CDOT R1 I-70 BAKERVILLE TO EJMT WB AUX LANE EXISTING CONDITIONS REPORT

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Prepared for:

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REVISION HISTORY

Revision	Date	Description
Draft	10/6/2022	Draft Report for Client Review
Draft	11/18/2022	Draft Report for Client Review
Final	12/7/2022	Final Report for Client Use

PROFESSIONAL ENGINEER

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Colorado.

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12/7 /2022	**Number**
Date	License No. 31650

ACRONYMS AND ABBREVIATIONS

%	Percent
AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
AADT	Average Annual Daily Traffic
ATR	Automatic Traffic Recorder
BMPs	Best Management Practices
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CDT	Continental Divide Trail
CSGC	Concrete Slab and Girder Continuous (Poured in Place)
CWA	Clean Water Act
DRCOG	Denver Regional Council of Governments
EB	Eastbound
EJMT	Eisenhower Johnson Memorial Tunnel
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
I-70	Interstate 70
ITS	Intelligent Transportation System
mi2	square miles
MP	Mile post
mph	miles per hour
NFIP	National Flood Insurance Program
NRCS	Natural Resources Conservation Service
OTIS	Online Transportation Information System
RockSol	RockSol Consulting Group, Inc.
ROW	Right-of-way
SCAP	Sediment Control Action Plan
SSA	Storm and Sanitary Analysis
UDFCD	Urban Drainage and Flood Control District
Ulteig	Ulteig Engineers, Inc.
US	United States
USACE	United States Army Corps of Engineers
USFS	United States Forest Service
USGS	United States Geological Survey
VMS	Variable Message Sign
vpd	Vehicles per day
VSL	Variable Speed Limit
WB	Westbound
WG	Welded Girder
WGCK	Welded Girder Continuous and Composite
WOUS	Waters of the United States

1 INTRODUCTION

The Colorado Department of Transportation (CDOT) is investigating the addition of a westbound (WB) auxiliary lane along Interstate 70 (I-70) in a section of high traffic volumes and steep grades in the mountain corridor to address existing operational challenges and safety issues. The proposed auxiliary lane stretches approximately from WB milepost (MP) 215.3 at the entrance of the Eisenhower Johnson Memorial Tunnel (EJMT) to MP 221.3 which represents the Bakerville interchange in Clear Creek County.

This project entails the following items on westbound I-70 with emphasis on minimizing impacts to stakeholders and the traveling public:

- Addition of an auxiliary lane for the full length of the project
- Evaluation and accommodation of two existing chain stations, and associated utility work
- Rock excavation
- Reconstruction and/or widening of two bridges to accommodate the auxiliary lane
- Potential interchange realignment (at US6)
- Guardrail improvements
- Intelligent Transportation System (ITS) improvements
- Pavement resurfacing
- Signing and striping
- Utility improvements including fiber backbone relocation
- Water quality features
- Wildlife crossing

CDOT has identified these improvements as a high priority to address immediate congestion and safety issues.

1.1 Study Corridor Overview

The I-70 Bakerville to EJMT Westbound Auxiliary Lane project's study area includes westbound I-70 between MP 215.3 to MP 221.3. I-70 connects Colorado's front range with mountain communities, recreational areas, and resorts through the Rocky Mountains of Colorado. It is a major east-west travel corridor through the state of Colorado that includes large volumes of commercial and recreational traffic.

I-70 recreational traffic is highest on the weekends. Volumes on weekend afternoons throughout the year are regularly well over capacity, causing severe congestion throughout the corridor. Access to recreational trails exist off the Bakerville and Herman Gulch interchanges. The project area also includes the recreational access to the Loveland Ski Area provided off the US 6 interchange.

In addition to providing recreational travel, I-70 serves as a critical freight corridor in Colorado. I-70 is listed on the Primary Highway Freight System which is a network of highways representing the most critical portions of the United States freight transportation system. Heavy vehicles rely on the Corridor for movement of goods and materials from both the east and the west, as no alternative continuous routes exists within Colorado. EJMT sits at the highest elevation along I-70 and gets considerable snow and ice during the winter. The project limit starts at an elevation around 9760 feet at the Bakerville Interchange and travels to 11,013 feet at EJMT. Thus, the grades up to EJMT are steep and create challenging conditions for trucks and passenger cars in the steady climb to the tunnel. Speed differentials between heavy commercial freight and faster moving vehicles cause significant operational and safety challenges leading to significant delays and impeding emergency response times. Freight vehicles hauling hazardous material and trucks that exceed the EJMT height restriction must exit at the US 6 interchange (MP 216) as they are not permitted to travel through EJMT.

The Corridor lies within a high elevation mountain environment where wildlife is abundant. Vehicle and animal collisions are frequent and mitigation efforts will be considered in the project. In addition, I-70 is within the United States Forest Service (USFS) property and resides on an easement. Part of the Corridor travels through the Arapaho National Forest.

Figure 1. Project overview map

Numerous factors could cause full closure of I-70 in the project area, raising the risks of keeping the interstate open and functional. An avalanche and debris chute exists within the project limits and aging structures at Bakerville, Herman Gulch and US 6 interchanges exist. The resiliency of I-70 is critical in preserving:

- Movement of commercial freight for the state and for the country
- The only continual east – west interstate route across the state of Colorado
- Connection between the Front Range to western Colorado

1.2 Report Resources

This report provides a description of the existing engineering design elements (geometric design, structures, water resources, utilities, and bicycle and pedestrian access) within the study limits. This review was prepared to identify the current conditions of the roadway and surrounding areas to help identify deficiencies.

The following resources were used to analyze existing conditions and to identify planned facilities and design guidelines:

- Site Visits (August 24, 2022, September 14, 2022 and September 20, 2022)
- As-built plans and other project related data
- CDOT Drone video of existing project site conditions captured October 2021
- CDOT, Online Transportation Information System (OTIS)
- CDOT Traffic Safety Assessment Report on I-70 between MP 215.3 – MP 221.5 (January 2022)
- CDPHE, 303(d) List of Water-Quality-Limited Segments Requiring TMDLs – 303(d) List and Colorado's Monitoring and Evaluation List, 2022
- CDPHE, COR400000 CDPS General Permit Stormwater Discharges Associated with Construction Activity, January 2021
- Clear Creek Watershed Foundation, Upper Clear Creek Watershed Plan Update, April 2014

- FEMA, FIRM Panel for Clear Creek County, Colorado and Incorporated Areas, Map Number 08019C0175D, March 19, 2007
- FEMA, Flood Insurance Study for Clear Creek County, Colorado and Incorporated Areas FEMA FIS Number 08019CV000C, Revised December 20, 2019
- I-70 Mountain Corridor Aesthetics Guidance
- Interstate 70 Directional Safety Assessment Report: MP 215.30 to MP 221.50 Bakerville Interchange to Eisenhower Tunnel East Portal (Draft Report, September 2022)
- Linkage Interference Zone Report
- Matrix, I-70 Clear Creek Corridor Sediment Control Action Plan, September 2013
- USGS, StreamStats, September 2022

2 EXISTING GEOMETRIC CONDITIONS

This section documents the existing geometric conditions of the westbound I-70 roadway within the project limits. The existing geometric conditions have been obtained from corridor as-built plans, existing topography survey, 2011 LiDAR data, aerial imagery, and from information recorded at several site visits. The existing conditions and critical issues are presented in the following existing geometric conditions categories.

2.1 Existing Design Speed

The existing design speed along the project corridor varies due to several reconstruction projects that have occurred since the construction of the initial I-70 corridor. The existing design speed, based on design criteria at the date of corridor as-built plans, varies between 50 mph and 65 mph. The speed limit from milepost 215 to 215.9 is 50 mph and the remaining stretch of the project is 65 mph.

2.2 Existing Horizontal Alignment

The preliminary project control line created by Ulteig is located along the centerline of the westbound I-70 roadway. The curve radii from the preliminary project control line, were estimated based on 2011 LiDAR data and aerial imagery, summarized in Table 1. The intent of this project is to widen the roadway only, therefore matching the existing roadway geometry. The three horizontal curves with substandard radii do no appear to have safety issues in evaluating existing crash data.

Figure 2. Overview of curve locations

Curve Number	WB I-70 Project Control Line Curve Radius (ft)	Posted Curve Speed (mph)	Minimum Recommended Curve Radius* (ft)	Meets Standards
1	1500	50	1120	☒
2	1870	65	1480	☒
3	11000	65	4200	☒
4	5720	65	5720	☒
5	2020	65	1480	☒
6	1970	65	2070	☐
7	6140	65	6140	☒
8	2300	65	2600	☐
9	12500	65	12900	☐
10	1720	65	1480	☒

*The minimum recommended curve radius was determined based on the posted speed and the maximum recorded superelevation (see Table 2) from the 2011 LiDAR data.

Table 1. Existing Curve Radius and Design Speed Summary

2.3 Existing Vertical Alignment

A preliminary vertical alignment was created along the project control line using 2011 LiDAR data. The vertical alignment is intended to match the existing ground as closely as possible. Several locations along the corridor exceed the maximum vertical grade recommended by CDOT's 2018 Roadway Design Guide of 5% for 65 mph. The maximum vertical grade measured was approximately 6.93%. All vertical curves met current American Association of State Highway and Transportation Officials (AASHTO) criteria for the posted speeds. On the final ascent towards the continental divide, grades increase on average 4.1% from Bakerville to EJMT, compared to 2.8% from Silver Plume to Bakerville.

2.4 Existing Superelevation

The existing superelevation rates were measured using cross sections built from 2011 LiDAR data. These superelevation rates are summarized in Table 2 along with the recommended superelevation rates per AASHTO design standards. Improvements and/or modifications to the existing superelevation rates are not planned at this time. Superelevation rates will be evaluated further after completion of the roadway survey, during the preliminary and final design.

Horizontal Curve Number	WB I-70 Project Control Line Radius (ft)	Maximum Recorded Superelevation	Recommended Superelevation $(e_{max} = 8\%)$
1	1500	7.3%	6.2%
2	1870	9.0%	7.6%
3	11000	4.3%	2.0%
4	5720	3.3%	3.2%
5	2020	10.6%	7.4%
6	1970	7.3%	7.4%
7	6140	3.0%	3.0%
8	2300	6.3%	6.8%
9	12500	1.8%	2.0%
10	1720	8.4%	7.8%

Table 2. Superelevation Rates of Existing Horizontal Curves

2.5 Existing Median Cross Overs

There are four existing median cross overs located on the corridor for use by emergency and authorized vehicles. These can be found at approximately MP 217.5, MP 218.7, MP 219.4, and MP 220.7.

2.6 Existing Interchanges

Bakerville Interchange (MP 221.3)

This is a standard diamond interchange with access to recreational trails on the south side of the interchange. A few residential homes exist on both sides with Silver Valley Road traveling on the south side connecting back east to the Town of Silver Plume. The WB on ramp curves around a large rock outcropping where a weather station also exists. Both ramps to and from WB I-70 meet AASHTO design standards for length.

Herman Gulch Interchange (MP 218.4)

This is a standard diamond interchange with access to recreational trails on the north side of the interchange along with access to seasonal cabins. Both ramps to and from WB I-70 meet AASHTO design standards for length.

US 6 Interchange (MP 216)

I-70 WB travels at a southwest direction through the US 6 interchange and curves west around the edge of a mountain creating sight distance issues for both WB and EB travel. The US 6 WB ramps consist of a tapered off ramp and a loop on ramp. These ramps come together as a two-way roadway before passing underneath I-70 where they intersect US 6. The loop for the WB on ramp is posted for 15 mph. The acceleration length for the WB on ramp is only approximately 540 feet long which does not meet the AASHTO recommendations of 2,498 feet for merging onto a 65-mph road on a 6% upgrade. The EB off ramp has a 90-degree bend to a stop condition at US 6. This bend does not provide sufficient room for larger vehicles to make the turning movement, causing the wheel path of larger vehicles to leave the road. For those wanting to get onto I-70 WB, they must turn left onto US 6 and take another left to access the loop on ramp. Continuing east on US 6, US 6 becomes a one-way road as it transitions to the EB on ramp at I-70. Both ramps to and from EB I-70 meet AASHTO design standards for length.

Figure 3. Aerial view of I-70 at the US 6 Interchange and Loveland Ski area

The Loveland Ski Area has western and eastern parking lots. To access the east parking lots, a left turn onto US 6 is required from both off ramps, intermixing with the EB US 6 traffic that is accessing EB and WB on ramps. Traffic backs up during the ski season as parking lots fill up and people are searching for a place to park, impeding highway traffic flow. Some vehicles chose to park along the western ramps on the dirt shoulder and along a narrow access road that parallels I-70 to the east. The eastern parking lots lack auxiliary lanes and do not contain a single-entry point but provide open access along US 6. Those traveling out of the Loveland Ski Area eastern parking lots impact EB ramp travel to the interstate.

Commercial vehicles hauling hazardous materials are not permitted to travel through EJMT and must exit at US 6, unless Loveland Pass is closed. A similar restriction also applies to over height vehicles as they approach EJMT. US 6 travels over Loveland Pass south of I-70 and connects back to I-70 on the west side of the tunnel at Silverthorne. Trucks required to leave I-70 and travel on US 6 detour approximately 20 miles.

2.7 Existing Road Conditions

The existing WB roadway surface appears to be in fair condition as a result of continuous maintenance and improvement projects. Recent construction projects in the area include:

- A 2.5" mill followed by a 2.5" overlay of SMA (STA 0703-426, 20510, M.P. 215.35 to M.P. 218.26) in 2016
- A 2" mill followed by a 2" overlay of HMA (Grading SX)(100)(PG 58-28) (STA 0703-432, 20850, M.P. 218.41 to M.P. 228.38) in 2017

Historic information from a 2016 Pavement Justification Report revealed the most prevalent distresses are fatigue cracking in the wheel paths, transverse cracking, and longitudinal cracking with the severity levels of low to medium. Block cracking is also observed at some locations. Moderate to severe rutting is also seen in the wheel paths.

Pavement cores will be taken to further document the existing road conditions.

2.8 Existing Guardrail

Table 3 summarizes the existing guardrail as found on CDOT's Online Transportation Information System (OTIS). There is very little existing guardrail found on the outside shoulder in the WB direction. Short sections of W-beam guardrail can be found along the outside shoulder at existing interchanges, the approach to EJMT, and near some existing features close to the road such as the existing variable message sign (VMS) at MP 217.4. Widening the roadway may cause additional obstructions to be within the roadway's clear zone and require additional guardrail.

Safety Feature	MP 216	MP 217	MP 218	MP 219	MP 220	MP 221
Median Safety Feature	Concrete Structural Fixed (Jersey)	3-Strand Cable	3-Strand Cable, Blocked Out W-Beam, 3-Strand Cable	3-Strand Cable	3-Strand Cable	3-Strand Cable, Blocked Out W-Beam, None
Primary (EB) Outside Shoulder Feature	Blocked Out W-Beam	Blocked Out W-Beam	Partial - Blocked Out W-Beam	Partial - Blocked Out W-Beam	Blocked Out W-Beam	Partial - Blocked Out W-Beam
Secondary (WB) Outside Shoulder Feature	Partial - Concrete Structural Fixed (Jersey)	None	None	None	None	None

Table 3. Overview of Existing Guardrail

2.9 Existing Median

I-70 has an approximately 12' wide paved median with concrete barrier from EJMT to MP 216.66, where it transitions to a depressed median with natural vegetation that is typically 36' wide with cable guardrail that continues to the end of the project. CDOT's 2018 Roadway Design Guide recommends 26' flush medians and 52' depressed medians. Median widths through the corridor are generally restrained by the geography of the area.

2.10 Existing Roadside Features

A roadside memorial plaque listing the names of the victims who died from a plane crash in 1970 is located near the crash site, adjacent to westbound I-70, at Dry Gulch (MP 217.3). A trail to the wreck site via Dry Gulch is approximately 0.4 miles past the memorial off exit 216. The occupants of the plane were football players and personnel from Wichita State University. The memorial was built by the university for those who died from the crash and is commonly referred to as the Memorial '70. It is documented that every year on October 2 at 9 a.m., a wreath is placed at this memorial. **Figure 4** of the memorial site shows active visitation occurs.

Figure 4. Roadside memorial at MP 217.3

3 EXISTING STRUCTURAL CONDITIONS

On September 14, 2022, Ulteig visited the study area to assess the condition of the existing major structures. The following five major structures were identified on I-70 between I-70 MP 216 and MP 222, with the corresponding structure numbers shown in parenthesis:

1. I-70 Mainline Westbound Bridge over US-6 (F-13-O)
2. I-70 Mainline Eastbound Bridge over US-6 (F-13-P)
3. I-70 Mainline at Herman Gulch Eastbound Bridge (F-13-L)
4. I-70 Mainline at Herman Gulch Westbound Bridge (F-13-J)
5. Bridge over I-70 Mainline at Bakerville On/Off Ramps (F-13-T)

Figure 5 shows the locations of the five structures and Table 4 provides the location by MP and the corresponding sufficiency rating. Each of the structures is discussed in more detail in the following sections.

Figure 5. Overview of structure locations

Description	Location (MP)	Structure Number	Built	Sufficiency Rate (date)
3-span, non-continuous steel plate girder bridge over US Highway 6	216.185	F-13-O	1964	81.2 (Sept 14, 2021)
3-span, continuous steel plate girder bridge over US Highway 6	216.185	F-13-P	1979	97.2 (Sept 14, 2021)
3-span, continuous parabolic reinforces concrete bridge over Herman Gulch Road	218.299	F-13-L	1972	95.3 (May 4, 2021)
3-span, continuous parabolic reinforces concrete bridge over Herman Gulch Road	218.3	F-13-J	1972	94.3 (May 4, 2021)
2-span, continuous steel plate girder bridge over I-70	221.25	F-13-T	1971	73.3 (May 4, 2021)

Table 4. Summary of Structures (Information taken from Structure Inspection Reports)

3.1 Major Structures

3.1.1 Structure F-13-O

F-13-O (Westbound) was built in 1964 and is a non-identical twin structure of F-13-P (Eastbound). The bridge is located at mile post 216.18 and crosses US Highway 6. The structure is a three-span, non-continuous steel plate girder supported by seat type abutments and multi-column bents. The roadway is on a horizontal curve alignment with varying skews and is on a 6.4% vertical grade. The bridge has a sufficiency rating of 81.2 according to the CDOT Structure Inspection and Inventory Report, dated 9/14/2021.

F-13-O is in direct contact with structure F-13-P via a longitudinal compression joint located in the median of I-70. There is one 4-inch diameter utility conduit attached to the left barrier on the outside of the bridge.

Figure 6. Elevation view (looking north)

Deck Topside
The driving surface of the deck has a 3-inch-thick asphalt overlay. The top of the concrete deck is not visible. Several patches of asphalt exist throughout the overlay and there several are areas of potholing and delamination of the top layer of asphalt. The asphalt is cracked the entire width of the roadway at both abutments and Pier 3.

The bridge rail is concrete barrier. The bridge rail on the right side of the traveled way is not attached to structure F-13-0 but is attached to F-13-P and acts as a median barrier. Spalls with exposed, corroded reinforcement is present throughout much of the length of the left bridge rail.

At Pier 2, the concrete joint header is abraded in the traffic lanes exposing aggregate. The anchors for the joint armor are also exposed through top of the header; no metal sections appear to be protruding from the header. The seal is impacted with debris most of its length.

Original plans show expansion joints at both Piers, but there is only an expansion joint at Pier 2. It is likely Pier 3 expansion joint has been paved over.

Figure 7. Asphalt patches in wearing surface

Figure 8. Typical deterioration of outside bridge rail

Figure 9. Expansion joint at Pier 2

Figure 10. Transverse cracking of asphalt over Abutment 1

Deck Underside

The underside of the deck has several areas that have had full depth concrete repairs. Several locations existing with patches less than 2 square feet in area in Bays 1B, 1D, 2B, and 3C. Some patches are cracked with efflorescence. There are also several areas of map cracking with efflorescence, scattered throughout the deck. Areas with efflorescence and patch account for 10% of the deck area.

The left edge of the deck has several areas of spalling with exposed and corroded reinforcement. The right edge of the deck along the expansion joint is in good condition, however the joint with bridge F-13-P allows water through and collects on Girder E.

Figure 11. Drainage through longitudinal joint with F-13-P on to Girder E, corrosion on top flange of Girder E

Figure 12. Typical view of underside of deck showing areas of patch and cracking with efflorescence

Girders and Bearings

The bridge girders are in overall fair condition, but several localized areas in poor condition.

Throughout the girders, cross frames, bearings, and other steel components the paint has failed and there are areas of surface corrosion. The corrosion is most severe on the exterior faces of the exterior girders and at the girder ends underneath the deck joints. Girder E has pitting the full length along the top flange and web and has 30% section loss of its web at Abutment 1.

Girder 1A is buried in 4ft of gravel and other debris for 10ft of its length at Abutment 1. The material is unable to be removed with hand tools. In areas where Girder 1A was uncovered and cleaned, only surface rust was observed. A complete uncovering and cleaning of Girder 1A is required to fully document its condition.

An additional observation of Girder 1A, when large vehicles cross the bridge in the driving lane or on ramp, Girder 1A laterally vibrates, up to ¼” from its resting position. The observation was not made on other girders.

The fixed bearings at both abutments are corroded and covered by debris. The movable rocker bearings are also corroded with debris on them from the deck joints above.

Figure 13. Debris on Girder 1A with uncovered area

Figure 14. View showing general condition of superstructure paint and corrosion on girders

Figure 15. Typical condition of movable bearings, Pier 2 Girder A

Abutments

Both abutments are in fair condition. At Abutment 1, there are delaminations running the length of the front of the girder seats under Girders C, D, and E. Some areas of the delamination exhibit rust staining. Water drains across the entire length of the girder seat from Girder E to A. The likely source of the water is through the longitudinal joint with F-13-P at the right side of the bridge.

Abutment 4 has similar delaminations and rust staining to Abutment 1 under Girders D and E. A previously patched area at the right end of Abutment 4 has failed and is now spalled with exposed, corroded reinforcement.

The berms in front of both abutments are extremely steep and comprised of erodible sand and silt material. The slopes sit at close to a 1:1 slope in areas have sparse rip rap protection. Erosion troughs are present at several locations on both embankments. There is an active drainage on the Abutment 4 embankment originating from the right end of Abutment 4 despite the lack of rainfall prior to the inspection.

Figure 16. Delamination and rust staining on Abutment 1 girder seat

Figure 17. Delamination, rust staining, and failed patch at right end of Abutment 4

Piers

The piers are in overall fair condition. There are patches throughout both pier caps. Many patches are cracked and are unsound. There are spalls with exposed reinforcement along the bottom edges and ends of both pier caps. All pier columns have chips near their bottoms throughout as well insignificant width cracks.

Figure 18. Failing, cracked patches on bottom edges of Pier 3

3.1.2 Structure F-13-P

F-13-P (Eastbound) was built in 1979 and is a non-identical twin structure of F-13-O (Westbound). The bridge is located at mile post 216.18 and crosses US Highway 6. The structure is a three-span, continuous curved steel plate girder supported by seat type abutments and multi-column bents. The roadway is on a horizontal curve alignment with varying skews and is on a 6.4% vertical grade. The bridge has a sufficiency rating of 97.2 according to the CDOT Structure Inspection and Inventory Report, dated 9/14/2021.

F-13-P is in direct contact with structure F-13-O via a longitudinal compression joint located in the median of I-70.

Figure 19. Elevation view

Deck Topside

The driving surface of the deck has a 4-inch-thick asphalt overlay. The top of the concrete deck is not visible. Potholes and dishing exist throughout much of the wearing surface with most severe concentration in Span 1. The paving seam along centerline roadway is crack up to 6in wide. Transverse cracks that run the full width of the roadway exist over Abutments 1 and 4.

The bridge rail is concrete barrier. The left bridge rail on F-13-P also serves as the right bridge rail on F-13-0. Spalls with exposed, corroded reinforcement is present throughout much of the length of both bridge rail.

A strip seal expansion joints is located at Abutment 1. The concrete joint header is abraded in the traffic lanes exposing aggregate. The anchors for the joint rail are also exposed through top of the header; no metal sections appear to be protruding from the header. The seal is impacted with debris most of its length.

Figure 20. Typical potholes in asphalt wearing surface

Figure 21. Expansion joint at Abutment 1

Figure 22. Transverse cracking in asphalt wearing surface over Abutment 1

Figure 23. Typical spalling with exposed corroded reinforcement in the concrete barriers

Deck Underside

The underside of the deck has scattered areas of transverse cracks with efflorescence. A few locations with map cracking with efflorescence exist, Bay 1B near Abutment 1 and Bay 3C and 3B near Abutment 4. The underside of the joint headers at the abutments both have cracking with efflorescence throughout.

Figure 24. Typical view of underside of deck showing areas of cracking with efflorescence

Figure 25. Cracking with efflorescence on underside of joint header at Abutment 4

Girders and Bearings

The bridge girders are in overall fair condition. Throughout the girders, cross frames, bearings, and other steel components the paint system has failed exposing primer and areas of surface corrosion.

The bearings at both abutments are covered in debris, which may be restricting movement.

Figure 26. Typical condition of movable bearings, Abutment 1 Girder B

Abutments

Both abutments are in good condition. There are scattered vertical insignificant width cracks throughout both abutment backwalls. There is one spall with exposed reinforcement on Abutment 1 in Bay D. The girder seats for both abutments are covered in debris.

Figure 27. Spall with exposed reinforcement on Abutment 1, Bay D

Piers

The piers are in overall good condition. Some insignificant width cracks are present in the caps and columns of both piers. The pier columns have chips near their bottoms throughout.

3.1.3 Structure F-13-L

F-13-L (Eastbound) was built in 1972 and is a twin structure of F-13-J (Westbound). The bridge is located at milepost 218.30 on I-70 and crosses Herman Gulch Road. The structure is a three-span, continuous parabolic reinforced concrete T-girder supported by integral abutments and multi-column bents with integral pier caps. The structure is on a straight alignment with no skew on a 3.74% vertical grade. The bridge has a sufficiency rating of 95.3 according to the CDOT Structure Inspection and Inventory Report, dated 5/4/2021.

Figure 28. Elevation View

Deck Topside

The driving surface of the deck has a 6 ½ inch thick asphalt overlay. The top of the concrete deck is not visible. The asphalt wearing surface is rutted in the driving lane wheel lines almost the entire length of the bridge. In some locations the ruts are up to 3 inches deep. The asphalt is also cracked up to 1 ½ inches wide along the longitudinal paving seam between the traffic lanes.

The bridge rail is galvanized Type 10M and is a retrofit to the original rails on the bridge. At many locations the anchor bolts for the rail do not extend beyond the curb enough to fully engage the nuts. The post base plates are also wider than the top of the curb and not fully seated on the curb.

The front face of both curbs is hidden by the asphalt wearing surface. At the ends of the approach curbs at Abutment 4, adjacent to the roadway, large erosion holes are present from drainage flowing off the bridge.

Figure 29. Asphalt rutting in driving lane

Figure 30. Erosion holes at ends of approach curbs

Deck Underside

The deck has widespread deterioration throughout. Approximately 30% of the underside of the deck has visible cracking, efflorescence, delamination, spalls, or patches made to the concrete.

Map cracking with efflorescence is present in all spans and girder bays, with the most severe conditions present in Girder C, D, and E. Throughout the efflorescence, isolated spots of rust staining are present. Discoloration of the concrete, separate from efflorescence, is also present throughout the underside of the deck indicating water can infiltrate and move through the deck. Large areas of “permanent” form work is present in Bay 3D from previous concrete repairs that obstructed the inspection of the area. There is also a large full depth repair in Bay 2D. Several spalls were visible with exposed corroded reinforcement at both edges of the deck.

Figure 31. General view of the underside of the deck in Span 1

Figure 32. General view of the underside of the deck in Span 2

Figure 33. Permanent form work for concrete repair (Bay 3D) and map cracking with efflorescence (Bay 3C)

Figure 34.Typical spalling with exposed reinforcement at edges of deck

Girders

The girders are in overall good condition. Some vertical cracks less than 0.012 inches wide are present at isolated location on most girders. Diaphragm 3E has (1) vertical crack with efflorescence.

Abutments

Both abutments are in fair condition. A few vertical cracks less than 0.012 inches wide are present in both abutments. At both abutments the berms have settled or eroded exposing the piles. Piles are exposed 8 inches and 3 inches at Abutment 1 and 4 respectively. Probing underneath Abutment 1 indicated there may be a 2- to 5-inch-wide void behind majority of the length of the abutment. It is also noted at Abutment 1 the pile under Girder C is not centered in the abutment cap and pile flange is visible and near flush with the front face of the abutment.

Figure 35. Exposed piles at Abutment 1

Figure 36. Off-center pile under Girder C at Abutment 1

The berms in front of both abutments are steep and only locally protected with riprap. Areas of erosion and piles of debris are present at all 4 corners of the bridge.

Figure 37. Erosion of berm embankments

Piers
The piers are in overall good condition. There are small chips and graffiti on the pier columns.

3.1.4 Structure F-13-J

F-13-J (Westbound) was built in 1972 and is a twin structure of F-13-L (Eastbound). The bridge is located at milepost 218.30 on I-70 and crosses Herman Gulch Road. The structure is a three-span, continuous parabolic reinforced concrete T-girder supported by integral abutments and multi-column bents with integral pier caps. The structure is on a straight alignment with no skew on a 3.74% vertical grade. The bridge has a sufficiency rating of 94.3 according to the CDOT Structure Inspection and Inventory Report, dated 5/4/2021.

Figure 38. Elevation View

Deck Topside
The driving surface of the deck has a 5-inch-thick asphalt overlay. The top of the concrete deck is not visible. Many large patches exist in the wearing surface and correspond in location to patches and formwork seen on the underside of the deck. The patches are mostly in the driving lane over Girder Bay B and C. The wearing surface is cracked up to 1.5 inch wide the full width of the roadway behind Abutment 1 allowing excess water to enter behind the abutment.

The bridge rail is galvanized Type 10M and is a retrofit to the original rails on the bridge. At many locations the anchor bolts for the rail do not extend beyond the curb enough to fully engage the nuts. The post base plates are also wider than the top of the curb and not fully seated on the curb.

The front face of both curbs is mostly hidden by the asphalt wearing surface, but localized areas of cracking and delamination are visible. Spalls, some with exposed reinforcement, are present under several rail posts.

Figure 39. Asphalt patches in wearing surface

Figure 40. Disengaged nuts on bridge rail anchors

Figure 41. Delamination and spalls on the front face of the curbs

Deck Underside

The deck has widespread deterioration throughout. Approximately 30% of the underside of the deck has visible cracking, efflorescence, delamination, spalls, or patches made to the concrete.

Map cracking with efflorescence is present in all spans and girder bays, with the most severe areas shown in Girder Bays A, B, and C. Throughout the efflorescence, isolated spots of rust staining are present. Discoloration of the concrete separate from efflorescence is also present throughout the underside of the deck indicating water can infiltrate and move through the deck. Large areas of "permanent" form work are present in Bays 1C, 2B, and 2C from previous concrete repairs. These repairs obstruct the inspection of these areas. In accessible areas near the abutments, delamination of the deck was detected using a hammer to sound the concrete at a few locations near Abutment 1. Several spalls with exposed corroded reinforcement are visible at both edges of the deck.

Figure 42. General view of the underside of the deck in Span 1

Figure 43. General view of the underside of the deck in Span 2

Figure 44. General view of the underside of the deck in Span 3

Figure 45. Typical spalling with exposed corroded reinforcement at edges of the deck

Girders

The girders are in overall good condition. The girders are free from defects aside from a few chips on Girders 2A and 2C from over-height vehicle collisions likely due to the minimum vertical clearance of 16'-6" over Herman Gulch Road. There are also isolated locations where cracks with efflorescence emanating from the deck have extended into the girders.

Abutments

Both abutments are in good condition. A few vertical cracks less than 0.012 inches are present in both abutments.

The berms in front of both abutments are steep and only locally protected with riprap. Areas of erosion and piles of debris are present at all 4 corners of the bridge.

Piers

The piers are in overall good condition. There are small chips and scrapes on the pier columns.

3.1.5 Structure F-13-T

F-13-T was built in 1971 and carries Bakerville Road over I-70 at MP 221.25. The structure is a two-span, continuous steel plate girder supported by seat abutments and a hammerhead pier. The structure is on a straight alignment with no skew or vertical grade. The bridge has a sufficiency rating of 73.3 according to the CDOT Structure Inspection and Inventory Report, dated 5/4/2021

Figure 46. Elevation view

Deck Topside

The driving surface of the deck has a 2-inch-thick asphalt overlay. The top of the concrete deck is not visible. A few scattered cracks are present throughout the wearing surface. Asphalt has been paved over the compression joint seals at both abutments. The asphalt is cracked the full width of the roadway over both joints.

The bridge rail is galvanized steel with two channel rails on square tubular posts. The bridge rail is referred to as “Type N” by CDOT’s bridge inspection unit. The bridge rail is not MASH compliant. The approach rail is also substandard, lacking stiffened transitions to the bridge rail, sufficient length, and end terminals. The length of the approach rails is restricted by the adjacent intersections. The end terminals are flared end caps and “turn down to ground” style.

Both curbs are deteriorated for majority of their lengths. The right curb is spalled with exposed corroded reinforcement for approximately 50% of its length and scaled or delaminated for most of the remainder. The left curb is scaled or delaminated for 80 to 90% of its length and has a few isolated spalls.

Both approach slabs are undermined on both sides of the bridge at the ends of the wingwalls. Undermining extends up to 5 feet under the approach slab at some locations. The curbs on the approach slabs are damaged to the extent that they are no longer effective.

The concrete protective coating applied to the deck overhangs and curbs is peeling or failed at most locations.

Figure 47. Typical spalls with exposed corroded reinforcement in curbs and “Type N” bridge rail

Figure 48. Transverse cracking of asphalt over compression joint at Abutment 3

Figure 49. Typical undermining of approach slabs and damage to curbs on approach slabs. Right side of rear approach slab

Deck Underside

The underside of the deck has large areas of transverse and map cracks, with efflorescence. The largest concentrations of the map cracking are in Bays 2B and 2C near Abutment 3 and in both spans near Pier 2. The transverse cracks are scattered throughout. A few spalls less than 6 inches in diameter, some with exposed reinforcement, are present on the left edge of the deck above eastbound I-70.

Figure 50. Typical view of underside of deck showing areas of cracking with efflorescence, Span 2 at Abutment 3

Girders and Bearings

The bridge girders are in overall fair condition. Throughout the girders, cross frames, bearings, and other steel components, the paint system has failed exposing primer and areas of surface corrosion. Areas experiencing the most severe corrosion are in the bottom flanges of the girders directly over I-70 and the left side Girder 1A over eastbound I-70. The girder ends also have surface corrosion for 4 to 5 feet beneath the compression joints at the abutments.

The elastomeric bearings at the abutments are crushing and bulging. Bearing 3E is the most severe, crushed approximately 15% of its depth and bulged approximately 10% of its thickness. The abutment bearings are all covered in debris and have surface corrosion on the bearing plates.

Figure 51. View showing general condition of superstructure paint and corrosion on girders

Figure 52. Crushing and bulging of bearing pad 3E

Abutments

The abutments are in fair condition. Horizontal delamination and rust staining on Abutment 1 are present in Bays A, C, and D. A previously patched area at the bottom edge of Abutment 1 has failed, exposing corroded reinforcement in Bay D. Both abutments have insignificant width vertical cracks in the abutment backwalls.

Isolated locations along Abutment 1 have been undermined, but no piles are currently exposed

The concrete protective coating applied to the abutments and wingwalls is peeling or failed at most areas across the girder seats and abutment backwalls.

Figure 53. Typical delamination and rust staining on girder seats, Abutment 1 Bay A

Figure 54. Failed patch exposing corroded reinforcement, Abutment 1 Bay D

Pier
The pier is in overall good condition. Some insignificant width cracks are present in the cap and wall. The pier is stained with rust from the girders and there is some graffiti on the north face.

3.2 Eisenhower Johnson Memorial Tunnel

Eisenhower Johnson Memorial Tunnel (EJMT) sits at the highest elevation along the I-70 corridor, and the eastern portal is at the western end of the project limits. The westbound portal was completed in 1973 and the eastbound portal was completed in 1979. The two portals are 115 feet apart at the east entrance. Each portal serves two lanes of one-directional traffic. The project's WB auxiliary lane will end upstream of the tunnel, so westbound I-70 will transition from three lanes down to two lanes prior to EJMT tunnel entrance. The East Portal sits at an elevation of 11,013 feet and the EJMT extends 1.7 miles west through the Continental Divide, connecting the western slope of the Rocky Mountains with the eastern slope.

EJMT is staffed 24 hours a day, 365 days a year to provide continual monitoring of the tunnel, road conditions and traffic. Cameras and weather stations exist along I-70 in the project limits to assist with this monitoring. Freight carrying hazardous materials is not allowed to travel through the tunnel unless Loveland Pass is closed. Metering of traffic at the tunnel approaches does occur on occasion due to weather, congestion, or incidents. The grade through the tunnel is 1.64 % rising to the west with the eastern approach on a 6% climbing grade.

The WB approach to the tunnel does have a pull-off area for trucks to check their brakes and a holding area for trucks carrying hazardous material or are over height or wide loads. The pull off area continues as a service road over the top of the tunnel entrance that can be used to turn trucks around, if needed. A parking lot of less than 30 spaces also exists on the west approach for the use of the employees that work there.

3.3 Minor Structures

The following four minor structures were identified on WB I-70 between I-70 MP 216 and MP 222. The four structures were classified as either CBC or CMP. The details of the minor structures and their existing conditions have been summarized:

1. Loveland Skier Underpass (MP 215.61)
2. Dry Gulch Culvert (MP 217.38)
3. Herman Gulch Culvert (MP 218.42)
4. Watrous Gulch Culvert (MP 219.29)

3.3.1 Loveland Skier Underpass

Minor culvert 070A215590BL was built in 1962 and is located at milepost 215.61. The culvert serves as an underpass for skiers to traverse under I-70 at the Loveland Ski Area, as well as providing a drainageway. The structure is a one cell 10 foot x 10 foot cast-in-place reinforced concrete box culvert. The culvert barrel is approximately 197 feet long and the fill depth varies from 3 feet at the inlet (north side of I-70) to 12 feet at outlet. I-70 above the structure is on a curved alignment and vertical grade. The culvert has a sufficiency rating of 56.0 according to the CDOT's Online Transportation Information System (OTIS).

Figure 55. Outlet Elevation

Figure 56. Inlet elevation

Figure 57. General view through culvert barrel

Existing Conditions

The culvert is in overall good condition. It is divided into two halves by a concrete divider: 4-foot-wide and 5'-6" wide. The wider section of the culvert lies on the left side when looking downstream. The culvert contains a lighting system for pedestrians with a metal conduit connected to an electrical panel at the south end of the barrel.

The culvert barrel has seven moderate to wide width circumferential cracks in the walls and top slab, with the cracks spaced over 20 feet apart. None of the cracks have evidence of leakage or efflorescence. There are 3 construction joints in culvert. The joint located 32 feet from the outlet (south) end of the culvert is spalled with evidence of leakage through the joint. The concrete divider on the bottom slab is also spalled at the same construction joint.

At the outlet (south) end of the culvert, the leading edge of the top slab is spalled with exposed reinforcement the entire width of the barrel. Both wingwalls are also leaning towards the inside of the barrel. The southeast wingwall is leaning 8 inches at its top, the southwest wingwall is leaning 4 inches at its top. At the culvert inlet (north end), there are four exposed rebars in the headwall due spalling and a lack of concrete cover.

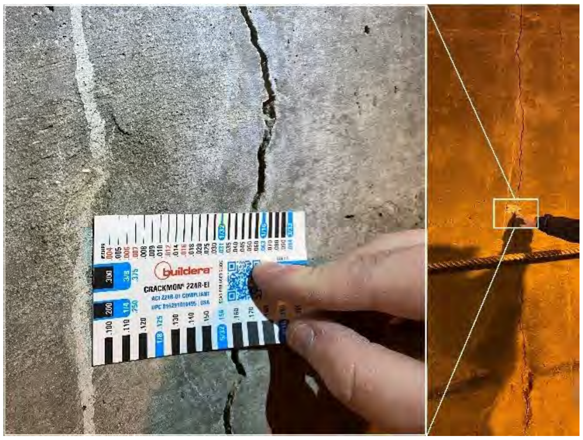


Figure 58. Typical wide width circumferential crack in culvert barrel

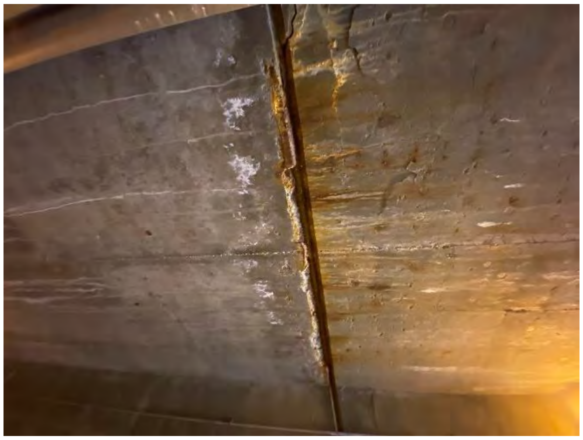


Figure 59. Spalling, leakage, and efflorescence at construction joint 32 feet from outlet

Figure 60. Spall with exposed rebar at outlet

Figure 61. Leaning of southeast wingwall

3.3.2 Dry Gulch Culvert (MP 217.38)

- 10.0 miles west of Georgetown
- Structure type – CMP
- Built in 1972
- Sufficiency rating 65
- Main facility carried I-70

3.3.3 Herman Gulch Culvert (MP 218.42)

- 9.0 miles west of Georgetown
- Structure type – CMP
- Built in 1972
- Sufficiency rating 54.8
- Main facility carried I-70

3.3.4 Watrous Gulch Culvert (MP 219.29)

- 8.1 miles west of Georgetown
- Structure type – CMP
- Built in 1972
- Sufficiency rating 43
- Main facility carried I-70

3.4 Miscellaneous Structures

In addition to major and minor structures through the project limits, there exists approximately 152 culverts ranging from diameter of 8” to 72” and a length of 5’ to 1311’.

There are two mast arms with structure id 070A215375B (westbound) and 070A215425A (eastbound) located at mile post 215.461 and 215.50 respectively.

4 EXISTING WATER RESOURCES, FLOODPLAIN, & WATER QUALITY CONDITIONS

An analysis of water resources, floodplains, and water quality issues was conducted as part of this existing conditions assessment in support of the CDOT I-70 Bakerville to EJMT WB Auxiliary Lanes. This chapter provides basic information for water resources, floodplain, and water quality within the study area. The information was derived from site visits, published reports, and discussions with CDOT staff. Additional information is in the I-70 Mountain Corridor Final Programmatic Environmental Impact dated March 2011.

4.1 Current Watershed Conditions

The study area is located within the Upper Clear Creek watershed. The watershed is 394 square miles (mi2). Clear Creek originates at the continental divide, west of the study area, near the Eisenhower Tunnel and flows east to the confluence of the South Platte River in the Denver metropolitan area. The watershed falls within areas of the Arapaho and Roosevelt National Forest. Tributaries to Clear Creek along the project include Quayle Creek, Kearney Gulch, Watrous Gulch, Herman Gulch and Dry Gulch.

The I-70 corridor follows the main stem of Clear Creek in the study area. A large portion of the watershed is steep rugged topography; therefore, the majority of development is along Clear Creek. Land uses in the watershed consist mostly of forest with small but developing communities, recreational use, transportation facilities – railroads and highways, and existing and historical mining operations. **Figure 62** from Upper Clear Creek Watershed Plan Update 2014 (Watershed Plan) identifies the subbasins of the Upper Clear Creek Watershed. The project falls within basin 0102.

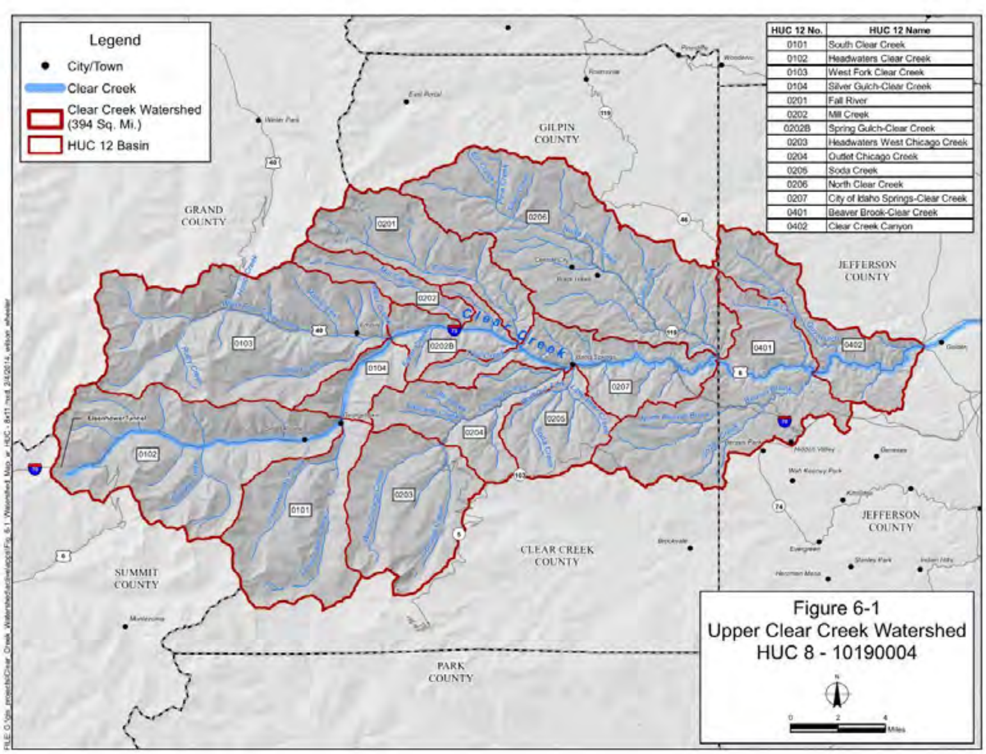


Figure 62. Upper Clear Creek Watershed

Clear Creek and its tributaries also serve as the primary drinking water supply for seven of the upper watershed towns. It also feeds one of the metro area reservoirs.

The United States Geological Survey (USGS) StreamStats identifies there are many washes that could cross I-70 within the project in addition to the major crossings. Drainageways are shown in blue in **Figure 63 and Figure 64** (figures from StreamStats).

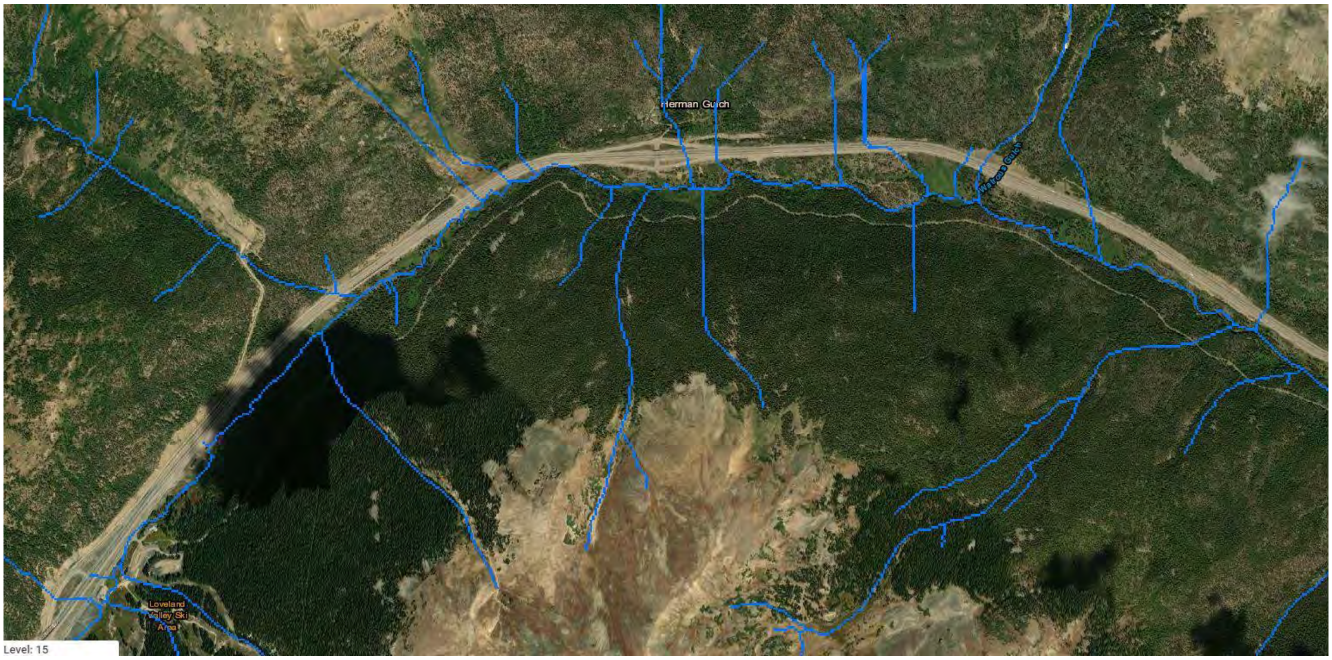


Figure 63. Drainage crossing west – East EJMT to Watrous Gulf

Figure 64. Drainage crossing west – Watrous Gulf to Bakerville

4.2 Clear Creek and Floodplain

Clear Creek is a perennial stream that flows along I-70 through the study area. Portions of Clear Creek were channelized with the construction of I-70 in the 1950s. The creek is a typical mountain stream with large cobbles and boulders and steep channel banks. It has a low stream sinuosity (ratio of the stream length to the valley length), slight meandering, and limited riparian (streamside) vegetation.

The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) includes Clear Creek within the project. Clear Creek runs west to east along the south side of I-70 within the project limits. The mapped floodplain is shown on FIRM Clear Creek County, Colorado and Incorporated Areas Map Number 08019C0175D, Effective Date March 19, 2007. Clear Creek is identified as a Zone A FEMA mapped floodplain. The limits of Clear Creek Zone A are near Herman Gulch, MP 218 on the west to the east limits of the project. The effective floodplain is shown in **Figure 65**.

The FEMA Flood Insurance Study (FIS) for Clear Creek County, Colorado and Incorporated Areas FIS Number 08019CV000C discusses the analysis of the floodplain study.

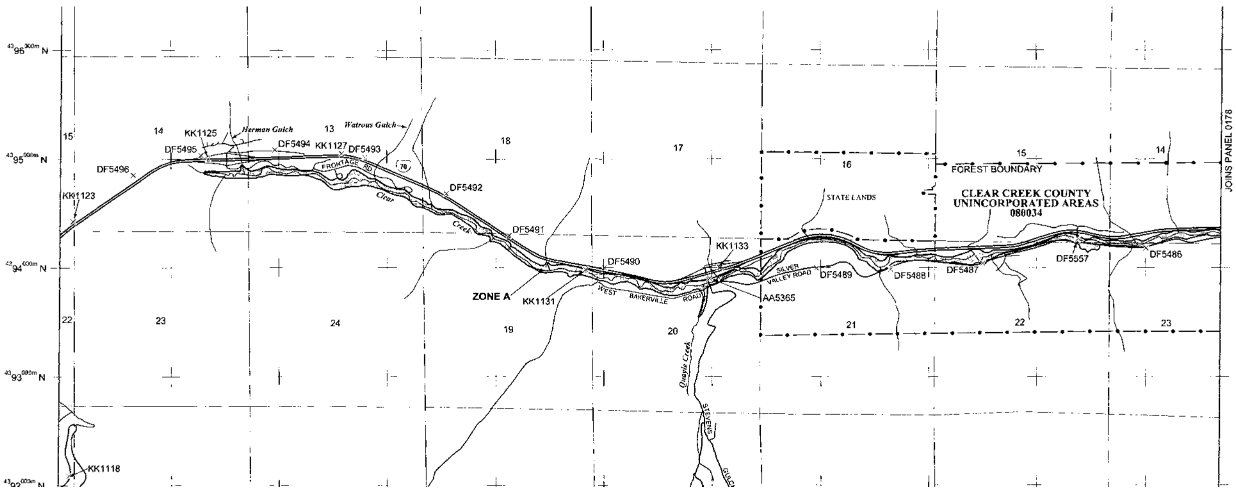


Figure 65. FEMA floodplain

4.3 Clear Creek Water Quality

Historic activities in the Clear Creek watershed, including mining, industry, recreation, and transportation have impacted the water quality of Clear Creek. The Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Commission Regulation No. 93 Colorado's Section 303(D) List of Impaired Waters and Monitoring and Evaluation List for the year 2021 was referenced for the latest water quality stream data collected. This is also known as the Section 303(d) list of impaired waters and monitoring and evaluation list. The mainstem of Clear Creek, within the project area, is included in segment COSPCL01 which includes the mainstem of Clear Creek, including all tributaries and wetlands, from the source to the I-70 bridge above Silver Plume, except for Kearney Gulch and Grizzly Gulch. This segment of Clear Creek is categorized as 1a/meets designated uses. Kearney and Grizzly Gulch have been retained on the M&E list which means there is insufficient data to make a determination. Downstream of the project at Silver Plume Clear Creek segment COSPCL02A_B is designated as 303d.

Figure 66 is from CDPHE impaired waters 303(d) ArcGIS online maps within the project areas.

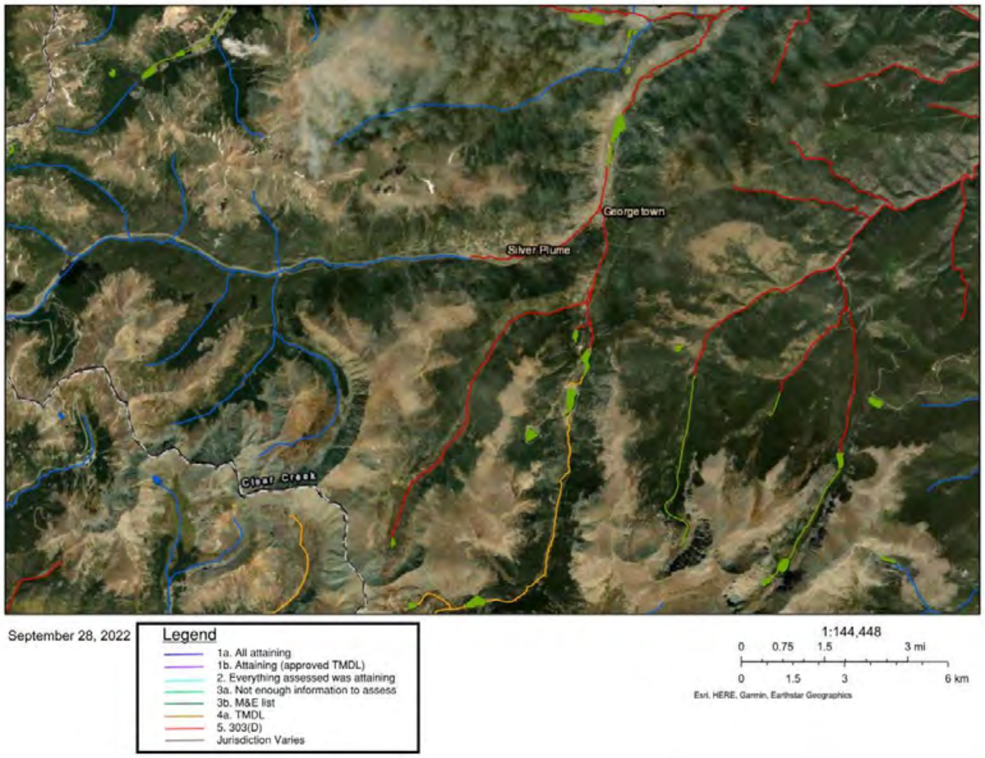


Figure 66. CDPHE stream segmentation

Clear Creek is monitored and has extensive water quality data including trace metal and nutrient concentrations. The trace-metals database is updated annually. The Watershed plan states that monitoring results show that high sediment concentrations result in higher nutrient and total trace-metal concentrations in Clear Creek. Sediment is the primary source of nutrient loading for total phosphorus and nitrogen resulting in values that exceed the proposed standard. Seasonal nutrient loads generated by sediment are two to three times greater than ambient (non-storm event) loads each year. The primary sources of sediment are from roads and unconsolidated mine waste residuals. Due to the recreational uses and environmental sensitivity of this reach of Clear Creek, CDOT has identified additional water quality requirements to be met with proposed projects in this study area to control and mitigate the impacts of sand and de-icer applications along the highway. The Stream and Wetland Ecological Enhancement Program Memorandum of Understanding was signed January 4, 2011 and provides direction for future projects through the I-70 Mountain Corridor.

Clear Creek mainstream receives it water from the source. This water serves all tributaries and wetlands in Clear Creek, except Kearney Gulch and Grizzly Gulch. Within the project area are Dry Gulch, Herman Gulch and Kearney Gulch.

The major existing water quality concern for this study area is disturbance of existing contamination, including heavy metals found in mine tailings and the application of sand and de-icing agents on I-70. Currently, there are no water quality treatment facilities along this section of I-70.

A Sediment Control Action Plan (SCAP) was developed in 2013 for the I-70 corridor with DOT and the local mountain communities participating. This document aids CDOT and other agencies manage roadway traction sand and other highway-related sediment sources that can adversely impact Clear Creek. CDOT has committed to implementing the SCAP for all reconstruction projects. This document was specifically developed for Clear Creek I-70 corridor between EJMT and Floyd Hill at Beaver Brook (MP 248). It provides guidance for environmental considerations and requirements, BMP design tools, CDOT maintenance program and implementation approach plan. The SCAP provides a map of sedimentation along this corridor. High traction sand use and/or highway slope erosion were found in the Project area. See **Figure 67** (SCAP Figure 2-7).

Figure 67. Sedimentation along I-70

In the 2014 Watershed Plan the sub-basin that covers the project was found to be high in spills form highways or publicly owned treatment works, highway sediment/salt loading, metal, and aggregate mining and moderate-high for channel erosion from hydrologic modification. The SCAP provides a sediment control strategy, hydraulic analysis, and treatment BMPs. Recommended preventive BMPs include snow fence, roadside ditches and swales, curb and gutter, clean water diversions, and snow storage. Recommended treatment BMPs include detention/sedimentation basins, loading dock sediment trap, inlet sediment traps and “sand cans”, underground vaults, infiltration-based retention areas, filter based, bioretention, filter strips and vegetated swales, constructed wetlands and erosion control.

The water quality approach will follow the recommendations in the SCAP for drainage analysis, BMPs, approach, targeted sources of pollutants.

There is currently one permanent water quality control measure near the project area, located near MP 223. This control was installed in 2019. This structure was found on CDOT OTIS.

5 EXISTING GEOTECHNICAL CONDITIONS

5.1 Avalanche

The main avalanche area along this section of corridor is located from MP 217.8 to 217.9. This avalanche path extends to the northwest above I-70 towards Mt. Bethel. Various mitigation methods have apparently been used in the past such as wind fences on top near the summit of Mt. Bethel and recontouring the slopes just above I-70 in an effort to break up an avalanche from impacting the roadway.

5.2 Debris Flow Pathways

The main historic debris flow that closed I-70 for a significant time period is located at what is known as Watrous Gulch located at MP 219.2. The USGS summarized the debris flow in a field trip publication (Coe, Open-File Report 02-398) in 2002. There is potentially a wildlife crossing planned at this location, but future debris flows will undoubtedly impact a future structure and should be considered when finalizing wildlife crossing locations in the design. At this time, it appears the areas above the other proposed wildlife crossings are mostly vegetated, but future forest fires and subsequent debris flows should be considered in the design.

5.3 Existing and Potential Landslides

The main historic landslide in this section of corridor is at the east portal of the westbound EJMT tunnel complex at MP 215. A large buttress was constructed over the tunnel portal to stabilize the hillside at this location.

Figure 68. Historic EJMT landslide area and buttress located at MP 215

Other potential large scale landslide sections extend from MP 215.5 to 216.4. The area above is mapped as Idaho Springs Formation (AIs) with glacial till (Qgt). The feature is not specifically mapped as a landslide but exhibits many of the geologic surfical conditions that are indicative of a landslide area. Potential cuts in the slope in this section may require an extensive geotechnical and geological investigation. Alignments that avoid cuts in this area would be preferable. If cuts are unavoidable, then extensive and creative slope stabilization mitigation may be required if there is the potential for a large-scale landslide.

Figure 69. USGS Mapped landslide area above I-70 from MP 215.5 to 216.4

Figure 70. Aerial view from US 6 interchange of landslide area above I-70 (MP 215.5 to 216.4)

5.4 Rockcuts and Ditch Widths

The existing rockcuts at the Bakerville exit were excavated using presplitting blasting techniques. Presplitting is generally the most straightforward blasting method and provides for the most stable rockcuts. However, it does leave a half cast of the vertical drill hole. **Figure 71** shows the westbound exit ramp at Bakerville (MP 221.3). Much of the **I**-70 corridor from Silver Plume to west of the Bakerville exit consist of presplitting with half casts.

Figure 71. Bakerville exit presplit rockcut

Some CSS related projects discourage presplit blasting techniques in favor of cushion or other blasting techniques. Cushion types of blasts generally leave a relatively unstable rockcut face that is much more prone to rockfall and unstable rock slopes. **Figure 72** below depicts a cushion blast on US 6 just east of the Bakerville exit.

Figure 72. US 6 cushion blast type rockcut

Cushion type rockcuts, while possibly more visually appealing than presplit, will require a much wider rockfall catchment ditch and/or other forms of rockfall netting and/or mesh to keep rockfall from impacting I-70. Depending on which rock blasting technique is permitted, the initial roadway design should consider the type of blasting cut proposed or accepted. Presplits are generally more stable and require less ditch vs cushion blasting that may require additional ditch width and/or mesh to ensure less rockfall on I-70.

6 EXISTING UTILITY CONDITIONS

6.1 Methodology

Subsurface Utility Engineering (SUE) Level C investigations are required during design and will be completed by the Farnsworth Group as part of the consultant team. This investigation will be in accordance with CDOT's 811 Summary (SB18-167) which requires location of underground utilities that meets or exceeds the Quality Level C.

6.2 Existing Conditions

Various overhead lighting exists within the project area. Lighting is provided for the parking lot and the truck pull-off in the approach to the EJMT, and lighting is provided along the chain stations. Electronic signs also exist in the approach to the EJMT and the chain stations. A mast arm with a traffic signal is used to meter traffic ahead of the eastern portal.

An underground fiber optic and electrical line runs parallel to I-70 on the north side of the westbound lanes. CDOT shares the fiber optic conduit with Comcast and Xcel Energy owns the electric lines. See figure below from bid plans of Project NO. SW 00-2264 I-70 Mesa, Garfield, Summit, Clear Creek, Jefferson Counties (Project Code 14606).

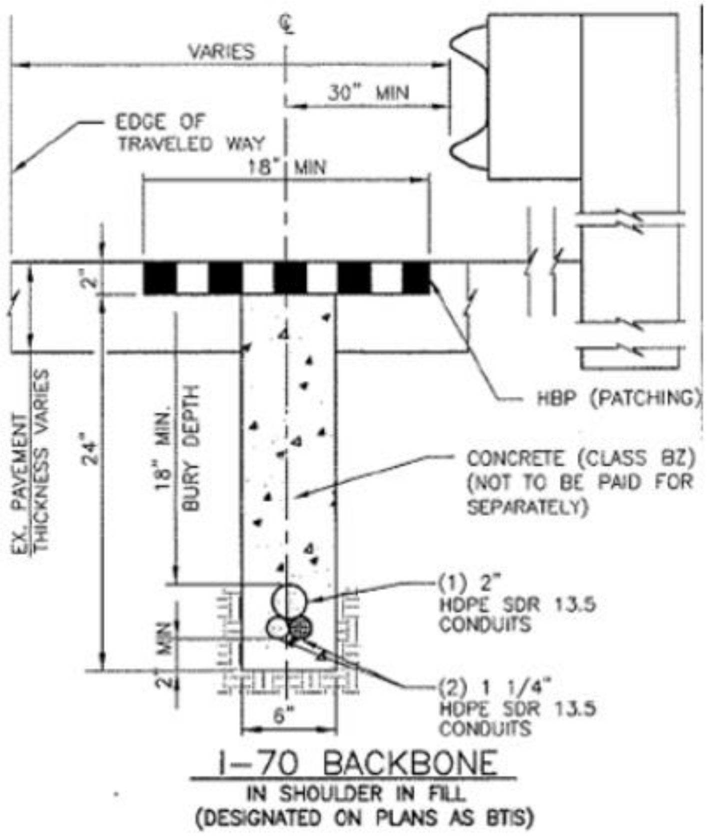


Figure 73. I-70 backbone diagram

Company/Agency	Utility Type	Name	Phone Number/Email Address
CDOT Region 1	Electric & Fiber		
CDOT ITS Fiber Backbone	Fiber	Jill Scott	(303) 512-5805 jill.scott@state.co.us
Century Link	Fiber & Telecom		
Comcast	CATV & Fiber	Local Contact – Tony Hildreth	(970) 589-5860 tony.hildreth@comcast.net
Xcel Energy	Electric, Gas, High Pressure Gas	Local Contact – Meredith Guinan	(970) 262-4022 meredith.quinan@xcelenergy.com
Zayo Bandwidth	Fiber Optic	Local Contact – Jeff Page	jeff.page@zayo.com
Lumen			
MCI/Verizon			

Table 5. Utilities Contact Information (**contacts pulled from other CDOT projects in the area, company/agency collected from 811 ticket)

7 EXISTING MULTIMODAL FACILITIES

7.1 Bicycle Facilities

The Bakerville to Loveland Trail runs parallel to I-70 on the south side of I-70 and Clear Creek, between Bakerville and the Loveland Ski Area. It is a 10-foot wide, paved, multi-use path that is also groomed in the winter months for fat bike, cross-country, and snowshoe access. There are parking areas at Bakerville and at the Loveland Ski Area for users to access the trail.

The US 6 Frontage Road (Silver Valley Road) east of the project area and US 6/Loveland Pass are designated as shared-use routes for vehicles and bicycles and provide connections to the east and to the west for regional bicycle trips.

7.2 Pedestrian Facilities

While pedestrians are prohibited on I-70 throughout the study area, the Bakerville to Loveland Trail provides the parallel connection that allows them to traverse from one end of the corridor to the other. Hikers use the Bakerville to Loveland Trail to access the Kearney Gulch hiking trail approximately one mile west of Bakerville, and the segment from Herman Gulch to Loveland Ski Area doubles as the Continental Divide Trail (CDT).

There are also two major hiking trailheads within the study area:

- The Bakerville interchange provides access to Grizzly Gulch Road and Stevens Gulch Road, the latter of which leads to the Grays Peak/Torreys Peak trailhead. An informal dirt parking area, along with 8 paved parking spaces, exist on the south side of the interchange. The parking area provides approximately 30 overall parking spaces for hikers/bicyclists and is filled on a regular basis on summer weekends.
- The Herman Gulch interchange serves as the trailhead for the Herman Gulch trail and provides access to the Watrous Gulch Trail and Bard Creek trail. It has an approximately 150-space parking lot that regularly fills early in the morning on summer weekends, with spillover vehicles parking along the westbound on- and off-ramps at the interchange. The USFS is currently designing a larger parking area to help alleviate the parking issues there.

Figure 74 shows the existing pedestrian and bicycle facilities in the study area.

Figure 74. Existing pedestrian and bicycle facilities and trails (source: Clear Creek County GIS website)

7.3 Transit Service

CDOT's Bustang/Snowstang regional transit service provides seasonal transit service to the study area. In the winter, Snowstang stops at the Loveland Ski Area at 8:30 AM and leaves the ski area at 4:00 PM every Saturday and Sunday during the ski season. During the summer, Bustang travels on I-70 but does not stop within the study area.

Although they do not stop within the study area, I-70 is used by the following transit and shuttle services:

- Greyhound
- Eagle Vail Express
- Epic Mountain Express
- Fresh Tracks Transportation
- Peak 1 Express
- Summit Express

8 TRAFFIC, TRAVEL FORECASTING, SAFETY, AND EXISTING ITS DEVICES

8.1 Roadway Environment

This segment of I-70 currently has two travel lanes in both the EB and WB directions. The EB and WB lanes of I-70 are separated by a median between Bakerville and the US 6/Loveland Pass exit, and by a concrete barrier between US 6/Loveland Pass and the EJMT entrance. There are three grade-separated interchanges along I-70 within the project limits (Bakerville, Herman Gulch and US 6/Loveland Pass) and chain up stations at MP 219.4 and MP 220.7.

The speed limit is posted at 65 mph with a minimum speed of 55 mph in the left lane. At MP 216 (near the US 6 Loveland Pass interchange) the speed limit is reduced to 50 mph as vehicles approaches the EJMT. There are variable speed limit signs for WB traffic at MP 220 (Bakerville on-ramp) and MP 221 (west of the Bakerville chain up station).

Colorado law requires that speed limits are not to be higher or lower than reasonable and prudent speeds under normal conditions (Section 42-4-1102, Colorado Revised Statutes). Posted speeds have limited effect on driver behavior; traffic investigations have shown that most people will drive the roadway as they perceive the conditions and will ignore a speed limit that is unrealistically too low or too high. To consider changing the posted speed of a roadway, a speed investigation is required that determines the prevailing speed, defined as the 85th percentile speed of motorists. Some speed studies have resulted in increasing the speed limit rather than reducing it.

CDOT is currently implementing variable speed limits (VSL) to the I-70 corridor between US 40 and Floyd Hill east of the study area. The concept of operations is based on the fact that after a certain critical threshold combination of speed and density is reached, the crash rate rises rapidly. The VSL project is developing an algorithm that will adjust speed limits based on volume, speed, weather, and road condition data. It will be first implemented in the eastbound direction using the existing VSL signs, followed by the westbound direction once the Floyd Hill widening project is complete.

The corridor's Annual Average Daily Traffic ranges is approximately 35,000 vehicles per day (vpd) near the EJMT, with WB Design Hourly Volumes at approximately 6.0 percent of the Annual Average Daily Traffic.

Observed field traffic data is contained in Appendix B of this document.

8.2 Data Collection Devices

CDOT collects a significant amount of traffic data along the I-70 Mountain Corridor using a variety of electronic devices listed below. These devices provided the data that was used to evaluate existing conditions for the study area.

- **Automatic Traffic Recorder (ATR).** These devices record volumes, speeds, and vehicle classifications on an hourly basis. There are ATRs at both portal entrances to the EJMT (MP 215.3 for the east portal and MP 213.6 for the west portal.
- **Microwave Vehicle Radar Detectors.** These devices use radar to record the speed of each vehicle. They are typically located on poles along the road and can also record speed data for each lane of a multi-lane facility. There are seven microwave vehicle radar detectors within the study area, four on the north side of I-70, two on the south side, and one in the median.
- **INRIX Data.** INRIX gathers real-time traffic data from commercial fleets, GPS, cell towers, mobile devices and cameras, and determines travel times and speed of vehicles through the corridor. INRIX data is available for the entire study segment (MP 215 to MP 221).

8.3 Seasonal Traffic Patterns

Figure 75 shows the monthly average daily traffic volumes at the EJMT ATR station. As the figure indicates, summer months (June through September) generate the highest daily traffic volumes, with winter volumes slightly lower. Traffic volumes drop significantly during the spring (April/May) and fall (October/November).

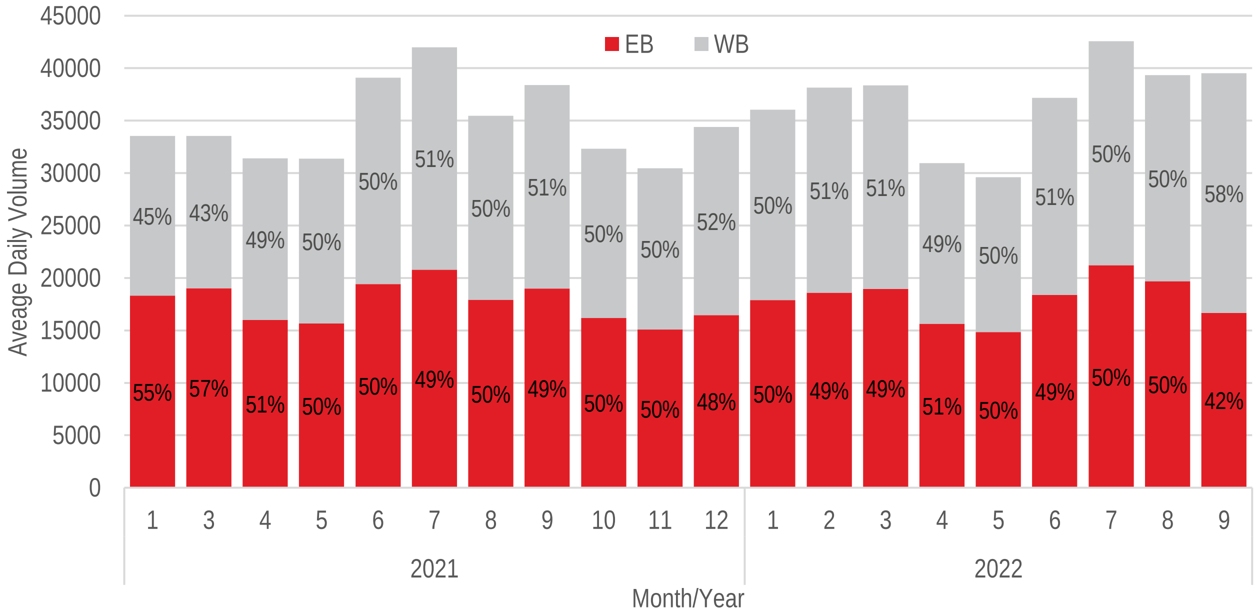


Figure 75. I-70 2021 & 2022 Average Daily Volumes by Month at EJMT

8.4 Daily Traffic Patterns

The I-70 mountain corridor is used for different purposes on weekdays (commercial, work, and recreation trips) and weekends (primarily recreation). **Figure 76** (summer) and **Figure 77** (winter) show that daily volume patterns during both seasons are highest on Friday through Sunday. While the total corridor traffic is highest on Sunday, westbound daily volumes are highest on Fridays and Saturdays as travelers drive into the mountains for recreational activities.

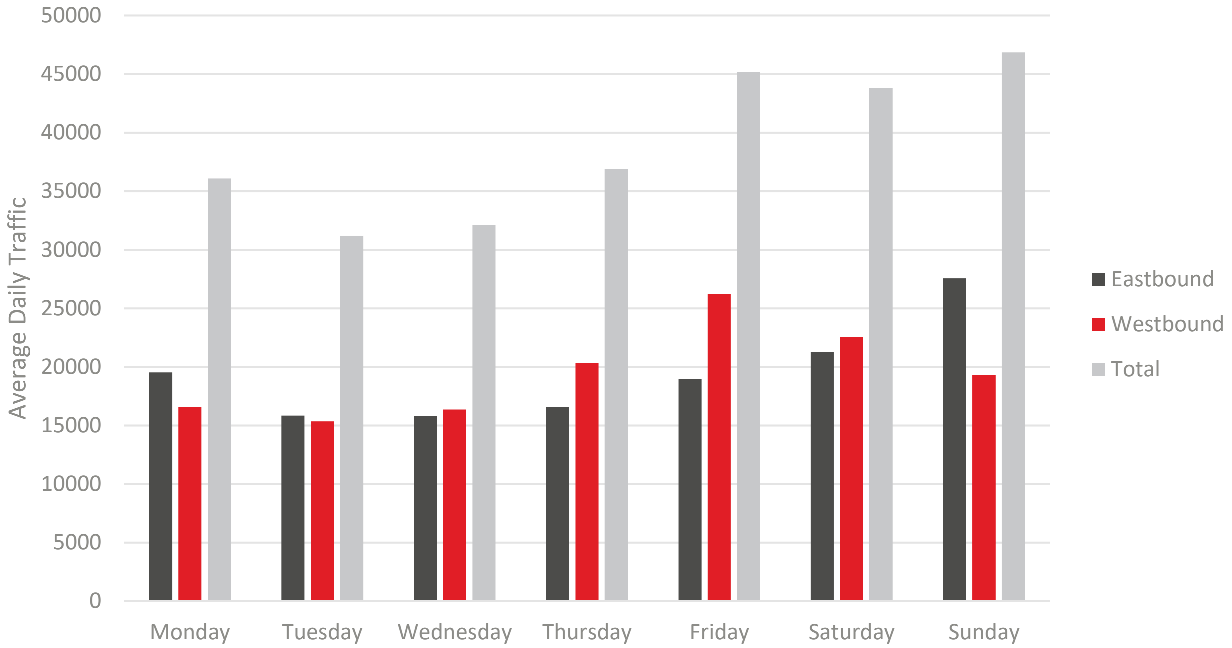


Figure 76. 2021 Summer Daily Traffic Patterns (June through September)

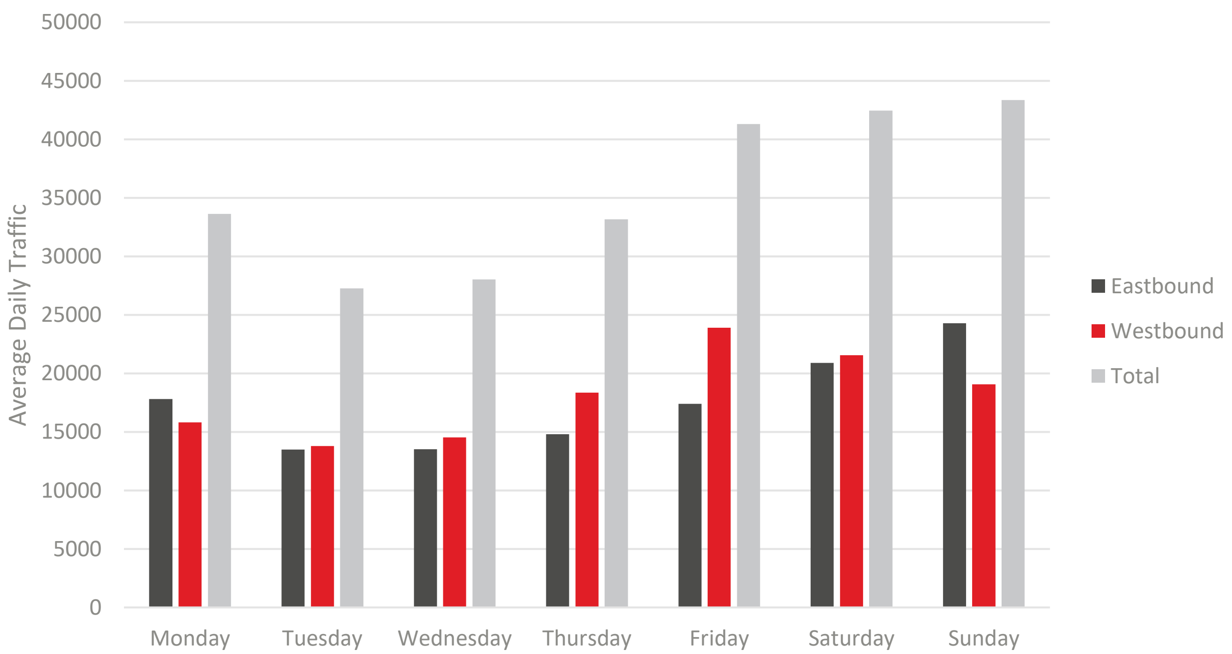


Figure 77. 2021 Winter Daily Traffic Patterns (December through March)

8.5 Truck Traffic

The annual average percentage of trucks traveling through the EJMT was 8.6 percent in 2021. Truck percentages vary by season due to variations in both truck volumes and passenger vehicle traffic. Further, truck volumes are lower and passenger traffic is highest during the weekend peak periods, so truck percentages on peak travel days are noticeably less than the annual average; winter weekend truck percentages are between 5 percent and 6 percent and summer weekend truck percentages are between 4 percent and 5 percent.

8.6 Chain-Up Stations

Colorado has a mandatory Chain Law which requires commercial vehicles, traveling in Colorado between September 1st through May 31st, to carry sufficient tire chains to be in compliance with the law. The law was initially enacted in 1996 and applies to all state, federal and interstate highways. Commercial vehicles without chains can often lose traction in inclement weather or poor road conditions, causing traffic delays and sometimes full closure of the highway. Passenger vehicles less than 16,001 pounds are required to carry chains if they do not have an all-wheel or four-wheel drive vehicle, or snow or all-weather tires with at least 3/16 inch tread.

There are two westbound chain-up stations on I-70 within the study area. The station at MP 220.7, west of the Bakerville interchange, provides 25 to 27 chain-up stalls over 2,345 feet of widened shoulder. The station at MP 219.4, east of the Herman Gulch interchange, provides 20 chain-up stalls over 1,640 feet of widened shoulder. The chain up stations consist of lighted parallel parking spaces of approximately 79 feet in length. The shoulder width at the chain-up stations are 15 feet versus the typical 10 foot outside shoulder. There is not a deceleration lane for vehicles to slow and pull into a stall, nor an acceleration lane for the vehicles to get back up to speed before entering traffic.

Commercial vehicles travelling slowly to find an open stall or waiting for one to vacate in the eastern-most chain-up station near Bakerville, cause large backups on the interstate. Traffic backups of 3 miles have been observed. Other commercial vehicles, where the driver is aware of the 2nd chain-up station, continue on and cause delays due to loss of traction on the uphill climb. Hazardous material drivers look for a stall covered in snow to help prevent any sparking as they chain up.

8.7 Design Day Volumes

CDOT has devices along the I-70 mountain corridor that continuously collect daily traffic volumes, so traffic data is readily available within the study area. For this project, data from the 2022 winter and summer peaks were analyzed. Conversations with CDOT indicated that the traffic evaluation should consider both a winter design day and a summer design day. Similar NEPA traffic evaluations for the I-70 WB PPSL and the WB Floyd Hill expansion projects considered traffic conditions based on 85th percentile volumes for those corridors, so for consistency with those evaluations, Saturday February 19, 2022 (President's Day weekend) was selected for the winter evaluation and Saturday July 9, 2022 was selected for the summer evaluation. The existing westbound daily volume on the winter design day within the Corridor was 25,420 vpd, which is generally representative of the 85th percentile volume for Fridays, Saturdays, and Sundays (typically the busiest days on the corridor) and 23,289 vpd on the summer design day, which is generally representative of the 85th percentile volume for the entire year.

On- and off-ramp traffic volumes were collected in August 2022 at the Bakerville, Herman Gulch and US 6 interchanges for this project.

Figure 78 shows the design day volumes for the study area.

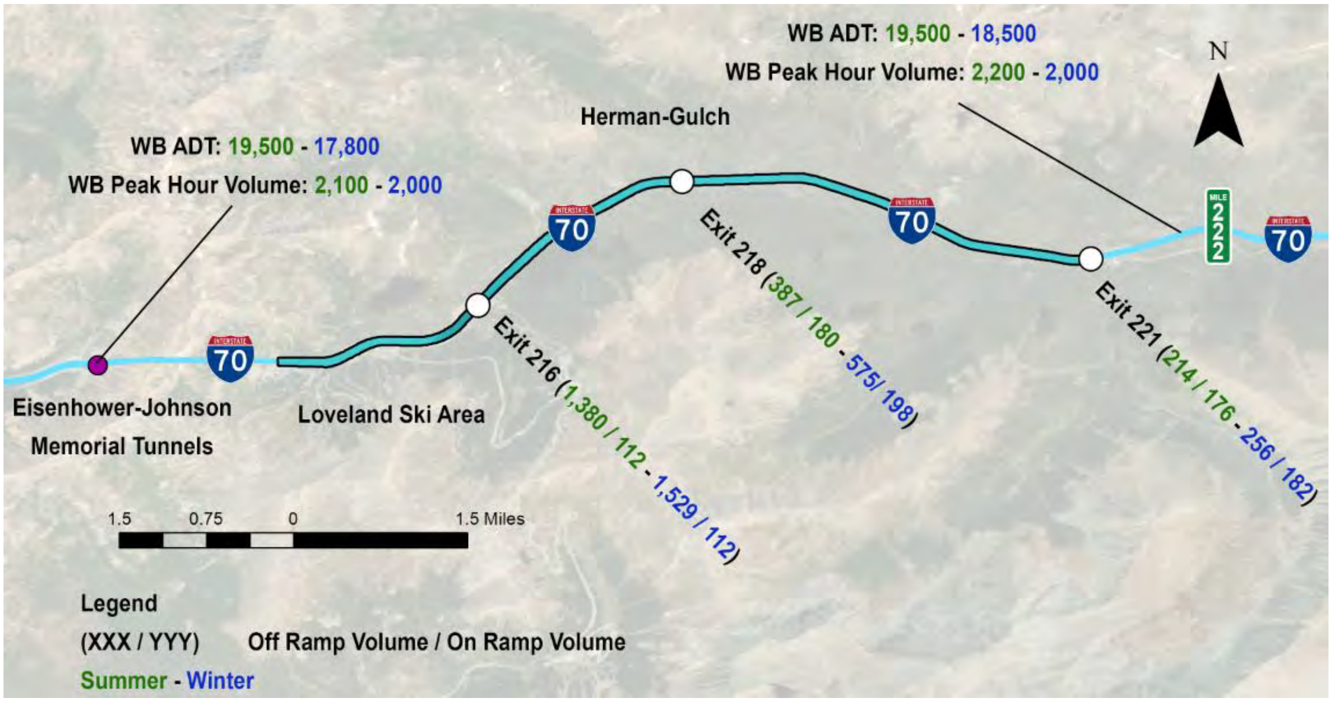
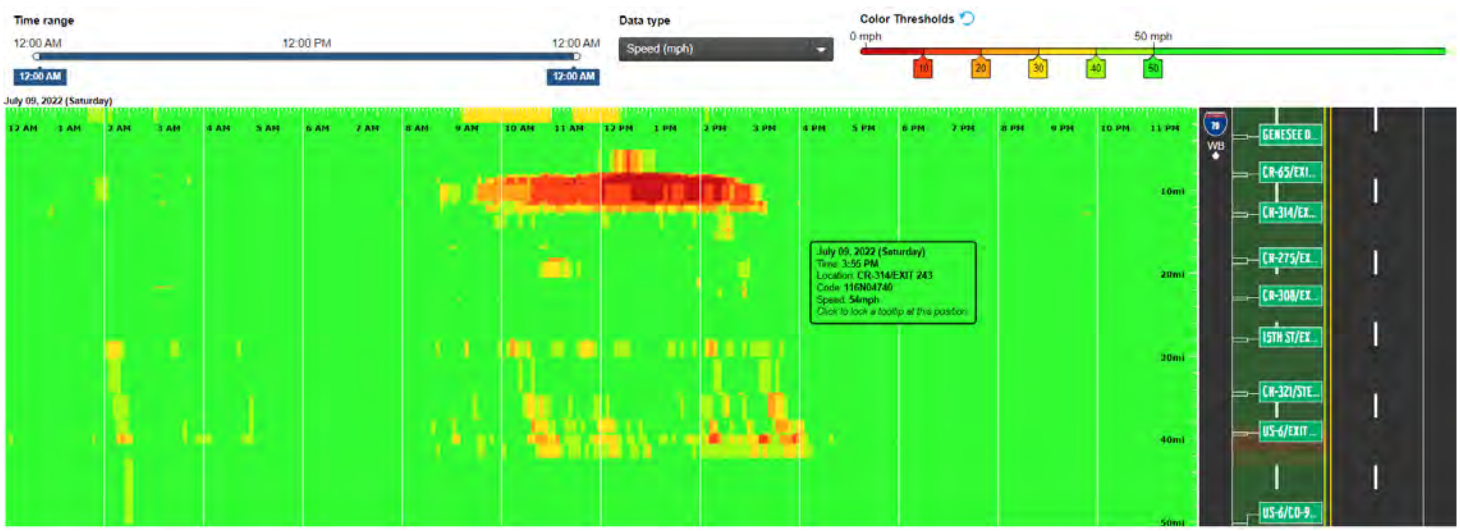


Figure 78. 2022 Winter and Summer Design Day Traffic Volumes

8.8 Design Day Congestion

Figure 79 and **Figure 80** show congestion for the summer and winter design days, respectively. **Figure 80** indicates that the winter congestion is heaviest between 6 AM and 8 AM around Floyd Hill, and from 7:30 AM to 9 AM through the PPSL segment. The study area for this project shows spot congestion near the US 6/Loveland Pass exit from 7 AM to 9 AM. **Figure 79** indicates that summer congestion persists at Floyd Hill from 9:30 AM to 3 PM, while congestion in the study area for this project is present from 10 AM to noon and again from 2 PM to 4 PM.



Source: INRIX Congestion Scan.

Figure 79. I-70 WB Congestion on July 09, 2022

Source: INRIX Congestion Scan.

Figure 80. I-70 WB Congestion on Feb 19, 2022

8.9 ITS Devices

ITS infrastructure is critical for informing the traveling public in this section of I-70 because of the terrain and variable weather conditions. CDOT's fiber trunk line runs along the north side of the study area, adjacent to pavement. The current inventory of ITS in the project study area includes variable speed limit (VSL) signs, overhead variable message sign (VMS), weather stations, one traffic camera, and one vehicle over-height sensor located approximately a quarter of mile east of the tunnel. **Figure 81** shows the current location of these structures in the project area.

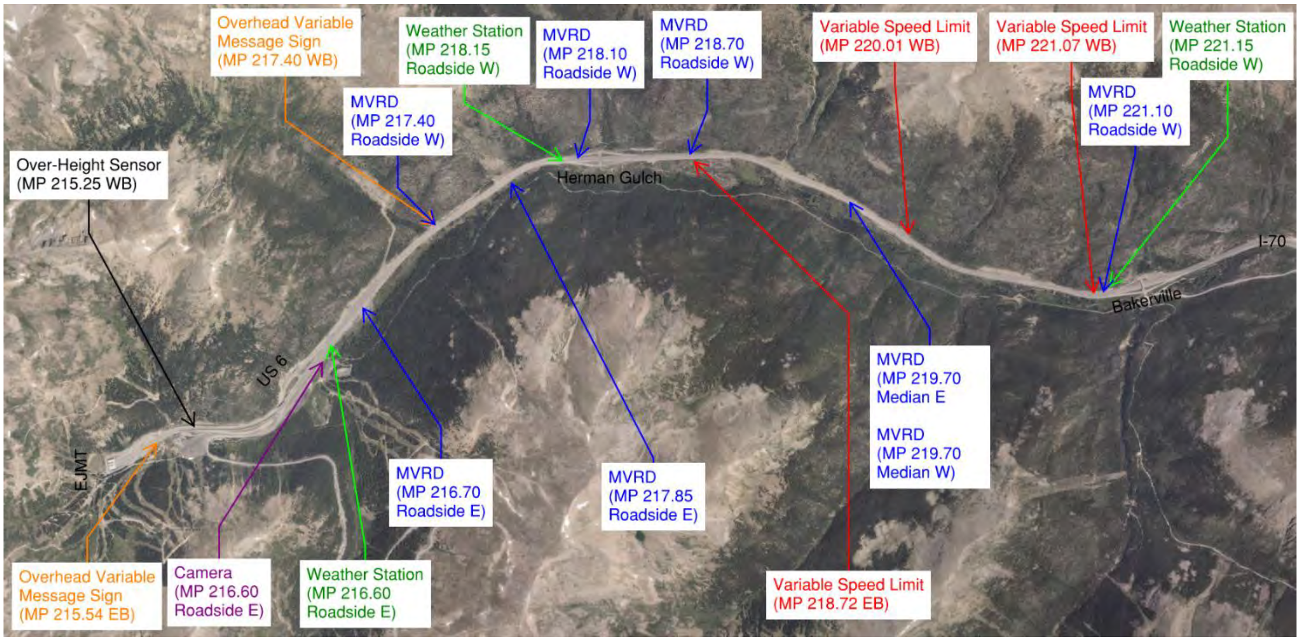


Figure 81. Existing ITS devices

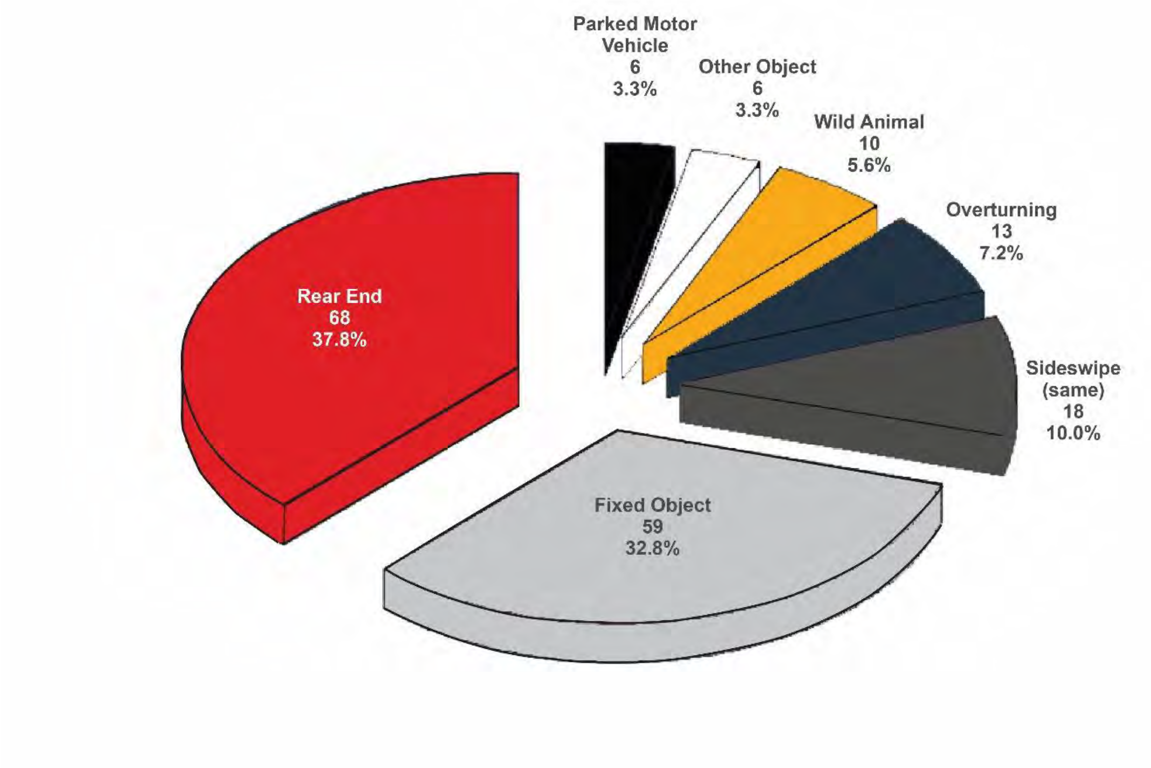
8.10 Safety Assessment

The following findings are taken from the *DRAFT Interstate 70 Directional Safety Assessment Report: MP 215.30 to MP 221.50 Bakerville Interchange to Eisenhower Tunnel East Portal* (DiExSys 2022; Appendix A). The safety assessment focused on crashes that occurred between January 1, 2015, and December 31, 2021 on westbound I-70 within the study area. All data reported here is for the WESTBOUND direction only.

8.10.1 Crash Patterns

A total of 180 crashes were reported in the westbound direction during the 6-year time period. This represents 37 percent of the 492 total crashes on the corridor (the balance was in the eastbound direction). Of these crashes, 73 percent were property damage-only crashes and 27 percent were injury or fatal crashes.

Figure 82 shows the distribution of WB crash types that occurred within the study area. The most predominant crash type was rear-ended collisions (38 percent), followed by fixed object collisions (33 percent) and sideswipe collisions (10 percent). Of the fixed object collisions, cable rail was the most common type of object struck, followed by embankment and guardrail.



(Source: *DRAFT I-70 Directional Safety Assessment Report: MP 215.30 to MP 221.50 Bakerville Interchange to Eisenhower Tunnel East Portal (DiExSys 2022)*)

Figure 82. I-70 Mainline Crash Distribution by Type, MP 215.30 to MP 221.50 (WB Direction)

Crash pattern recognition identified a pattern of cable rail and embankment collisions for the segment between the EJMT and the Herman Gulch interchange. Crashes occurring during adverse winter road and weather conditions are also an identified pattern in that segment. For the segment between the Herman Gulch interchange and the Bakerville interchange, the crash pattern recognition identified a pattern of injury, multi-vehicle, rear-end, and cable rail crashes, as well as crashes occurring under winter road conditions.

8.10.2 Crash Locations

To facilitate a more detailed crash analysis, the 6-mile corridor was divided into two segments:

- Segment 1: Herman Gulch to EJMT – MP 218.38 to MP 215.30
- Segment 2: Bakerville to Herman Gulch– MP 221.50 to MP 218.39

Level of Service of Safety (LOSS) is calculated for both crash frequency and crash severity in each segment. The concept of LOSS uses qualitative measures that characterize safety of a roadway segment in reference to its expected performance. If the level of safety predicted represents a normal or expected number of crashes at a specific level of Average Daily Traffic, selected percentiles within the frequency distribution are stratified to represent specific LOSS.

- LOSS I—Indicates a low potential for crash reduction (below 20th percentile)
- LOSS II—Indicates a low to moderate potential for crash reduction (20th percentile to mean)
- LOSS III—Indicates a moderate to high potential for crash reduction (mean to 80th percentile)
- LOSS IV—Indicates a high potential for crash reduction (above 80th percentile)

For the WB frequency of crashes, both segments operate at LOSS II and thus have low to moderate potential for crash reduction.

For the severity of crashes, Segment 1 operates at LOSS II and thus has low to moderate potential for crash reduction, while Segment 2 operates at LOSS III and thus has a moderate to high potential for crash reduction.

9 AESTHETIC GUIDELINES

While evaluating the addition of an auxiliary lane to westbound I-70, design changes will consider all aesthetic principles set out by the core values in the I-70 Mountain Corridor Context Sensitive Solutions. Overall, the aesthetic principles are inspired by the surroundings, protect scenic integrity, and incorporate the context of place.

As a reference, aesthetic design treatments will:

- Support safety and mobility
- Support communities and regional destinations by providing direct and subliminal messaging for gateways, connections, access, and identification
- Maintain a sense of the greater whole
- Respect the current time and place
- Integrate with functional elements
- Borrow materials from the landscape
- Showcase key views while buffering inconsistent views
- Include maintenance considerations and responsibilities

9.1 Guardrail

Currently throughout the project limits, there exists types of guardrails that do not currently meet the I-70 Mountain Corridor Aesthetic Guidance for the Crest of the Rockies segment which the project falls into. As the design of the auxiliary lane progresses, consideration for impacting/replacing guardrail will be taken into consideration. As the guideline's state, the use of cable rail is strongly discouraged in this segment of the corridor because of the long-term maintenance cost and aesthetics. The use of Type 3 Guardrail W Beam with wooden posts are preferred for guardrails. Median barriers should only be considered where the median width or the vertical separation between east and west bound lanes cannot meet the Design Criteria.

Currently, the median guardrail features from MP 216 to MP 221 include concrete structural fixed guardrail, 3-strand cable rail, and blocked out W-beam. Sections of these safety features within the median and outside shoulder are subject to improvement.

9.2 Structures

The existing structures in the study area do not meet many of the design criteria presented in the Crest of the Rockies Aesthetic Guidance. The existing structures are of different designs, utilizing different materials, geometries, and features that do not promote visual continuity throughout the corridor. Some of the prominent deficiencies are:

- The approach and abutment embankments are at slopes steeper than those allowed by the earthwork guidelines
- The structures do not employ the correct color schemes or deliberate shadows
- Some of the structures have open abutments and appear cluttered underneath
- The structure guidelines recommend using box girder superstructures, which none of the bridges utilize

9.3 Rock Cuts & Modifications

Several methods of rock cuts have been utilized throughout the project limits. The existing rock cuts at the Bakerville exit occurred prior to the aesthetic guidelines being established. This area used a presplitting blasting technique that left vertical drill holes which is in disagreement with the guidelines. Any future rock cuts should employ custom naturalize cuts and staggered benches and avoid the use of straight vertical cuts and benches that have a sheer, unnatural appearance. In addition, any rock cuts should use scatter blasting techniques and random rock drilling at varying depths to cause rock to break in natural patterns and expose natural rock fractures.

Other aspects of the aesthetic guidelines, other than the specific techniques for rock cutting that will be considered during the design process, is to evaluate moving the road away from the rock face to avoid rock fall protection. This may be difficult due to the narrow median width along the corridor.

10 RECOMMENDATIONS FROM THE EXISTING CONDITIONS REPORT

10.1 Changes within the Roadway Footprint

Due to substandard ramps, sight distance and alignment of US 6 interchange, it is highly recommended that the US interchange be relocated to the east. Moving the interchange east will allow removal of the loop on-ramp to WB I-70 which requires low speeds and a lack of acceleration length to get up to speed traveling uphill with I-70 climbing grades. Moving east will also provide greater sight distance around the mountain to the northwest, increasing reaction time for queues in the approach to EJMT. Numerous accidents occur EB where sight distance is hampered in the approach to US 6 and icing of the I-70 skewed structure over US 6 is common. Relocating the interchange to the east will improve sight distance for both WB and EB travel and will allow for a perpendicular bridge over US 6 resulting in less deck surface for icing.

Additional foreseeable changes along the roadway include the relocation of utilities and fiber optic. The underground fiber optic and electrical line that exist parallel to I-70 on the north side of the westbound lanes will be impacted in areas the auxiliary lane is added to the north. Coordination with the owners will be necessary and it is currently known that CDOT shares the fiber optic conduit with Comcast and Xcel Energy owns the electric lines. As the fiber optics approaches the Eisenhower Johnson Memorial Tunnel, relocation of the utilities will be evaluated as to avoid landslides or major rock cuts in non-stable areas.

10.2 Consideration of Risk and Resiliency

Due to the critical function of I-70 and being the only east-west continual corridor through Colorado that is heavily depended on for freight movement, preserving the function of the interstate is critical. Shifting US 6 to the east will allow for upgrading the ramps to standard lengths and avoids impacting the hillside in the approach to EJMT, thus avoiding a potential landslide area.

Increasing the height or length of the berm at the avalanche chute at MP 217.8 and installing detection and automatic launch devices could prevent a large avalanche from building and moving onto the interstate.

At MP 219.2, an increase in the culvert size under I-70 and adding a dissipation field for the debris flow at Watrous Gulch could help to mitigate debris from closing the interstate.

Two wildlife crossings near each end of the project, along with wildlife fence, will improve the safety for the traveling public and reduce vehicle and animal collisions that can close down the interstate.

10.3 Structures Recommendations

The following are Ulteig's preliminary recommendations for the 6 structures in the project limits based on the existing conditions.

F-13-O

The recommended action for structure F-13-O is replacement. To widen the structure, rehabilitation of the existing bridge deficiencies will need to be addressed. It is anticipated US Highway 6 will be realigned east of the current bridge location to intersect I-70 at a perpendicular angle. The replacement of F-13-O could also be combined with a replacement of F-13-P placing both westbound and eastbound I-70 onto one structure.

F-13-P

The recommended action for structure F-13-P is replacement. It is anticipated US Highway 6 will be realigned east of the current bridge location to intersect I-70 at a perpendicular angle. Additionally, given F-13-P's proximity to F-13-O, replacing F-13-O will require modifications to F-13-P since the structures share a deck joint, abutments, and traffic barriers. The replacement of F-13-P could also be combined with a replacement of F-13-O placing westbound and eastbound I-70 onto one structure.

F-13-J

The recommended action for structure F-13-J is replacement. To widen the structure, the poor condition of the existing deck needs to be addressed. The deck has widespread cracking, delamination, and efflorescence indicating the deck is at the end of its service life and should be replaced. For cast-in-place monolithic T-girders superstructures, girder shoring will be required to replace the deck. The girder shoring will require a prolonged closure of Herman Gulch Road. Replacing the bridge would not require the prolonged closures of Herman Gulch Road. Drainage west of the bridge needs to be addressed with rundowns to keep surface water from flowing onto the structure.

Additionally, the bridge is 50 years old and is near the end of its life cycle. Replacing the deck is necessary to widen the bridge but would be a large cost that would not extend the overall life of the structure.

F-13-L

The recommended action for structure F-13-L is replacement. The deck has widespread cracking, delamination, and efflorescence indicating the deck is at the end of its service life and should be replaced. For cast-in-place monolithic T-girders superstructures, girder shoring will be required to replace the deck. The girder shoring will require a prolonged closure of Herman Gulch Road. Replacing the bridge would not require the prolonged closures of Herman Gulch Road.

An additional alternative is to combine the replacement of F-13-J and F-13-L. If the widening of F-13-J is towards the median, the bridges will be in close proximity, and it may be viable to place westbound and eastbound I-70 onto one structure.

Additionally, the bridge is 50 years old and is near the end of its life cycle. Replacing the deck is necessary to widen the bridge but would be a large cost that would not extend the overall life of the structure.

F-13-T

Although this structure was not listed in the RFP, it is in the project limits and the field inspection shows a need for repairs. The recommended action for structure F-13-T is rehabilitation pending no action is required to correct section loss on corroded areas of the steel girders. The following maintenance items should be performed to extend the life of the structure and improve public safety:

- Replace the bridge rail with MASH compliant bridge rail including upgrading the approach rail transitions and end terminals
- Repair or replace the curbs on the bridge and approach slabs
- Repair the erosion underneath the approach slabs and install adequate drainage to mitigate further erosion
- Clean and paint all girders, cross frames and bearing plates
- Replace deformed elastomeric bearing pads
- Remove asphalt impacted into expansion joints
- Remove the existing, peeled concrete coatings on the abutments, wingwalls, curbs, and deck overhang and replace with new coating

It is understood that westbound structures F-13-O and F-13-J will need to be widened to accommodate the new auxiliary lane, but a comparative analysis between widening, rehabilitation, and replacement still needs to be performed to determine the best course of action.

Culvert 070A215590BL

The recommended action for structure 070A215590BL is rehabilitation. The following maintenance items should be performed to extend the life of the structure and improve its appearance:

- Patch the exposed reinforcement in the culvert headwalls and divider

- Clean and seal the construction joint near the culvert outlet
- Replace the tipping wingwalls at the culvert outlet
- Apply a colored concrete coating to improve the aesthetic appearance of the culvert

10.4 Safety Recommendations

The safety assessment recommends the following safety enhancements for the corridor:

- In general, a westbound auxiliary lane would contribute to improved operations along a corridor which experiences a notable amount of heavy commercial vehicle traffic on steeper grades. As such, any widening efforts would improve safety as it applies to all traffic.
- A flow and weather based VSL system in both WB and EB direction will have the potential to meaningfully improve safety.
- Added stalls, improvement in signage and acceleration/deceleration lanes into chain-up stations would prevent mile long queues and delays due to commercial vehicles looking for open stalls or pulling in or out of traffic.

Appendix A

Safety Study

Colorado Department of Transportation
Traffic Safety and Engineering Services
2829 West Howard Place
Denver, CO 80204

Interstate 70
Directional Safety Assessment Report
MP 215.30 to 221.50
Bakerville Interchange to Eisenhower Tunnel East Portal

Colorado Department of Transportation
Traffic Safety and Engineering Services
2829 West Howard Place
Denver, CO 80204

This report is prepared solely for the purpose of identifying, evaluating and planning safety improvements on public roads. It is subject to the provisions of 23 U.S.C.A. 409, and therefore is not subject to discovery and is excluded from evidence. Applicable provisions of 23 U.S.C.A. 409 are cited below:

> *Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130, 144, and 152 of this title or for the purpose of developing any highway safety construction improvement project which may be implemented utilizing Federal-aid highway funds shall not be subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists or data.*

Any intentional or inadvertent release of this report, or any data derived from its use shall not constitute a waiver of privilege pursuant to 23 U.S.C.A. 409.

Colorado Department of Transportation
Traffic Safety and Engineering Services
2829 West Howard Place
Denver, CO 80204

STATEMENT OF PHILOSOPHY

The efficient and responsible investment of resources in addressing safety problems is a difficult task. Since crashes occur on all highways in use, it is inappropriate to say of any highway that it is safe. However, it is correct to say that highways can be built to be safer or less safe. Road safety is a matter of degree. When making decisions effecting road safety it is critical to understand that expenditure of limited available funds on improvements in places where it prevents few injuries and saves few lives can mean that injuries will occur and lives will be lost by not spending them in places where more accidents could have been prevented[1]. It is CDOT's objective to maximize crash reduction within the limitations of available budgets by making road safety improvements at locations where it does the most good or prevents the most crashes.

INTRODUCTION

The primary intent of this report is to update with most current crash data and validate an existing safety assessment report of the corridor provided by CDOT. Additionally, we will introduce directional safety analysis using Colorado-specific predictive and diagnostic tools. The report is prepared in the context of a planned westbound lane widening effort and identifies opportunities for safety improvements justified by crash history, to improve safety on the I-70 corridor between Bakerville (Stevens Gulch Road interchange) and the Eisenhower Tunnel east portal. This study will:

- Assess the magnitude and nature of the safety problem within the project limits by direction.
- Relate crash causality to roadway geometrics, roadside features, traffic control devices, traffic operations, driver behavior, road conditions, maintenance and vehicle type.

This report is based on the comprehensive analysis of 6 years of crash history, and traffic volume available from CDOT website and databases. The Region is advised to verify through field survey the information included in this report regarding physical features and roadside characteristics in the study area.

[1] Hauer, E., (1999) Safety Review of Highway 407: Confronting Two Myths. TRB

SITE LOCATION

The original safety assessment provided by CDOT addressed the I-70 corridor between MP 215.30-221.50 as a whole for both directions. This study addresses I-70 eastbound and westbound separately between the Eisenhower Tunnel east portal, MP 215.30, and the Stevens Gulch Road (Bakerville) interchange, MP 221.50. The included distance is approximately 6.20 miles.

SITE CONDITIONS

I-70 is classified as a rural interstate freeway on mountainous terrain. I-70 is a 4-lane, divided freeway with 12’ lanes. According to the most current information available on the CDOT OTIS website, the Average Annual Daily Traffic (AADT) is 36,000 west of MP 216.19 and 37,000 east of MP 216.19.

The speed limits eastbound are 50 mph west of MP 216.00, then 65 mph to 221.50. Westbound, the speed limit is 65 mph from MP 221.50 to MP 215.90, and west of MP 215.90 the speed limit is 50 mph.

Outside shoulder width along the study segment is typically 15 feet, while inside shoulder width is typically 4 feet. There is a median concrete barrier from MP 215.30 to approximately MP 216.35, after which a depressed grass median is typically seen for the remainder of the study limits. There is also median cable rail in the eastbound direction from MP 216.35 to MP 221.50.

CRASH HISTORY AND PROBLEM ANALYSIS

The mainline, non-intersection crash history for the period of 01/01/2015 through 12/31/2020 was examined between MP 215.30 and MP 221.50 to locate crash clusters and identify crash causes. Four hundred and ninety-two (492) crashes (310 or 63% of crashes eastbound, 180 or 36.6% of crashes westbound, and 2 unknown) were reported in the 6-year period with 363 Property Damage Only (PDO) (229 eastbound, 132 westbound, 2 Unknown), and 128 Injury crashes (80 eastbound, 48 westbound) with 211 people injured (127 eastbound, 84 westbound), and there was 1 Fatal crash with 1 fatality occurring eastbound.

Table 1 summarizes the crash history for I-70 (both directions) over the 6-year period from 01/01/2015 to 12/31/2020, with the number of people injured or killed in parentheses.

Year	AADT	PDO	Injury	Fatal	Total
2015	32,847	62	29 (44)	1 (1)	**92**
2016	36,540	75	16 (32)	0 (0)	**91**
2017	36,847	61	17 (35)	0 (0)	**78**
2018	36,000	52	23 (34)	0 (0)	**75**
2019	37,847	60	21 (38)	0 (0)	**81**
2020	37,847	53	22 (28)	0 (0)	**75**
Average	**36,321**	**60.5**	**21.3 (35.2)**	**0.16 (0.16)**	**82**

Table 1: Summary of Crash History, I-70 MP 215.30 – 221.50 (Both Directions)

Crash history records for the 6-year period which was analyzed confirm the same distribution of crash types for the entire corridor as identified in the safety assessment furnished by CDOT. That is, Rear End crashes were the most common crash type observed (41.3%), followed by Fixed Object crashes (35.4%) and sideswipe same direction crashes (10%). In terms of fixed object crashes the most common crash type was Cable Rail (36.2%), followed by Guard Rail (23%) and Concrete Barrier (16.7%) for mainline only crashes.

SAFETY PERFORMANCE FUNCTIONS and LEVEL OF SERVICE OF SAFETY

We have refined the assessment of the magnitude of safety problems on highway segments through the use of Safety Performance Functions (SPF). The SPF reflects the complex relationship between traffic exposure measured in AADT, and crash count for a unit of road section measured in crashes per mile per year (CPMPY). The SPF models provide an estimate of the normal or expected crash frequency and severity for a range of AADT among similar facilities. Two kinds of Safety Performance Functions were calibrated. The first one addresses the total number of crashes and the second one looks only at crashes involving an injury or fatality. Together they allow us to assess the magnitude of the safety problem from the frequency and severity standpoint.

Development of the SPF lends itself well to the conceptual formulation of the Level of Service of Safety (LOSS). The concept of Level of Service of Safety uses qualitative measures that characterize safety of a roadway segment in reference to its expected performance and severity. If the level of safety predicted by the SPF will represent a normal or expected number of accidents at a specific level of AADT, then the degree of deviation from the norm can be stratified to represent specific levels of safety.

LOSS I - Indicates low potential for crash reduction
LOSS II - Indicates low to moderate potential for crash reduction
LOSS III - Indicates moderate to high potential for crash reduction

LOSS IV - Indicates high potential for crash reduction

LOSS boundaries are calibrated by computing the 20^{th} and the 80^{th} percentiles using the Gamma Distribution Probability Density Function[2]. Gradual change in the degree of deviation of the LOSS boundary line from the fitted model mean reflects the observed increase of variability in crashes/mile as AADT increases. This increase is consistent with a Gamma Distribution error structure and reflects dispersion around the mean typical of this highway environment. LOSS reflects how the roadway segment is performing in regard to its expected crash frequency and severity at a specific level of ADT. If the safety problem is present, LOSS will only describe its magnitude from the frequency and severity standpoint. The nature of the problem is determined through diagnostic analysis using direct diagnostics and pattern recognition techniques.

CORRECTING FOR REGRESSION TO THE MEAN BIAS USING THE EMPIRICAL BAYES METHOUD

In road safety the average of several years of crash history of a highway segment or of an intersection provides us with an estimate of what is likely to be observed in the future. The precision of this estimate, however, can be improved upon by correcting it for the Regression to the Mean (RTM) bias. RTM phenomenon reflects the tendency for random events, such as vehicle crashes to move toward the average during the course of an experiment or over time. For instance, if a segment or an intersection exhibits unusually high or unusually low crash frequency in a particular year, because of RTM we need to be aware that over the long run its true average is closer to the mean representing safety performance of similar facilities. The existence of the RTM bias has been long recognized and is now effectively addressed by using the Empirical Bayes (EB) method[3]. The use of the EB method is particularly effective when it takes a long time for a few accidents to occur, as is often the case on Colorado rural roads.

The EB method for the estimation of safety increases the precision of estimation and corrects for the regression to the mean bias. It is based on combining the information contained in crash counts (known crash history) with the information contained in knowing the safety of similar entities. The information about safety of similar entities is brought into the EB procedure by the SPF through use of expected mean value and over-dispersion parameter associated with the specific SPF. EB corrected values of frequency and severity of crashes will be used in the SPF analysis to assess the magnitude of the safety problem.

[2] Kononov, J., Durso, K, Lyon, C and Allery, B. Level of Service of Safety Revisited. , *In* T*ransportation Research Record No 2514,* TRB, National Research Council, Washington, DC 2015, pp 10-21

[3] Hauer et al. Estimating Safety by the Empirical Bayes Method. In *Transportation Research Record 1174,* TRB, National Research Council, Washington, D.C., 2002, pp 126-131.

SAFETY PERFORMANCE ANALYSIS WITHIN PROJECT LIMITS

Figure 1 and **Figure 2** show typical sections of I-70 in each direction within the study segment.

Figure 1: Typical View Eastbound, I-70 MP 215.30-221.50

Figure 2: Typical View Westbound, I-70 MP 215.30-221.50

Figure 3 shows continuous corridor SPF analysis of the safety performance of the study area of I-70, MP 215.30 – 221.50. From the severity standpoint about half of the study area performs in the LOSS-III and LOSS-IV category, primarily between MP 215.30 to MP 218.30, reflecting moderate to high potential for crash reduction and high potential for crash reduction, respectively, with a local departure to LOSS-II in advance of MP 217.30. The other half performs in the LOSS-II category generally, between MP 218.30 to 221.50, reflecting low to moderate potential for crash reduction, with a local departure into LOSS-I following MP 219.30.

In terms of total crash frequency, the study area performs primarily in LOSS-II category, reflecting low to moderate potential for crash reduction. Except between MP 215.60 and MP 216.70 approximately, where it moves through performing in the LOSS-III and LOSS-IV categories, reflecting moderate to high potential for crash reduction and high potential for crash reduction, respectively.

The highest LOSS in terms of both total crash frequency and crash severity is seen between the eastern portal of the tunnel and the Loveland Pass interchange.

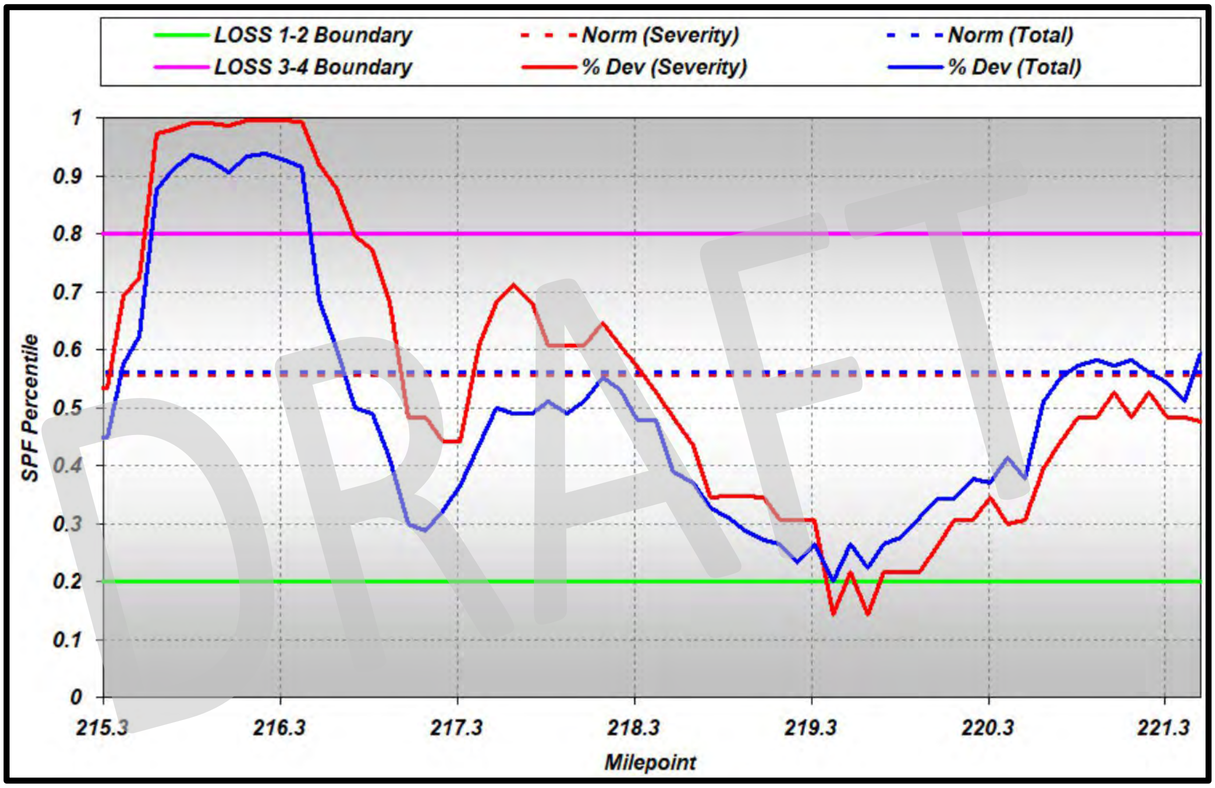


Figure 3: Continuous Corridor SPF (Both Directions)

Figure 4 shows that crashes are not split evenly by direction in the study area. Eastbound is characterized by downhill grades while westbound is characterized by uphill grades. From this point forward the analysis builds on the initial safety assessment provided by CDOT and becomes directional, with the eastbound and westbound corridor considered separately.

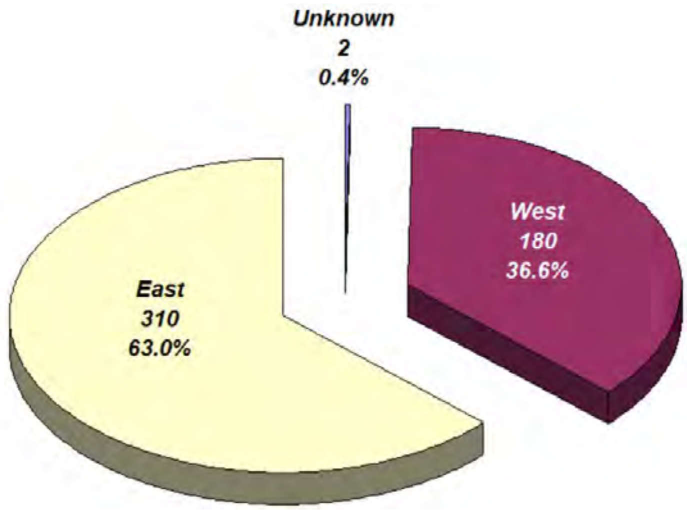


Figure 4: Directional Split of Crashes MP 215.30-221.50

Furthermore, the corridor will be split into segments for directional analysis. Typically, a segment would be measured between the midpoints of major interchanges, however, because there are only three major interchanges along the study segment (Loveland Pass MP 216.21, Herman Gulch Road MP 218.38, and Stevens Gulch Road MP 221.31) with the study limits extending a short distance westbound in advance of the first interchange and a small distance eastbound beyond the third interchange, the study area will be split into two segments in each direction for analysis as follows (see **Figure 5**):

- Segment 1: MP 215.30 to MP 218.38, Eisenhower Tunnel east portal to Herman Gulch Road interchange (referred to as Segment E1 and Segment W2, for eastbound and westbound directions, respectively)
- Segment 2: MP 218.39 to MP 221.50, Herman Gulch Road interchange to Stevens Gulch Road interchange (referred to as Segment E2 and Segment W1, for eastbound and westbound directions, respectively)

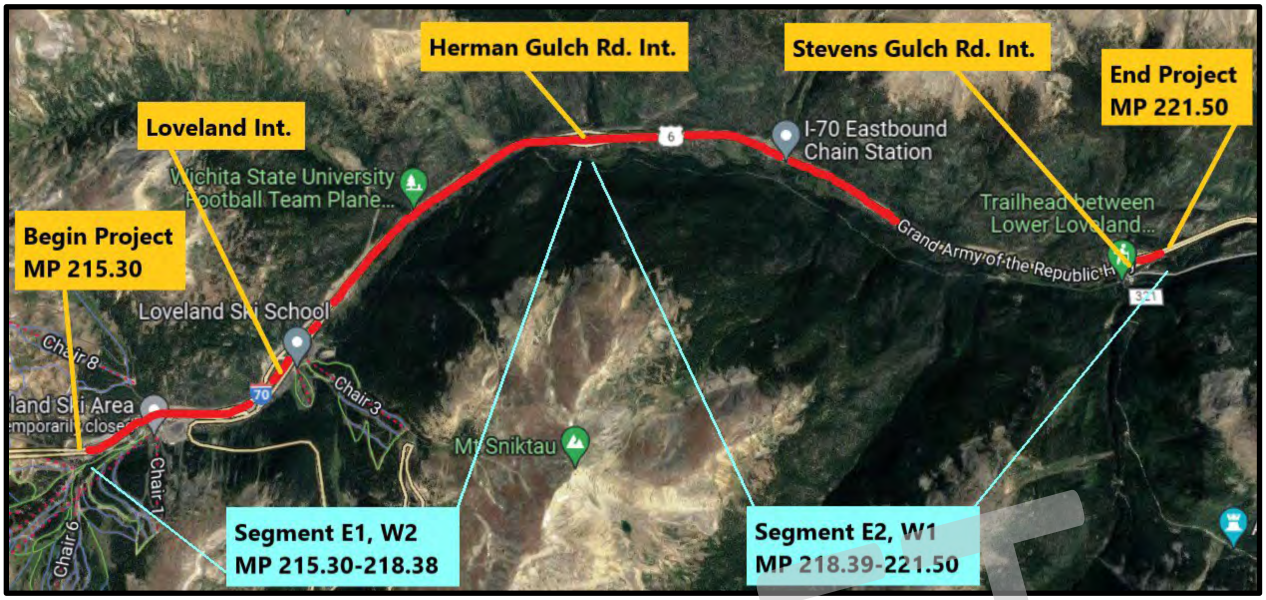


Figure 5: Segment Delineations

EASTBOUND

Table 2 summarizes the crash history for I-70 eastbound within the study limits, over the 6-year period from 01/01/2015 to 12/31/2020, with the number of people injured or killed in parentheses.

Year	AADT	PDO	Injury	Fatal	Total
2015	32,847	42	19 (24)	1 (1)	**62**
2016	36,540	43	10 (19)	0 (0)	**53**
2017	36,847	37	8 (18)	0 (0)	**45**
2018	36,000	39	15 (23)	0 (0)	**54**
2019	37,847	42	12 (23)	0 (0)	**54**
2020	37,847	27	16 (20)	0 (0)	**43**
Average	**36,321**	**38.2**	**13.3 (21.2)**	**0.16 (0.16)**	**51.7**

Table 2: Summary of Crash History, I-70 Eastbound MP 215.30 – 221.50

As described above, the eastbound corridor is split into two segments for analysis:

- Segment E1, MP 215.30 – MP 218.38
- Segment E2, MP 218.39 – MP 221.50

Figure 6 and **Figure 7** represent EB corrected segment safety performance of I-70 EASTBOUND ONLY within the study limits.

Figure 6 shows safety performance from the total crash frequency standpoint. Eastbound segment E1 performed in the LOSS-IV category, reflecting high potential for crash reduction. Eastbound segment E2 performed in the LOSS-II category, reflecting low to moderate potential for crash reduction.

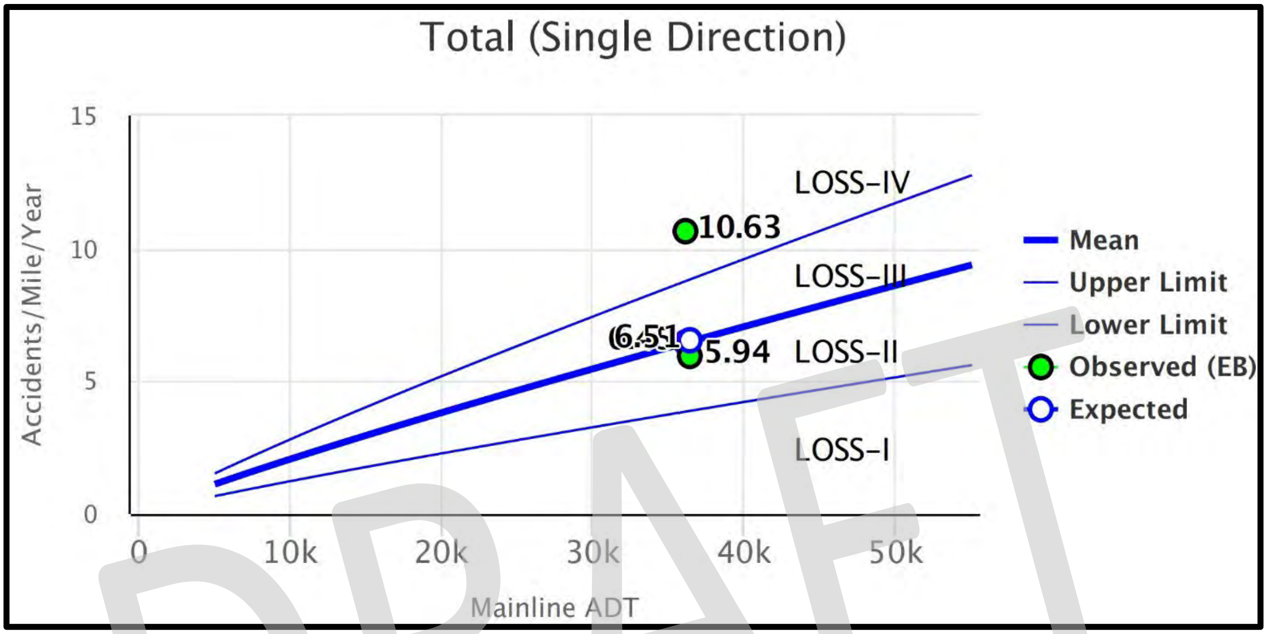


Figure 6: EB Corrected Segment Safety Performance, Total Crashes I-70 Mainline EASTBOUND ONLY

	AADT	Expected Frequency	Observed Frequency
Segment E1	36,143	6.45	10.63
Segment E2	36,500	6.51	5.94

Figure 7 shows safety performance from the standpoint of severity and considers injury and fatal crashes only. Eastbound segment E1 performed in the LOSS-IV category, reflecting high potential for crash reduction. Eastbound segment E2 performed in LOSS-II category, reflecting low to moderate potential for crash reduction.

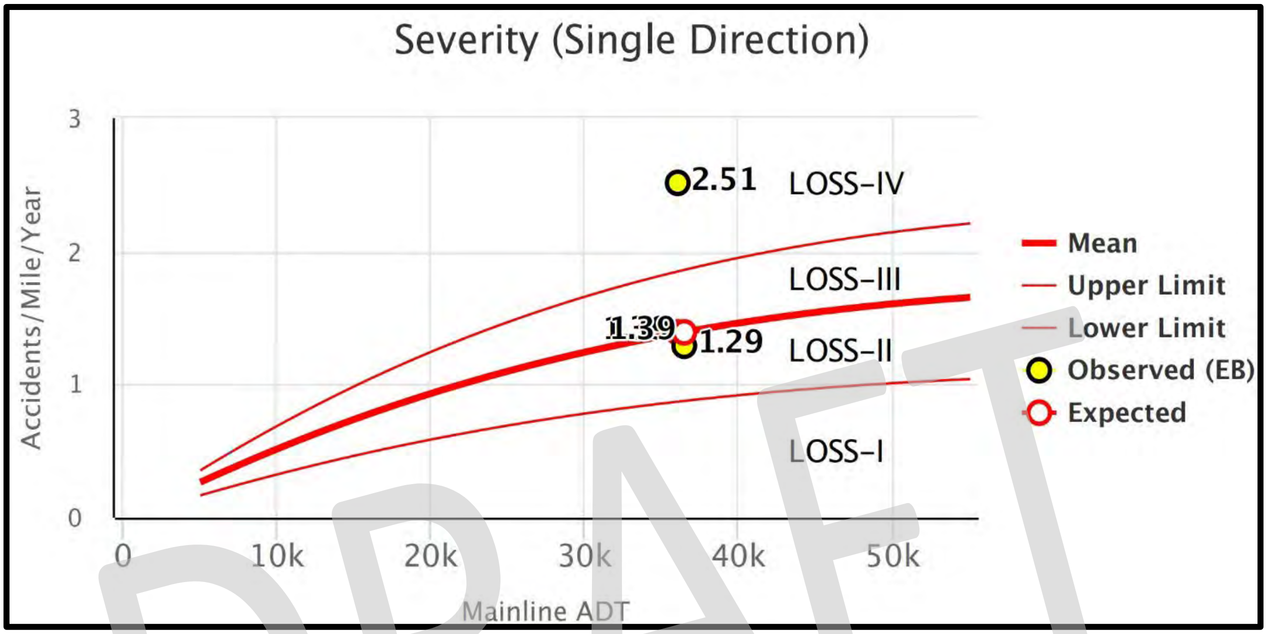


Figure 7: EB Corrected Segment Safety Performance, INJ + FAT Crashes
I-70 Mainline EASTBOUND ONLY

	AADT	Expected Frequency	Observed Frequency
Segment E1	36,143	1.39	2.51
Segment E2	36,500	1.39	1.29

In summary, segment E1 EASTBOUND from the Eisenhower Tunnel east portal to the Herman Gulch Road interchange performs worse than expected when compared to similar facilities, from both the total crash frequency and the crash severity standpoint. Meanwhile, segment E2 EASTBOUND from the Herman Gulch Road interchange to the Stevens Gulch Road interchange performs very close to the mean predicted by the SPF when compared to similar facilities, from both the total crash frequency and the crash severity standpoint.

The overall distribution of crash types on eastbound I-70 within the study limits is provided in **Figure 8**. Rear-end collisions were most common, followed by Fixed-Object collisions and Same-Direction Sideswipe collisions. **Figure 9** shows the distribution of fixed object collisions by type of object struck. Cable rail was most common, followed by Guardrail and Concrete Barrier.

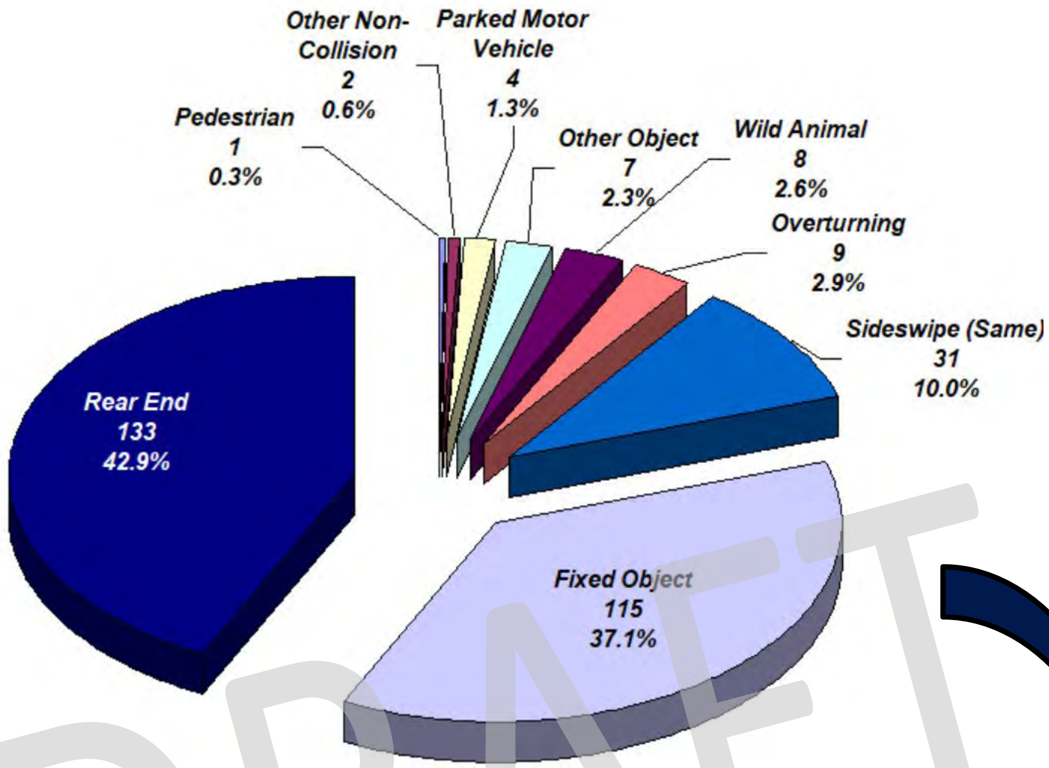


Figure 8: Eastbound I-70 MP 215.30-221.50 Mainline Crash Type Distribution

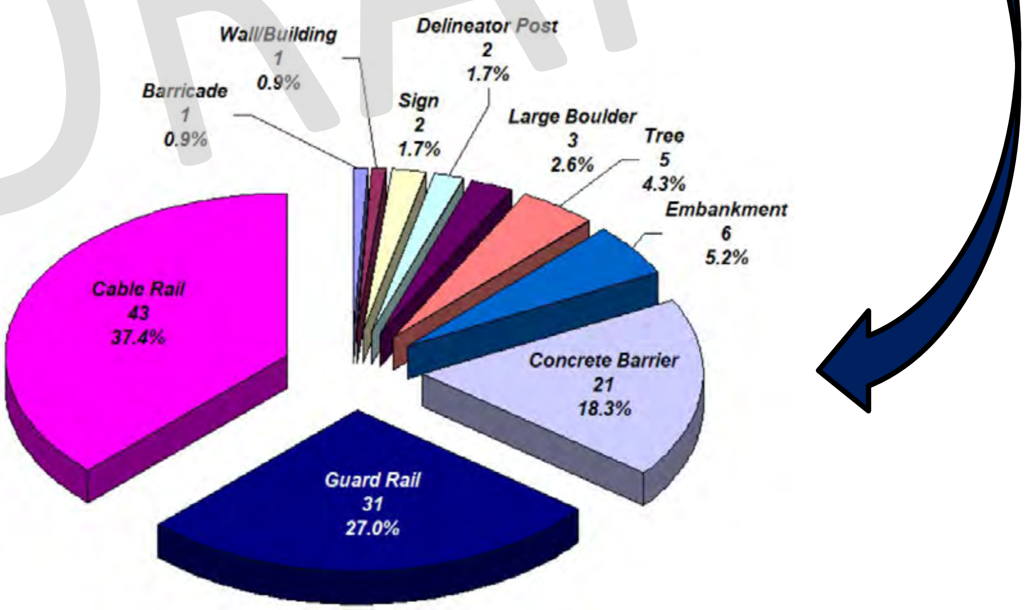


Figure 9: Fixed Objects Distribution, Eastbound I-70 MP 215.30-221.50

Table 3 shows the results of direct diagnostics for EASTBOUND I-70 segment E1.

08/10/2022

DiExSys™ Vision Zero Suite
Diagnostics Report

I-70 Segment E1 Pattern Rec — **Cutoff:** 5 Acc's @ 95

Category/Trait	Statewide Average %	This Location # Crashes	This Location %	Probability %
Crash Severity				
Injury (INJ)	21.84%	57	28.5%	98.73%
Number Of Vehicles				
Two Vehicle Accidents	34.98%	94	47%	99.95%
Three or More Vehicle Accidents	6.85%	34	17%	100%
Crash Location				
On Road	49.41%	124	62%	99.97%
Crash Type				
Rear End	25.23%	90	45%	100%
Cable Rail	0.74%	16	8%	100%
Weather Conditions				
Snow or Sleet or Hail	25.72%	90	45%	100%
Road Conditions				
Snowy Road	9.62%	57	28.5%	100%
Wet Icy Road Treatment	0.68%	5	2.5%	99.88%
Snowy with Icy Road Treatment	1.79%	11	5.5%	99.97%
Human Contributing Factor				
Preoccupied	4.5%	19	9.5%	99.93%

Table 3: Direct Diagnostics for EASTBOUND I-70 Segment E1

Pattern recognition for segment E1 EASTBOUND identified an Injury crash pattern, as well as patterns of multivehicle, rear-end and cable rail collisions. Rear-end crashes tend to be multiple vehicle collisions which is why we see both patterns identified here. As indicated in the safety assessment provided by CDOT, some rear-end crashes which occurred in the tunnel were miscoded to the east portal at the western end of this segment E1, however not to any degree that would have any meaningful effect on the pattens observed. Crashes occurring during adverse road and weather conditions are also an identified pattern in segment E1. There were also patterns of sideswipe same direction crashes, and crashes under dark conditions in spot locations.

Figure 10 is the result of pattern recognition for segment E1 for eastbound I-70 in the study area. It shows there is a clear overlap between the locations where injury level, multi-vehicle crashes, rear-end and cable rail crashes are occurring and where crashes recorded during adverse winter road and weather conditions are occurring.

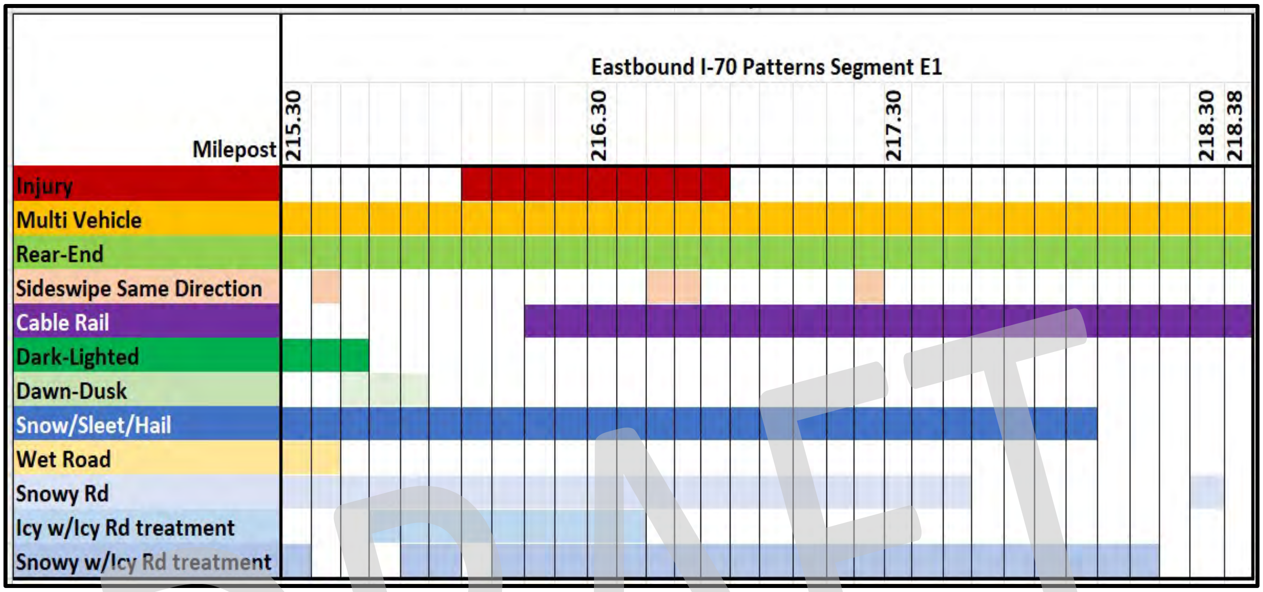


Figure 10: Mainline Crash Patterns, Eastbound I-70 Segment E1, MP 215.30 – 218.38

Rear-end crashes by nature are multivehicle collisions. The presence of multivehicle rear-end crashes eastbound at the west end of the corridor are observed to be concentrated during the afternoon hours of 2 P.M. to 6 P.M. (see **Figure 11**) and show a clear pattern of incidents occurring on Sundays (see **Figure 12**), with crashes highest for the months of January through March (see **Figure 13**). The area is a winter recreation destination which sees traffic eastbound being heavier on Sunday afternoons as patrons depart the nearby ski areas and return towards the Denver metro area. As eastbound is characterized by downhill grades, it is likely that traffic exiting the Eisenhower tunnel is not prepared for queued traffic ahead, resulting in rear-end collisions.

In over 80% of rear-end crashes the vehicle which was struck was either slowing for traffic or stopped in traffic. All of this suggests high-speed, high-density operations, which are unforgiving and associated with high crash rates, are contributing to the pattern.

Additionally, this segment is characterized by a combination of downhill grades and horizontal curvature, which further contributes to crashes. **Figure 14** shows that there is a cluster of rear end collisions near MP 216 eastbound which is located at a curve on grade. As identified in the safety assessment provided by CDOT Exit 216 for US-6 is immediately downstream for vehicles which have just exited the Eisenhower tunnel (**Figure 15**) and may not be expecting vehicles to be slowing to exit in front of them and so end up braking suddenly, resulting in rear-end collisions, a situation which is likely being exacerbated during times of congestion.

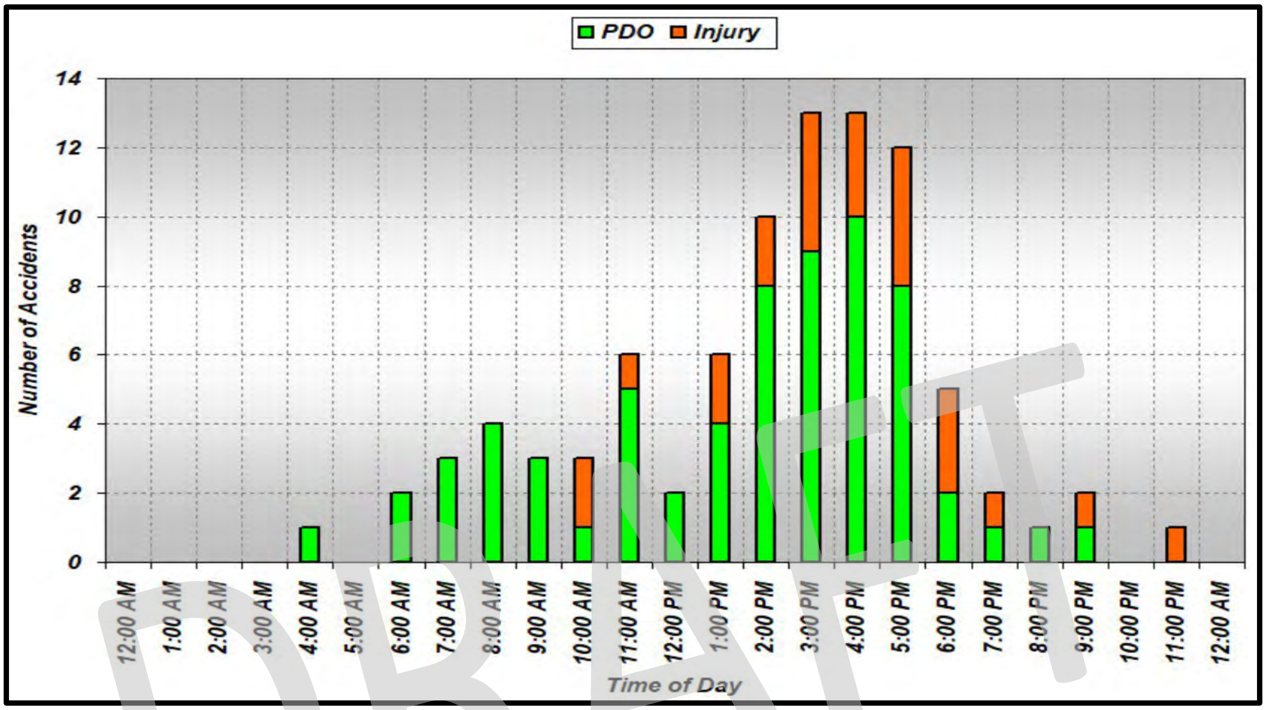


Figure 11: Rear-Ends by Time of Day, EB I-70 Segment E1

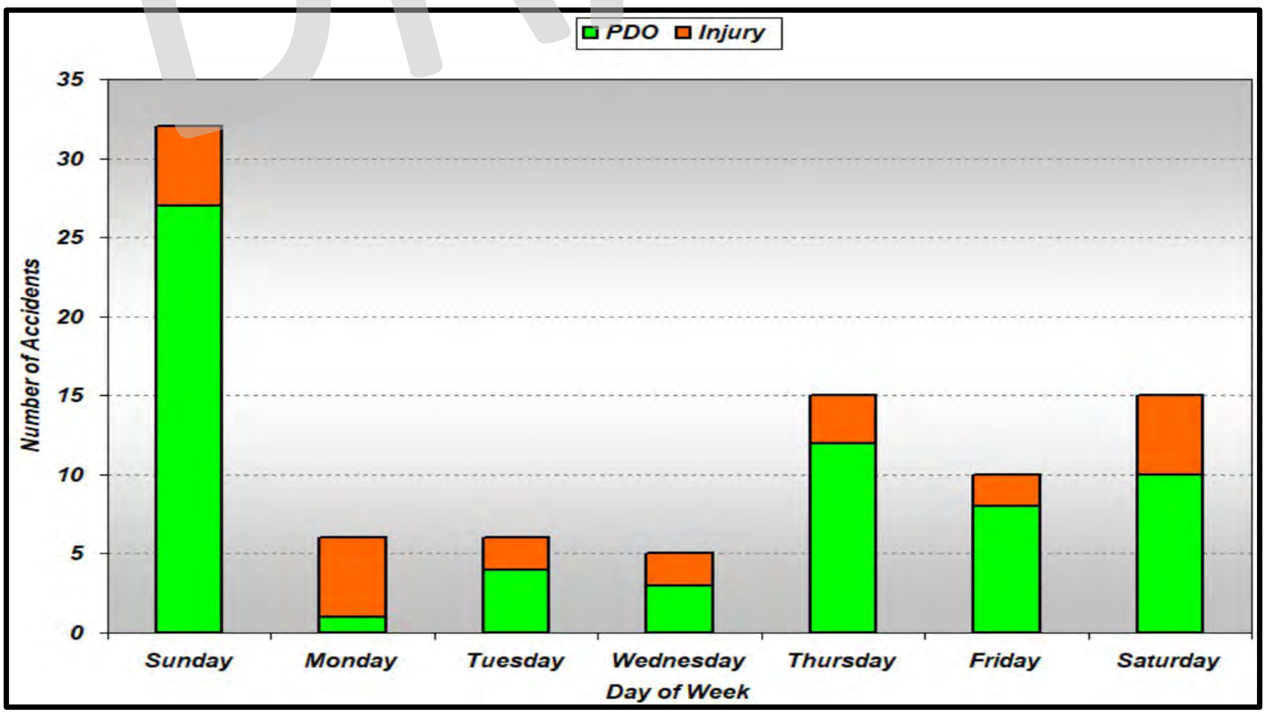


Figure 12: Rear-Ends by Day of Week, EB I-70 Segment E1

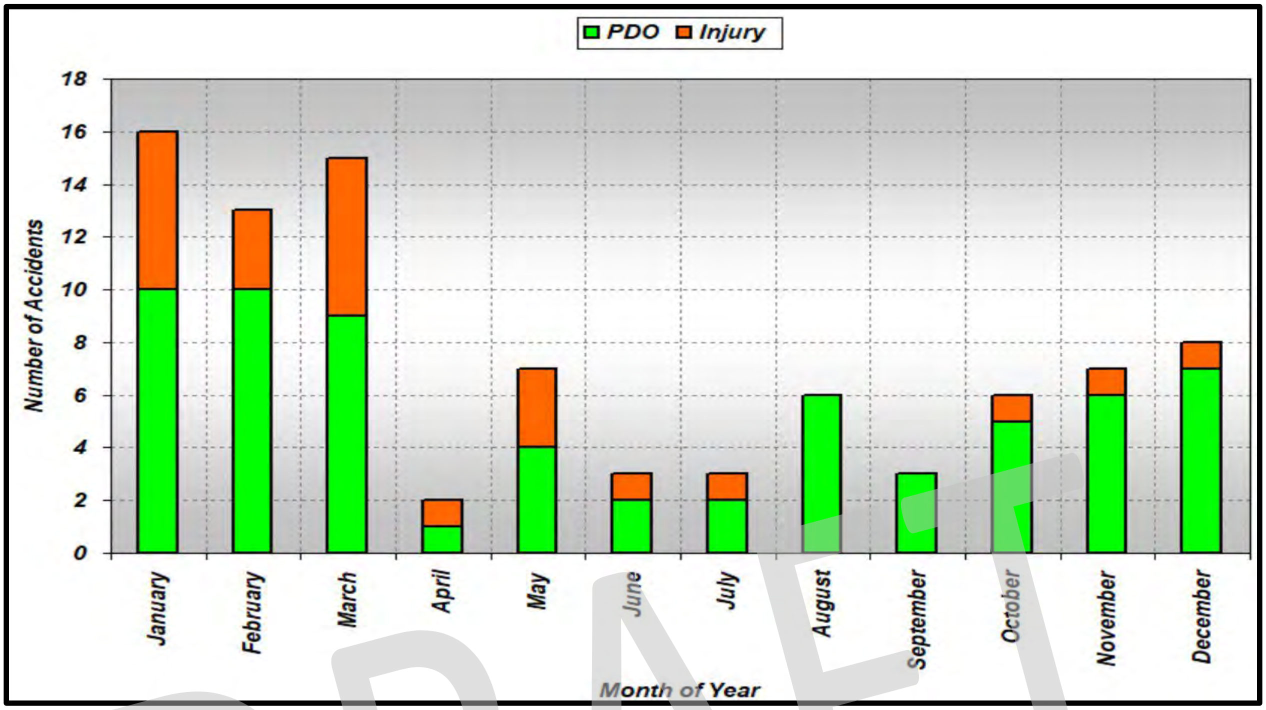


Figure 13: Rear-Ends by Month of Year, EB I-70 Segment E1

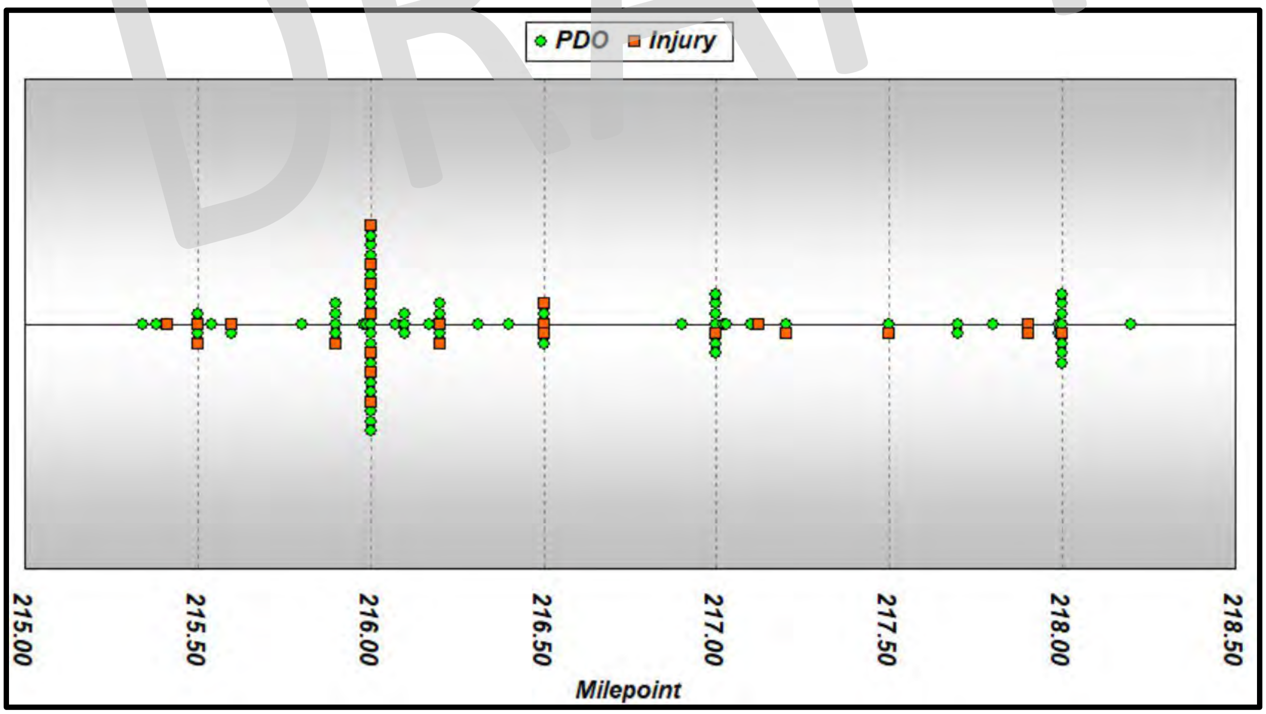


Figure 14: Straight Line Diagram Rear Ends Segment E1

Figure 15: View Eastbound near Exit 216, June 2022

As identified in the safety assessment provided by CDOT, the corridor is characterized by reasonably wide outside shoulders and narrower inside shoulders, with the latter closely bordering either the concrete barrier or median cable rail for the majority of the corridor. Having a wider inside shoulder would allow vehicles in the inside eastbound lane more room for correction to avoid a rear-end collision.

The appropriate degree of crash reduction achieved by widening of only the inside shoulder on a freeway facility has not been decidedly determined. A chapter concerning freeways in the Highway Safety Manual[4] discusses several possibilities based on several research efforts and includes a "proposed" crash modification factor (CMF). **Figure 16** is an excerpt from that chapter and uses 6 feet as the default shoulder width. It is evident from the graph that wider widths are expected to experience fewer crashes while narrower widths are expected to experience more crashes i.e., in the former case the CMF is below 1.0 and, in the latter, it is above 1.0. **Figure 16** shows a 2009 CMF proposed by Bonneson and Pratt, specific to Rural Freeways, such as the I-70 corridor we are concerned with. We will consider both the Bonneson-Pratt CMF and the Proposed CMF.

[4] HSM Freeway Chapter (final report), NCHRP Project 17-45, TRB, Washington, D.C. 2012

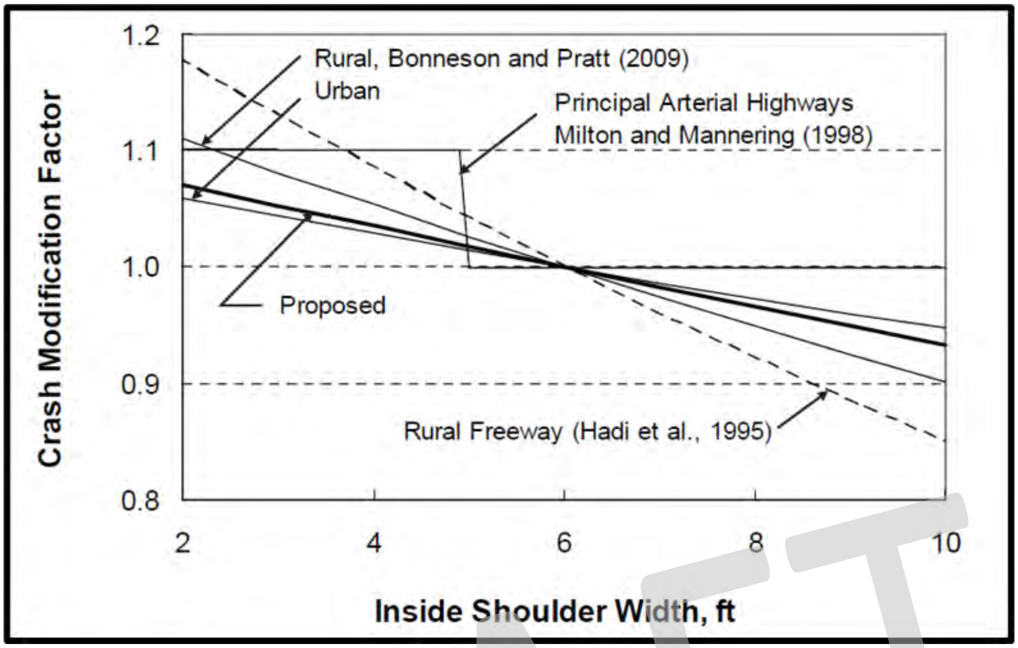


Figure 16: Calibrated Freeway Inside Shoulder Width CMF (from Highway Safety Manual, Freeways Chapter)

Table 4 shows tabulated CMFs which have been determined from the graph shown in **Figure 11**.

Inside Shoulder Width (ft)	Proposed CMF	Bonneson CMF
4	1.035	1.053
6	1.000	1.000
10	0.934	0.900

Table 4: Tabulated Crash Modification Factors for Inside Shoulder Width

To calculate a Crash Reduction Factor (CRF), such as is used in Vision Zero Suite analysis, given CMFs for the before (narrow shoulder) and after (wider shoulders) conditions:

$$CRF = 1 - \frac{CMF_{After}}{CMF_{Before}}$$

Table 5 shows the resulting CRFs which were computed and the degree of crash reduction which might be expected if the inside eastbound shoulders were to be widened. A crash reduction in the range of 3-15% could be expected.

Change Shoulder Width	Proposed CMF, CRF	Bonneson CMF, CRF
4 to 10 ft	10%	15%
4 to 6 ft	3%	5%

Table 5: Tabulated Crash Reduction Factors for Inside Shoulder Widening

Widening of the eastbound inside shoulder would contribute to improved mobility along a corridor which experiences a notable amount of heavy commercial vehicle traffic (in the region of 9%). As such any shoulder widening efforts would improve safety as it applies to all traffic.

In general, addressing high-density operations by adding VSL could ameliorate the rear-end pattern, but as will be discussed in the following sections, so too would addressing the winter road conditions which are contributing to the problem.

Cable rail crashes were an identified pattern in eastbound segment E1. There is no discernable pattern to the cable rail collisions, other than that most of them tended to occur in advance of the Herman Gulch Road interchange, where there is a curve on grade and there is frequent reference to loss of vehicle control in the crash records. Cable rail crashes are likely due to challenging driving in adverse weather and road conditions, as is expanded on in the following sections.

Rear-end crashes and cable rail crashes accounted for approximately 44% of all Injury level crashes. Furthermore, sideswipe same direction crashes, which along with rear-end collisions are also characteristic of a high-density high-speed operation, accounted for about another 12% of all injury crashes. In combination with this, other fixed object crash types, namely guard rail and concrete barrier collisions, represented approximately 14% and 10% of injury crashes, respectively. While rear-end and sideswipe same direction crashes are representative of congested (high density) conditions, the fixed object crash types are run-off-the-road crashes. Both congestion-related and single vehicle run-off-the-road crashes can be exacerbated by adverse winter weather and road conditions which make stopping and maneuvering more difficult.

Out of the 199 crashes in segment E1, 41 involved run-off-the-road left or in median crashes while about the same number, 35, involved run-off-the-road right crashes. The CDOT safety assessment suggests that a wider inside shoulder would assist in correction for run-off-the-road left crashes. As detailed above, widening of the eastbound inside shoulder might be expected to achieve a reduction in crashes in the range of 3-15% depending on the degree of widening.

Approximately 53% of all injury crashes occurred during adverse winter weather and/or road conditions. Approximately 38% of cable rail crashes occurred during adverse winter weather and/or road conditions. Similarly, about 45% of rear-end collisions occurred during adverse winter weather and/or road conditions.

All of this suggests that driving during adverse winter weather and road conditions is challenging and further contributes to the patterns of rear-end, multivehicle and cable rail collisions seen on segment E1. The presence of frozen precipitation (snow, sleet, and hail) and winter road conditions patterns combined with the high incidence of fixed object crashes and multivehicle crashes on a segment which is characterized by a combination of steep downhill grades and horizontal curvature, suggest that deployment of VSL may have potential to improve safety.

Table 6 shows the results of direct diagnostics analysis for EASTBOUND I-70 segment E2.

08/11/2022

DiExSys™ Vision Zero Suite
Diagnostics Report

I-70 Segment E2 Pattern Rec — **Cutoff:** 5 Acc's @ 95

Category/Trait	Statewide Average %	This Location # Crashes	This Location %	Probability %
Number Of Vehicles				
Two Vehicle Accidents	34.98%	47	42.34%	95.64%
Crash Type				
Rear End	25.23%	44	39.64%	99.97%
Cable Rail	0.74%	27	24.32%	100%
Lighting Conditions				
Dark - Unlighted	22.27%	33	29.73%	97.44%
Road Conditions				
Snowy Road	9.62%	26	23.42%	100%
Snowy with Icy Road Treatment	1.79%	6	5.41%	99.6%
Human Contributing Factor				
Preoccupied	4.5%	15	13.51%	100%

Table 6: Direct Diagnostics for EASTBOUND I-70 Segment E2

Pattern recognition for segment E2 EASTBOUND identified a pattern of property damage only, multivehicle, rear-end and cable rail crashes, as well a pattern of crashes occurring under dark conditions and during adverse weather and road conditions.

Figure 17 shows the results of pattern recognition for segment E2 for eastbound I-70 in the study area. It shows there is an overlap between the locations where property damage only, rear-end and cable rail crashes are occurring and where crashes recorded during adverse weather and road conditions and under dark conditions are occurring.

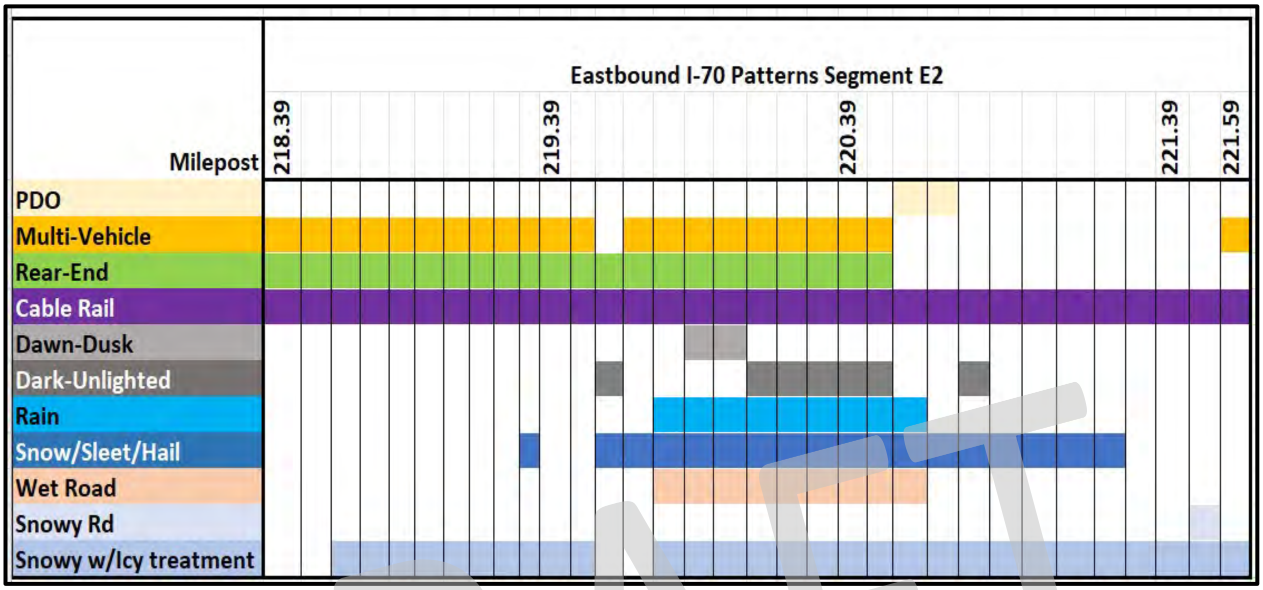


Figure 17: Mainline Crash Patterns, Eastbound I-70 Segment E2, MP 218.39 – 221.50

Rear-end crashes by nature are multivehicle collisions. The presence of multivehicle rear-end crashes eastbound in the eastern part of the corridor are observed to be concentrated during the afternoon hours between 2 P.M. and 6 P.M. (see **Figure 20**) and show a clear pattern of incidents occurring on Sundays (see **Figure 21**), with crashes highest for the months of January and September (see **Figure 22**). This segment of the eastbound corridor shows similar patterns to the western segment. It reflects the seasonal nature of both winter and summer recreational traffic to ski and mountain destinations west of Denver, with drivers returning to the Denver metro area on Sunday afternoons.

Figure 18 shows there is a cluster of crashes around MP 219 and MP 220. There is a chain station and brake cooling area located between these two mileposts in the eastbound direction. It is possible that slow moving and heavy vehicles entering and exiting the station are creating turbulent flow conditions and contributing to rear-end collisions in the more heavily congested winter and summer weekends (**Figure 19**).

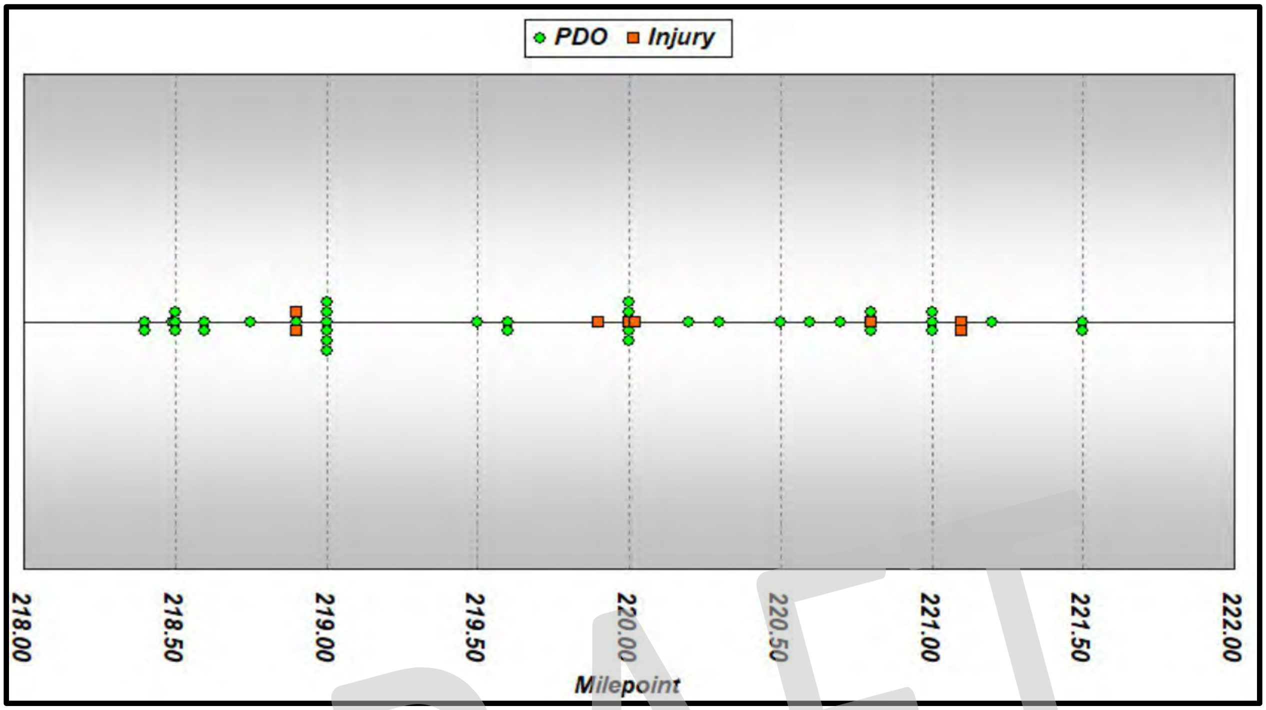


Figure 18: Straight Line Diagram for Rear-Ends Segment E2

Figure 19: Eastbound I-70 Chain Station near MP 219

In 75% of rear-end crashes the vehicle which was struck was either slowing for traffic or stopped in traffic. All of this suggests high-speed, high-density operations, which are unforgiving and associated with high crash rates, are contributing to the rear-end multivehicle patterns. Additionally, like segment E1, this segment is characterized by downhill grades and horizontal curvature, which requires a greater focus on the driving task.

As identified in the safety assessment provided by CDOT, the corridor is characterized by reasonably wide outside shoulders and narrower inside shoulders, with the latter closely bordering median cable rail for the majority of the corridor. Having a wider inside shoulder would allow vehicles in the inside eastbound lane more room for correction to avoid a rear-end collision. As discussed previously, widening of the inside shoulder might be expected to achieve somewhere in the region of a 3-15% crash reduction, which would contribute to improved mobility along a corridor which experiences a notable amount of heavy commercial vehicle traffic (in the region of 9%). As such any inside shoulder widening efforts would improve safety as it applies to all traffic.

In general, addressing high-density/high-speed operations thru VSL could ameliorate the rear-end pattern, but as will be discussed in the following sections, so too would addressing the winter road conditions which are contributing to the problem.

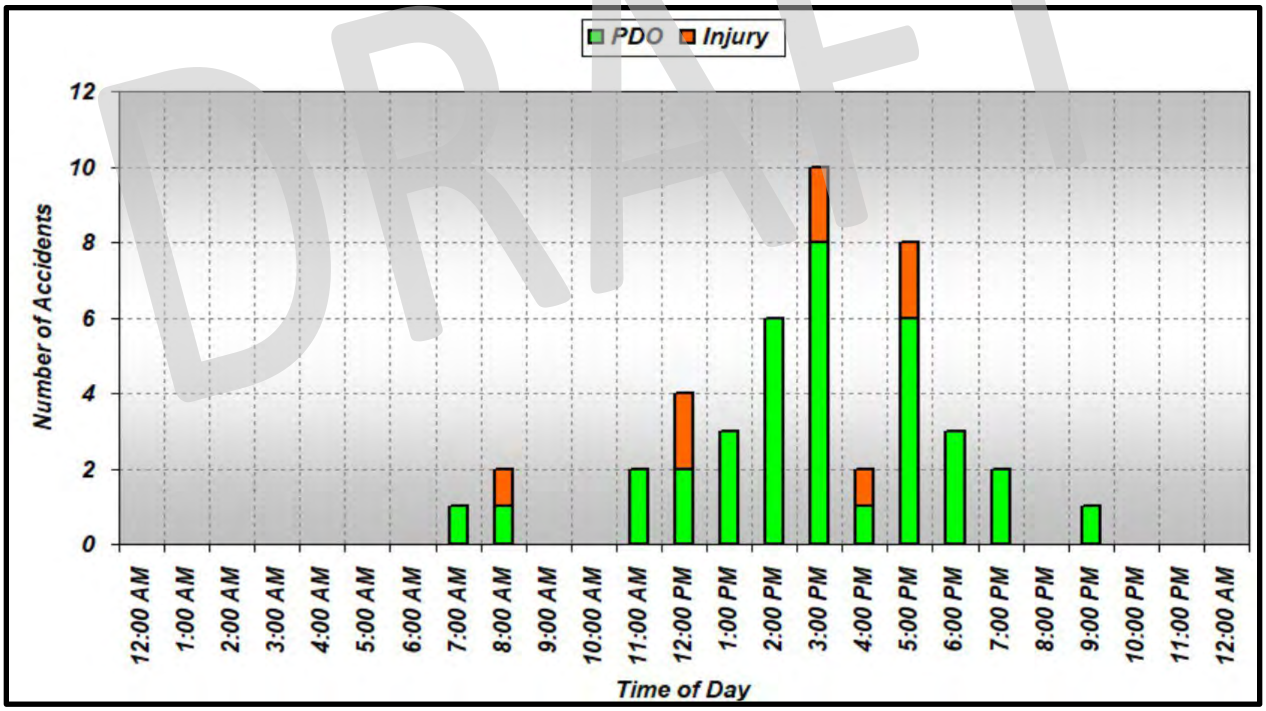


Figure 20: Rear-Ends by Time of Day EB I-70 Segment E2

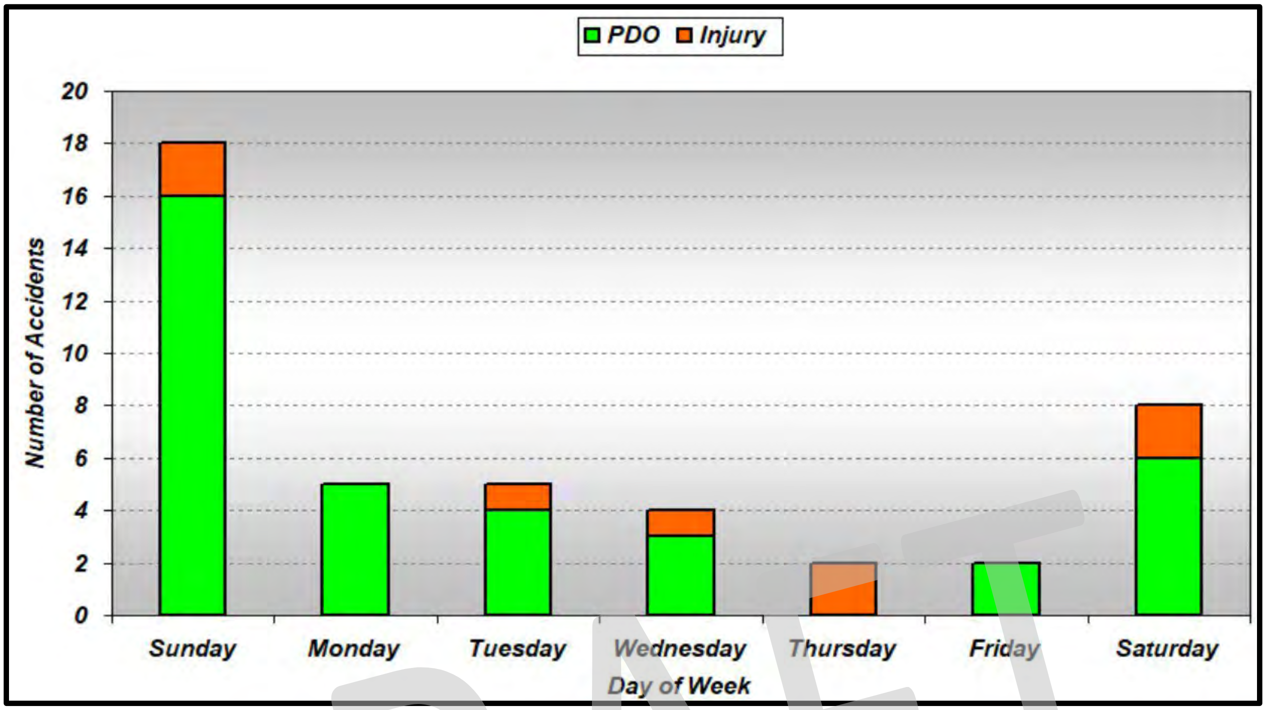


Figure 21: Rear-Ends by Day of Week EB I-70 Segment E2

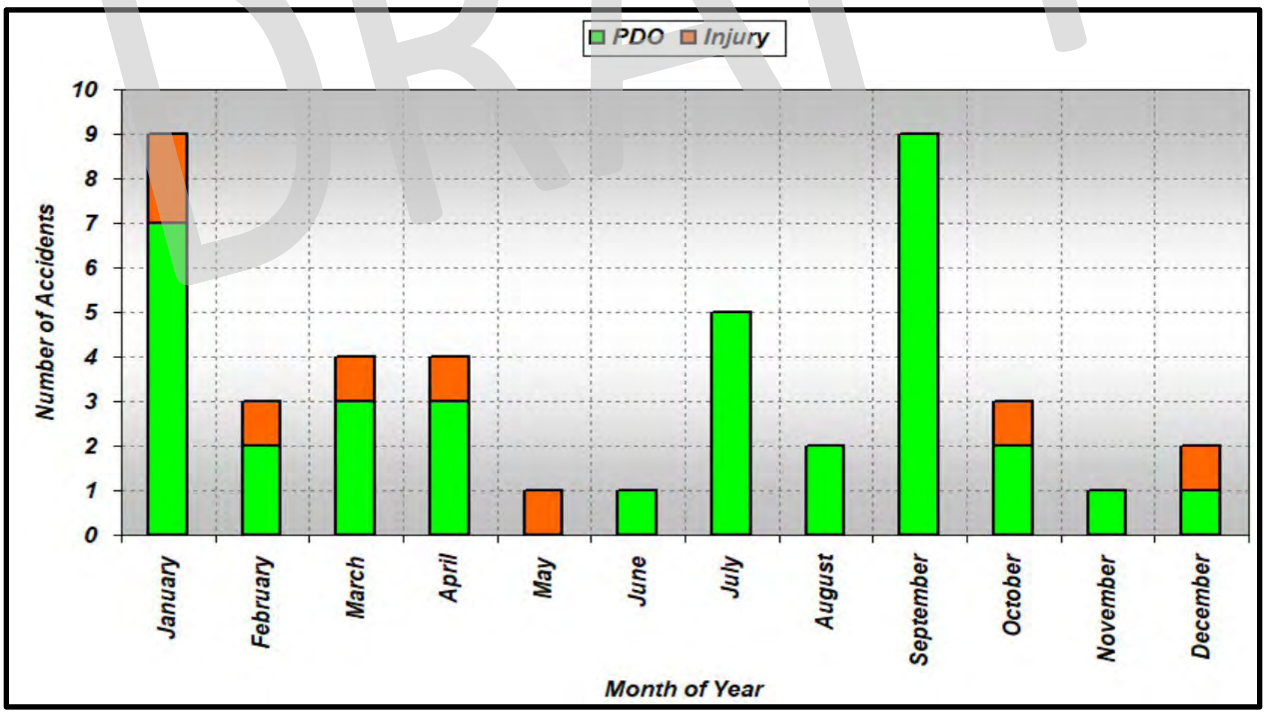


Figure 22: Rear-Ends by Month of Year EB I-70 Segment E2

There is no discernable pattern to the cable rail collisions, however, as outlined already, the segment is characterized by a combination of downhill grades and horizontal curvature. This combined with high speeds and adverse road conditions can make braking and maneuvering challenging. About 41% of all cable rail crashes occurred during adverse winter weather and/or road conditions. Crash records also contain frequent references to the driver losing control of the vehicle. This suggests that speed as well as weather and road conditions are contributing factors.

Crash records for rear-end collisions frequently mention drivers losing control of their vehicles. Also, approximately 30% of all rear-end collisions occurred during adverse winter weather and/or road conditions.

The presence of a pattern of adverse winter road conditions combined with the patterns of cable rail, multivehicle and rear-end crashes on a segment which is characterized by downhill grades and horizontal curvature, as well as challenging driving under adverse road conditions, suggests that addressing high-density operations would at least partially address the patterns observed. The CDOT safety assessment suggested widening of the inside shoulder as a potential measure, which could be expected to provide a certain degree of crash reduction. Furthermore, patterns and trends confirm that a VSL has potential to improve safety.

Crashes under Dark-Unlighted conditions were also an identified pattern in segment E2. **Figure 23** shows that there is no clear pattern to the crashes in terms of location, with crashes occurring along the entirety of the segment.

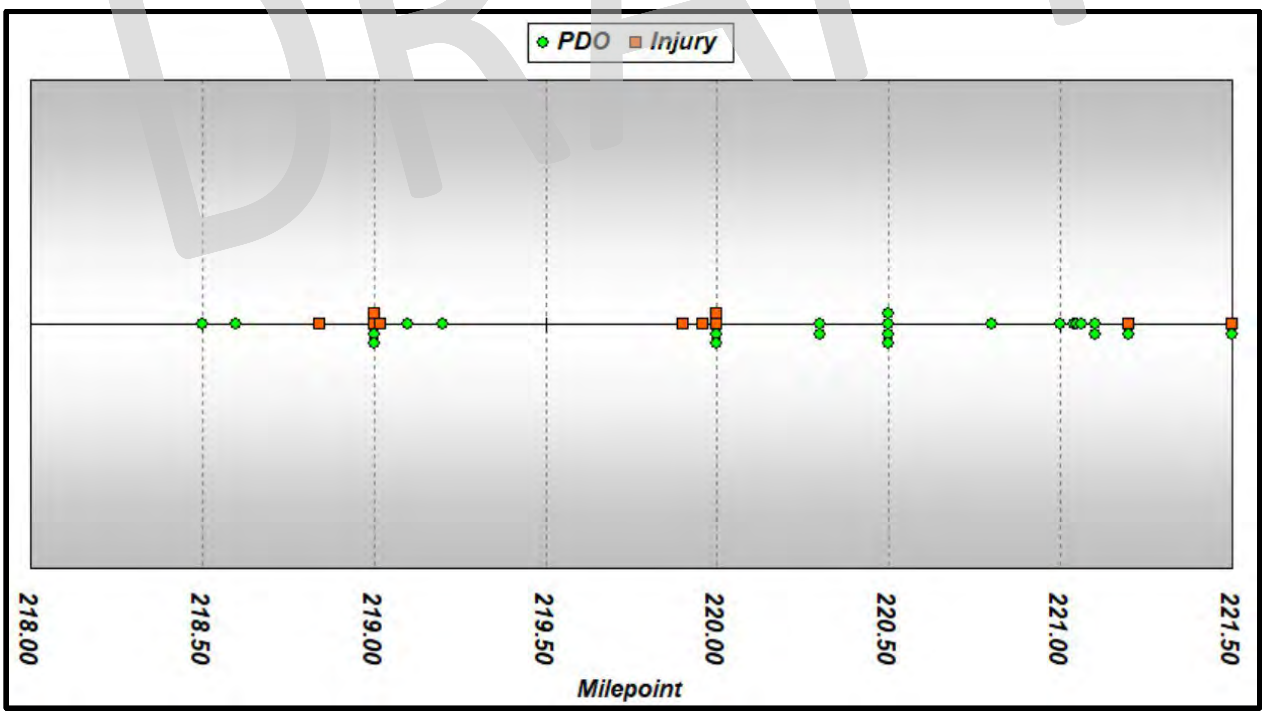


Figure 23: Straight Line Diagram for Dark-Unlighted Crashes Segment E2

About 27% of crashes occurring under dark-unlighted conditions also occurred under adverse winter road conditions, with about 24% also occurring under adverse winter weather conditions. Furthermore, the data reflects the patterns discussed above in that 55% of crashes involved fixed object type crashes while 21% involved rear-end. This further emphasizes the degree of overlap between rear-end and cable rail crash patterns and adverse weather and poor lighting, along with other factors such as geometric alignment.

Segment E2 is only partially lighted by highway lighting and this for the most part is on the north side of the freeway for westbound traffic. Eastbound, the area at the chain station has highway lighting. The CDOT safety assessment recommended increasing of pavement marking reflectivity to improve visibility. This would be a suitable measure in contributing towards the reduction of crashes under dark-unlighted conditions in segment E2, however under heavy winter weather and road conditions where snow accumulation and snow drift often covers the pavement marking, this might not be an adequate countermeasure. There are reflective delineator posts situated within the median adjacent to the cable rail in the eastbound direction throughout the segment. It would be advisable to ensure the integrity of the existing reflective delineators and to consider increasing the frequency of reflective delineators in the median, as 42% of crashes under dark-unlighted conditions involved a vehicle leaving the roadway on the left side. However, delineators would be subject to the same coverage from snow in adverse weather conditions, as such the Region might consider the extension of existing highway lighting on the south side i.e., in the eastbound direction along the segment. A crash reduction in the region of 20-22% for crashes under dark-unlighted conditions could be achieved by provision of highway lighting.

Table 7 below shows that when assuming a conservative 20% reduction in eastbound nighttime crashes on segment E2, spending up to $763,000 on highway lighting for eastbound traffic is expected to be cost effective.

Colorado Department of Transportation
DiExSys™ Vision Zero Suite
Economic Analysis Report

09/06/2022
Job #: 20220906022748

Location: 70 A **Begin:** 218.39 **End:** 221.50 **From:** 01/01/2015 **To:** 12/31/2020

Benefit Cost Ratio Calculations

Crashes			Projected Crashes and Reduction Factors			Other Information	
PDO:	24		Weighted PDO:	4.91	20% :CRF for PDO	Cost of PDO:	$ 11,100
INJ:	10	12 :Injured	Weighted INJ:	2.46	20% :CRF for INJ	Cost of INJ:	$ 101,800
FAT:	0	0 :Killed	Weighted FAT:	0.00	20% :CRF for FAT	Cost of FAT:	$ 1,820,600
			B/C Weighted Year Factor:	6.00	20% :Weighted CRF	Interest Rate:	5%
						AADT Growth Factor:	2.0%
						Service Life:	20
						Capital Recovery Factor:	0.080
						Annual Maintenance/Delay Cost:	$ 0

Cost: $ 763,000
From: 01/01/2015
To: 12/31/2020 Days: 2192

Benefit Cost Ratio: 1.00 (B/C Based on Injury Numbers : PDO/Injured/Killed)

Type of Improvement: Provide Highway Lighting Eastbound MP 218.39-221.50
Special Notes: Eastbound Night Time Crashes Only. Base Condition No Lighting

Table 7: B/C Analysis for Eastbound Highway Lighting for Segment E2

WESTBOUND

Table 8 summarizes the crash history for I-70 westbound within the study limits, over the 6-year period from 01/01/2015 – 12/31/2020, with the number of people injured or killed in parentheses.

Year	AADT	PDO	Injury	Fatal	Total
2015	32,847	20	10 (20)	0 (0)	**30**
2016	36,540	32	6 (13)	0 (0)	**38**
2017	36,847	24	9 (17)	0 (0)	**33**
2018	36,000	13	8 (11)	0 (0)	**21**
2019	37,847	18	9 (15)	0 (0)	**27**
2020	37,847	26	6 (8)	0 (0)	**32**
Average	**36,321**	**26.4**	**9.6 (16.8)**	**0 (0)**	**36**

Table 8: Summary of Crash History, I-70 Westbound MP 215.30 – 221.50

- Segment W1, MP 221.50 – 218.39
- Segment W2, MP 218.38 – 215.30

Figure 24 and **Figure 25** represent EB corrected segment safety performance of I-70 WESTBOUND ONLY within study limits. **Figure 24** shows safety performance from the total crash frequency standpoint. Westbound segments W1 and W2 both performed in the LOSS-II category, reflecting low to moderate potential for crash reduction.

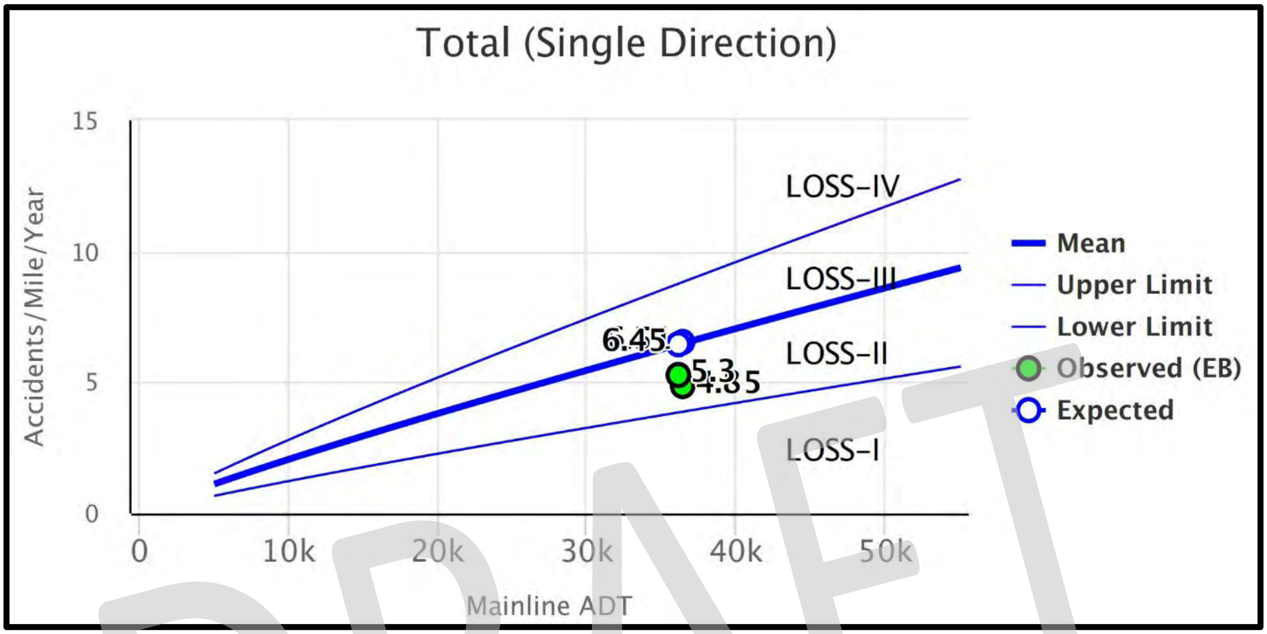


Figure 24: EB Corrected Segment Safety Performance, Total Crashes I-70 Mainline WESTBOUND ONLY

	AADT	Expected Frequency	Observed Frequency
Segment W1	36,500	6.51	4.85
Segment W2	36,143	6.45	5.30

Figure 25 shows safety performance from the standpoint of severity and considers injury and fatal crashes only. Westbound segment W1 performed in LOSS-II category, reflecting low to moderate potential for crash reduction. Westbound segment W2 performed in LOSS-III category, reflecting moderate to high potential for crash reduction.

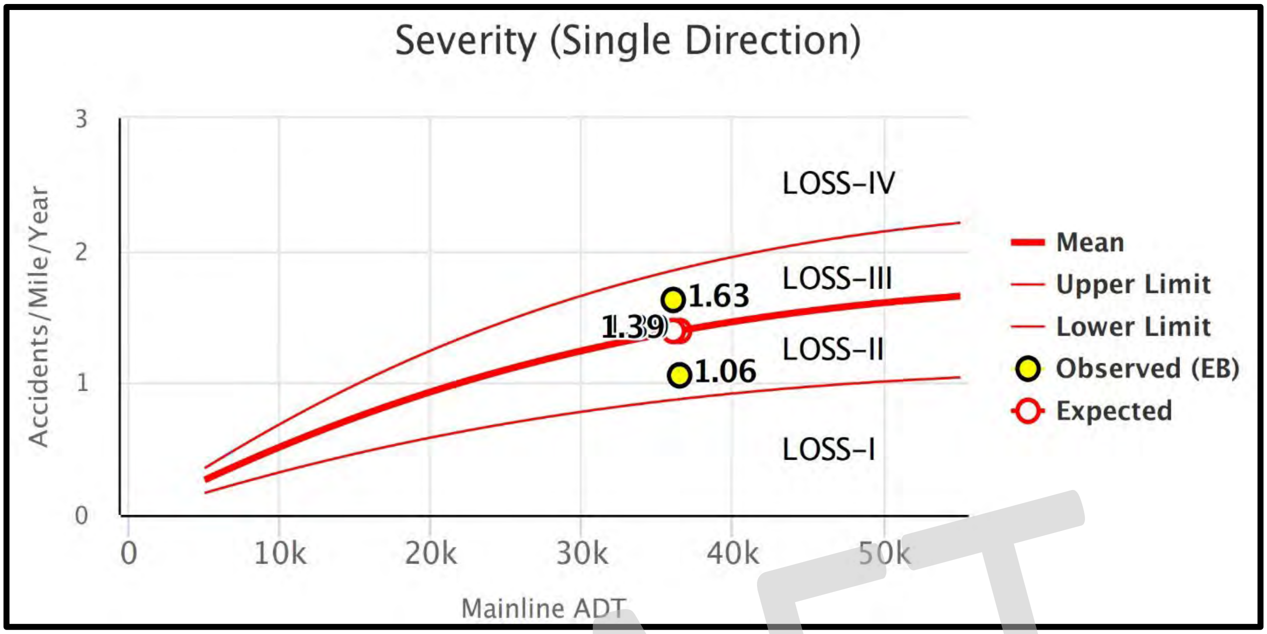


Figure 25: EB Corrected Segment Safety Performance, INJ+ FAT Crashes I-70 Mainline WESTBOUND ONLY

	AADT	Expected Rate	Observed Rate
Segment W1	36,500	1.39	1.06
Segment W2	36,143	1.39	1.63

The overall distribution of crash types on westbound I-70 within the study limits is provided in **Figure 26**. Rear-End crashes were most common, followed by collisions with fixed objects and same-direction sideswipes. **Figure 27** shows the distribution of fixed object collisions by type of object struck. Cable rail was most common, followed by embankment and guardrail.

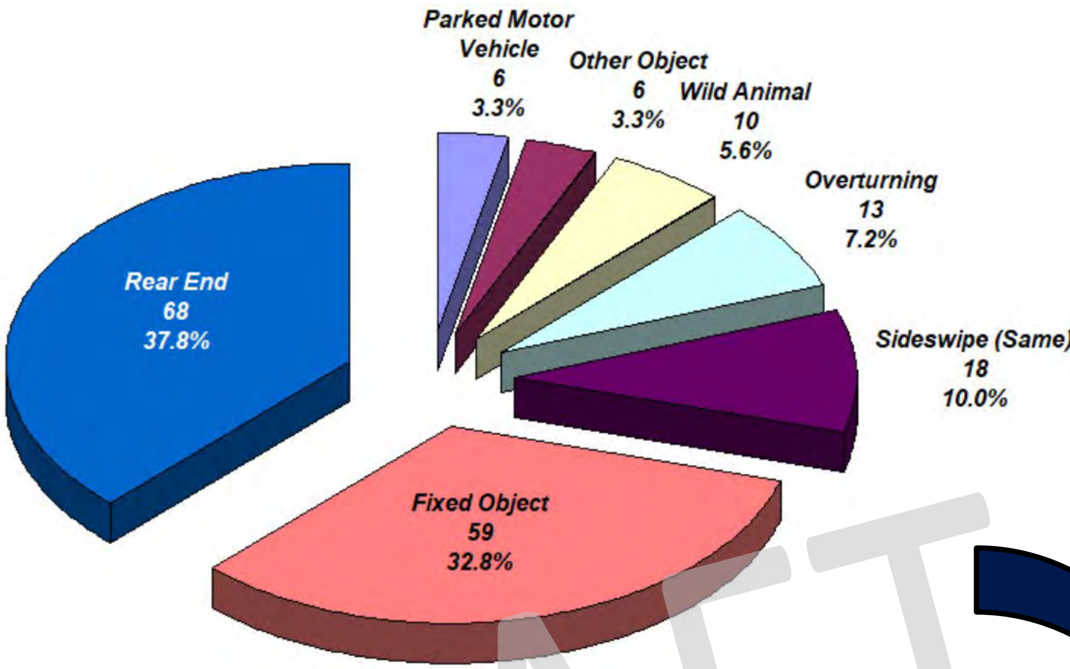


Figure 26: Westbound I-70 MP 215.30-221.50 Mainline Crash Type Distribution

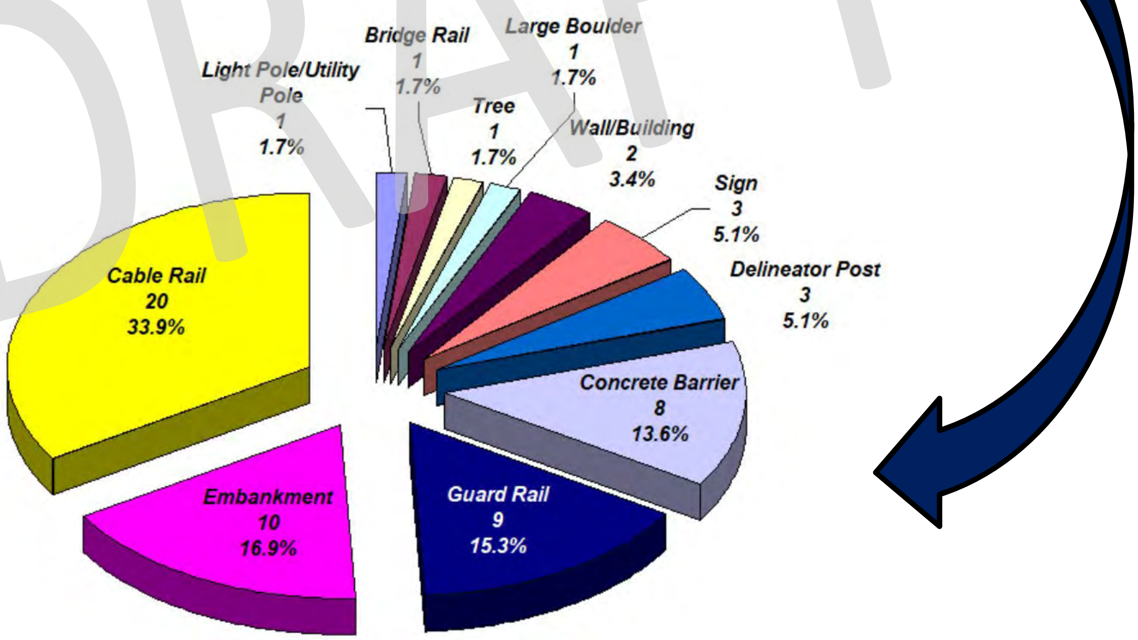


Figure 27: Fixed Objects Distribution, Westbound I-70 MP 215.30-221.50

Table 9 shows the results of direct diagnostics analysis for WESTBOUND I-70 segment W1.

08/11/2022

DiExSys™ Vision Zero Suite
Diagnostics Report

I-70 Segment W1 Pattern Rec — **Cutoff:** 5 Acc's @ 95

Category/Trait	Statewide Average %	This Location # Crashes	This Location %	Probability %
Crash Type				
Cable Rail	0.74%	13	14.77%	100%
Embankment	4.32%	7	7.95%	96.34%
Weather Conditions				
Snow or Sleet or Hail	25.72%	35	39.77%	99.87%
Road Conditions				
Snowy Road	9.62%	32	36.36%	100%

Table 9: Direct Diagnostics for WESTBOUND I-70 Segment W1

Pattern recognition for segment W1 WESTBOUND identified a pattern of rear-end, cable rail and embankment collisions. There were also spot locations where patterns of PDO, injury, multi-vehicle, off-road, and overturning crashes, as well as crashes under dark-unlighted conditions were identified. Crashes occurring during adverse winter road and weather conditions are also an identified pattern in segment W1.

Figure 28 shows the results of pattern recognition analysis on segment W1 for westbound I-70. It shows there is an overlap between the locations where crashes recorded during adverse winter road and weather conditions are occurring and all other crash patterns.

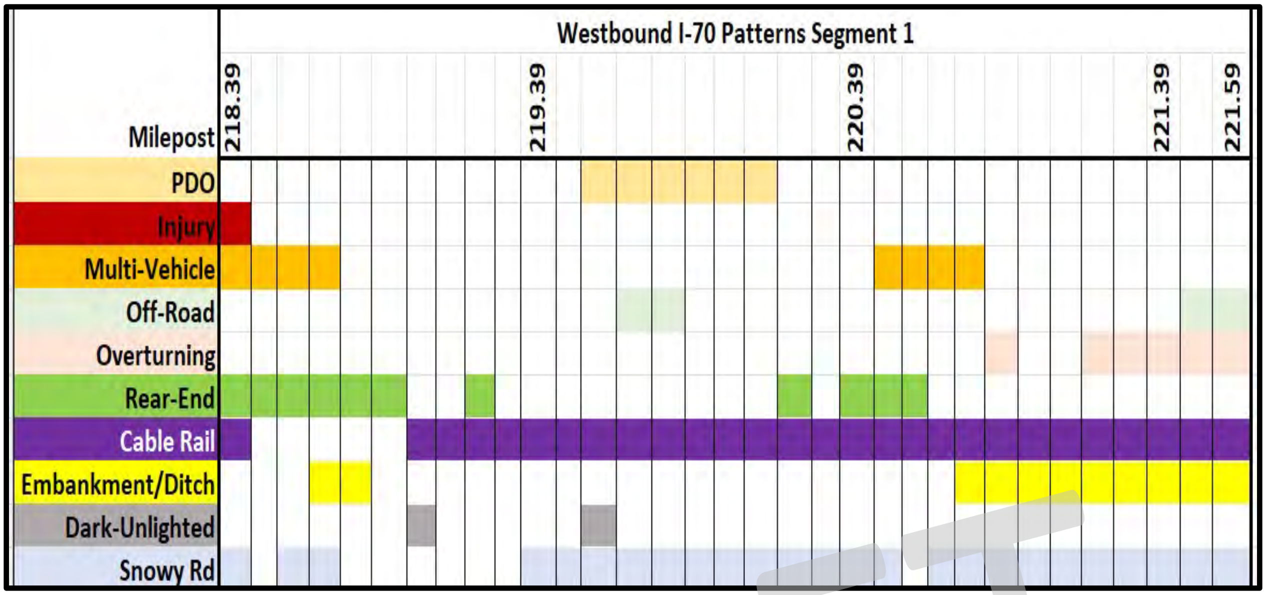


Figure 28: Mainline Crash Patterns, Westbound I-70 Segment 1, MP 218.39-221.50

There were 7 embankment crashes recorded on segment W1 over the 6-year study period. The straight-line diagram in **Figure 29** shows that most crashes (5) were concentrated between MP 221.30 and MP 221.00. Of these 5 crashes, 2 were off-left and 3 were off-right.

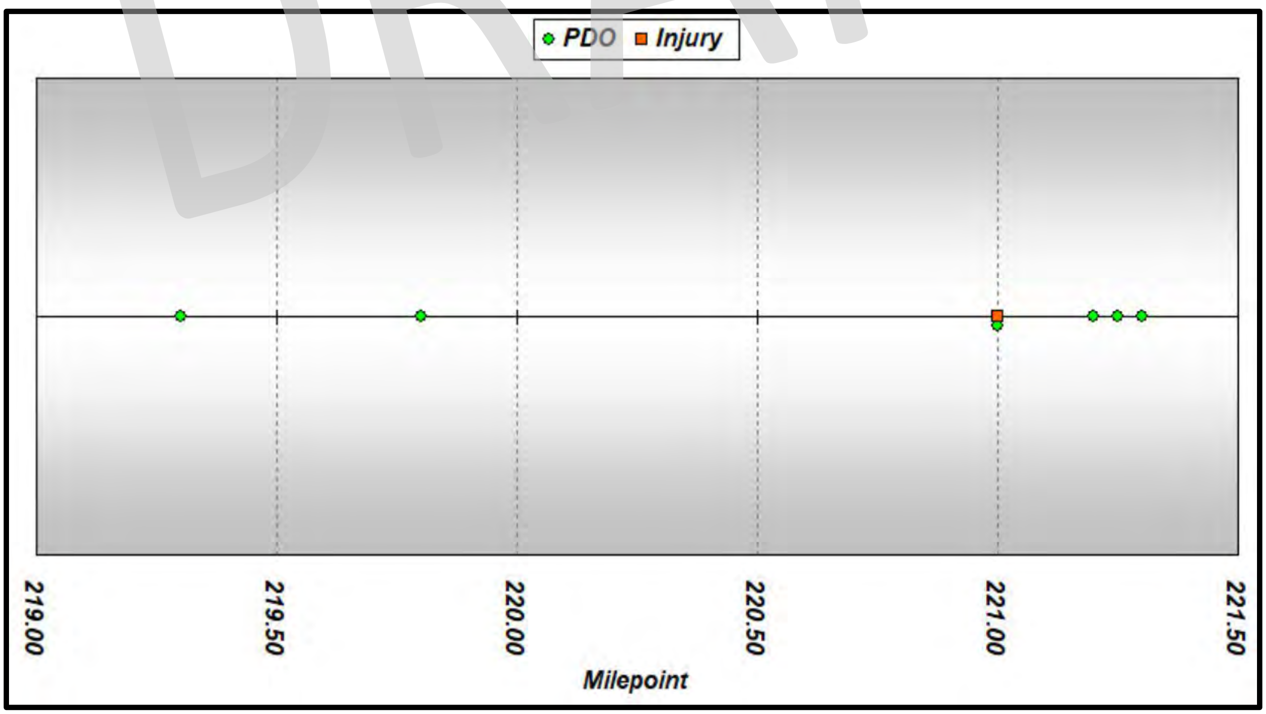


Figure 29: Embankment Crashes Westbound I-70 Segment W1, MP 218.39-221.50

The area between MP 221.30-221.00 is at the Stevens Gulch Road interchange and is on a horizontal curve. As seen in **Figure 30**, the area includes a merge with traffic entering from the I-70 westbound on-ramp. This portion of the roadway has grass embankments on either side, without cable or guard rail. However, there are both inside and outside shoulder rumble strips.

Figure 30: Westbound I-70 Cross Section near MP 221

Embankment crash records have frequent reference to vehicles spinning and/or losing control. Furthermore, all 5 of the embankment crashes between MP 221.30-221.00 occurred during adverse winter and/or road conditions.

There were 13 cable rail crashes on segment W1 over the study period. The cable rail in this area is located on the side of eastbound traffic so that westbound vehicles which run of the road resulting in a cable rail crash would have had to traverse the median. **Figure 31** shows that some crashes are occurring between MP 221.20-221.00 near the Stevens Gulch Road interchange where there is a merge with the I-70 WB on-ramp, this demonstrates an overlap with where embankment crashes were recorded. All cable rail crashes were off-left. Two-thirds of crashes between MP 221.20-221.00 occurred during adverse winter weather and/or road conditions. Regarding this area of overlap between cable rail and embankment crashes, which are both run-off-the-road crashes, between MP 221.30-221.00, this brings to 5 the total number of off-left crashes in this location over the 6-year period, with only 1 injury level off-left crash in that period, there are no recommendations for guard rail at this time.

Figure 31 indicates another cluster of cable rail crashes between MP 219.90-220.20. This area is characterized by a straight uphill grade. In this cluster 4 out of 6 crashes occurred during adverse winter weather and road conditions. There is an existing adjustable speed limit sign on the westbound outside shoulder near mile marker 220 which is activated during conditions precipitating the use of the westbound chain-up area adjacent to it (see **Figure 32**).

The crash records for all cable rail crashes in this segment have frequent reference to vehicles spinning and losing control, however low severity of crashes suggests that cable rail performs as intended.

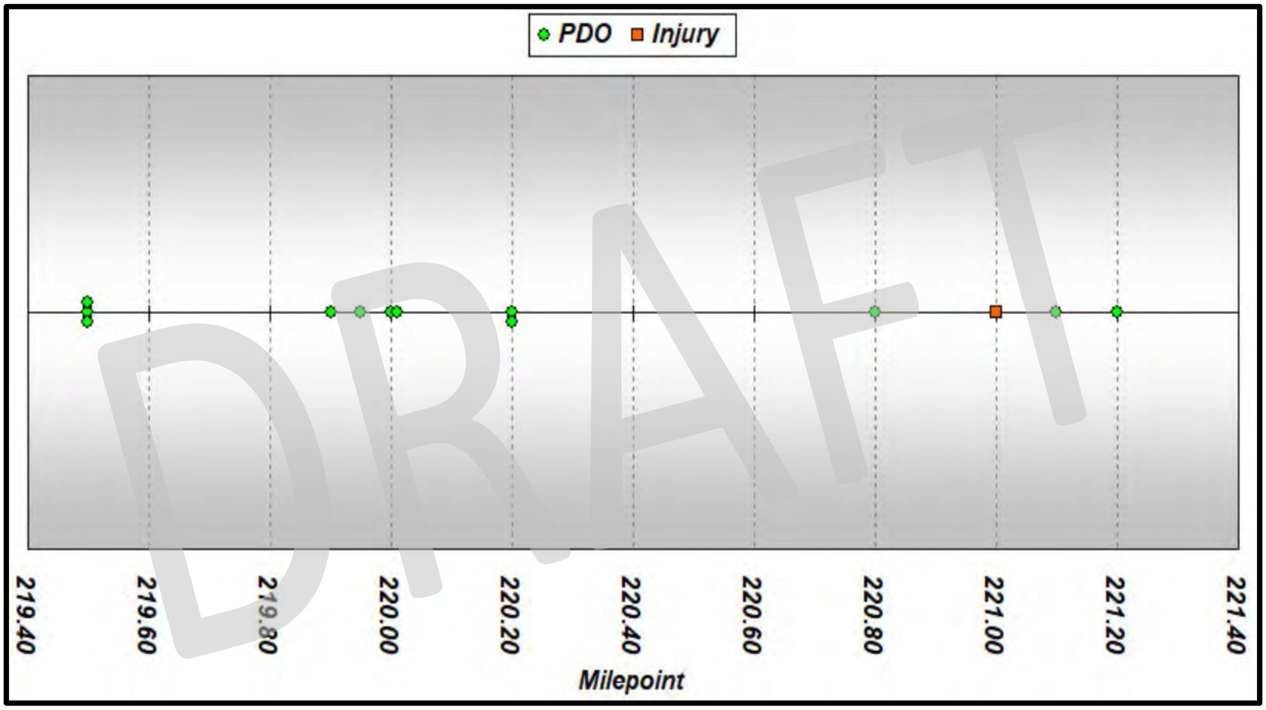


Figure 31: Straight Line Diagram for Cable Rail Crashes Segment W1

Figure 32: Adjustable Speed Limit Sign WB I-70 MP 220, Oct. 2021

Table 10 shows the results of direct diagnostics analysis for WESTBOUND I-70 segment W2.

08/11/2022

DiExSys™ Vision Zero Suite
Diagnostics Report

I-70 Segment W2 Pattern Rec				Cutoff: 5 Acc's @ 95
Category/Trait	**Statewide Average** %	**This Location** # Crashes	%	**Probability** %
Crash Severity				
Injury (INJ)	21.84%	32	34.41%	99.82%
Number Of Vehicles				
Two Vehicle Accidents	34.98%	49	52.69%	99.98%
Crash Location				
On Road	49.41%	58	62.37%	99.55%
Crash Type				
Rear End	25.23%	42	45.16%	100%
Cable Rail	0.74%	7	7.53%	100%
Road Conditions				
Snowy Road	9.62%	27	29.03%	100%
Human Contributing Factor				
Inexperienced	10.61%	16	17.2%	98.21%
Preoccupied	4.5%	8	8.6%	97.56%

Table 10: Direct Diagnostics for WESTBOUND I-70 Segment W2

Pattern recognition for segment W2 WESTBOUND identified a pattern of injury, multivehicle, rear-end, cable rail and embankment crashes, as well as crashes occurring under winter road conditions. There were also some spot locations where sideswipe same direction crashes and crashes under dark-lighted conditions were identified patterns. As well as this a pattern of crashes occurring off-left overlaps generally with the area where embankment crashes were an identified pattern.

Figure 33 shows the results of pattern recognition for segment W2 for westbound I-70. It shows there is a degree of overlap between the locations where injury, multivehicle, rear-end, and cable rail crashes are occurring and where crashes recorded during adverse winter road conditions are occurring.

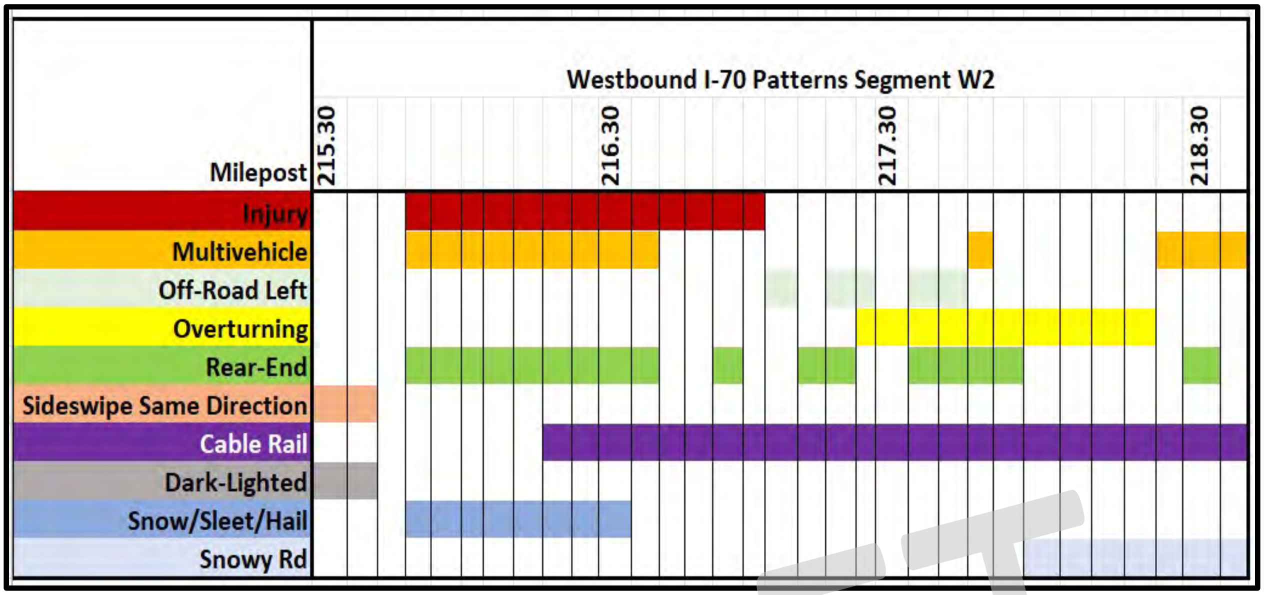


Figure 33: Mainline Crash Patterns, Westbound I-70 Segment 2, MP 215.30-218.38

Rear-end crashes are multivehicle crashes by nature which is why we see the overlap in patterns here. The presence of multivehicle rear-end crashes westbound at the west end of the corridor are observed to be concentrated on Fridays (see **Figure 34**), with crashes elevated throughout the day from 9 A.M. to 5 P.M. (see **Figure 35**). Crashes show spikes in the months of March, August and October (see **Figure 36**), which can be popular times for seasonal recreational travel to mountainous destinations west of the Denver metro area.

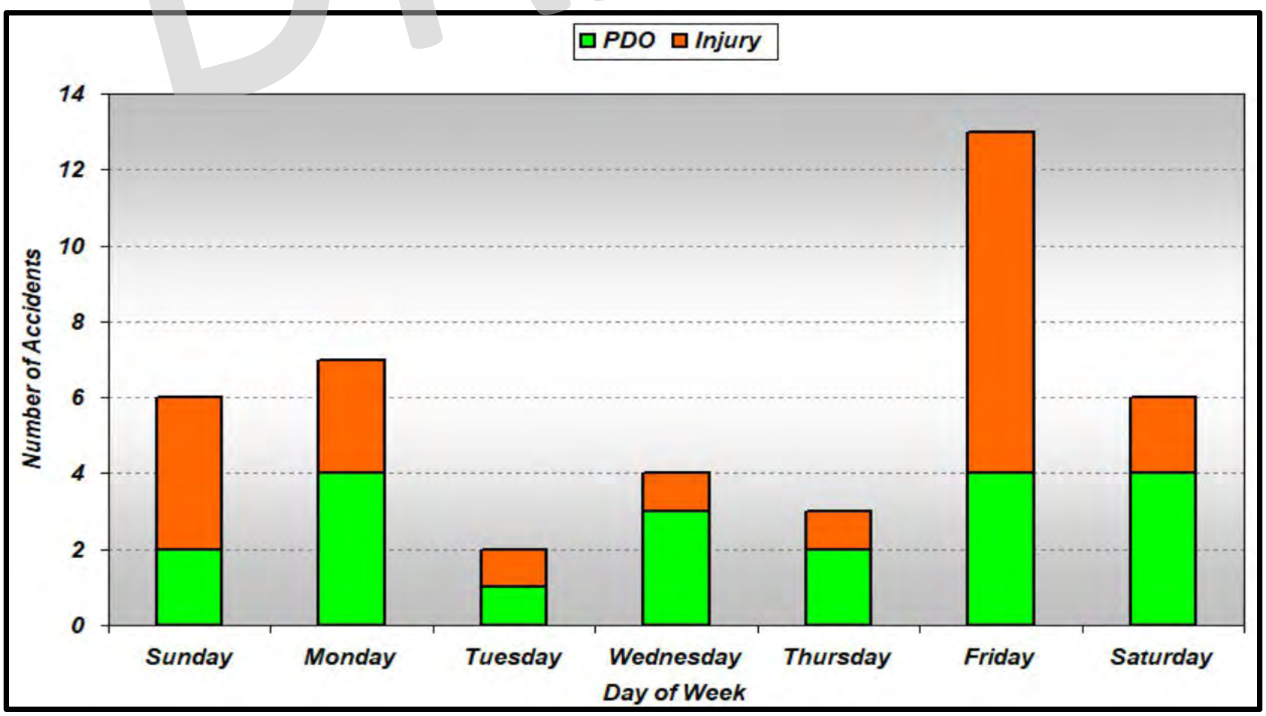


Figure 34: Rear-Ends Westbound I-70 Segment 2, MP 215.20-218.38

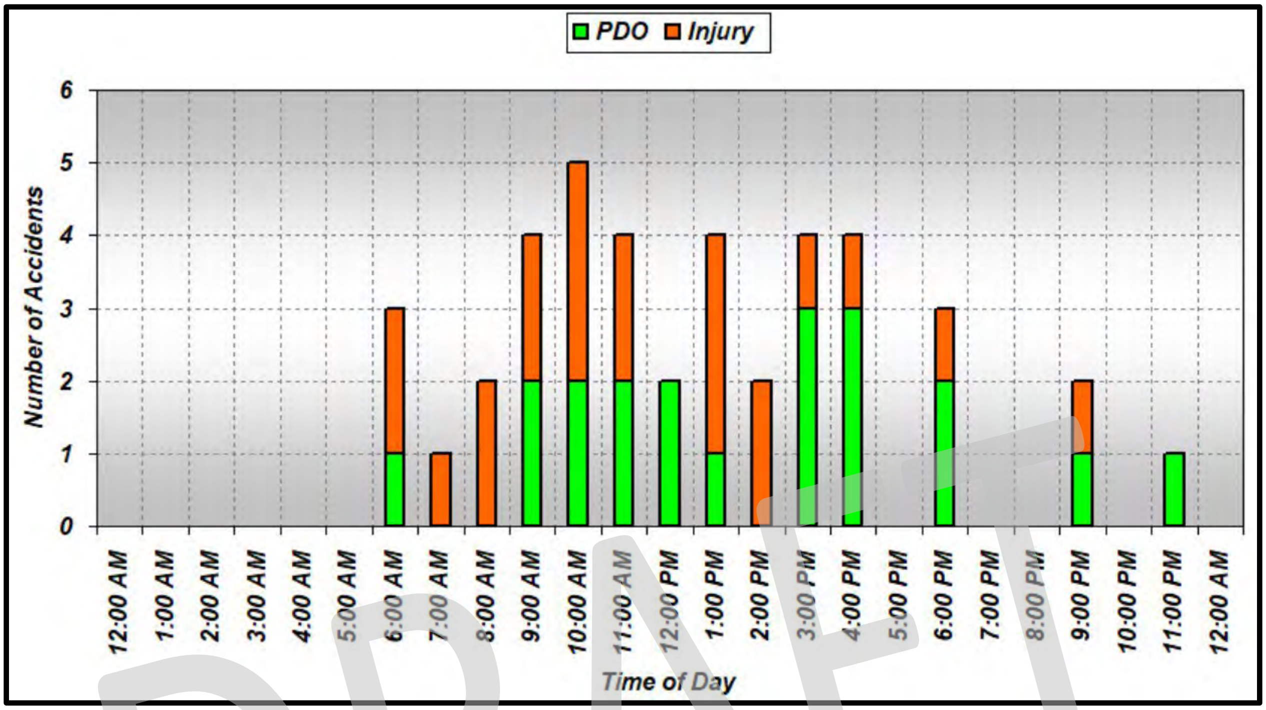


Figure 35: Rear-Ends by Time of Day Westbound I-70 Segment 2, MP 215.30-218.38

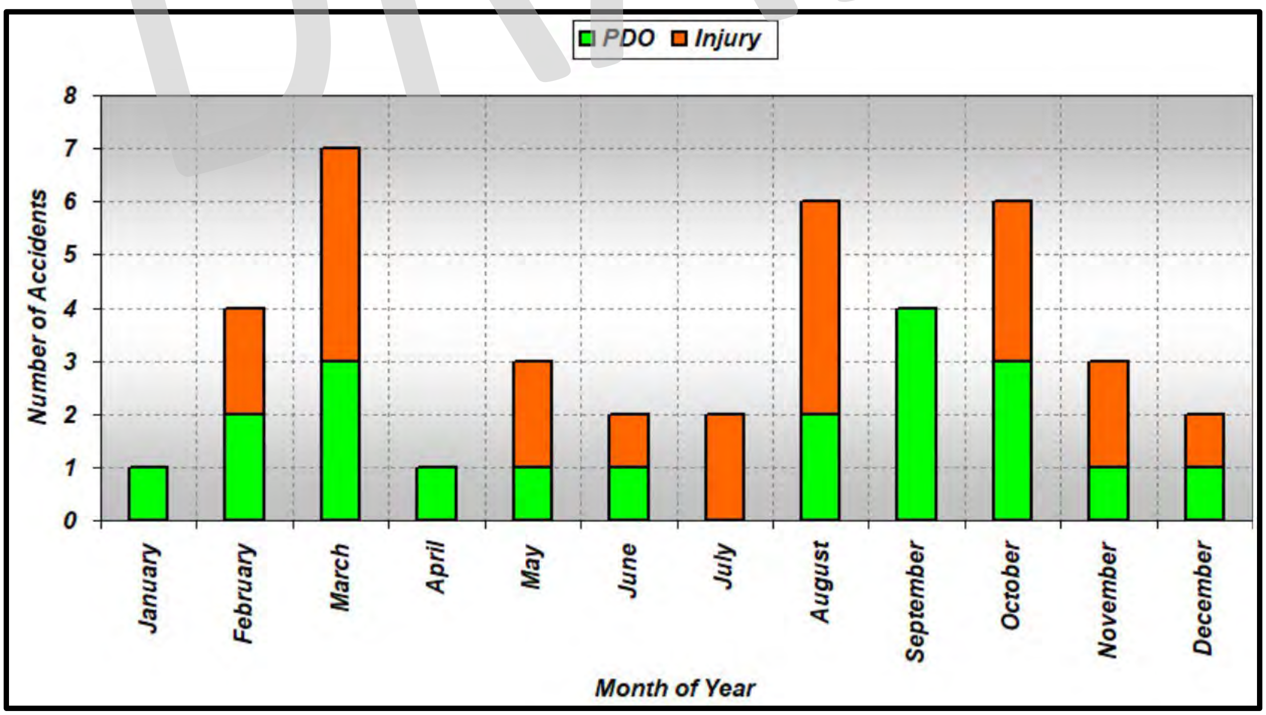


Figure 36: Rear-Ends Month of Year Westbound I-70 Segment 2, MP 215.30-218.38

Figure 37 shows that rear-ends are clustered near MP 218.00 and MP 216.00. In the former case, this is just downstream of the on-ramp from the Herman Gulch Road interchange. In the latter, this is following a horizontal curve (see **Figure 38**) beyond which traffic enters the Eisenhower tunnel, such that drivers navigating the curve may not expect traffic queues. This is compounded by a change in speed limit in the westbound direction from 65mph down to 50mph at MP 215.90.

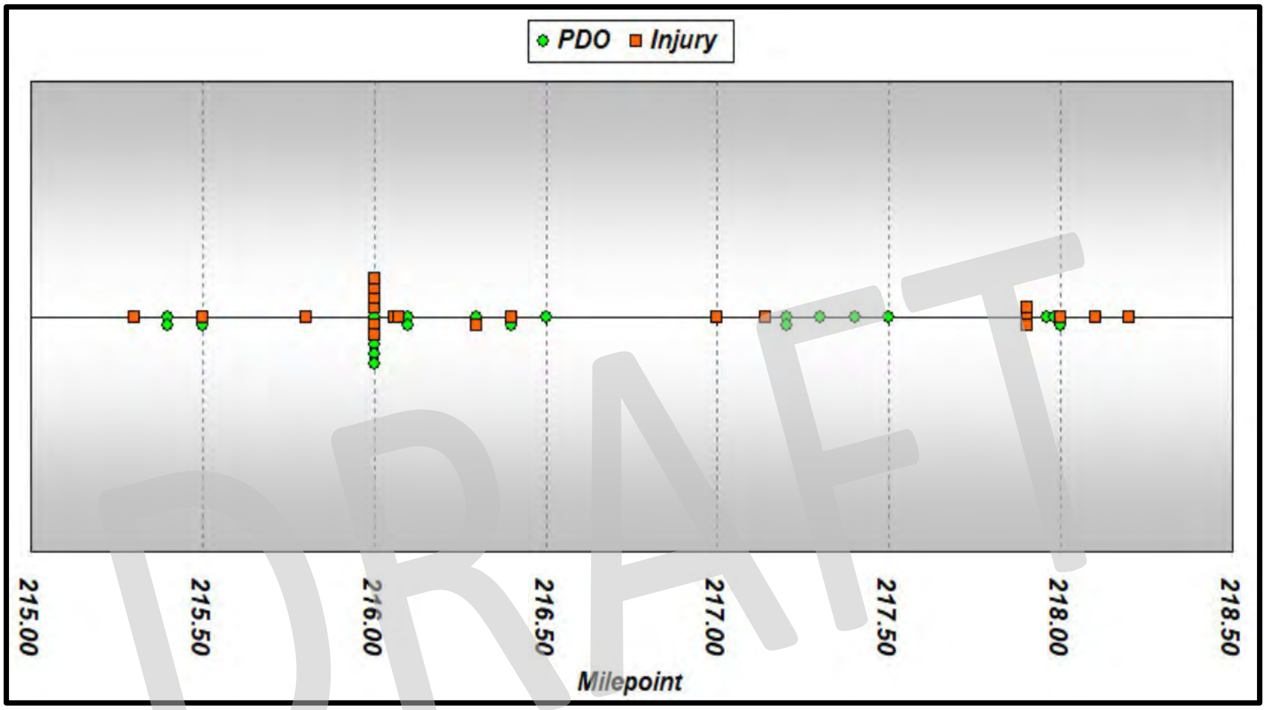


Figure 37: Rear-Ends Westbound I-70 Segment 2, MP 215.30-218.38

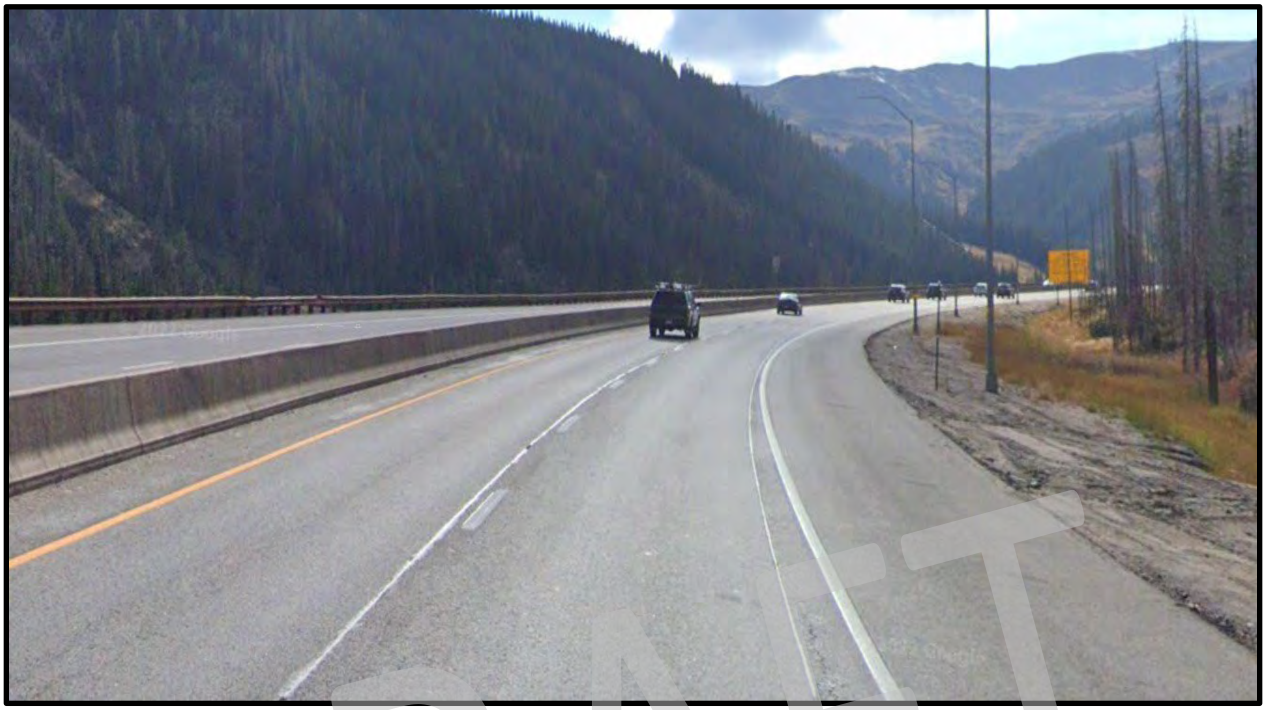


Figure 38: View approaching tunnel near MP 216 Westbound I-70 Segment 2

Rear-end collisions made up around 66% of all Injury crashes and around 79% of all injuries, indicating that the observed injury pattern is likely due to an elevated rear-end pattern. If this is considered in combination with the fact that in about 73% of rear-end crashes the vehicle which was struck was either slowing or stopped in traffic, all of this suggests high-speed, high-density operations, which are unforgiving and associated with high crash rates, are contributing to the patterns of rear-end and injury crashes.

As the safety assessment provided by CDOT highlighted, there is a substantial difference in the speed between the vehicle which was struck and the at-fault vehicle in many rear-end collisions in segment W2. Crash records show that on average the at-fault vehicle was traveling about 30 mph faster than the vehicle which was struck. The pattern of rear-end collisions in this segment is occurring in an area where grades are typically around 6% and where truck traffic is about 9%. Uphill grades combined with larger slower moving vehicles can result in drivers undertaking risky maneuvers to pass slower moving vehicles. Slow moving heavy vehicles focused on control of their vehicles can create turbulent conditions. Sudden stopping and sudden lane changes can often result in rear-end collisions. The addition of a climbing lane, as suggested within the CDOT safety assessment, would provide opportunity for drivers to pass slower moving vehicles more safely. A recent study with 4-star rating by Haq et al.[5] published in the CMF Clearinghouse under CMF ID number 10074[6], shows a Crash Reduction Factor (CRF) of 43% could be expected when truck climbing lanes are added to an interstate facility with significant

[5] Haq et al., (2019). Evaluating Safety Effectiveness of Truck Climbing Lanes Using Cross-Sectional Analysis and Propensity Score Models. TRB.
[6] http://www.cmfclearinghouse.org/detail.cfm?facid=10074 . Accessed 8/12/22

uphill grades and truck traffic, such as I-80 in Wyoming where the study was performed. Climbing lanes are also included as part of the FHWA's infrastructure safety practices when it comes to commercial vehicles[7]. In general, widening of the westbound corridor would contribute to improved mobility along a corridor which experiences a notable amount of heavy commercial vehicle traffic (in the range of 9%) on an uphill grade in the region of 5-6%. As such, any widening efforts to accommodate an additional lane would improve safety as it applies to all traffic.

A brief benefit-cost analysis for the installation of a westbound truck climbing lane using the CRF of 43% identified by Haq et al., shows an expected B/C ratio of 0.34 (**Table 11**). The analysis uses an anticipated project cost of $32 million. This analysis shows that this project might not be cost effective in terms of safety alone, however it generates some indication that the project could be viewed to be more cost-effective when mobility and operational benefits are considered in concert with safety components.

Colorado Department of Transportation
DiExSys™ Vision Zero Suite
Economic Analysis Report

09/06/2022
Job #: 20220906031543

Location: 70 A **Begin:** 215.30 **End:** 221.50 **From:** 01/01/2015 **To:** 12/31/2020

Benefit Cost Ratio Calculations

Crashes			Projected Crashes and Reduction Factors			Other Information	
PDO:	132		Weighted PDO:	27.02	43% :CRF for PDO	Cost of PDO:	$ 11,100
INJ:	48	84 :Injured	Weighted INJ:	17.20	43% :CRF for INJ	Cost of INJ:	$ 101,800
FAT:	0	0 :Killed	Weighted FAT:	0.00	43% :CRF for FAT	Cost of FAT:	$ 1,820,600
			B/C Weighted Year Factor:	6.00	43% :Weighted CRF	Interest Rate:	5%
						AADT Growth Factor:	2.0%
						Service Life:	20
						Capital Recovery Factor:	0.080
						Annual Maintenance/Delay Cost:	$ 0

Cost: $ 32,000,000
From: 01/01/2015
To: 12/31/2020 Days: 2192

Benefit Cost Ratio: 0.34 (B/C Based on Injury Numbers : PDO/Injured/Killed)

Type of Improvement: Install Truck Climbing Lane Westbound
Special Notes: CMF ID# 10074. Westbound Crashes Only.

Table 11: B/C Analysis of Westbound Truck Climbing Lane

In addition to congestion and flow related problems, about 27% of rear-end collisions occurred during adverse winter road conditions.

Of the 7 cable rail collisions recorded 6 occurred during adverse winter road conditions. There is no other discernable pattern to cable rail collisions in the segment, however crash records have several references to loss of control.

RAMPS AND FRONTAGE ROADS

[7] https://safety.fhwa.dot.gov/cmv_rtc/ch2.cfm#s2 . Accessed 8/12/22

There were 20 crashes recorded at ramps and 1 at a frontage road on the corridor over the 6-year study period. **Table 12** shows the location and distribution of those crashes. It shows the majority of crashes were ramp crashes which occurred at the eastbound off-ramp from I-70 at Exit 216 at the US-6/Loveland interchange. (Note, a few of crashes were miscoded to the incorrect ramp type and location, however crash narratives assisted in correctly identifying crash locations. Additionally, one crash was coded as a ramp crash but was found to have occurred in the eastbound chain station parking area).

MP	Description	PDO	INJ	FAT
216.35	Hook On-Ramp from US-6 to I-70 WB	2	0	0
215.73	EB Off-Ramp US-6/Loveland Interchange	11	2 (2)	1 (1)
215.50	East Portal Parking (westbound)	1	0	0
216.20	US-6 EB/I-70 Frontage Road (Loveland Ski Driveway access)	1	0	0
218.18	EB Off-Ramp Herman Gulch Rd. Interchange	1	0	0
221.29	EB Off-Ramp Stevens Gulch Rd. Interchange	0	2 (3)	0

Table 12: Ramp & Frontage Road Crashes I-70 MP 215.30-221.50

MP 216.35 - Hook On-Ramp, US-6 to I-70 WB

This ramp presents drivers with a sharp turning radius and is also located on a grade. Both crashes were off-left. One crash was an embankment crash in which the driver inexperience was recorded. The other crash was a collision with another object, in which the driver was unfamiliar with the area. There were no adverse weather, road or lighting conditions present for either crash. With only 2 PDO crashes over 6 years, there are no safety recommendations at this time.

MP 215.73 - Eastbound Off-Ramp, US-6/Loveland Interchange

This ramp intersection experienced the most ramp crashes on the corridor over the study period, as well as the most severe ramp crashes. Out of the 14 recorded crashes, 10 were off-left. The off-ramp curves sharply 90 degrees near its end before terminating in a 3-leg stop-controlled intersection (**Figure 39**).

In all but one case, crashes were recorded as occurring during adverse winter road conditions (snowy, snowy with icy road treatment or icy with icy road treatment). Crash records show 8 out of 14 crashes were embankment crashes, 2 were rear-ends, 2 were collisions with a sign, and there was 1 collision with a parked vehicle and 1 with guard rail.

Figure 39: I-70 Eastbound Off-Ramp to US-6/Loveland Interchange, Exit 216

The fatal crash did not occur under adverse weather or road conditions; however, it did occur under dark unlighted conditions. The driver was cited for careless driving causing death.

Records show that the majority of drivers were inexperienced or unfamiliar with the area. The ramp serves as access to a seasonal ski resort which can attract non-local drivers. As outlined in the report provided by CDOT, placement of a curve ahead warning sign and speed advisory plaque (W1-1a (15)) and a stop ahead sign (W3-1) were installed between 2016 and 2017 (**Figure 40**). Records indicate one embankment crash, the one parked motor vehicle collision and one of the rear-end collisions occurred since this time. All 3 crashes occurred during adverse winter weather and road conditions.

The Region might consider placement of a SLIPPERY CONDITIONS warning sign (*MUTCD W8-5*) on the left side of the ramp between the first curve warning sign and the STOP ahead sign. Inclusion of a supplemental 'ICE' plaque (*MUTCD W8-5aP*) below the sign would be advisable. This combination would benefit the unfamiliar and inexperienced driver.

Figure 40: Exit 216 EB, US-6/Loveland Interchange Off-Ramp

MP 215.50 – East Portal Parking (Westbound)

The one rear-end crash which occurred was coded to MP 216.19, however crash narratives indicate that it occurred in the westbound direction close to the east portal parking, as both vehicles came to a rest in the east portal parking area. Narratives suggest there may have been construction activity at the time, or some other kind of traffic management in place. There are no safety recommendations at this time.

MP 216.20 – US-6/I-70 WB Frontage Road

There was 1 embankment crash recorded on the I-70 westbound frontage road (US-6). It involved a vehicle making a right turn into a private driveway for the Loveland Ski area. The crash occurred under adverse winter weather and road conditions. The driver was cited for careless driving. There are no safety recommendations at this time.

MP 218.18 – Herman Gulch Road Interchange

There was one collision with a sign recorded on the eastbound I-70 off-ramp at the Herman Gulch Rd. interchange. The crash occurred under adverse winter weather and road conditions. There are no safety recommendations at this time.

MP 221.29 – Stevens Gulch Road Interchange

There were 2 injury level guard rail crashes recorded on the eastbound I-70 off-ramp at the Stevens Gulch Rd. interchange. Both occurred under dark unlighted conditions. One involved alcohol and occurred under wet road conditions. The other involved driver fatigue as well as adverse winter weather and road conditions. There are no safety recommendations at this time.

CONCLUSIONS AND RECOMMENDATIONS

The intent of the report was to provide an updated safety assessment of current conditions on the I-70 corridor between MP 215.30 and MP 221.00 (Eisenhower Tunnel east portal to Stevens Gulch Road interchange), and to enhance those findings with a directional safety analysis.

This report is based on the comprehensive analysis of 6 years of crash history (1/1/2015-12/31/2020), traffic volume and operations data available from the CDOT website and databases. The Region is advised to verify through field survey the information included in this report regarding physical features and roadside characteristics in the study area.

Each direction was evaluated independently and split into two segments which were chosen based on the locations of interchanges and the extents of the study limits.

EASTBOUND

Eastbound in the study corridor is characterized by a downhill grade and horizontal curves. The level of service of safety varied from LOSS-IV for segment E1 in terms of total crashes and crash severity, to LOSS-II for segment E2 in terms of total crashes and crash severity.

- Segment E1, MP 215.30 – MP 218.38
- Segment E2, MP 218.39 – MP 221.50

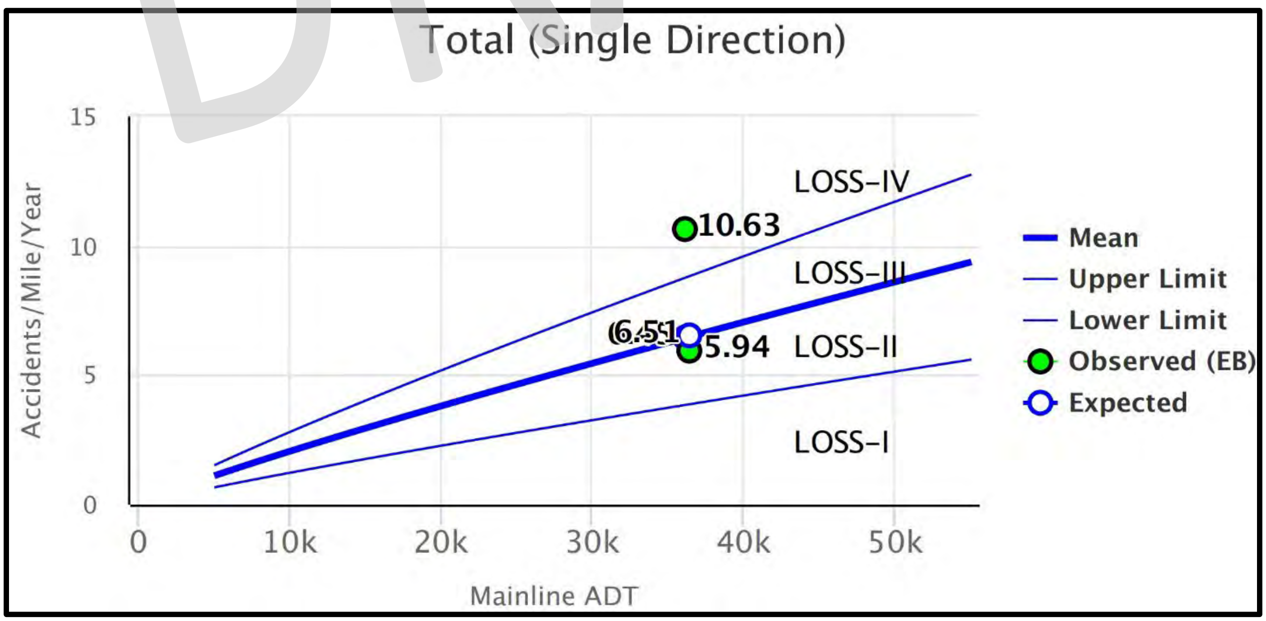


Figure 41: SPF Total Crashes I-70 Eastbound Segment E1 and E2

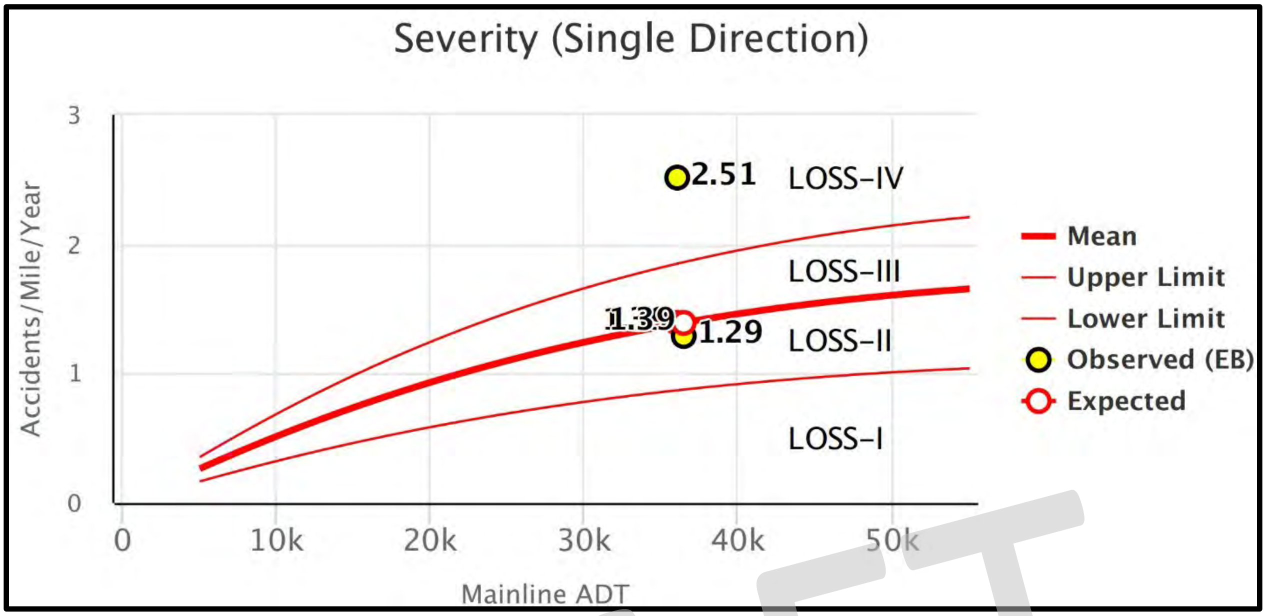


Figure 42: SPF INJ+FAT Crashes I-70 Eastbound Segment E1 and E2

Most patterns identified on the eastbound corridor were correlated with weather and road conditions, but also with high-speed, high-density operations. The suggestion made in the CDOT report to widen the eastbound inside shoulder would be a suitable countermeasure towards addressing the specific crash patterns which were identified. It is also recommended that consideration be given to the extension of existing highway lighting in segment E2.

WESTBOUND

Westbound in the study corridor is characterized by an uphill grade and horizontal curves. The level of service of safety varied from LOSS-II in terms of total crashes and crash severity for segment W1, to LOSS-II in terms of total crashes and LOSS-III in terms of crash severity for segment W2.

- Segment W1, MP 221.50 – 218.29
- Segment W2, MP 218.38 – 215.30

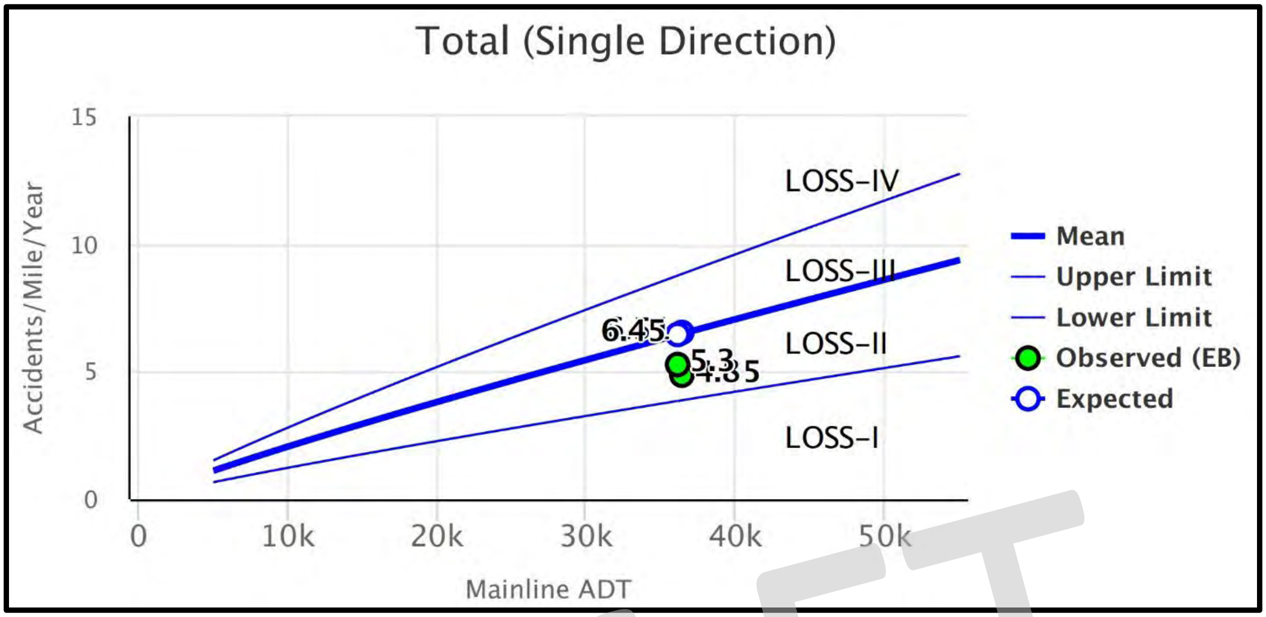


Figure 43: SPF Total Crashes I-70 Westbound Segment W1 and W2

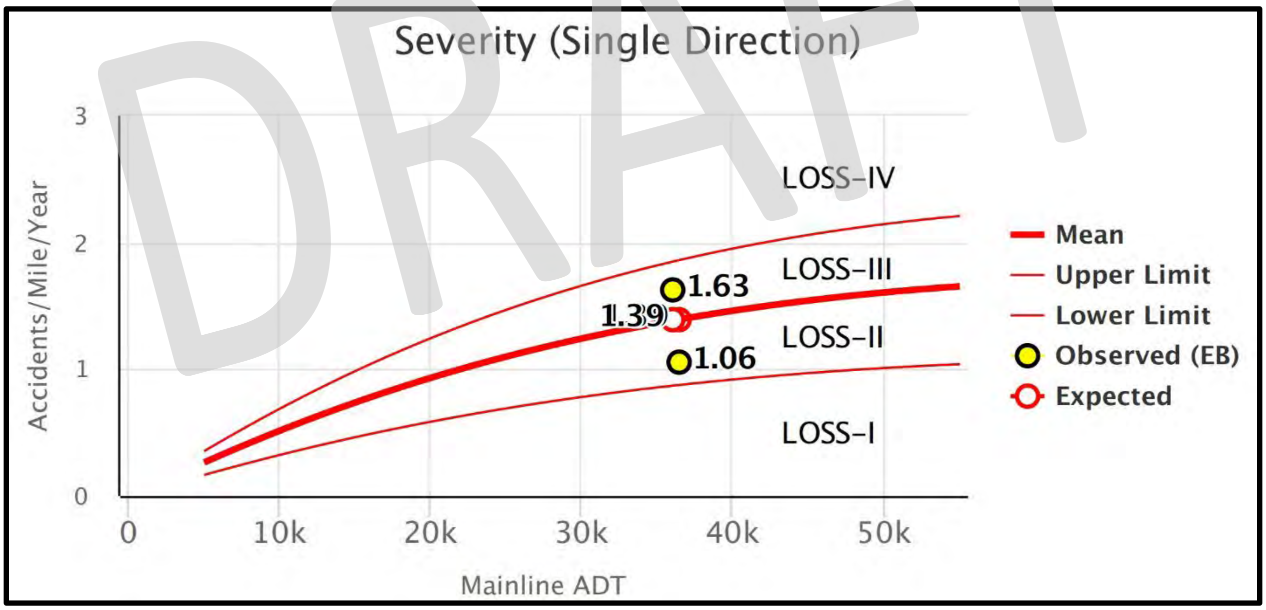


Figure 44: SPF INJ+FAT Crashes I-70 Westbound Segment W1 and W2

Most crash patterns identified in the westbound corridor were correlated with road conditions and alignment, as well as high-speed, high-density operations.

The CDOT report was made in the context of a planned future project which adds a climbing lane in the westbound direction. This would allow safer passing of slower moving vehicles on a segment which experiences a substantial percentage of truck traffic on an uphill grade.

In general, widening of the corridor would contribute to improved mobility along a corridor which experiences a notable amount of heavy commercial vehicle traffic (in the range of 9%) on grade. As such, any widening efforts would improve safety as it applies to all traffic.

A primary feature of this report was the *directional* evaluation of the safety performance of the corridor. As such, it is necessary to acknowledge as part of any conclusions that the highest potential for crash reduction is in the eastbound direction. Crash distribution is predominantly in the eastbound direction, with 63% of crashes occurring in that direction, compared to 36.6% westbound.

It is in the eastbound direction that safety performance is seen in the LOSS-IV level in segment E1, indicating high potential for crash reduction. This is true for both total crash frequency and crash severity. While it is the case that in the westbound direction the W2 segment enters the LOSS-III level for crash severity (moderate to high potential for crash reduction), on the whole the eastbound direction is performing worse than comparable facilities in terms of safety.

The planned project is for widening to accommodate a climbing lane in the westbound direction. A brief benefit-cost analysis, considering safety benefits only, showed that the expected B/C for such a project is 0.36 using a project cost of $32M. Thus, without considering potential mobility benefits or any additional safety countermeasures, the project is not expected to be cost-effective. Considering disparity in safety performance by direction a flow and weather-based VSL system in both directions will have the potential to meaningfully improve safety.

A more detailed evaluation of the VSL feasibility and cost-effectiveness will be provided in the next phase of the report.

RAMPS AND FRONTAGE ROADS

The eastbound I-70 off-ramp at Exit 216 at the US-6/Loveland interchange was the only ramp which experienced any notable crash history over the 6-year study period. Most crashes were embankment crashes, and most crashes were also related to adverse winter road and weather conditions. As outlined in the CDOT safety report, horizontal alignment and speed advisory signs, as well as a stop ahead sign, were installed on the ramp between 2016 and 2017. There have been 3 crashes since then, including 2 PDO and 1 Injury. Since planned project is going to reconfigure the interchange the designers may keep this crash history in mind. The region might consider installation of a SLIPPERY CONDITIONS warning sign (*MUTCD W8-5)* with supplemental ICE plaque (*MUTCD W8-5aP*) between the current advisory signs.

Appendix B

Observed Traffic Counts

All Traffic Data Services, LLC
www.alltrafficdataservices.com

Site Code: 1
Station ID: 1
WB I-70 ON RAMP FROM BAKERVILLE RD

Latitude: 0' 0.0000 Undefined

Start Time	05-Aug-22 Fri	WB								
12:00 AM		0								
01:00		0								
02:00		2								
03:00		0								
04:00		5								
05:00		4								
06:00		3								
07:00		5								
08:00		18								
09:00		12								
10:00		9								
11:00		**22**								
12:00 PM		20								
01:00		22								
02:00		20								
03:00		21								
04:00		**25**								
05:00		17								
06:00		10								
07:00		11								
08:00		3								
09:00		5								
10:00		3								
11:00		2								
Total		239								
AM Peak	-	11:00	-	-	-	-	-	-	-	-
Vol.	-	22	-	-	-	-	-	-	-	-
PM Peak	-	16:00	-	-	-	-	-	-	-	-
Vol.	-	25	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
www.alltrafficdataservices.com

Site Code: 1
Station ID: 1
WB I-70 ON RAMP FROM BAKERVILLE RD

Latitude: 0' 0.0000 Undefined

Start Time	06-Aug-22 Sat	WB								
12:00 AM		1								
01:00		0								
02:00		0								
03:00		2								
04:00		0								
05:00		1								
06:00		7								
07:00		4								
08:00		10								
09:00		16								
10:00		**18**								
11:00		18								
12:00 PM		14								
01:00		**24**								
02:00		17								
03:00		14								
04:00		12								
05:00		7								
06:00		7								
07:00		2								
08:00		6								
09:00		1								
10:00		1								
11:00		1								
Total		183								
AM Peak	-	10:00	-	-	-	-	-	-	-	-
Vol.	-	18	-	-	-	-	-	-	-	-
PM Peak	-	13:00	-	-	-	-	-	-	-	-
Vol.	-	24	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
www.alltrafficdataservices.com

Site Code: 1
Station ID: 1
WB I-70 ON RAMP FROM BAKERVILLE RD

Latitude: 0' 0.0000 Undefined

Start Time	07-Aug-22 Sun	WB								
12:00 AM		2								
01:00		6								
02:00		1								
03:00		1								
04:00		0								
05:00		1								
06:00		5								
07:00		3								
08:00		5								
09:00		13								
10:00		**16**								
11:00		14								
12:00 PM		14								
01:00		**16**								
02:00		10								
03:00		14								
04:00		7								
05:00		5								
06:00		3								
07:00		8								
08:00		3								
09:00		1								
10:00		0								
11:00		9								
Total		157								
AM Peak	-	10:00	-	-	-	-	-	-	-	-
Vol.	-	16	-	-	-	-	-	-	-	-
PM Peak	-	13:00	-	-	-	-	-	-	-	-
Vol.	-	16	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
www.alltrafficdataservices.com

Site Code: 1
Station ID: 1
WB I-70 ON RAMP FROM BAKERVILLE RD

Latitude: 0' 0.0000 Undefined

Start Time	08-Aug-22 Mon	WB								
12:00 AM		2								
01:00		0								
02:00		2								
03:00		1								
04:00		0								
05:00		1								
06:00		13								
07:00		14								
08:00		7								
09:00		**28**								
10:00		7								
11:00		11								
12:00 PM		16								
01:00		16								
02:00		**18**								
03:00		15								
04:00		8								
05:00		16								
06:00		4								
07:00		4								
08:00		3								
09:00		3								
10:00		0								
11:00		0								
Total		189								
AM Peak	-	09:00	-	-	-	-	-	-	-	-
Vol.	-	28	-	-	-	-	-	-	-	-
PM Peak	-	14:00	-	-	-	-	-	-	-	-
Vol.	-	18	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
www.alltrafficdataservices.com

Site Code: 1
Station ID: 1
WB I-70 ON RAMP FROM BAKERVILLE RD

Latitude: 0' 0.0000 Undefined

Start Time	09-Aug-22 Tue	WB								
12:00 AM		0								
01:00		0								
02:00		0								
03:00		0								
04:00		0								
05:00		4								
06:00		13								
07:00		**21**								
08:00		8								
09:00		12								
10:00		20								
11:00		9								
12:00 PM		17								
01:00		**23**								
02:00		10								
03:00		14								
04:00		12								
05:00		11								
06:00		5								
07:00		9								
08:00		5								
09:00		3								
10:00		0								
11:00		0								
Total		196								
AM Peak	-	07:00	-	-	-	-	-	-	-	-
Vol.	-	21	-	-	-	-	-	-	-	-
PM Peak	-	13:00	-	-	-	-	-	-	-	-
Vol.	-	23	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
www.alltrafficdataservices.com

Site Code: 1
Station ID: 1
WB I-70 ON RAMP FROM BAKERVILLE RD

Latitude: 0' 0.0000 Undefined

Start Time	10-Aug-22 Wed	WB								
12:00 AM		1								
01:00		3								
02:00		1								
03:00		4								
04:00		0								
05:00		2								
06:00		**13**								
07:00		11								
08:00		7								
09:00		12								
10:00		12								
11:00		6								
12:00 PM		10								
01:00		**19**								
02:00		13								
03:00		13								
04:00		19								
05:00		10								
06:00		9								
07:00		8								
08:00		12								
09:00		6								
10:00		1								
11:00		1								
Total		193								
AM Peak	-	06:00	-	-	-	-	-	-	-	-
Vol.	-	13	-	-	-	-	-	-	-	-
PM Peak	-	13:00	-	-	-	-	-	-	-	-
Vol.	-	19	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
www.alltrafficdataservices.com

Site Code: 1
Station ID: 1
WB I-70 ON RAMP FROM BAKERVILLE RD

Latitude: 0' 0.0000 Undefined

Start Time	11-Aug-22 Thu	WB								
12:00 AM		1								
01:00		1								
02:00		1								
03:00		5								
04:00		0								
05:00		0								
06:00		7								
07:00		13								
08:00		6								
09:00		9								
10:00		8								
11:00		**14**								
12:00 PM		**29**								
01:00		29								
02:00		20								
03:00		15								
04:00		14								
05:00		10								
06:00		8								
07:00		8								
08:00		4								
09:00		7								
10:00		2								
11:00		0								
Total		211								
AM Peak	-	11:00	-	-	-	-	-	-	-	-
Vol.	-	14	-	-	-	-	-	-	-	-
PM Peak	-	12:00	-	-	-	-	-	-	-	-
Vol.	-	29	-	-	-	-	-	-	-	-
Grand Total		1368								
ADT		ADT 195	AADT 195							

All Traffic Data Services, LLC
www.alltrafficdataservices.com

Site Code: 2
Station ID: 2
WB I-70 OFF RAMP TO HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	05-Aug-22 Fri	WB								
12:00 AM		5								
01:00		0								
02:00		1								
03:00		2								
04:00		11								
05:00		13								
06:00		22								
07:00		32								
08:00		**33**								
09:00		15								
10:00		20								
11:00		13								
12:00 PM		4								
01:00		**13**								
02:00		5								
03:00		8								
04:00		12								
05:00		8								
06:00		9								
07:00		3								
08:00		1								
09:00		7								
10:00		2								
11:00		2								
Total		241								
AM Peak	-	08:00	-	-	-	-	-	-	-	-
Vol.	-	33	-	-	-	-	-	-	-	-
PM Peak	-	13:00	-	-	-	-	-	-	-	-
Vol.	-	13	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
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Site Code: 2
Station ID: 2
WB I-70 OFF RAMP TO HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	06-Aug-22 Sat	WB								
12:00 AM		3								
01:00		1								
02:00		2								
03:00		4								
04:00		13								
05:00		36								
06:00		**80**								
07:00		53								
08:00		34								
09:00		28								
10:00		30								
11:00		22								
12:00 PM		17								
01:00		21								
02:00		**23**								
03:00		13								
04:00		10								
05:00		7								
06:00		6								
07:00		2								
08:00		1								
09:00		3								
10:00		1								
11:00		2								
Total		412								
AM Peak	-	06:00	-	-	-	-	-	-	-	-
Vol.	-	80	-	-	-	-	-	-	-	-
PM Peak	-	14:00	-	-	-	-	-	-	-	-
Vol.	-	23	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
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Site Code: 2
Station ID: 2
WB I-70 OFF RAMP TO HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	07-Aug-22 Sun	WB								
12:00 AM		1								
01:00		0								
02:00		2								
03:00		4								
04:00		7								
05:00		19								
06:00		**45**								
07:00		21								
08:00		26								
09:00		13								
10:00		23								
11:00		10								
12:00 PM		**12**								
01:00		8								
02:00		12								
03:00		5								
04:00		8								
05:00		4								
06:00		9								
07:00		2								
08:00		2								
09:00		1								
10:00		1								
11:00		3								
Total		238								
AM Peak	-	06:00	-	-	-	-	-	-	-	-
Vol.	-	45	-	-	-	-	-	-	-	-
PM Peak	-	12:00	-	-	-	-	-	-	-	-
Vol.	-	12	-	-	-	-	-	-	-	-

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Site Code: 2
Station ID: 2
WB I-70 OFF RAMP TO HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	08-Aug-22 Mon	WB								
12:00 AM		1								
01:00		1								
02:00		0								
03:00		0								
04:00		4								
05:00		8								
06:00		11								
07:00		12								
08:00		**16**								
09:00		9								
10:00		14								
11:00		8								
12:00 PM		5								
01:00		**12**								
02:00		9								
03:00		4								
04:00		5								
05:00		2								
06:00		1								
07:00		3								
08:00		2								
09:00		0								
10:00		1								
11:00		2								
Total		130								
AM Peak	-	08:00	-	-	-	-	-	-	-	-
Vol.	-	16	-	-	-	-	-	-	-	-
PM Peak	-	13:00	-	-	-	-	-	-	-	-
Vol.	-	12	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
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Site Code: 2
Station ID: 2
WB I-70 OFF RAMP TO HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	09-Aug-22 Tue	WB								
12:00 AM		4								
01:00		0								
02:00		1								
03:00		0								
04:00		4								
05:00		9								
06:00		15								
07:00		12								
08:00		**21**								
09:00		20								
10:00		13								
11:00		10								
12:00 PM		7								
01:00		9								
02:00		4								
03:00		8								
04:00		**10**								
05:00		1								
06:00		0								
07:00		3								
08:00		5								
09:00		2								
10:00		3								
11:00		10								
Total		171								
AM Peak	-	08:00	-	-	-	-	-	-	-	-
Vol.	-	21	-	-	-	-	-	-	-	-
PM Peak	-	16:00	-	-	-	-	-	-	-	-
Vol.	-	10	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
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Site Code: 2
Station ID: 2
WB I-70 OFF RAMP TO HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	10-Aug-22 Wed	WB								
12:00 AM		1								
01:00		1								
02:00		0								
03:00		2								
04:00		1								
05:00		6								
06:00		20								
07:00		14								
08:00		**27**								
09:00		20								
10:00		12								
11:00		8								
12:00 PM		**11**								
01:00		9								
02:00		4								
03:00		10								
04:00		3								
05:00		5								
06:00		2								
07:00		3								
08:00		1								
09:00		2								
10:00		0								
11:00		1								
Total		163								
AM Peak	-	08:00	-	-	-	-	-	-	-	-
Vol.	-	27	-	-	-	-	-	-	-	-
PM Peak	-	12:00	-	-	-	-	-	-	-	-
Vol.	-	11	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
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Site Code: 2
Station ID: 2
WB I-70 OFF RAMP TO HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	11-Aug-22 Thu	WB								
12:00 AM		3								
01:00		5								
02:00		8								
03:00		0								
04:00		2								
05:00		6								
06:00		11								
07:00		**24**								
08:00		19								
09:00		11								
10:00		7								
11:00		4								
12:00 PM		**20**								
01:00		12								
02:00		5								
03:00		10								
04:00		3								
05:00		14								
06:00		3								
07:00		1								
08:00		2								
09:00		1								
10:00		2								
11:00		0								
Total		173								
AM Peak	-	07:00	-	-	-	-	-	-	-	-
Vol.	-	24	-	-	-	-	-	-	-	-
PM Peak	-	12:00	-	-	-	-	-	-	-	-
Vol.	-	20	-	-	-	-	-	-	-	-
Grand Total		1528								
ADT		ADT 217		AADT 217						

All Traffic Data Services, LLC
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Site Code: 3
Station ID: 3
WB I-70 ON RAMP FROM HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	05-Aug-22 Fri	WB								
12:00 AM		1								
01:00		2								
02:00		1								
03:00		1								
04:00		6								
05:00		2								
06:00		5								
07:00		8								
08:00		9								
09:00		8								
10:00		9								
11:00		**16**								
12:00 PM		11								
01:00		8								
02:00		6								
03:00		**12**								
04:00		10								
05:00		8								
06:00		8								
07:00		2								
08:00		1								
09:00		4								
10:00		1								
11:00		1								
Total		140								
AM Peak	-	11:00	-	-	-	-	-	-	-	-
Vol.	-	16	-	-	-	-	-	-	-	-
PM Peak	-	15:00	-	-	-	-	-	-	-	-
Vol.	-	12	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
www.alltrafficdataservices.com

Site Code: 3
Station ID: 3
WB I-70 ON RAMP FROM HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	06-Aug-22 Sat	WB								
12:00 AM		3								
01:00		3								
02:00		1								
03:00		0								
04:00		4								
05:00		6								
06:00		8								
07:00		13								
08:00		10								
09:00		15								
10:00		**20**								
11:00		20								
12:00 PM		**19**								
01:00		15								
02:00		19								
03:00		6								
04:00		6								
05:00		4								
06:00		6								
07:00		2								
08:00		0								
09:00		0								
10:00		1								
11:00		4								
Total		185								
AM Peak	-	10:00	-	-	-	-	-	-	-	-
Vol.	-	20	-	-	-	-	-	-	-	-
PM Peak	-	12:00	-	-	-	-	-	-	-	-
Vol.	-	19	-	-	-	-	-	-	-	-

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Site Code: 3
Station ID: 3
WB I-70 ON RAMP FROM HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	07-Aug-22 Sun	WB								
12:00 AM		1								
01:00		0								
02:00		1								
03:00		2								
04:00		1								
05:00		3								
06:00		9								
07:00		3								
08:00		**11**								
09:00		6								
10:00		8								
11:00		7								
12:00 PM		8								
01:00		9								
02:00		**10**								
03:00		10								
04:00		8								
05:00		3								
06:00		4								
07:00		2								
08:00		2								
09:00		0								
10:00		1								
11:00		1								
Total		110								
AM Peak	-	08:00	-	-	-	-	-	-	-	-
Vol.	-	11	-	-	-	-	-	-	-	-
PM Peak	-	14:00	-	-	-	-	-	-	-	-
Vol.	-	10	-	-	-	-	-	-	-	-

All Traffic Data Services, LLC
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Site Code: 3
Station ID: 3
WB I-70 ON RAMP FROM HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	08-Aug-22 Mon	WB								
12:00 AM		1								
01:00		1								
02:00		0								
03:00		0								
04:00		2								
05:00		5								
06:00		1								
07:00		4								
08:00		6								
09:00		5								
10:00		**8**								
11:00		3								
12:00 PM		3								
01:00		6								
02:00		**14**								
03:00		3								
04:00		4								
05:00		7								
06:00		1								
07:00		4								
08:00		0								
09:00		0								
10:00		1								
11:00		2								
Total		81								
AM Peak	-	10:00	-	-	-	-	-	-	-	-
Vol.	-	8	-	-	-	-	-	-	-	-
PM Peak	-	14:00	-	-	-	-	-	-	-	-
Vol.	-	14	-	-	-	-	-	-	-	-

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Site Code: 3
Station ID: 3
WB I-70 ON RAMP FROM HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	09-Aug-22 Tue	WB								
12:00 AM		4								
01:00		0								
02:00		1								
03:00		0								
04:00		3								
05:00		4								
06:00		3								
07:00		4								
08:00		3								
09:00		4								
10:00		1								
11:00		**9**								
12:00 PM		6								
01:00		6								
02:00		**7**								
03:00		6								
04:00		6								
05:00		5								
06:00		4								
07:00		0								
08:00		4								
09:00		2								
10:00		2								
11:00		0								
Total		84								
AM Peak	-	11:00	-	-	-	-	-	-	-	-
Vol.	-	9	-	-	-	-	-	-	-	-
PM Peak	-	14:00	-	-	-	-	-	-	-	-
Vol.	-	7	-	-	-	-	-	-	-	-

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Site Code: 3
Station ID: 3
WB I-70 ON RAMP FROM HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	10-Aug-22 Wed	WB								
12:00 AM		0								
01:00		0								
02:00		4								
03:00		4								
04:00		0								
05:00		0								
06:00		2								
07:00		1								
08:00		5								
09:00		7								
10:00		**21**								
11:00		14								
12:00 PM		8								
01:00		**14**								
02:00		8								
03:00		6								
04:00		7								
05:00		6								
06:00		5								
07:00		2								
08:00		1								
09:00		1								
10:00		3								
11:00		0								
Total		119								
AM Peak	-	10:00	-	-	-	-	-	-	-	-
Vol.	-	21	-	-	-	-	-	-	-	-
PM Peak	-	13:00	-	-	-	-	-	-	-	-
Vol.	-	14	-	-	-	-	-	-	-	-

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Site Code: 3
Station ID: 3
WB I-70 ON RAMP FROM HERMAN GULCH RD

Latitude: 0' 0.0000 Undefined

Start Time	11-Aug-22 Thu	WB								
12:00 AM		0								
01:00		0								
02:00		6								
03:00		2								
04:00		3								
05:00		1								
06:00		8								
07:00		2								
08:00		7								
09:00		9								
10:00		9								
11:00		**11**								
12:00 PM		3								
01:00		9								
02:00		**13**								
03:00		4								
04:00		9								
05:00		2								
06:00		11								
07:00		1								
08:00		1								
09:00		3								
10:00		1								
11:00		2								
Total		117								
AM Peak	-	11:00	-	-	-	-	-	-	-	-
Vol.	-	11	-	-	-	-	-	-	-	-
PM Peak	-	14:00	-	-	-	-	-	-	-	-
Vol.	-	13	-	-	-	-	-	-	-	-
Grand Total		836								
ADT		ADT 119		AADT 119						

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Site Code: 4
Station ID: 4
WB I-70 ON-OFF RAMPS AT US 6

Latitude: 0' 0.0000 Undefined

Start Time	05-Aug-22 Fri	WB ON RAM	WB OFF RA							Total
12:00 AM		0	7							7
01:00		1	8							9
02:00		2	5							7
03:00		1	8							9
04:00		3	11							14
05:00		0	12							12
06:00		3	49							52
07:00		0	45							45
08:00		2	48							50
09:00		3	61							64
10:00		8	83							91
11:00		**11**	**89**							**100**
12:00 PM		**11**	93							**104**
01:00		11	83							94
02:00		9	76							85
03:00		7	**95**							102
04:00		9	80							89
05:00		6	87							93
06:00		4	92							96
07:00		6	45							51
08:00		2	42							44
09:00		1	16							17
10:00		2	12							14
11:00		1	9							10
Total		103	1156							1259
Percent		8.2%	91.8%							
AM Peak	-	11:00	11:00	-	-	-	-	-	-	11:00
Vol.	-	11	89	-	-	-	-	-	-	100
PM Peak	-	12:00	15:00	-	-	-	-	-	-	12:00
Vol.	-	11	95	-	-	-	-	-	-	104

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Site Code: 4
Station ID: 4
WB I-70 ON-OFF RAMPS AT US 6

Latitude: 0' 0.0000 Undefined

Start Time	06-Aug-22 Sat	WB ON RAM	WB OFF RA							Total
12:00 AM		0	8							8
01:00		1	6							7
02:00		1	4							5
03:00		0	10							10
04:00		2	11							13
05:00		1	28							29
06:00		1	67							68
07:00		3	109							112
08:00		3	88							91
09:00		7	121							128
10:00		**9**	143							152
11:00		9	**146**							**155**
12:00 PM		**14**	**153**							**167**
01:00		12	112							124
02:00		12	116							128
03:00		10	95							105
04:00		4	63							67
05:00		14	45							59
06:00		5	32							37
07:00		2	32							34
08:00		1	12							13
09:00		0	9							9
10:00		3	13							16
11:00		0	7							7
Total		114	1430							1544
Percent		7.4%	92.6%							
AM Peak	-	10:00	11:00	-	-	-	-	-	-	11:00
Vol.	-	9	146	-	-	-	-	-	-	155
PM Peak	-	12:00	12:00	-	-	-	-	-	-	12:00
Vol.	-	14	153	-	-	-	-	-	-	167

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Site Code: 4
Station ID: 4
WB I-70 ON-OFF RAMPS AT US 6

Latitude: 0' 0.0000 Undefined

Start Time	07-Aug-22 Sun	WB ON RAM	WB OFF RA							Total
12:00 AM		3	3							6
01:00		0	4							4
02:00		1	4							5
03:00		0	9							9
04:00		0	7							7
05:00		0	8							8
06:00		2	37							39
07:00		1	48							49
08:00		2	43							45
09:00		3	68							71
10:00		**4**	84							88
11:00		3	**111**							**114**
12:00 PM		5	90							95
01:00		**12**	**100**							**112**
02:00		8	60							68
03:00		9	74							83
04:00		6	42							48
05:00		11	40							51
06:00		2	39							41
07:00		3	27							30
08:00		3	13							16
09:00		1	3							4
10:00		0	9							9
11:00		0	7							7
Total		79	930							1009
Percent		7.8%	92.2%							
AM Peak	-	10:00	11:00	-	-	-	-	-	-	11:00
Vol.	-	4	111	-	-	-	-	-	-	114
PM Peak	-	13:00	13:00	-	-	-	-	-	-	13:00
Vol.	-	12	100	-	-	-	-	-	-	112

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Site Code: 4
Station ID: 4
WB I-70 ON-OFF RAMPS AT US 6

Latitude: 0' 0.0000 Undefined

Start Time	08-Aug-22 Mon	WB ON RAM	WB OFF RA							Total
12:00 AM		1	5							6
01:00		0	1							1
02:00		1	5							6
03:00		1	13							14
04:00		1	8							9
05:00		0	16							16
06:00		2	57							59
07:00		10	34							44
08:00		4	40							44
09:00		9	45							54
10:00		**19**	**65**							**84**
11:00		18	60							78
12:00 PM		15	51							66
01:00		9	**58**							**67**
02:00		7	49							56
03:00		10	49							59
04:00		6	45							51
05:00		**18**	29							47
06:00		9	26							35
07:00		3	29							32
08:00		5	10							15
09:00		3	11							14
10:00		4	5							9
11:00		0	7							7
Total		155	718							873
Percent		17.8%	82.2%							
AM Peak	-	10:00	10:00	-	-	-	-	-	-	10:00
Vol.	-	19	65	-	-	-	-	-	-	84
PM Peak	-	17:00	13:00	-	-	-	-	-	-	13:00
Vol.	-	18	58	-	-	-	-	-	-	67

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Site Code: 4
Station ID: 4
WB I-70 ON-OFF RAMPS AT US 6

Latitude: 0' 0.0000 Undefined

Start Time	09-Aug-22 Tue	WB ON RAM	WB OFF RA							Total
12:00 AM		0	7							7
01:00		1	8							9
02:00		3	6							9
03:00		1	12							13
04:00		3	9							12
05:00		1	19							20
06:00		1	72							73
07:00		8	43							51
08:00		2	38							40
09:00		7	41							48
10:00		9	**75**							**84**
11:00		**14**	70							84
12:00 PM		**15**	**58**							**73**
01:00		7	47							54
02:00		14	57							71
03:00		10	48							58
04:00		13	39							52
05:00		15	22							37
06:00		11	28							39
07:00		6	27							33
08:00		3	9							12
09:00		4	12							16
10:00		0	11							11
11:00		2	13							15
Total		150	771							921
Percent		16.3%	83.7%							
AM Peak	-	11:00	10:00	-	-	-	-	-	-	10:00
Vol.	-	14	75	-	-	-	-	-	-	84
PM Peak	-	12:00	12:00	-	-	-	-	-	-	12:00
Vol.	-	15	58	-	-	-	-	-	-	73

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Site Code: 4
Station ID: 4
WB I-70 ON-OFF RAMPS AT US 6

Latitude: 0' 0.0000 Undefined

Start Time	10-Aug-22 Wed	WB ON RAM	WB OFF RA							Total
12:00 AM		1	9							10
01:00		0	8							8
02:00		0	11							11
03:00		2	11							13
04:00		2	11							13
05:00		4	22							26
06:00		2	67							69
07:00		10	30							40
08:00		4	37							41
09:00		7	59							66
10:00		**14**	76							90
11:00		12	**79**							**91**
12:00 PM		12	56							68
01:00		9	**65**							74
02:00		11	65							**76**
03:00		11	46							57
04:00		4	54							58
05:00		**17**	46							63
06:00		7	26							33
07:00		2	14							16
08:00		1	23							24
09:00		1	12							13
10:00		0	13							13
11:00		1	12							13
Total		134	852							986
Percent		13.6%	86.4%							
AM Peak	-	10:00	11:00	-	-	-	-	-	-	11:00
Vol.	-	14	79	-	-	-	-	-	-	91
PM Peak	-	17:00	13:00	-	-	-	-	-	-	14:00
Vol.	-	17	65	-	-	-	-	-	-	76

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Site Code: 4
Station ID: 4
WB I-70 ON-OFF RAMPS AT US 6

Latitude: 0' 0.0000 Undefined

Start Time	11-Aug-22 Thu	WB ON RAM	WB OFF RA							Total
12:00 AM		1	8							9
01:00		1	6							7
02:00		2	13							15
03:00		1	7							8
04:00		0	9							9
05:00		3	17							20
06:00		1	72							73
07:00		**11**	32							43
08:00		2	40							42
09:00		2	50							52
10:00		4	66							70
11:00		8	**77**							**85**
12:00 PM		9	75							84
01:00		**13**	**94**							**107**
02:00		8	87							95
03:00		10	55							65
04:00		9	59							68
05:00		12	47							59
06:00		2	32							34
07:00		1	34							35
08:00		7	16							23
09:00		0	16							16
10:00		1	10							11
11:00		0	16							16
Total		108	938							1046
Percent		10.3%	89.7%							
AM Peak	-	07:00	11:00	-	-	-	-	-	-	11:00
Vol.	-	11	77	-	-	-	-	-	-	85
PM Peak	-	13:00	13:00	-	-	-	-	-	-	13:00
Vol.	-	13	94	-	-	-	-	-	-	107
Grand Total		843	6795							7638
Percent		11.0%	89.0%							
ADT		ADT 1,091		AADT 1,091						