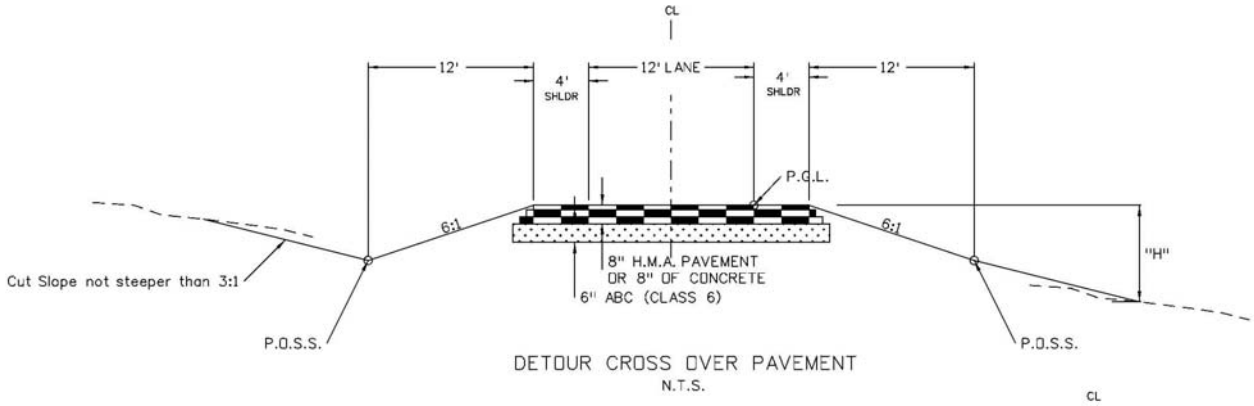
**Cost Summary Notes:*

- *Cost savings for deletion of ABC challenging to quantify because item is paid for as part of Detour Pavement, per SY. Assume average cubic yard cost of $35/CY for ABC from 2016 Cost Data book.*
- *This VE alternative is similar and related to VE #8 (reduce detour pavement section), if both implemented cost are not additive.*
- *Cost Savings would be reduced by approximately 35% (to $366,140) if combined with VE alternatives 1A or 2, and 7.*

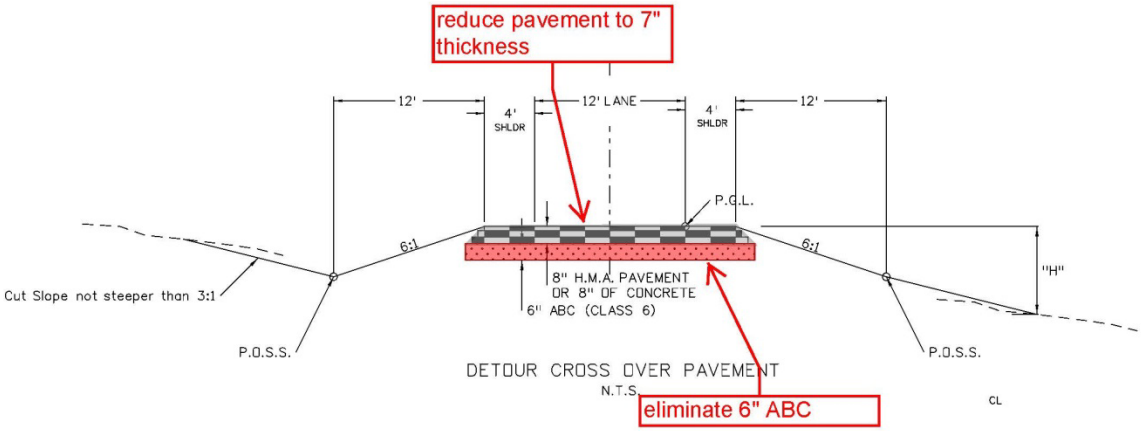
**Recommendation/Discussion:**

The VE Team recommends this Alternative for further consideration.
This VE alternative related and similar to VE #8

**Original Concept Sketch:**




**VE Proposal Sketch:**



# *COST WORKSHEET*

**Proposal No:** VE-#10

**Idea No:**

| Item | Qty | Unit | Original Estimate | | New Estimate | |
|---|---|---|---|---|---|---|
| | | | Cost | Total | Cost | Total |
| Current Design | | | | | | |
| ABC Class 6" depth (Detour) | 6,630.16 | CY | $ 35 | $ 232,056 | | |
| Detour pavement section from 8" HMA | 39,781 | SY | **$ 60** | $2,386,860 | | |
| plus 6" ABC | | | | | | |
| Proposed Design | | | | | | |
| Delete ABC Class 6" depth (Detour) | 0.00 | CY | | | $ 35 | $0 |
| Reduce detour pavement section to 7" HMA | 39,781 | SY | | | **$ 56** | $2,227,736 |
| *Markup =32.2% ( includes Mobilization | | | | | | |
| Const.Engr and Minor Contract Rev.) | | | | | | |
| Total: | | | | $ 2,618,916 | | $ 2,227,736 |
| *Markup | 32.2% | | | $ 843,291 | | $ 717,331 |
| Totals | | | | $ 3,462,206 | | $ 2,945,067 |
| | | | | $ (2,945,067) | | |
| **Difference :** | | | | **$ 517,139** | | |

COLORADO DEPARTMENT OF TRANSPORTATION

**CDOT**

I-70 Arriba: East and West
Arriba, CO

By: RG/WH Date: 9/27/17 Page: 3 of 3

| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#12** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-# 12 Proposal:**
Use Thin White Topping for East Bound I-70

**Current Design:**
The current design calls for removing 6-inch of the existing HMA and then pulverizing the remaining 6-inches to be used as base. Following the shaping and compaction, a 12-inch concrete pavement section will be placed full width of the pavement cross section. The pavement will be constructed using 1.5" dowel bars in the transverse joints and #6 tie bars in the longitudinal joints.

**Description of VE Alternative #12:**
Mill 7-inches of the existing pavement followed by placement of 7.5-inches of bonded concrete pavement (see attached white topping design calculation). The old HMA pavement will be milled to remove the top 7 inches, including the petromat, and leave 5" of exiting HMA.

**Advantages:**

1. Using the lower lifts of the existing pavement will save both time and construction costs because of the reuse of material and also not having to process the existing HMA.
2. The thinner concrete section will result in a large savings for the EB lanes

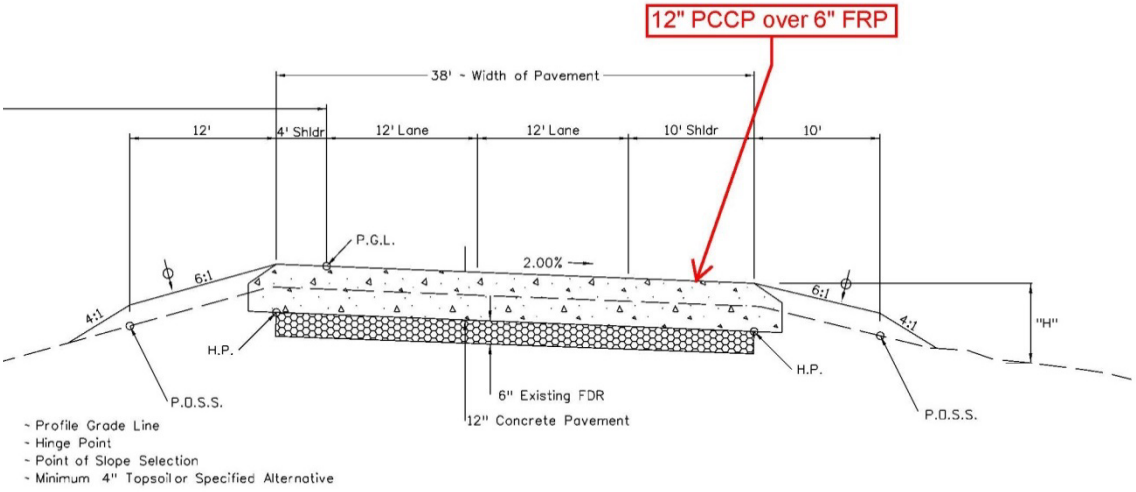
**Disadvantages:**
1. The smaller panel sizes will result more joint maintenance than a standard pavement
2. The pavement will be more susceptible to faulting because there is not load transfer in the transverse joints
3. Based on the core from previous testing, the condition of the lower lifts of existing HMA is suspect and from discussion with local CDOT personnel (maintenance personnel) have also encountered problems with performance of portions of the east bound lanes.

| Cost Summary | | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | | $28,731,864 | $28,731,864 |
| Proposed | | $17,227,704 | $17,227,704 |
| Savings | | $11,504,160 | $11,504,160 |

**Recommendation/Discussion:**

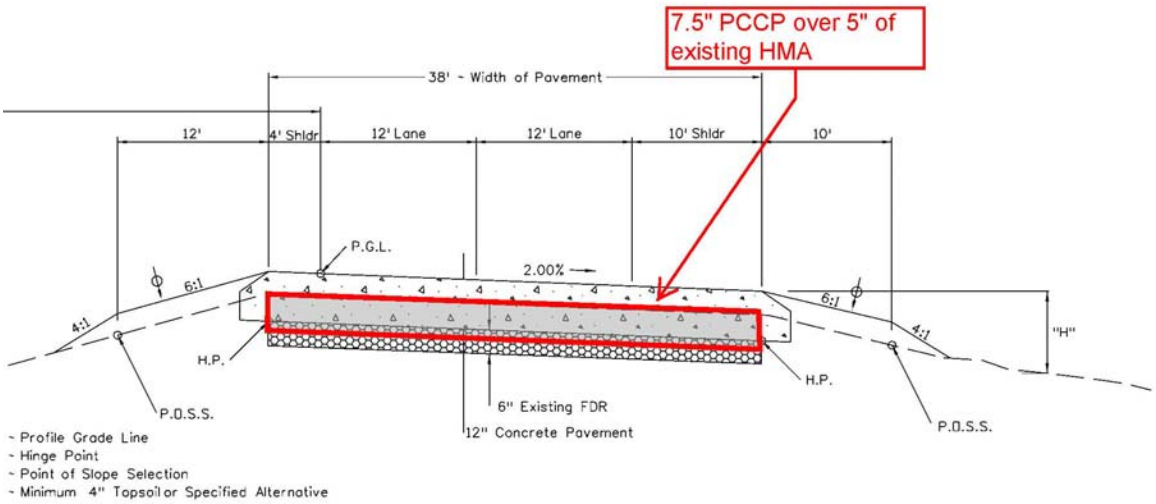
The VE Team does not recommend this Alternative. Based upon the questionable core samples and discussion with CDOT staff, the existing lower lifts of HMA may not be stable enough, and may create more maintenance issues and pavement failure in the future.

**Original Concept Sketch:**




I-70 EB Lanes

**VE Proposal Sketch:**




The VE Team does not recommend this Alternative

## CDOT 2004 Thin Whitetopping Design Procedure

### Whitetopping Input Parameters

| | |
|---|---|
| Highway Category (Primary or Secondary)* | Primary |
| Joint Spacing, in. | 72 |
| Trial Concrete Thickness, in. | 7.5 |
| Concrete Flexural Strength, psi | 650 |
| Concrete Elastic Modulus, psi | 4,000,000 |
| Concrete Poisson's Ratio | 0.15 |
| Asphalt Thickness, in. | 5 |
| Asphalt Elastic Modulus, psi | 350,000 |
| Asphalt Poisson's Ratio | 0.35 |
| Asphalt Fatigue Life Previously Consumed, % | 25 |
| Subgrade Modulus, pci | 150 |
| Temperature Gradient, °F/in. | 3 |
| Design ESALs | 28,619,217 |

| | |
|---|---|
| Converted Concrete Thickness, in. = | 9.07 |
| ESAL Conversion Factor = | 0.9903 |
| Neutral Axis = | 4.86 |
| le = | 39.14 |
| L/le = | 1.84 |

| Critical Concrete Stresses and Asphalt Strains | | | | | |
|---|---|---|---|---|---|
| Load Induced | | Bond Adjustment | | Support Adjustment | |
| Stress, psi | µstrain | Stress, psi | µstrain | Stress, psi | µstrain |
| 1 | 2 | 3 | 4 | 5 | 6 |
| **174** | **118** | **263** | **105** | **293** | **105** |

| ESAL Fatigue Analysis | | | | | | |
|---|---|---|---|---|---|---|
| No. of 18-kip ESALs | Concrete Fatigue Analysis | | | Asphalt Fatigue Analysis | | |
| | Stress Ratio | Allowable ESALs | Fatigue, % | Asphalt µstrain | Allowable ESALs | Fatigue, % |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| **2.8E+07** | **0.451** | **5.7E+07** | **50.1** | **105** | **1.4E+07** | **209.8** |

**Concrete Fatigue, % = 50.1** **Asphalt Fatigue, % = 234.8**

**Required Whitetopping Thickness = 7.5 in.**

# *COST WORKSHEET*

**Proposal No:** VE-#12

**Idea No:**

| Item | Qty | Unit | Original Estimate | | New Estimate | |
|---|---|---|---|---|---|---|
| | | | Cost | Total | Cost | Total |
| Current Design | | | | | | |
| | | | | | | |
| Full Depth Reclamation | 336,630 | SY | $6.50 | $ 2,188,092 | | |
| PCCP 12" | 355,374 | SY | $55.00 | $ 19,545,543 | | |
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| Proposed Design | | | | | | |
| | | | | | | |
| Full Depth Reclamation | 336,630 | SY | $0 | | $0.00 | $ - |
| PCCP 7.5" | 355,374 | SY | $37 | | $36.67 | $ 13,031,546 |
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| *Markup =32.2% ( includes Mobilization | | | | | | |
| Const.Engr and Minor Contract Rev.) | | | | | | |
| | | | | | | |
| Total: | | | | $ 21,733,634 | | $ 13,031,546 |
| *Markup | 32.2% | | | $ 6,998,230 | | $ 4,196,158 |
| Totals | | | | $ 28,731,864 | | $ 17,227,704 |
| | | | | $ (17,227,704) | | |
| **Difference :** | | | | **$ 11,504,160** | | |

COLORADO DEPARTMENT OF TRANSPORTATION

**CDOT**

I-70 Arriba: East and West
Arriba, CO

By: RFL | Date: 9/27/17 | Page: 4 of 4

| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#13** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-# Proposal:**
For Eastbound lanes only use unbonded white topping

**Current Design:**
The current design calls for milling 6-inches of existing HMA followed by pulverization, or full depth reclamation (FDR) of the 6-inches below; then placement of a new 12-inch PCCP pavement on the graded and compacted FDR material.

**Description of VE Alternative #13:**
For the east bound lanes, as was done on the PCCP project immediately east of Flagler, the pavement could be milled to remove 6 inches of existing HMA. Following milling the existing HMA would be overlaid with a 1.5-inch layer of HMA to prevent bonding to the old HMA, and then a 10.5-inch PCCP pavement section could be placed for the final surface.

**Advantages:**

1. This treatment should provide a durable wearing surface that should address a 30-year loading which will reduce the cost of pulverizing of the existing pavement.

**Disadvantages:**

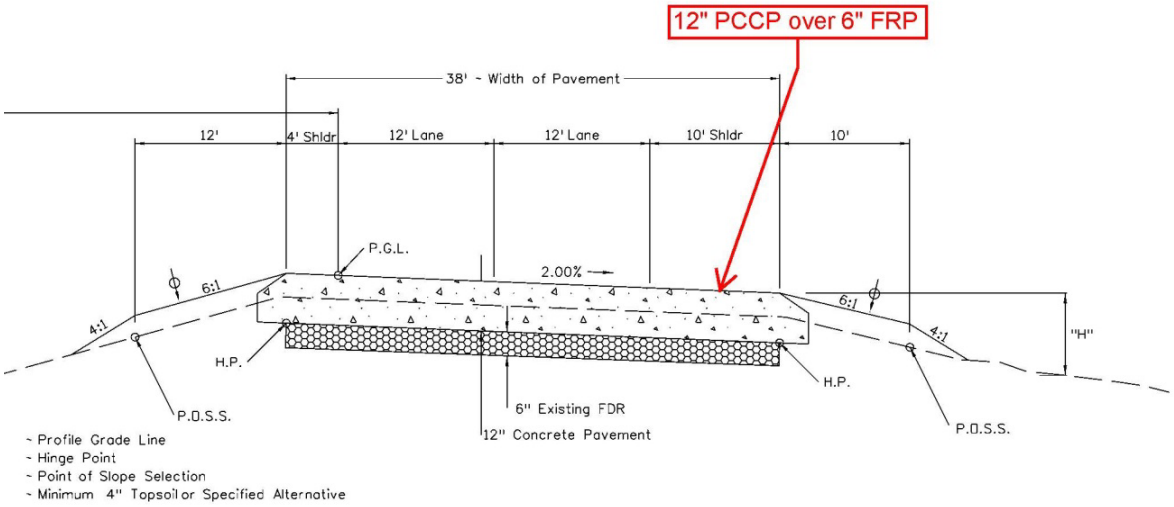
1. The bond breaking overlay will require an additional HMA layer and will add cost, also it require an additional subcontractor and operation on the project.

| Cost Summary | | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | $0 | $28,731,864 | $28,731,864 |
| Proposed | $0 | $26,121,089 | $26,121,089 |
| Savings | $0 | $2,610,775 | $2,610,775 |

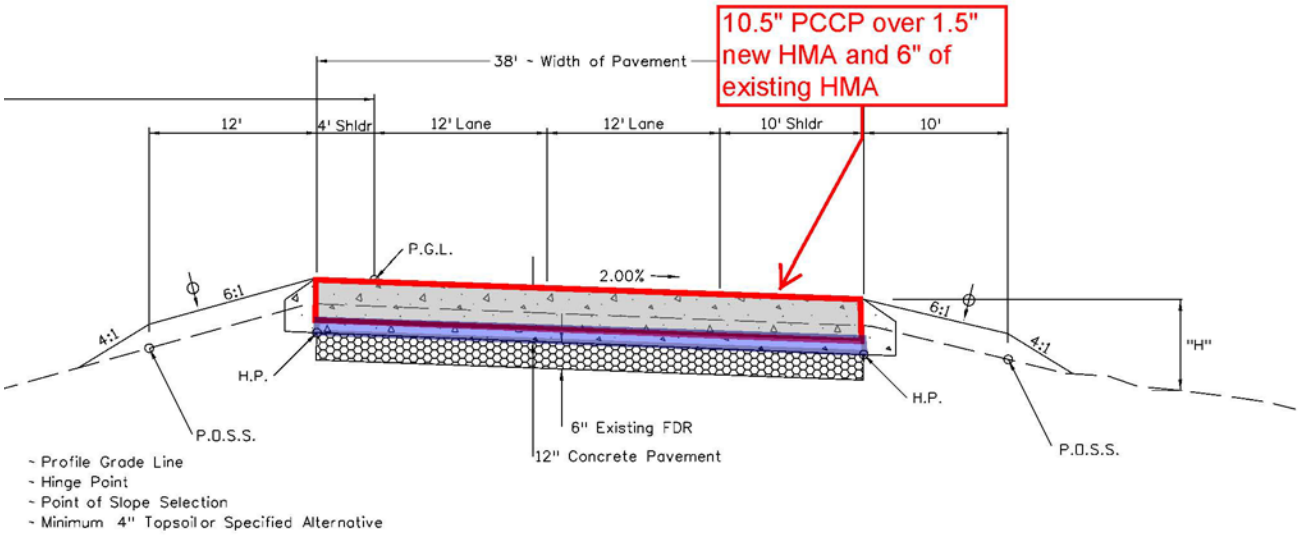
**Recommendation/Discussion:**

The VE Team does not recommend this Alternative. This alternative is not recommended because of the questionable condition of the lower asphalt layers.

## Original Concept Sketch:




## VE Proposal Sketch:



# *COST WORKSHEET*

**Proposal No:** VE-#13

**Idea No:**

| Item | Qty | Unit | Original Estimate | | New Estimate | |
|---|---|---|---|---|---|---|
| | | | Cost | Total | Cost | Total |
| Current Design | | | | | | |
| | | | | | | |
| Full Depth Reclamation | 336,630 | SY | $6.50 | $ 2,188,092 | | |
| PCCP 12" | 355,374 | SY | $55.00 | $ 19,545,543 | | |
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| Proposed Design | | | | | | |
| | | | | | | |
| Full Depth Reclamation | 336,630 | SY | $0 | | $0.00 | $ - |
| Bond Breaker Overlay | 355,374 | SY | | | $6.60 | $ 2,345,465 |
| PCCP 10.5" | 355,374 | SY | | | $ 49.00 | $ 17,413,302 |
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| *Markup =32.2% ( includes Mobilization | | | | | | |
| Const.Engr and Minor Contract Rev.) | | | | | | |
| | | | | | | |
| Total: | | | | $ 21,733,634 | | $ 19,758,767 |
| *Markup | 32.2% | | | $ 6,998,230 | | $ 6,362,323 |
| Totals | | | | $ 28,731,864 | | $ 26,121,089 |
| | | | | $ (26,121,089) | | |
| **Difference :** | | | | **$ 2,610,775** | | |

COLORADO DEPARTMENT OF TRANSPORTATION

**CDOT**

I-70 Arriba: East and West
Arriba, CO

By: RFL Date: 9/27/17 Page: 3 of 3

| COLORADO DEPARTMENT OF TRANSPORTATION | *VE RECOMMENDATION* | **Proposal No. VE-#14** |
|---|---|---|
| | **Project:** | **I-70 Arriba: East and West CDOT** |

**VE-# Proposal:**
Remove unstable pavement to limits necessary for reconstruction (Mill and Overlay Patching)

**Current Design:**

Not currently included in plans

**Description of VE Alternative #14:**

This proposal is a recommendation to address what appear to be massive quantities of maintenance patching that will be required in the near future if construction funds are delayed.

Based on the forensic investigation conducted by NCAT and Region 4, we believe that through the winter and with spring moisture, there will continue to be massive failures particularly in the west bound lanes. If a very large number of pavement failures do occur having a maintenance mill and fill project will be needed to keep I-70 serviceable.

We believe that milling 4 to 6 inches and planning an unmodified HMA mix would be required to maintain interstate.

**Advantages:**

1. Will maintain I-70 in a serviceable condition

**Disadvantages:**

1. High Maintenance Cost:

| Cost Summary | | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | $11,340,000 | $0 | $11,340,000 |
| Proposed | $0 | $0 | $0 |
| Savings | $11,340,000 | $0 | $11,340,000 |

**Recommendation/Discussion:**

This is a design consideration, if CDOT delays project, then estimated maintenance costs to mill and fill patches could reach up to $12M.

# *COST WORKSHEET*

**Proposal No:** VE-#14

**Idea No:**

| Item | Qty | Unit | Original Estimate | | New Estimate | |
|---|---|---|---|---|---|---|
| | | | Cost | Total | Cost | Total |
| | | | | | | |
| | | | | | | |
| Future O&M Cost | | | | | | |
| Mill 4" of Asphlt | 200,000 | SY | | | $ 6 | $ 1,200,000 |
| Fill 4" of Apshalt | 200,000 | SY | | | $ 48 | $ 9,640,000 |
| | | | | | | |
| Traffic Control | 200 | DAY | | | $ 2,500 | $ 500,000 |
| $2,500/day = 1,000 sy/day= $2.5/sy | | | | | | |
| | | | | | | |
| | | | | | | |
| Assume 1/4 of project would need mill& fill | | | | | | |
| which equals 200,000 SY | | | | | | |
| Equals approximately: | | SY | $ 56.70 | | | |
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| Total: | | | | | | $ 11,340,000 |
| *Markup | | | | | | $ - |
| Totals | | | | | | $ 11,340,000 |
| | | | | | | |
| **Total O&M :** | | | | **$ 11,340,000** | | |

COLORADO DEPARTMENT OF TRANSPORTATION

**CDOT**

I-70 Arriba: East and West
Arriba, CO

By: BL/WH | Date: 9/27/17 | Page: 2 of 2

COLORADO
DEPARTMENT OF
TRANSPORTATION

JACOBS

# 3.0
# COST DATA

## 3.0 COST DATA

GENERAL

The VE Team was provided with the FOR Cost Estimate, submitted on September 19, 2017, with a total of project cost totaling $79.25 million.

The VE team prepared a Cost Model using the estimate provided and reviewed the overall project cost for specific higher priced elements of the project. As expected with this type of rehabilitation project, the proposed concrete pavement was the most significant portion of the work along with asphalt removal, representing almost 80-percent of the total cost. The Cost Model and the current FOR construction cost estimate used in the study are attached at the end this section.

VE MARKUPS

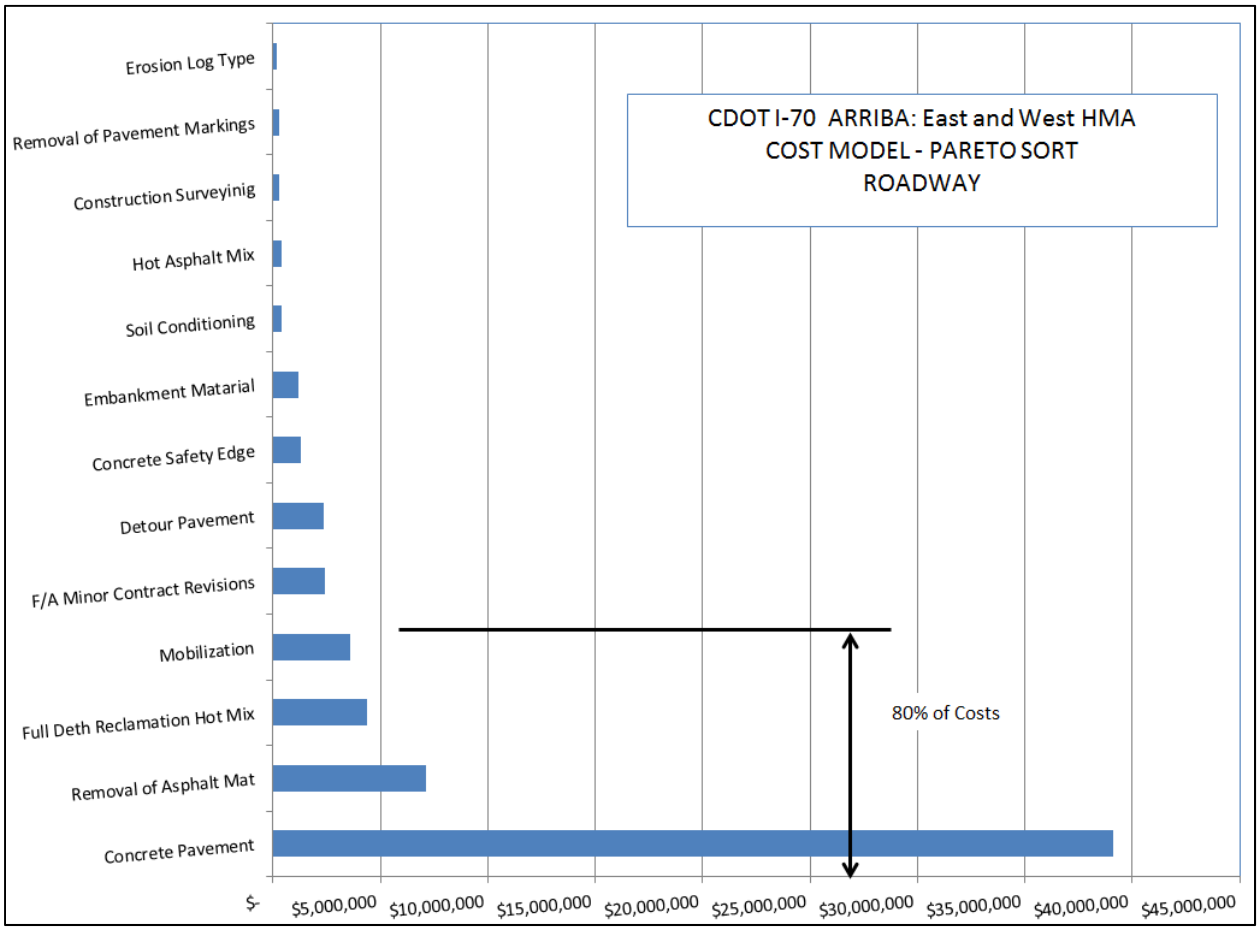
The project cost estimate provided to the VE team for use during the study was $79.25 million, which included cost for construction engineering and indirect costs. After further analysis and break down of the cost estimate, the construction items totaled to $59.9 million with markups and construction engineering adding another at $19.3 million. The markups are necessary to capture the costs for: mobilization, construction engineering and minor contract revisions. The added cost, results in an additional markup of 32.2% on any VE proposal when comparing in 2017 dollars.

VE PROPOSAL ESTIMATES

As a generalization, VE studies use the project estimate as the basis for calculating cost savings. The VE Proposals do not include the cost of engineering redesign, if required. Based upon the project schedule and stage of the project, redesign cost could be considerable depending upon the VE item. The added redesign, along with time and schedule impacts should be considered in the implementation determinations by CDOT and the design team.

LIFE CYCLE COSTS

The VE Team did not specifically address life cycle costs, as they were viewed to be minimal or difficult to quantify in the time frame of the study. However, the VE team tried to recognize when there would be opportunity for some life cycle savings with implementation of the recommended VE proposal.




**I-70 Arriba Cost Model**

During the VE study, as part of the review of materials, the VE team noticed a few items on the cost estimate and had comments to pass along to the design team:

**Cost Estimate comments**

1. Costs for temporary lighting not included yet.
2. Detour Pavement cost of $60 per SY seems low. This was cost per SY or Awarded contractor 2 years ago.
3. May need to saw cut asphalt prior to widening for cross overs. Will need to include replacement pavement quantity.
4. May want contingency for FIR/FOR level plans. 3-5% may be adequate since have high pavement cost.
5. Some items are estimated without quantities

# Colorado Department Of Transportation
# Preliminary Detail Cost Estimate

**Prime Project:** 21878
**Project Number:** NHPP0705-082
**Project Name:** I-70 ARRIBA: EAST AND WEST HMA

**Total Project Length:** 0.0000 MILES
**Total Bridge Length:** 0.0000 FEET
**Counties:** KIT CARSON, LINCOLN

I-70 ARRIBA

**Date Printed:** 9/19/2017

## Project Summary Log

| PCN | Description | Federal/State Proiect Number | Date Estimate | Date Revised | Prepared By |
|---|---|---|---|---|---|
| 21878-BID | I-70 ARRIBA | NHPP0705-082 | | 9/19/2017 | Travis A. Miller - Region 4 RE |
| 21878-NONBID | I-70 ARRIBA | NHPP0705-082 | | 9/19/2017 | Travis A. Miller - Region 4 RE |

**Colorado Department Of Transportation**
**Detail Estimate Cost Summary**

Printed On: **09/19/2017**


**Prime Project:** 21878 **Project No:** NHPP0705-082

**Project ID:** 21878-BID **Project Description:** I-70 ARRIBA

| Fund Package | | | Cost | Const Engr | Total | Funding Limit | Funding |
|---|---|---|---|---|---|---|---|
| **Fund Class:** H402 | H402 | HUT - STATE FUNDS | | | | | |
| Package 0000 | | | 13,188,598.46 | 2,640,357.41 | 15,828,955.87 | | 15,828,955.87 |
| **Fund** H402 | | **Totals** | **$13,188,598.46** | **$2,640,357.41** | **$15,828,955.87** | | **$15,828,955.87** |
| **Fund Class:** F0AU | F0AU | ADVANCE CONSTRUCTION | | | | | |
| Package 0000 | | | 52,754,393.84 | 10,561,429.65 | 63,315,823.49 | | 63,315,823.49 |
| **Fund** F0AU | | **Totals** | **$52,754,393.84** | **$10,561,429.65** | **$63,315,823.49** | | **$63,315,823.49** |
| **Fund Class:** CEPOOL | CEPOOL | COSTS TO BE TRANSFERED TO CE POOL | | | | | |
| Package 0400 | | | 102,500.00 | 0.00 | 102,500.00 | | 102,500.00 |
| **Fund** CEPOOL | | **Totals** | **$102,500.00** | **$0.00** | **$102,500.00** | | **$102,500.00** |
| **Project Total** | **21878-BID** | | **$66,045,492.30** | **$13,201,787.06** | **$79,247,279.36** | | **$79,247,279.36** |

**Colorado Department Of Transportation**
**Detail Estimate Cost Summary**

**Prime Project:** 21878 **Project No:** NHPP0705-082
**Project ID:** 21878-NONBID **Project Description:** I-70 ARRIBA

| Fund Package | | Cost | Const Engr | Total | Funding Limit | Funding |
|---|---|---|---|---|---|---|
| Project Project Item Line Number '0005' is not associated with a fund package. | | | | | | |
| **Estimate Totals** | **21878** | **$66,945,128.25** | **$13,201,787.06** | **$79,247,279.36** | | **$79,247,279.36** |

**Prime Project:** 21878 **PCN:** 21878-BID **Project No:** NHPP0705-082 **Contract ID:** 21878

**PCN:** 21878-BID I-70 ARRIBA: EAST AND WEST HMA

**Category: 0200 ROADWAY**

**Construction Type :**

**Work Classification :** 0200 ROADWAY

**Construction Class :** B - Biddable Items

| Line No. | Item Number | Item Description | Estimated Quantity | Item Unit | Unit Price | Amount | Fund Package ID |
|---|---|---|---|---|---|---|---|
| 0005 | 202-00090 | Removal of Delineator | 705.000 | EACH | 5.00000 | 3,525.00 | 0000 |
| 0010 | 202-00240 | Removal of Asphalt Mat (Planing) | 710,747.000 | SY | 10.00000 | 7,107,470.00 | 0000 |
| 0015 | 202-00250 | Removal of Pavement Marking | 136,235.000 | SF | 2.00000 | 272,470.00 | 0000 |
| 0020 | 202-00810 | Removal of Ground Sign | 153.000 | EACH | 70.00000 | 10,710.00 | 0000 |
| 0025 | 202-00821 | Removal of Sign Panel | 7.000 | EACH | 20.00000 | 140.00 | 0000 |
| 0030 | 202-01130 | Removal of Guardrail Type 3 | 1,033.000 | LF | 4.00000 | 4,132.00 | 0000 |
| 0035 | 202-01300 | Removal of End Anchorage | 5.000 | EACH | 200.00000 | 1,000.00 | 0000 |
| 0040 | 203-00050 | Unsuitable Material | 1,500.000 | CY | 20.00000 | 30,000.00 | 0000 |
| 0045 | 203-00060 | Embankment Material (Complete In Place) | 59,379.000 | CY | 20.00000 | 1,187,580.00 | 0000 |
| 0050 | 203-01500 | Blading | 260.000 | HOUR | 120.00000 | 31,200.00 | 0000 |
| 0055 | 203-01590 | Front End Loader (Rubber Tire) | 440.000 | HOUR | 150.00000 | 66,000.00 | 0000 |
| 0060 | 208-00002 | Erosion Log Type 1 (12 Inch) | 40,570.000 | LF | 5.00000 | 202,850.00 | 0000 |
| 0065 | 208-00035 | Aggregate Bag | 3,280.000 | LF | 15.00000 | 49,200.00 | 0000 |
| 0070 | 208-00070 | Vehicle Tracking Pad | 22.000 | EACH | 1,500.00000 | 33,000.00 | 0000 |
| 0075 | 208-00103 | Removal and Disposal of Sediment (Labor) | 2,630.000 | HOUR | 50.00000 | 131,500.00 | 0000 |

**Prime Project:** 21878 **PCN:** 21878-BID **Project No:** NHPP0705-082 **Contract ID:** 21878

**PCN:** 21878-BID I-70 ARRIBA: EAST AND WEST HMA

| Line No. | Item Number | Item Description | Estimated Quantity | Item Unit | Unit Price | Amount | Fund Package ID |
|---|---|---|---|---|---|---|---|
| 0080 | 208-00105 | Removal and Disposal of Sediment (Equipment) | 380.000 | HOUR | 75.00000 | 28,500.00 | 0000 |
| 0085 | 208-00106 | Sweeping (Sediment Removal) | 790.000 | HOUR | 130.00000 | 102,700.00 | 0000 |
| 0090 | 208-00207 | Erosion Control Management | 525.000 | DAY | 60.00000 | 31,500.00 | 0000 |
| 0095 | 212-00006 | Seeding (Native) | 245.560 | ACRE | 550.00000 | 135,058.00 | 0000 |
| 0100 | 212-00032 | Soil Conditioning | 245.560 | ACRE | 1,700.00000 | 417,452.00 | 0000 |
| 0105 | 213-00004 | Mulching (Weed Free Straw) | 387.800 | ACRE | 420.00000 | 162,876.00 | 0000 |
| 0110 | 213-00061 | Mulch Tackifier | 77,561.000 | LB | 2.00000 | 155,122.00 | 0000 |
| 0115 | 216-00041 | Soil Retention Blanket (Straw/Coconut) | 36,790.000 | SY | 3.00000 | 110,370.00 | 0000 |
| 0120 | 216-00301 | Turf Reinforcement Mat (Class 1) | 11,390.000 | SY | 15.00000 | 170,850.00 | 0000 |
| 0125 | 217-00000 | Herbicide Treatment | 175.000 | SY | 0.50000 | 87.50 | 0000 |
| 0130 | 304-06007 | Aggregate Base Course (Class 6) | 650.000 | CY | 30.00000 | 19,500.00 | 0000 |
| 0135 | 310-00608 | Full Depth Reclamation of Hot Mix Asphalt Pavement (0-8") | 673,259.000 | SY | 6.50000 | 4,376,183.50 | 0000 |
| 0140 | 403-00720 | Hot Mix Asphalt (Patching) (Asphalt) | 2,500.000 | TON | 150.00000 | 375,000.00 | 0000 |
| 0145 | 403-34741 | Hot Mix Asphalt (Grading SX) (75) (PG 64-22) | 0.100 | TON | 1.00000 | 0.10 | 0000 |
| 0150 | 411-10255 | Emulsified Asphalt (Slow-Setting) | 0.100 | GAL | 1.00000 | 0.10 | 0000 |
| 0155 | 412-01200 | Concrete Pavement (12 Inch) | 710,747.000 | SY | 55.00000 | 39,091,085.00 | 0000 |
| 0160 | 412-02000 | Concrete Safety Edge | 320,192.000 | LF | 4.00000 | 1,280,768.00 | 0000 |
| 0165 | 606-00301 | Guardrail Type 3 (6-3 Post Spacing) | 1,200.000 | LF | 22.00000 | 26,400.00 | 0000 |
| 0170 | 606-01370 | Transition Type 3G | 6.000 | EACH | 2,000.00000 | 12,000.00 | 0000 |

**Prime Project:** 21878 **PCN:** 21878-BID **Project No:** NHPP0705-082 **Contract ID:** 21878

**PCN:** 21878-BID I-70 ARRIBA: EAST AND WEST HMA

| Line No. | Item Number | Item Description | Estimated Quantity | Item Unit | Unit Price | Amount | Fund Package ID |
|---|---|---|---|---|---|---|---|
| 0175 | 606-02003 | End Anchorage (Nonflared) | 2.000 | EACH | 2,000.00000 | 4,000.00 | 0000 |
| 0180 | 606-02005 | End Anchorage (Flared) | 5.000 | EACH | 1,500.00000 | 7,500.00 | 0000 |
| 0185 | 612-00036 | Delineator (Flexible) (Square Base) | 1,063.000 | EACH | 15.00000 | 15,945.00 | 0000 |
| 0190 | 612-00037 | Delineator (Flexible) (Flat Mounted) | 0.100 | EACH | 1.00000 | 0.10 | 0000 |
| 0195 | 612-00038 | Delineator (Flexible) (Clamp Mounted) | 4.000 | EACH | 25.00000 | 100.00 | 0000 |
| 0200 | 614-00011 | Sign Panel (Class I) | 573.000 | SF | 16.00000 | 9,168.00 | 0000 |
| 0205 | 614-00012 | Sign Panel (Class II) | 1,158.000 | SF | 20.00000 | 23,160.00 | 0000 |
| 0210 | 614-00013 | Sign Panel (Class III) | 733.000 | SF | 25.00000 | 18,325.00 | 0000 |
| 0215 | 614-00615 | Steel Sign Post (W 6x15) | 155.000 | LF | 65.00000 | 10,075.00 | 0000 |
| 0220 | 614-00818 | Steel Sign Post (W 8x18) | 85.000 | LF | 70.00000 | 5,950.00 | 0000 |
| 0225 | 614-01512 | Steel Sign Support (2-Inch Round)(Post) | 1,501.000 | LF | 10.00000 | 15,010.00 | 0000 |
| 0230 | 614-01522 | Steel Sign Support (2-Inch Round)(Socket) | 147.000 | EACH | 60.00000 | 8,820.00 | 0000 |
| 0235 | 614-01585 | Steel Sign Support (2-1/2 Inch Round Sch 80) (Post) | 1,050.000 | LF | 30.00000 | 31,500.00 | 0000 |
| 0240 | 614-01588 | Steel Sign Support (2-1/2 Inch Round Sch 80)(Slipbase) | 87.000 | EACH | 250.00000 | 21,750.00 | 0000 |
| 0245 | 621-00450 | Detour Pavement | 39,781.000 | SY | 60.00000 | 2,386,860.00 | 0000 |
| 0250 | 622-00350 | Trash Receptacle | 5.000 | EACH | 1,000.00000 | 5,000.00 | 0000 |
| 0255 | 624-20300 | Detour Drainage Pipe (Class 0) | 1,725.000 | LF | 50.00000 | 86,250.00 | 0000 |
| 0260 | 625-00000 | Construction Surveying | 1.000 | L S | 300,000.00000 | 300,000.00 | 0000 |
| 0265 | 625-00001 | Construction Surveying (Hourly) | 44.000 | HOUR | 150.00000 | 6,600.00 | 0000 |

**Prime Project:** 21878 **PCN:** 21878-BID **Project No:** NHPP0705-082 **Contract ID:** 21878

**PCN:** 21878-BID I-70 ARRIBA: EAST AND WEST HMA

| Line No. | Item Number | Item Description | Estimated Quantity | Item Unit | Unit Price | Amount | Fund Package ID |
|---|---|---|---|---|---|---|---|
| 0270 | 626-00000 | Mobilization | 1.000 | L S | 3,600,000.00000 | 3,600,000.00 | 0000 |
| 0275 | 626-01103 | Public Information Services (Tier III) | 1.000 | L S | 20,000.00000 | 20,000.00 | 0000 |
| 0280 | 627-00008 | Modified Epoxy Pavement Marking | 1,400.000 | GAL | 100.00000 | 140,000.00 | 0000 |
| 0285 | 627-00013 | Pavement Marking Paint (High Build) | 2,504.000 | GAL | 60.00000 | 150,240.00 | 0000 |
| 0290 | 627-30410 | Preformed Thermoplastic Pavement Marking (Xwalk-Stop Line) | 270.000 | SF | 15.00000 | 4,050.00 | 0000 |
| 0295 | 630-00000 | Flagging | 1,100.000 | HOUR | 25.00000 | 27,500.00 | 0000 |
| 0300 | 630-00007 | Traffic Control Inspection | 350.000 | DAY | 200.00000 | 70,000.00 | 0000 |
| 0305 | 630-00012 | Traffic Control Management | 175.000 | DAY | 700.00000 | 122,500.00 | 0000 |
| 0310 | 630-80338 | Barricade (Type 3 M-D) (Temporary) | 26.000 | EACH | 150.00000 | 3,900.00 | 0000 |
| 0315 | 630-80341 | Construction Traffic Sign (Panel Size A) | 530.000 | EACH | 40.00000 | 21,200.00 | 0000 |
| 0320 | 630-80342 | Construction Traffic Sign (Panel Size B) | 210.000 | EACH | 50.00000 | 10,500.00 | 0000 |
| 0325 | 630-80343 | Construction Traffic Sign (Panel Size C) | 136.000 | EACH | 60.00000 | 8,160.00 | 0000 |
| 0330 | 630-80344 | Construction Traffic Sign (Special) | 700.000 | SF | 20.00000 | 14,000.00 | 0000 |
| 0335 | 630-80355 | Portable Message Sign Panel | 8.000 | EACH | 4,500.00000 | 36,000.00 | 0000 |
| 0340 | 630-80358 | Advance Warning Flashing or Sequencing Arrow Panel (C Type) | 8.000 | EACH | 1,000.00000 | 8,000.00 | 0000 |
| 0345 | 630-80360 | Drum Channelizing Device | 330.000 | EACH | 25.00000 | 8,250.00 | 0000 |
| 0350 | 630-80363 | Drum Channelizing Device (With Light) (Flashing) | 110.000 | EACH | 50.00000 | 5,500.00 | 0000 |
| 0355 | 630-80370 | Concrete Barrier (Temporary) | 3,720.000 | LF | 35.00000 | 130,200.00 | 0000 |
| 0360 | 630-80380 | Traffic Cone | 438.000 | EACH | 10.00000 | 4,380.00 | 0000 |

**Prime Project:** 21878 **PCN:** 21878-BID **Project No:** NHPP0705-082 **Contract ID:** 21878

**PCN:** 21878-BID I-70 ARRIBA: EAST AND WEST HMA

| Line No. | Item Number | Item Description | Estimated Quantity | Item Unit | Unit Price | Amount | Fund Package ID |
|---|---|---|---|---|---|---|---|
| 0365 | 630-80391 | Channelizing Device (Fixed) | 2,407.000 | EACH | 40.00000 | 96,280.00 | 0000 |
| 0370 | 630-85011 | Impact Attenuator (Temporary) | 3,217.000 | DAY | 60.00000 | 193,020.00 | 0000 |
| 0375 | 700-70010 | F/A Minor Contract Revisions | 1.000 | F A | 2,400,000.00000 | 2,400,000.00 | 0000 |
| 0380 | 700-70011 | F/A Partnering | 1.000 | F A | | | 0000 |
| 0385 | 700-70016 | F/A Fuel Cost Adjustment | 1.000 | F A | | | 0000 |
| 0390 | 700-70018 | F/A Roadway Smoothness Incentive | 1.000 | F A | | | 0000 |
| 0395 | 700-70019 | F/A Asphalt Cement Cost Adjustment | 1.000 | F A | | | 0000 |
| 0400 | 700-70023 | F/A On-The-Job Trainee | 1.000 | F A | | | 0000 |
| 0405 | 700-70025 | F/A Quality Incentive Payment | 1.000 | F A | | | 0000 |
| 0410 | 700-70035 | F/A | 1.000 | F A | | | 0000 |
| 0415 | 700-70380 | F/A Erosion Control | 1.000 | F A | | | 0000 |
| | | | | | **Category Total:** | $65,655,922.30 | |

**Category: 0300 G-24-V**

**Construction Type :**

**Work Classification :** 0300 G-24-V

**Construction Class :** B - Biddable Items

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0420 | 202-00246 | Removal of Asphalt Mat (Planing) (Special) | 528.000 | SY | 10.00000 | 5,280.00 | 0000 |
| 0425 | 202-00425 | Removal of Bridge Railing | 80.000 | LF | 10.00000 | 800.00 | 0000 |
| 0430 | 202-00450 | Removal of Portions of Present Structure (Class 1) | 27.000 | SY | 70.00000 | 1,890.00 | 0000 |
| 0435 | 202-00453 | Removal of Portions of Present Structure (Class 2) | 27.000 | SY | 220.00000 | 5,940.00 | 0000 |

**Prime Project:** 21878 **PCN:** 21878-BID **Project No:** NHPP0705-082 **Contract ID:** 21878

**PCN:** 21878-BID I-70 ARRIBA: EAST AND WEST HMA

| Line No. | Item Number | Item Description | Estimated Quantity | Item Unit | Unit Price | Amount | Fund Package ID |
|---|---|---|---|---|---|---|---|
| 0440 | 202-00460 | Removal of Portions of Present Structure (Class 3) | 6.000 | SY | 250.00000 | 1,500.00 | 0000 |
| 0445 | 202-00504 | Removal of Expansion Device | 85.000 | LF | 160.00000 | 13,600.00 | 0000 |
| 0450 | 202-00505 | Removal of Portions of Present Structure | 22.000 | SF | 100.00000 | 2,200.00 | 0000 |
| 0455 | 210-00530 | Rebuild Portions of Present Structure | | SF | | | 0000 |
| 0460 | 509-00001 | Structural Steel (Galvanized) | 27.000 | LB | 5.00000 | 135.00 | 0000 |
| 0465 | 514-01011 | Bridge Rail (Steel) | | LF | | | 0000 |
| 0470 | 515-00400 | Concrete Sealer | 108.000 | SY | 15.00000 | 1,620.00 | 0000 |
| 0475 | 518-00000 | Bridge Compression Joint Sealer | 85.000 | LF | 95.00000 | 8,075.00 | 0000 |
| 0480 | 518-00010 | Roadway Compression Joint Sealer | 84.000 | LF | 120.00000 | 10,080.00 | 0000 |
| 0485 | 518-03000 | Sawing and Sealing Bridge Joint | | LF | | | 0000 |
| 0490 | 519-03035 | Place Thin Bonded Overlay (Polyester Concrete) | 509.000 | SY | 40.00000 | 20,360.00 | 0000 |
| 0495 | 519-03055 | Furnish Thin Bonded Overlay (Polyester Concrete) | 359.000 | CF | 115.00000 | 41,285.00 | 0000 |
| 0500 | 601-03000 | Concrete Class D | 7.000 | CY | 700.00000 | 4,900.00 | 0000 |
| 0505 | 601-06100 | Concrete (Patching) | | CY | | | 0000 |
| 0510 | 602-00020 | Reinforcing Steel (Epoxy Coated) | 185.000 | LB | 2.00000 | 370.00 | 0000 |
| 0515 | 606-11010 | Bridge Rail Type 10R | 80.000 | LF | 220.00000 | 17,600.00 | 0000 |
| | | | | | **Category Total:** | $135,635.00 | |

**Prime Project:** 21878 **PCN:** 21878-BID **Project No:** NHPP0705-082 **Contract ID:** 21878

**PCN:** 21878-BID I-70 ARRIBA: EAST AND WEST HMA

| Line No. | Item Number | Item Description | Estimated Quantity | Item Unit | Unit Price | Amount | Fund Package ID |
|---|---|---|---|---|---|---|---|
| **Category: 0301 G-24-W** | | | | | | | |
| **Construction Type :** | | | | | | | |
| **Work Classification :** 0301 G-24-W | | | | | | | |
| **Construction Class :** B - Biddable Items | | | | | | | |
| 0520 | 202-00246 | Removal of Asphalt Mat (Planing) (Special) | 528.000 | SY | 10.00000 | 5,280.00 | 0000 |
| 0525 | 202-00425 | Removal of Bridge Railing | 80.000 | LF | 10.00000 | 800.00 | 0000 |
| 0530 | 202-00450 | Removal of Portions of Present Structure (Class 1) | 27.000 | SY | 70.00000 | 1,890.00 | 0000 |
| 0535 | 202-00453 | Removal of Portions of Present Structure (Class 2) | 27.000 | SY | 220.00000 | 5,940.00 | 0000 |
| 0540 | 202-00460 | Removal of Portions of Present Structure (Class 3) | 6.000 | SY | 250.00000 | 1,500.00 | 0000 |
| 0545 | 202-00504 | Removal of Expansion Device | 85.000 | LF | 160.00000 | 13,600.00 | 0000 |
| 0550 | 202-00505 | Removal of Portions of Present Structure | 28.000 | SF | 100.00000 | 2,800.00 | 0000 |
| 0555 | 210-00530 | Rebuild Portions of Present Structure | | SF | | | 0000 |
| 0560 | 509-00001 | Structural Steel (Galvanized) | 27.000 | LB | 5.00000 | 135.00 | 0000 |
| 0565 | 514-01011 | Bridge Rail (Steel) | 30.000 | LF | 300.00000 | 9,000.00 | 0000 |
| 0570 | 515-00400 | Concrete Sealer | 108.000 | SY | 15.00000 | 1,620.00 | 0000 |
| 0575 | 518-00000 | Bridge Compression Joint Sealer | 85.000 | LF | 95.00000 | 8,075.00 | 0000 |
| 0580 | 518-00010 | Roadway Compression Joint Sealer | 84.000 | LF | 120.00000 | 10,080.00 | 0000 |
| 0585 | 518-03000 | Sawing and Sealing Bridge Joint | | LF | | | 0000 |
| 0590 | 519-03035 | Place Thin Bonded Overlay (Polyester Concrete) | 509.000 | SY | 40.00000 | 20,360.00 | 0000 |

**Prime Project:** 21878 **PCN:** 21878-BID **Project No:** NHPP0705-082 **Contract ID:** 21878

**PCN:** 21878-BID I-70 ARRIBA: EAST AND WEST HMA

| Line No. | Item Number | Item Description | Estimated Quantity | Item Unit | Unit Price | Amount | Fund Package ID |
|---|---|---|---|---|---|---|---|
| 0595 | 519-03055 | Furnish Thin Bonded Overlay (Polyester Concrete) | 359.000 | CF | 115.00000 | 41,285.00 | 0000 |
| 0600 | 601-03000 | Concrete Class D | 7.000 | CY | 700.00000 | 4,900.00 | 0000 |
| 0605 | 601-06100 | Concrete (Patching) | 2.000 | CY | 3,100.00000 | 6,200.00 | 0000 |
| 0610 | 602-00020 | Reinforcing Steel (Epoxy Coated) | 185.000 | LB | 2.00000 | 370.00 | 0000 |
| 0615 | 606-11010 | Bridge Rail Type 10R | 80.000 | LF | 220.00000 | 17,600.00 | 0000 |
| | | | | | **Category Total:** | $151,435.00 | |

**Category: 0400 CONSTRUCTION ENGINEERING BID ITEMS**

**Construction Type :**

**Work Classification :** 0400 CONSTRUCTION ENGINEERING

**Construction Class :** B - Biddable Items

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0620 | 620-00002 | Field Office (Class 2) | 1.000 | EACH | 60,000.00000 | 60,000.00 | 0400 |
| 0625 | 620-00012 | Field Laboratory (Class 2) | 1.000 | EACH | 35,000.00000 | 35,000.00 | 0400 |
| 0630 | 620-00020 | Sanitary Facility | 5.000 | EACH | 1,500.00000 | 7,500.00 | 0400 |
| | | | | | **Category Total:** | $102,500.00 | |

**Project Total 21878-BID** **$66,045,492.30**

**Prime Project:** 21878 **PCN:** 21878-NONBID **Project No:** NHPP0705-082 **Contract ID:** 21878

**PCN:** 21878-NONBID I-70 ARRIBA: EAST AND WEST HMA

| Line No. | Item Number | Item Description | Estimated Quantity | Item Unit | Unit Price | Amount | Fund Package ID |
|---|---|---|---|---|---|---|---|
| **Category: 1100 INDIRECT COSTS** | | | | | | | |
| **Construction Type :** | | | | | | | |
| **Work Classification :** 1100 INDIRECT COSTS | | | | | | | |
| **Construction Class :** N - Non Biddable Items | | | | | | | |
| 0005 | 000-00050 | Indirect Costs (CE Only) | 1.000 | L S | 899,635.95000 | 899,635.95 | |
| | | | | | **Category Total:** | $899,635.95 | |
| | | | | | **Project Total 21878-NONBID** | **$899,635.95** | |
| | | | | | **Estimate Total 21878** | **$66,945,128.25** | |

** Flags: (F)ixed Price, (N)on Bid, (L)ow Cost Contributor, (B)id as Lump Sum*

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# APPENDIX A
# VE METHODS & PROCEDURES

## APPENDIX A METHODS & PROCEDURES

GENERAL

Jacobs was commissioned to facilitate a 3-day, Value Engineering (VE) Study for CDOT on the I-70 Arriba Project, pavement rehabilitation east and west of Arriba through the Flagler and Arriba interchanges.

The study was conducted using the Value Engineering and/or Value Analysis techniques created by Larry Miles and promoted by The Lawrence D. Miles Value Foundation and *SAVE International* – "The Value Society" (formerly known as the Society of American Value Engineers) utilizing a multi-disciplined team approach stressing function and creativity.

Due to project location, the VE Study was conducted at two CDOT offices. The first day of the VE study was conducted at the CDOT office in Limon, CO with a site visit along I-70 through Arriba and Flagler interchanges. The remainder of the VE study was performed at the CDOT offices in Centennial, CO. The study was performed during the period of September 26th to September 28th, 2017.

The Value Engineering team consisted of both consultants and CDOT staff.

The consultant VE Team included the following individuals:

| Participant | Role | Representing |
|---|---|---|
| Randall Sprague, CVS® | VE Team Leader | Jacobs |
| Bill Hickey, AVS | Asst. Team Leader | Jacobs |
| Rick Gabel | Construction | Jacobs |
| Leonard Cheslock | Traffic/MOT | Jacobs |
| Dean VanDeWege | Roadway | Jacobs |
| Bob LaForce | Materials | Yeh & Associates |

CDOT provided the following individuals to support the Value Engineering effort, some of whom were only part-time (P) available:

| Participant | Role | Representing |
|---|---|---|
| James Miller | Project Manager | CDOT |
| Karl Larson | Project Engineer | CDOT |
| Mike Hines (P) | Designer | CDOT |
| Travis Miller (P) | Resident Engineer | CDOT |

PROCEDURES

The six-step "Value Engineering Job Plan" was followed throughout the Value Engineering Study effort and the following paragraphs outline specifics of each step.

Information Phase: Prior to the workshop materials were made available by CDOT to the team. A project design briefing was performed were project background, history and the current status of design was presented. After the design briefing the project team, led by CDOT, performed a site visit, driving along I-70 through the project limits. Several stops were made to evaluate the existing conditions and have group discussions. The information phase is detailed in Appendix B of this report.

Function Analysis Phase: After returning from the site visit the VE team reviewed cost models and identified project functions with noun-verb association and identified the functions as secondary or higher order functions.

Speculation Phase: During this phase, a "creative thinking" atmosphere was established and ideas were generated through the use of the group "brainstorming" techniques. A list of the ideas generated during the Speculation Phase of this study has been compiled and is presented for reference in Appendix C.

Evaluation Phase: During this phase of the study, analysis of each of the ideas generated during the Speculation Phase was undertaken. Additional functions and a rough cost analysis/discussion were performed and the basic advantages and disadvantages of each alternative were reviewed, with additional comments added. Ideas considered to be most relevant and worth further analysis were then progressed to the Development Phase, and ideas not considered relevant proceeded no further.

Development Phase: Each of the viable alternatives developed during the "Evaluation Phase" was studied in detail and proposal text was prepared, including cost estimates and life cycle costs if relevant. During this phase some of the ideas were discarded and not recommended by the VE team (i.e. proved to be either not cost effective or of low value).

Presentation Phase: The VE team presented the VE proposals and recommendations during a presentation back to CDOT staff. Each viable alternative further analyzed by the VE team that was fully developed is presented in detail as a specific "VE Proposal". Meeting minutes of the presentation for reference are in Appendix D.

Value Engineering Study
I-70 ARRIBA: EAST AND WEST HMA
Study Location: Limon/Centennial, CO
**Sign-in Sheet**
**Dates: September 26-28, 2017**

| T | W | T | NAME | FIRM/AGENCY | VE TITLE/ROLE | PHONE | EMAIL |
|---|---|---|---|---|---|---|---|
| x | x | x | Randy Sprague, PE CVS | Jacobs | VE Team Leader/Facilitator | 201.400.7235 | William.Hickey@jacobs.com |
| x | x | x | Bill Hickey, PE, AVS | Jacobs | Assistant Team Leader | 425.213.2713 | William.Hickey@jacobs.com |
| x | x | x | Rick Gabel | Jacobs | VE Team: Construction | 847.833.0809 | Richard.Gabel@jacobs.com |
| x | x | x | Leonard Cheslock, PE, PTOE | Jacobs | VE Team: Traffic/MOT | 719.651.2769 | Leonard.Cheslock@jacobs.com |
| x | x | x | Bob LaForce | Yeh & Associates | VE Team: Materials | 303.781.9590 | blaforce@yeh-eng.com |
| x | x | x | Dean VanDeWege, PE | Jacobs | VE Team: Roadway | 303.653.6214 | Dean.vandewege@jacobs.com |
| x | x | P | Karl Larson | CDOT | CDOT Project Engineer | 719.740.1052 | Karl.larson@state.co.us |
| x | x | | James Miller, PE | CDOT | CDOT Project Manager | 303.365.7261 | james.miller@state.co.us |
| x | | | Mike Hines | CDOT | CDOT Designer | | |
| P | | | Travis Miller, PE | CDOT | CDOT Resident Engineer | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

x= attended full session
P= part-time attendance

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# APPENDIX B
# INFORMATION PHASE
# DESIGN PRESENTATION MEETING MINUTES

## APPENDIX B INFORMATION PHASE

DOCUMENTS

The following Project Documents were provided by CDOT for the Value Engineering Team for the I-70 Street Arriba project, for use prior to and during the Value Engineering Study:

Contract Plans:

- Set of drawings for the I-70 Arriba Project, FOR draft set, dated 10/19/17, 103 sheets

Cost Data:

- I-70 Arriba Project, FOR set; Preliminary Detail Cost Estimate, dated 9/19/17

Specifications:

- Draft CO Special Provisions for I-70 Arriba East and West HMA Failure, dated January 29, 2015, 59 pages.

Traffic

- Limited traffic information provided on Plan set Cover sheet (DHV, ADT and Truck %)

Geotechnical

- National Colorado Asphalt Technology (NCAT) , Forensic Investigation, 2017

The following lists of additional design references were also made available by CDOT during the study:

- CDOT Roadway Design Guide, 2005
- AASHTO, A policy on Geometric Design o Highways and Streets, 6th Edition, 2011
- CDOT Standard Specifications for Roads and Bridge Construction, 2017

SITE OBSERVATIONS

A site visit was performed during this Value Engineering study. After the conclusion of the Design Briefing the VE team headed out to the site in two vehicles and drove towards Arriba along I-70. The VE team stopped several times along the interstate and along ramps to get out and view the site conditions and future layouts of detour and cross-ramps. The VE team stopped five times along the corridor from Arriba to Flagler, stopping both along the westbound and eastbound ramps. The VE team wore personal protective (PPE) gear while on the site visit. The team took notice of the pavement condition and the difference in the westbound and eastbound lanes. Also there was a large percentage of truck traffic along the interstate during the site visit.

I-70 eastbound lanes, looking east near Arriba

I-70 westbound lanes, looking east near Arriba interchange

FUNCTION ANALYSIS

As part of the Information Phase of the VE Study, design documents were studied and discussed. The VE Team then discussed the functions of the construction of the project in terms of schedule, risk, costs, safety, mobility, and constructability. The results of this procedure are summarized below:

FUNCTION ANALYSIS TABLE

Functions are categorized as Basic (B), Secondary (S), or Higher Order (H). Basic functions are those which must be achieved, secondary functions identify how the basic functions are achieved, while higher order functions are outside the scope of the project and will always be considered regardless of the scope.

The VE team provided the following during the discussion of function analysis for the project:

| FUNCTION<br>B=Basic S=Secondary H=Higher Order | | | | | |
|---|---|---|---|---|---|
| ITEM | VERB | NOUN | B | S | H |
| Project | Improve | Ride | | x | |
| | Reduce | Maintenance | x | | |
| | Increase | Service Life | X | | |
| | Improve | Driving Safety | X | | |
| | Maintain | Traffic | | x | |
| | Satisfy | Bridge Clearances | | X | |
| | Improve | Bridge Service Life | | x | |
| | Update | Safety Edge | | x | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

## VE DESIGN BREIFING NOTES

Date: Sept 26, 2017
Time: 9:30 am- 11:30 am
Attendees: See the “VE Attendance Sheets” located in Appendix B.

The VE briefing began at 9:30 am in the CDOT office, in Limon, CO.

Because of the project location, the kick-off and first day of the VE study was held in the CDOT office in Limon. A site visit followed the briefing. Listed below are the meeting notes:

1. Introductions of the VE team were made.
2. Randall Sprague, the VE Team Leader, opened the meeting and thanked all for attending and gave an introduction to the VE process discussing the VE methodology and process to be followed during the study. Randy discussed the VE job plan and the use of function analysis and adding value.
3. Design briefing followed:
    a. James Miller (CDOT) provided a background of the project
        i. This is 15.1 mile reconstruction project.
        ii. About 4 years ago CDOT performed a 2.5-inch “mill & fill” along the same segment. There is now pavement failure at several locations and patching has already occurred. At this time continual maintenance is needed.
        iii. The current design intent is to remove the first 6-inches down to aggregate base, then place on top 12” of net new. So the grade will be raised by about 6-inches.
        iv. Geotech info: CDOT anticipates getting the Geotech report by tomorrow
        v. The corridor intent is to have concrete sections for the whole segment, as funds are available. This will connect the concrete sections.
        vi. There are two bridge overpasses at Arriba and Flagler; the plan is to remove and replace at these locations because of clearance issues.
        vii. One bridge crossing
        viii. Due to construction staging, there will be construction cross-over required and ramp cross-overs
        ix. CDOT does not prefer to do this construction all 15-miles at once (traffic will be head on head through construction zone), so cross-overs will be required. CDOT is looking at doing this in 8 mile segments.
        x. Anticipate four construction phases
        xi. Current schedule: Final office review (FOR) in a few weeks. Then the design will be taken close to 100% with a shelf date in December. Shelf ready until funding is available.
        xii. Parallel ramps vs taper ramps; large trucks prefer parallel ramps.
        xiii. Detour pavement: question about the thickness of pavement and can the contractor modify? CDOT is going to review thickness going from 8-inch to 6-inch, but there is a history of maintenance issues on detours, and sometimes this needs to occur on bad weekends.
        xiv. There is not any future expansion or compatibility that needs to be considered.
        xv. No corrections trying to be made with this project.
        xvi. This is anticipated to be a two year project, with shut-down during the winter.
        xvii. Cross-overs will be removed after project is completed.

xviii. No utility concerns along corridor. There is snow gates at ramps, may need power for flashing light.
xix. Water table? Not usually an issue here, but not sure, Geotech report should provide more information,
xx. Pavement failure has occurred due to water getting trapped and bad material below.
xxi. Design speeds: 55mph at cross-overs and 30 mph slowdown (James will confirm). 55mph on detour , head to head traffic
xxii. No super elevation on ramps.

4. Designer Briefing ended at 11:30 am with the site visit following immediately afterwards.

5. After the briefing the team had lunch in Arriba and headed out to the project site in two vehicles. The team drove east on I-70 to the project site, beginning near Arriba. The team stopped at several locations to view the existing pavement, traffic, surroundings, the interchanges and cross-over areas. The team drove to the Flagler interchange and then westbound through the 15 mile long project.

The site visit concluded approximately at 2:30, and the team headed to the CDOT offices in Limon to continue the study session.

Value Engineering Study
I-70 ARRIBA: EAST AND WEST HMA
Study Location: Limon/Centennial, CO
**Sign-in Sheet**
**Dates: September 26-28, 2017**

| T | W | T | NAME | FIRM/AGENCY | VE TITLE/ROLE | PHONE | EMAIL |
|---|---|---|---|---|---|---|---|
| x | x | x | Randy Sprague, PE CVS | Jacobs | VE Team Leader/Facilitator | 201.400.7235 | William.Hickey@jacobs.com |
| x | x | x | Bill Hickey, PE, AVS | Jacobs | Assistant Team Leader | 425.213.2713 | William.Hickey@jacobs.com |
| x | x | x | Rick Gabel | Jacobs | VE Team: Construction | 847.833.0809 | Richard.Gabel@jacobs.com |
| x | x | x | Leonard Cheslock, PE, PTOE | Jacobs | VE Team: Traffic/MOT | 719.651.2769 | Leonard.Cheslock@jacobs.com |
| x | x | x | Bob LaForce | Yeh & Associates | VE Team: Materials | 303.781.9590 | blaforce@yeh-eng.com |
| x | x | x | Dean VanDeWege, PE | Jacobs | VE Team: Roadway | 303.653.6214 | Dean.vandewege@jacobs.com |
| x | x | P | Karl Larson | CDOT | CDOT Project Engineer | 719.740.1052 | Karl.larson@state.co.us |
| x | x | | James Miller, PE | CDOT | CDOT Project Manager | 303.365.7261 | james.miller@state.co.us |
| x | | | Mike Hines | CDOT | CDOT Designer | | |
| P | | | Travis Miller, PE | CDOT | CDOT Resident Engineer | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

x= attended full session
P= part-time attendance

| Oversight / NHS | |
|---|---|
| FHWA PROJECTS OF DIVISION INTEREST (PoDI) OVERSIGHT? | □ NO ■ YES |
| NATIONAL HIGHWAY SYSTEM? | □ NO ■ YES |

# DEPARTMENT OF TRANSPORTATION
# STATE OF COLORADO

HIGHWAY CONSTRUCTION BID PLANS OF PROPOSED
**FEDERAL AID PROJECT NO. IM 0705-082**
STATE HIGHWAY NO. 70
**LINCOLN / KIT CARSON COUNTY**
CONSTRUCTION PROJECT CODE NO. 21878

Related Projects:
P. E. UNDER PROJECT:
Project Number
Project Code:

R.O.W. Projects:
R.O.W. Project Description

**TABULATION OF LENGTH & DESIGN DATA**

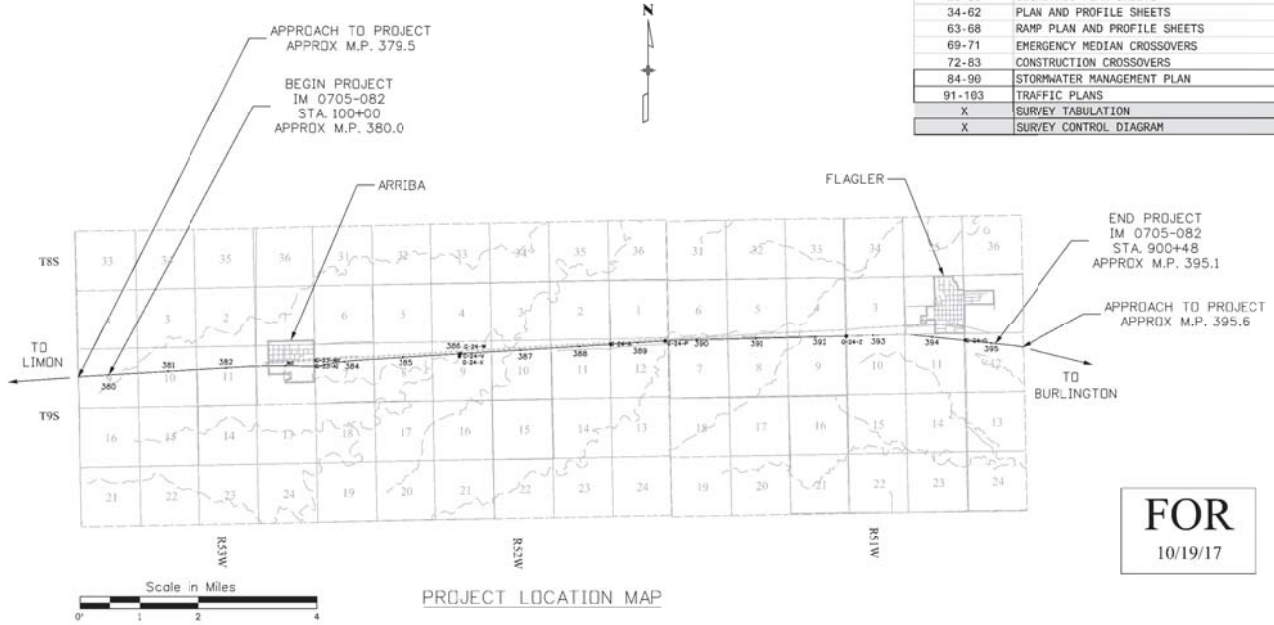
| STATION | FEET ROADWAY I-70 |
|---|---|
| APPROACH TO PROJECT M.P. 379.5 | |
| BEGIN PROJECT IM 0705-082 | |
| STA. 100+00 APPROX M.P. 380.0 ON I-70 | 3,609 |
| STA. 416+09 BEGIN STRUCTURES NO. G-24-V & G-24-W | |
| STA. 417+20 END STRUCTURES NO. G-24-V & G-24-W | |
| END PROJECT IM 0705-082 | |
| STA. 900+48 APPROX M.P. 395.1 ON I-70 | 76,008 |
| APPROACH TO PROJECT M.P. 395.6 | |
| TOTAL | 79617 |
| SUMMARY OF PROJECT LENGTH | FEET |
| ROADWAY (NET LENGTH) | 79,617 |
| MAJOR STRUCTURE | - |
| PROJECT GROSS LENGTH | 79,728 |

0.021

15.1

| DESIGN DATA | I-70 |
|---|---|
| MAXIMUM RADIUS OF CURVE | >2210 FT. |
| MAXIMUM GRADE | >3.0% |
| MINIMUM S.S.D. HORIZONTAL | >820 FT. |
| MINIMUM S.S.D. VERTICAL | >820 FT. |
| MAXIMUM DESIGN SPEED | 75 MPH |
| 2017 DESIGN TRAFFIC | DHV = 1584 ADT = 9,900 |
| DHV TRUCK % | 29.40% |
| CLEAR ZONE DISTANCE | 38 FT. |

| SHEET NO. | INDEX OF SHEETS |
|---|---|
| 1 | TITLE SHEET |
| 2 | STANDARD PLANS LIST SHEET |
| 3-4 | TYPICAL SECTIONS SHEET |
| 5 | GENERAL NOTES SHEET |
| 6 | ENVIRONMENTAL NOTES |
| 7-9 | SUMMARY OF APPROXIMATE QUANTITIES |
| 10-11 | TABULATION OF SURFACING |
| 12 | TABULATION OF DELINEATORS |
| 13 | TABULATION OF GUARDRAIL |
| 14-20 | BRIDGE PLANS |
| 21 | MAINLINE SUPERELEVATION DATA |
| 22 | CROSSOVER SUPERELEVATION DATA |
| 23-33 | GEOMETRIC PLAN SHEETS |
| 34-62 | PLAN AND PROFILE SHEETS |
| 63-68 | RAMP PLAN AND PROFILE SHEETS |
| 69-71 | EMERGENCY MEDIAN CROSSOVERS |
| 72-83 | CONSTRUCTION CROSSOVERS |
| 84-90 | STORMWATER MANAGEMENT PLAN |
| 91-103 | TRAFFIC PLANS |
| X | SURVEY TABULATION |
| X | SURVEY CONTROL DIAGRAM |




PROJECT LOCATION MAP

FOR
10/19/17

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Print Date: 9/15/2017 | | Sheet Revisions | | | Colorado Department of Transportation | As Constructed | Contract Information | Project No./Code |
| File Name: 21878 TitleSht.dgn | | Date: | Comments | Init. | 401 A Avenue<br>Limon, CO 80828<br>Phone: 719-775-8002 FAX: 719-775-8014 | No Revisions: | Contractor: | NHPP 0705-082 |
| Horiz. Scale: 1:1 Vert. Scale: As Noted | | | | | | Revised: | Resident Engineer: | 21878 |
| Unit Information Unit Leader Initials | | | | | | Void: | Project Engineer: | Sheet Number: 1 |
| | | | | | Region 4 TAM | | PROJECT STARTED: / / ACCEPTED: / / | |
| | | | | | | | Comments: | |

| PLAN NUMBER | NEW OR REVISED | M STANDARD TITLE | PAGE NUMBER |
|---|---|---|---|
| M-100-1 | | STANDARD SYMBOLS (3 SHEETS) | 1-3 |
| M-100-2 | | ACRONYMS AND ABBREVIATIONS (4 SHEETS) | 4-7 |
| M-203-1 | ▭ | APPROACH ROADS (REVISED ON JULY 08, 2013) | 8 |
| M-203-2 | | DITCH TYPES | 9 |
| M-203-11 | | SUPERELEVATION CROWNED AND DIVIDED HIGHWAYS (3 SHEETS) | 10-12 |
| M-203-12 | | SUPERELEVATION STREETS (2 SHEETS) | 13-14 |
| M-206-1 | | EXCAVATION AND BACKFILL FOR STRUCTURES (2 SHEETS) | 15-16 |
| M-206-2 | | EXCAVATION AND BACKFILL FOR BRIDGES (2 SHEETS) | 17-18 |
| M-208-1 | ■ | TEMPORARY EROSION CONTROL (11 SHEETS) (REVISED ON AUGUST 10, 2017) | ~~19-30~~ |
| M-210-1 | | MAILBOX SUPPORTS (2 SHEETS) | 31-32 |
| M-214-1 | | PLANTING DETAILS | 33 |
| M-216-1 | ▭ | SOIL RETENTION COVERING (2 SHEETS) (NEW ON JULY 16, 2015) | |
| M-412-1 | ▭ | CONCRETE PAVEMENT JOINTS (5 SHEETS) (REVISED ON JULY 24, 2012) | ~~34-38~~ |
| M-510-1 | | STRUCTURAL PLATE PIPE H-20 LOADING | 39 |
| M-601-1 | ▭ | SINGLE CONCRETE BOX CULVERT (2 SHEETS) (REVISED ON NOVEMBER 25, 2015) | ~~40-41~~ |
| M-601-2 | ▭ | DOUBLE CONCRETE BOX CULVERT (2 SHEETS) (REVISED ON NOVEMBER 25, 2015) | ~~42-43~~ |
| M-601-3 | ▭ | TRIPLE CONCRETE BOX CULVERT (2 SHEETS) (REVISED ON NOVEMBER 25, 2015) | ~~44-45~~ |
| M-601-10 | | HEADWALL FOR PIPES | 46 |
| M-601-11 | | TYPE "S" SADDLE HEADWALLS FOR PIPE | 47 |
| M-601-12 | | HEADWALLS AND PIPE OUTLET PAVING | 48 |
| M-601-20 | | WINGWALLS FOR PIPE OR BOX CULVERTS | 49 |
| M-603-1 | ■ | METAL PIPE (4 SHEETS). (REVISED ON OCTOBER 02, 2014) | ~~50-53~~ |
| M-603-2 | ▭ | REINFORCED CONCRETE PIPE. (REVISED ON OCTOBER 02, 2014) | ~~54~~ |
| M-603-3 | | PRECAST CONCRETE BOX CULVERT | 55 |
| M-603-4 | ▭ | CORRUGATED POLYETHYLENE PIPE (AASHTO M294) (REVISED ON OCT. 02, 2014). | ~~56~~ |
| M-603-5 | ▭ | POLYVINYL CHLORIDE (PVC) PIPE (AASHTO M304). (REVISED ON OCT. 02, 2014). | ~~57~~ |
| M-603-6 | ▭ | STEEL REINFORCED POLYETHYLENE RIBBED PIPE (AASHTO MP 20) (NEW ON APRIL 30, 2015) | |
| M-603-10 | | CONCRETE AND METAL END SECTIONS (2 SHEETS) | 58-59 |
| M-604-10 | | INLET, TYPE C | 60 |
| M-604-11 | | INLET, TYPE D | 61 |
| M-604-12 | | CURB INLET TYPE R (2 SHEETS) | 62-63 |
| M-604-13 | | CONCRETE INLET TYPE 13 | 64 |
| M-604-20 | | MANHOLES (3 SHEETS) | 65-67 |
| M-604-25 | | VANE GRATE INLET (5 SHEETS) | 68-72 |
| M-605-1 | | SUBSURFACE DRAINS | 73 |
| M-606-1 | ■ | GUARDRAIL TYPE 3 W-BEAM (20 SHEETS) (REVISED ON OCTOBER 27, 2014) | ~~74-92~~ |
| M-606-1 | ■ | MIDWEST GUARDRAIL SYSTEM (MGS) TYPE 3 W-BEAM 31 INCHES (20 SHEETS) (REVISED ON DECEMBER 29, 2015) | |
| M-606-13 | ■ | GUARDRAIL TYPE 7 F-SHAPE BARRIER (4 SHEETS) (REVISED ON AUGUST 30, 2013) | ~~93-96~~ |
| M-606-14 | | PRECAST TYPE 7 CONCRETE BARRIER (3 SHEETS) | 97-99 |

| PLAN NUMBER | NEW OR REVISED | M STANDARD TITLE | PAGE NUMBER |
|---|---|---|---|
| M-607-1 | | WIRE FENCES AND GATES (3 SHEETS) | 100-102 |
| M-607-2 | | CHAIN LINK FENCE (3 SHEETS) | 103-105 |
| M-607-3 | | BARRIER FENCE | 106 |
| M-607-4 | ▭ | DEER FENCE, GATES, AND GAME RAMPS (5 SHEETS) (REVISED ON APRIL 30, 2015) | ~~107-109~~ |
| M-607-10 | | PICKET SNOW FENCE | 110 |
| M-607-15 | | ROAD CLOSURE GATE (9 SHEETS) | 111-119 |
| M-608-1 | ▭ | CURB RAMPS (10 SHEETS) (REVISED ON FEBRUARY 23, 2017) | ~~120-125~~ |
| M-609-1 | ▭ | CURBS, GUTTERS, AND SIDEWALKS (4 SHEETS) (REVISED ON JULY 24, 2012). | ~~126-129~~ |
| M-611-1 | | CATTLE GUARD (2 SHEETS) | 130-131 |
| M-611-2 | ▭ | DEER GUARD (2 SHEETS) (NEW ON APRIL 30, 2015) | |
| M-613-1 | | ROADWAY LIGHTING (4 SHEETS) | 132-135 |
| M-614-1 | | RUMBLE STRIPS (3 SHEETS) | 136-138 |
| M-614-2 | | SAND BARREL ARRAYS (2 SHEETS) | 139-140 |
| M-615-1 | | EMBANKMENT PROTECTOR TYPE 3 | 141 |
| M-615-2 | | EMBANKMENT PROTECTOR TYPE 5 | 142 |
| M-616-1 | | INVERTED SIPHON | 143 |
| M-620-1 | | FIELD LABORATORY CLASS 1 | 144 |
| M-620-2 | | FIELD LABORATORY CLASS 2 (2 SHEETS) | 145-146 |
| M-620-11 | | FIELD OFFICE CLASS 1 | 147 |
| M-620-12 | | FIELD OFFICE CLASS 2 | 148 |
| M-629-1 | | SURVEY MONUMENTS (2 SHEETS) | 149-150 |

COLORADO
DEPARTMENT OF TRANSPORTATION

M&S STANDARDS PLANS LIST

July 04, 2012

Revised on August 10, 2017

ALL OF THE M&S STANDARD PLANS, AS SUPPLEMENTED AND REVISED, APPLY TO THIS PROJECT WHEN USED BY DESIGNATED PAY ITEM OR SUBSIDIARY ITEM.

NEW OR REVISED STANDARD PLAN SHEETS APPLICABLE TO THIS PROJECT, INDICATED BY A MARKED BOX ■, WILL BE ATTACHED TO THE PLANS.

| PLAN NUMBER | NEW OR REVISED | S STANDARD TITLE | PAGE NUMBER |
|---|---|---|---|
| S-612-1 | ■ | DELINEATOR INSTALLATIONS (7 SHEETS) (REVISED ON DEC. 1, 2016). | ~~151-157~~ |
| S-614-1 | ■ | GROUND SIGN PLACEMENT (2 SHEETS) (REVISED ON DECEMBER 12, 2014). | ~~158-159~~ |
| S-614-2 | ■ | CLASS I SIGNS (REVISED ON JUNE 24, 2016) | ~~160~~ |
| S-614-3 | | CLASS II SIGNS | 161 |
| S-614-4 | ■ | CLASS III SIGNS (3 SHEETS) (REVISED ON DECEMBER 17, 2014) | ~~162-164~~ |
| S-614-5 | ■ | BREAK-AWAY SIGN SUPPORT DETAILS (REVISED ON FEBRUARY 8, 2017) FOR GROUND SIGNS (2 SHEETS) | ~~165-166~~ |
| S-614-6 | ■ | CONCRETE FOOTINGS AND SIGN ISLANDS FOR CLASS III SIGNS (2 SHEETS) (REVISED ON SEPTEMBER 16, 2013) | ~~167-168~~ |
| S-614-8 | ■ | TUBULAR STEEL SIGN SUPPORT DETAILS (6 SHEETS) (REVISED ON DECEMBER 1, 2016) | ~~169-173~~ |
| S-614-9 | ▭ | PEDESTRIAN PUSH BUTTON POST ASSEMBLY (REVISED ON MAY 24, 2016) | ~~174~~ |
| S-614-10 | | MARKER ASSEMBLY INSTALLATIONS | 175 |
| S-614-11 | | MILEPOST SIGN DETAIL FOR HIGH SNOW AREAS | 176 |
| S-614-12 | | STRUCTURE NUMBER INSTALLATION | 177 |
| S-614-14 | | FLASHING BEACON AND SIGN INSTALLATIONS (3 SHEETS) | 178-180 |
| S-614-20 | | TYPICAL POLE MOUNT SIGN INSTALLATIONS | 181 |
| S-614-21 | ▭ | CONCRETE BARRIER SIGN POST INSTALLATIONS (REVISED ON MAY 24, 2016) | ~~182~~ |
| S-614-22 | | TYPICAL MULTI-SIGN INSTALLATIONS | 183 |
| S-614-40 | ▭ | TYPICAL TRAFFIC SIGNAL INSTALLATION DETAILS (5 SHEETS) (REVISED ON JUNE 17, 2016) | ~~184-188~~ |
| S-614-40A | ▭ | ALTERNATIVE TRAFFIC SIGNAL INSTALLATION DETAILS (4 SHEETS) (REVISED ON JUNE 17, 2016) | ~~189-192~~ |
| S-614-41 | ▭ | TEMPORARY SPAN WIRE SIGNALS (REVISED ON APRIL 2, 2015) | ~~193~~ |
| S-614-42 | | CABINET FOUNDATION DETAIL (4 SHEETS) | 194-197 |
| S-614-43 | | TRAFFIC LOOP AND MISCELLANEOUS SIGNAL DETAILS (10 SHEETS) | 198-207 |
| S-614-44 | ▭ | PEDESTAL POLE SIGNALS (2 SHEETS) (REVISED ON JUNE 17, 2016) | |
| S-614-50 | ▭ | STATIC SIGN MONOTUBE STRUCTURES (12 SHEETS) (REVISED ON JUNE 17, 2016) | ~~208-219~~ |
| S-614-60 | ▭ | DYNAMIC SIGN MONOTUBE STRUCTURES (14 SHEETS) (REVISED ON JUNE 17, 2016) | ~~220-233~~ |
| S-627-1 | ■ | PAVEMENT MARKINGS (8 SHEETS) (REVISED ON FEBRUARY 8, 2017). | ~~234-238~~ |
| S-630-1 | ■ | TRAFFIC CONTROLS FOR HIGHWAY CONSTRUCTION (24 SHEETS) (REVISED ON JUNE 23, 2016) | ~~239-258~~ |
| S-630-2 | ■ | BARRICADES, DRUMS, CONCRETE BARRIERS (TEMP). AND VERTICAL PANELS (REVISED ON JUNE 23, 2016) | ~~259~~ |
| S-630-3 | | FLASHING BEACON (PORTABLE) DETAILS | 260 |
| S-630-4 | | STEEL SIGN SUPPORT (TEMPORARY) INSTALLATION. DETAILS (2 SHEETS) | 261-262 |
| S-630-5 | ▭ | PORTABLE RUMBLE STRIPS (TEMPORARY) (2 SHEETS) (REVISED ON AUGUST 13, 2015) | ~~263-264~~ |
| S-630-6 | | EMERGENCY PULL-OFF AREA (TEMPORARY) | 265 |
| S-630-7 | | ROLLING ROADBLOCKS FOR TRAFFIC CONTROL (3 SHEETS) | 266-268 |

| Computer File Information | | |
|---|---|---|
| Creation Date: 07/04/12 | Initials: JBK | |
| Last Modification Date: 08/10/17 | Initials: LTA | (R-X) |
| Full Path: www.coloradodot.info/business/designsupport | | (R-X) |
| Drawing File Name: Standards Plans List.dgn | | (R-X) |
| CAD Ver.: MicroStation V8 Scale: Not to Scale Units: English | | (R-X) |

| Sheet Revisions | |
|---|---|
| Date: | Comments |
| | |
| | |
| | |
| | |

Colorado Department of Transportation
4201 East Arkansas Avenue
CDOT HQ, 4th Floor
Denver, CO 80222
Phone: 303-757-9021 FAX: 303-757-9868
Division of Project Support JBK/LTA

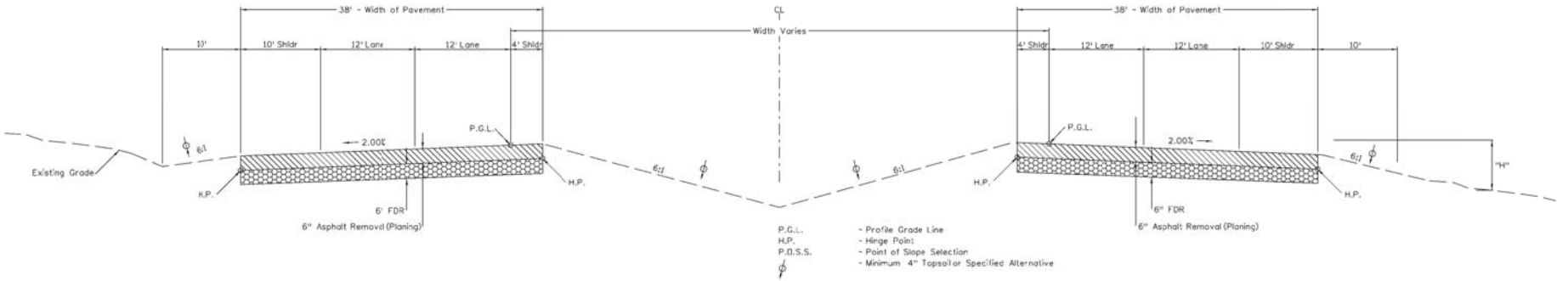
# STANDARDS PLANS LIST

Issued By: Project Development Branch July 4, 2012

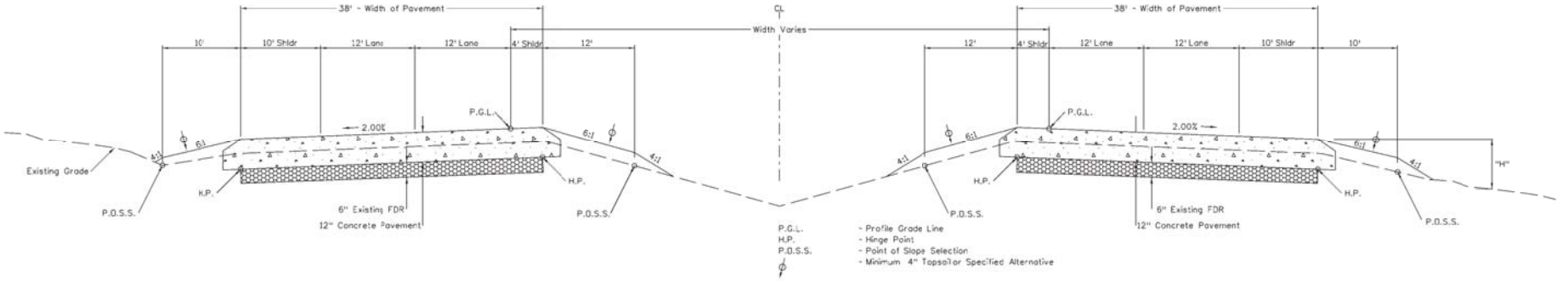
STANDARD PLAN NO.

STANDARDS PLANS LIST

Sheet No. 1 of 1




NOT TO SCALE

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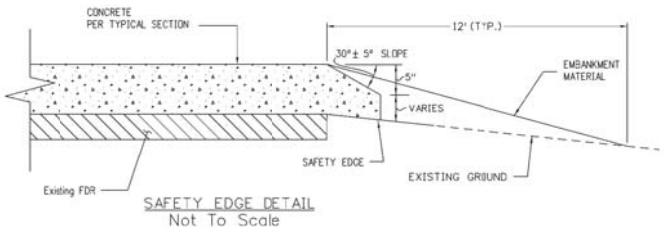



SAFETY EDGE DETAIL
Not To Scale

## SAFETY EDGE NOTES

1. THE SAFETY EDGE WILL BE CONSTRUCTED AS PART OF THE ROADWAY PAVEMENT. A SHOULDER WEDGE DEVICE WILL BE ADDED TO THE SCREED OF THE PAVING MACHINE.
2. THE CONTRACTOR MAY USE A SHOULDER WEDGE MAKER OR A SIMILAR DEVICE THAT PRODUCES THE SAME COMPACTION RESULTS.
3. SHORT SECTIONS OF HANDWORK WILL BE ALLOWED WHEN NECESSARY FOR TRANSITIONS AND TURNOUTS.
4. SITE PREPARATION AND ADDITIONAL EARTHWORK REQUIRED TO CONSTRUCT THE SAFETY EDGE WILL NOT PAID FOR SEPARATELY BUT SHALL BE INCLUDED IN THE WORK.

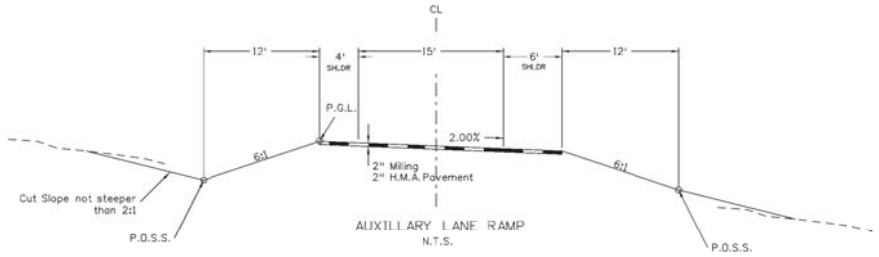
THE GRADE LINE WAS ESTABLISHED WITH THE BEST INFORMATION AVAILABLE. THE INTENT WAS TO PRODUCE A SMOOTH LINE WITH CONSIDERATIONS FOR SUPERELEVATIONS AND STOPPING SIGHT DISTANCE REQUIREMENTS. THE CONTRACTOR SHALL VERIFY THIS INFORMATION IN THE FIELD AND MAKE ADJUSTMENTS WHILE MAINTAINING VERTICAL CURVES AND STOPPING SIGHT DISTANCES TO ENSURE MINIMUM DESIGN THICKNESS, MINIMIZE EXCESS THICKNESS, AND/OR TIE INTO THE STRUCTURES. EXISTING TANGENT OR SUPERELEVATIONS SHALL BE PREPARED FOR CONCRETE OVERLAY WITH ADDITIONAL CONCRETE.

THE CONTRACTOR SHALL ESTABLISH A PROCESS TO DETERMINE THE FINAL GRADE LINE. THE PROCESS SHALL BE SUBMITTED TO THE ENGINEER FOR APPROVAL 2 WEEKS PRIOR TO PAVING. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE FINAL GRADE AND ASSOCIATED COSTS NECESSARY TO SATISFY THESE REQUIREMENTS.

| | | | | | |
|---|---|---|---|---|---|
| Print Date: 9/15/2017 | Sheet Revisions | | | As Constructed | TYPICAL SECTIONS |
| File Name: 21878DES_TyplSect01.dgn | Date: | Comments | Init. | No Revisions: | Designer: J.D. Miller |
| Horiz. Scale: 1:20 Vert. Scale: As Noted | | | | Revised: | Detailer: M. Hines |
| Unit Information Unit Leader Initials | | | | Void: | Sheet Subset: Typical |
| | | | | | Structure Numbers |
| | | | | | Subset Sheets: 1 of 2 |

Colorado Department of Transportation
401 A Avenue
Limon, CO 80828
Phone: 719-775-8002 FAX: 719-775-8014
Region 4 TAM

| Project No./Code |
|---|
| NHPP 0705-082 |
| 21878 |
| Sheet Number 3 |

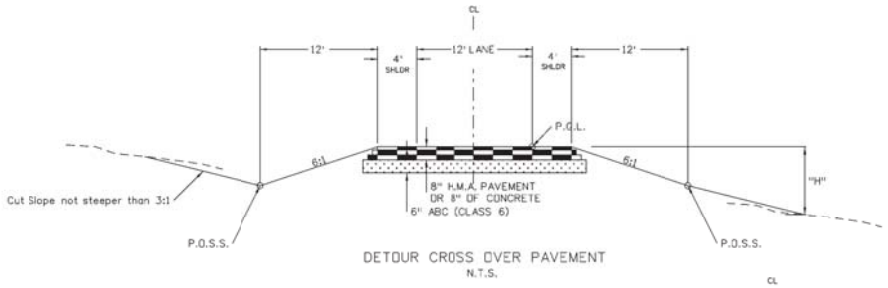



AUXILLARY LANE RAMP
N.T.S.

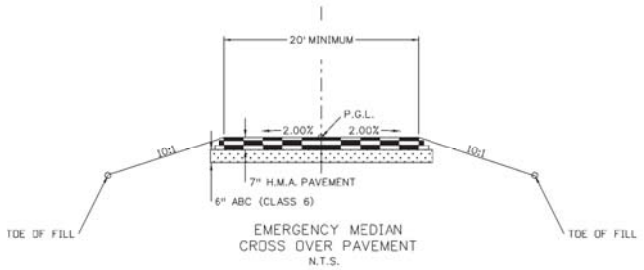
THE GRADE LINE WAS ESTABLISHED WITH THE BEST INFORMATION AVAILABLE. THE INTENT WAS TO PRODUCE A SMOOTH LINE WITH CONSIDERATIONS FOR SUPERELEVATIONS AND STOPPING SIGHT DISTANCE REQUIREMENTS. THE CONTRACTOR SHALL VERIFY THIS INFORMATION IN THE FIELD AND MAKE ADJUSTMENTS WHILE MAINTAINING VERTICAL CURVES AND STOPPING SIGHT DISTANCES TO ENSURE MINIMUM DESIGN THICKNESS, MINIMIZE EXCESS THICKNESS, AND/OR TIE INTO THE STRUCTURES. EXISTING TANGENT OR SUPERELEVATIONS SHALL BE PREPARED FOR CONCRETE OVERLAY WITH ADDITIONAL CONCRETE.

THE CONTRACTOR SHALL ESTABLISH A PROCESS TO DETERMINE THE FINAL GRADE LINE. THE PROCESS SHALL BE SUBMITTED TO THE ENGINEER FOR APPROVAL 2 WEEKS PRIOR TO PAVING. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE FINAL GRADE AND ASSOCIATED COSTS NECESSARY TO SATISFY THESE REQUIREMENTS.

P.G.L. - Profile Grade Line
P.O.S.S. - Point of Slope Selection




DETOUR CROSS OVER PAVEMENT
N.T.S.




EMERGENCY MEDIAN
CROSS OVER PAVEMENT
N.T.S.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Print Date: 9/15/2017 | | Sheet Revisions | | | Colorado Department of Transportation | As Constructed | TYPICAL SECTIONS | | | Project No./Code |
| File Name: 21878DES_TyplSect01.dgn | | Date: | Comments | Init. | 401 A Avenue<br>Limon, CO 80828<br>Phone: 719-775-8002 FAX: 719-775-8014 | No Revisions: | | | | NHPP 0705-082 |
| Horiz. Scale: 1:20 Vert. Scale: As Noted | | | | | | Revised: | Designer: J.D. MILLER | Structure Numbers | | 21878 |
| Unit Information Unit Leader Initials | | | | | Region 4 TAM | Void: | Detailer: M. HINES | | | Sheet Number 4 |
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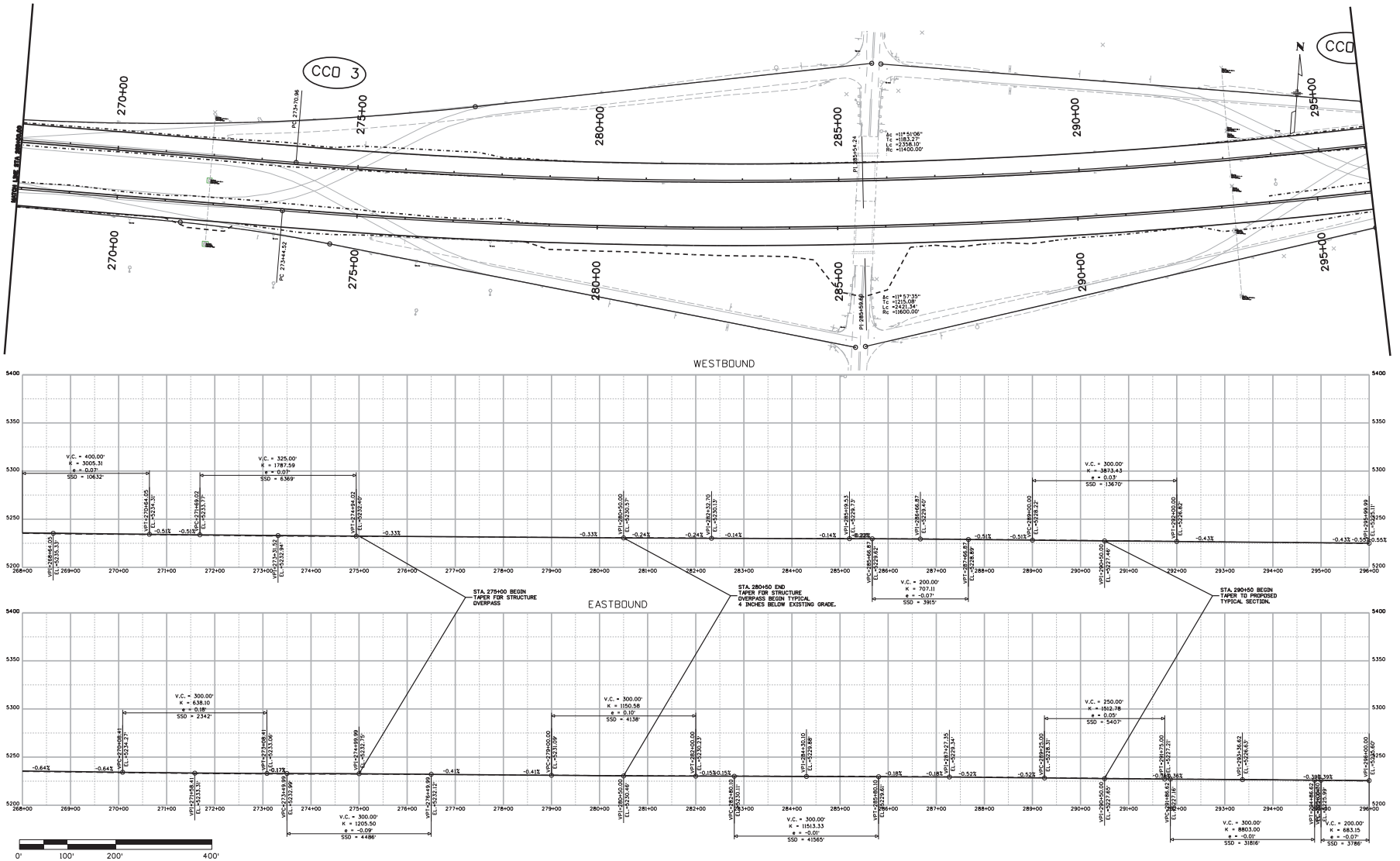


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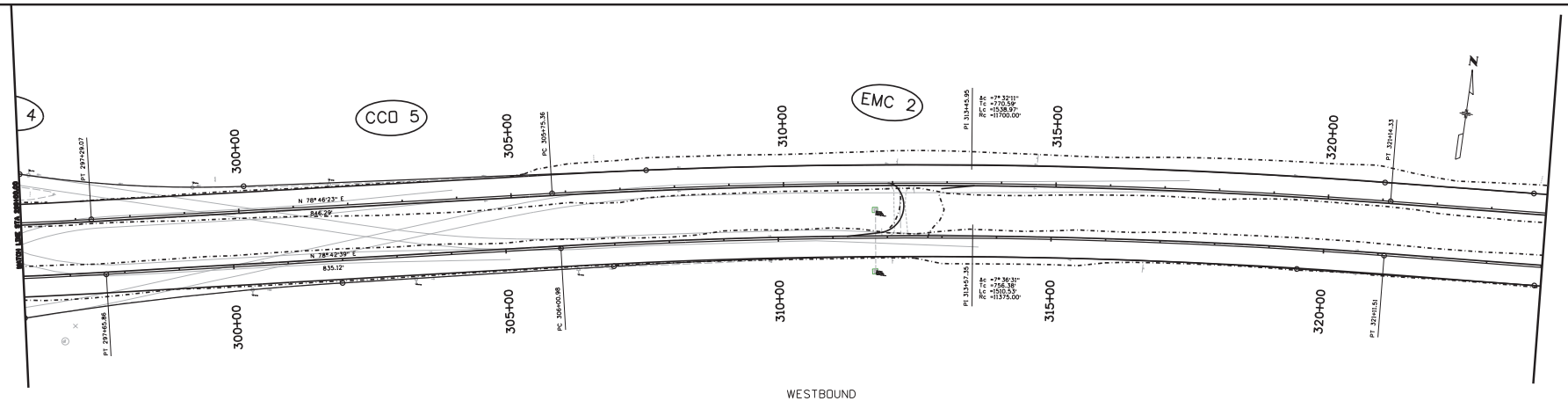


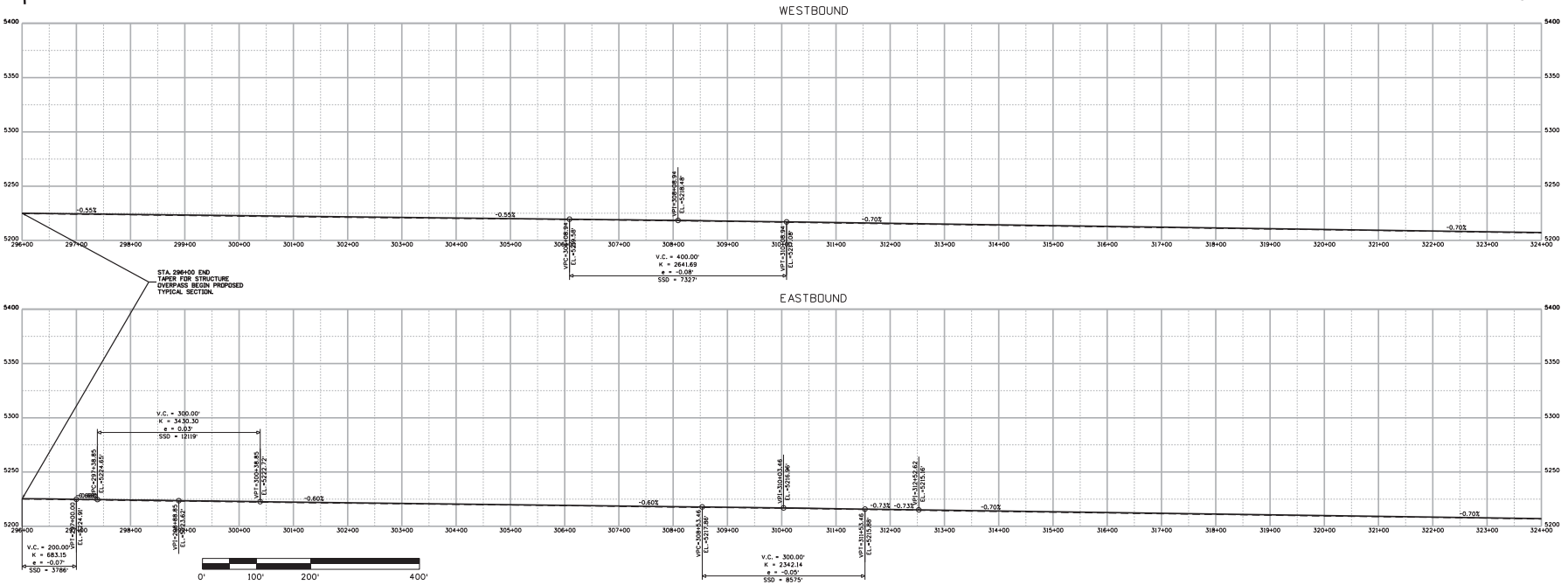


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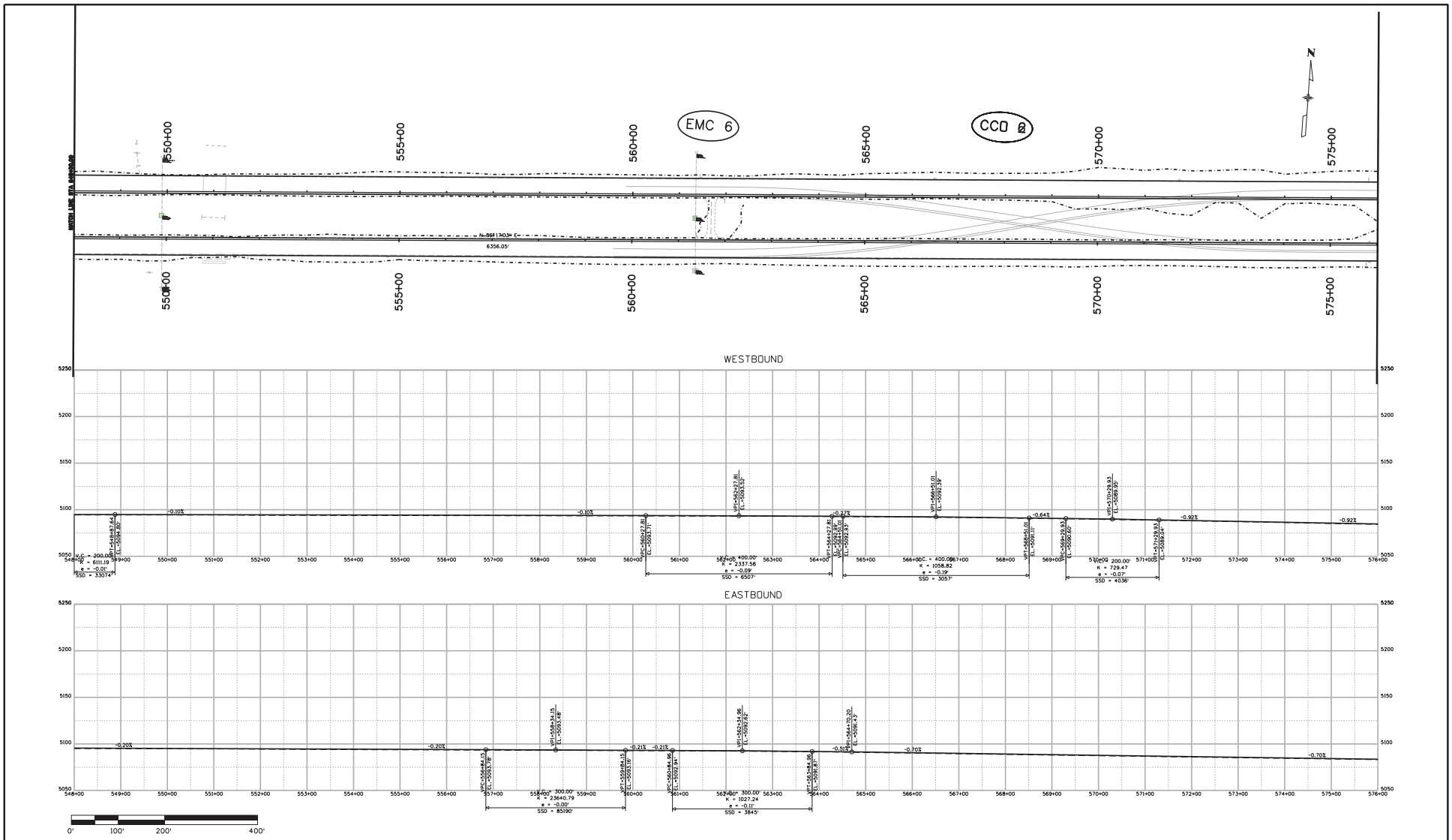


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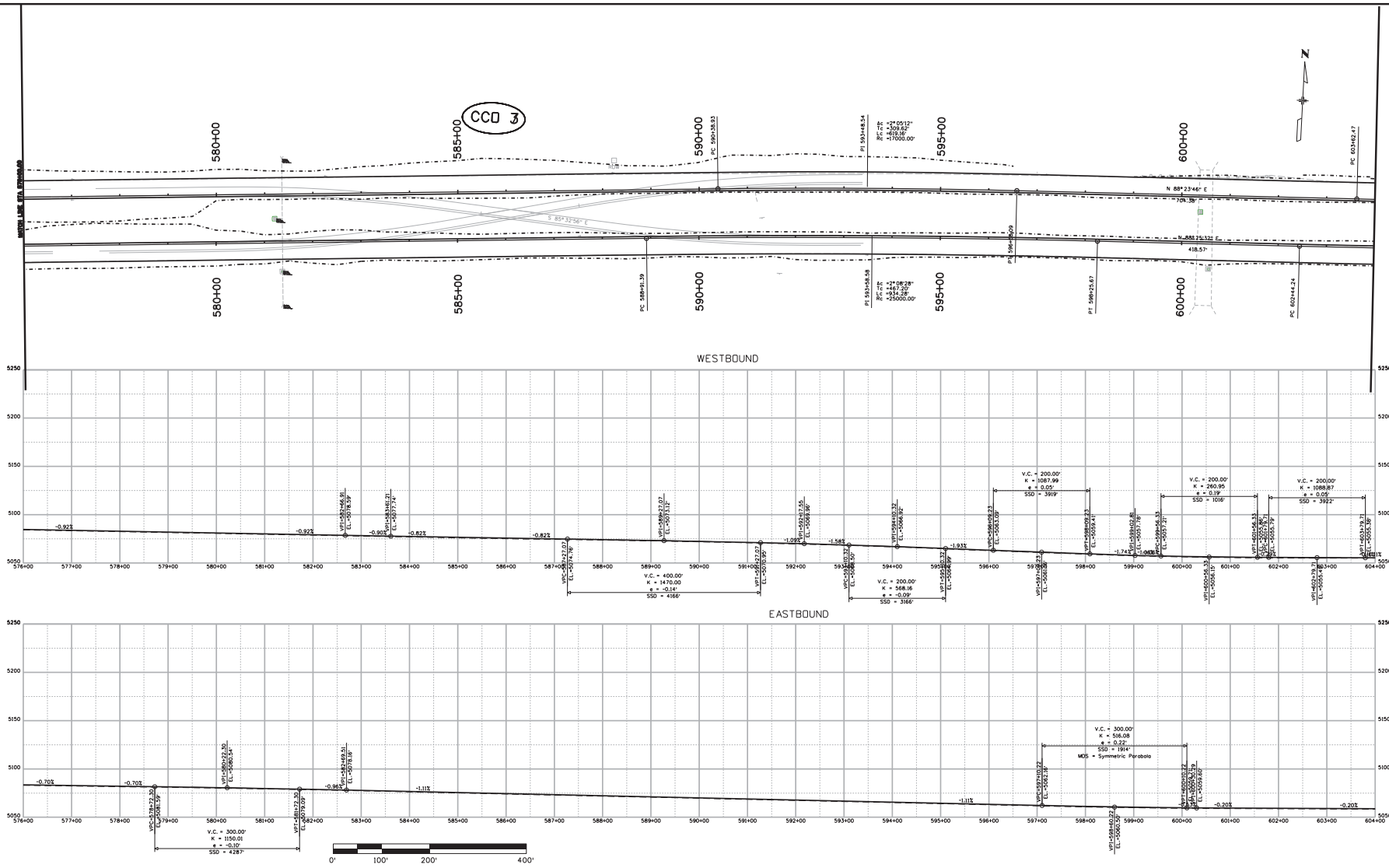


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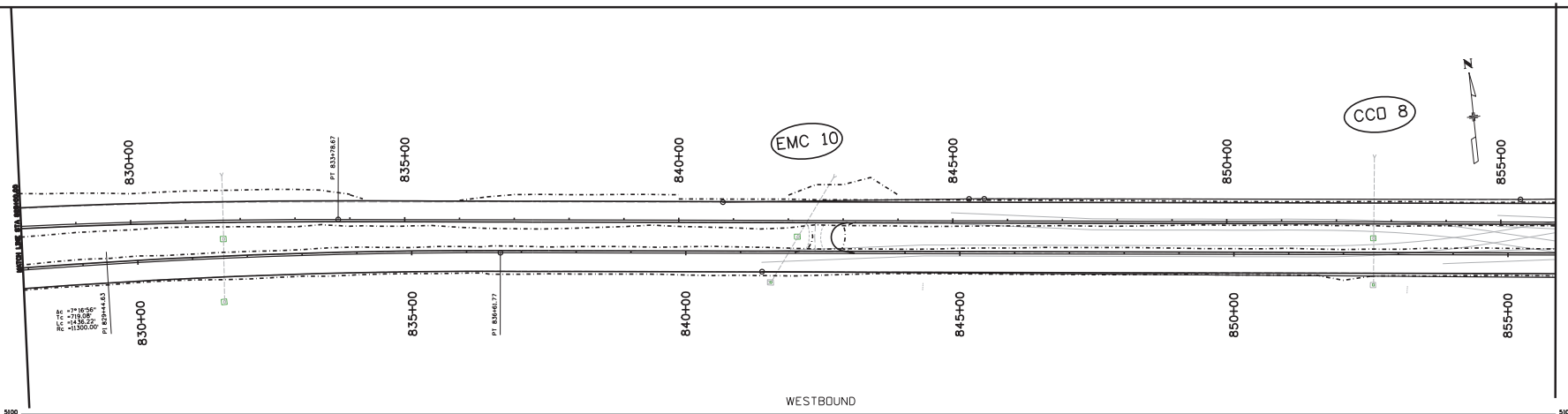


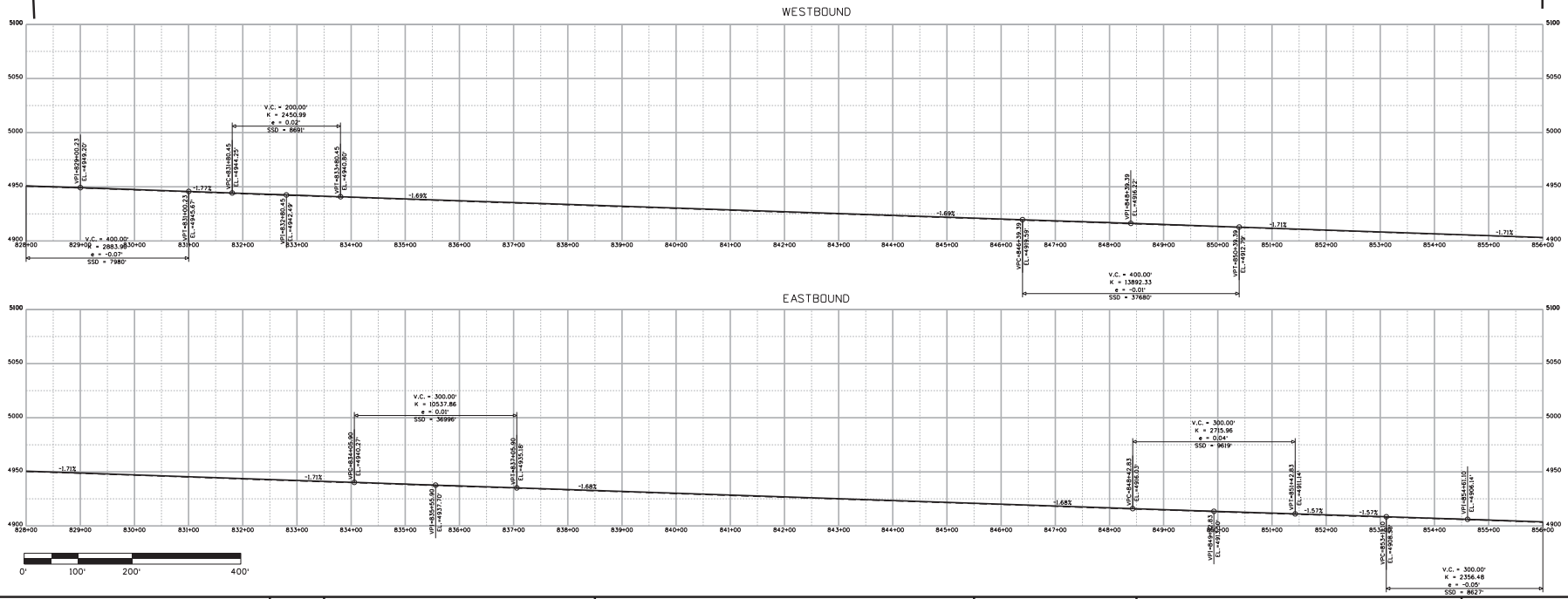


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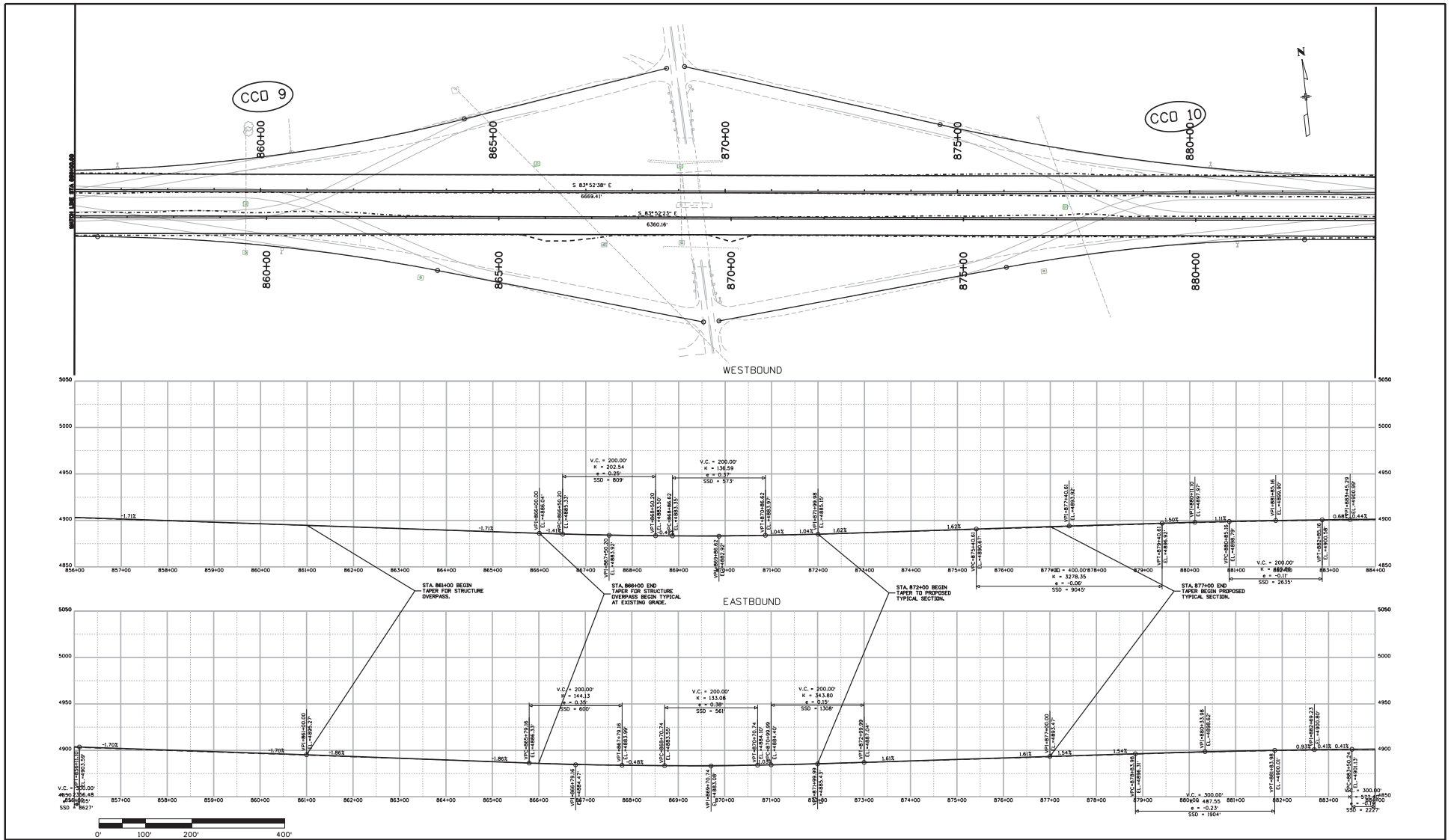


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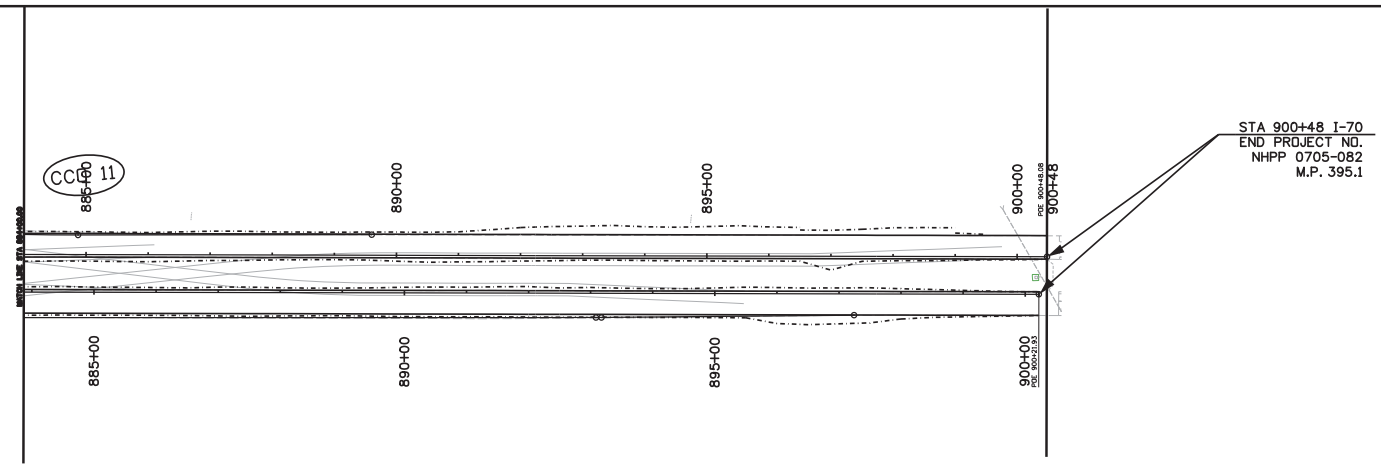


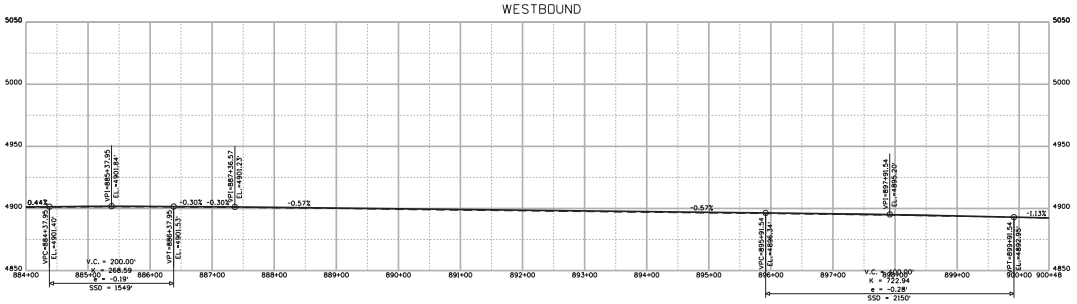


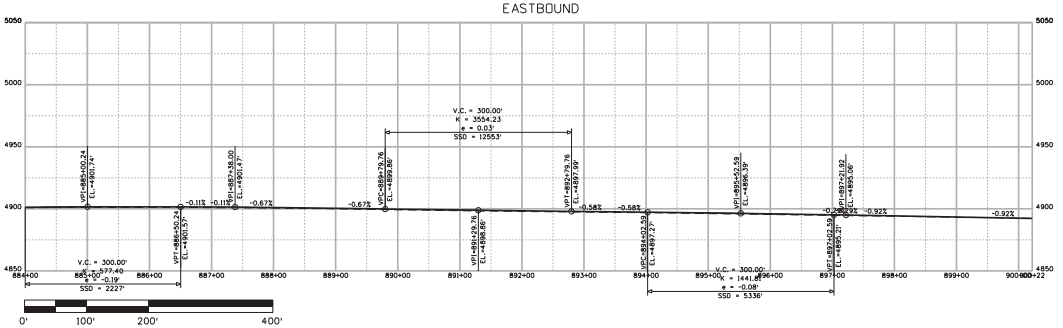


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| Unit Information Unit Leader Initials | | | | | Region 4 TAM | Void: | Sheet Subset: XXXXXXX | Subset Sheets: XXX of XXX | | Sheet Number 62 |

COLORADO
DEPARTMENT OF
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# APPENDIX C
# BRAINSTORMING & IDEA EVALUATIONS

## APPENDIX C BRAINSTORMING & IDEA EVALUATION

The following pages include the list of ideas generated by the VE Team during the Brainstorming Session/Speculation Phase of the study. The listing also displays advantages and disadvantages of each idea that were discussed during the Evaluation/Analysis Phase of the study.

After the discussion of advantages and disadvantages, each idea was rated to indicate its potential for further development. Ideas were rated on a scale of 0 to 1, based on the opportunity to improve value as the major advantage. Ideas that were rated as a 1 were developed further into proposals, while ideas that were rated as 0 were dropped from consideration.

All ideas generated were retained on the list, as future considerations may warrant that these items be revisited, combined, or modified in the final VE proposals. The title of the idea is subject to change as the proposal is developed (Section 2).

| IDEA# | DESCRIPTION | ADVANTAGES | DISADVANTAGES | RANK* | Initials |
|---|---|---|---|---|---|
| 1 | Interchange Ramp Crossover – Right in Right Out – Two way ramp. | ✧ Reduce detour pavement<br>✧ Reduce embankment<br>✧ Save time | ✧ Driver familiarity<br>✧ Reduce exit speed<br>✧ Longer deceleration<br>✧ Less desirable for trucks<br>✧ U-turn for trucks | 1 | DV |
| 1A | Interchange Ramp Crossover – Low Speed Crossovers. | ✧ Reduce detour pavement<br>✧ Reduce embankment<br>✧ Save time | ✧ Driver familiarity<br>✧ Reduce exit speed<br>✧ Longer deceleration<br>✧ Less desirable for trucks | 1 | DV |
| 2 | Use taper style off-ramps versus parallel for temporary detour | ✧ Less detour pavement<br>✧ Save cost | ✧ None | 1 | LC |
| 3 | Use taper style off-ramps versus parallel for permanent | ✧ Less permanent pavement<br>✧ Save cost<br>✧ Already in scope | ✧ Requires more embankment | 1 | LC |
| 4 | Use 13 foot slab width to allow thinner slab | ✧ Save cost<br>✧ Save pavement thickness | ✧ CDOT regional preference | 1 | BL |
| 5 | Use asphalt shoulders | ✧ Save cost | ✧ Maintenance issue<br>✧ Not acceptable to CDOT | 0 | - |
| 6 | Use thinner concrete section for outside shoulders | ✧ Save cost | ✧ Not universally accepted by CDOT<br>✧ Cracking issues<br>✧ Performed separate from mainline paving | 1 | RG |
| 7 | Reduce width of detour crossover from 20 feet to 16 feet. | ✧ Reduce detour pavement<br>✧ Less embankment | ✧ Stalled vehicle safety | 1 | LC |
| 8 | Reduce detour pavement section from 8” HMA plus 6” ABC to 6” HMA and 6” ABC. | ✧ Reduce detour pavement<br>✧ Save cost<br>✧ Related to #10 | ✧ Durability? | 1 | RG |
| 9 | Issue west bound reconstruction as a separate contract if funding is limited. | ✧ Address more critical area first<br>✧ Reduce maintenance | ✧ Will disturb cross over areas | DS | RS |
| 10 | Remove six inches of ABC in detour (full depth asphalt). | ✧ May save cost<br>✧ Save time<br>✧ Related to #8 | ✧ May cost more | 1 | RG |
| 11 | Require WB construction as first construction phase. | ✧ See #9 | ✧ | See #9 | - |
| 12 | For EB lanes use unbonded white topping | ✧ Reduced Cost | ✧ Service life | 1 | BL |

| IDEA# | DESCRIPTION | ADVANTAGES | DISADVANTAGES | RANK* | Initials |
|---|---|---|---|---|---|
| 13 | For EB lanes use bonded white topping | ✧ Reduced Cost | ✧ Service life | 1 | BL |
| 14 | Remove unstable soil to limits necessary for reconstruction of base. | ✧ Maintains I-70 in a serviceable condition | ✧ High maintenance cost | 1 | BL |
| 15 | Use PCCP over existing HMA. | ✧ See #12 and #13 | ✧ | 0 | - |

*1= write-up, 0= do not write-up, DS=design consideration (write-up)

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# APPENDIX D
# PRESENTATION MINUTES

## VE PRESENTATION MEETING MINUTES

Date: September 28, 2017
Time: 1:00pm- 2:00pm
Attendees: See the “Meeting Attendance Sheet” located within Appendix D

The VE presentation meeting began at 1:00 in the CDOT office, in Centennial CO.

Meeting Minutes:

1. Randall Sprague, PE, CVS, the VE Team Leader, opened the meeting with introductions and thanked those for attending. Randy gave a brief discussion on the Value Engineering process, VE methodology and presented an overview of the study phases; a power point was used for the presentation, and is attached at the end of this section.

2. Mr. Sprague gave a brief summary of the information phase which included the designer briefing, project focus and site visit that took place on the first day.

3. Mr. Sprague discussed the current state of the cost estimate, markups and presented the cost models. The current cost estimate of $83.2 million was used as the primary basis of this VE study and the VE proposals.

4. The VE study generated 16 value ideas; 11 of those ideas were deemed to be appropriate for development into proposals and one is design consideration. This presentation meeting will present those proposals, some of which are not recommended but will be discussed so that the logic for rejection is understood.

5. Dean VanDeWege (VE team member) kicked-off the VE proposal presentation with the first two VE proposals.
    a. VE-1: Interchange Ramp Crossover – Right in Right Out – Two way ramps
    b. VE-1A: Interchange Ramp Crossover – Low Speed Crossovers

6. Leonard Cheslock (VE team member) discussed the next two VE proposals
    a. VE-2: Use taper style off-ramps versus parallel for all eight temporary off ramp detours
    b. VE-3: Use taper style off-ramps at the interchanges versus parallel ramps, for permanent ramps

7. Bob LaForce (VE Team Member) discussed the next two VE ideas:
    a. VE-4: Use 13-foot width PCCP slab to allow for a thinner slab
    b. VE-5: use asphalt shoulders, was discussed but not recommended;
        i. Gary DeWitt agreed and mentioned they have 80 miles of example why this is not a good idea.
8. Rick Gabel (VE Team member) then discussed the next VE proposal:
    a. VE-6: Use thinner concrete section for outside shoulders
9. Leonard discussed VE-7
    a. VE-7: Reduce width of detour crossovers (mainline and ramps) from 20-feet to 16-feet.
10. Rick discussed VE-8
    a. VE-8: reduces detour pavement section

11. Randy discussed VE-9 (design consideration):
    a. VE-9: Issue west bound reconstruction as a separate contract if funding is limited.
    b. Question: was there a discussion about leaving the cross-overs in-place.
    c. Response: Yes, this was this discussed with CDOT team members, and possibly putting in a barrier to close off and leave in-place during the winter.
12. Bob discussed VE#12:fFor EB lanes use unbonded white topping
    a. Only on the Eastbound lanes (not shown on slide)
    b. Question: were core's available?
    c. Response: yes, and a big reason why we are not recommending; too high of risk in the opinion of the VE team, despite potential cost savings.
13. Bob discussed VE #13: for EB lanes use bonded white topping
    a. Thickness came out to be 10.5 inches
    b. This will still have questionable lower asphalt layers
    c. Not recommended
    d. Question: did we discuss how this would raise the profile?
    e. Response: yes, we discussed the profile and the concerns at the bridges
14. Bob discussed VE#14: Remove unstable soil to limits necessary for reconstruction of base.
    a. This would be what you would to instead of full replacement, just fix the areas that need fixing
    b. Put together to potentially assist CDOT in getting more funding quicker; this VE item points out the need for replacement soon. Maintenance cost will continue to climb and may occur more quickly than anticipated.
    c. At least 4-inches of stripping maybe more
    d. Assumed $60/square yard
    e. There still would be a traveling public safety issue
    f. Cores have been done in this area over the last 4 years
    g. Bad Spring in 2018, and you could have a lot more to replace; condition could get worse quickly
15. VE items presentation concluded and Randy summarized the study.
    a. Potential estimated savings up to $6M
16. Open for questions:
    a. Discussion about what to do with the 6-inches of millings that will be created from project. CDOT hopes to stockpile and offer to other projects in the area.
    b. An additional future VE item could be review using millings for fill embankment to decrease need for embankment. Could replace up to 40% of embankment with millings.
    c. Gary asked about public notice for VE items 1, 1A or 2: yes, the VE team recommends putting out public information on the construction and cross-overs. CDOT does not allow the detouring during the winter; normal construction season is mid-March to early October.
    d. This project had started as an SMA problem
    e. Gary said in regards to VE#6, using thinner concrete on the shoulders, that CDOT would not be in-favor of implementing. Probably not as much savings as you think, once all is accounted for, unit cost for thinner concrete should be higher and not a time savings.

VE Presentation concluded at approximately 2pm.

Value Engineering Study
I-70 ARRIBA: EAST AND WEST HMA
Study Location: Limon/Centennial, CO
**Presentation Sign-in Sheet**
**Dates: September 28, 2017**

| NAME | FIRM/AGENCY | VE TITLE/ROLE | PHONE | EMAIL |
|---|---|---|---|---|
| Randy Sprague, PE CVS | Jacobs | VE Team Leader/Facilitator | 201.400.7235 | William.Hickey@jacobs.com |
| Bill Hickey, PE, AVS | Jacobs | Assistant Team Leader | 425.213.2713 | William.Hickey@jacobs.com |
| Rick Gabel | Jacobs | VE Team: Construction | 847.833.0809 | Richard.Gabel@jacobs.com |
| Leonard Cheslock, PE, PTOE | Jacobs | VE Team: Traffic/MOT | 719.651.2769 | Leonard.Cheslock@jacobs.com |
| Bob LaForce | Yeh & Associates | VE Team: Materials | 303.781.9590 | blaforce@yeh-eng.com |
| Dean VanDeWege, PE | Jacobs | VE Team: Roadway | 303.653.6214 | Dean.vandewege@jacobs.com |
| Karl Larson | CDOT | CDOT Project Engineer | 719.740.1052 | Karl.larson@state.co.us |
| James Miller, PE | CDOT | CDOT Project Manager | 303.365.7261 | james.miller@state.co.us |
| Gary DeWitt | CDOT | CDOT R4 Materials Engineer | 970.350.2379 | gary.dewitt@state.co.us |
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# I-70 Arriba Project
# Value Engineering Presentation

September 28, 2017



Value Engineering Presentation
I-70 Arriba:
East & West

## Value Engineering Team Members

| Name | Role | Firm |
|---|---|---|
| Randy Sprague, PE, CVS | VE Team Leader | Jacobs |
| Bill Hickey, PE, AVS | VE Assistant | Jacobs |
| Leonard Cheslock, PE, PTOE | Traffic/Phasing | Jacobs |
| Rick Gabel | Construction | Jacobs |
| Dean VanDeWege, PE | Roadway Design | Jacobs |
| Bob LaForce | Project Manager | Yeh |

## Resource Team Members

| Name | Role | Firm |
|---|---|---|
| James Miller, PE | Project Manager | CDOT |
| Karl Larson | Construction and Design | CDOT |
| Travis Miller, PE | Resident Engineer | CDOT |

Value Engineering Presentation
I-70 Arriba:
East & West

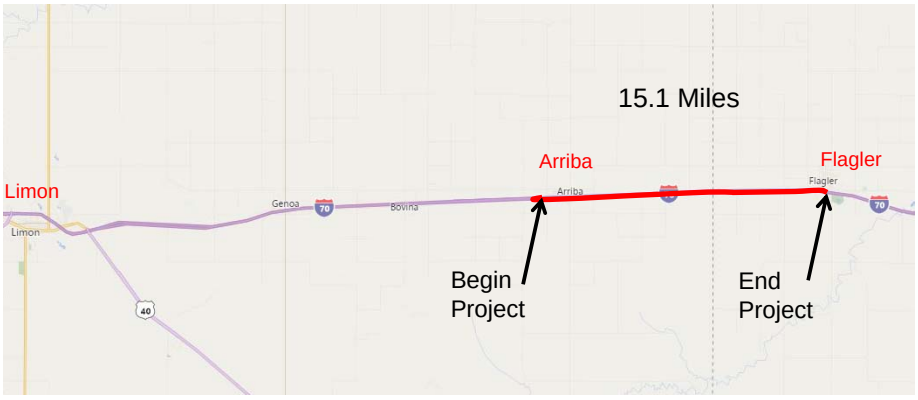
The Value Engineering Study was conducted following the *SAVE International* six-step Value Engineering Job Plan which includes the following phases:

1. Investigation
2. Function Analysis
3. Creativity
4. Evaluation
5. Development
6. Presentation

3

Value Engineering Presentation
I-70 Arriba:
East & West

**I-70 Arriba Project Location**



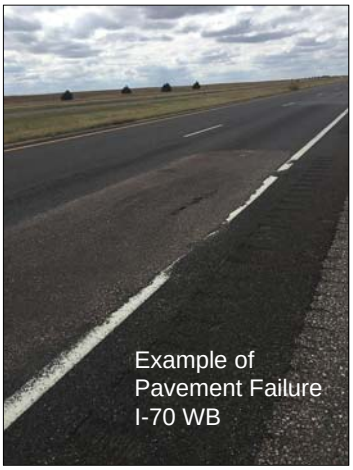
Value Engineering Presentation
I-70 Arriba:
East & West

## I-70 East Bound

5

Value Engineering Presentation
I-70 Arriba:
East & West

## I-70 West Bound

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COLORADO DEPARTMENT OF TRANSPORTATION

Value Engineering Presentation
I-70 Arriba:
East and West

Project Basic Functions:

- Improve Highway Safety
- Reduce Highway Maintenance
- Increase Service Life

7

COLORADO DEPARTMENT OF TRANSPORTATION

Value Engineering Presentation
I-70 Arriba:
East and West

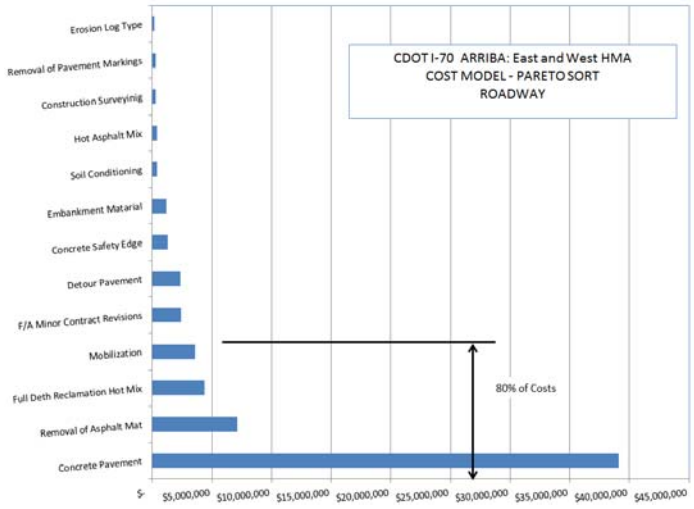
Project Cost Estimate:

- Budget $85 Million
- Current Estimate $80 Million
- Estimate Used for VE Pricing

8

COLORADO DEPARTMENT OF TRANSPORTATION

## Value Engineering Presentation
## I-70 Arriba:
## East and West

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COLORADO DEPARTMENT OF TRANSPORTATION

## Value Engineering Presentation
## I-70 Arriba:
## East and West

### Schedule Milestones

| | |
|---|---|
| Current Design Status | 30% to 60% |
| Final Office Review | October 2017 |
| Shelf Date (100% design) | December 2017 |
| Bidding | Funding Dependant |
| Construction | Two Years |

10

Idea Generation:

## Idea Generation Summary

16 Total Ideas Generated

After Further Refinement:

- 13 Alternatives
- 1 Design Considerations

11

Value Engineering Presentation
I-70 Arriba:
East & West

## VE STUDY ITEMS 1: Interchange Ramp Crossover – 2 Way

**Description:**

- This idea isolates impacted ramp cross over construction to less area by utilizing a two way ramp, ending in a T intersection with a right in and right out configuration.
- The proposed idea constructs accel and decel lanes along the existing pavement in the median, minimizing cross overs and earthwork. Cross overs will only be required over a 300' area, and will handle both the long term and short term crossover needs.
- Design does require accel and decel lanes be built to accommodate 0-55 mph speed transition

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VE STUDY ITEMS 1: Interchange Ramp Crossover – 2 Way

**Advantages:**

- Reduce detour pavement
- Reduce embankment
- Construction time savings –
  - Switching between standard crossover and short term crossover requires less work.
  - Two ramp gores can be built during mainline construction.
- Avoid filling over mainline

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Value Engineering Presentation
I-70 Arriba:
East & West

VE STUDY ITEMS 1: Interchange Ramp Crossover – 2 Way

**Disadvantages**

- Ramp Access Configuration different than normal expectations
- Reduced speeds with essentially stop conditions at ramp gores
- Acceleration and Deceleration take place after crossover.
- Requires longer acceleration lane to go from 0 mph to 55 mph
- Less desirable for trucks
- U-turn movement for trucks
- On the Flagler interchange where the median is only 60' instead of 120', the median alignment will be tighter. See following detail
- Ramps < 25 foot width may make 2 way traffic difficult

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Value Engineering Presentation
I-70 Arriba:
East & West


15

Value Engineering Presentation
I-70 Arriba:
East & West

VE STUDY ITEM 1: Interchange Ramp Crossover – 2 Way

**Potential VE Savings:**

| | Cost Summary | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | $0.00 | $2,241,107 | $2,241,107 |
| Proposed | $0.00 | $1,256,000 | $1,256,000 |
| **Savings** | **$0.00** | **$985,107** | **$985,107** |

Potential Savings: **$985k**

VE recommendation: VE team recommends implementation of either VE #1, VE #1A or VE #2.

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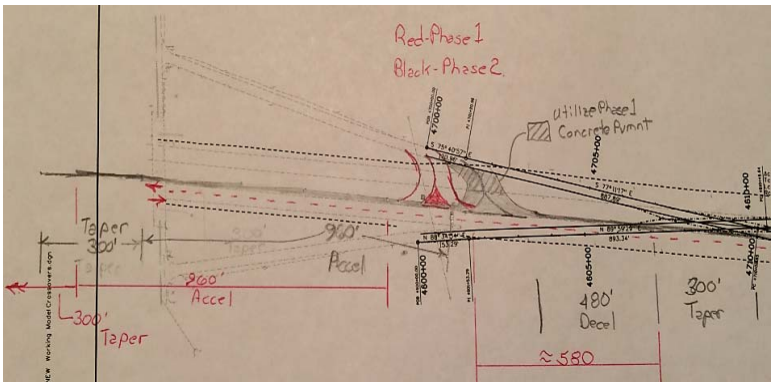
Value Engineering Presentation
I-70 Arriba:
East & West

VE STUDY ITEM 1 SKETCH.

**Proposal Sketch**

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Value Engineering Presentation
I-70 Arriba:
East & West

VE STUDY ITEMS 1A: Low Speed Interchange Ramp Cross Over

**Advantages:**

- Reduce detour pavement
- Reduce embankment
- Construction time savings –
  - Switching between standard crossover and short term crossover requires less work.
- Avoid filling over constructed mainline during 2nd phase movements
- Advantages over VE #1
  - Normal expected ramp and highway access.
  - Avoids temporary lane widening in median under bridge.

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## VE STUDY ITEMS 1A : Low Speed Interchange Ramp Cross Over

**Disadvantages**

- Configuration different than normal expectations – Normal ramp access configurations.
- Reduced speeds with essentially stop conditions at ramp gores – Acceleration and Deceleration take place after crossover.
- Requires longer acceleration lane
- Less desirable for trucks – although better than VE #1

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## VE STUDY ITEMS 1A: Low Speed Interchange Ramp Cross Over

**Potential VE Savings:**

| | Cost Summary | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | $0.00 | $2,241,107 | $2,241,107 |
| Proposed | $0.00 | $1,438,659 | $1,438,659 |
| Savings | $0.00 | $802,449 | $802,449 |

Potential Savings: **$802k**

VE recommendation: VE team recommends implementation of either VE #1, VE #1A or VE #2.

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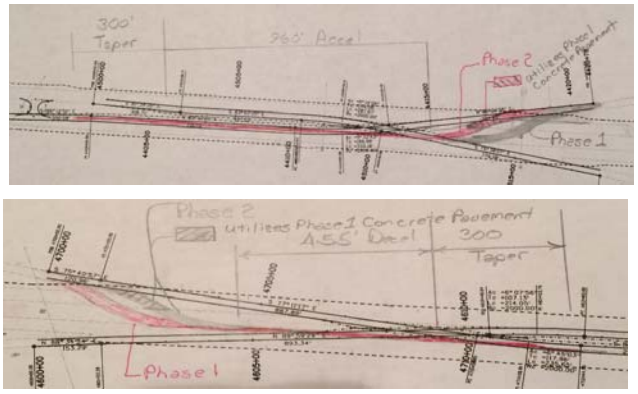
VE STUDY ITEM #1A SKETCH.

**Proposal Sketch**

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VE STUDY ITEMS 2:

**Description:**
Use taper style off-ramps versus parallel for all eight temporary off ramp detours.

Advantages:
- Less detour pavement
- Save cost
- Compatible with current design
- Accommodates 35mph exit ramp speed.

Disadvantages:
- None

Potential VE Savings:
$1,027,759

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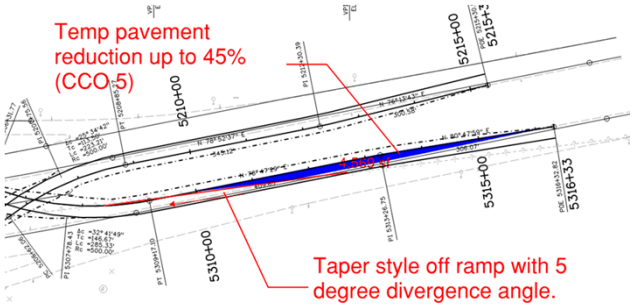
VE STUDY ITEM 2 SKETCH.

**Proposal Sketch**

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VE STUDY ITEMS 2: Interchange Ramp Crossover – 2 Way

**Potential VE Savings:**

| | Cost Summary | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | $0.00 | $2,303,453 | $2,303,453 |
| Proposed | $0.00 | $1,275,674 | $1,275,674 |
| **Savings** | **$0.00** | **$1,027,759** | **$1,027,759** |

Potential Savings: **$1.03M**

VE recommendation: VE team recommends implementation of either VE #1, VE #1A or VE #2.

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## VE STUDY ITEM 4: Use Widened Slab for I-70

**Description:**

- The current pavement design uses a 12' spacing on the longitudinal joints. We explored using both a 13' spacing and a 14' spacing similar to other pavements on I-70 West.
- Based on the program outputs, the required thicknesses would be 8.5" or 8.0"

**Advantages:**

- There would be significant savings with the thinner pavement sections with the thinner sections
- With the thtures.inner sections will eliminate the removal and complete reconstruction under at least structure.

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## VE STUDY ITEM 4: Use Widened Slab for I-70

**Disadvantages:**

- Past experience at CDOT that 8" slabs have not performed adequately over time with the high truck volumes experienced by I-70 in this area.

- The 12" of PCCP will raise the level of the pavement and require reconstruction of the entire pavement under two structures

**Potential VE Savings:** $15,033,721

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## VE STUDY ITEM 4: Discussion.

- The **VE Team <u>does not</u>** recommend 8" pavement thickness based upon experience with 8" pavements.
- However, wider slabs have proven very successful on I-70 east and we believe that the pavement thickness design should be revisited to determine if savings from the wider slabs or a thinner section can be justified. The saving per inch of concrete thickness reduction would be $3,000,000 per inch.

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## VE STUDY ITEM 6: -Use thinner concrete section for outside shoulders

**<u>Description:</u>**

- Current Pavement design thickness for the driving lanes of 12" is continued through the outside shoulders
- VE Alternative : Since the shoulder is only used for emergency parking the thickness of the section may be reduced from 12" to 8".

**<u>Advantages:</u>**

- Reducing in thickness reduces quantity of concrete required and corresponding cost savings.

**<u>Disadvantages:</u>**

- Contractor will most likely need to do an additional paving operation to place the shoulder separate from the driving lanes.
- Possible differential settlement between shoulder and driving lanes due to different thickness.

**<u>Potential VE Savings:</u>** **$1,771,656**

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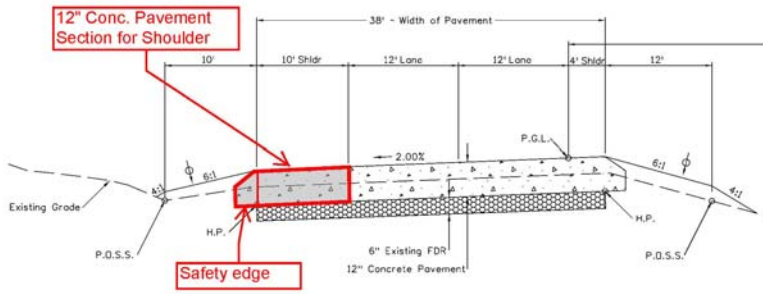
VE STUDY ITEM 06 SKETCH.

**Existing Concept**

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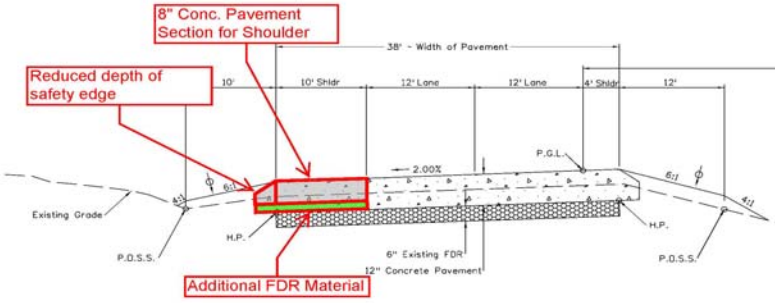
VE STUDY ITEM 06 SKETCH.

**Proposed Concept**

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VE STUDY ITEM 6: Use thinner concrete section for outside shoulders

**Potential VE Savings:**

| | Cost Summary | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | $0.00 | $6,773,766 | $6,773,766 |
| Proposed | $0.00 | $5,002,110 | $5,002,110 |
| **Savings** | **$0.00** | **$1,771,656** | **$1,771,656** |

Potential Savings: **$1.78M**

VE Recommendation: The VE recommends Implementation

Note: if VE #4 is implemented then potential savings will reduce by approx 10%

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VE STUDY ITEMS 7: Reduce width of detour crossovers

**Description:**
Reduce width of detour crossovers (mainline and ramps) from 20 feet to 16 feet.

Advantages:
- Reduce detour pavement
- Less embankment

Disadvantages:
- Stalled vehicle safety – cannot pass a stalled if temp barrier is used

Potential VE Savings:
$ 262,708

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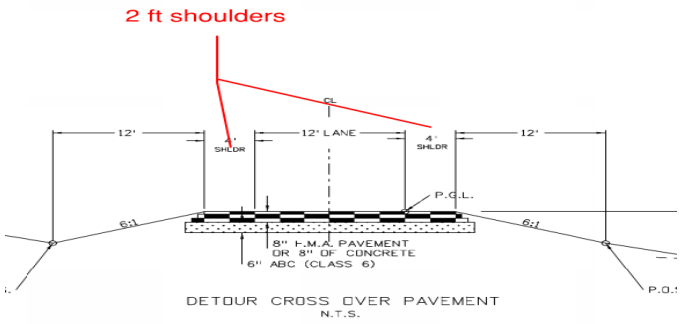
VE STUDY ITEM #7 SKETCH.

**Proposal Sketch**

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VE STUDY ITEMS 7: Reduce width of detour crossovers

**Potential VE Savings:**

| | Cost Summary | | |
|---|---|---|---|
| | O&M Cost | Capital Cost | Total |
| Original | $0.00 | $3,155,429 | $3,155,429 |
| Proposed | $0.00 | $2,892,721 | $2,892,721 |
| **Savings** | **$0.00** | **$262,708** | **$262,708** |

Potential Savings: **$263k**

VE Recommendation: The VE recommends Implementation

Note: if VE#1, 1A or 2 are implemented then potential savings will reduce to approx. $200k

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VE STUDY ITEM 8: Reduce detour pavement section

**Description:**
Current Detour Design section is 8" of HMA over 6" of ABC (Class 6).

VE Alternative. By using Darwin 3.1 Pavement Design software the detour section can be reduced to 7" HMA or 7" of PCCP over 6" of ABC.

**Advantages:**

Reducing in thickness reduces quantity of HMA or concrete required and corresponding cost savings.

**Disadvantages:**

Possible reduction in reliability and maintenance of detour under traffic

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**Potential VE Savings: $387,810**

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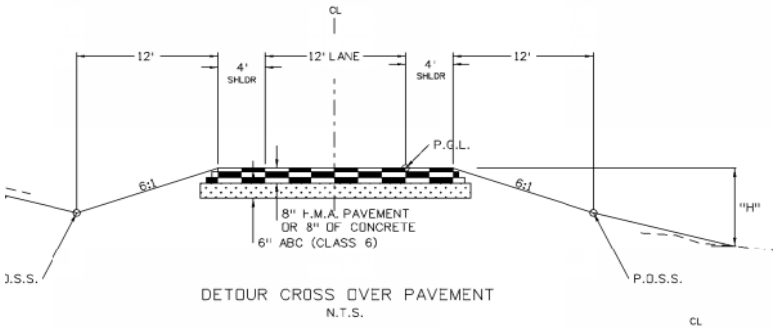
VE STUDY ITEM 08 SKETCH.



DETOUR CROSS OVER PAVEMENT
N.T.S.

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VE STUDY ITEMS 9:

**Description:**
Issue west bound reconstruction as a separate contract if funding is limited.

**Advantages:**
- Address more deteriorated lane first as the condition in more critical.
- Reduce maintenance which would otherwise be required if the westbound lanes are not rehabilitated.

**Disadvantages:**
- Additional work to crossover.

**Design Suggestion:**

The VE Team recommends this Alternative only if funding is limited.

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VE STUDY ITEM 10: Remove six inches of ABC in detour (use full depth asphalt or PCCP)

**Description:**
Current Detour Design section is 8" of HMA over 6" of ABC (Class 6).

VE Alternative : Using Darwin 3.1 Pavement Design software the detour section can be reduced to 7" HMA or 7" of PCCP without requiring any ABC (Class 6).

**Advantages:**

Eliminating ABC (Class 6) should result in a cost savings.

**Disadvantages:**

Possible reduction in reliability and maintenance of detour under traffic

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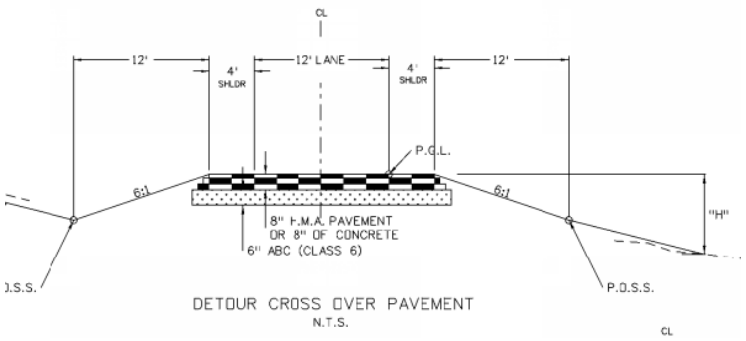
**Potential VE Savings:** **$232,055.60**

VE STUDY ITEM 10 SKETCH.

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VE STUDY ITEM 12: Use of Thin White Topping

**Description:**

- Mill 7 inches of the existing pavement followed by placement of 7.5" of bonded concrete pavement.
- The old HMA pavement will be milled to remove the top 7 inches, including the petromat

**Advantages:**

- Reducing in thickness reduces quantity of concrete required and corresponding cost savings
- Using the lower lifts of the existing pavement will save both time and construction costs because of the reuse of material and also not having to process the existing HMA.
- The thinner section will reduce the requirement for complete reconstruction under the structures for clearance.

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## VE STUDY ITEM 12: Use of Thin White Topping

**Disadvantages:**

- The smaller panel sizes will result more joint maintenance than a standard pavement
- The pavement will be more susceptible to faulting because there is not load transfer in the transverse joints.

**Potential VE Savings:** $11,504,160

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## VE STUDY ITEM 12

**Discussion**

- **VE team does not recommend implementation**
- Based on the core from previous testing, the condition of the lower lifts of existing HMA is suspect and from discussion with local CDOT personnel, maintenance personnel have also encountered problems with performance of portions of the east bound lanes also.

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VE STUDY ITEM 13: Use of Unbonded PCCP Overlay

**Description:**
The pavement would be milled to remove 6 inches of existing HMA. Following milling the existing HMA would be overlaid with a 1.5 inch layer of HMA to prevent bonding to the old HMA, then a 10.5 inch PCCP pavement could be placed for the final surface

**Advantages:**

- Reducing in thickness reduces quantity of concrete required and corresponding cost savings.

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VE STUDY ITEM 13: Use of Unbonded PCCP Overlay

**Disadvantages:**

- The bond breaking overlay will require an additional HMA layer will add cost and also require an additional subcontractor and operation on the project.
- This treatment also will result in a rise of 7.5 inches in the pavement elevation.

**Potential VE Savings** $2,610,775

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VE STUDY ITEM 13 discussion.

**Proposal Discussion**

- **The VE team does not recommend this alternative.**
- There is questionable condition of the lower asphalt layers

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VE STUDY ITEM 14: Remove unstable base as necessary and reconstruct base, then just mill and overlay

**Description:**
Mill and Overlay Patching if full reconstruction funding is significantly delayed.

**Advantages:**
- Will maintain I-70 in a serviceable condition

**Disadvantages:**
- Extensive Costs particularly for Maintenance

**Potential VE Cost:** ($60/yd2)

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VE STUDY ITEM 14: Remove unstable base as necessary and reconstruct base, then just mill and overlay

**Proposal Discussion**

- **The VE team does not recommend this alternative.**
- If reconstruction not performed could result in $8-$12M
- There is questionable condition of the lower asphalt layers

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Potential Savings

| IDEA# | DESCRIPTION | Potential Savings | Max Potential Savings |
|---|---|---|---|
| 1 | Interchange Ramp Crossover – Right in Right Out – Two way ramp. | $ 985,000.00 | |
| 1A | Interchange Ramp Crossover – Low Speed Crossovers. | $ 802,000.00 | |
| 2 | Use taper style off-ramps versus parallel for temporary detour | $ 1,030,000.00 | $ 1,030,000.00 |
| 3 | Use taper style off-ramps versus parallel for permanent | - | |
| 4 | Use 13 foot slab width to allow thinner slab | $ 15,000,000.00 | $ 3,000,000.00 |
| 5 | Use asphalt shoulders | | |
| 6 | Use thinner concrete section for outside shoulders | $ 1,780,000.00 | $ 1,206,000.00 |
| 7 | Reduce width of detour crossover from 20 feet to 16 feet. | $ 263,000.00 | $ 200,000.00 |
| 8 | Reduce detour pavement section from 8” HMA plus 6” ABC to 6” HMA and 6” ABC. | $ 387,000.00 | $ 250,000.00 |
| 9 | Issue west bound reconstruction as a separate contract if funding is limited. | | |
| 10 | Remove six inches of ABC in detour (full depth asphalt). | $ 232,000.00 | |
| 11 | Require WB construction as first construction phase. | | |
| 12 | For EB lanes use unbonded white topping | $ 11,500,000.00 | |
| 13 | For EB lanes use bonded white topping | $ 11,000,000.00 | |
| 14 | Remove unstable soil to limits necessary for reconstruction of base. | | |
| 15 | Use PCCP over existing HMA. | | |
| | Maximum Potential Savings | | $ 6,082,000.00 |

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Questions/Comments

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