



VALUE ENGINEERING WORKSHOP REPORT

for:

Colorado Department of Transportation - Region 1



COLORADO

Department of Transportation

Region 1

**Project: I-70 Westbound Peak Period Shoulder Lane
Veterans Tunnels to US-40 Empire Junction
Clear Creek County, Colorado**

PN: NHPP 0703-445 (21893)



Project Designers:



August 6, 2018



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Subject: Value Engineering Study Report – Final
Interstate 70 Westbound Peak Period Shoulder Lane, Clear Creek County, Colorado
Project No.: NHPP 0703-445 (21893)

Dear Mr. Smith and Mr. Ogden:

Enclosed is the final Value Engineering (VE) Report for the planned I-70 Westbound Peak Period Shoulder Lane (PPSL) Operational Improvements project. The VE workshop was conducted on 26-29 June 2018, at the Region 1 offices located in Golden.

The I-70 improvements are designated as interim operational improvements by adding and intermittent use managed shoulder lane to the existing lane configuration. The project will improve approximately 10.85 miles of westbound I-70 mainline and shoulders, with minor improvements to the eastbound PPSL and connecting roadway work. The improvements are all located within Clear Creek County. The total construction estimate is currently \$62 million with a forecast project duration of eighteen (18) months and spanning two (2) construction seasons.

The WB PPSL improvements are intended to relieve traffic congestion during high-volume periods, typically on weekends at holidays. The planned work will also address localized drainage issues, provide roadway safety enhancements, and improve local access and corridor through travel times.

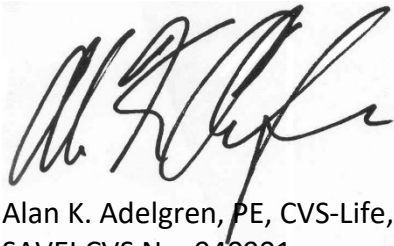
During the VE study workshop, the VE Team identified 108 alternative ideas or concepts, and produced sixteen (16) VE Recommendations. The VE Team also identified eight (8) Design Suggestions and Notes to Management (NTM). These items are presented within this preliminary report.

The report includes a summary of results table that encapsulates estimated construction cost impacts, and notes which recommendations are mutually exclusive. The stated costs are order of magnitude, and intended to identify the nominal impact that may be realized by acceptance and implementation within the current schematic design documents.

On behalf of Atkins North America, we personally want to thank you for this opportunity to participate in the I-70 Westbound Peak Period Shoulder Lane operational improvements project. CDOT is a valued client for Atkins, and we hope that our services and performance for this project have been helpful to both CDOT and the other project stakeholders.

Please contact either Derek Lindvall (303-548-0093), Dennis Largent (720-526-6256) or Al Adelgren if you have any questions or concerns regarding the suggested value engineering recommendations and alternative ideas presented within this report.

Sincere regards,



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EXECUTIVE SUMMARY

This report presents the results from the value engineering (VE) workshop review of the Colorado Department of Transportation (CDOT), Region 1 planned interstate I-70 Westbound (WB) Peak Period Shoulder Lane (PPSL) project, located within Clear Creek County.

The planned I-70 WB PPSL project encompasses approximately 12 miles of existing interstate mainline and shoulders. The I-70 WB PPSL project is an interim operational improvement intended as a temporary solution to relieve existing corridor congestion. This VE workshop study effort reviewed the defined I-70 WB PPSL project work scope, based on the 30% schematic design documents provided to the VE Team.

The I-70 WB PPSL improvements have been allocated under one project number, and will be constructed over 18-months in two phases based on annual construction seasons. The planned WB PPSL project is part of an I-70 Mountain Corridor Infrastructure for Rebuilding America (INFRA) grant program that will include three additional projects within the same area, which are:

- Fall River Road Bridge, which will improve cross valley connectivity.
- Clear Creek Greenway, which will improve and extend the current creekside pedestrian and bicycle trail system.
- County Road (CR) 314 (I-70 Frontage Road), Phase II which extends nominally from the Doghead Rail Bridge Trailhead west to the Colorado Boulevard intersection near the I-70 eastbound Exit 241.

The VE Team reviewed the I-70 WB PPSL project field inspection review (FIR) plans and other related available pertinent documents.

Project Purpose

As the population of Colorado has continued to grow, traffic volumes along I-70 have also increased during weekends due to recreation and during the week due to long distance commuters. The additional traffic has increased congestion and traffic safety problems within the I-70 / Clear Creek Canyon corridor.

The completed eastbound (EB) PPSL project was highly successful, reducing congestion and improving travel time reliability. The EB PPSL project yielded a 20-50 percent reduction in travel time, reduced corridor crashes by 15 percent in the winter season, decreased congestion on the frontage roads, and increased business within the local communities. The WB PPSL is expected to yield comparable results.

The stated goals for the planned I-70 improvements are as follows:

1. Improve highway operations and reduce congestion: Operational improvements to allow more vehicles to travel through the corridor during peak periods, thus, reducing both congestion and travel time.

2. Improve safety: Safety improvement measures include rockfall mitigation, expanding sight lines at curves, construction of emergency / enforcement pull-outs, and widening the barrier “shy” distance (separation between crash barrier and lane edge).
3. Improve travel time reliability: Traffic congestion relief will reduce travel time, thus providing a more consistent and predictable travel time through this corridor.

Currently approximately 25% of all I-70 WB traffic exits at US-40, Empire Junction, which is the western or upper end of the project corridor. The I-70 corridor is a nationally significant primary east-west commercial freight corridor

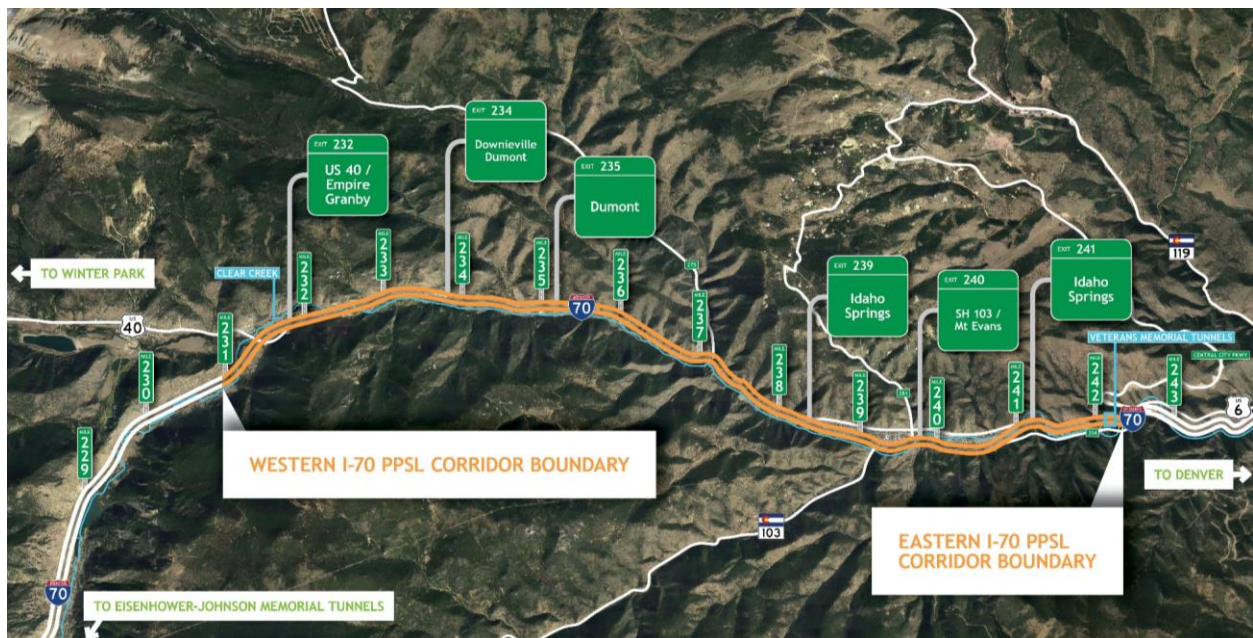
Project Scope

The planned I-70 improvements project will minimally widen the facility at selection locations within the existing CDOT right of way (ROW), without any ROW acquisitions being required. The planned I-70 WB PPSL project is approximately 12 miles long. The project scope of work includes widening and improving the existing shoulder to establish tolled managed peak period shoulder lane for use only during peak traffic periods that experience heavy congestion.

Various utilities are parallel to, or intersect with the roadway alignment within the existing CDOT ROW. Measures to protect or relocate these existing utilities including a primary sanitary sewer main line, have been incorporated within the project design.

The total cost for the I-70 WB PPSL operational improvements work scope is currently estimated at \$62 million, including allowances for construction contingencies and construction / field engineering services. CDOT is anticipating \$25 million in Federal aid to develop this project.

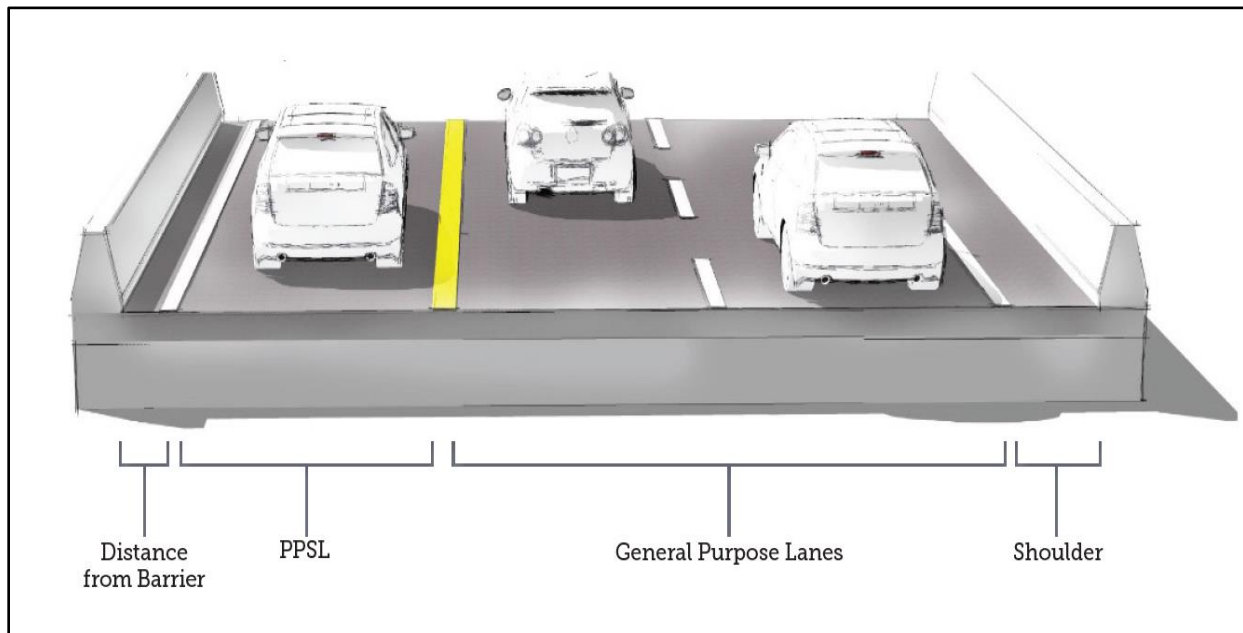
Figure 1: Project Location



The existing WB I-70 roadway is approximately 38-feet wide; inside shoulder (4-feet), two general purpose lanes (each, 12-feet) and an outside shoulder (10-feet). Several curves are tight with poor sight lines.

The I-70 WB PPSL work scope will widen the roadway width where circumstances allow to approximately 41-feet; inside shoulder / barrier (2-feet shy distance), inside shoulder / PPSL lane (11-feet), two (2) general-purpose traffic lanes (each, 12-feet), and outside shoulder (4-feet, with emergency / enforcement pull-outs approximately 16-feet width).

Figure 2: Typical Roadway, Peak Period Shoulder / Express Lane



Construction will be performed as a design-bid-build contract. The contractor will not be required to perform any design related activities. However, the contractor will be required to develop a rock cut / removal plan.

The I-70 WB PPSL project will be released for competitive bidding in late 2018 or early 2019, with the construction contract award in spring / summer 2019. Early construction documents release would allow the successful bidding contractor to complete the planned work in two (2) construction seasons spanning eighteen (18) months – the period of performance.

Project Need

Heavy weekend traffic volumes result with decreased travel time reliability, adversely impacts local access, and increases congestion-related traffic accidents. The existing WB I-70 facility is not equipped to manage traffic operations during heavy volume periods.

The I-70 WB PPSL project will create a tolled lane, only available during high traffic volume periods. This managed lane will help to relieve congestion and improve travel time. Dynamic tolling of the express lanes allows CDOT to provide travel time reliability.

Project Stakeholders

CDOT is the key stakeholder. Other key stakeholders include the FHWA, Clear Creek County, City of Idaho Springs, Denver Regional Council of Governments, area first responder / emergency services agencies, and other nearby communities.

Additional stakeholders include project area residents, home owner associations, commercial, and retail enterprises; commercial freight haulers and the Colorado Motor Carriers Association; and several public utilities with services that parallel or intersect the project area. Other stakeholders include the U.S. Forest Service, Clear Creek Watershed Foundation, Colorado Parks and Wildlife (CPW), Trout Unlimited, and the I-70 Coalition.

The I-70 WB PPSL project 30% schematic design, or field investigation review (FIR), documents were developed Region 1, CDOT. The project plans, specifications, and engineering (PS&E) consultant is HDR Inc. (HDR), of Denver, CO.

Workshop Results

The process used for this VE workshop is the Job Plan as defined within the Value Methodology Standard (2015), published by SAVE International (formerly the Society of American Value Engineers) and recognized by CDOT and the Federal Highways Administration (FHWA), U.S. Department of Transportation (DOT). The VE Job Plan is an organized, multidisciplinary approach designed to find alternative ways to achieve the project's necessary and desired functions at the lowest life cycle cost.

The VE team identified the important project functions and potential alternative means to achieve these functions, then selected the best alternatives using evaluation techniques for development into workable recommendations for project improvement and cost savings.

The VE Team identified 108 alternative ideas during the Creative Phase for consideration as part of the workshop efforts. These alternative ideas were generated under four (4) categories which were project functions as defined by the VE Team:

- Manage Corridor (MC)
- Improve Safety (IS)
- Protect Environment (PE)
- Develop Project (DP)

The complete listing of alternative ideas is within Appendix E, Creative / Alternative Ideas.

Several alternative ideas identified by the VE Team were considered to have lower importance, or limited potential for improved value contribution to the project scope. While these ideas

were not developed during the VE Workshop, the VE Team considered these items to have potential merit. These items may be further investigated by CDOT and HDR, the plans, specifications and engineering (PS&E) consultant.

The VE Team designated eight (8) of the creative items as either a Design Suggestion (design related) or Notes to Management (NTM), which are agency level items, for consideration by CDOT regarding both the I-70 WB PPSL and other future construction operations.

Sixteen (16) alternative ideas or concepts were highlighted by the VE Team as being of higher importance than the remaining ideas based on relative scoring. These alternative ideas were investigated by the VE Team, and have been developed into formal recommendations for incorporation into the overall project work scope.

The VE Team identified several recommendations that can be consolidated under common themes. Many of these recommendations are project betterments, and potentially would increase the total estimated cost for construction. These recommendations will require further investigation during PS&E development.

1. Several roadway safety enhancements were identified.
 - a. Addition of high friction surface treatment course to curves and high slope ramps. This addition would serve to reduce accident rates in such locations.
 - b. Use of solar powered LED lighting and signage can improve both sight lines and messaging throughout the corridor, without need for any additional infrastructure (i.e., line power). Solar powered devices have an additional advantage that these elements can be installed quickly, as needed for observation of traffic operations.
 - c. Solar powered LED lane delineator pucks should be considered for locations where sight lines are limited, curves are tight, or other potentially hazardous locations. The EB PPSL has solar LED delineators installed at the US-6 left hand exit lane / ramp and on Floyd Hill.
 - d. Development of an unplanned rockfall mitigation plan during design development, which would be incorporated as an update to the existing corridor incident management plan. This unplanned rockfall events plan should include contractor response actions (i.e., labor and equipment) as a unit cost bid item.

2. Several construction traffic management and control recommendations were identified:
 - a. Incorporate smart work zones with live queue / delay information output into the traffic management strategy. Live feed queue / delay information should be sent directly to the CDOT project engineer to determine if any construction activities need to be suspended for congestion relief. Likewise, the live feed data can be fed to variable messaging signs ahead of the work zone, thereby allowing drivers the decision opportunity to exit the roadway, or remain in the queue.

- b. Establish a corridor wide lane closure strategy concurrent with the construction phasing plan to ensure that the WB PPSL closures are consistent with other planned corridor projects. The contractor should be required to develop its own closure strategy for integration into the Region 1 lane closure plan.
- c. Utilize the existing EB PPSL as a WB through lane during temporary short-term closures; head to head traffic separated by temporary barrier devices (i.e., concrete traffic barriers and barrels). This short-term measure would allow for full closure of the existing WB lanes as required to support construction activities, thereby allowing the contractor to perform work more efficiently and reduce the overall closure duration.

In addition, the VE Team recommended several non-construction actions that could be taken by CDOT which should benefit the I-70 WB PPSL as well as the three (3) other planned corridor construction projects. These recommendations can be considered as Region 1 level, consolidated corridor management during and after construction.

1. The local communities are stakeholders and are experiencing construction fatigue as a result of several projects being completed in recent years. Several services currently assigned to the contractor to perform should be under direct control of Region 1 to ensure a consistent approach for the WB PPSL project, as well as the follow-on projects within the corridor. Services that could be directly contracted and controlled by CDOT include:
 - a. Public information (PI) consultant to provide clear messaging before the WB PPSL project commences. The PI consultant could be retained to support all projects. The PI would have the duty to provide CDOT defined information regarding construction activities, closures and detours, as well as PPSL operations (i.e., entry, exit, tolling, etc.).
 - b. Corridor wide traffic control (TC) contractor to ensure that CDOT strategy is consistently applied across all projects. Construction contractors would be required to make reservations for any closures in advance of the work to be performed, thereby providing an additional inter-contractor coordination point. Further, the TC contractor would be available to support non-construction events such as law enforcement actions (i.e., major accidents) as well as unplanned rockfall events.
 - c. Landscape maintenance (LM) is to be performed by the contractors typically as a warranty item. Establishing a separate LM contract for the I-70 corridor would provide greater control of the quality and maintenance of plantings. A corridor wide LM contract can also be used for routine ROW maintenance activities such as mowing and cleaning of sediment basins.

The VE Team identified the following items as recommended improvements.

Table 1: Summary of Results

Idea No.	Idea Title / Description	Initial Savings ¹	O&M Savings ²
MC-02	Utilize solar / low voltage for lighting and signage.	\$210,000	TBD
MC-03	Smart work zones with queue / delay information.	(\$1,000,000)	\$0
MC-17	Establish lane closure strategy prior to construction.	TBD	TBD
MC-22	Install LED pucks at hazardous locations (i.e., tight corners.)	(\$9,000)	(\$14,000)
IS-07	Media educational campaign on lane usage.	(\$5,000)	TBD
IS-14	Install friction course asphalt on curves.	(\$1,685,000)	TBD
IS-23	Develop plan for rockfall events during construction. (as an update to the corridor incident management plan.)	TBD	TBD
IS-28	Individual traffic control contract for the corridor.	(\$1,185,000)	(\$2,576,000)
PE-05	Create wetlands for I-70 wetlands bank at Empire Junction.	(\$575,000)	\$0
PE-14	Establish corridor landscape maintenance contract(s).	(\$15,000)	TBD
PE-19	Open ditches / channels in lieu of culvert and manholes.	\$14,000	\$0
DP-06	Constructability reviews for all major elements (i.e., phasing, ITS, schedule, etc.).	TBD	TBD
DP-08	Establish corridor wide public information consultant.	(\$65,000)	\$0
DP-11	Utilize completion incentives.	TBD	TBD
DP-13	Use EB PPSL for one WB through lane during temporary closures.	\$745,000	\$0
DP-16	Avoid Rock Cuts by Implementing Alternative Mitigation Measures.	TBD	TBD
Totals =		(\$2,085,000)	(\$2,590,000)

Each of the recommendations listed above are discussed in greater detail within this document.

These estimated costs in the preceding table represent the order of magnitude cost impact for each individual recommendation. Estimated costs reflect the cost differential between the project schematic design, and the VE Team recommended alternative concept. The VE Team

¹ Cost savings are the difference between the schematic design estimate and the VE Team recommended change. Items with “negative” savings, i.e., (\$), are cost additive improvements or project betterments that the VE Team recommend for inclusion. These items should improve project performance, or meet an undefined requirement.

² Total life cycle cost savings is the sum of initial / construction cost savings plus O&M cost savings, if any. O&M costs, calculated as net present worth (NPW) of discounted annual costs over 20-years period, unless otherwise noted within the recommendation.

utilized the project schematic design cost estimate, which was based upon recent CDOT actual project unit price cost averages.

Workshop Team

The VE workshop was convened on site in the CDOT Region 1 offices located in Golden. The VE Team was composed of professional staff from CDOT Region 1, FHWA – Colorado Division, Ulteig Engineers, and ATKINS.

Table 2: VE Workshop Team Members

Name	Organization	Role
Bob Smith, PE	CDOT – Region 1	Resident Engineer
Neil Ogden, PE	CDOT – Region 1	Resident Engineer
Jana Spiker, PE	CDOT – Region 1	Resident Engineer, Design
Jessica Myklebust, LEED AP	CDOT – Region 1	Environmental Manager, Region 1
Robert Group, PE	CDOT – Region 1	Geohazards
Matt Greer, PE	FHWA – Colorado Division	Bridge Engineer
Jeffery Hampton, PE	CDOT – Region 1	Professional Engineer I
David Nasiatka, PE	CDOT – Region 1	Geotechnical
Tyler Brady, PE	CDOT – Region 1	Project Management
Maddy Cieciorca	CDOT – Region 1	Engineering Intern
Clark Roberts, PE	Ulteig Engineers	Senior Engineer
Dennis Largent, PE	Atkins North America	Sr. Resident Engineer
Al Adelgren, PE, CVS-Life, LEED AP, CPP	Atkins North America	VE Team Leader / Facilitator

PROJECT DESCRIPTION

Environmental

The existing Environmental Assessment / Environmental Impact Statement (2011) does not include the I-70 WB PPSL operational improvements as a planned project. The WB PPSL work scope is being performed in accordance with a categorical exclusion, as traffic facility operational improvements.

Environmental issues within the I-70 WB PPSL operational improvements work area are complex, with frequently competing requirements:

- Maintaining water quality is problematic along the corridor.
 - Majority of stormwater and ice / snow melt run off as flows to the Clear Creek, which I-70 parallels and crosses at multiple locations along the project corridor.
 - Abandoned mine water discharge must be diverted to a treatment plant before entering the Clear Creek.
- Abandoned mines as well as mine and mill tailings are located throughout the corridor.
- Traffic noise due to the high volume of through-commercial and passenger vehicles, with occupied structures in proximity to the roadway. Canyon geometry further compounds the traffic noise issues.
- Rockfall from the canyon walls onto the roadway in several locations.
- Wildlife movements along and across the corridor include large animals such as deer, elk, mountain goats, mountain sheep, bears, and mountain lions.
- Fishery resources located near the US-40 Empire Junction.

The WB PPSL retaining walls were not designed as noise mitigation features; however, these walls do provide an incidental noise reduction benefit in some areas.

Figure 3: Sediment Basin



Planned Improvements

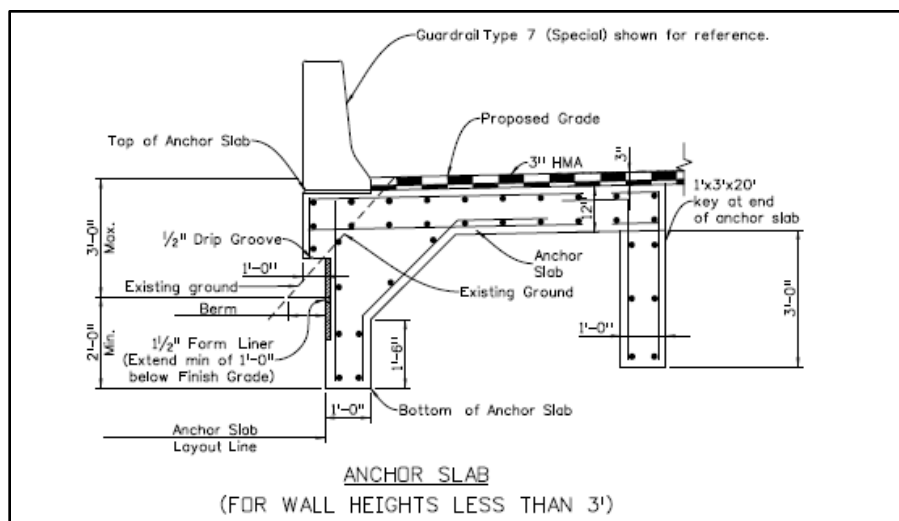
On the first day of the VE workshop the CDOT Region 1 project manager provided a thorough presentation of the project including known constraints, as well as attributes that could not be changed due to stakeholder commitments. The design presentation was based upon the CDOT and consultant prepared schematic design documents.

The I-70 WB PPSL project total length encompassed by this VE workshop effort is approximately 12 miles, based on the defined project start and end station points.

The planned construction work activities include:

- Rockfall mitigation to improve sightlines and maintain the outside shoulder width or improve rockfall hazard reduction.
- Roadway improvements include minor widening along select locations to allow for sufficient width for an inside PPSL, and addition of emergency / law enforcement pull-outs on the outside shoulder along both directions (two on EB, four on WB), as well as exit / entrance ramps improvements.
- Entrance ramp improvements and pavement at Exit 240 to EB I-70.
- The existing WB weigh-in-motion truck scale at Dumont (Exit 234) will be shifted to the outside by one-half lane to allow construction of the PPSL on the inside.
- Center median retaining walls as well as barrier and guardrail improvements.
- Lighting and signage improvements.
- Intelligent transportation system (ITS) and communications infrastructure, including toll collection system.
- Minor concrete work for pedestrian access across intersections.
- Modifications to the existing Fall River Road and Lawson sediment basins.
- Three (3) new sediment basins along the WB outside shoulder.
- Extension of several existing culverts.

Figure 4: Guardrail / Retaining Wall Anchor Slab Typical Detail



Project Cost

The current estimated cost for the defined I-70 WB PPSL operational improvements project is \$62 million. The project cost includes all construction scope elements with contingencies for unforeseen conditions or changes; temporary environmental protection measures; and construction traffic control.

The primary construction cost elements are rockfall mitigation / rock removal, pavement including subbase, retaining walls and concrete structures, as well as guardrails and traffic barriers. Lesser cost elements include drainage, ITS / communications, signage, pavement markings and professional services (i.e., surveying and public relations). However, these elements represent only 53.3% of the total estimated project cost, or \$33.15 million.

The project cost estimate includes allowances for several items such as construction engineering / field support, contingencies, traffic control, force account items (i.e., risk items including fuel and asphalt cost adjustments). Minor allowances are also included for escalation to midpoint of construction, erosion control, lighting, and landscaping / aesthetics. These allowances represent 46.7% of the total project cost, or \$29.01 million.

Cost model based upon the 30% schematic design cost estimate is included within Appendix C.

Project Constraints / Challenges

During the Information Phase on the first day of the VE study, the VE Team identified known project constraints and challenges:

- No reasonable alternative routes. Closest option is US-285 which would add significant distance and travel time for through traffic.
- Region lane closure strategy.
- Night work with noise restrictions.
- Confined work zone; very limited area to work within and directly adjacent to the roadway suitable for temporary lane shifts and contractor staging.
- High volume corridor:
 - Commuters from mountain residences to Denver area workplaces.
 - Commercial freight.
 - Recreational.
- Public perception regarding toll / managed lanes.
- Weather – the corridor is subject to occasional isolated, heavy storms. Canyon geography is tight, with steep side slopes that drain to Clear Creek which is parallel to the I-70 roadway.
- High visibility corridor with local, regional and national interests.
- Historic and environmentally sensitive corridor.
- Several historic mines and structures along the corridor, several in proximity to the roadway, in addition to the City of Idaho Springs historic district.

- All stormwater flows into Clear Creek, which the roadway parallels through the canyon along the entire corridor.
- ITS / intensive technical infrastructure.
- Public expectations that project will be done in timely manner.
- Mitigation acceptability – what we say we’ll do is acceptable to public and stakeholders.
- Project overload or construction fatigue – too many recent construction projects, several more projects planned by CDOT and other stakeholders.
- Geotechnical conditions are variable or unknown.
 - Presence of abandoned mine shafts and tunnels (or drifts) along the corridor on both sides of roadway, and potentially beneath the roadway.
 - Canyon exposed rock walls with known fissures and fractures that result in unplanned rockfall events onto the roadway.
- Substantial number of engaged stakeholders, many with conflicting interests and requirements that must be considered.
- Any substantial changes require stakeholder approval.

Several elements along the corridor were defined as “untouchable” or outside the scope of the VE Workshop efforts due to prior stakeholder agreements. The elements that cannot be changed without prior consent of the corridor stakeholders include:

- Eventual WB PPSL facility will be consistent with the completed EB PPSL facility.
- Roadway section width is limited to 41-feet where context allows, exclusive of designated emergency / law enforcement pull-outs (approximately 16-feet wide).
- Roadway alignment remains as-is, with minor offsets to avoid rock faces.
- Existing bridges cannot be widened; outside shoulder is reduced at bridges.
- Sediment Control Action Plan (SCAP) implementation approach is minimalistic.
- WB PPSL work scope is to be fast tracked, minimum reasonable construction schedule.
- No right-of-way (ROW) impacts; minor temporary construction easements.

Right of Way

The I-70 WB PPSL project has been planned and designed to be constructed entirely within the existing CDOT right of way (ROW) limits; no additional ROW is required. All planned improvements, including the stormwater detention basin and soundwall relocation, can be constructed within the confines of the existing ROW. However, two (2) small temporary construction easements will be required.

Schedule

The I-70 WB PPSL operational improvements project is currently forecast to be released for contractor bidding in late 2018 or early 2019, with construction anticipated to commence in Spring / Summer 2019. The current anticipated construction scope period of performance is 18-months, which encompasses two construction seasons. Actual construction season duration is dependent on weather conditions.

PROJECT SPECIFIC WORKSHOP APPROACH

The typical VE workshop would identify individual alternative ideas in contrast to the baseline concept. All alternative ideas are recorded without initial judgment, to foster further creative idea generation. This also supports the intent to maximize the potential opportunities.

The cost comparisons typically reflect a comparable level of detail as depicted within the baseline project estimate. The estimated costs developed for each VE recommendation would be derived from project-defined unit pricing and estimated costs.

A life-cycle cost analysis based on net present worth, or discounted cash flow, may also be prepared, if appropriate. The VE Team performed life cycle cost analysis calculations with respect to some of the proposed recommendations.

Workshop Timing

The project was at the schematics stage of design development when the VE workshop commenced. The VE workshop was conducted on June 26-29, 2018. The VE Team evaluated the FIR 30% design arrangement plan, roadway sections, and profile drawings dated June 1, 2018. The VE Team evaluated the preliminary construction cost estimate dated June 1, 2018.

Workshop Objectives / Approach

The objective of this VE effort was to identify potential cost reduction recommendations, as well as project betterment opportunities, specific to this project.

Information Phase

A thorough presentation of the project need, issues and constraints, as well as various I-70 facility operational issues was provided to the VE Team. The planned I-70 WB PPSL project is intended to provide interim operational improvements and temporary congestion relief. An overview of project environmental was discussed, including the current Environmental Assessment (2011),

The VE Team was asked to investigate the following project attributes:

- Roadway configuration.
- Structures including retaining walls and sediment basins.
- Geotechnical including rockfall mitigation.

Suggested objectives or goals for the VE Team included:

- Minimizing rockwork within the corridor, which requires roadway closures.
- Maintenance of traffic during construction operations, two (2) 11-foot wide lines.
- Minimize construction impacts.
- Reduce construction cost and schedule.
- Minimize PPSL infrastructure.
- Maintenance access, with emphasis on sediment basins.

After further independent review of the project documents, the VE Team collectively identified key success factors for both the VE workshop effort and the overall I-70 project:

- Results in good public opinion:
 - Safe work zone delineated
 - Provides good access to businesses during construction
- Minimizes delays to travelling public on I-70.
- Provides smooth Traffic flow.
- Minimizes change orders.
- Promotes positive partnering; minimal disputes.
- Contributes to success of project.
- Validates design.
- Identifies best value solutions.
- Improves safety during construction and enhances traffic operations during and after completion of construction.
- Employs a robust and thorough communication plan.

The VE Team discussed project related elements that were at risk of unplanned events, or could result with cost growth and/or schedule delays. The VE Team defined risk items were:

- **Mitigate Rockfall:** Rock removal and unplanned rockfall.
 - Precision rock cut blasting is expensive, longer preparation.
 - Back rock wall requires protection to avoid unintended fractures.
 - Rock removal requires lane closures, full width both directions if blasting is performed to cut rock.
- **Manage Traffic:** Traffic control and management during construction operations to maintain two (2) through travel lanes (except during temporary closures).
 - Construction activities that require lane closures or diversions.
 - Accidents, emergencies and law enforcement actions within the corridor.
 - Unplanned rockfall events.

Figure 5: Typical Rock Face



- **Utilize Technology:** Current ITS and tolling technology is evolving at a rapid pace; new systems and equipment must be compatible with the EB PPSL system.
- **Utilize Shoulder:** Conversion of the inside shoulder and median strip for use as a peak period express lane pushes the through lanes to the right, drastically reducing the outside shoulder width. The overall roadway width does not meet FHWA interstate design standards, and requires design variances.
- **Inform Public:** Keeping the public informed regarding construction operations and closures, as well as PPSL (EB and WB) operations.

Function Phase

During the Function Phase, the VE Team utilized a two-word descriptive pairing (active verb plus measurable noun) to define the project elements. These functions were linked together using a “Why” / “How” logic to construct a *Function Analysis System Technique* (FAST) diagram. The FAST diagram was used to help the VE team understand the interplay between functions within the project under study.

The project specific FAST diagram is provided within Appendix D.

Creative Phase - Alternative Ideas

The VE Team conducted brainstorming work session to identify creative ideas which could help meet the goals of the project. This brainstorming session followed these basic rules:

1. All ideas were considered good pending evaluations, which would occur later.
2. All ideas were recorded.
3. Questions to clarify the intent of the idea were allowed.
4. No criticism of ideas was allowed during the Creative Phase.
5. It was permissible to modify or combine ideas to create a wholly new idea.

The VE Team collectively selected defined functions within the FAST diagram as focal points for the alternative ideas. The VE Team’s selected functions were:

- **Manage Corridor (MC)**, which encompasses all measures necessary to manage and operate the corridor during construction, along the length of the corridor.
- **Improve Safety (IS)**, which encompasses all measures related to enhancing safety during construction and normal traffic operations after the project has been completed.
- **Protect Environment (PE)**, which encompasses all features of construction including best management practices (BMP) to mitigate any environmental impacts.
- **Develop Project (DP)**, which encompasses all project development and delivery items.

Several of the creative ideas could be associated with two or more of the selected functions.

Evaluation Phase

During the evaluation phase, the VE Team considered the identified alternatives individually with respect to the baseline schematic design. The VE Team considered the following evaluation criteria:

1. Accelerates construction schedule
2. Considers future facility life cycle, particularly compatibility;
3. Complies with the record of decision (ROD).
4. Reduces cost of construction.
5. Reduces maintenance.
6. Meets durability requirements.
7. Preserves viewshed.
8. Improves safety.
9. Maintains minimum level of mobility.

In addition to the above VE Team defined criteria, the VE Team was instructed to consider:

10. Already Being Done / As designed:
Have any of the identified ideas already been incorporated into the schematic design documents?
11. Commonality:
Are any of the ideas similar enough to be combined into a common theme? Are any of these ideas a duplicate of another idea?
12. Relevance:
Are any of the ideas non-construction agency actions (i.e., contract documents), or minor construction elements that require further investigation?

The complete creative idea listing with evaluations are provided within Appendix E.

Development Phase

During the Development Phase, the VE Team members were instructed to pair up and investigate specific ideas, then prepare the VE recommendation. The intent was to expand the perspective given to each idea, building on both team member's individual technical expertise or other related experience.

Available Project Information

The following project documents were provided to the VE Team for their review before, and during the workshop:

- Schematic design arrangement plans, roadway sections, and profiles.
- Schematic design cost estimate.
- Traffic analysis and model.

The complete listing of project information that was available to the VE Team during the workshop is included within Appendix G.

Project Issues

The VE workshop commenced with a review of known project issues and past on site observations and experience. The following summarizes key project issues and site visit observations identified during these sessions.

The following are some of the issues and concerns associated with the project:

- Planned work scope is an interim (10-15 years) operational improvement, not long-term corridor congestion solution.
- Narrow roadway corridor.
- Eastbound general purpose and peak period shoulder lanes are narrow.
- Geotechnical issues include rockfall, as well as unknown subsurface conditions (i.e., abandoned mine shafts / tunnels along corridor).
- Diverse stakeholders, with conflicting concerns or requirements.
- Water quality management due to surface runoff-transported sediments.
- Requirement to maintain access to the Hukill Gulch area directly from the WB I-70 roadway shoulder west of Idaho Springs; primary entry point to private properties as well as areas frequented by hikers and four-wheel drive enthusiasts.

VALUE ENGINEERING RECOMMENDATIONS

An alternative idea that survives the evaluation phase may be developed into a value engineering recommendation. Each value engineering recommendation is comprised of several parts, as appropriate to the concept.

- Recommendation summary
- Comparative advantages and disadvantages
- Narrative discussion
- Sketches for baseline and proposed concept
- Representative product or equipment data sheets
- Calculations for baseline and proposed concept
- Estimated quantities and costs for baseline and proposed concept
- Life cycle cost analysis where appropriate

The VE recommendations were considered with respect to the FHWA defined evaluation categories:

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

Value Engineering Recommendation

Idea Number: **MC-02**

Idea Title

Utilize Solar Powered with Low Voltage for Lighting and Signage (Construction Signing and Warning Signs) in the Corridor. (MC-02)

Original Concept Description:

The original concept calls for traditional lighting and signage within the corridor. The design would make use of existing power supplies and conduits from an existing power source. Where needed, installing a new power supply would require trenching and possibly a small bore to get power to the new lights and signs. According to the EB PPSL Final Payment file – LED lightbulbs were utilized for the EB PPSL so it is assumed that LED fixtures would be used for the WB PPSL.

Proposed Concept Description:

Solar powered street lighting and signage systems are an efficient means to provide lighting without the need for standard utility power. The recommendation for solar using low voltage was made based on the premise that installing and moving the electrical support network for lights and signage has a large footprint, adds to the project cost, and may need to be upgraded in the future as technology advances within transportation corridors.

Summary:

By using a low voltage solar powered lighting and signage approach the project would see a reduction in the project cost due to a decreased need for trenching and pulling standard electric wires, conduit installation, and long-term power needs.

A photometric calculation has not yet been run for this project.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input checked="" type="checkbox"/>		Original =	\$834,000	TBD	\$834,000
Environment	<input checked="" type="checkbox"/>		Proposed =	\$624,000	TBD	\$624,000
Construction	<input checked="" type="checkbox"/>		Savings =	\$210,000	TBD	\$210,000
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **MC-02**

Advantages

Operations:

- LED lights minimize roadway glare when snow is on the ground.
- Decreased maintenance cost over the life of the light bulb.
- Decreased electric costs for the corridor.
- Promotes future thinking about innovative ideas for CDOT as being #1 DOT.
- Battery backup when snow, moisture, and shade are within corridor.
- Can be built from standard CDOT parts.
- Reduces cost through not needing to buy transformers.
- Reduces cost through not needing to buy inverters.
- Improves visibility and, potentially, compliance with signage.
- Because LED bulbs are so efficient they can easily be powered by solar.

Environment:

- Decreased project footprint and impact on adjacent areas by eliminating need for trenching.
- Energy reliability within the corridor.
- Energy independence within the corridor.
- LED fixtures will likely take the place of mercury containing bulbs.

Construction:

- Self-sustained and off-grid with low voltage battery backup will require no AC to DC conversion.
- Will expedite project delivery by removing the need for trenching and boring for electrical.
- Will eliminate external wires and reduce risk of accident and exposure to high voltage.

Advantages / Disadvantages

Idea Number: **MC-02**

Disadvantages

Operations:

- Sunlight exposure and shading within the corridor may increase backup battery sizes.
- Higher initial investment than traditional lighting.
- Potential panel deterioration due to snow and adverse weather.
- Maintenance training on maintaining panels and equipment will be required.
- Current design guidelines may/may not allow the implementation of this recommendation.
- Snow or dust combined with moisture can accumulate on PV panels and reduce or stop energy production.

Environment:

- Inconsistent viewshed since solar approach was not used on EB PPSL where conventional line utility pole mounted lighting was installed.
- Lighting can be controlled from a remote location allowing the lights to be dimmed during late night hours or adjusted to reflect time of day.

Construction:

- No existing specifications to direct solar powered / low voltage LED lighting and signage work.

Discussion

Idea Number: **MC-02**

The lighting along the corridor (as a minimum) could be powered by solar. Currently, all major solar installations use solar panels that inherently produce safe, clean, DC (Direct Current) power.

The technology exists to have solar panels create DC power that then can power LED lights directly, without the need for a DC / AC inverter. Much energy and cost is associated with the process of transforming the high voltage AC back down to low voltage DC to make the LED work. For this project, the proposed technology use would create the ultimate energy free or low energy use corridor.

As a minimum the use of LED lights is recommended – this is what was used on EB PPSL. Second, solar power for the lights is recommended. The VE Team recommends consideration of this technology to use the low energy power source for lights and signs.

EPA Regional HQ, Raleigh, NC



Discussion

Idea Number: **MC-02**

Eagle County Transit, Gypsum, CO



Proposed Concept – Sketch

Idea Number: **MC-02**

Currently, the project does not include any plans for the use of solar, low-voltage signs or lighting systems.

There are several steps to be followed to determine the details of implementing this concept.

- 1) Calculate the right light – how much light is required for visibility. Point by point photometric calculations required to determine the number of luminaires and their relative wattage. This could be completed by a lighting contractor.
- 2) Calculate the power assembly in watts – this takes into consideration geographic locations and available insolation in the winter months.
- 3) Select desired solar power assembly and battery assembly by amperage. There are many types of solar light poles that can be selected. Solar panels can be placed on the ground or on the top of the pole. In the mountain corridor, it seems appropriate to place them in the most prominent location for light harvest.
- 4) Determine fixture mounting – how the panels attach to the light pole and if these fixtures can be attached to standard light pole.
- 5) Solar power configuration – determine the arrangement and tilt of the panel for performance and any required aesthetic requirements. The I-70 Corridor has aesthetic requirements that adhere to US Forest Service guidelines.

The following graphic* depicts the configuration from SEPCO – Guide to Solar Lighting Systems Brochure available online

https://www.sepco-solarlighting.com/hubfs/Brochures_and_White_Papers/SEPCO%20Brochure%202017.pdf?hsCtaTracking=1d54ed8f-4f08-4f4c-9669-41db49b34584%7C5d11f915-9ca8-4ad3-b7bc-9fd13183535f

Several solar electric power assembly mounting methods are available. The illustrations represent the most common arrangements, other configurations are available to meet on-site performance and aesthetic requirements.



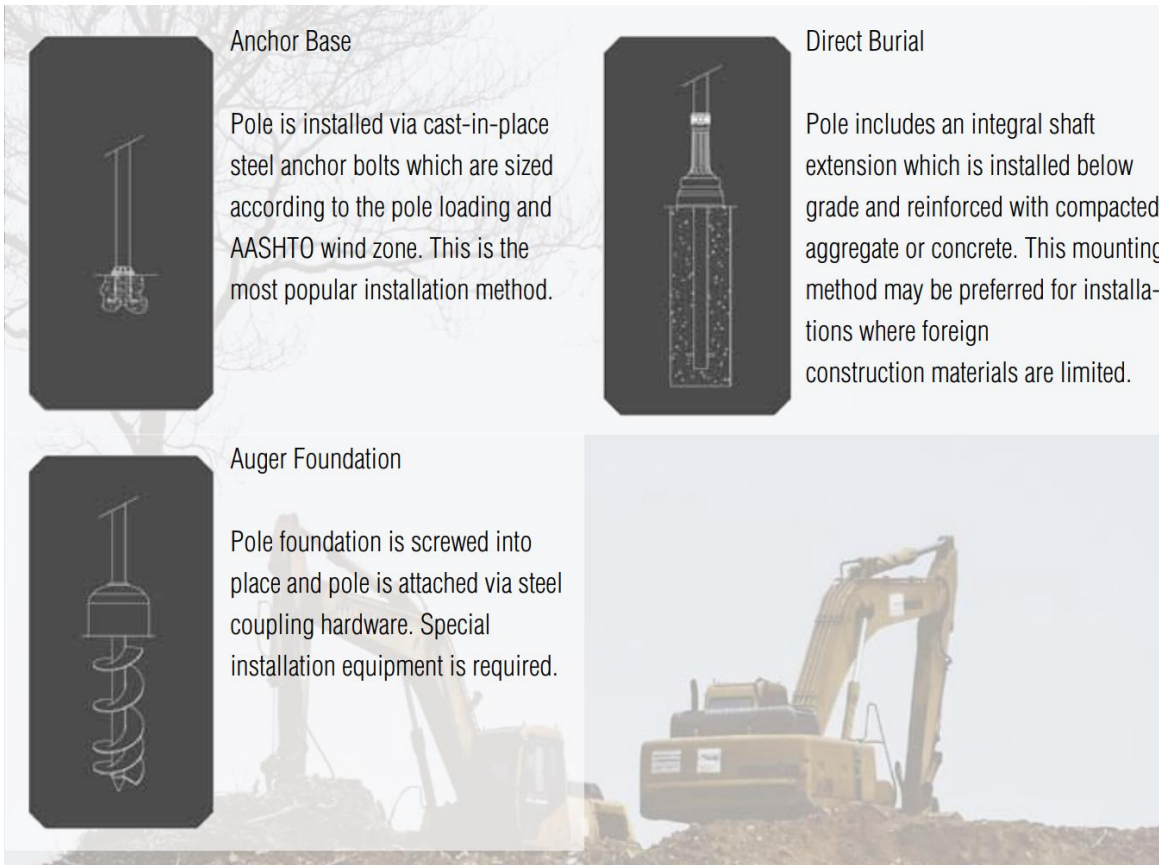
*provided for reference only

Proposed Concept – Sketch

Idea Number: **MC-02**

- 6) Pole configuration for base and foundation – determine whether cast-in-place anchor based, auger foundation, or direct burial with integral shaft extension is appropriate.

The following graphic* depicts the pole configuration for the base and foundation from SEPCO – *Guide to Solar Lighting Systems Brochure* available online:



*for reference only

Cost Estimate Worksheet

Idea Number: **MC-02**

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
Removal of light standard	EACH	67394	5	336,970
Light standard steel (35 ft.)	EACH	4509.75	4	18,039
Luminaire (LED)	EACH	1149.75	4	4,599
Light standard steel (40 ft.)	EACH	4845.75	2	9,691
Light Standard Foundation	EACH	2126.25	6	12,757
2 Inch Electrical Conduit (bored)	LF	7.75	5790	334,372
2 Inch Electrical Conduit (plastic)	LF	24.15	4881	117,876
Total (ORG) =				834,305

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
Removal of light standard	EACH	67394		336,970
Solar Panel, battery, inverter	EACH	<2000	6	12,000
Light Standard Steel (40 ft.)	EACH	4845.75	6	29,074
Light Standard Foundation	EACH	2126.25	6	12,757
Luminaire (LED)	EACH	1149.75	6	6898.50
2-inch electrical conduit (bored)	EACH			167,186*
2-inch electrical conduit (plastic)	EACH			58,938*
Total (PRO) =				623,824
Difference (PRO – ORG) =				210,481

*assume 50% of electrical feeds lights and signs in corridor so assumed 50% conduit savings. Would need to be confirmed.

Assumptions:

- Assumed LED bulbs are used based on EB PPSL
- Assume original costs are same as EB PPSL
- Assume only 20% of electrical conduit is feeding the lighting

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Life Cycle Cost Analysis

Idea Number: **MC-02**

The payback time for the excess investment for LED was calculated to be 2.2 years, the excess investment of LED was 3.3 years for the solar powered LED. Given that the course of this interim project is 15 years a payback would be achieved about 5 times.

The dollar savings from not pulling electrical from the grid justifies the cost of the equipment.

General Notes:

- Annual costs are current values, without escalation.
- Discounted net present worth calculation of annual / recurring costs.

Value Engineering Recommendation

Idea Number: **MC-03**

Idea Title:

Smart Work Zone with Queue Detection and Vehicle Speeds. (MC-03)

Original Concept Description:

Utilizes traditional construction traffic control devices and message boards to provide traffic control in the active work zones.

Proposed Concept Description:

Utilize “smart” technology in work zones for the purpose of providing real-time information relative to queue lengths and downstream vehicle speeds to both the traveling public and the Project Engineer in the field. Delay information, traffic volumes, etc. can also be captured and made available to the Project Engineer to monitor/document and report on traffic conditions as lane closures remain in place.

Summary:

Using a smart work zone strategy provides information to the traveling public using message boards and potentially social media (i.e., manufacturer iCone has partnership with Waze smartphone navigation app). Accurate and timely information helps the traveling public plan their trip (time of day) to avoid congestion, reduces driver frustration in the corridor, and reduces the secondary accidents from occurring in traffic queues.

Using Traditional traffic control devices is significantly cheaper but does not provide additional traveler information or safety benefits.

Cost for work zone queue detection system is approximately \$50,000 per month, or \$1.0 million for the duration of this project.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input checked="" type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input checked="" type="checkbox"/>		Original =	\$0	\$0	\$0
Environment	<input type="checkbox"/>		Proposed =	\$1,000,000	\$0	\$1,000,000
Construction	<input checked="" type="checkbox"/>		Savings =	-\$1,000,000	\$0	-\$1,000,000
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **MC-03**

Advantages

- Provides real-time traffic information to the traveling public through VMS messages.
- Smart work zone data has web interface capabilities.
- Reduces secondary accidents (accidents occurring in queue) 30% to 40%.
- Collects delay (travel time) from the back of queue through the workzone.
- Collects volume and speed data.
- Provides speed advisory information.
- Provides data through XML feed to CTMC.
- Several brands provide “off the shelf” technology that allows a modular system to be tailored to specific project needs.
- Very flexible deployment within the project limits.
- Would qualify for Safety funds (i.e., HSIP or FASTER Safety) that could be added to the project to pay for the smart work zone System.
- This information will help the PE make decisions related to traffic control operations.

Disadvantages

- Significant cost increase to project over the cost of traditional devices.
- Project needs and details must be developed to tailor the smart work system to meet the needs of the project.
- Multiple proprietary systems exist. They are hard to competitively bid so the desired system needs to be identified early (design process prior to project Advertisement).

Discussion

Idea Number: **MC-03**

The project specific traffic control needs should be identified prior to implementation and discussed with vendors to help identify the types and quantities of the proprietary devices needed for the project. This is when the actual cost of the system can be determined in detail. Most of the systems available are modular, and as the system requirements are identified (such as: queue detection, traveler delay information, surveillance of the work zone, traffic volumes, running speeds of the highway facility, etc.) devices are simply added to the system to collect the necessary data.

The WB PPSL Project will have significant impacts on the traveling public (delays, queuing, congestion, etc.). Collecting real-time traffic information can help mitigate these impacts and reduce driver frustration while improving overall project safety during construction. The data collected can be used to provide accurate and timely information that helps travelers choose an alternative route, consider their modal choice, or select a different time of day to travel through the corridor. For travelers already in the corridor, the information and messaging can improve safety (reduce accidents in the queue) and reduce driver frustration.

The data collected by the smart work zone devices that is not used for specific messaging information to the traveling public can provide significant benefits to the Project Engineer. Information like (vehicle speeds through the work zone, total delay from queue through the work zone, traffic volumes, etc.) help the project staff to document work zone performance, address complaints, enhance reporting to upper management, and as a tool for determining if the project needs to pick up lane closure to mitigate congestion (when type of construction operation allows).

Benefits provided by a smart work zone outweigh the increased project cost.

See also Minnesota DOT ***Monitoring Traffic in Work Zones: The iCone System:***
http://www.dot.state.mn.us/guidestar/2006_2010/icone/icone_final_report.pdf

Original Concept – Sketch

Idea Number: **MC-03**

Example: Traditional Traffic Control Barrel



Example: Traditional Messaging Trailer



Proposed Concept – Sketch

Idea Number: **MC-03**

Example: iCone Device – easy to move around within project limits.



Example: Smart Work Zone Time within Construction Messaging



Value Engineering Recommendation

Idea Number: **MC-17**

Idea Title:

Establish Lane Closure Strategy Prior to Construction. (MC-17)

Original Concept Description:

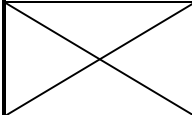
Traffic Control Plan - General Project Special Provision (PSP) identifies hours in accordance with the Region 1 Lane Closure Strategy and as advised by the Project Team and Region 1 Traffic concurrence.

Proposed Concept Description:

Traffic Control Plan- General PSP language should be developed with concurrence from the appropriate decision makers to define the lane closure strategy to be used during construction.

Summary:

The project team should anticipate that failure to implement Traffic Control General – Plan as specified in the contract is a significant risk to successfully delivering the project on-time and within-budget. Recent experience within this Corridor (i.e., I-70 EB PPSL, I-70 EJMT to Georgetown Resurfacing, I-70/US-6 Accel Lane projects) has demonstrated that contract hours which are determined at the project and region level are subject to change by others within CDOT; therefore, Contractors are being told to stop working even though the hours are listed as allowable within their Contract. Development of the TCP-General language with concurrence from the appropriate decision makers would reduce the risk of costly changes during construction.

FHWA CATEGORIES		ESTIMATED COST IMPACT			
Safety	<input type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost
Operations	<input type="checkbox"/>		Original =		
Environment	<input type="checkbox"/>		Proposed =	No Cost Estimate	
Construction	<input checked="" type="checkbox"/>	Savings =			
ROW	<input type="checkbox"/>				

Advantages / Disadvantages

Idea Number: **MC-17**

Advantages

- Improves accuracy of construction schedule using defined hours.
- Lowers risk to contractor – better bid prices.
- Improves owner control to hold contractor to method statements.
- Lane Closure Reports to public will be consistent and not varying daily.
- Project staff and CDOT Operations will be consistent with lane closures.

Disadvantages

- Traffic delays will occur.

Discussion

Idea Number: **MC-17**

The current Lane Closure Strategy Report for Region 1 allows lane closures that will severely impact traffic operations based on user experiences. Single lane closures are allowed on Saturday mornings through the project corridor until as late as 10 AM. Weekday closures are not as significant; however, the VE Team discussed the need for an HQ approved lane closure strategy specific to the project. This will create transparency in the bid documents and allow the project team and contractor to proceed with the knowledge that HQ supports the lane closure times allowed in the project specifications.

Approval of a project lane closure strategy will reduce costs and limit the potential for disputes/claims pertaining to work hours and durations. It will also allow for better communication to stakeholders and a better user expectancy based on consistency from day to day during construction operations.

It is recommended that this be implemented in the Traffic Control Plan – General Project Specification for use on the project.

Value Engineering Recommendation

Idea Number: **MC-22**

Idea Title:

Install LED Pucks at Hazardous Locations. (MC-22)

Original Concept Description:

LED Pucks were not included in Project.

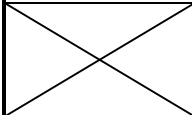
Proposed Concept Description:

This proposed concept would install solar powered LED Pucks in the pavement between lanes in the curves at Fall River Road.

Summary:

The addition of LED delineator pucks would greatly improve lane delineation in adverse weather conditions.

The original project concept would provide the typical lane delineation (i.e., inlaid tape skips).

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input checked="" type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input checked="" type="checkbox"/>		Original =	\$0	\$0	\$0
Environment	<input type="checkbox"/>		Proposed =	\$9,000	14,000	\$23,000
Construction	<input type="checkbox"/>		Savings =	-\$9,000	-\$14,000	-\$23,000
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **MC-22**

Advantages

- In pavement solar powered are easy to install.
- Highly visible at night.
- Visible through snow pack.
- Very effective for lane delineation.
- Very popular with the public.
- Reduces the need for highway lighting.

Disadvantages

- Locations must receive direct sunlight in daytime hours to charge.
- Maintenance efforts – cleaning and replacing.
- Potential for overuse resulting in driver indifference.
- Can cause driver confusion if two or more sequential pucks are not working.

Proposed Concept – Sketch

Idea Number: **MC-22**

Solar Powered LED In-Pavement Lane Delineator Puck



I-70 EB at US-6, Floyd Hill



Proposed Concept – Calculations

Idea Number: **MC-22**

This Recommendation would be to install the LED Pucks along the Skip line on an 80' Spacing (per MUTCD) for the 2 curves in the westbound direction around the Fall River Road interchange.

Total length with the tangent between the 2 curves is 2900' which would require 37 pucks. Adding 4 additional in advance of the first curve would total 41 pucks needed.

Total installed cost for each puck is typically \$225, **resulting in a total cost increase of \$9,225 for solar powered LED delineators between the two travel lanes.**

Solar powered LED lane delineators could also be installed to mark the inside and outside shoulder lanes, as well as between the WB PPSL and the inside through lane. Each additional installation would require a string of 41 LED delineators, with a cost increase of approximately \$9,225 per LED delineator string.

Cost Estimate Worksheet

Idea Number: **MC-22**

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
Total (ORG) =				

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
In pavement LED Puck	EA	\$225	41	\$9,225
Total (PRO) =				\$9,225
Difference (PRO – ORG) =				\$9,225

Assumptions:

- LED pucks placed at 80-foot intervals.

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Value Engineering Recommendation

Idea Number: **IS-07**

Idea Title:

Media Campaign on Lane Usage. (IS-07)

Original Concept Description:

When the WB PPSL opens the media will promote the lane but education will diminish as the lane remains open.

The EB PPSL was advertised through the CBS news channel, CDOT website, write ups in local papers (i.e., WestWord), and other local sources with information including what the lane was but little information regarding how to use the lane.

Proposed Concept Description:

Proactive, targeted education campaign on how to use the lane – when to enter, when to exit, how to pay for tolls etc. that is continued well after the project is completed.

Summary:

The education campaign for the EB PPSL began once the lane opened and then diminished as time passed; however, recreation travelers through the corridor would benefit from regular and continued education. Education was limited to what the lane was with minimal information on how to use the lane. Components included with the ‘how’ should include – how the lane is striped, when to enter and exit the lane, how to sign up for the toll and be billed etc. Videos on CDOT’s website were centered around what the lane is but not how to the lane system works. This information could also be posted in the rest areas and at visitor information centers such as the one at Georgetown.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input checked="" type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input checked="" type="checkbox"/>		Original =	\$0	\$0	\$0
Environment	<input type="checkbox"/>		Proposed =	\$5,000	\$0	\$5,000
Construction	<input type="checkbox"/>		Savings =	-\$5,000	\$0	-\$5,000
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **IS-07**

Advantages

Safety

- Increases safety as motorists enter and exit the lane at appropriate locations.
- Decreases conflict points for accidents.
- Enhances user expectancy.

Operations

- Increases operational efficiency if users understand how the lane works.
- May reduce complaints by drivers receiving charges for tolls they aren't expecting.

Disadvantages

- Small cost to make video and continue education.

Note:

The cost of educating the public is minimal compared to the cost of a fatality or crash for a misuse of the lane. While data does not currently depict that there have been severe crashes, the data does not pick up near misses or swerves in the EB PPSL. Enhanced education will pay for itself vs. the cost for a crash resulting from lane misuse.

Discussion

Idea Number: IS-07

I-70 EB PPSL project website:

How does the I-70 Mountain Express Lane Work?



Before Express Lanes



Express Lane Closed



Express Lane Open

The above graphic is from the CDOT project website:
<https://www.codot.gov/projects/I70mtnpps/>

The graphic shows how to know if the lane is open or closed but stops short of educating a potential user how to correctly enter and exit the lane. It also does not show or educate the user on how to proactively get set up with the tolling device.

Proposed Concept:

The proposed could include the following:

- **Video** - Video posted on CDOT's website showing when and where to enter and exit the lane.
- **Radio** - Communication from local radio when lane is open reminding drivers how to enter and exit the lane. Continued communication every season that the lane is open.
- **Newspaper** - Newspaper articles explaining and showing graphics how to enter and exit lane.
- **Visible Signs** - VMS outside of corridor directing users that lane is open and how to enter and exit.
- **Phone app** - Put a link on the CoTrip.org app for the lanes that give quick directions on how to use the lanes.

Proposed Concept - Cost Estimate

Idea Number: **IS-07**

The following exhibits assumptions about the cost:

- Video – Cost range of \$1,200 to \$5,000 to hire local videographer.
- Radio – no cost, assume free from radio stations through CDOT public communications.
- Newspaper – no cost, assume publicity and interest from papers.
- Vehicle Signs – no cost, will use existing signs and available technology.
- Phone app – no cost, CDOT owns the app and it can be adjusted as needed for our needs.

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.
- Contractor overhead / markups, not included.

Cost Estimate Worksheet

Idea Number: **IS-07**

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
Total (ORG) =				

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
Videographer	1	\$5,000	1	\$5,000
Total (PRO) =				\$5,000
Difference (PRO – ORG) =				\$5,000

Assumptions:

- Assume that radio, newspaper, vehicle sign, and phone app are all free, need to confirm with CDOT HQ PIO.

General Notes:

- No general notes

Additional Information

Idea Number: **IS-07**

The following are links to existing information on the EB PPSL. These links prove that information dissemination decreased the longer that the lane was open and essentially disappeared within the last year. The existing information only address 'what' the lane is and not 'how' to properly use and navigate the lane.

- EB PPSL CDOT Project Page: <https://www.codot.gov/projects/I70mtnppsl>
- CBS News Construction Lane Closure: <https://denver.cbslocal.com/tag/peak-period-shoulder-lane-project/>
- Westword Article 2016 on Success of PPSL: <http://www.westword.com/news/wtf-i-70-express-toll-lane-actually-reducing-mountain-traffic-hell-8352787>

Value Engineering Recommendation

Idea Number: **IS-14**

Idea Title:

Install Friction Course on Curves. (IS-14)

Original Concept Description:

High Friction Surface Treatment (HFST) was not included within the project.

Proposed Concept Description:

Install a High Friction Surface Treatment (HFST) on the curves at Fall River Road, two curves east of the SH 103 interchange, and the westbound exit ramp at Fall River Road.

Summary:

The application of HFST would greatly increase the friction coefficient of the pavement surface. The original project concept would only provide the typical friction coefficient of friction for asphalt pavement.

Select locations along EB I-70 within the project corridor may also benefit from the application of HFST course.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input checked="" type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input checked="" type="checkbox"/>		Original =	\$0	\$0	\$0
Environment	<input type="checkbox"/>		Proposed =	\$1,185,000	\$2,576,000	\$3,761,000
Construction	<input type="checkbox"/>		Savings =	-\$1,185,000	-\$2,576,000	-\$3,761,000
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **IS-14**

Advantages

- Improves safety / accident reduction.
- Improves traffic operations.
- Improved Traction on steeper grades (i.e., Fall River Road in advance of Stop Condition), and tighter curves.
- CDOT has prior experience with HFST applications along I-70 corridor.

Disadvantages

- Additional cost to project.
- Required maintenance – patching at locations.

Proposed Concept – Sketch

Idea Number: IS-14

Friction Course Application



Friction Course – Finished Installation



Proposed Concept – Calculations

Idea Number: **IS-14**

Assume four (4) curves on I-70 WB with curve lengths of 1800 feet (41 feet wide) and the WB Fall River Road exit ramp (600' long by 16' wide).

Five (5) locations for an approximate total of 33,866 Square Yards. Typical cost range \$25 per Square Yard up to \$35 per Square Yard.

Assuming \$35 per square yard the total cost for this improvement is \$1,185,310

Cost Estimate Worksheet

Idea Number: **IS-14**

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
Total (ORG) =				

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
High Friction Surface treatment	SY	\$35	33,866	\$1,185,310
Total (PRO) =				\$1,185,310
Difference (PRO – ORG) =				\$1,185,310

Assumptions:

- HFST applied to noted locations on WB I-70.

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Life Cycle Cost Analysis

Idea Number: **IS-14**

LIFE CYCLE PERIOD:		20	years					ORIGINAL	PROPOSED
INTEREST RATE:		2.80%		ESCALATION:		0.00%		Asphalt	High Friction
A. FIRST / INITIAL COST		(Note - Use 0.00% escalation for constant dollar LCC analysis)					Amount =	\$ -	\$ 1,185,000
	Useful Life (Years)					Years =	30	30	
INITIAL COST SAVINGS									(1,185,000)
B. RECURRING COSTS (Annual Expenditures)									
Maintenance:	Simple, estimated percentage of install cost					0.0%	-		
						0.0%		-	
	Detailed (carried over from Recurring Costs sheet)					Original	-		
						Alternate		-	
Operations:	Detailed (carried over from Recurring Costs sheet)					Original	-		
						Alternate		-	
Total Annual Costs								-	-
Present Worth Factor								15.1563	15.1563
Present Worth of RECURRENT COSTS								-	-
C. SINGLE EXPENDITURES (Future)									
			Year			Amount		PW factor	
ORG	PRO	< Put "x" in appropriate box (original design or proposed alternate)							
								1.000	-
	X		6			1,185,310		0.847	1,004,323
	X		12			1,185,310		0.718	850,971
	X		18			1,185,310		0.608	721,034
								1.000	-
								1.000	-
								1.000	-
								1.000	-
SINGLE EXPENDITURES sub-total								-	2,576,328
D. SALVAGE VALUE (income)									
			Year			Amount		PW factor	
								1.000	-
								1.000	-
								1.000	-
								1.000	-
								1.000	-
								1.000	-
SALVAGE VALUE sub-total								-	-
Present Worth of SINGLE EXPENDITURES (C + D)								-	2,576,328
E. Total Recurrent Costs (B) & Single (C + D) Expenditures									
								-	2,576,328
								(ROUNDED)	2,576,000
RECURRING COSTS & SINGLE EXPENDITURES SAVINGS									(2,576,000)
PRESENT WORTH TOTAL COST (A + E) (ROUNDED)								-	3,761,000
TOTAL LIFE CYCLE SAVINGS (ROUNDED)									(3,761,000)

General Notes:

- Annual costs are current values, without escalation.
- Discounted net present worth calculation of annual / recurring costs.

Value Engineering Recommendation

Idea Number: **IS-23**

Idea Title:

Develop Plan for Response to Rockfall Event During Construction. (IS-23)

Original Concept Description:

No current response plan exists to address unplanned rockfall event during construction.

Proposed Concept Description:

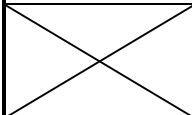
Project team should develop a plan or add a Project Special Provision requiring the Contractor to develop a plan to respond to unplanned rockfall events during construction. This plan should address communication protocol, detours, and contractor response plan.

Unplanned rockfall events during construction create a unique set of challenges compared to other emergencies:

- Large boulders that require size reduction for removal.
- Long traffic delays.
- Progressive rock failures.

Summary:

Unplanned rockfall events within project limits present a risk to deliver the project and are a safety hazard to workers and the public.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input checked="" type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input checked="" type="checkbox"/>		Original =			
Environment	<input type="checkbox"/>		Proposed =	No Cost Estimate		
Construction	<input checked="" type="checkbox"/>		Savings =			
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **IS-23**

Advantages

- Should a rockfall event occur, response can begin immediately and communication needs will be known.
- Ensures appropriate response to assess slope stability of an active rockfall and potential rockslide areas.
- Equipment and personnel will be on site reducing need for stand-by personnel.
- Specifications should include daily/weekly monitoring requirements as a method of prevention.
- Response can be included in the work scope as "Emergency Rock Removal" bid item.
- Potential reduction in schedule delays that may result from rockfall events.

Disadvantages

- Additional costs to the project.

Discussion

Idea Number: **IS-23**

Maintenance during construction is typical during all construction projects and this would arguably fall under maintenance activities. A Project Special Provision can be drafted to clearly define what would be necessary and acceptable for both parties to address these situations. Payment could be considered as a Force Account item as well.

Plan should address communication protocol, detours, and contractor response plan. With limited detours routes and heavy construction activity, it is imperative to develop an incident response plan for emergency events during WB PPSL construction to ensure proper communication and response as the incident is resolved. Rockfall incidents add an element of uncertainty and potentially elevated risk as many contractors are not experienced in responding to this type of event. Additionally, rockfalls do not always occur as a singular event – rather they can develop progressively from a small event to a large event as a section of slope destabilizes.

A component of the rockfall emergency response plan should include an evaluation of the rock slope by a qualified geologist or geological engineer. In the case of a significant event, this should occur prior to cleanup or re-opening the highway to traffic. Within the project limits there are at least two documented cases of slopes failing progressively, starting with smaller rockfall events and developing into larger slope failures of 600 cubic yards or more (approximate stations 425+00 and station 535+50).

Clearing larger slope failures from the highway may require large or specialty equipment, such as downsizing large boulders through the use of explosives. The contractor's response plan should address the potential for removing large boulders from the highway.

Many rockfall events can be cleared from the highway in a short timeframe; however, some events may require an extended full closure. The contractor's plan should consider detour routes for long term full closures of the westbound I-70 lanes.

Value Engineering Recommendation

Idea Number: **IS-28**

Idea Title:

Individual Traffic Control Contract for the I-70 Corridor. (IS-28)

Original Concept Description:

The construction project contract includes a specification requiring the contractor to provide traffic control (TC) items and services for the duration of the project.

Proposed Concept Description:

Establish a separate contract to provide traffic control items and services for the I-70 corridor and not project specific. Corridor limits would include the WB PPSL project work zone, from Veterans Tunnels to the US-40 Empire Junction interchange.

Summary:

The original concept is typical practice for CDOT that has TC included as part of the original contract. This typically means that a prime contractor hires a sub-contractor to provide TC to the project.

The proposed concept removes the TC items and services from the original contract and establishes a separate contract to provide those TC items and services. The separate contract would have a prime contractor that would typically be a TC contractor.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input checked="" type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input checked="" type="checkbox"/>		Original =	\$3,515,000	\$0	\$3,515,000
Environment	<input type="checkbox"/>		Proposed =	\$5,000,000	\$0	\$5,000,000
Construction	<input checked="" type="checkbox"/>		Savings =	-\$1,685,000	\$0	-\$1,685,000
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **IS-28**

Advantages

- CDOT has more direct control of the TC operations.
- Improves communications to project public information consultant for lane closure report.
- Long term commitment from a TC contractor.
- Better control of actual use of lane closures.
- Ensures that the lane closure strategy is consistently used throughout the corridor.
- Individual contractors must schedule their work including lane closures in advance to reserve their needed TC services.
- Provides a larger firm to provide items and services for multiple work zones.
- Could require prime to sub to DBE/ESB firms.
- May qualify for federal funding participation although bid separately from any one construction project.
- Provides ability to establish urgent need TC in response to law enforcement or unplanned rockfall events within the corridor.

Disadvantages

- Potential conflict for TC needs between multiple contractors.
- Delay issues on multiple contracts.
- Long term commitment to a TC contractor.
- There is a limited number of qualified contractors that could provide corridor wide TC services and may be difficult for smaller firms to provide full services; may require larger firm to prime.

Discussion

Idea Number: **IS-28**

Under the original concept the traffic control items and services are part of the original contract. The company performing the TC work is a sub to the original prime contractor. The original prime has to provide administrative support until the project is completed but has no other interest in the work being done.

A separate contract allows for a traffic control firm to be responsible for managing their own contract. This should provide a higher level of service and response.

Establishing a separate contract for traffic control for the corridor places coordination for the TC operations for the corridor under one contract. This improves multiple aspects of corridor TC.

- Consistent TC strategy and devices along the corridor, across multiple projects.
- Better communication to public information consultant for lane closure reports.
- Fewer multiple delay points or at least better coordination of delay points.

Corridor limits can be expanded beyond the WB PPSL project work zone, from Veterans Tunnels to the US-40 Empire Junction interchange, to encompass entire I-70 corridor commencing at the C-470 interchange west to the Eisenhower-Johnson Memorial Tunnels.

Cost Estimate

Idea Number: **IS-28**

Original Concept

Original project FIR estimate for I-70 EB PPSL for traffic control is 10% of the items or \$3.3M. This amount does not include potential TC costs for Fall River Bridge, Clear Creek Greenway, CR 314, Floyd Hill or any other projects west of PPSL. Traffic control costs for Floyd Hill could easily exceed \$3M.

Proposed Concept

Assuming a 3-year period of performance, the total I-70 corridor traffic control services contract cost is estimated to be approximately \$5M.

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.
- Contractor overhead / markups, not included.

Cost Estimate Worksheet

Idea Number: **IS-28**

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
Traffic Control				3,315,029
Total (ORG) =				3,315,029

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
Traffic Control				5,000,000
Total (PRO) =				5,000,000
Difference (PRO – ORG) =				1,684,971

Assumptions:

-
-
-

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Value Engineering Recommendation

Idea Number: **PE-05**

Idea Title:

Create Wetlands Bank near I-70 at the US-40 Empire Junction. (PE-05)

Original Concept Description:

No new wetlands included within project.

Proposed Concept Description:

The contract documents would provide for additional wetlands banking to mitigate possible aquatic resource impacts on future I-70 improvements. This will also improve water quality and attract wildlife.

Summary:

This will provide wetlands banking which would be a benefit to future I-70 projects.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input type="checkbox"/>		Original =	\$0	\$0	\$0
Environment	<input checked="" type="checkbox"/>		Proposed =	\$575,000	TBD	\$575,000
Construction	<input type="checkbox"/>		Savings =	-\$575,000	TBD	-\$575,000
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **PE-05**

Advantages

- Improves wetlands and aquatic environment.
- Improves viewshed along I-70 and US 40.
- Potential wetlands sites are located along Clear Creek, and within the existing CDOT ROW; no land acquisition costs.

Disadvantages

- Additional cost to project budget.
- Wetlands are hard to establish at high elevations.
- Wetlands impacts are unknown on future projects.
- Wildlife would be attracted to the wetlands, potentially increasing number of vehicle strike incidents.

Discussion

Idea Number: **PE-05**

Wetlands creation provides improved habitat for various vegetation and wildlife species. Three potential locations at the I-70/US 40 Empire Junction have been identified for possible wetlands creation. These potential wetlands locations are at approximately:

- Latitude N 39.76160, Longitude W 105.64890
- Latitude N 39.75920, Longitude W 105.65541
- Latitude N 39.75827, Longitude W 105.65679

These locations comprise a total of approximately 1.6 acres.

Current environmental regulations require offsetting destruction of existing wetlands by creating new wetlands at adjacent locations. Providing additional wetlands banking to mitigate possible aquatic resource impacts on future I-70 improvements.

Proposed Concept – Sketch

Idea Number: PE-05

US-40 / I-70 Empire Junction



Value Engineering Recommendation

Idea Number: **PE-14**

Idea Title:

Establish Corridor Landscape Maintenance Contract. (PE-14)

Original Concept Description:

The construction project contract includes a specification requiring the contractor to maintain and warrant the contract installed landscape items for a period of two years.

Proposed Concept Description:

It is recommended that a separate contract be established to provide landscape maintenance and warranty throughout the entire I-70 corridor, encompassing all projects within the corridor.

Summary:

The original concept requires a prime contractor, who is typically not a landscape contractor, to maintain landscape items planted as part of the overall construction project for a period after the project.

The proposed concept would release the original contractor from any responsibilities regarding the landscape materials once the project has been final accepted. A separate contract, with a landscape contractor, would provide maintenance for the entire corridor for any length of time desired by CDOT.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input checked="" type="checkbox"/>		Original =	\$110,000	TBD	\$110,000
Environment	<input checked="" type="checkbox"/>		Proposed =	\$125,000	TBD	\$125,000
Construction	<input checked="" type="checkbox"/>		Savings =	-\$15,000	TBD	-\$15,000
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **PE-14**

Advantages

- Common landscape maintenance prime contractor that is responsible for all maintenance and warranty items.
- CDOT has more direct control over landscape maintenance operations.
- Contractor gets paid for services via bid items not a lump sum contract; greater control to CDOT and less risk to the contractor.
- Project closure for the original construction project can be done and release remaining funds.
- The maintenance period could be longer than stated two-year normal warranty period stated within construction specifications.
- The separate contract may qualify for Maintenance Level of Service (MLOS) funds if these services cannot be federally funded,
- Additional maintenance items such as sediment basin clean out, mowing, etc., could be added to the corridor landscape maintenance contract.

Disadvantages

- Original Prime is not responsible for the long-term health of plantings.
- May not qualify for Federal funding participation

Discussion

Idea Number: **PE-14**

Under the original concept the landscape maintenance period is part of the original contract. The company doing the LM work is a sub to the original prime contractor. The original prime has to provide administrative support until the LM period is completed but has no interest in the work being done.

Establishing a LM contract allows for the original construction contract to be closed and any remaining funds be released. The original contractor has no long-term responsibility for the plantings so their reason for caring for the plantings until the project is completed is minimized. This could diminish the success of the plantings.

A separate contract allows for a landscape firm to be responsible for managing their own contract. This should provide a higher level of service and response.

The beginning of the Landscape Establishment period depends upon receipt of the written Notice of Substantial Landscape Completion from the Engineer. Substantial Landscape Completion occurs when all plant materials in the Contract have been planted and all work under Sections 212, 213, 214 and 623 has been performed, except for the Section 214 pay item, Landscape Maintenance. If the Notice of Substantial Landscape Completion is issued during the spring planting season, the Landscape Establishment period begins immediately and lasts for a period of 12 months. If the Notice of Substantial Landscape Completion is issued at any other time, the Landscape Establishment period begins at the start of the next spring planting season and lasts for a period of 12 months.

Cost Estimate

Idea Number: **PE-14**

Original Concept

FIR Estimate: Landscape and Aesthetics 1% of items is \$330k. Est maintenance to be 1/3 of that cost or \$110k.

Proposed Concept

2017 CDB for Big Thompson Canyon Landscape Maintenance 2019 is \$125,000 LS.

Assume Big Thompson Canyon scope is comparable for overall types of services and quantities that would be required along I-70 WB PPSL corridor.

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.
- Contractor overhead / markups, not included.

Cost Estimate Worksheet

Idea Number: **PE-14**

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
Landscape and Aesthetics 1% of items is \$330k. Est maintenance to be 1/3 of that cost	LS	110,000	1	110,000
Total (ORG) =				110,000

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
Landscape Maintenance from CDB for BTC 2019	LS	125,000	1	125,000
Total (PRO) =				125,000
Difference (PRO – ORG) =				+15,000

Assumptions:

-

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Value Engineering Recommendation

Idea Number: **PE-19**

Idea Title:

Open Ditches/Channels in lieu of Culverts and Manholes Where There Are Steep Slopes. (PE-19)

Original Concept Description:

The hydraulic designs at Sta 630+00 and 650+00 requires a series of three vaults and five vaults, respectively on a slope at nearly 1:1 with a 40- to 44-foot drop.

Proposed Concept Description:

Replace the manholes and vaults with a grouted riprap rundown channel, both locations.

Elimination of the vaults will avoid confined space entry requirements during maintenance operations such as sediment removal.

Summary:

Construction of the proposed idea will be difficult although it should be easier than the original design. The proposed idea will simplify future maintenance and eliminate confined space entry permits.

Estimated cost savings do not include slope stabilization which may be required to construct the design basis vaults with manholes; this was not quantified.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input checked="" type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input checked="" type="checkbox"/>		Original =	\$78,000	\$0	\$78,000
Environment	<input type="checkbox"/>		Proposed =	\$64,000	\$0	\$64,000
Construction	<input checked="" type="checkbox"/>		Savings =	\$14,000	\$0	\$14,000
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

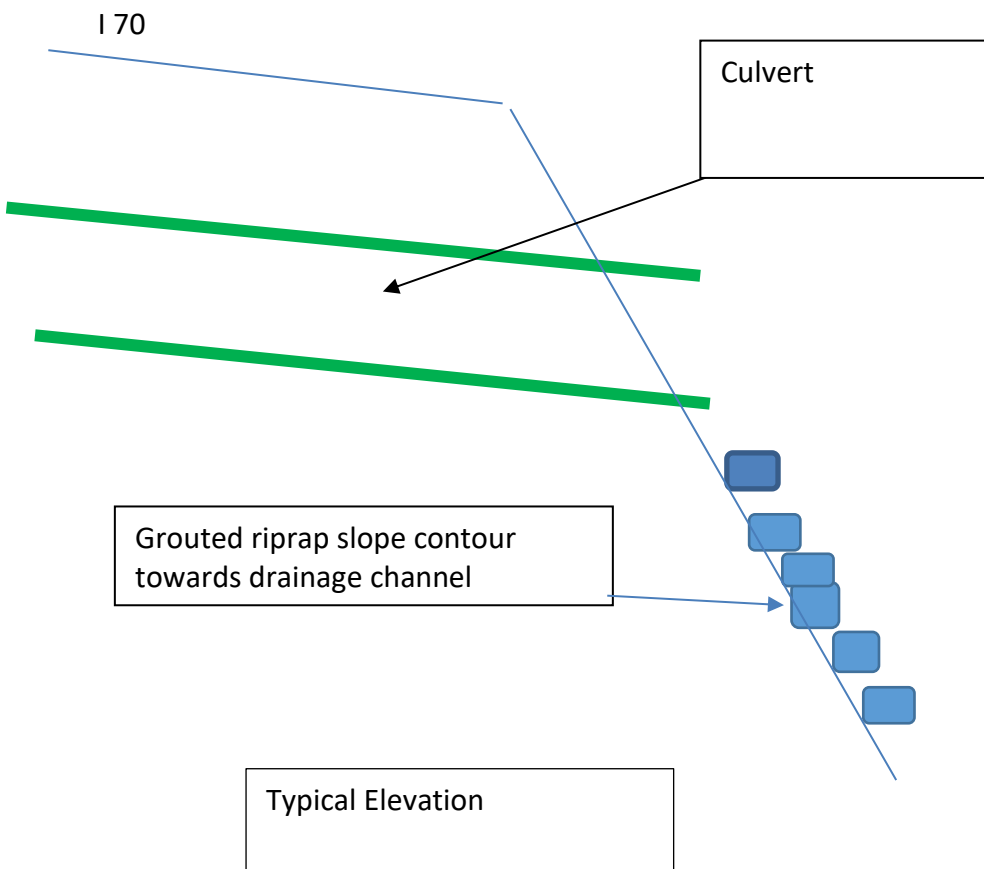
Idea Number: PE-19

Advantages

- Saves project costs.
- Simplifies construction and easier for maintenance.
- Eliminates confined space entry requirements.

Disadvantages

- Grouted riprap slope may have slight visual impacts



Discussion

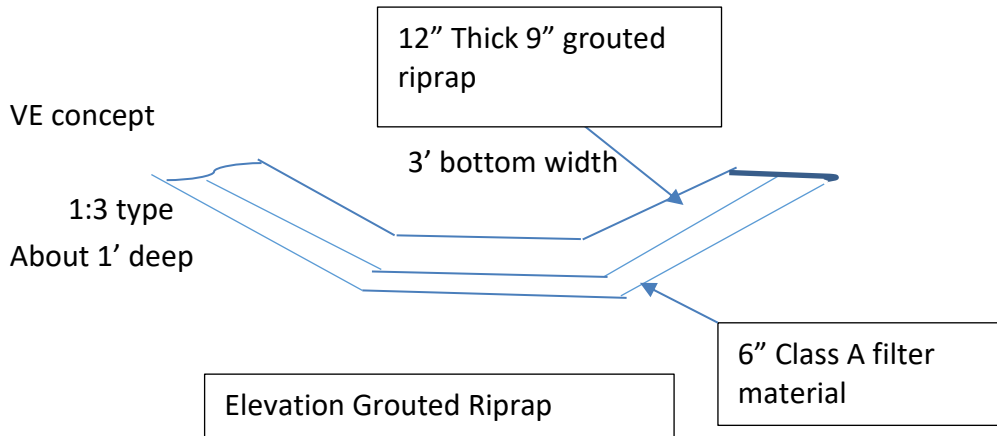
Idea Number: **PE-19**

Cost Estimate for current design at Stat 630+ 00
 Based on bid costs PPL EB 70 SA 20306

Item	Costs EA	No.	Total Costs
Item 604-30010	8700	3	\$26,100

Costs at Sta 650+00

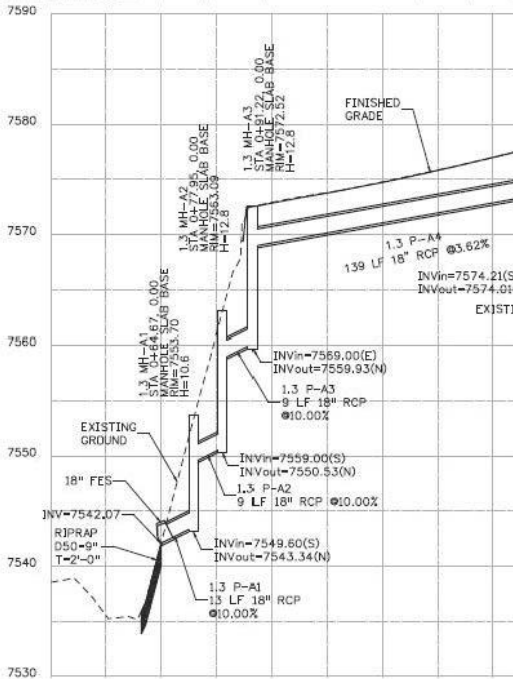
Item 604-00305	Type C	7570	1	7570
604-30010	Manhole	8700	4	34800
				\$ 68470



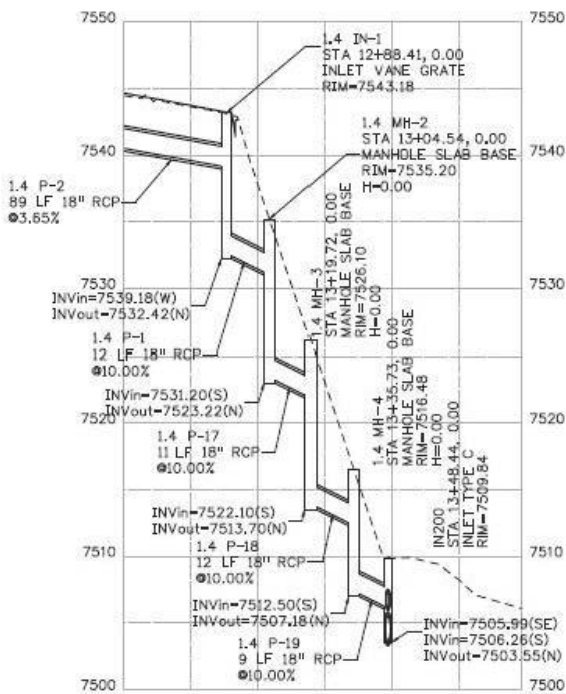
Note: Lateral footings may be required as anchorage points to ensure that the grouted riprap channel remains in place, does not slide down the slope.

Original Concept - Sketch

Idea Number: PE-19



Sta 630+00



Sta 650+00

Proposed Concept - Calculations

Idea Number: **PE-19**

Grouted Riprap 9" $3.16' \times 2 + 3 = 9.3246$ cu ft. = .3545 cu yd./ ft.

44' drop on a 1:1 $44 \times 1.414 = 62.225$ feet add 30% = 81' ea.

Grouted Riprap Cost \$947 cu yd.

$81 \times .3545 = 28.71$ cu yd. $\times 947 = \$ 27,188$ ea. Note based on 15" riprap

Filter Class A 206-0050 \$210 cu yd.

Volume Calculations Additional Calcs from lower elevation

Class A $9.3246/2 + 2/2(1.5811) = 6.2434$ cu ft. = .231 cu yd./ft.

$81 \times .231 \times 210 = \$3,929$

Total 31,117 rundown each $\times 2 = \$62,235$

Cost Estimate Worksheet

Idea Number: **PE-19**

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
Station 630+00				
Item 604-30010 Manhole	EA	\$8700	3	\$26,100
Item 603-01185 18in RCP (CIP)	LF	\$125	31	\$3,875
Station 650+00				
Item 604-00305 Type C	EA	\$7570	1	\$7570
Item 604-30010 Manhole	EA	\$8700	4	\$34,800
Item 603-01185 18in RCP(CIP)	LF	\$125	44	\$5,500
Total (ORG) =				\$77,845

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
Station 630+00				
Grouted riprap, 15-inch	CY	\$947	28.71	\$27,881
Item 206-6050 Class 4	CY	\$210	18.711	\$3,929
Station 650+00				
Grouted riprap, 15-inch	CY	\$947	28.71	\$27,881
Item 206-6050 Class 4	CY	\$210	18.711	\$3,929
Total (PRO) =				\$63,620
Difference (PRO – ORG) =				-\$14,225

Assumptions:

- Slope stabilization for placement of vaults and manholes not included within Original Concept cost estimate. Shoring costs vary greatly based upon numerous factors. A SWAG of slope stabilization costs based upon Cost Data Book information would be a LS cost of between \$25,000 and \$80,000 or a weighted average of around \$45,000 per site. This amount would be included in cost savings.

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Value Engineering Recommendation

Idea Number: **DP-06**

Idea Title:

Constructability Reviews for All Major Elements: Phasing, ITS, Schedule, Etc. (DP-06)

Original Concept Description:

Standard Design Reviews per CDOT standards including FIR and FOR reviews prior to Advertisement.

Proposed Concept Description:

Conduct Constructability reviews for the major elements of the project utilizing CDOT specialty units and industry experts to better analyze the design concepts prior to FOR/Advertisement.

Summary:

At approximately 80% design, the project team is tasked with completing constructability reviews for the major elements of work on the project. The major elements identified during the VE study were based on cost or complexity and include the following elements: Project Phasing, ITS/Communications, Rock Removal, Retaining Walls/Structures, Drainage/Utilities, Barriers/Guardrail, and Project Schedule. The purpose is to use industry experts to quantify and assess risks associated with these items and allow the opportunity for designers to mitigate potential risks prior to completion of design.

FHWA CATEGORIES		ESTIMATED COST IMPACT			
Safety	<input checked="" type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost
Operations	<input checked="" type="checkbox"/>		Original =		
Environment	<input type="checkbox"/>		Proposed =	No Cost Estimates	
Construction	<input checked="" type="checkbox"/>		Savings =		
ROW	<input type="checkbox"/>				

Advantages / Disadvantages

Idea Number: **DP-06**

Advantages

- Lower construction costs – by identifying cost saving situations or alternative designs.
- Risk Reduction – identification of potential risk areas and mitigation prior to advertisement.
- Better Quality – with optimal construction techniques identified and clear design/specifications for bidding, the contractors can focus on the quality of the work.
- Lower chance of dispute/claims – with clear design/specifications for bidding and working time that accurately reflects the proposed work, there is less chance of disputes or claims resulting from design flaws or prolonged durations due to difficult construction techniques.

Disadvantages

- Additional costs – increased cost of Task Order to provide experts for review.
- Schedule Impacts – additional meetings and review time/ redesign from results could lengthen the design process schedule.
- Possibility of contractor not being forthcoming about potential construction problems.

Discussion

Idea Number: **DP-06**

The VE Team discussed the need for constructability reviews for major work items as the potential for risk and disputes/claims was deemed very high. The major work items were identified based on the cost estimate provided by HDR and the expertise of the VE group. As indicated above, the following areas were identified for review:

- **Project Phasing**
- **ITS/Communications**
- **Rock Removal**
- **Retaining Walls/Structures**
- **Drainage/Utilities**
- **Barriers/Guardrail**
- **Project Schedule**

Each of these areas accounted for a large percentage of the estimated construction costs or posed a potential risk to CDOT for timely completion of the project.

A Constructability Review is a formalized process that utilizes a team with extensive construction knowledge to ensure that a design is buildable while also cost-effective, biddable, and maintainable, with reduced overruns and delays. A Constructability Review is intended to be conducted separate from and independent of the design team. The scope of a Constructability Review is to be flexible to suit the individual project requirements.

Value Engineering Recommendation

Idea Number: **DP-08**

Idea Title:

Establish Corridor Wide Public Information Consultant. (DP-08)

Original Concept Description:

The specifications include contract bid item “Public Information Services – Tier III -1 LS” in which the Contractor will perform or sub-contract the work to be performed.

Proposed Concept Description:

All Public Information Services for the I-70 Mountain Corridor between C-470 and the Eisenhower-Johnson Memorial Tunnels (EJMT) will be managed under a separately bid contract, directly reporting to CDOT.

Summary:

If the Public Information Services are provided under a separate contract, then quality and consistency about communication around travel impacts along the corridor can managed more effectively and robustly. Communication efforts will be the sole focus of this contract and not be competing with other priorities of the prime contractor of the project.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input checked="" type="checkbox"/>		Original =	\$65,000	\$0	\$65,000
Environment	<input type="checkbox"/>		Proposed =	\$0	\$0	\$0
Construction	<input type="checkbox"/>		Savings =	\$65,000	\$0	\$65,000
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **DP-08**

Advantages

- Improves consistency of messaging travel impacts along the corridor.
- Single point of information for multiple projects along the corridor (I-70 WB PPSL, Fall River Road Bridge, I-70 Floyd Hill, other Region Traffic and ITS projects).
- Project level communications can occur prior to NTP for project contract.
- CDOT can select consultant which provides the most quality and has the best work plan and understands corridor commitments and issues.

Disadvantages

- DBE goals may more difficult to achieve.

Discussion

Idea Number: **DP-08**

- Scope can be managed by CDOT on an as-needed basis vs. paying for a lump sum based on the specification and then having to pay for additional services when outside scope.
- Costs will occur outside typical project construction durations, but in construction CDOT pays for it by Lump Sum and are therefore inherently paying for down-time anyway. Under this scenario CDOT would only pay when valuable services are received.

Original Concept - Cost Estimate

Idea Number: **DP-08**

I-70 EB PPSL = \$120,000 for Public Information Services
@ average \$75/hr. → 1,600 hrs.

I70 EB PPSL = 18-month construction duration

→ approximately 90 hrs./month (or ~20/week) of Public Information Services should have been received.

→ in actuality, on average 8 hrs./week of services were performed

→ Cost savings:

12 hr./week X 4 wk./month X 18 months X \$75/hr. = \$64,800 or 54%

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.
- Contractor overhead / markups, not included.

Value Engineering Recommendation

Idea Number: **DP-11**

Idea Title:

Completion Incentives. (DP-11)

Original Concept Description:

Standard Design/Bid/Build Construction Delivery with Contract Time determined by CDOT Form 859.

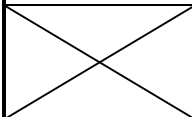
Proposed Concept Description:

Design/Bid/Build Construction Delivery with Contract Time determined by CDOT Form 859 with attainable completion incentives determined by contract milestones or performance criteria.

Summary:

The VE Team proposes including completion incentives for the overall completion of the project and/or for portions that may significantly accelerate completion in areas that have emergency or local access issues. Specifically, if the Fall River Road Bridge is included in the overall project package, the early completion of this bridge would assist emergency access throughout the I-70 WB PPSL project.

Incentives shall be included using the guidelines provided in Section 7 of the CDOT Innovative Contracting Guidelines and FHWA Technical Advisory T5080.10.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input type="checkbox"/>		Original =			
Environment	<input type="checkbox"/>		Proposed =	No Cost Estimate		
Construction	<input checked="" type="checkbox"/>		Savings =			
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **DP-11**

Advantages

- Reduction in impacts to stakeholders and travelling public by reducing overall construction time.
- Potential accessibility gains due to early completion of project elements.
- Encourages contractor efficiency and productivity.
- Reduces construction engineering inspection and traffic control costs.
- Improves public perception.

Disadvantages

- Potential risk and elevated costs due to disputes/claims based on owner caused delays.
- Requires additional agency resources to assist in construction to ensure timely responses to inquiries to keep the project moving
- Makes contract change negotiations difficult
- Plans and specifications must be complete, accurate, and conflict-free to facilitate a contractor's understanding of the project. They should indicate any unusual conditions or restrictions under which the contractor may be required to work.
- Additional cost to project.
- Contractor management may "feel entitled" to incentives, and performance reflects such behavior.

Discussion

Idea Number: **DP-11**

As the I-70 corridor is one of the most highly travelled corridors in the state, the minimization of construction duration and impact on the travelling public is of the utmost importance. There have been several recent projects completed and more scheduled in the next 5 years between C-470 and the Eisenhower and Johnson Memorial Tunnels. The public may experience "Construction Fatigue" and any opportunity to expedite the construction impacts should be evaluated.

The inclusion of completion incentives motivates the selected contractor to complete the project or identified portions thereof in an accelerated manner thus shortening the impact to the stakeholders and the travelling public.

However, the increased risk potential must be carefully evaluated and mitigated to ensure the owner does not incur the costs of the incentive without the benefit of the early completion. This can occur with any owner caused delay that would directly influence early completion of the items related to the incentive payments. Careful consideration of potential impacts is necessary. Potential impacts discussed by the VE team could include undetectable subsurface impacts (old mine shafts), geotechnical impacts (excessive rock), groundwater, and potential unidentified utilities.

Total amount of incentives will have to be calculated using CDOT and FHWA guidelines. General guideline per FHWA is that incentive should not exceed 5% of the overall contract amount. CDOT guidelines include the calculation of road user costs, lane use costs, and CM/consultant costs as well.

Cooperation and coordination between the contractor and CDOT are extremely important. CDOT should quickly respond to any decision-making questions or requests for approval. Both parties should have well defined time limits for submittals, reviews, and any other administrative issues within the contract and the project schedule.

Discussion

Idea Number: DP-11

Early Completion provisions are useful for projects where time plays a key role and/or where there are significant road user costs that impact the community and local businesses. The CalTRANS *Alternative Procurement Guide* provides the following list of appropriate projects:

- **Projects with a fixed date or sequential contracts.** These are projects where finishing early would provide some benefit but finishing late would cause severe damages. (e.g. projects with an arrangement of multiple construction contracts where finishing late would cause collateral impacts to subsequent contractors, or a road opening to accommodate major traffic events)
- **Projects with high user impacts.** These are projects that require traffic restrictions, lane closures, or detours that if delayed would result in increasing road user costs and impacts.
- **Projects with impacts on local community.** Projects where there are severe impacts to the residential or business community.
- **Projects with public or political interests.** Projects where public or political interests may require completion by a certain date to minimize user impacts.

Value Engineering Recommendation

Idea Number: **DP-13**

Idea Title:

Use EB PPSL for One WB Lane During Temp Closures. (DP-13)

Original Concept Description:

Conventional lane closures for work items such as paving, widening, etc.

Proposed Concept Description:

Using crossovers, put one WB lane into EB PPSL. This proposal would allow greater production for paving, etc. and provide for improved safety for workers.

Summary:

Using this concept, when traffic volumes are low enough, the entire WB section would be available for construction. When volumes require two lanes, one lane would be in WB and one in the EB PPSL, leaving 24 ft. of work area.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input checked="" type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input checked="" type="checkbox"/>		Original =	\$745,000	\$0	\$745,000
Environment	<input type="checkbox"/>		Proposed =	\$0	\$0	\$0
Construction	<input checked="" type="checkbox"/>		Savings =	\$745,000	\$0	\$745,000
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **DP-13**

Advantages

- Enhances worker safety.
- Time savings from high production paving at night using multiple pavers and milling equipment.
- Higher quality work.
- Cost savings from higher production, shorter project length, and not requiring added plant opening fees.
- Since existing condition has rumble strip between PPSL and Lane 1, this would become the centerline for this phase condition.

Disadvantages

- Potential for head on collision.
- EB PPSL would not be available while this is in operation.
- Decision for ramp access would have to be made several miles in advance of decision point depending on use of crossover.
- Narrow lane widths would further slow traffic.

Discussion

Idea Number: **DP-13**

There are three crossovers currently within the PPSL project limits. These crossovers can be utilized to move the WB traffic or half of the WB traffic into the EB PPSL in order to increase production, create project savings, and cut project time.

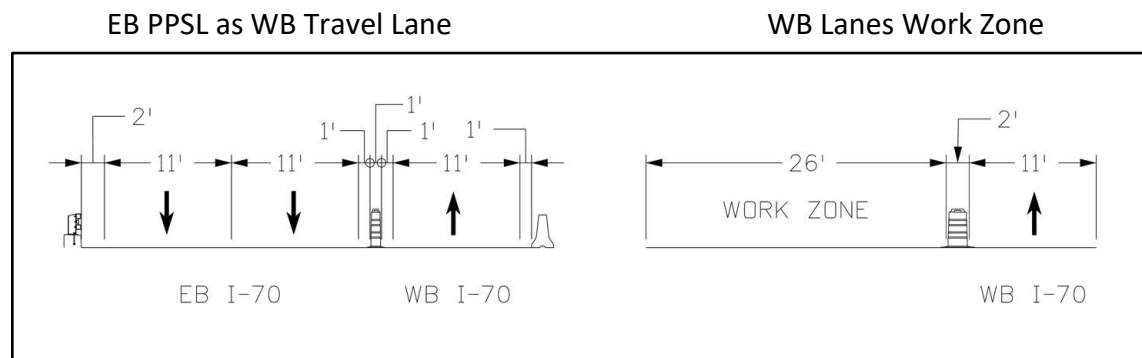
During EB PPSL, paving was done at night, one lane at a time, with milling and paving of the lane the same night. This severely hampered production. Average production was 800 ton per night.

If one lane of WB was put into EB PPSL, paving could either be done during the day with the WB traffic split between the EB PPSL and one lane WB or at night with the WB lanes completely traffic free.

During Rock blasting and scaling, CDOT has had the best success closing all lanes for 20 minutes a time and then opening all lanes to get traffic back to free flowing before closing them again. The approach of using the EB PPSL may prove beneficial in the blasting and cleanup as well.

Other items such as pouring concrete could be done during daytime using this same approach, saving the nightly cost of \$5000 per night for plant opening fee plus \$50 per load cost for concrete.

Storm sewer and culvert work may benefit from this approach as well. The contractor could be much more efficient doing.



Calculations

Idea Number: **DP-13**

Original Concept

Use typical lane closure WB as original concept and zero cost compare to proposed concept

Proposed Concept

PPSL concrete added cost for night work = \$178,000 save 50% \$89,000

Daily time savings calculation

Daily Time savings calculation

contractor overhead			\$ 5,000
Public info			\$ 1,000
ECS			\$ 200
tcm			\$ 1,300
attenuator signs, drums, flagger, etc.			\$ 2,000
consultant	13 each	900	\$ 11,700
			\$ 21,200

\$21200 per day *25 WD = \$530,000

increase production of paving from 800 ton to 1800 ton per night
 42000 tons at \$3 per ton=\$126,000

Final Cost Savings

plant opening fee savings			\$ 89,000
asphalt production savings			\$ 126,000
shortening project length by 25 WD			\$ 530,000
total savings			\$ 745,000

Additional Information

Idea Number: **DP-13**

\$3 per ton estimate came from phone conversation with contractor.

Contractor also stated that with enough incentives, they will get creative, (i.e. Paving 9300 tons over a weekend on I-25).

Value Engineering Recommendation

Idea Number: **DP-16**

Idea Title:

Avoid Rock Cuts by Implementing Alternative Mitigation Measures. (DP-16)

Original Concept Description:

Mitigate rockfall hazard and accommodate additional lane width by constructing a rock cut from station 549+27.96 to station 558+60.00, Exit 239 entrance-ramp.

Proposed Concept Description:

Mitigate rockfall hazard and accommodate additional lane width by constructing retaining walls on the south side of the highway and/or alternative mitigation measures (anchored wire mesh system and low energy rockfall barrier system) on the north side of the highway from station 549+27.96 to 558+60.00.

Summary:

By avoiding rock cuts at the specified location, the project would see a reduction in construction costs, a shortened construction timeline, and a reduced impact to the traveling public in the form of full road closures for blasting work during construction. The rockfall risk can be reduced to an acceptable level through the installation of an anchored wire mesh system on the existing rock cut and a low energy rockfall barrier at the top of the existing cut. The required roadway width may be achieved by shifting traffic to the north and/or south through the addition of retaining walls and the use of space that was formerly considered rockfall catchment.

FHWA CATEGORIES		ESTIMATED COST IMPACT				
Safety	<input checked="" type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost	
Operations	<input type="checkbox"/>		Original =	\$3,819,000	TBD	\$3,819,000
Environment	<input checked="" type="checkbox"/>		Proposed =	\$2,334,000	TBD	\$2,333,000
Construction	<input checked="" type="checkbox"/>		Savings =	\$1,485,000	TBD	\$1,486,000
ROW	<input type="checkbox"/>					

Advantages / Disadvantages

Idea Number: **DP-16**

Advantages

- Full closures not required.
- Reduces cost for construction.
- Reduces timeline for construction.
- More predictable construction timeline.
- More predictable construction product versus rock excavation.
- Reduces delays to the traveling public during construction.
- Reduces area of disturbance.
- Reduces environmental impact including viewshed.
- Improves safety.

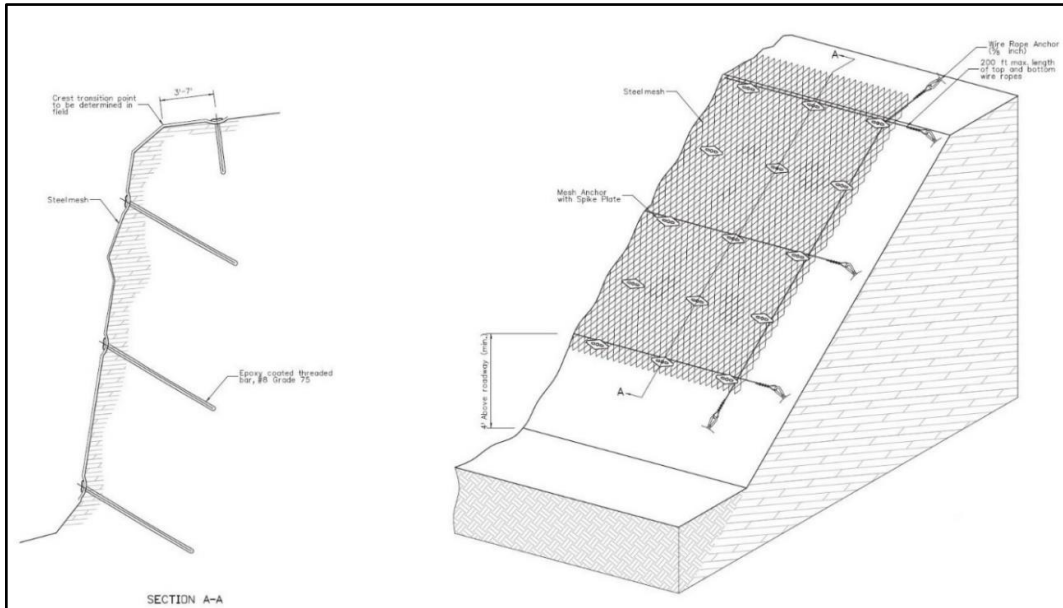
Disadvantages

- Rockfall mitigation devices may require maintenance.
- Narrower overall roadway template when considering future improvements.
- Alternative mitigation measures (i.e., narrow gauge mesh, and low energy rockfall barriers) may be less aesthetically pleasing.

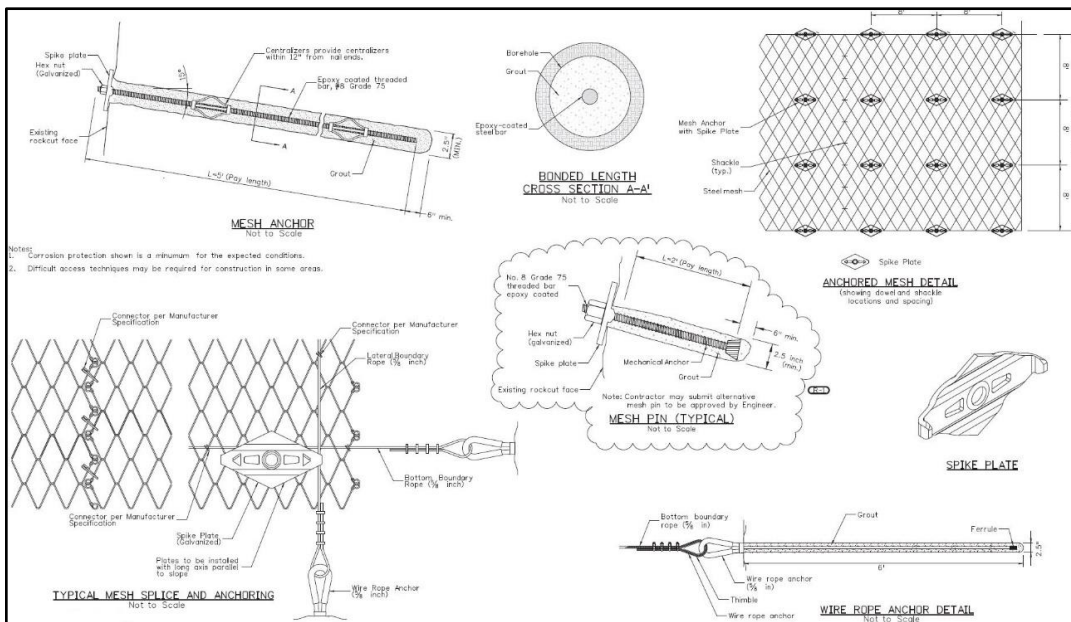
Proposed Concept – Sketch

Idea Number: **DP-16**

Steel Mesh Stabilized Rock Face



Rockfall Mitigation System Details



Proposed Concept – Calculations

Idea Number: **DP-16**

Treatment area from station 549+27.96 to 558+60.00 – 932 linear feet

Assume average slope height of 80 feet – **36,425 sf treatment area**

Assume 1 mesh anchor per 55 sf of mesh – 1356 anchors

Assume wall treatment along 1/3 of treatment area – 310 linear feet

Assume average 6 ft. wall height – **1860 sf wall area**

Cost Estimate

Idea Number: **DP-16**

Original Concept

FIR rock removal estimate - \$3,819,200

Proposed Concept

Mesh anchor cost - \$700 per each installed (\$540 each installed on EB PPSL)

Mesh cost - \$6.50 per sf installed (\$5.20 per sf installed on EB PPSL)

Retaining wall cost assumption - \$350 per sf

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.
- Contractor overhead / markups, not included.

Cost Estimate Worksheet

Idea Number: **DP-16**

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
Rock Excavation (FIR Estimate)	CY	150	25461	3819150
Total (ORG) =				\$3,819,150

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
Wire Mesh	SF	7.00	74,560	521,920
Mesh Anchor	EA	700.00	1,350	945,000
Rock Scaling	HR	125.00	120	15,000
Rockfall Fence	LF	400.00	500	200,000
Retaining Wall	SF	350.00	1,860	651,000
Total (PRO) =				\$2,333,920
Difference (PRO – ORG) =				1,486,000

Assumptions:

- Unit costs based on EB PPSL project, escalated to 2019.

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

VALUE ENGINEERING PROCESS

A systematic approach is used in the VE workshop. The key procedures followed were organized into three distinct parts:

- (1) Pre-Workshop Preparation,
- (2) VE Workshop, and
- (3) Post-Workshop.

Pre-Workshop Preparation

In preparation for the VE workshop, the team leader reviewed critical aspects of the project and areas for improvement. In the week prior to the start of the VE workshop, the VE team members reviewed the documents provided by the designer to become better prepared for the workshop. In addition, performance attributes and requirements were initially identified that are relevant to the project.

VE Job Plan

The SAVE International recognized six-phase VE Job Plan was utilized to guide the team members in the consideration of project functionality and performance, potential schedule issues, high cost areas, and risk factors in the design. These considerations were considered in developing alternative solutions for the optimization of project value. The prescribed VE Job Plan phases are:

- Information Phase
- Function Phase
- Creative Phase
- Evaluation Phase
- Development Phase
- Presentation Phase

Information Phase

During the traditional VE workshop, the design team presented a more detailed review of the design concept and the various component systems. This presentation included an overview of the project as well as its various requirements and user constraints, with the intent to further enhance the VE team's knowledge and understanding of the project. The project design team responded to questions posed by the VE team during the presentation.

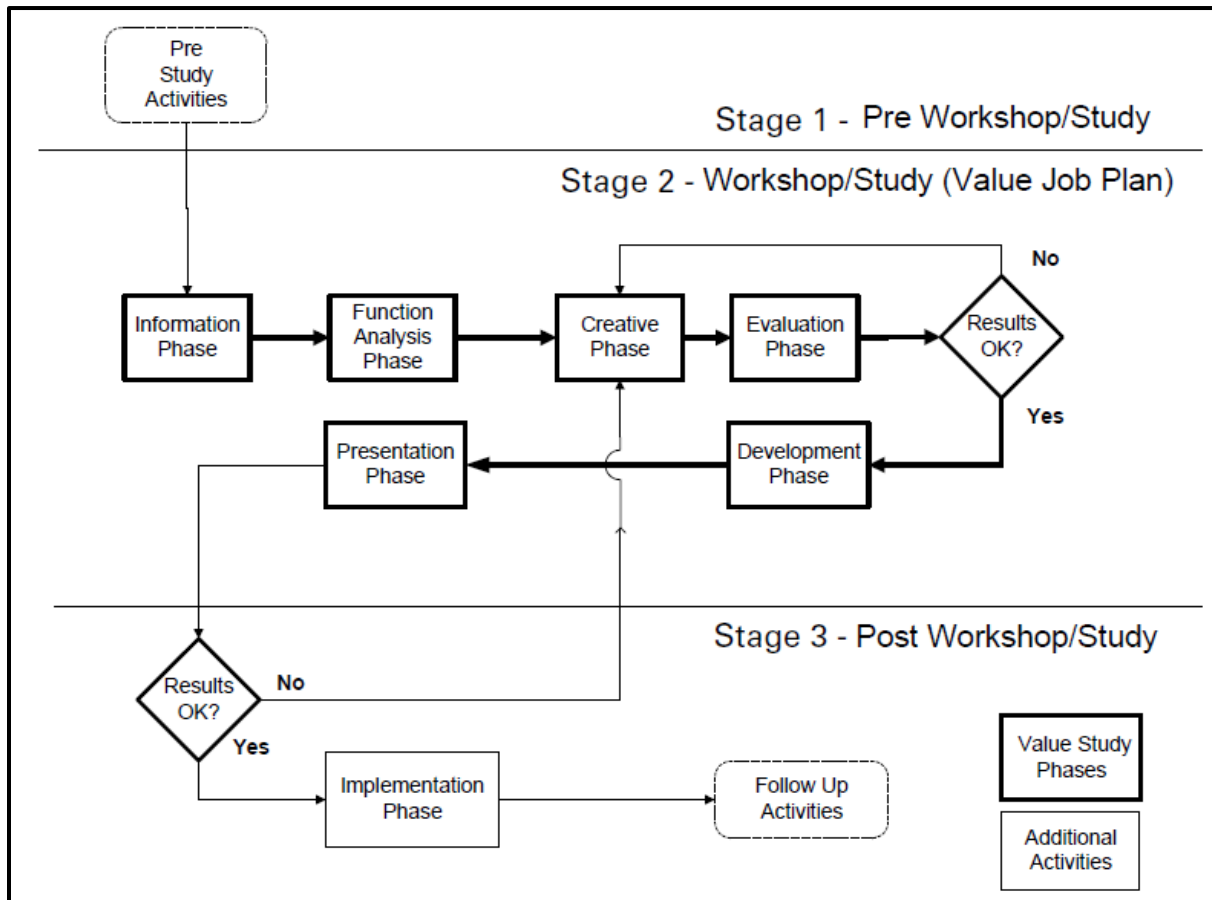
After the briefing, the VE Team further reviewed the project schematic design documents, reports, and cost estimates. The VE Team also reviewed the project in the context of access for existing property owners, and anticipated traffic related to future real estate development.

The VE Team reviewed a Pareto format cost model which was based on the schematic design cost estimate. The Pareto cost model was used to focus the VE Team on the higher cost elements of the project.

The VE Team discussed the Pareto cost models relative to project risk. The Team members were instructed to consider each defined major cost element based upon low, medium and high potential to deviate from the estimated costs.

The Pareto cost model can be found in Appendix C.

Figure 6: Value Methodology Job Plan Process Diagram



Function Phase

The purpose of Function Analysis is to understand the project from a functional perspective; what must the project do, rather than how the project is defined in the scoping documents. The fundamental question is: **What are the functions and how are they related?**

During this phase, the VE Team was challenged to define the project functions using a simple two-word, active verb / measurable noun sentence construct. The VE Team defined the project attributes by considering two questions:

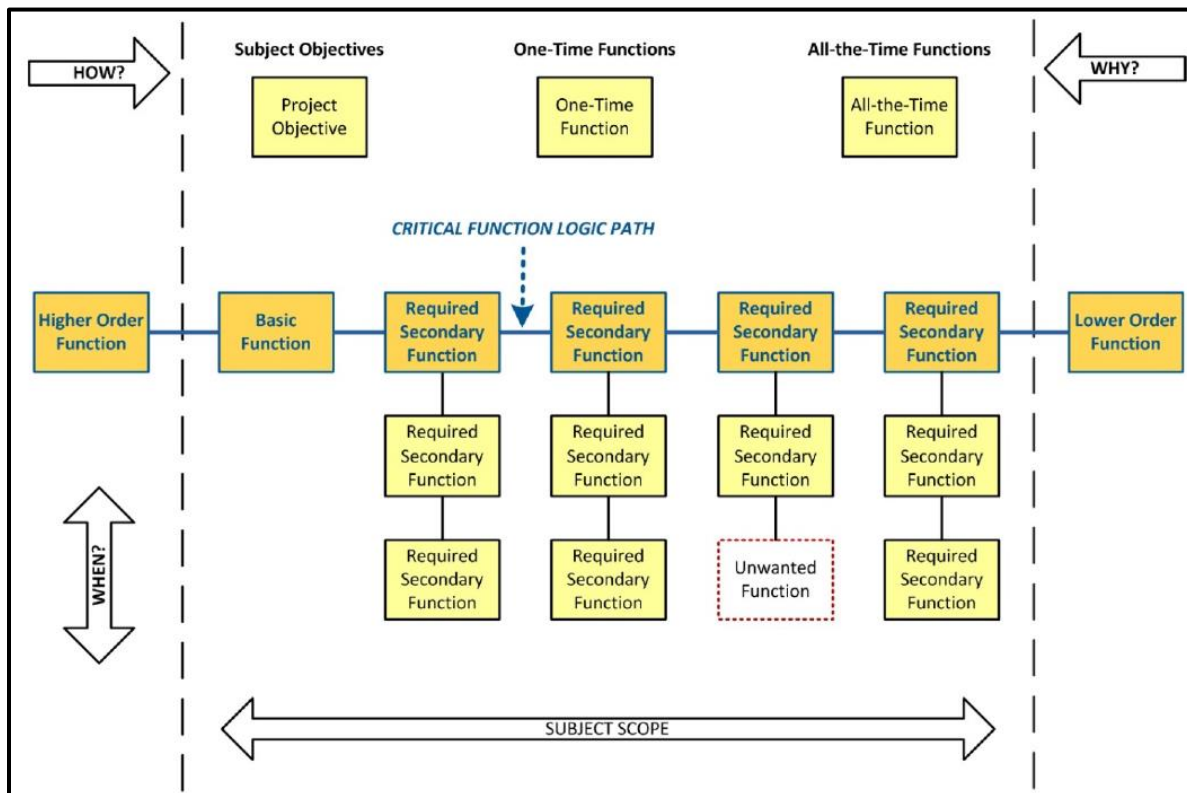
- “What must it do?” [Active Verb]
- “What must it do it to?” [Measurable Noun]

This function definition process is beneficial to the VE Team, as it requires the participants to think in terms of concise functions and their relative importance towards achieving the project’s need and purpose. This facilitates a deeper understanding of the project.

The functions are related by a “How-Why” logic, or questioning technique.

- “Why is this function (to the right) performed?” determines higher order function.
- “How is this function (to the left) performed?” determines secondary function.

Figure 7: Function Analysis System Technique (FAST)



The VE Team was then asked to review and analyze these functions to determine which needed improvement, elimination, or creation to meet the project’s goals.

The VE Team considered the defined functions using the same risk perspectives discussed in relation to the Pareto cost models. Different colored dots were used to annotate the draft FAST diagram to highlight which functions would be influenced by risk associated with the primary cost estimate elements.

Creative Phase

The Creative Phase involves identifying and listing alternative ideas. During this phase, the VE team participates in a brainstorming session to identify as many means as possible to provide the necessary project functions. Judgment of the ideas is not permitted to preserve a positive environment and thereby foster the generation a large quantity and broad range of ideas.

The idea list includes all alternative ideas suggested during the workshop. These ideas should be reviewed further by the project team, since they may contain ideas that are worthy of further evaluation and may be used as the design develops.

Evaluation Phase

In this workshop phase, the VE Team selected the ideas with the most merit for further development. The basic criteria used for selection were:

1. Inherent value, benefit and technical appropriateness of the idea.
2. Expected magnitude of the potential capital construction and life cycle cost savings.
3. Potential for owner-user agency acceptance of the idea.

There are a wide variety of evaluation tools that are available to VE Teams to review and cull the amassed alternative ideas. These tools are typically selected based on the scope of the VE workshop, as well as the quantity of the alternative ideas generated.

Team members were encouraged to identify any duplicate alternative ideas, or ideas that could easily be consolidated based on common theme. The Team consolidated several ideas into common concepts.

For this VE workshop, the alternative ideas were evaluated using a modified version of the Nominal Group Technique (NGT). The VE team members were given adhesive backed colored dots for use to “vote” on the creative ideas. The number of votes given to each VE Team Member was directly proportional to the total number of ideas, inclusive of all function groups.

Each of the team members were issued several “votes” to cast, nominally 15% of the total number of creative ideas generated. Ideas evaluation using the NGT method directly applies the Pareto principle; Team Members select the top ideas based on their individual perspective.

Different colored dots may be used in some circumstances (i.e., separate colors for design, construction, operational and maintenance perspectives). However, all team members used the same color dots as votes for this VE workshop.

VE team members were instructed to initial or otherwise uniquely mark each of their dots prior to voting. Each person then could cast “votes” for the alternative ideas that they felt held the best potential to enhance the project. However, each person could vote only once for an idea and cannot move or disturb the votes of another team member.

Votes were tallied with the team selecting the alternative ideas that scored highest. These ideas became the focal point for further development by the team during the limited time allowed within working sessions.

Team members were encouraged to identify any duplicate alternative ideas, or ideas that could easily be consolidated based on common theme. The Team consolidated several ideas into common concepts.

The Team again reviewed the list to determine if any key points were missed, or not clearly understood during the initial evaluation sweep. Some additional ideas were promoted upward as the result of the post vote review and discussions.

Development Phase

Idea development typically includes summarization of the advantages / disadvantages for the alternative, a narrative description of the alternative idea intent and expected performance, preparation of comparative capital construction and life cycle cost comparisons, concept proof calculations, and sketches.

Life cycle cost analysis is typically performed on a discounted cash flow net present worth basis and will typically include maintenance, repairs, energy consumption, replacement, salvage and other recurring costs. The analysis period will vary based on the construction feature, ranging from 30 to 50 years, and up to 100 years in some instances.

Presentation Phase

On the final day of the VE workshop, the VE Team presented their findings and collective recommendations to the senior representatives from Region 1 of CDOT. The objective of this presentation was to provide a succinct overview of each recommendation, as well as an overall summary of results. Each item was discussed with an explanation of the VE Team's logic for the recommendation.

Implementation Phase

Implementation of the CDOT accepted or approved recommendations will occur during the design development efforts, and part of the Post-Workshop activities. Each recommendation will be further investigated for respective benefit to the project, as applicable.

APPENDICES

- A. Attendance Rosters
- B. Workshop Agenda
- C. Cost Estimate and Model
- D. Function Analysis
- E. Creative / Alternative Ideas
- F. Design Suggestions
- G. Analyzed Not Proposed
- H. Available Project Information
- I. Project Orientation Briefing
- J. Summary of Results Briefing

Appendix A: Attendance Rosters

Table 3: Information Phase –Design Briefing

Firm / Location			
Team Member	Team Role / Discipline	Email	Phone
Colorado Department of Transportation – Region 1 / Golden, CO			
Bob Smith, PE	Resident Engineer	robertm.smith@state.co.us	720-497-6961
Jana Spiker	Resident Engineer, Design	jana.spiker@state.co.us	720-497-6959
Jeffery Hampton, PE	Professional Engineer	jeffery.hampton@state.co.us	303-501-3695
Tyler Brady, PE	Project Management	tyler.brady@state.co.us	
Vanessa Henderson	I-70 Environmental Manager	vanessa.henderson@state.co.us	720-497-6924
Maddy Ciecioraka	Engineering Intern	madison.ciecorka@rams.colostate.edu	720-291-3692
Neil Ogden	Resident Engineer	neil.ogden@state.co.us	720-497-6928
Colorado Department of Transportation – Region 1 / Denver, CO			
Jessica Myklebust, LEED AP	Environmental Manager, Region 1	jessica.myklebust@state.co.us	303-757-9929
Robert Group, PE	Geohazards	robert.group@state.co.us	303-398-6589
David Nasiatka, PE	Geotechnical	david.nasiatka@state.co.us	303-895-6485
Ulteig Engineers – Denver, CO			
Clark Roberts, PE	Senior Engineer	clark.roberts@ulteig.com	303-349-5042
HDR – Denver, CO			
Chau T Nguyen, PE	Project Engineer	chau.nguyen@hdrinc.com	303-478-2150
Tory Jackson, PE	Roadway Engineer	tory.jackson@hdrinc.com	720-318-0008
Terrance Powers, PE	Structures	terrance.powers@hdrinc.com	720-280-0361
FHWA – Lakewood, CO			
Matt Greer, PE	Bridge Engineer	matt.greer@dot.gov	720-963-3008
Atkins North America / Denver, CO			
Dennis Largent	Sr. Resident Engineer	dennis.largent@atkinsglobal.com	720-626-5256
Atkins North America / Grand Junction, CO			
Al Adelgren, PE, CVS-Life	VE Facilitator	alan.adelgren@atkinsglobal.com	970-260-0124

Table 4: Presentation Phase – VE Team Briefing

Firm / Location			
Team Member	Team Role / Discipline	Email	Phone
Colorado Department of Transportation – Region 1 / Golden, CO			
Bob Smith, PE	Resident Engineer	robertm.smith@state.co.us	720-497-6961
Jana Spiker	Resident Engineer, Design	jana.spiker@state.co.us	720-497-6959
Jeffery Hampton, PE	Professional Engineer	jeffery.hampton@state.co.us	303-501-3695
Tyler Brady, PE	Project Management	tyler.brady@state.co.us	
Vanessa Henderson	I-70 Environmental Manager	vanessa.henderson@state.co.us	720-497-6924
Maddy Cieciorcka	Engineering Intern	madison.ciecorka@rams.colostate.edu	720-291-3692
Neil Ogden	Resident Engineer	neil.ogden@state.co.us	720-497-6928
Colorado Department of Transportation – Region 1 / Denver, CO			
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Tory Jackson, PE	Roadway Engineer	tory.jackson@hdrinc.com	720-318-0008
Terrance Powers, PE	Structures	terrance.powers@hdrinc.com	720-280-0361
Stephen Long	Project Manager	Stephen.long@hdrinc.com	303-764-1520
FHWA – Lakewood, CO			
Matt Greer, PE	Bridge Engineer	matt.greer@dot.gov	720-963-3008
Kelly Galardi	Area Engineer	Kelly.galardi@dot.gov	720-963-3002
Atkins North America / Denver, CO			
Derek Lindvall	Division Manager	Derek.lindvall@atkinsglobal.com	303-221-7275
Atkins North America / Grand Junction, CO			
Al Adelgren, PE, CVS-Life	VE Facilitator	alan.adelgren@atkinsglobal.com	970-260-0124

Appendix B: Workshop Agenda

The VE Team used the following agenda to plan and perform the Workshop efforts. The agenda was adjusted during the Workshop based on actual progress.

Figure 8: VE Workshop Agenda

Project: I-70 WB Peak Period Shoulder Lane Veterans Tunnels to US 40 Empire Junction (12 miles) PN: NHPP 0703-445 (21893)	
<u>Day 1: Tuesday, 26 June</u>¹	
8:00 am – 8:15 am	VE Team Assembles
8:15 am – 8:30 am	Introductions / Ground Rules / Safety Minute
8:30 am – 10:30 am	Information Phase – CDOT <ul style="list-style-type: none">• Project Delivery Team Presentation
10:30 am – 11:30 Noon	Information Phase – VE Team (<i>laptop computer required</i>) ² <ul style="list-style-type: none">• Documents Review / Project Data Familiarization
11:30 am – 12:30 pm	Lunch Break
12:30 pm – 1:30 pm	Information Phase – Continued <ul style="list-style-type: none">• VE Team - Project Data Familiarization• Cost Models / Risk Identification
1:30 pm – 3:00 pm	Function Analysis
3:00 pm – 4:45 pm	Creative Ideas Phase
4:45 pm – 5:00 pm	Review the Day's Work / Prepare for next day
<u>Day 2: Wednesday, 27 June</u>	
8:00 am – 10:00 am	Evaluation/Judgment Phase
10:00 am – 10:30 am	Development Phase <ul style="list-style-type: none">• Team Discussion – Forms• Recommendations Selection / Assignment
11:00 am – 12:00 Noon	Development Phase - Prepare Recommendations <ul style="list-style-type: none">• Team Discussion – Forms• Recommendations Selection / Assignment
12:00 Noon – 1:00 pm	Lunch Break
1:00 pm – 4:45 pm	Development Phase (continued)
4:45 pm – 5:00 pm	Review the Day's Work / Prepare for next day
<u>Day 3: Thursday, 28 June</u>	
8:00 am – 12:00 noon	Development Phase (continued)
12:00 Noon – 1:00 pm	Lunch Break
1:00 pm – 4:45 pm	Development Phase – QC Review
4:45 pm – 5:00 pm	Review the Day's Work / Prepare for next day
<u>Day 4: Friday, 29 June</u>	
8:00 am – 10:00 am	Preparation for Presentation
10:00 am – 12:00 pm	VE Team Presentation to Region / Stakeholders

Appendix C: Cost Estimate and Model

Construction Cost Estimates

The VE Team was provided the FIR 30% design *Opinion of Probable Cost* (OPC) estimate.

Figure 9: Construction Cost Estimate


R1 COLORADO DEPARTMENT OF TRANSPORTATION 21893		MODIFIED CREATED		6/1/2018	
Opinion of Probable Costs WB I-70 PPSL		CREATED BY: TLJ			
		CHECKED BY: CTN			
ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	CURRENT COST
201-00000	CLEARING AND GRUBBING	LS	1	\$ 10,000.00	\$ 10,000.00
202-00203	REMOVAL OF CURB AND GUTTER	LF	120	\$ 12.00	\$ 1,434.18
202-00210	REMOVAL OF CONCRETE PAVEMENT	SY	2,940	\$ 15.00	\$ 44,107.45
202-00220	REMOVAL OF ASPHALT MAT	SY	24,760	\$ 8.00	\$ 198,081.11
202-00240	REMOVAL OF ASPHALT MAT (PLANING)	SY	204,351	\$ 2.00	\$ 408,701.22
202-01000	REMOVAL OF FENCE	LF	2,435	\$ 2.00	\$ 4,870.59
202-01130	REMOVAL OF GUARDRAIL TYPE 3	LF	56,042	\$ 3.50	\$ 196,147.49
202-01170	REMOVAL OF GUARDRAIL TYPE 7	LF	1,839	\$ 25.00	\$ 45,980.83
202-01200	REMOVAL OF TENSIONED CABLE BARRIER	LF	654	\$ 3.75	\$ 2,454.13
202-01300	REMOVAL OF END ANCHORAGE	EACH	24	\$ 250.00	\$ 6,000.00
203-00010	UNCLASSIFIED EXCAVATION (COMPLETE IN PLACE)	CY	20,000	\$ 25.00	\$ 500,000.00
203-00400	ROCK EXCAVATION	CY	38,000	\$ 100.00	\$ 3,800,000.00
203-00599	ROCK SCALER	HOURL	160	\$ 120.00	\$ 19,200.00
203-01597	POTHOLING	HOURL	30	\$ 300.00	\$ 9,000.00
304-06000	AGGREGATE BASE COURSE (CLASS 6)	TON	12,677	\$ 35.00	\$ 443,687.11
403-34821	HOT MIX ASPHALT (GRADING SX) (100) (PG 58-28)	TON	9,124	\$ 80.00	\$ 729,943.01
403-34851	HOT MIX ASPHALT (GRADING SX) (100) (PG 64-28)	TON	42,927	\$ 85.00	\$ 3,648,828.43
403-40000	HMA SAFETY EDGE	LF	36,742	\$ 1.25	\$ 45,927.60
411-10255	EMULSIFIED ASPHALT (SLOW-SETTING)	GAL	8,295	\$ 3.50	\$ 29,031.82
412-00800	CONCRETE PAVEMENT (8 INCH)	SY	1,040	\$ 150.00	\$ 155,945.61
412-02000	CONCRETE SAFETY EDGE	LF	342	\$ 1.25	\$ 427.53
420-00113	GEOTEXTILE (DRAINAGE) (CLASS 2)	SY	62	\$ 5.50	\$ 341.00
503-00036	DRILLED CAISSON (36 INCH)	LF	140	\$ 400.00	\$ 56,000.00
503-00042	DRILLED CAISSON (42 INCH)	LF	299	\$ 500.00	\$ 149,500.00
504-03411	RETAINING WALL	SF	67,132	\$ 100.00	\$ 6,713,200.00
506-00209	RIPRAP (9 INCH)	CY	27	\$ 135.00	\$ 3,699.00
601-03000	CONCRETE CLASS D	CY	6,407	\$ 600.00	\$ 3,844,200.00
602-00000	REINFORCING STEEL	LB	1,009,900	\$ 0.80	\$ 807,920.00
603-01185	18 INCH REINFORCED CONCRETE PIPE (COMPLETE IN PLACE)	LF	5,005	\$ 125.00	\$ 625,625.00
603-01245	24 INCH REINFORCED CONCRETE PIPE (COMPLETE IN PLACE)	LF	204	\$ 165.00	\$ 33,660.00
603-01305	30 INCH REINFORCED CONCRETE PIPE (COMPLETE IN PLACE)	LF	19	\$ 225.00	\$ 4,275.00
603-02185	23X14 INCH REINFORCED CONCRETE PIPE (COMPLETE IN PLACE)	LF	97	\$ 150.00	\$ 14,550.00
603-05018	18 INCH REINFORCED CONCRETE END SECTION	EACH	4	\$ 1,200.00	\$ 4,800.00
603-05024	24 INCH REINFORCED CONCRETE END SECTION	EACH	4	\$ 1,400.00	\$ 5,600.00
603-05030	30 INCH REINFORCED CONCRETE END SECTION	EACH	1	\$ 2,000.00	\$ 2,000.00
604-00305	INLET TYPE C (5 FOOT)	EACH	3	\$ 4,500.00	\$ 13,500.00
604-00505	INLET TYPE D (5 FOOT)	EACH	3	\$ 6,000.00	\$ 18,000.00
604-16505	INLET TYPE 16 (DOUBLE) (5 FOOT)	EACH	1	\$ 7,350.00	\$ 7,350.00
604-16605	INLET TYPE 16 (TRIPLE) (5 FOOT)	EACH	7	\$ 12,750.00	\$ 89,250.00
604-20010	SETTLING BASIN	EACH	8	\$ 24,000.00	\$ 192,000.00
604-25005	VANE GRATE INLET (5 FOOT)	EACH	65	\$ 5,000.00	\$ 325,000.00
604-30005	MANHOLE SLAB BASE (5 FOOT)	EACH	13	\$ 4,000.00	\$ 52,000.00
604-30010	MANHOLE SLAB BASE (10 FOOT)	EACH	6	\$ 6,000.00	\$ 36,000.00
606-00301	GUARDRAIL TYPE 3 (6-3 POST SPACING)	LF	30,845	\$ 27.00	\$ 832,815.00
606-00350	GUARDRAIL TYPE 3 (DOUBLE) (6-3 POST SPACING)	LF	4,692	\$ 40.00	\$ 187,680.00
606-00705	GUARDRAIL TYPE 7 (SPECIAL)	LF	13,254	\$ 120.00	\$ 1,590,480.00
606-00730	GUARDRAIL TYPE 7 (STYLE CD)	LF	721	\$ 80.00	\$ 57,680.00
606-00740	GUARDRAIL TYPE 7 (STYLE CE)	LF	530	\$ 120.00	\$ 63,600.00
606-00745	GUARDRAIL TYPE 7 (STYLE CE)(CONCRETE GLARE SCREEN)	LF	941	\$ 130.00	\$ 122,330.00
606-01340	END ANCHORAGE TYPE 3D	EACH	23	\$ 1,500.00	\$ 34,500.00
606-02005	END ANCHORAGE (FLARED)	EACH	25	\$ 2,600.00	\$ 65,000.00
606-11030	BRIDGE RAIL TYPE 10M	LF	4,109	\$ 250.00	\$ 1,027,250.00
607-55040	MESH ANCHOR	EACH	100	\$ 500.00	\$ 50,000.00
607-55050	MESH ANCHOR (SPECIAL)	EACH	60	\$ 1,800.00	\$ 108,000.00
607-55100	WIRE MESH	SF	70,000	\$ 4.00	\$ 280,000.00
608-00000	CONCRETE SIDEWALK	SY	7	\$ 100.00	\$ 700.22
608-00010	CONCRETE CURB RAMP	SY	86	\$ 175.00	\$ 14,976.69
609-21011	CURB AND GUTTER TYPE 2 (SECTION I-M)	LF	537	\$ 25.00	\$ 13,419.50
609-21020	CURB AND GUTTER TYPE 2 (SECTION II-B)	LF	11	\$ 35.00	\$ 367.50
610-00030	MEDIAN COVER MATERIAL (CONCRETE)	SF	545	\$ 20.00	\$ 10,896.33

Figure 10: Construction Cost Estimate (continued)

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	CURRENT COST
612-00001	DELINEATOR (TYPE I)	EACH	100	\$ 28.00	\$ 2,800.00
612-00002	DELINEATOR (TYPE II)	EACH	100	\$ 28.00	\$ 2,800.00
612-00003	DELINEATOR (TYPE III)	EACH	20	\$ 28.00	\$ 560.00
612-00021	DELINEATOR (TYPE I) (BARRIER)	EACH	40	\$ 20.00	\$ 800.00
612-00022	DELINEATOR (TYPE II) (BARRIER)	EACH	40	\$ 20.00	\$ 800.00
614-00011	SIGN PANEL (CLASS I)	SF	250	\$ 20.00	\$ 5,000.00
614-00012	SIGN PANEL (CLASS II)	SF	1,200	\$ 25.00	\$ 30,000.00
614-00013	SIGN PANEL (CLASS III)	SF	3,500	\$ 30.00	\$ 105,000.00
614-00818	STEEL SIGN POST (W 8X18)	LF	200	\$ 75.00	\$ 15,000.00
614-01585	STEEL SIGN SUPPORT (2-1/2 INCH ROUND SCH 80) (POST)	LF	1,500	\$ 22.00	\$ 33,000.00
614-01588	STEEL SIGN SUPPORT (2-1/2 INCH ROUND SCH 80)(SLIPBASE)	EACH	120	\$ 400.00	\$ 48,000.00
614-03003	CONCRETE FOOTING (TYPE 3)	EACH	20	\$ 1,800.00	\$ 36,000.00
614-31800	MONOTUBE OVERHEAD SIGN CANTILEVER (18 INCH DIAMETER)	EACH	7	\$ 35,000.00	\$ 245,000.00
614-32400	MONOTUBE OVERHEAD SIGN CANTILEVER (24 INCH DIAMETER)	EACH	13	\$ 40,000.00	\$ 520,000.00
614-87100	AUTOMATIC TRAFFIC RECORDING STATION	EACH	1	\$ 10,000.00	\$ 10,000.00
614-87320	CLOSED CIRCUIT TELEVISION	EACH	2	\$ 5,200.00	\$ 10,400.00
614-87350	TEST FIBER OPTIC CABLE	LS	1	\$ 75,000.00	\$ 75,000.00
614-87650	FIBER OPTIC CABLE (SINGLE MODE)(216 STRANDS)	EACH	68,000	\$ 9.00	\$ 612,000.00
614-87692	ETHERNET SWITCH TYPE II (3930)	EACH	12	\$ 4,000.00	\$ 48,000.00
614-87698	ETHERNET AGGREGATION SWITCH TYPE II (5150)	EACH	2	\$ 40,000.00	\$ 80,000.00
625-00000	CONSTRUCTION SURVEYING	LS	1	\$ 100,000.00	\$ 100,000.00
626-00000	MOBILIZATION	LS	1	\$ 3,000,000.00	\$ 3,000,000.00
626-01103	PUBLIC INFORMATION SERVICES (TIER III)	LS	1	\$ 100,000.00	\$ 100,000.00
627-00008	MODIFIED EPOXY PAVEMENT MARKING	GAL	1,100	\$ 75.00	\$ 82,500.00
627-01010	PREFORMED PLASTIC PAVEMENT MARKING (TYPE I)(INLAID)	SF	5,800	\$ 14.00	\$ 81,200.00
627-30405	PREFORMED THERMOPLASTIC PAVEMENT MARKING (WORD-SYMBOL)	SF	200	\$ 20.00	\$ 4,000.00
627-30410	PREFORMED THERMOPLASTIC PAVEMENT MARKING (XWALK-STOP LINE)	SF	500	\$ 14.00	\$ 7,000.00
641-10070	SHOTCRETE SCULPTING	SY	350	\$ 250.00	\$ 87,500.00
700-70010	F/A MINOR CONTRACT REVISIONS	F A	1	\$ -	\$ -
700-70011	F/A PARTNERING	F A	1	\$ -	\$ -
700-70016	F/A FUEL COST ADJUSTMENT	F A	1	\$ -	\$ -
700-70019	F/A ASPHALT CEMENT COST ADJUSTMENT	F A	1	\$ -	\$ -
700-70023	F/A ON-THE-JOB TRAINEE	F A	1	\$ -	\$ -
700-70082	F/A FURNISH & INSTALL ELECTRICAL SERVICE	F A	1	\$ -	\$ -
700-70230	F/A COMMUNICATION LINES	F A	1	\$ 50,000.00	\$ 50,000.00
	SUBTOTAL ITEMS				\$ 33,150,293.35
	Force Account Items	10.0%	of Items		\$ 3,315,029.33
	Traffic Control	10.0%	of Items		\$ 3,315,029.33
	Erosion Control and SWMP	3.0%	of Items		\$ 994,508.80
	Lighting	1.0%	of Items		\$ 331,502.93
	Landscaping and Aesthetics	1.0%	of Items		\$ 331,502.93
	SUBTOTAL CONSTRUCTION ITEMS				\$ 41,437,866.69
	Contingencies	20%	of Subtotal		\$ 8,287,573.34
	Project Subtotal				\$ 49,725,440.02
	Cost Escalation for 2019 Construction (1 yr at 4% Inflation)				\$ 1,989,017.60
	Construction Engineering and Indirects	20.2%	of Items		\$ 10,446,320.44
	PROJECT TOTAL				\$ 62,160,778.06

Assumptions:

The costs above reflect today's (2018) current costs. Since project will not be constructed until 2019, an inflationary rate of 4% per year for additional costs should be accounted for when the project is constructed.

A depth of 6 inches was used for the calculation of Aggregate Base Course (Class 3 and Class 6) at 133 LBS/CF

A depth of 7 inches was used for the calculation of Hot Mix Asphalt at 110 LBS/SY-INCH

Pareto Cost Models

The VE Team developed a Pareto Cost Model based upon the FIR 30% design OPC estimate, included with the 30% design package. Individual line items within the OPC were sorted into several categories to prepare the Pareto cost model.

Figure 11: Pareto Cost Model (Tabular)

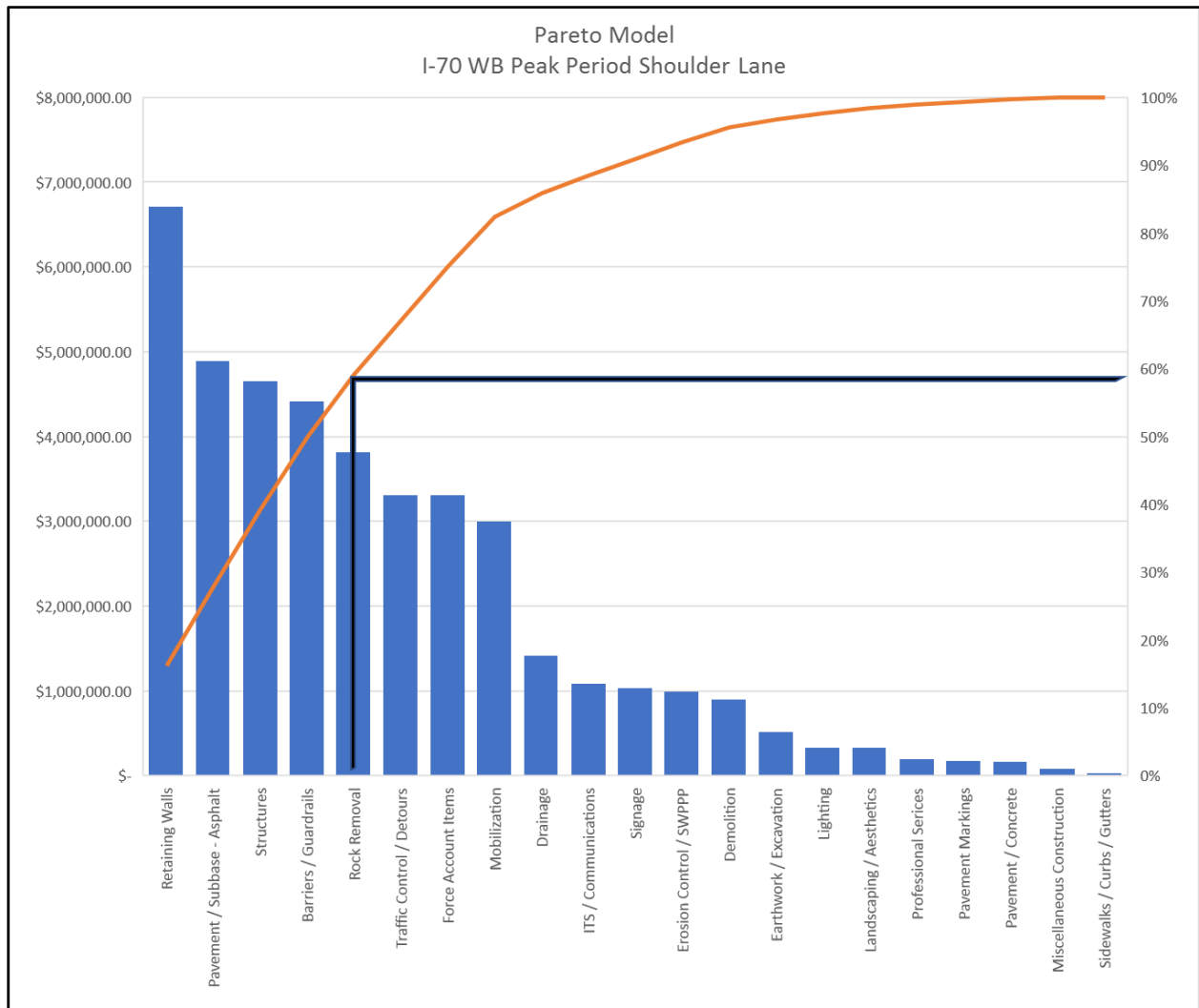
I-70 WB Peak Period Shoulder Lane						
From Veterans Tunnals to Empire Junction						
PN: NHPP 0703-445 (21893)						
	Description		Cost	Share	Const	Est'd
	Earthwork / Excavation		\$ 519,000.00	0.8%	1.3%	1.6%
	Demolition		\$ 907,766.50	1.5%	2.2%	2.7%
	Rock Removal		\$ 3,819,200.00	6.1%	9.2%	11.5%
	Pavement / Subbase - Asphalt		\$ 4,897,370.00	7.9%	11.8%	14.8%
	Pavement / Concrete		\$ 167,327.50	0.3%	0.4%	0.5%
	Retaining Walls		\$ 6,716,845.00	10.8%	16.2%	20.3%
	Structures		\$ 4,652,120.00	7.5%	11.2%	14.0%
	Drainage		\$ 1,423,951.00	2.3%	3.4%	4.3%
	Signage		\$ 1,037,000.00	1.7%	2.5%	3.1%
	Pavement Markings		\$ 182,460.00	0.3%	0.4%	0.6%
	Barriers / Guardrails		\$ 4,419,335.00	7.1%	10.7%	13.3%
	Sidewalks / Curbs / Gutters		\$ 29,560.00	0.0%	0.1%	0.1%
	ITS / Communications		\$ 1,090,900.00	1.8%	2.6%	3.3%
	Miscellaneous Construction		\$ 87,500.00	0.1%	0.2%	0.3%
	Professional Serices		\$ 200,000.00	0.3%	0.5%	0.6%
	Mobilization		\$ 3,000,000.00	4.8%	7.2%	9.0%
	Estimates Sub-Total =		\$ 33,150,335.00	53.3%	80.0%	100.0%
Allowances	Traffic Control / Detours	10%	\$ 3,315,033.50	5.3%	8.0%	
	Force Account Items	10%	\$ 3,315,033.50	5.3%	8.0%	
	Erosion Control / SWPPP	3%	\$ 994,510.05	1.6%	2.4%	
	Lighting	1%	\$ 331,503.35	0.5%	0.8%	
	Landscaping / Aesthetics	1%	\$ 331,503.35	0.5%	0.8%	
	Allowances Sub-Total =		\$ 8,287,583.75	13.3%	20.0%	
	Construction Sub-Total =		\$ 41,437,918.75			
Uplifts	Contingencies	20%	\$ 8,287,583.75	13.3%		
	Escalation	4%	\$ 1,989,020.10	3.2%		
	Construction Engineering	20%	\$ 10,446,333.57	16.8%		
	Project Total =		\$ 62,160,856.17	33.3%		
	Top Six Items		\$ 39,419,587.32	63.4%		
	Top Six (minus uplifts)		\$ 27,819,903.50		67.1%	
	Top Six (minus allowances)		\$ 27,504,870.00			83.0%
	Length =		10.85	miles		
	Cost per mile =		\$ 5,730,134.41			

The individual line items stated within the FIR 30% Cost Estimate were consolidated into nominally representative categories. However, some line items may not be correctly categorized due to the limited description for that particular line item.

The “**Share**” column depicts the percentage influence on the total project cost for each category, shown to the left. The “**Const**” column depicts the percentage influence of each category, minus the “**Uplifts**” grouping. The “Uplifts” are those categories or FIR 30% Cost Estimate line items that contractor direct costs. The “**Est’d**” column depicts the percentage influence of each category, minus the “**Uplifts**” and “**Allowances**” groupings. The “Allowances” are costs based upon a percentage allowance added to the itemized construction cost estimate.

The following figure depicts the graphical Pareto Cost Model, based on all estimated project costs inclusive of allowances and uplifts.

Figure 12: Pareto Cost Model (Graphical)



Appendix D: Function Analysis / FAST Diagram

The Function Analysis System Technique (FAST) diagram was prepared by the VE Team, which identified the project functions, then linked these using a HOW-WHY logic. The highlighted functions represent project elements which the VE Team considered to have a higher risk of cost growth and / or schedule slippage.

Figure 13: FAST Diagram (part 1)

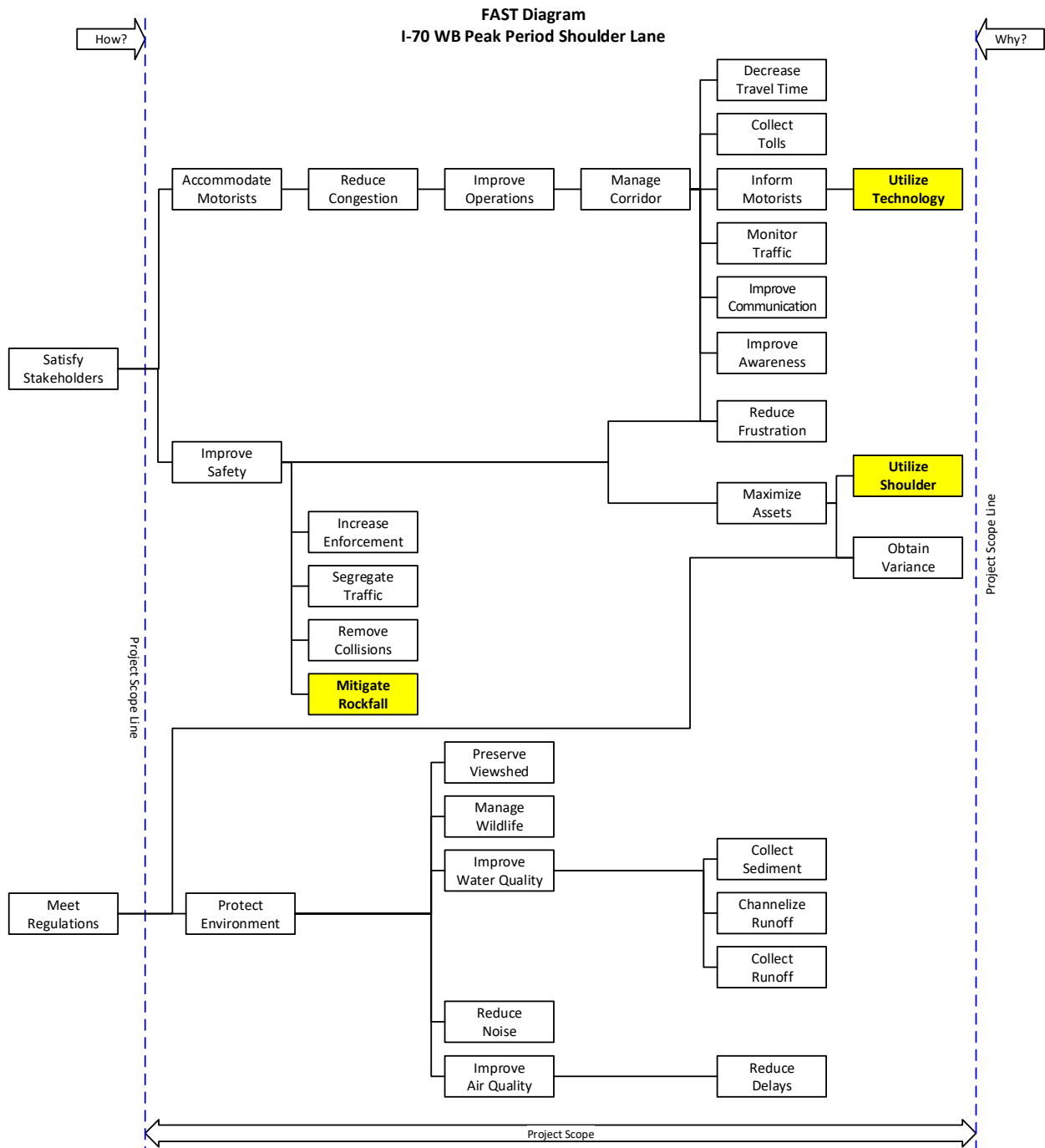
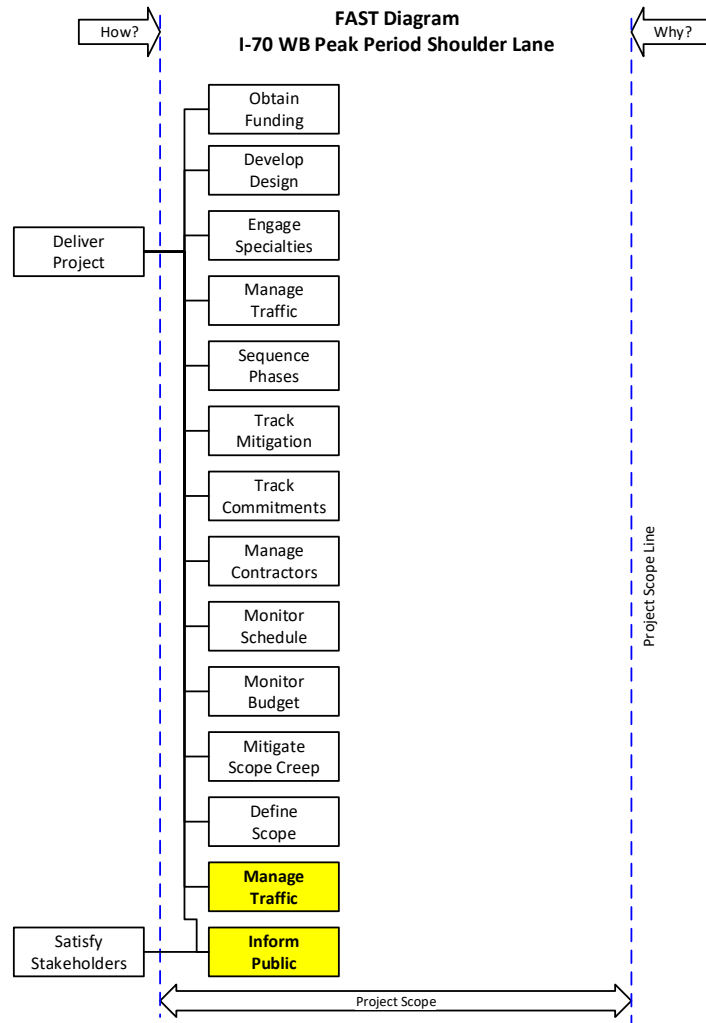


Figure 14: FAST Diagram (part 2)



Appendix E: Creative / Alternative Idea Listing

The following tables contain the creative ideas, with corresponding Nominal Group Technique (NGT) method evaluation scores and notes.

Table 5: Manage Corridor

Manage Corridor (MC)		
Idea No.	Description	Action ³ 4
MC-1	Utilize wireless technology in lieu of buried fiber optics.	3
MC-2	Utilize solar / low voltage for lighting and signage.	3
MC-3	Smart work zones with queue / delay information.	5
MC-4	Ramp metering – during construction and permanent.	1
MC-5	Utilize social media for communications.	C w/ IS-07
MC-6	Dynamic tolling based on occupancy.	
MC-7	Dynamic pricing toll lane volume management.	
MC-8	Utilize Traffic Incident Management Plan for accidents and breakdown removal (courtesy patrols).	DS
MC-9	Text alert to CDOT smart phone application for road closures and openings.	
MC-10	Daily releases of blasts / closures to media.	
MC-11	Text alerts that manage lanes are open.	
MC-12	Increase enforcement by funding county / state law enforcement agencies to patrol during and after construction.	NTM
MC-13	Variable speed limits.	
MC-14	Utilize ITS to monitor speeds within corridor.	
MC-15	Provide CDOT ITS real-time data to law enforcement.	
MC-16	Integrated with CDOT ITS vehicle to everything (VTX) technology.	
MC-17	Establish lane closure strategy prior to construction.	4
MC-18	Improve video camera coverage throughout corridor.	
MC-19	Utilize pan / tilt / zoom (PTZ) cameras.	
MC-20	Install more friction sensors to monitor weather / roadway conditions.	

³ Action codes (NGT method):
 Numeric value indicates number of votes idea received using Nominal Group Technique evaluation method.
 ABD = Already Being Done (i.e. As Designed,) C = Combine with idea number (XX-##)
 D = Duplicate of idea number (XX-##) DS = Design Suggestion

⁴ Idea actions that were changed as result of VE Team discussions are shown as double strikethrough with new assigned action (i.e., ~~3~~ ANP).

Manage Corridor (MC)		
Idea No.	Description	Action³₄
MC-21	Minimize lane shifts and pavement markings removal during construction.	ABD
MC-22	Install LED pucks at hazardous locations (i.e., tight corners.)	DS
MC-23	Install automated liquid deicers in hazardous locations.	
MC-24	Install automated liquid deicers with friction sensors in hazardous locations.	
MC-25	Utilize infrared cameras to detect icing.	
MC-26	Add VMS signs prior to exits – information before I-70 exit points.	
MC-27	Increase fiber optic laterals frequency – plan now to accommodate future to median.	
MC-28	Reroute fiber along median.	
MC-29	Utilize eastbound fiber optic cable.	
MC-30	Limiting truck traffic to off peak hours.	
MC-31	Restrict truck to right lane only.	NTM
MC-32	No weekend day hours for truck traffic.	
MC-33	Put trucks on US-6, meter onto I-70.	
MC-34	Engage stakeholders to use county facilities for construction detours.	1
MC-35	Reconstruct weigh-in-motion system as precast or offline to minimize disruption.	DS

Table 6: Increase Safety

Increase Safety (IS)		
Idea No.	Description	Action
IS-1	Decrease speed limits.	
IS-2	Control speed differential by enforcement and variable speed limits.	1
IS-3	Control access to managed lane.	
IS-4	Increase number of toll points.	1
IS-5	Add dummy cameras to deter toll violators / avoidance.	
IS-6	Phot enforcement of managed lanes (i.e., speed, weavings, etc.).	2
IS-7	Media educational campaign on lane usage.	3
IS-8	Restrict access during winter to all-wheel drive vehicles in left lane.	
IS-9	Temporary physical barrier during rockfall mitigation efforts.	
IS-10	Update corridor incident management plan (EB and WB).	ABD
IS-11	Wildlife detection system at known crossing points.	
IS-12	Rockfall detection sensors and warning system.	1
IS-13	Ramp metering.	DS
IS-14	Indents curves for use of friction course asphalt.	DS
IS-15	Live radar feedback warning signs.	
IS-16	Add wildlife crossings (i.e., over or under-pass).	
IS-17	Flatten slopes to 3:1.	
IS-18	Increase visibility along corridor – high mast lighting.	1
IS-19	Add new chain-up station before Floyd Hill.	
IS-20	Increase length of existing chain-up stations.	1
IS-21	Add runaway truck ramp on Floyd hill.	
IS-22	Install LED lighting on barriers.	
IS-23	Develop plan for rockfall events during construction. (as update to corridor incident management plan.)	3
IS-24	Indents curves for use of friction course asphalt.	
IS-25	Live radar feedback warning signs.	
IS-26	Take advantage of public traffic apps (i.e., Waze) to notify travelers of incidents, etc.	
IS-27	Require smart work zone devices that report out to CTMC (and public apps).	C w/ MC-03
IS-28	Individual traffic control contract for corridor.	3

Table 7: Protect Environment

Protect Environment (PE)		
Idea No.	Description	Action
PE-1	Move Lawson sediment basin closer to discharge point.	
PE-2	Add curb and inlet on CR 308, pipe runoff to Lawson basin.	
PE-3	Monitor water quality above and below project during construction.	
PE-4	Add water filtration system to clarify runoff.	
PE-5	Create wetlands for I-70 wetlands bank at Empire Junction.	3
PE-6	Enforce Jake brake muffler laws within corridor (add signage).	
PE-7	Add channelizing deer fence to wildlife crossings.	
PE-8	Plant wildflowers around interchanges.	DS
PE-9	Sponsor planning new trees within corridor.	
PE-10	Compress construction schedule and duration; acceleration clauses.	1
PE-11	Local incentives for ride sharing, public transit.	1
PE-12	Use existing water quality bank.	
PE-13	Plant pollinator species.	
PE-14	Establish corridor landscape maintenance contract(s).	5
PE-15	Partner with Jobs Corp or trade school for landscape maintenance.	
PE-16	Convene water quality charrette with water quality and maintenance specialists to determine appropriate solutions.	1
PE-17	Bring in Colorado State University extension services to evaluate vegetation options within corridor.	
PE-18	Identify dedicated environmental compliance officer for project corridor (construction contractor and CDOT).	1
PE-19	Open ditches / channels in lieu of culvert and manholes.	3

Table 8: Deliver Project

Deliver Project (DP)		
Idea No.	Description	Action
DP-1	A+B contracting model (cost plus schedule).	2
DP-2	More stringent requirements for personnel qualifications from prime and key subcontractors.	1
DP-3	Performance based ITS specifications.	1
DP-4	Engage ITS group to develop performance specifications.	1
DP-5	Convene ITS constructability review with prospective contractors.	1
DP-6	Constructability reviews for all major elements (i.e., phasing, ITS, schedule, etc.).	6
DP-7	Develop alternate corridor management plan.	1
DP-8	Establish corridor wide public information consultant.	3
DP-9	Establish corridor wide project controls and scheduling consultant (independent, third party).	1
DP-10	Separate, independent project controls and scheduling consultants.	1
DP-11	Completion incentives.	5
DP-12	Use innovative contracting to purchase long lead items.	1
DP-13	Use EB PPSL for on WB lane during temporary closures.	5
DP-14	Consolidate all corridor projects under one common contract.	1
DP-15	Multiple bid schedule.	
DP-16	Move roadway to south, avoid rock cuts.	4
DP-17	Engage Colorado Motor Carriers to facilitate messaging.	C w/ DP-08
DP-18	Truck only travel land during and after construction.	1
DP-19	Week long head-to-head traffic to accelerate short sections.	
DP-20	Utilize precast retaining walls.	1
DP-21	Cellular concrete backfill for retaining walls.	DS
DP-22	Use warm mix, night paving.	
DP-23	Full depth pavement reclamation with recycle.	1
DP-24	Develop milling and paving phasing plan.	DS
DP-25	Precast concrete pavement panels.	1
DP-26	Eliminate all walls, construct cut and fill slopes.	

Appendix F: Design Suggestions / Note to Management

The following alternative ideas were initially deemed worthy of further investigation by the VE Team. However, the VE Team determined that these items may be outside the scope for project construction package as currently defined, or required additional information that was not available to the VE Team.

Design Suggestions are those items that the VE Team recommends for the designer to further investigate to determine feasibility. These items may result with cost impact (additive or deductive / savings), and may improve overall construction schedule.

Table 9: Design Suggestions

Idea No.	Description
MC-08	Utilize Traffic Incident Management Plan for accidents and breakdown removal (i.e., courtesy patrols).
MC-35	Reconstruct weigh-in-motion system as precast or offline to minimize disruption.
IS-15	Live radar feedback warning signs.
PE-08	Plant wildflowers around interchanges.
DP-21	Cellular concrete backfill for retaining walls.
DP-24	Develop milling and paving phasing plan.

Notes to Management are those items that would be considered as CDOT agency level internal actions. These items can only be initiated by CDOT itself, and would require interaction with one or more stakeholders.

Table 10: Note to Management

Idea No.	Description
MC-12	Increase enforcement by funding county / state law enforcement agencies to patrol during and after construction.
MC-31	Restrict truck to right lane only.

<h2 style="margin: 0;">Design Suggestion</h2>									
Idea Number:								MC-08	
Idea Title: Utilize Traffic Incident Management Plan Specification (TIMP). (MC-08)									
Original Concept Description: Traffic incident management is not included within construction scope.									
Proposed Concept Description: Utilize CDOT’s Traffic Incident Management Plan (TIMP) project special provision to include a contract requirement for heavy tow capability.									
Advantages <ul style="list-style-type: none"> Provides for quick removal of accidents or breakdowns from the roadway. Decreases traffic congestion due to accidents or breakdowns. Decreases secondary accidents due to traffic congestion from first accident or breakdown. 					Disadvantages <ul style="list-style-type: none"> Increases cost to the project. 				
Discussion CDOT has successfully utilized this specification in several contracts on major projects. It is a win-win for the project. It will decrease congestion due to accidents or breakdowns by providing a public service and it is applying a good public relation tool. In this portion of the I-70 Mountain Corridor, there are not many viable alternate routes or detours. Therefore, it becomes necessary to be able to clear accidents/breakdowns quickly to maintain traffic flow. With narrow lanes and limited shoulder widths, there aren’t many places for accidents and breakdowns to find refuge out of the lanes of traffic. These vehicles need to be removed quickly to restore traffic flow in the lane(s) they block. Without this specification included in the contract, any accident or breakdown would necessitate a call and wait for a towing service. This creates an additional hazard and increases the potential for additional accidents downstream due to increased congestion.									
FHWA CATEGORIES									
Safety	<input checked="" type="checkbox"/>	Operations	<input checked="" type="checkbox"/>	Environment	<input type="checkbox"/>	Construction	<input checked="" type="checkbox"/>	ROW	<input type="checkbox"/>

Design Suggestion

Idea Number: **MC-08**



Note to Management

Idea Number: **MC-12**

Idea Title:

Increase Enforcement by Funding County and/or State Agencies to Patrol During and After Construction. (MC-12)

The VE Team suggests that CDOT consider providing funding to local agencies or Colorado State Patrol (CSP) to increase patrols in the I-70 corridor during and after construction of the WB PPSL lane.

Increased enforcement of traffic laws such as “Keep Right Except to Pass” and speed limits, including minimum speeds in the left lane, would further help reduce congestion in the corridor. Reducing congestion would also decrease the number of multiple vehicle accidents related to congestion.

The VE Team believes that the increased presence of law enforcement patrols would be advantageous to the safe completion of the construction project and overall safety/operations of the corridor.

FHWA CATEGORIES

Safety	<input checked="" type="checkbox"/>	Operations	<input checked="" type="checkbox"/>	Environment	<input type="checkbox"/>	Construction	<input checked="" type="checkbox"/>	ROW	<input type="checkbox"/>
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Design Suggestion

Idea Number: **MC-13**

Idea Title:

Variable Speed Limits Reflective of Driving Conditions. (MC-13)

Original Concept Description:

Standard fixed speed limits.

Proposed Concept Description:

Variable speed limit based on traffic demand and weather conditions may enhance mobility and reduce accidents.

Advantages

- Improves mobility through the corridor.
- Reduces the number of accidents.
- Improves traffic flow during peak demand periods.

Disadvantages

- Electronic signs will require additional maintenance.
- Will require additional staff time to monitor corridor traffic.

Discussion

A static speed limit with a congested highway may impede flow as the aggressive drivers will tend to weave in order to attain or exceed the posted speed. The consequence of erratic behavior causes sudden stops and possible rear end or side-swipe collisions.

Installation of variable speed signs adjusted to ADT could having a calming effect on the traffic as the speeds will be slower as congestion increases. The aggressive driver will have to slow down. The consequences for the typical driver will result in fewer sudden stops, thus safety should be improved.

FHWA CATEGORIES

Safety	<input checked="" type="checkbox"/>	Operations	<input checked="" type="checkbox"/>	Environment	<input type="checkbox"/>	Construction	<input type="checkbox"/>	ROW	<input type="checkbox"/>
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Note to Management

Idea Number: **MC-31**

Idea Title:

Restrict Truck Traffic to Right Lane. (MC-31)

The I-70 WB PPSL Value Engineering group suggests that CDOT initiate legislation to restrict semi-truck traffic to traveling in the right lane on I-70 in the mountain corridor.

Trucks slowed by the uphill grades on I-70 cause a large differential in speed between car traffic and the trucks. This differential in speed is a major cause for accidents. Restricting truck traffic to the right lane on two lane sections and the farthest right lane on three lane sections, except to pass when trucks could use the middle lane, could decrease accidents and periods of congestion after accidents.

There is a public perception on the I-70 corridor that slow moving trucks in general and trucks driving in the left lane in particular are a major cause of congestion. Enforcement of current traffic laws requiring traffic to keep right except to pass and augmenting that law to keep trucks in the right lane on two lane sections and the farthest right lane on three lane sections, except to pass when the trucks could use the middle lane, would be a good thing in the public's eye and for driving safety.

FHWA CATEGORIES

Safety	<input checked="" type="checkbox"/>	Operations	<input checked="" type="checkbox"/>	Environment	<input type="checkbox"/>	Construction	<input checked="" type="checkbox"/>	ROW	<input type="checkbox"/>
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Design Suggestion

Idea Number: **MC-35**

Idea Title:

Reconstruct Weigh-In-Motion System as a Precast or Off Line to Minimize Disruption. (MC-35)

Original Concept Description:

The section of roadway that includes the weigh-in-motion concrete pavement would be removed\replaced in single lane closure operation for a duration dependent upon the construction duration, including the concrete curing time. This operation is estimated to take 72 hours. This could necessitate I-70 WB traffic to be restricted to a single lane for that period of time.

Proposed Concept Description:

Utilize precast or other construction methods to construct the section of road off line to reduce the time required for lane restrictions.

Advantages

- Lane closures only during authorized times (not 24 hrs.)
- Safety for the workers and traveling public.
- Fewer lane closures means less congestion which means fewer accidents.

Disadvantages

- Potentially increased cost
- Weigh-in-motion has to be a very smooth driving surface.

Discussion

Lane closure for the entire duration of the operation (est. to be 72 hrs.) versus Construction off line

Off line construction would still require lane closures to remove the existing section of road, prepare for the installation of the new road section and then installation of the new section. These operations would be required to be done using the contract lane closure strategy.

FHWA CATEGORIES

Safety	<input checked="" type="checkbox"/>	Operations	<input checked="" type="checkbox"/>	Environment	<input type="checkbox"/>	Construction	<input checked="" type="checkbox"/>	ROW	<input type="checkbox"/>
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Design Suggestion

Idea Number: **IS-15**

Idea Title:

Live Radar Feedback Warning Signs. (IS-15)

Original Concept Description:

Unknown if this is included in the current plans.

Proposed Concept Description:

Utilize live radar speed warning signs in the construction zone.

Advantages

- Will help to control speed
- Will increase awareness of potentially dangerous areas where speed is a safety concern

Disadvantages

- Will increase cost to project

Discussion

The use of live radar speed warning signs is suggested to help control the speed of vehicles in the work zone. Lower speeds in the workzone increases safety for the workers and traveling public.



FHWA CATEGORIES

Safety	<input checked="" type="checkbox"/>	Operations	<input checked="" type="checkbox"/>	Environment	<input type="checkbox"/>	Construction	<input checked="" type="checkbox"/>	ROW	<input type="checkbox"/>
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Design Suggestion

Idea Number: **PE-08**

Idea Title:

Wildflower Introduction Around Interchanges. (PE-08)

Original Concept Description:

The original design shows little to no plan on landscaping and aesthetics along the corridor.

Proposed Concept Description:

Two functions of the WB PPSL project were to decrease motorist frustration and to preserve the view shed. By planting wildflowers, the intent is to beautify the corridor's view shed as well as calm drivers stuck in construction/peak period/accident traffic.

Advantages

- Introducing natural vegetation after construction will be aesthetically pleasing
- Will require minimal initial and longer-term maintenance costs
- Minimal cost

Disadvantages

- Food source for wildlife, could attract wildlife towards I-70

Discussion

A recommendation of a corridor wide landscape maintenance contract was proposed with the intent to delegate an entity or individual to be well versed in the corridor's needs in terms of maintenance and different protocols for cleaning out sediment basins and other landscape needs. The introduction/maintenance of wildflowers could fall under that list of this individual's duties.

Addition of wildflowers would also benefit the overall driving experience due to the beautification of the corridor.

FHWA CATEGORIES

Safety	<input type="checkbox"/>	Operations	<input type="checkbox"/>	Environment	<input checked="" type="checkbox"/>	Construction	<input type="checkbox"/>	ROW	<input type="checkbox"/>
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Design Suggestion

Idea Number: **DP-21**

Idea Title:

Cellular Concrete Backfill for Retaining Walls. (DP-21)

Original Concept Description:

Construct retaining walls with traditional compacted structural backfill

Proposed Concept Description:

Consider constructing retaining walls with lightweight cellular concrete or other similar lightweight flowable fill.

Advantages

- Accelerates construction.
- Reduces structural requirements for resisting lateral loads.
- Reduces settlement and stability problems.

Disadvantages

- Increases material cost vs. conventional structural fill.
- Potential environmental concerns.

Discussion

Retaining walls may be constructed using lightweight cellular concrete in place of conventional structural backfill. Although more expensive, these fills may be placed more quickly and do not require compaction, resulting in decreased construction duration. Flowable fills may be placed by setting forms and pumping fill into place.

More information can be found at:

Ground Improvement Methods- Volume I. Federal Highway Administration, NHI-06-020; Elias, V., Welsh, J., Warren, J., Lukas, R., Collin, J. G., and Berg, R. R. (2006).

FHWA CATEGORIES

Safety	<input type="checkbox"/>	Operations	<input type="checkbox"/>	Environment	<input type="checkbox"/>	Construction	<input checked="" type="checkbox"/>	ROW	<input type="checkbox"/>
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Design Suggestion

Idea Number: **DP-24**

Idea Title:

Develop Milling and Paving Phasing Plan. (DP-24)

Original Concept Description:

Unknown if there will be a milling and paving plan included in the plans.

Proposed Concept Description:

Develop a milling and paving phasing plan.

Advantages

- Identification of potential problems
- Potential to develop thorough work and phasing plan.
- Opportunity to engage County and City public works stakeholders.

Disadvantages

- Increase design cost

Discussion

The VE Team suggests that CDOT develop a milling and paving phasing plan.

The process of developing a phasing plan would produce several advantages. The process would generate thoughts regarding:

- Joint locations for temporary and final asphalt in relationship to wheel line.
- Constructability of temporary pavement widths
- Locations for traffic crossing over rumble strips
- Stripe removal/restriping
- Identification of potential fatal flaws in the plans related to milling and paving

CDOT has a longer period of time to consider how to phase this work than the contractor will have prior to bid. This gives CDOT the opportunity to develop a thorough phasing plan. Combined with a constructability review this could result in cost and schedule savings.

The phasing plan should be included in the bid documents with a requirement for the contractor to submit for approval any alternative plan they propose.

FHWA CATEGORIES

Safety	<input checked="" type="checkbox"/>	Operations	<input checked="" type="checkbox"/>	Environment	<input type="checkbox"/>	Construction	<input checked="" type="checkbox"/>	ROW	<input type="checkbox"/>
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Appendix G: Analyzed Not Proposed

The following alternative idea was initially deemed worthy of further analysis and development by the VE Team. However, the VE Team determined through in-depth analysis that the intent of the alternative idea was not viable for inclusion within this project. Therefore, the developed alternative idea was not proposed.

Table 11: Concepts Analyzed, Not Proposed

Idea No.	Description
MC-01	Utilize Wireless Technology In lieu of Buried Fiber Optics.

Value Engineering Recommendation

Idea Number: **MC-01**

Idea Title:

Utilize Wireless Technology In lieu of Buried Fiber Optics. (MC-01)

Original Concept Description:

Current design concept is to trench conduit for fiber optic along the shoulder and laterals into median for comm to devices.

Proposed Concept Description:

Proposed design concept is to utilize wireless cell towers to carry the signal in lieu of buried fiber optic cable.

Summary:

- Comparison of the two concepts: Wireless would be above ground construction of cell towers V. fiber optic cable would be buried in a trench along the shoulder for the length of the project.
- This idea is not related to another idea

Disadvantages outweigh advantages; therefore, this alternative is not recommended.

FHWA CATEGORIES		ESTIMATED COST IMPACT			
Safety	<input type="checkbox"/>		Construction Cost	Present Worth O&M Cost	Present Worth Total Cost
Operations	<input type="checkbox"/>		Original =		
Environment	<input checked="" type="checkbox"/>		Proposed =	Analyzed Not Proposed	
Construction	<input checked="" type="checkbox"/>		Savings =		
ROW	<input checked="" type="checkbox"/>				

Advantages / Disadvantages

Idea Number: **MC-01**

Advantages

- Eliminate digging trench on the shoulder
- Eliminates the need to trench through rocky conditions (resulting in shallow Conduit depths)

Disadvantages

- Cell towers above ground would be unsightly
- Due to the probable need for multiple towers the cost could exceed the cost of buried fiber optic
- May pose network security risks
- Comm may be degraded by weather conditions
- Band Width capabilities may be an issue when transmitting data.

Discussions

Idea Number: **MC-01**

The original concept is for trenching, placing conduit in the trench, burying the conduit and pulling fiber optic into the buried conduit. The EB PPSL project experienced difficulty with trenching through the existing shoulder. The EB PPSL project also direct bored laterals from the shoulder to the median. This work as a risk item for the CMGC project.

The utilization of wireless technology could eliminate the need to do any additional trenching, direct boring, or pulling additional fiber optic cable. Construction of cell towers, either, multi leg or mono towers, could be done on the shoulders or other locations within the ROW.

If the existing conduit can be utilized to pull new fiber optic cable and no new trenching is required then this idea is not needed.

Cost Estimate

Idea Number: **MC-01**

Original Concept

614-87650	FIBER OPTIC CABLE (SINGLE MODE)(216 STRANDS)	lf	68,000	\$9.00	\$612,000.00
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Proposed Concept

Google search shows cost of constructing a cell tower range from \$100k to \$250k per tower.

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.
- Contractor overhead / markups, not included.

Cost Estimate Worksheet

Idea Number: **MC-01**

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
Fiber Optic Cable	LF	9.00	68,000	612,000
Total (ORG) =				612,000

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
Cell Tower	Each	100,000	6	600,000
Total (PRO) =				600,000
Difference (PRO – ORG) =				-12,000

Assumptions:

- Only six towers are needed
- The cost of infrastructure to support the tower is readily available, i.e power and phone

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Appendix H: Available Project Information

The following project documents were provided to the VE Team:

- WB I-70 Removal and Utility Plan (25 sheets) (June 1, 2018) (HDR)
- WB I-70 Plan and Profile (48 sheets) (June 1, 2018) (HDR)
- WB I-70 Drainage Plan (17 sheets) (June 1, 2018) (HDR)
- WB I-70 Wall Plan and Profile (21 sheets) (June 1, 2018) (HDR)
- WB I-70 Signing and Striping Plan (48 sheets) (June 1, 2018) (HDR)
- Phasing Plan Typical Section (1 sheet) (June 1, 2018) (HDR)
- Highway Construction Bid Plans of Proposed Federal Aid Project No. NHPP 0703-445, Interstate No. 70, Clear Creek County, Construction Project Code No. 21893 – 30% Field Inspection Review (FIR) Plans (7 sheets) (June 01, 2018)

The following additional documents were available via CDOT I-70 WB PPSL project website (<https://www.codot.gov/projects/i-70-westbound-peak-period-shoulder-lane>):

- I-70 Mountain Corridor Record of Decision and Final Programmatic Environmental Impact Statement (June 16, 2011) (CDOT)
- I-70 Frontage Road Improvements, Categorical Exclusion (March 2012) (Michael Baker Jr., Inc)
- Westbound I-70 Concept Development Process Final Report (August 21, 2017) (CDOT)
- WB I-70 Floyd Hill / CDOT Project #21912; Project Leadership Team - Kick Off Meeting (September 13, 2017), Meeting Summary

Appendix I: Project Orientation Briefing

The following slides were used during the development team's project overview presentation to the VE Team.



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**I-70 Westbound Peak Period Shoulder Lane Project
Delivery Team Overview
Value Engineering Workshop: June 26th, 2018**



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Presentation Overview

- Project Overview
- Decisions/Untouchables
- Project Details by Discipline
- Desired Outcomes/Initial VE Goals
- Questions/Discussion





Project Overview: Purpose

The purpose of the Westbound PPSL project is to improve westbound highway operations, safety, and travel time reliability, specifically during peak period times, from the Veterans Memorial Tunnels (aka, Twin Tunnels) to US 40 at Empire Junction.



Project Overview: Related Projects

- INFRA - WB PPSL
- Mainline PPSL
 - CR 314
 - Fall River Road Bridge
 - Clear Creek Greenway



- Floyd Hill
- PPSL initial and future (with FH) condition





Project Overview: Major Scope Elements

- Minor Roadway Widening
- Exit 240 (I-70 and SH 103) Safety and Drainage Improvements
- Retaining Walls
- Rock Fall Mitigation
- Guardrail Improvements
- ITS Backbone Relocation
- Tolling Infrastructure/ATM Devices
- Drainage and Water Quality Improvements
- Wildlife Safety enhancements (signage and vegetation removal)
- Resurfacing, Signing and Striping
- SH 103 pedestrian improvements over I-70



Project Overview: Current Status

Current Estimate:

- \$50 Million Construction Bid Items and Force Accounts
- \$62 Million Construction Program Cost

NEPA:

- Documented Categorical Exclusion
- Anticipated completion October/November 2018

Schedule:

- FIR (30% Design) - June 21st 2018
- FOR (90% Design) - Fall 2018
- Project Delivery
- AD - Late 2018/Early 2019
- Construction Commencement - Spring/Summer 2019



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Project Decisions (Untouchables!!)

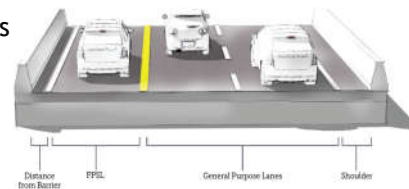
- Section Width
- Lane/Shoulder Location/Striping Configuration
- No Bridge Widening
- Roadway Alignment
- SCAP Implementation Approach
- Schedule
- ROW Impacts
- Others?



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Project Details: Roadway

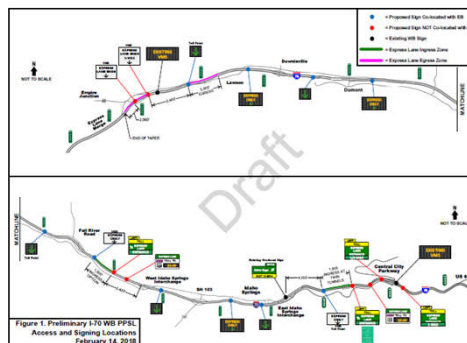
- Widening and Overlay Corridor Wide
- Variable Section Width (Shoulder) with Consistent Lane Widths
- Shoulder/Lane Widths (Lt to Rt): 2ft/11ft/12ft/12ft/4ft
- Ramp widening
- Exit 240 (I-70 and SH 103) Safety and Drainage Improvements
- Guardrail Replacement
- Safety Improvements
- Emergency/Enforcement Pull Outs





Project Details: Utilities/ITS/ATM/Traffic

- Sanitary Sewer Relocation
- ITS Fiber Backbone Relocation
- ATM Devices
- Tolling Infrastructure
- Signing/Striping



Project Details: Drainage/Water Quality

- Minor Drainage Improvements Corridor Wide
 - Evaluation/Cleaning
 - Extensions
- Storm Drains at select locations
 - I-70 at SH 103 (Exit 240)
 - Other Locations?
- Water Quality Features
 - I-70 SCAP Element Approach
 - Lawson Basin
 - Fall River Road Basin





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Questions/Discussion?

Workshop Project Team Resources:

- HDR: Tori Jackson and Terrance Powers
- CDOT: Tyler Brady and Vanessa Henderson

Appendix J: Summary of Results Briefing

The following slides were used during the VE Team's summary of the workshop results presentation to the Agency.



I-70 WB Peak Period Shoulder Lane Clear Creek County

PN: NHPP 0703-445 (21893)

Summary of Results

Value Engineering Workshop

26-29 June, 2018

I-70 WB PPSL // Project Location



I-70 WB PPSL // Project Overview

Need:

- Increased congestion during seasonal traffic peak loads:
 - Winter ski / sports.
 - Summer camping.
 - Autumn tree color.
- Peak loads increasing with population growth.

Purpose

- Interim operational improvement.
- Reduce congestion during peak travel times.
- Improve safety during peak travel times.
- Provide off-line law enforcement and emergency pull outs.

I-70 WB PPSL // Overview

- Project limits:
 - Veterans Tunnels to US-40 Empire Junction.
- Project scope:
 - Widen westbound shoulder for use during peak period.
 - Minor EB PPSL improvements based on stakeholder feedback.
 - Safety improvements including guardrail replacements.
 - Drainage improvements.
 - Ramps widening.
 - Emergency / enforcement pull outs.
- Approx. \$62M, all inclusive (at 30% design).
 - Design / bid / build delivery.
- Anticipated schedule:
 - Advertise for bid – Late 2018 / Early 2019.
 - Construction start – Spring / Summer 2019.
 - Duration – 18 months (two work seasons).

Project Success Factors – VE Team Defined

- Positive public opinion:
 - Safe work zone delineated
 - Access to businesses
- Minimal delays to travelling public on I-70.
- Smooth traffic flow.
- Minimal change orders.
- Positive partnering; minimal disputes.
- Contribute to success of project.
- Validate design.
- Identify best value solutions.
- Improved safety:
 - During construction
 - After completion
- Robust and thorough communication plan.

Constraints & Challenges

- No reasonable alternative routes.
- Region lane closure strategy.
- Night work with noise restrictions.
- Confined work zone.
- High volume corridor:
 - Commercial freight.
 - Recreational.
 - Commuters.
- Public perception regarding toll / managed lanes.
- Weather.
- High visibility corridor.

Constraints & Challenges

- Large number of engaged stakeholders.
- Historic and environmentally sensitive corridor.
- ITS / intensive technical infrastructure.
- Geotechnical
 - Rockfall
 - Unknown subsurface
- Public expectation that project will be done in timely manner.
- Mitigation acceptability – what we say we'll do is acceptable to public and stakeholders.
- Project overload – too many recent and planned projects within corridor.

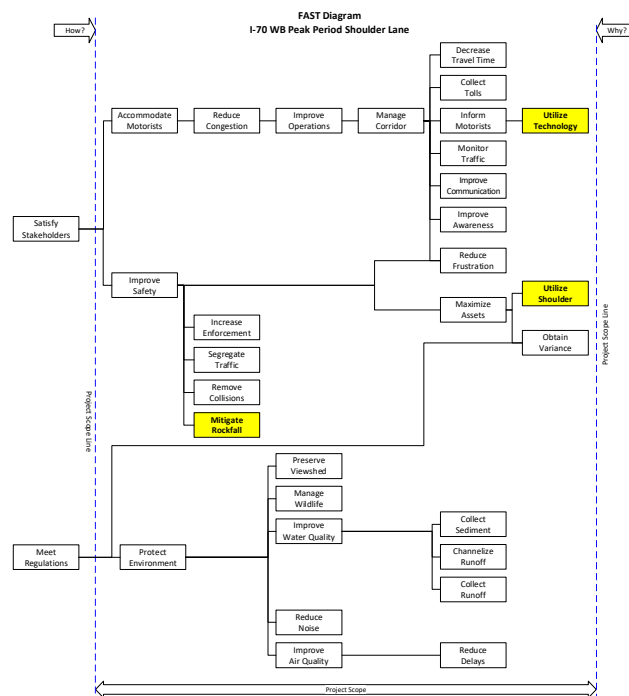
VE Team Observations

- Cost estimate:
 - May contain redundant items within allowances.
 - Traffic control allowance may be low based on scope.
 - Professional services (i.e., surveying) may be low based on scope.
 - Unit costs for EB PPSL were higher; WB project may be low.
 - EB work to be segregated from WB work.
- Plans:
 - Drainage needs to be further evaluated and developed.
 - Phasing plan needs to be developed.
 - Work restrictions (i.e., time, weekends, events, etc.) to be developed.

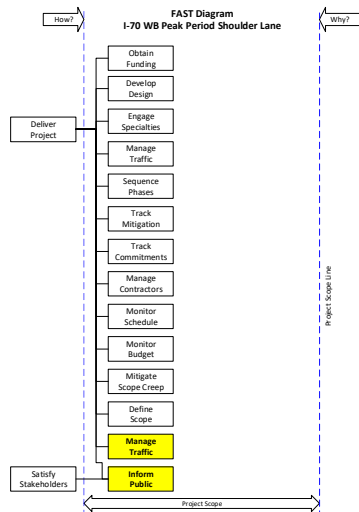
Project Untouchables

- Lane / Shoulder Location; striping configuration
 - PPSL to inside
- Roadway alignment
- No ROW impacts, new takes
 - Temporary construction easements only
- NEPA process – CatEx
- No bridge widening
- SCAP implementation approach
- Schedule

FAST Diagram



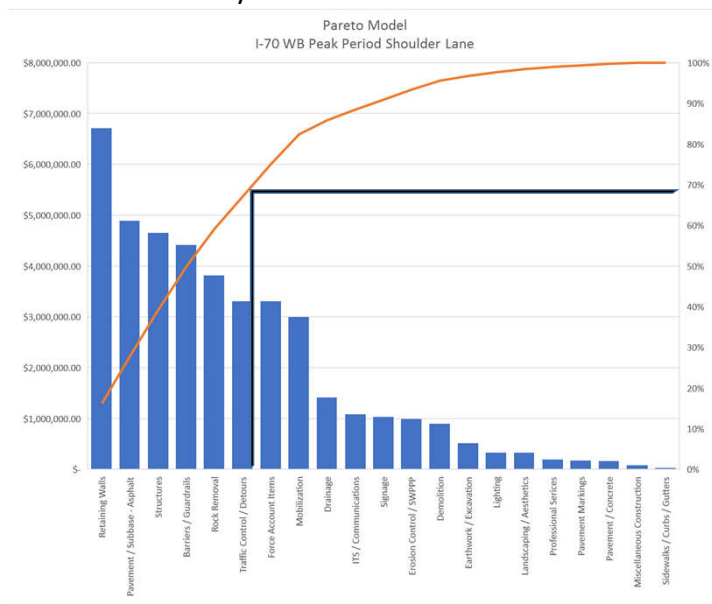
FAST Diagram



Cost Estimates / Pareto Model

I-70 WB Peak Period Shoulder Lane				
From Veterans Tunnals to Empire Junction				
PN: NHPP 0703-445 (21893)				
Description	Cost	Share	Const	
Earthwork / Excavation	\$ 519,000.00	0.8%	1.3%	1.6%
Demolition	\$ 907,766.50	1.5%	2.2%	2.7%
Rock Removal	\$ 3,819,200.00	6.1%	9.2%	11.5%
Pavement / Subbase - Asphalt	\$ 4,897,370.00	7.9%	11.8%	14.8%
Pavement / Concrete	\$ 167,327.50	0.3%	0.4%	0.5%
Retaining Walls	\$ 6,716,845.00	10.8%	16.2%	20.3%
Structures	\$ 4,652,120.00	7.5%	11.2%	14.0%
Drainage	\$ 1,423,951.00	2.3%	3.4%	4.3%
Signage	\$ 1,037,000.00	1.7%	2.5%	3.1%
Pavement Markings	\$ 182,460.00	0.3%	0.4%	0.6%
Barriers / Guardrails	\$ 4,419,335.00	7.1%	10.7%	13.3%
Sidewalks / Curbs / Gutters	\$ 29,560.00	0.0%	0.1%	0.1%
ITS / Communications	\$ 1,090,900.00	1.8%	2.6%	3.3%
Miscellaneous Construction	\$ 87,500.00	0.1%	0.2%	0.3%
Professional Serices	\$ 200,000.00	0.3%	0.5%	0.6%
Mobilization	\$ 3,000,000.00	4.8%	7.2%	9.0%
Estimates Sub-Total =	\$ 33,150,335.00	53.3%	80.0%	100.0%
Traffic Control / Detours	10% \$ 3,315,033.50	5.3%	8.0%	
Force Account Items	10% \$ 3,315,033.50	5.3%	8.0%	
Erosion Control / SWPPP	3% \$ 994,510.05	1.6%	2.4%	
Lighting	1% \$ 331,503.35	0.5%	0.8%	
Landscaping / Aesthetics	1% \$ 331,503.35	0.5%	0.8%	
Allowances Sub-Total =	\$ 8,287,583.75	13.3%	20.0%	
Construction Sub-Total =	\$ 41,437,918.75			
Contingencies	20% \$ 8,287,583.75	13.3%		
Escalation	4% \$ 1,989,020.10	3.2%		
Construction Engineering	20% \$ 10,446,333.57	16.8%		
Project Total =	\$ 62,160,856.17	33.3%		
Top Six Items	\$ 39,419,587.32	63.4%		
	\$ 27,819,903.50	67.1%		
	\$ 27,504,870.00			83.0%

Cost Estimates / Pareto Model



Summary of VE Workshop

Creative Ideas

- 108 Alternative Ideas
- 16 Ideas developed into VE Recommendations
 - 1 Idea developed, not proposed (failed analysis)
- 6 Design Suggestions
- 2 Notes to Management

Team Defined Criteria

- Accelerates construction schedule
- Forward compatibility
- Meet record of decision
- Reduces construction costs
- Reduces maintenance costs
- Durability
- Preserve viewshed
- Constructability
- Improves safety
- Maintain level of mobility

Summary of Recommendations

	VE Recommendations	FHWA Category					Cost Impacts	
		Safety	Operations	Environment	Construction	ROW	Construction	Operations & Maintenance
Manage Corridor (MC)								
MC-01	Utilize wireless technology in lieu of buried fiber optics.			Y	Y	Y	<i>Analyzed Not Proposed</i>	
MC-02	Utilize solar / low voltage for lighting and signage.		Y	Y	Y		\$210,000	TBD
MC-03	Smart work zones with queue / delay information.	Y	Y		Y		(\$1,000,000)	\$0
MC-17	Establish lane closure strategy prior to construction.				Y		TBD	TBD
MC-22	Install LED pucks at hazardous locations (i.e., tight corners.)	Y	Y				(\$10,000)	TBD
Improve Safety (IS)								
IS-07	Media educational campaign on lane usage.	Y	Y				TBD	TBD
IS-14	Install friction course asphalt on curves.	Y	Y				(\$1,185,000)	TBD
IS-23	Develop plan for rockfall events during construction. (as update to corridor incident management plan.)	Y	Y		Y		TBD	TBD
IS-28	Individual traffic control contract for corridor.	Y	Y		Y		(\$1,685,000)	\$0
Protect Environment (PE)								
PE-05	Create wetlands for I-70 wetlands bank at Empire Junction.			Y			(\$575,000)	\$0
PE-14	Establish corridor landscape maintenance contract(s).		Y	Y	Y		(\$15,000)	TBD
PE-19	Open ditches / channels in lieu of culvert and manholes.		Y		Y		\$6,000	\$0
Deliver Project (DP)								
DP-06	Constructability reviews for all major elements (i.e., phasing, ITS, schedule, etc.).	Y	Y		Y		TBD	TBD
DP-08	Establish corridor wide public information consultant.		Y		*		(\$65,000)	\$0
DP-11	Completion incentives.	Y	Y		Y		TBD	TBD
DP-13	Use EB PPSL for one WB through lane during temporary closures.	Y	Y		Y		\$745,000	\$0
DP-16	Avoid Rock Cuts by Implementing Alternative Mitigation Measures.	Y	Y		Y		\$1,485,000	TBD
Totals =							(\$2,089,000)	\$0

MC-02: Utilize Solar / Low Voltage for Lighting and Signage.

Design Basis Concept

- Traditional lighting and signage approach.
 - Power supplied from existing source via conduits.
 - Trenching and / or small diameter bores to connect new lights and signs.

Proposed Concept

- Solar powered low voltage lighting and signage.

MC-02: Utilize Solar / Low Voltage for Lighting and Signage.



Eagle County Transit, Gypsum, CO

Proposed Concept



EPA Regional HQ, Raleigh, NC

MC-02: Utilize Solar / Low Voltage for Lighting and Signage.

Proposed Concept

Several solar electric power assembly mounting methods are available. The illustrations represent the most common arrangements, other configurations are available to meet on-site performance and aesthetic requirements.



MC-03: Smart Work Zones with Queue / Delay Information.

Design Basis Concept

- Traditional construction traffic control devices and message boards.

Proposed Concept

- Smart technology work zone devices.
 - Real time information for downstream queue lengths and vehicle speeds.
 - Data available to CDOT Field Project Engineer and traveling public.

MC-03: Smart Work Zones with Queue / Delay Information.

Design Basis Concept



MC-03: Smart Work Zones with Queue / Delay Information.

Proposed Concept



MC-17: Establish Lane Closure Strategy Prior to Construction.

Design Basis Concept

- Traffic control plan – general PSP IAW Region 1 lane closure strategy.
 - Single lane closures allowed on Saturdays until 10 AM.

Proposed Concept

- Project specific lane closure strategy with defined working hours.
 - TSM&O and HQ endorsed closure plan.
 - Consistent day-to-day lane closure hours.

MC-22: Install LED Pucks at Hazardous Locations (i.e., Tight Corners.)

Design Basis Concept

- Traditional pavement markings and delineation
 - Inlaid tape skips

Proposed Concept

- Solar powered LED lane marker pucks
 - Between lanes in curves at Fall River Road
 - Approximately 2900 LF
 - Improved delineation during adverse weather, or when striping is worn

MC-22: Install LED Pucks at Hazardous Locations (i.e., Tight Corners.)



Proposed Concept



EB I-70 at US-6, Jefferson County

IS-07: Media Educational Campaign on Lane Usage.

Design Basis Concept

- Media campaign after WB PPSL opens
- EB PPSL media campaign identified what it was, not how to use PPSL.

Proposed Concept

- Proactive, targeted campaign that commences before and continues after construction.
 - How to use PPSL
 - When to enter / exit
 - How to pay tolls

IS-07: Media Educational Campaign on Lane Usage.

Design Basis Concept

How does the I-70 Mountain Express Lane Work?



Before Express Lanes



Express Lane Closed



Express Lane Open

IS-14: Install Friction Course Asphalt on Curves.

Design Basis Concept

- High Friction Surface Treatment (HFST) not included.

Proposed Concept

- High Friction Surface Treatment (HFST) course:
 - Curves at Fall River Road
 - Curves east of SH-103 interchange
 - WB exit ramp at Fall River Road
 - Additional EB and WB locations to be determined by accident review
 - Mitigates lane and shoulder width reduction

IS-14: Install Friction Course Asphalt on Curves.



Proposed Concept



IS-23: Develop Plan for Rockfall Events During Construction.

Design Basis Concept

- No defined plan for unplanned rockfall event.

Proposed Concept

- Develop plan or add Project Special Provision for contractor to plan response to unplanned rockfall events during construction.
- Plan should include:
 - Communication protocols
 - Detours
 - Contractor response plan

IS-28: Individual Traffic Control Contract for Corridor.

Design Basis Concept

- Contract specifications requires contractor to provide traffic control items and services.

Proposed Concept

- Separate traffic control items and services contract for corridor, not project specific.
 - Support multiple corridor construction projects.
 - Support unplanned actions including law enforcement and rockfall events.
 - Facilitates implementation of smart work zones.

PE-05: Create Wetlands for I-70 Wetlands Bank at Empire Junction.

Design Basis Concept

- No new wetlands within project corridor.

Proposed Concept

- Constructed wetlands at US-40 Empire Junction:
 - Mitigate possible aquatic resource impacts.
 - Improve water quality.
 - Attract and support wildlife.
 - Locations within existing DOT ROW.

PE-05: Create Wetlands for I-70 Wetlands Bank at Empire Junction.

Proposed Concept



PE-14: Establish Corridor Landscape Maintenance Contract.

Design Basis Concept

- Construction contractor maintains project specific landscape items for two-years.

Proposed Concept

- Establish corridor wide landscape maintenance contract:
 - Releases roadway contractor from landscape maintenance.
 - Landscape maintenance continuity throughout corridor.

PE-19: Open Ditches / Channels in lieu of Culvert and Manholes.

Design Basis Concept

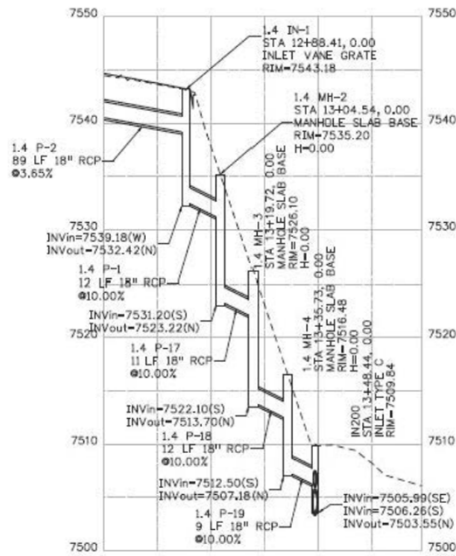
- Hydraulic design with series of 3-vaults and 5-vaults, slopes of approx. 1:1 with 40-44 foot drop.
 - Vaults with manholes.
 - Confined space entry to maintain.

Proposed Concept

- Grouted riprap rundown channel.

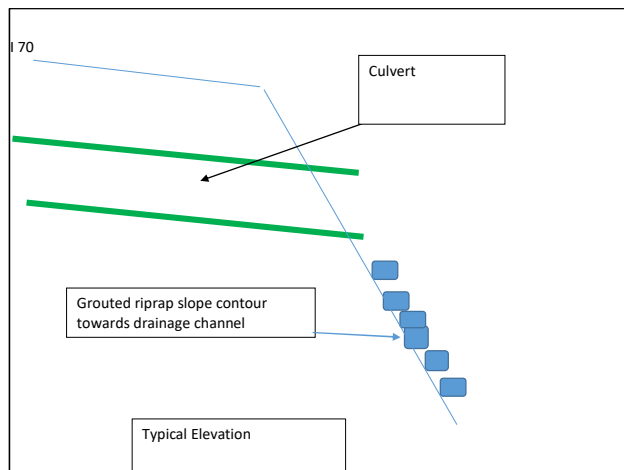
PE-19: Open Ditches / Channels in lieu of Culvert and Manholes.

Design Basis Concept



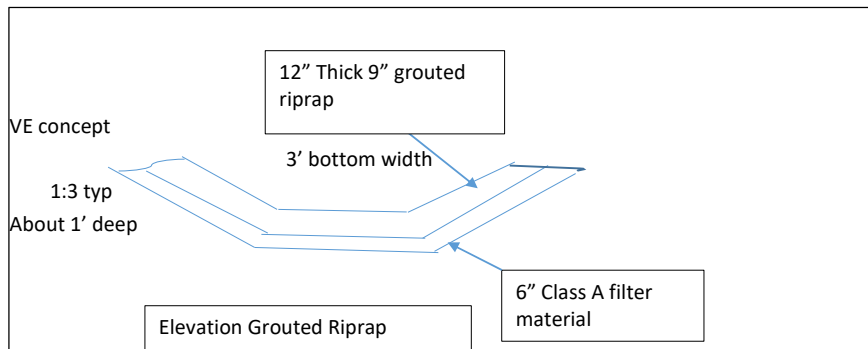
PE-19: Open Ditches / Channels in lieu of Culvert and Manholes.

Proposed Concept



PE-19: Open Ditches / Channels in lieu of Culvert and Manholes.

Proposed Concept



DP-06: Constructability Reviews for All Major Elements (i.e., Phasing, ITS, Schedule, etc.).

Design Basis Concept

- Standard design reviews IAW CDOT policies, including FIR and FOR reviews prior to advertisement.

Proposed Concept

- Constructability review for all major project elements including CDOT specialty units and industry experts.
 - Project phasing
 - ITS / Communications
 - Rock removal
 - Retaining walls / structures
 - Drainage / utilities
 - Barriers / guardrails
 - Project schedule

DP-08: Establish Corridor Wide Public Information Consultant.

Design Basis Concept

- Contract specifications include bid item:
 - “Public Information Services – Tier III, 1 L.S.”
 - Contractor may self perform or subcontract.

Proposed Concept

- Establish I-70 Corridor public information services contract:
 - Full corridor, from C-470 to Eisenhower-Johnson Tunnels
 - Single point of information for all I-70 corridor projects
 - Direct report to CDOT, controlled messaging

DP-11: Completion incentives.

Design Basis Concept

- Standard design/bid/build construction delivery with contract time per 859.

Proposed Concept

- Design/bid/build construction delivery with contract time per 859:
 - Attainable completion incentives defined by contract milestones or performance criteria.
 - Incentives can be defined as monetary and/or schedule float days.

DP-13: Use EB PPSL for One WB Through Lane During Temporary Closures.

Design Basis Concept

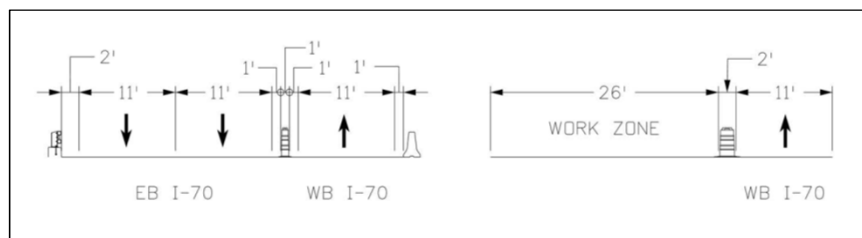
- Conventional lane closures.

Proposed Concept

- Utilize EB PPSL with crossovers to accept one WB lane through traffic.
 - Allows greater production rates for full closures.
 - Improved worker safety.

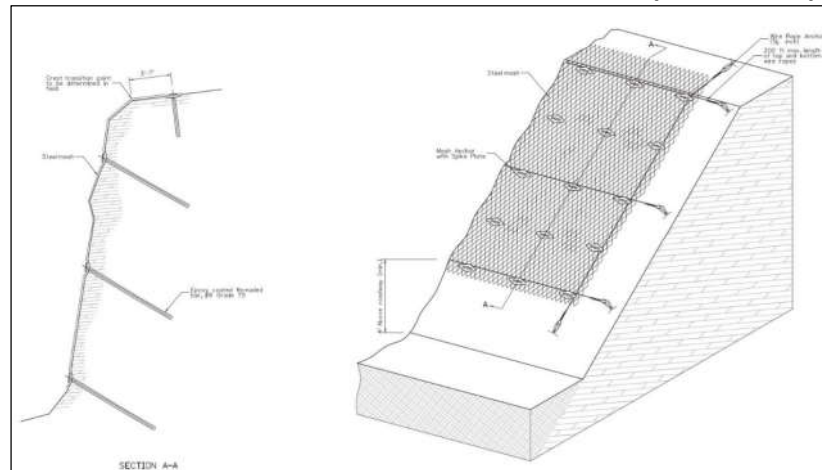
DP-13: Use EB PPSL for One WB Through Lane During Temporary Closures.

Proposed Concept



DP-16: Avoid Rock Cuts by Implementing Alternative Mitigation Measures.

Proposed Concept



Design Suggestions / Notes to Management

Design Suggestions

- Utilize Traffic Incident Management Plan.
- Reconstruct WB Weigh-in-Motion precast or offline.
- Live radar feedback warning signs.
- Plant wildflowers.
- Cellular concrete backfill.
- Develop milling and paving phasing plan.

Notes to Management

- Increase enforcement by funding county / state agencies.
- Restrict truck traffic to right lane.

Questions?

