Bridges Technical Memorandum

July 09, 2018

1. Introduction

Fact sheets for each bridge of interest are included in this Technical Memorandum. This includes bridges on and over I-25 within the project limits as well as bridges adjacent to I-25 at major interchanges.

The total structure length and width reported are rounded to the nearest foot and the area of deck is rounded to the nearest 10-square-feet for simplicity.

Sufficiency ratings provided are calculated based on a national formula that evaluates a bridge's sufficiency to remain in service. The formula generates a percentage-based sufficiency rating where 100 percent represents an entirely sufficient bridge and zero percent represents an entirely insufficient or deficient bridge.

Condition ratings are assigned to each structure on a scale of 0 to 9. These are obtained from the most recent inspection report as of July 9, 2018 provided by CDOT and are reported per FHWA guidelines. A condition coding guide is shown in the following table.

Deck, Superstructure, and Substructure Condition Coding Guide	
CODE	**DESCRIPTION**
N	NOT APPLICABLE
9	EXCELLENT CONDITION
8	VERY GOOD CONDITION - no problems noted.
7	GOOD CONDITION - some minor problems.
6	SATISFACTORY CONDITION - structural elements show some minor deterioration.
5	FAIR CONDITION - all primary structural elements are sound but may have minor section loss, cracking, spalling, or scour.
4	POOR CONDITION - advanced section loss, deterioration, spalling, or scour.
3	SERIOUS CONDITION - loss of section, deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present.
2	CRITICAL CONDITION - advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	"IMMINENT" FAILURE CONDITION - major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put it back in light service.
0	FAILED CONDITION - out of service; beyond corrective action.
99	Miscoded data.

The load capacity provided in the following tables is based on the most recently performed Load Rating provided by CDOT. This is reported at Inventory Level and is calculated per either the LRFR or LFR method, depending on date of construction and date of load rating. The corresponding load rating method is reported on each bridge fact sheet.

The current AASHTO requirement for Test Level 4 bridge rail height is 2-feet-8-inches and the compliance of each structure's railing with this standard is listed below.

NB Santa Fe Flyover Ramp to NB I-25

Structure Number: F-16-XR **I-25 Milepost: 207.36**

Key Bridge Data	
Year Built	2013
Structure Type	Continuous Prestressed Concrete Tub Girders
Spans	11
Length	1,754’
Width (out-to-out)	39’
Area of Deck	68,410 SF
Curb-to-Curb Width	36’-0”
Median	N/A
Sidewalks	N/A
Vertical Clearance over I-25	16’-6”
Sufficiency Rating	85%
Deck Condition	7 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	44.3 Tons (LFR Inventory)
Bridge Rail Type	Type 7
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	5 X 2” electrical conduits

Major Inspection Findings

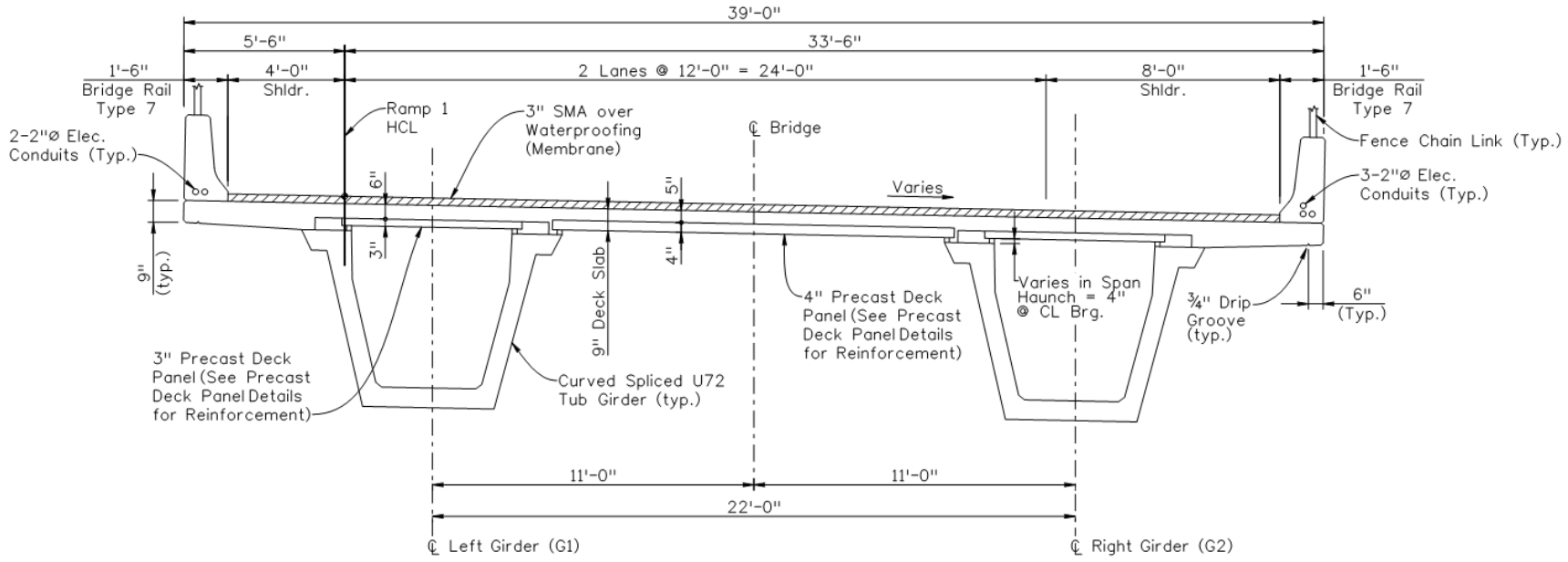
No major findings.

Rehabilitations/Widenings

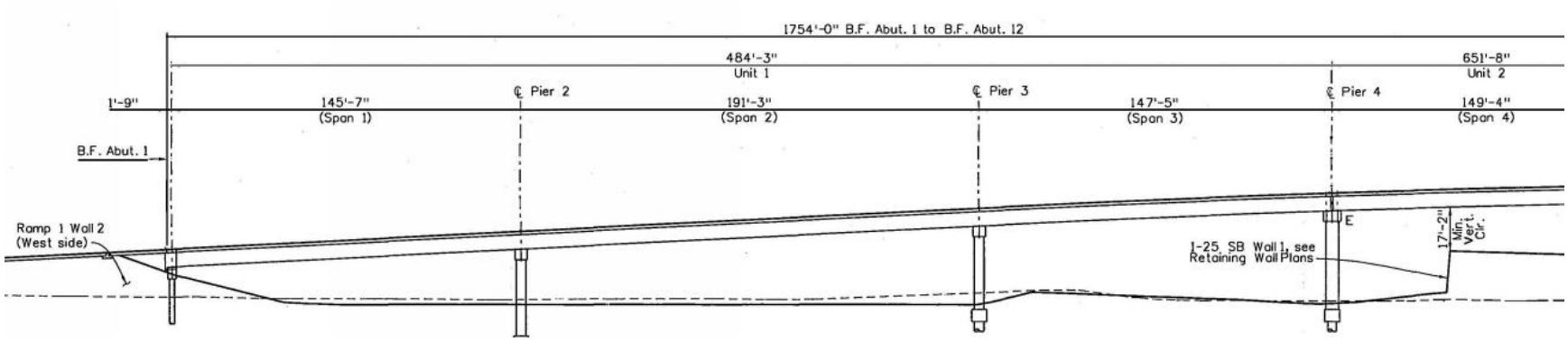
No rehabilitations nor widenings.

Additional Notes

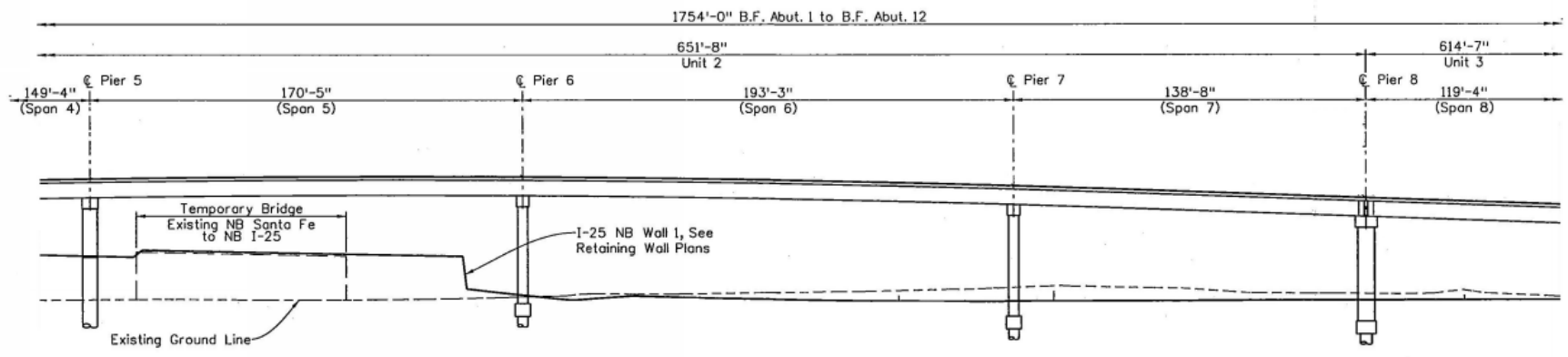
None.



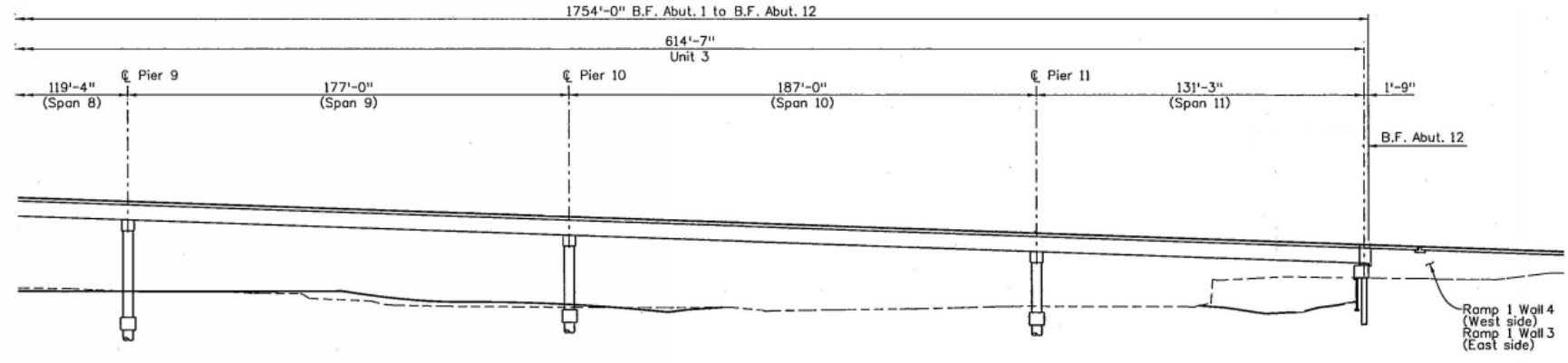
Section - F-16-XR



Elevation 1 - F-16-XR



Elevation 2 - F-16-XR



Elevation 3 - F-16-XR

This Page Intentionally Left Blank.

I-25 over Santa Fe

Structure Number: F-16-XS **I-25 Milepost: 207.69**

Key Bridge Data	
Year Built	2013
Structure Type	Continuous Prestressed Concrete Tub Girders
Spans	3
Length	547’
Width (out-to-out)	149’
Area of Deck	81,500 SF
Curb-to-Curb Width	71’-0” (NB), 71’-0” (SB)
Median	3’-0”
Sidewalks	N/A
Vert. Clearance over Santa Fe	17’-5”
Sufficiency Rating	89%
Deck Condition	8 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	8 out of 9
Load Capacity	52.0 Tons (LFR Inventory)
Bridge Rail Type	Type 7
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

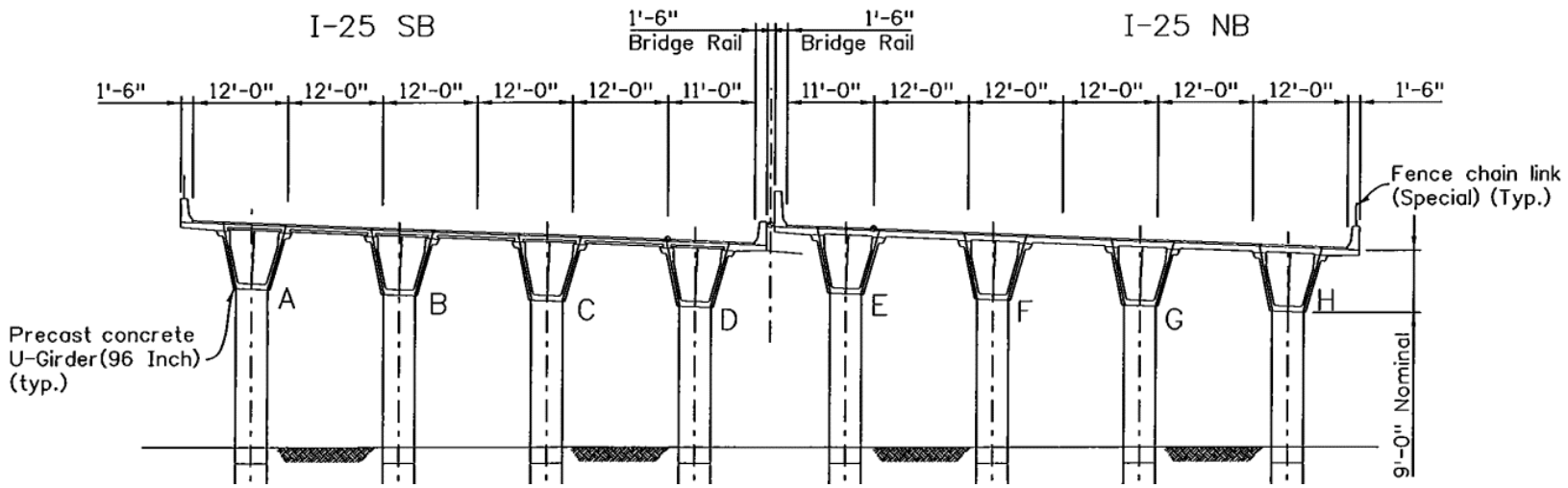
No major findings.

Rehabilitations/Widenings

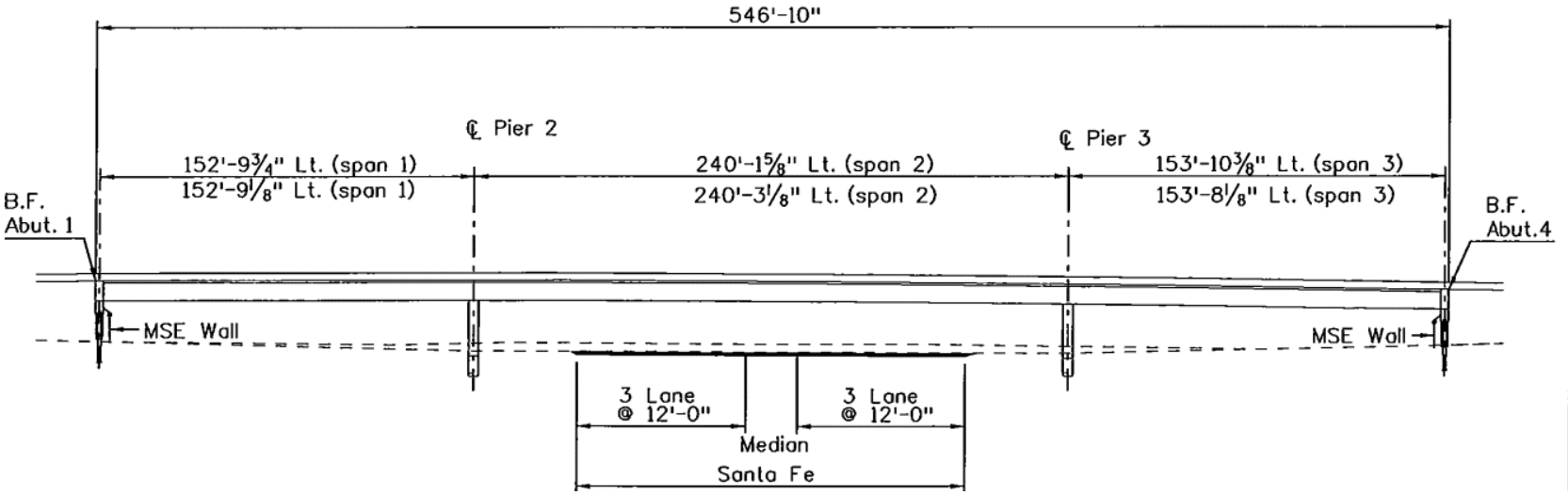
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-XS



Elevation - F-16-XS

Alameda Ave over I-25

Structure Number: F-16-XU **I-25 Milepost: 207.99**

Key Bridge Data	
Year Built	2012
Structure Type	Continuous Prestressed Concrete Girders
Spans	2
Length	239’
Width (out-to-out)	142’
Area of Deck	33,940 SF
Curb-to-Curb Width	47’-0” (EB), 58’-0” (WB)
Median	15’-0”
Sidewalks	10’-6” (North) & 8’-6” (South)
Vert. Clearance over I-25	17’-10”
Sufficiency Rating	90%
Deck Condition	8 out of 9
Superstructure Condition	8 out of 9
Substructure Condition	8 out of 9
Load Capacity	39.6 Tons (LFR Inventory)
Bridge Rail Type	Type 10M (Special)
Bridge Rail Height	3’-6” (meets current standard)
Utilities Carried	4 X 3” & 4 X 2” electrical conduits Qwest and Level 3 Conduits Xcel Conduits

Major Inspection Findings

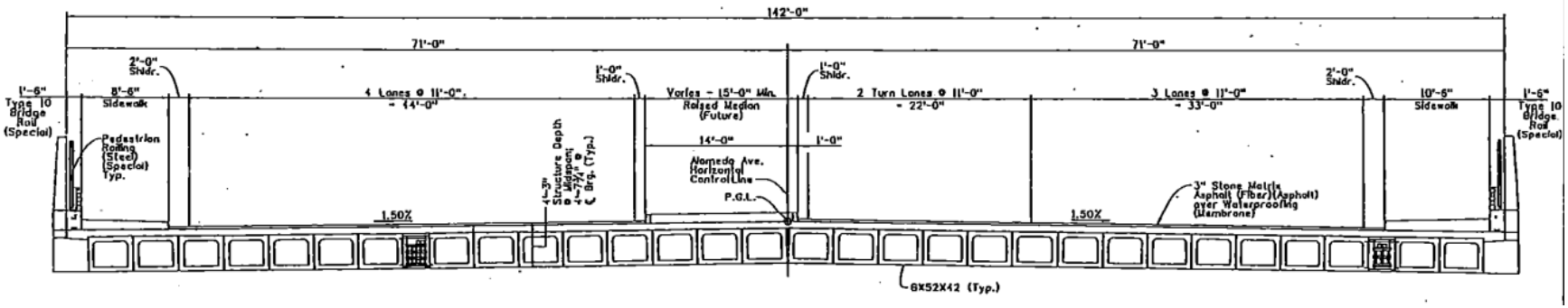
No major findings.

Rehabilitations/Widenings

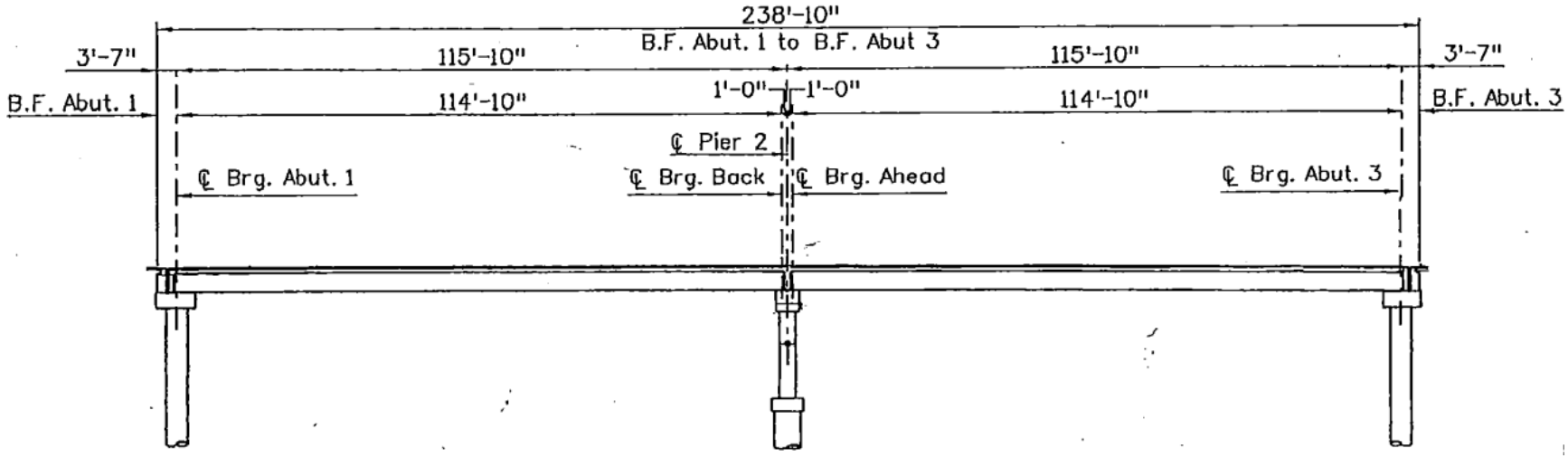
No rehabilitations nor widenings.

Additional Notes

The ultimate roadway configuration for Alameda is reported here and shown in the following cross-section. At of the time of this writing, Alameda has not been configured in the ultimate configuration.



Section - F-16-XU



Elevation - F-16-XU

Alameda Ave over S Platte River

Structure Number: F-16-BI **I-25 Milepost: 207.99**

Key Bridge Data	
Year Built	1911
Structure Type	Riveted Plate Girder
Spans	3
Length	180’
Width (out-to-out)	107’
Area of Deck	34,660 SF
Curb-to-Curb Width	87’-0”
Median	N/A
Sidewalks	12’-0” (North) & 5’-0” (South)
Vert. Clearance over I-25	N/A
Sufficiency Rating	63%
Deck Condition	5 out of 9
Superstructure Condition	6 out of 9
Substructure Condition	6 out of 9
Load Capacity	22.0 Tons (LFR Inventory) **(does not meet current standard)**
Bridge Rail Type	North: Steel Tube Railing South: Hybrid Railing with Steel Tubing, Thrie Beam, and Chain Link Fencing **(does not meet current standard)**
Bridge Rail Height	3’-6”
Utilities Carried	6” PVC Conduit (unknown owner) Timber Shielded Utility (unknown owner)

Major Inspection Findings

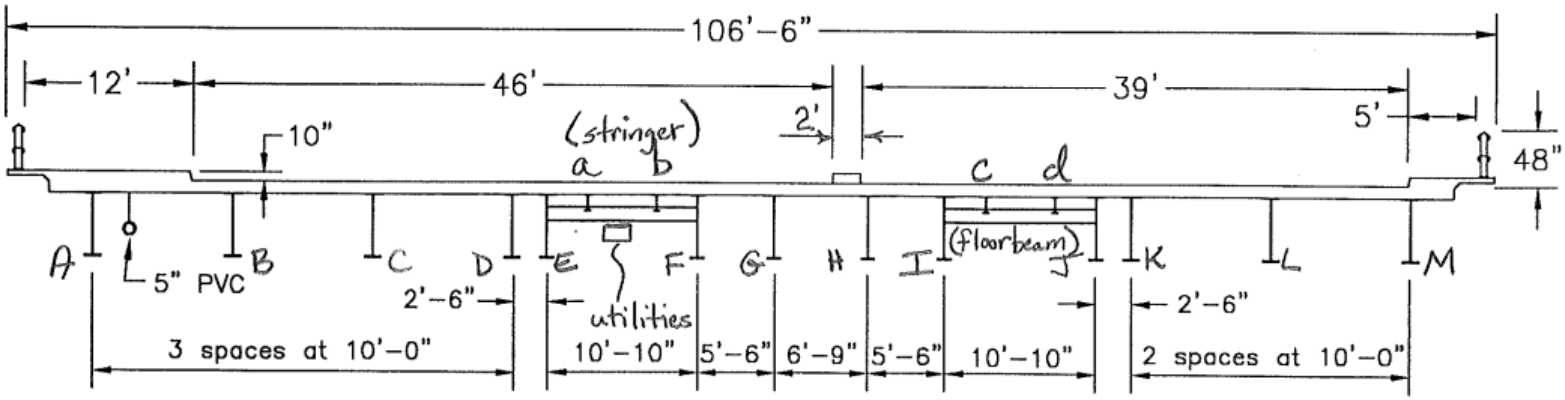
Numerous locations of heavy concrete cracking and spalling throughout substructure and deck overhang.

Rehabilitations/Widenings

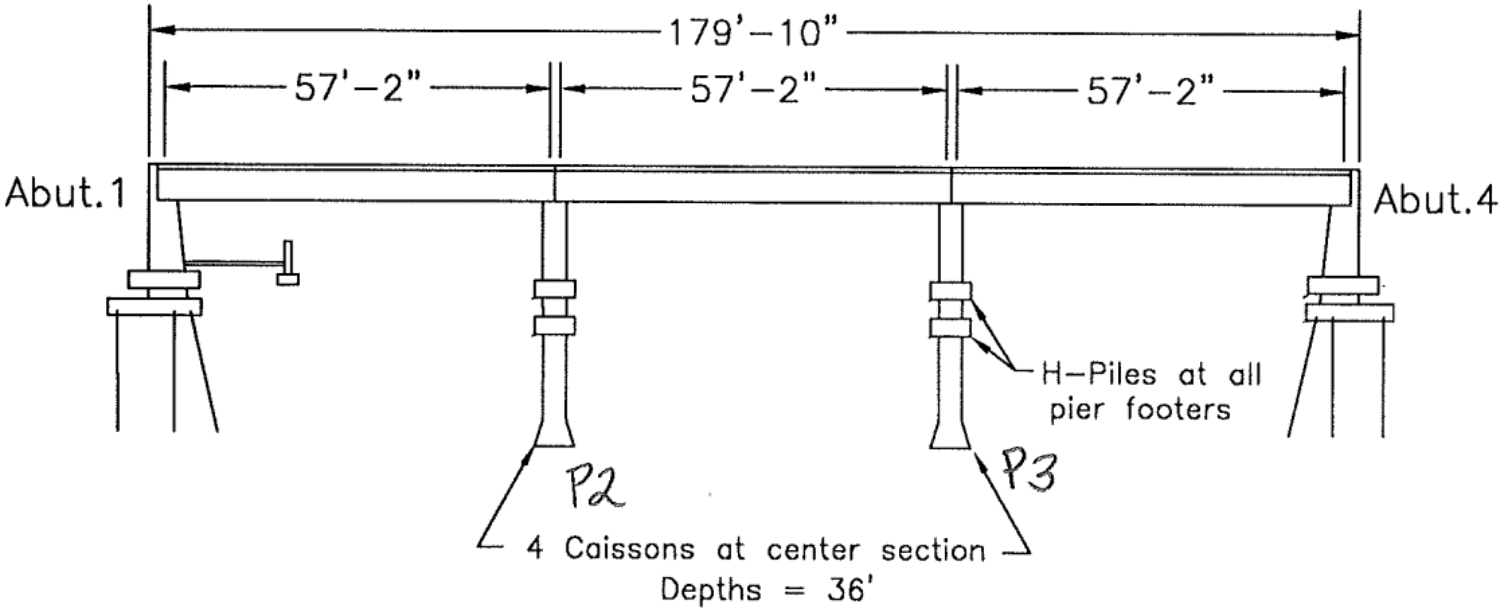
Widening to north and south was completed in 1959. Concrete repairs to deck overhang were completed in 2006. South bridge rail rehab completed in 2010.

Additional Notes

None.



Section - F-16-BI



Elevation - F-16-BI

I-25 over BNSF

Structure Number: F-16-EG **I-25 Milepost: 209.07**

Key Bridge Data	
Year Built	1987 (Ramp Bridge) 1958 (Mainline Bridges)
Structure Type	Continuous Rolled Steel Girders
Spans	3
Length	147’
Width (out-to-out)	206’
Area of Deck	30,280 SF
Curb-to-Curb Width	53’-0” (Ramp Bridge) 72’-6”(NB), 72’-6” (SB)
Median	2 X 2’-0”
Sidewalks	N/A
Vert. Clearance over BNSF	23’-4”
Sufficiency Rating	78%
Deck Condition	6 out of 9
Superstructure Condition	6 out of 9
Substructure Condition	6 out of 9
Load Capacity	27.0 Tons (LFR Inventory) **(does not meet current standard)**
Bridge Rail Type	Type 7 & Type 10M
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	Yes

Major Inspection Findings

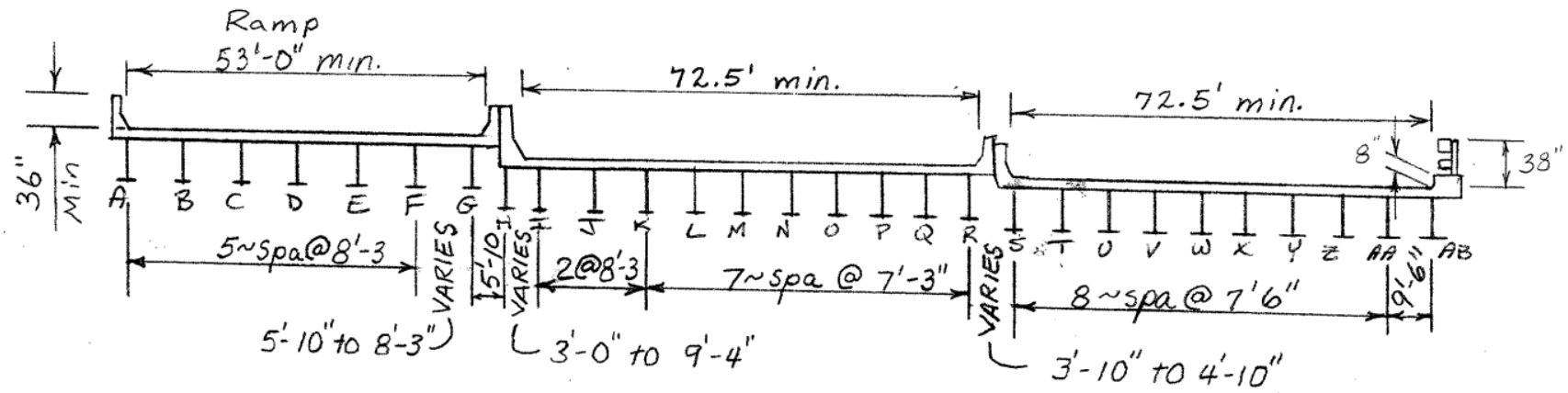
Actively leaking longitudinal construction joints in deck.

Rehabilitations/Widenings

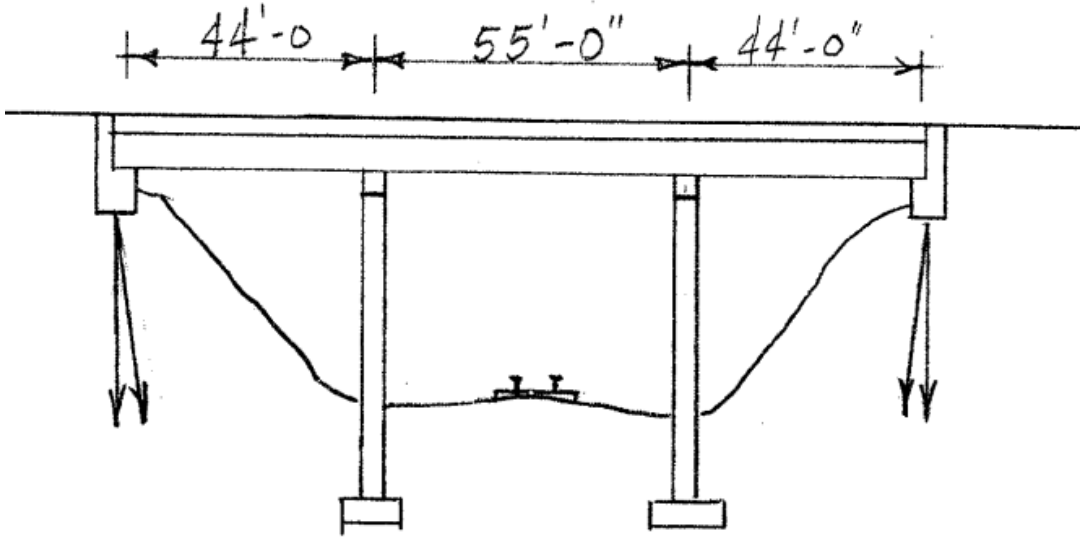
Concrete repair to deck and abutments completed and new expansion joint installed in 1998.

Additional Notes

None.



Section - F-16-EG



Elevation - F-16-EG

NB I-25 Off Ramp over BNSF

Structure Number: F-16-D **I-25 Milepost: 209.07**

Key Bridge Data	
Year Built	2014
Structure Type	Continuous Prestressed Concrete Girders
Spans	3
Length	198’
Width (out-to-out)	28’
Area of Deck	5,540 SF
Curb-to-Curb Width	25’-0”
Median	N/A
Sidewalks	N/A
Vert. Clearance over BNSF	23’-11”
Sufficiency Rating	85%
Deck Condition	8 out of 9
Superstructure Condition	8 out of 9
Substructure Condition	8 out of 9
Load Capacity	58.3 Tons (LRFR Inventory)
Bridge Rail Type	Type 7 (Special)
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	2 X 2” electrical conduits

Major Inspection Findings

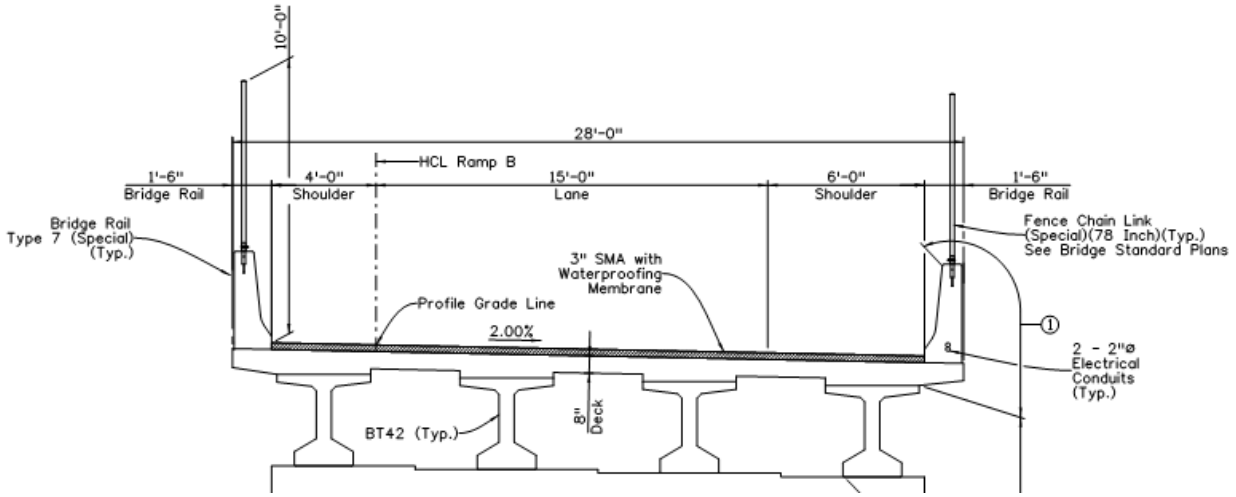
No major findings.

Rehabilitations/Widenings

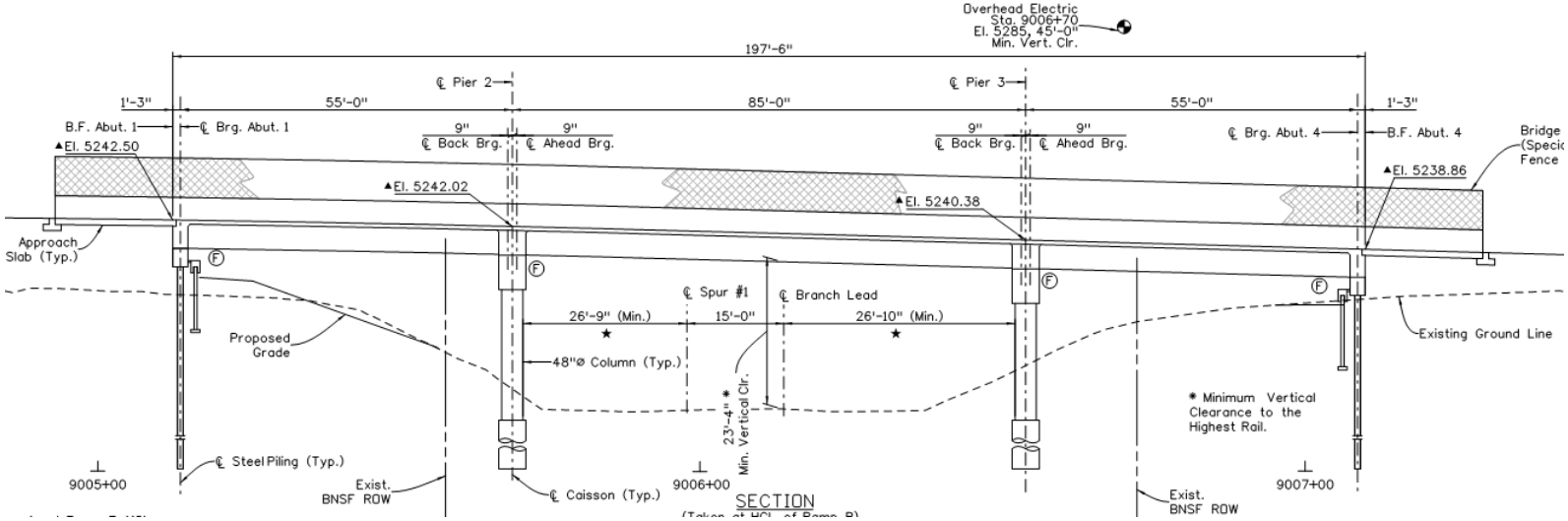
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-D



Elevation - F-16-D

WB 6th Ave Flyover Ramp to SB I-25

Structure Number: F-16-OL **I-25 Milepost: 209.19**

Key Bridge Data	
Year Built	1989
Structure Type	Continuous Steel Box Girders
Spans	10
Length	1,194’
Width (out-to-out)	34’
Area of Deck	40,600 SF
Curb-to-Curb Width	31’-0”
Median	N/A
Sidewalks	N/A
Vert. Clearance over I-25	>20’
Vert. Clearance over 6th Ave.	18’-2”
Sufficiency Rating	93%
Deck Condition	7 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	43.0 Tons (LFR Inventory)
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

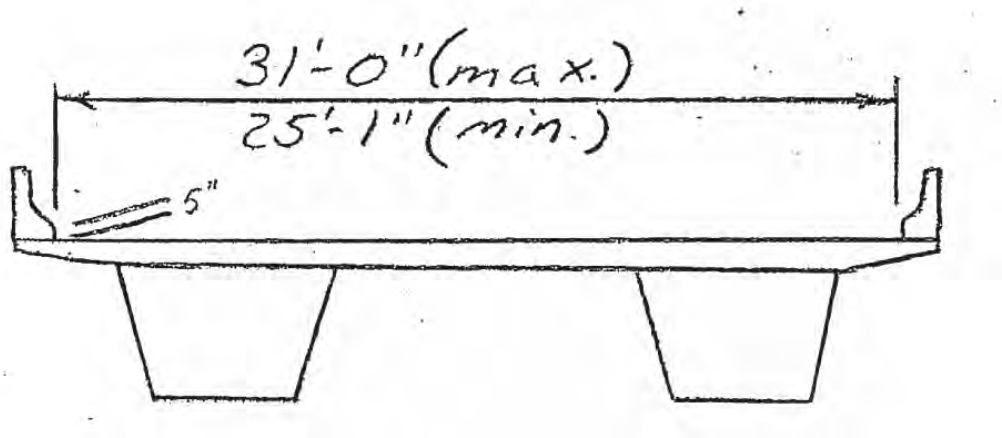
No major findings.

Rehabilitations/Widenings

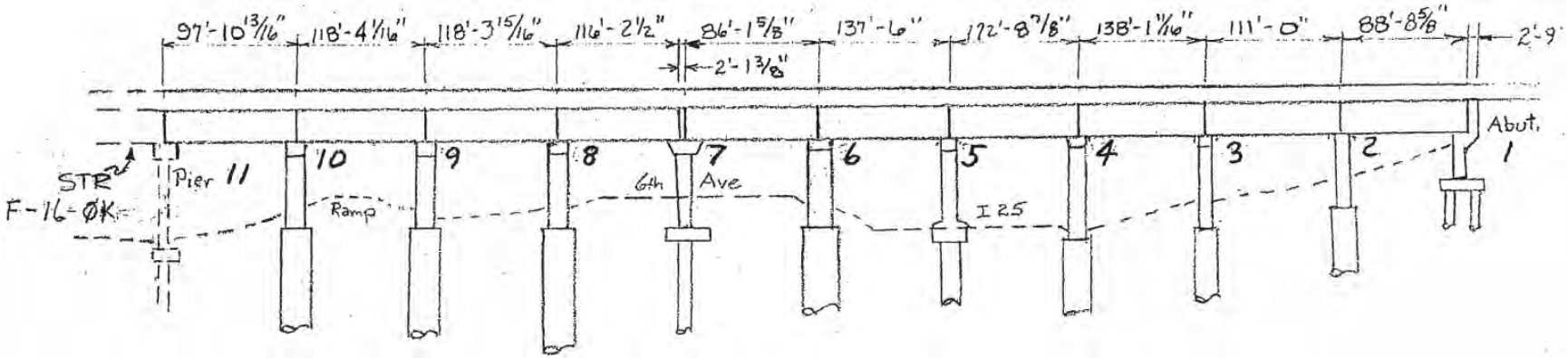
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-OL



Elevation - F-16-OL

EB 6th Ave Flyover Ramp to NB I-25

Structure Number: F-16-OG **I-25 Milepost: 209.19**

Key Bridge Data	
Year Built	1989
Structure Type	Continuous Steel Box Girders
Spans	12
Length	1,378’
Width (out-to-out)	42’
Area of Deck	57,880 SF
Curb-to-Curb Width	39’-0”
Median	N/A
Sidewalks	N/A
Vert. Clearance over I-25	>20’
Vert. Clearance over 6th Ave.	17’-4”
Sufficiency Rating	33%
Deck Condition	7 out of 9
Superstructure Condition	3 out of 9
Substructure Condition	8 out of 9
Load Capacity	36.0 Tons (LFR Inventory)
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

More than 20 cracks were discovered in a 4-year time period, thus bridge is on a 12-month inspection cycle. Many cracks have been arrested but some still exist as of 2017 inspection.

Sixteen feet of rail damaged/missing due to vehicular impact on August 2017.

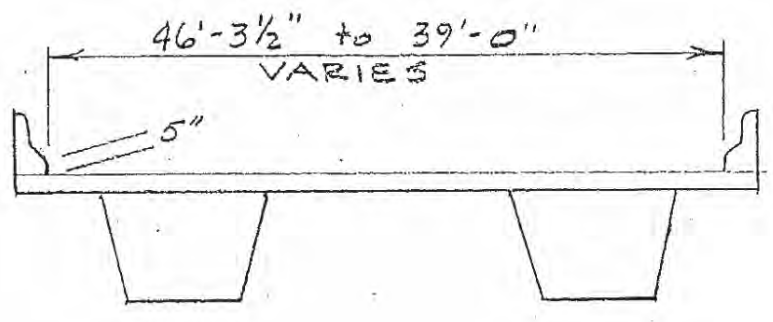
Expansion joints are actively leaking at Piers 1 and 13.

Rehabilitations/Widenings

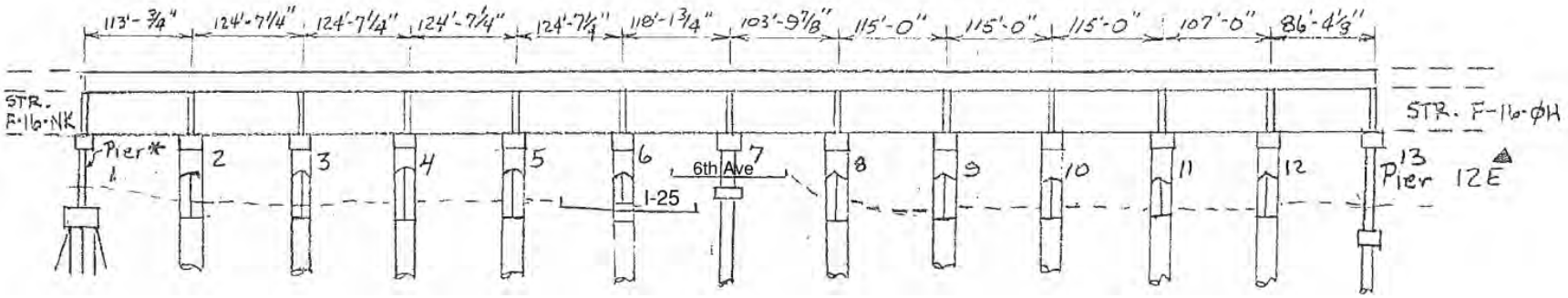
Cracks from 2014 and 2016 inspections were arrested in May 2016.

Additional Notes

None.



Section - F-16-OG



Elevation - F-16-OG

EB 6th Ave Off Ramp over South Platte River

Structure Number: F-16-NK **I-25 Milepost: 209.19**

Key Bridge Data	
Year Built	1987
Structure Type	Continuous Prestressed Concrete Box Girders
Spans	3
Length	362’
Width (out-to-out)	Varies 55’ to 73’
Area of Deck	21,000 SF
Curb-to-Curb Width	60’-6” Avg.
Median	N/A
Sidewalks	N/A
Vert. Clearance over I-25	N/A
Sufficiency Rating	89%
Deck Condition	7 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	44.9 Tons (LFR Inventory)
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

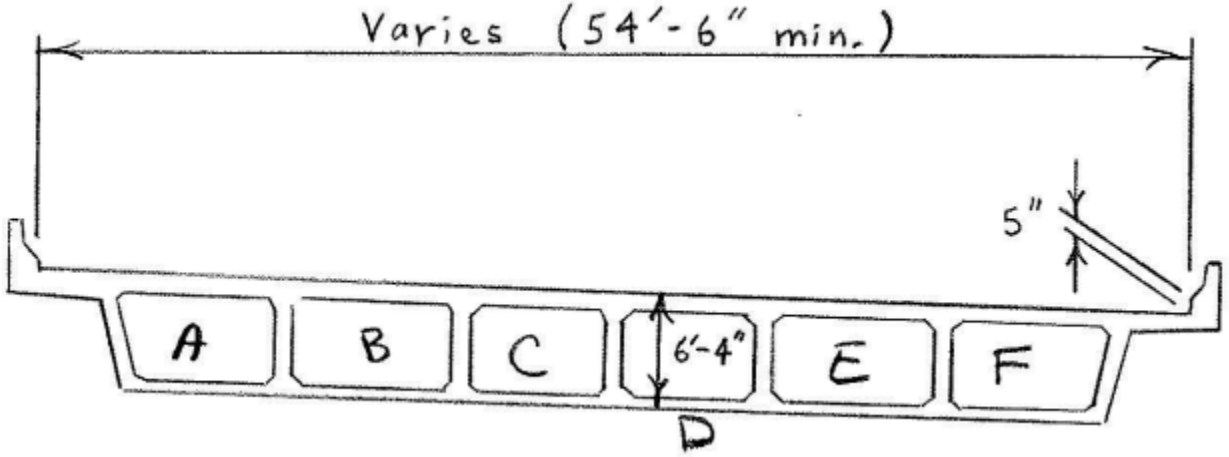
No major findings.

Rehabilitations/Widenings

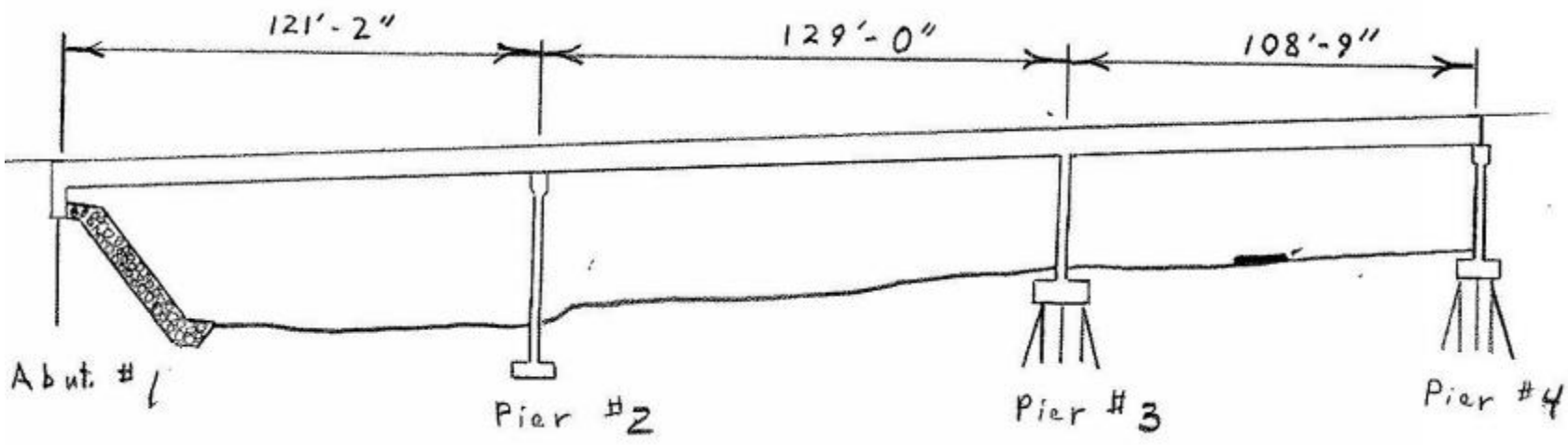
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-NK



Elevation - F-16-NK

EB 6th Ave Off Ramp to SB I-25

Structure Number: F-16-OE **I-25 Milepost: 209.19**

Key Bridge Data	
Year Built	1987
Structure Type	Continuous Prestressed Concrete Box Girders
Spans	4
Length	539’
Width (out-to-out)	41’
Area of Deck	22,100 SF
Curb-to-Curb Width	38’-0”
Median	N/A
Sidewalks	N/A
Vert. Clearance over I-25	N/A
Sufficiency Rating	89%
Deck Condition	7 out of 9
Superstructure Condition	6 out of 9
Substructure Condition	7 out of 9
Load Capacity	46.3 Tons (LFR Inventory)
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	4” & 2” electrical conduits

Major Inspection Findings

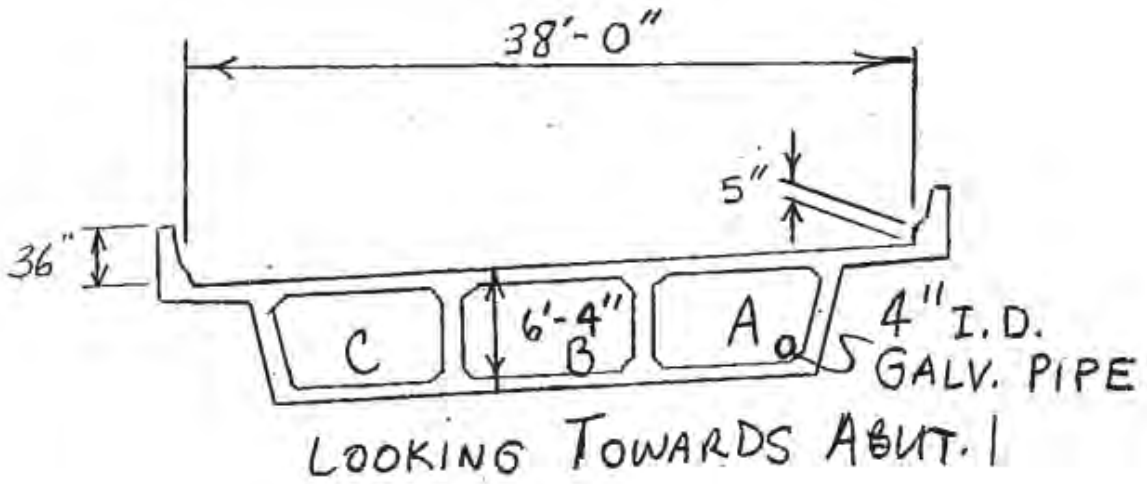
No major findings.

Rehabilitations/Widenings

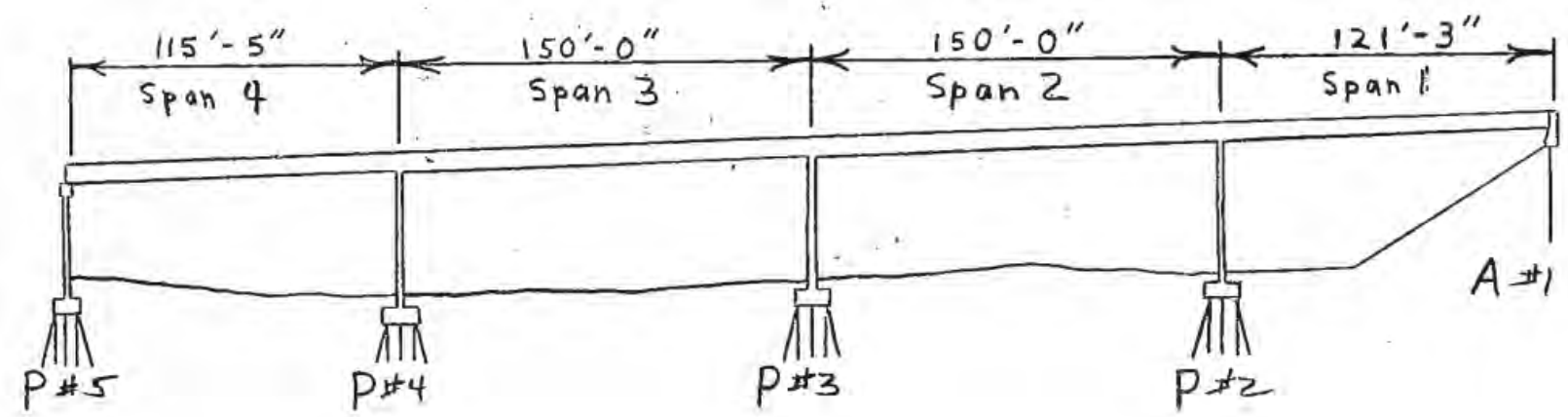
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-OE



Elevation - F-16-OE

6th Ave over I-25

Structure Number: F-16-ZC **I-25 Milepost: 209.19**

Key Bridge Data	
Year Built	2014
Structure Type	Continuous Prestressed Concrete Girders
Spans	2
Length	196’
Width (out-to-out)	109’
Area of Deck	21,360 SF
Curb-to-Curb Width	48’-0” (WB), 56’-0” (EB)
Median	2’-0”
Sidewalks	N/A
Vert. Clearance over I-25	16’-6”
Sufficiency Rating	76%
Deck Condition	8 out of 9
Superstructure Condition	8 out of 9
Substructure Condition	8 out of 9
Load Capacity	36.0 Tons (LRFR Inventory)
Bridge Rail Type	Type 7
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	1 X 2” electrical conduit

Major Inspection Findings

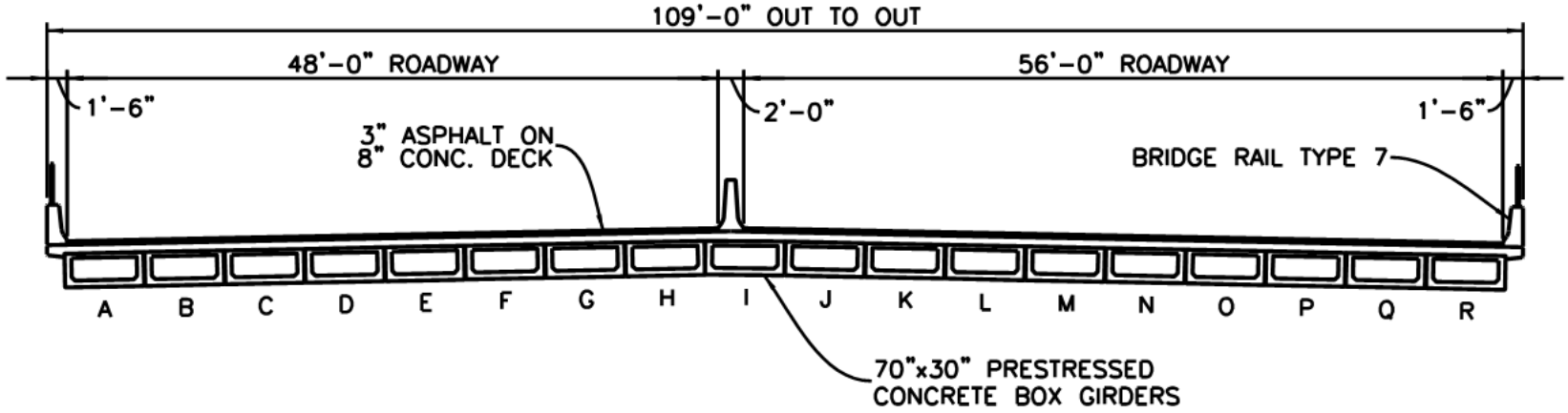
No major findings.

Rehabilitations/Widenings

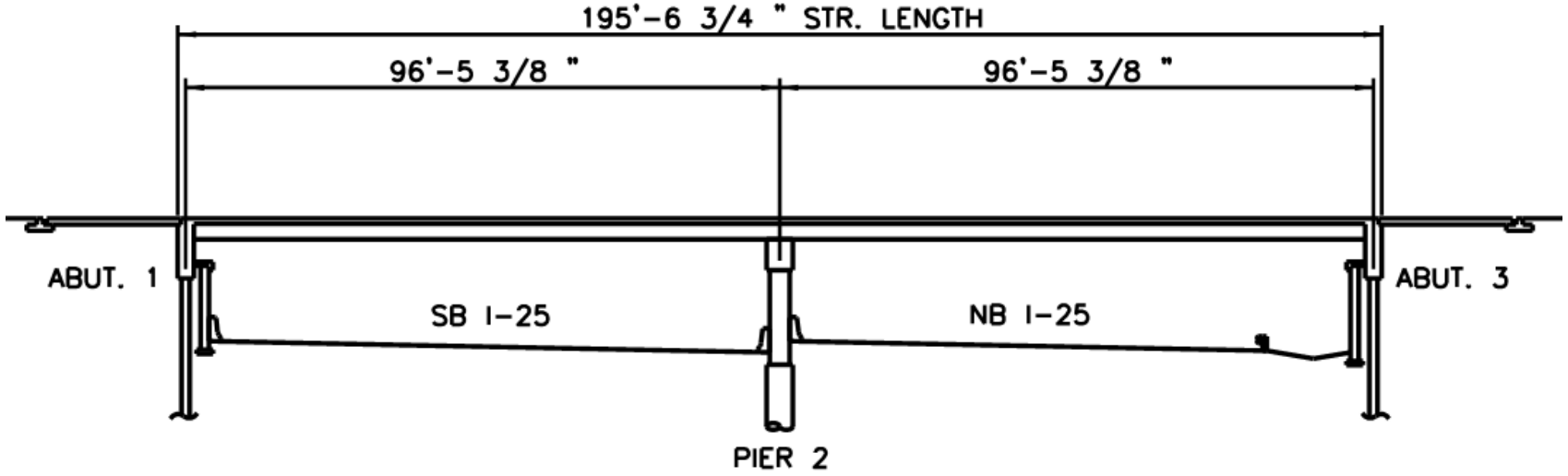
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-ZC



Elevation - F-16-ZC

NB I-25 Off Ramp to WB 6th Ave

Structure Number: F-16-AZ **I-25 Milepost: 209.19**

Key Bridge Data	
Year Built	2014
Structure Type	Continuous Prestressed Concrete Girders
Spans	2
Length	183’
Width (out-to-out)	28’
Area of Deck	5,120 SF
Curb-to-Curb Width	25’-0”
Median	N/A
Sidewalks	N/A
Vert. Clearance over I-25	16’-6”
Sufficiency Rating	93%
Deck Condition	8 out of 9
Superstructure Condition	8 out of 9
Substructure Condition	8 out of 9
Load Capacity	42.5 Tons (LRFR Inventory)
Bridge Rail Type	Type 7
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	1 X 2” electrical conduit

Major Inspection Findings

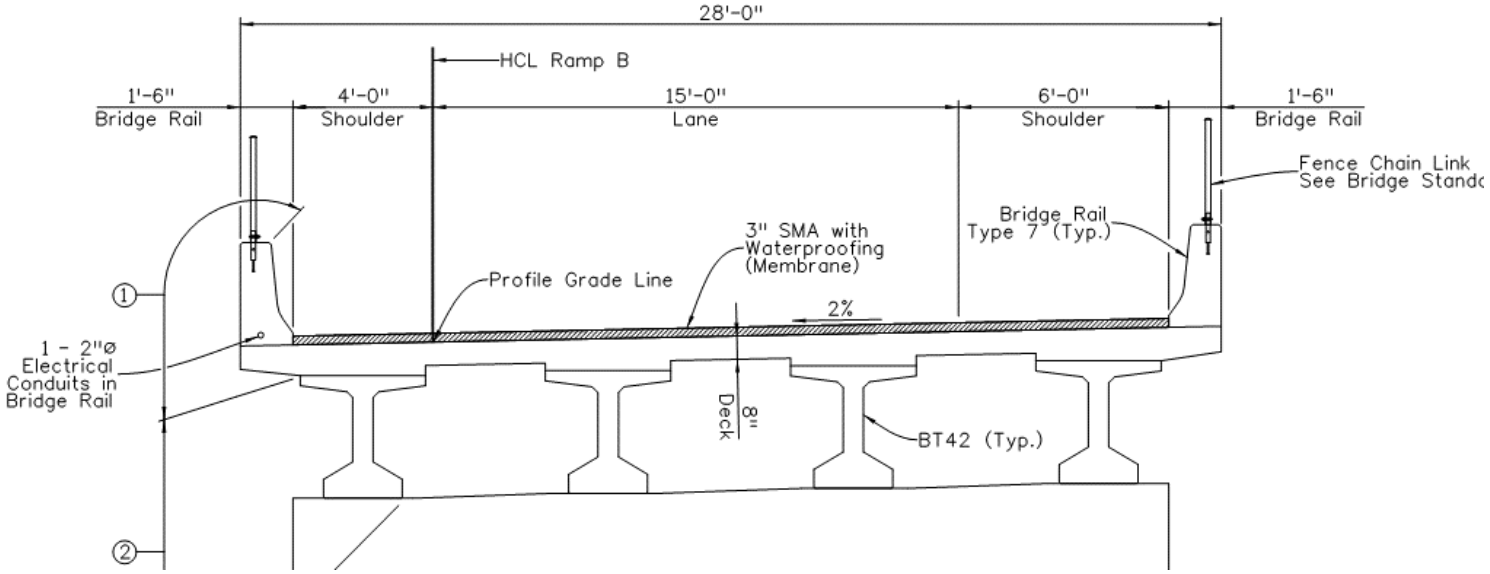
No major findings.

Rehabilitations/Widenings

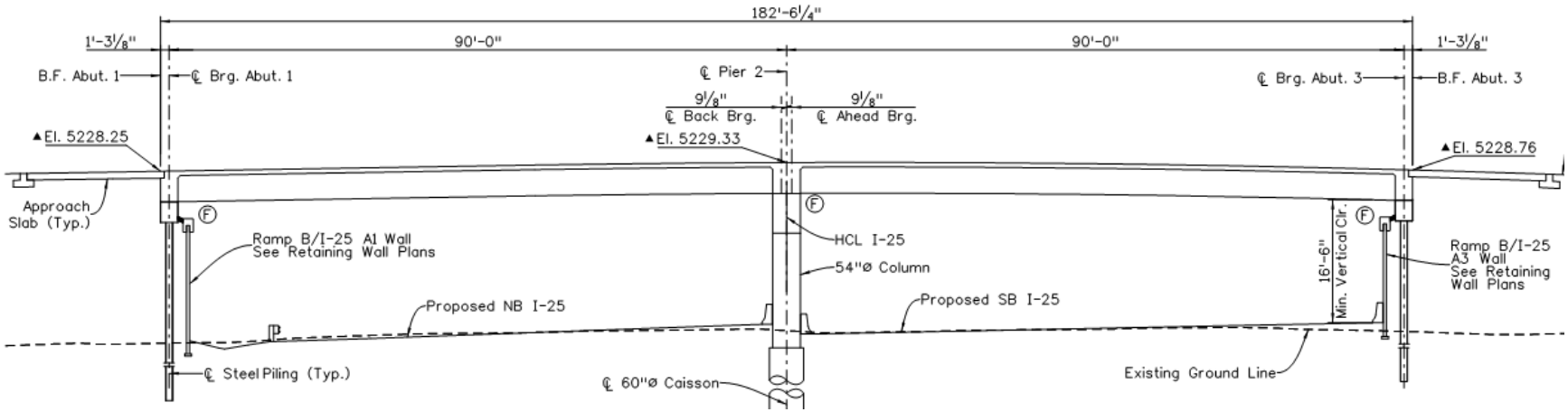
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-AZ



Elevation - F-16-AZ

6th Ave over BNSF

Structure Number: F-16-YJ **I-25 Milepost: 209.19**

Key Bridge Data	
Year Built	2014
Structure Type	Continuous Prestressed Concrete Girders
Spans	2
Length	197’
Width (out-to-out)	137’
Area of Deck	26,990 SF
Curb-to-Curb Width	72’-3” (EB), 60’-0” (WB)
Median	2’-0”
Sidewalks	N/A
Vert. Clearance over Local Rd	17’-9”
Vert. Clearance over BNSF	23’-4”
Sufficiency Rating	80%
Deck Condition	8 out of 9
Superstructure Condition	8 out of 9
Substructure Condition	8 out of 9
Load Capacity	36.0 Tons (LFR Inventory)
Bridge Rail Type	Type 7 (Special)
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	2” electrical conduit

Major Inspection Findings

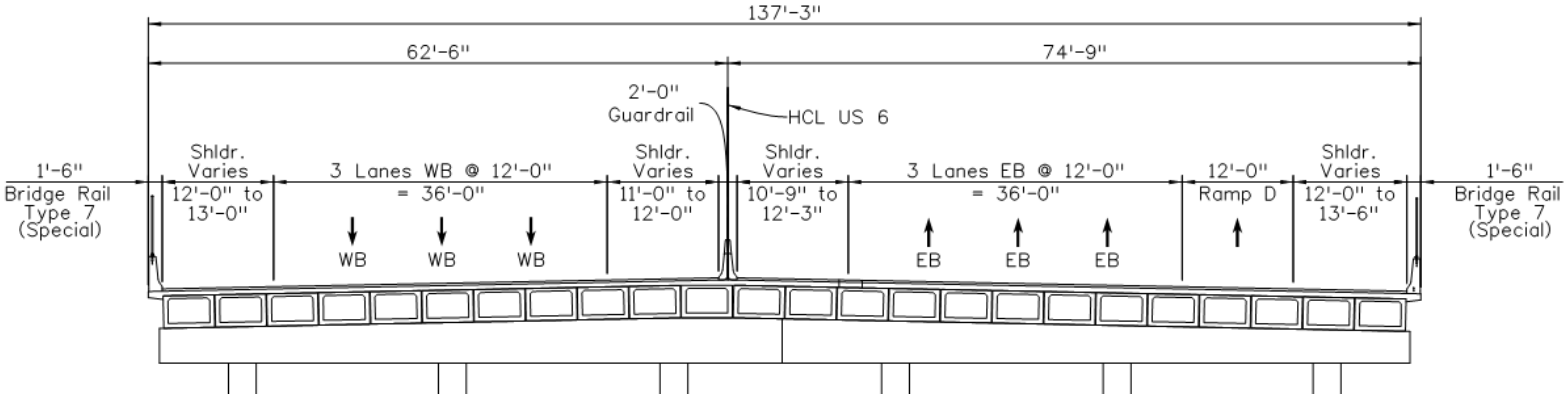
No major findings.

Rehabilitations/Widenings

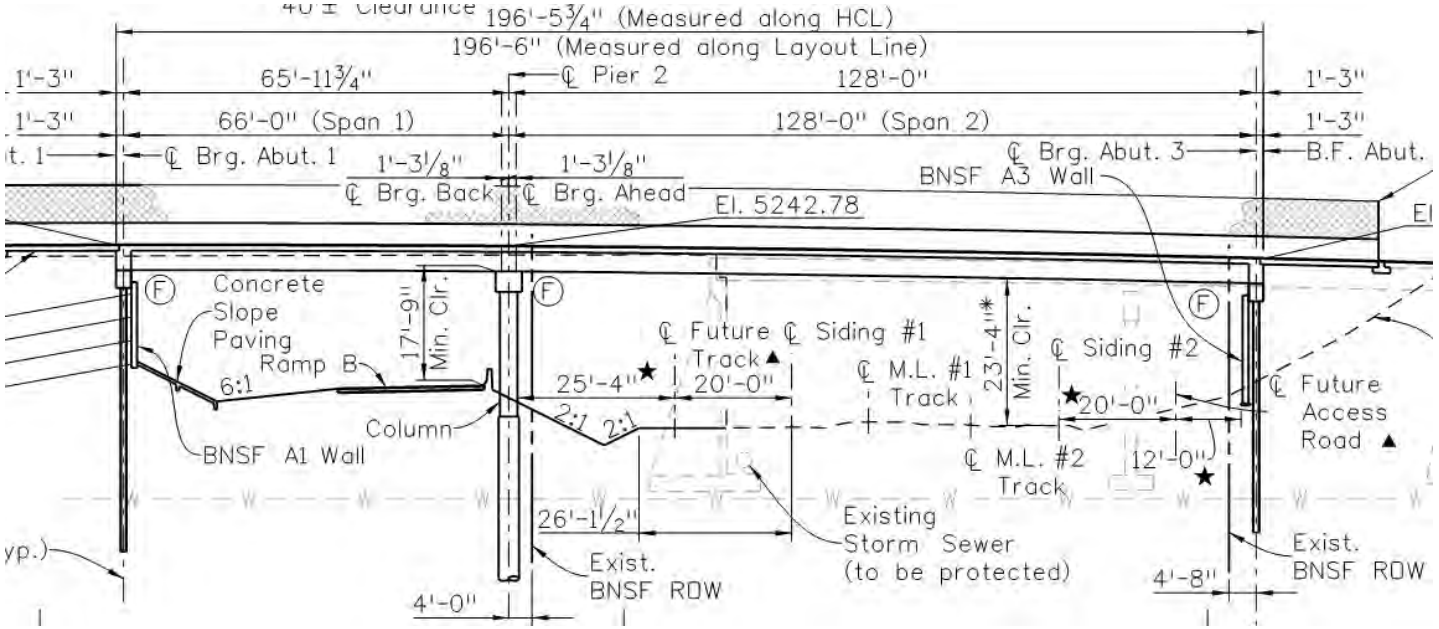
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-YJ



Elevation - F-16-YJ

WB US 6 Off Ramp over BNSF

Structure Number: F-16-OK **I-25 Milepost: 209.19**

Key Bridge Data	
Year Built	1988
Structure Type	Continuous Prestressed Concrete Box Girders
Spans	2
Length	311’
Width (out-to-out)	Varies 30’ to 87’
Area of Deck	17,260 SF
Curb-to-Curb Width	Varies 27’-0” to 84’-0”
Median	N/A
Sidewalks	N/A
Vert. Clearance over BNSF	27’-0”
Sufficiency Rating	92%
Deck Condition	7 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	36.0 Tons (LFR Inventory)
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

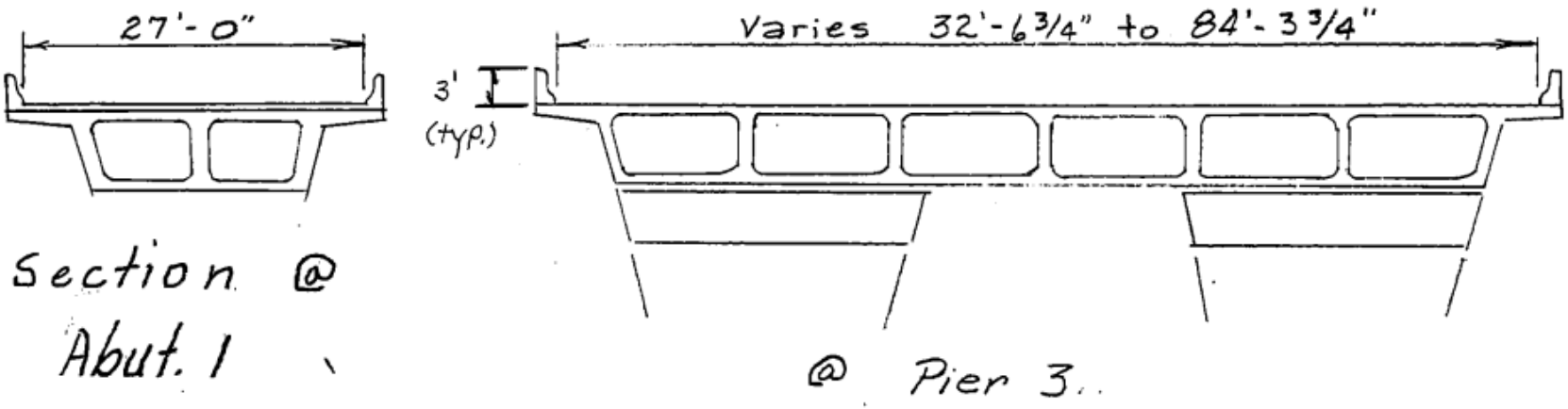
No major findings.

Rehabilitations/Widenings

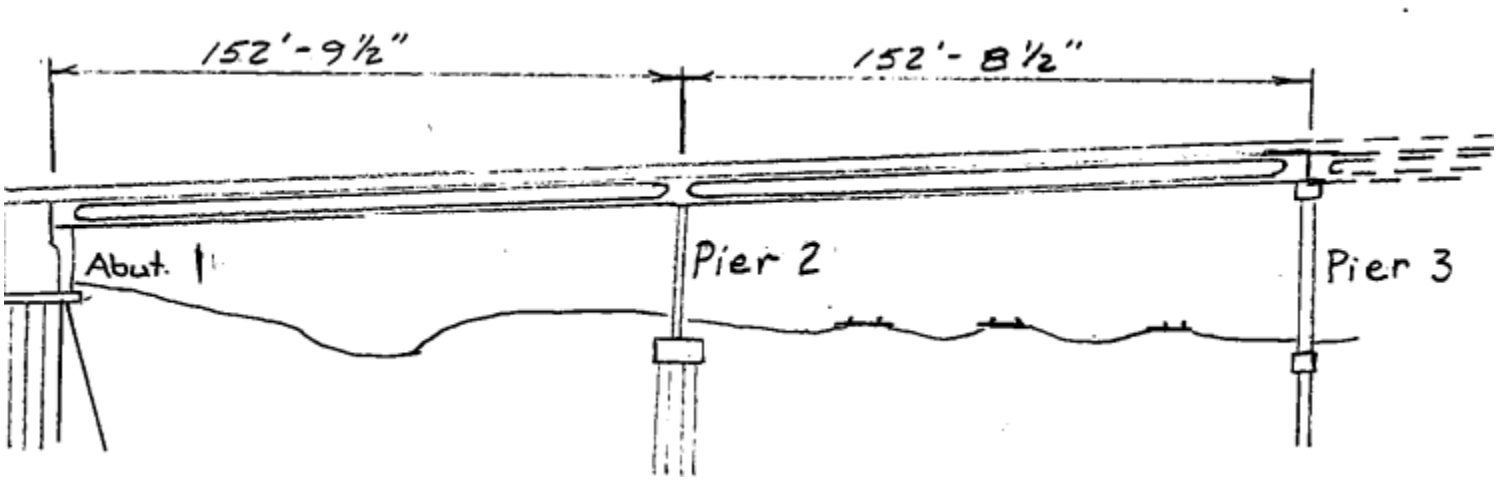
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-OK



Elevation - F-16-OK

WB US 6 Off Ramp to NB I-25

Structure Number: F-16-NO **I-25 Milepost: 209.19**

Key Bridge Data	
Year Built	1989
Structure Type	Continuous Prestressed Concrete Box Girders
Spans	5
Length	664’
Width (out-to-out)	30’
Area of Deck	19,920 SF
Curb-to-Curb Width	27’-0”
Median	N/A
Sidewalks	N/A
Vert. Clearance over I-25	N/A
Sufficiency Rating	98%
Deck Condition	7 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	50.0 Tons (LFR Inventory)
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

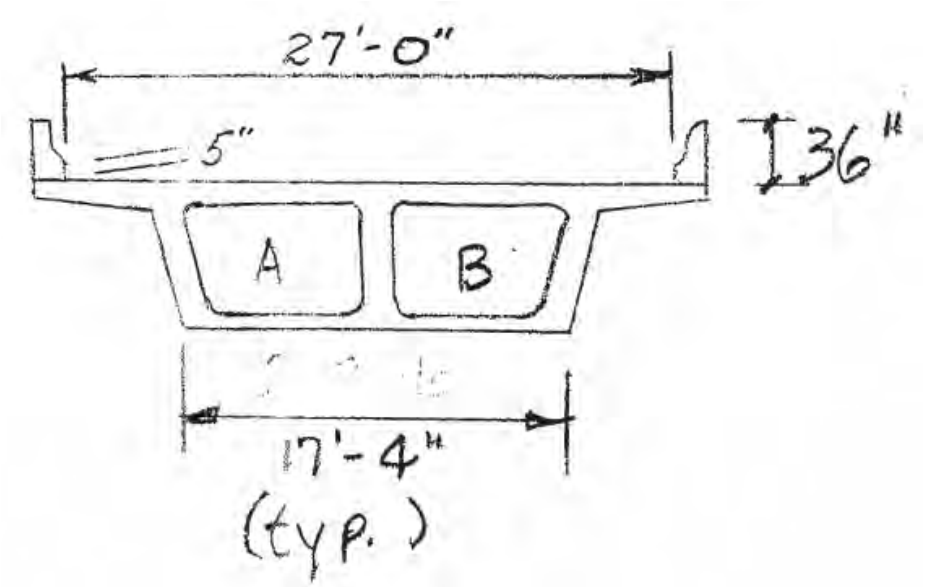
No major findings.

Rehabilitations/Widenings

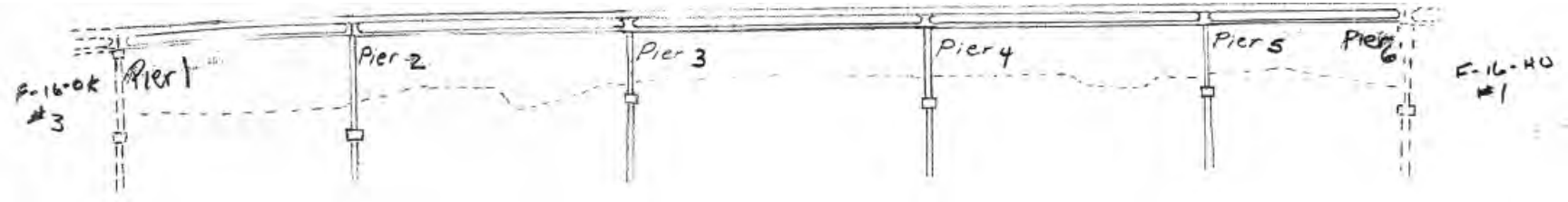
No rehabilitations nor widenings.

Additional Notes

None.



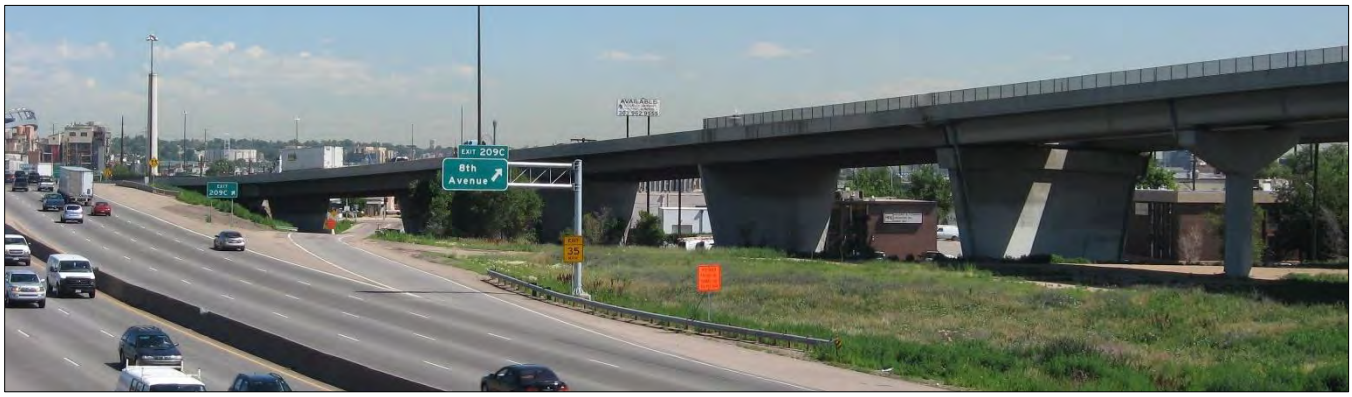
Section - F-16-NO



Elevation - F-16-NO

US 6 Ramp to NB I-25

Structure Number: F-16-OH **I-25 Milepost: 209.36**



Key Bridge Data	
Year Built	1988
Structure Type	Continuous Prestressed Concrete Box Girder
Spans	5
Length	738’
Width (out-to-out)	Varies 49’ to 78’
Area of Deck	44,650 SF
Curb-to-Curb Width	Varies 46’-0” to 75’-0”
Median	N/A
Sidewalks	N/A
Vert. Clearance over I-25	16’-9”
Sufficiency Rating	88%
Deck Condition	7 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	6 out of 9
Load Capacity	42.4 Tons (LFR Inventory)
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

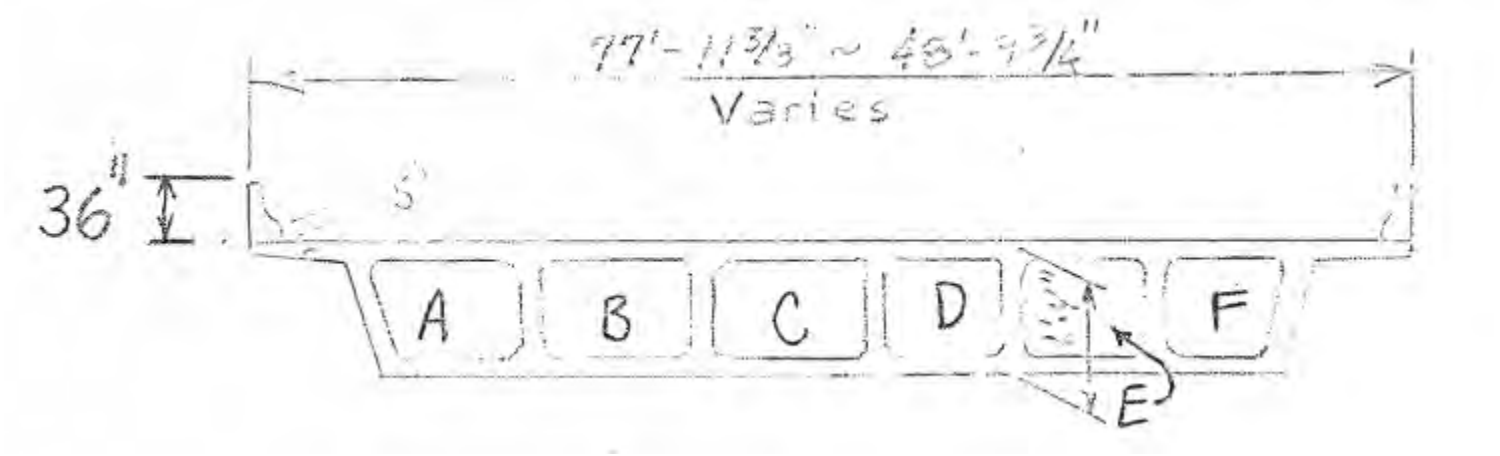
No major findings.

Rehabilitations/Widenings

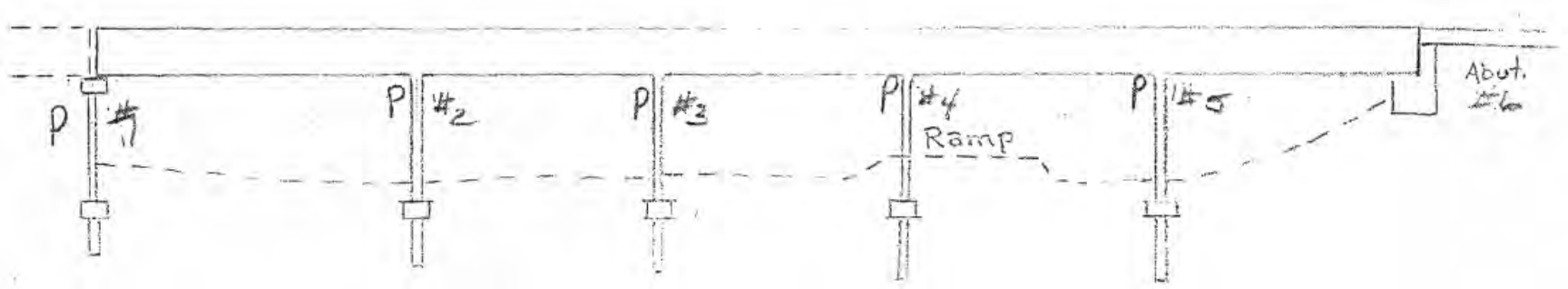
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-OH



Elevation - F-16-OH

I-25 over 8th Ave

Structure Number: F-16-DX **I-25 Milepost: 209.48**

Key Bridge Data	
Year Built	1958
Structure Type	Continuous Rolled Steel Girders
Spans	3
Length	154’
Width (out-to-out)	Varies 199’-0” to 220’
Area of Deck	32,260 SF
Curb-to-Curb Width	90’-6” (SB), 127’-7” (NB)
Median	2’-0”
Sidewalks	N/A
Vert. Clear. over 8th Ave.	15’-0” **(does not meet current standard)**
Sufficiency Rating	71%
Deck Condition	6 out of 9
Superstructure Condition	6 out of 9
Substructure Condition	6 out of 9
Load Capacity	23 Tons (LFR Inventory) **(does not meet current standard)**
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	2 X 1.5” conduits (unknown owner)

Major Inspection Findings

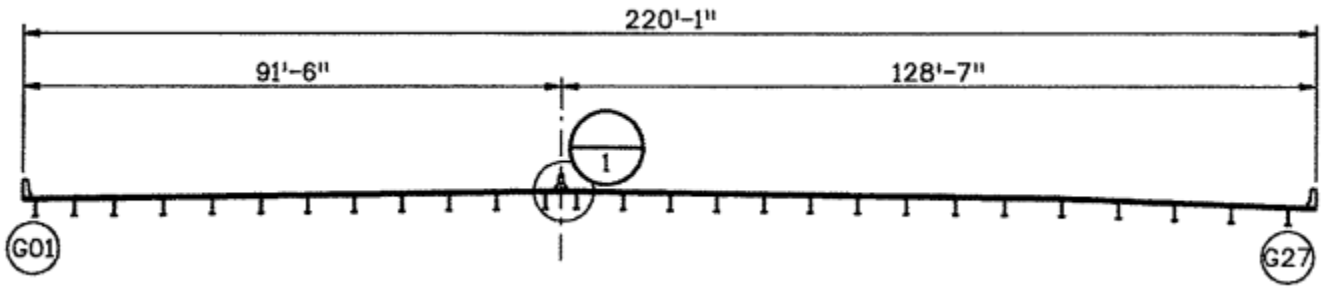
Indications found in two pins at Girder E near Pier #2 at the pin and hanger connections.

Rehabilitations/Widenings

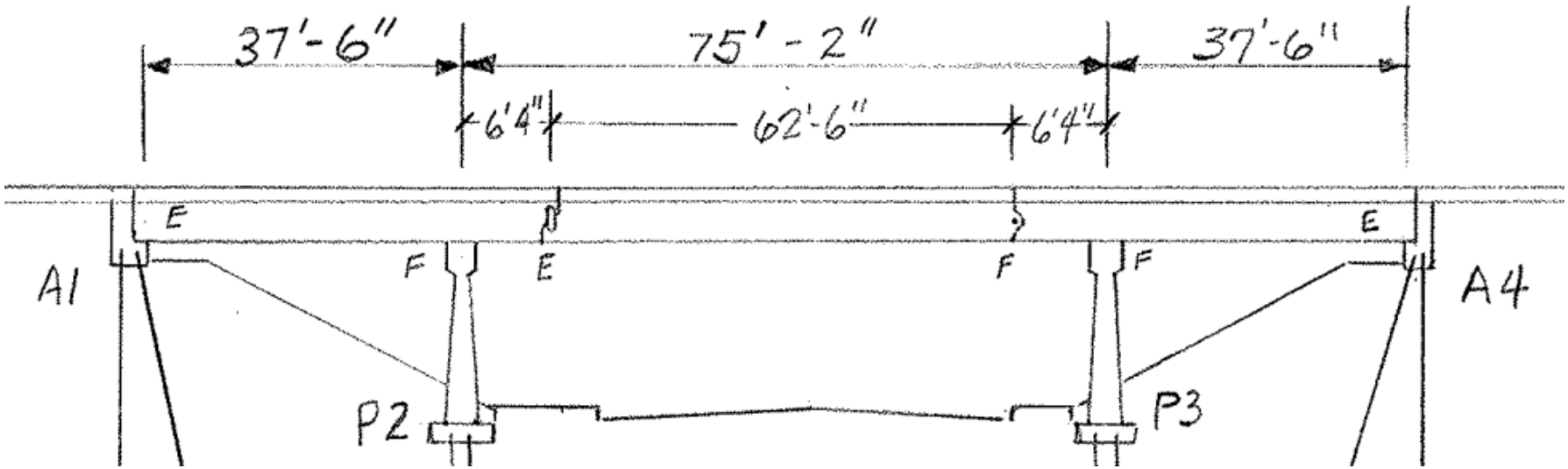
Original bridge consisted of two twin 40-foot wide structures. A major widening was completed in 1974 to join the two bridges and increase width to 166 feet. Another widening was completed in 1987 to bring the structure width to what it is today. Rehab work was completed in 2010 to repair longitudinal and transverse joints in the bridge deck.

Additional Notes

None.



Section - F-16-DX



Elevation - F-16-DX

I-25 over 13th Ave

Structure Number: F-16-EC **I-25 Milepost: 210.06**

Key Bridge Data	
Year Built	1956
Structure Type	Continuous Concrete Slab and Girder
Spans	3
Length	173’
Width (out-to-out)	223’
Area of Deck	38,580 SF
Curb-to-Curb Width	97’-2” (SB), 76’-10” (NB), 40’-0” (Off Ramp)
Median	2 X 2’-0”
Sidewalks	N/A
Vert. Clear. over 13th Ave.	20’-6”
Sufficiency Rating	70%
Deck Condition	5 out of 9
Superstructure Condition	6 out of 9
Substructure Condition	7 out of 9
Load Capacity	23 Tons (LFR Inventory) **(does not meet current standard)**
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	2.5” conduit (unknown owner)

Major Inspection Findings

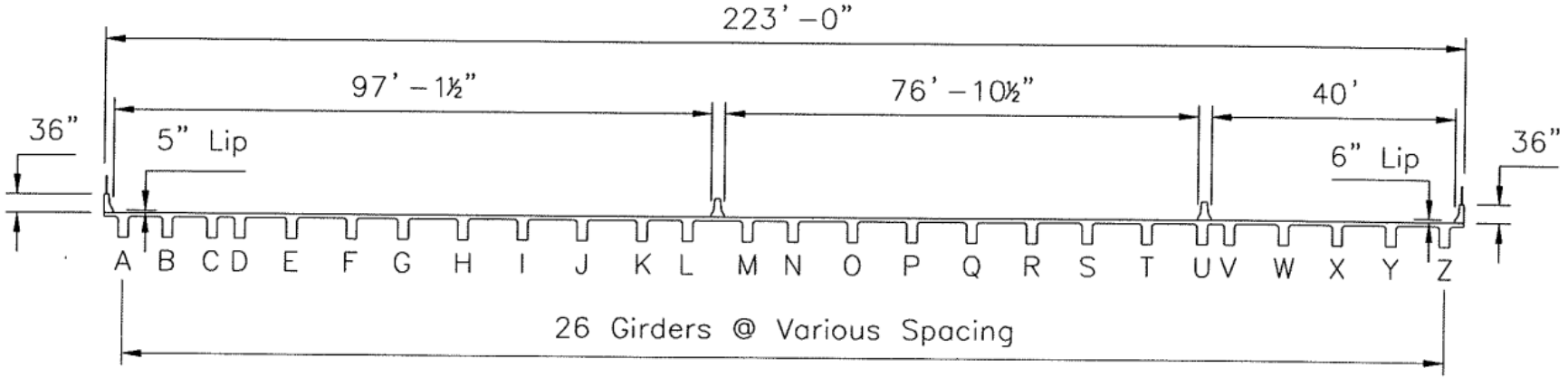
About 10 percent of deck contains spalled concrete with exposed rebar. Steel piles are exposed at abutments.

Rehabilitations/Widenings

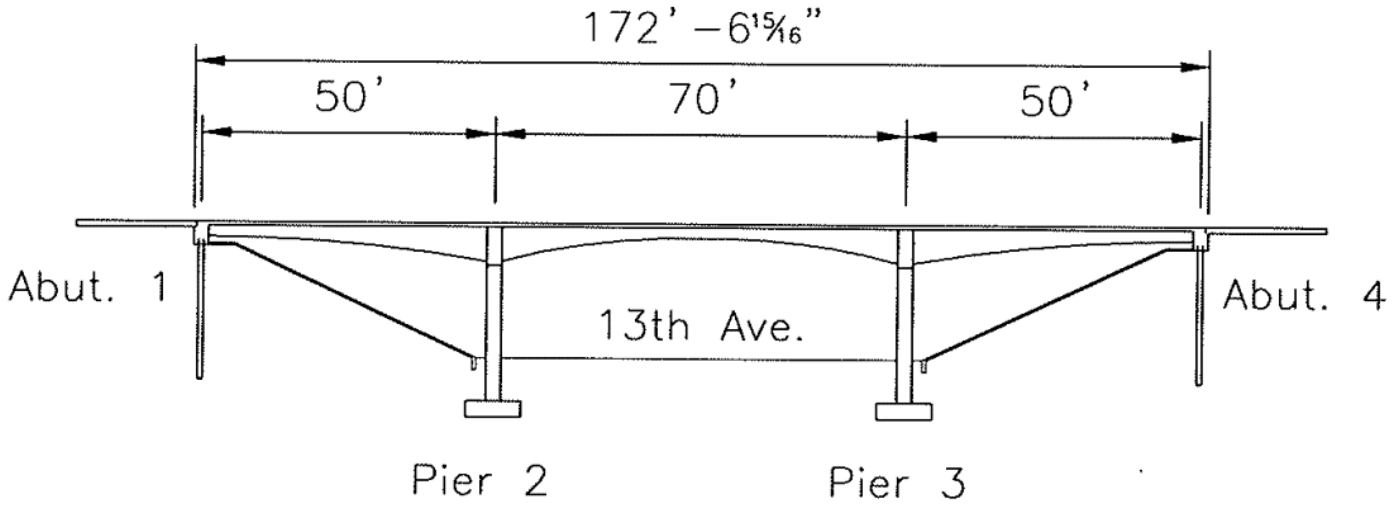
Original bridge consisted of two twin 40-foot wide structures. A major widening was completed in 1972 to join the two bridges and increase width to 159 feet. Another widening was completed in 1991 and yet another in 2004.

Additional Notes

None.



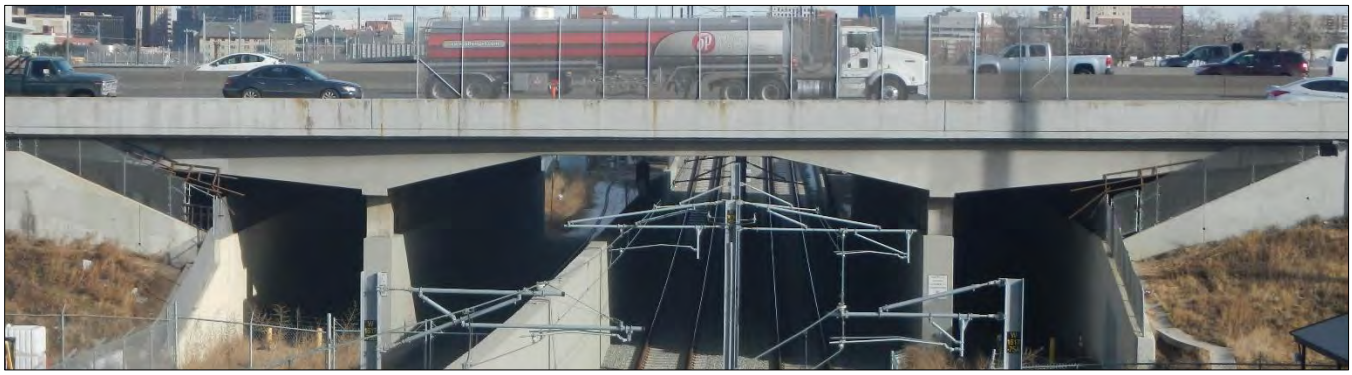
Section - F-16-EC



Elevation - F-16-EC

I-25 over RTD W Line

Structure Number: F-16-DC **I-25 Milepost: 210.11**



Key Bridge Data	
Year Built	1956
Structure Type	Continuous Concrete Slab and Girder
Spans	3
Length	139’
Width (out-to-out)	Varies 221’ to 234’
Area of Deck	31,620 SF
Curb-to-Curb Width	102’-0” (SB), 77’-0” (NB), 38’-0” (Off Ramp)
Median	2 X 2’-0”
Sidewalks	N/A
Vert. Clear. over Track	19’-8”
Sufficiency Rating	60%
Deck Condition	6 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	19.3 Tons (LFR Inventory) **(does not meet current standard)**
Bridge Rail Type	Type 7
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	2 X 2.5” conduits (unknown owner)

Major Inspection Findings

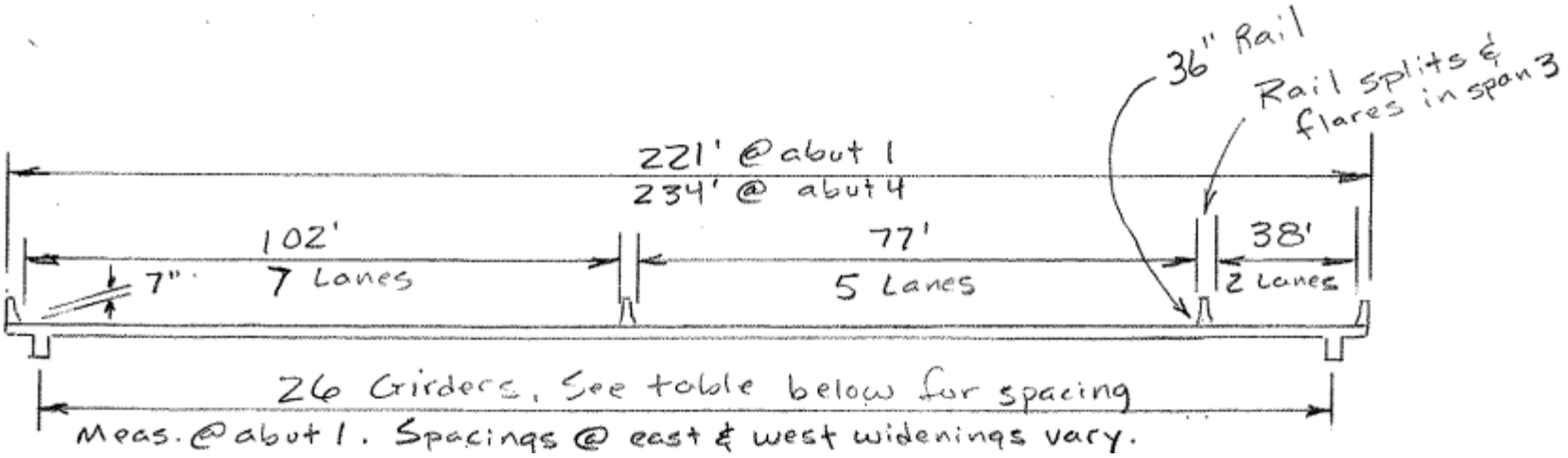
No major findings.

Rehabilitations/Widenings

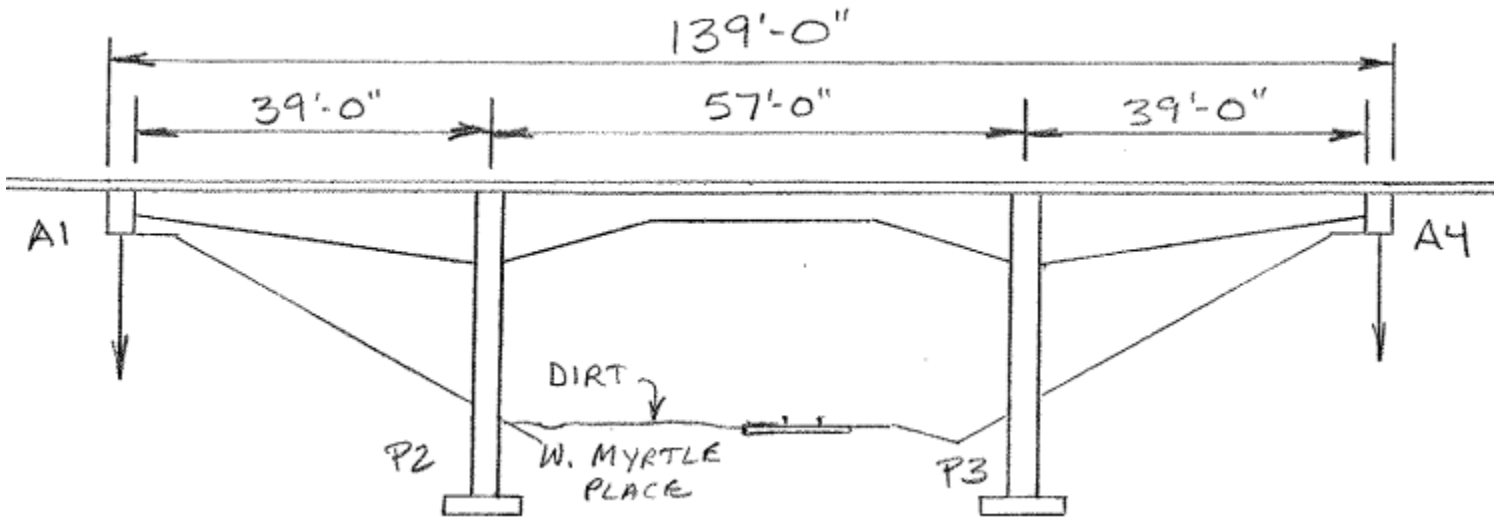
Original bridge consisted of two twin 40-foot wide structures. A major widening was completed in 1972 to join the two bridges and increase width to 159 feet. Another widening was completed in 1987 and yet another in 1991.

Additional Notes

None.



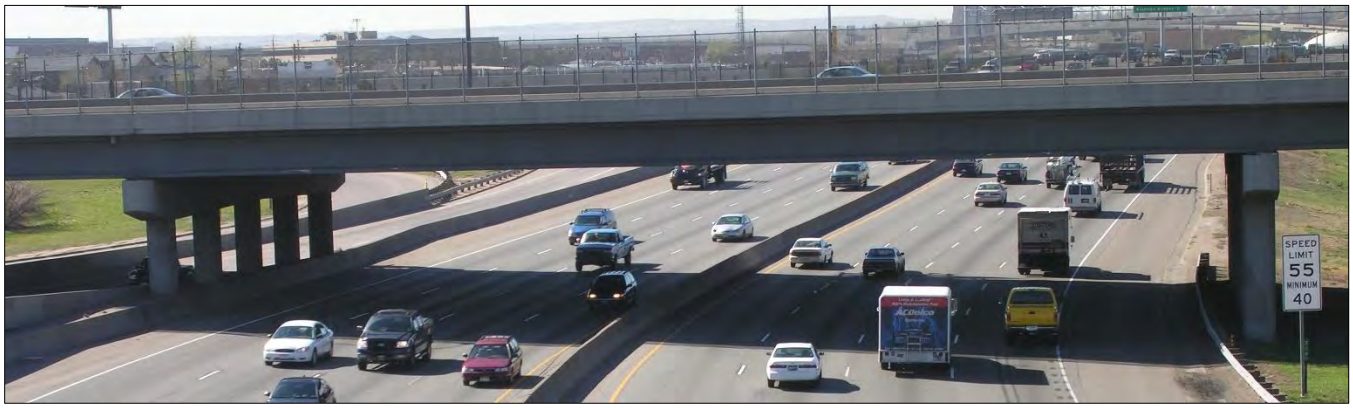
Section - F-16-DC



Elevation - F-16-DC

Colfax Ave over I-25

Structure Number: F-16-JX **I-25 Milepost: 210.31**



Key Bridge Data	
Year Built	1984
Structure Type	Continuous Prestressed Concrete Girder
Spans	37
Length	4,383’
Width (out-to-out)	Varies 94’ to 108’
Area of Deck	444,520 SF
Curb-to-Curb Width	Varies 80’-0” to 93’-9”
Median	Varies 2’-7” to 4’-0”
Sidewalks	8’-0”
Vert. Clear. over I-25	19’-7”
Sufficiency Rating	87%
Deck Condition	6 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	6 out of 9
Load Capacity	36.5 Tons (LFR Inventory)
Bridge Rail Type	Type 7
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	2 X 2” conduits

Major Inspection Findings

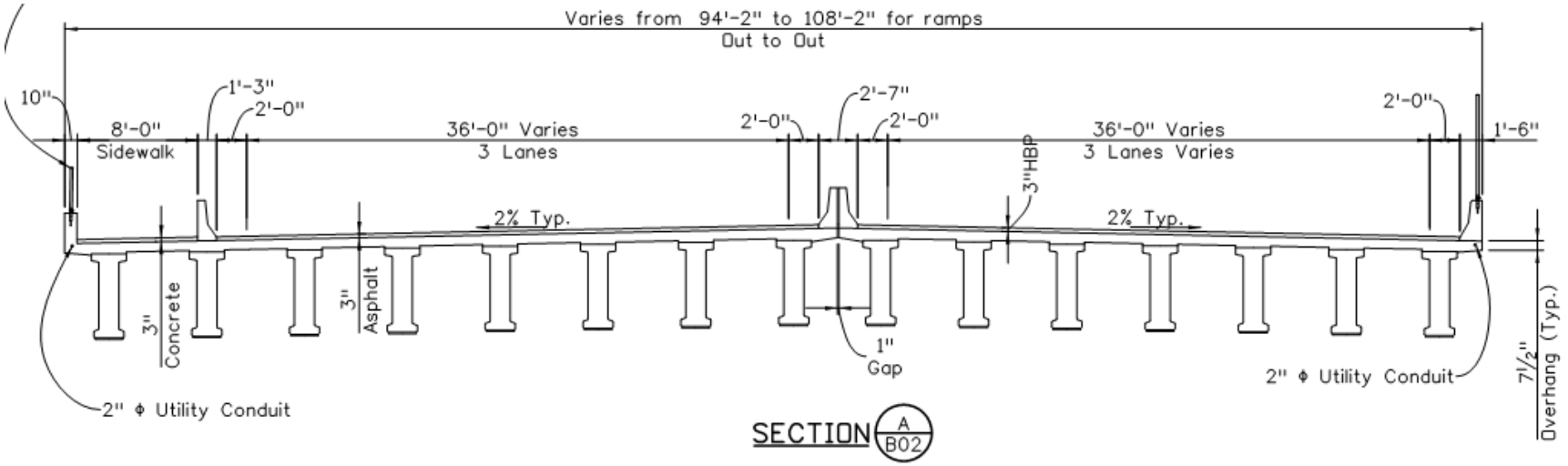
No major findings.

Rehabilitations/Widenings

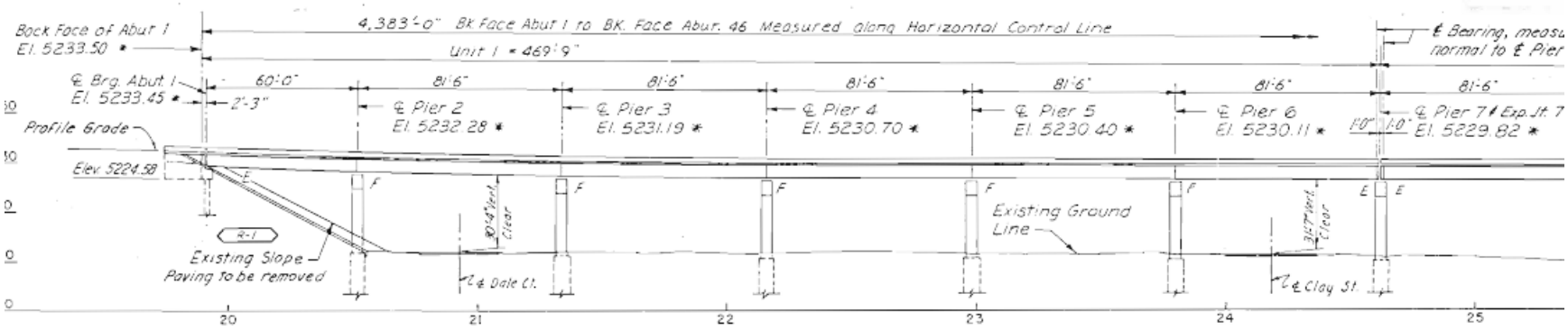
The structure has been widened multiple times to accommodate off ramps from Colfax EB/WB onto I-25 NB/SB. Expansion joints were replaced and pier cap concrete was patched in various areas in 2015.

Additional Notes

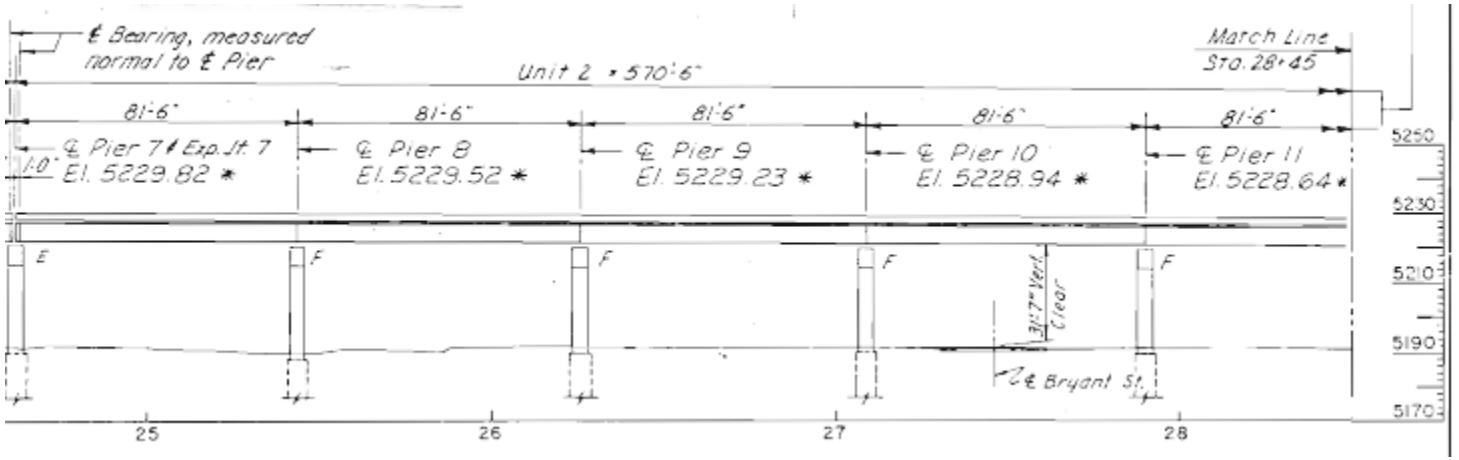
None.



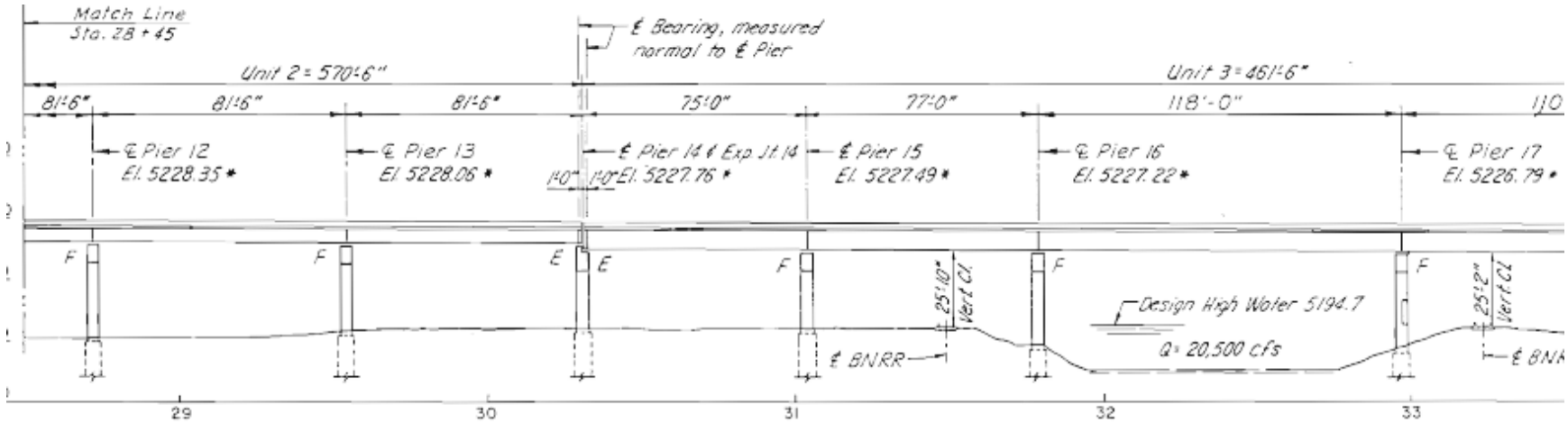
Section - F-16-JX



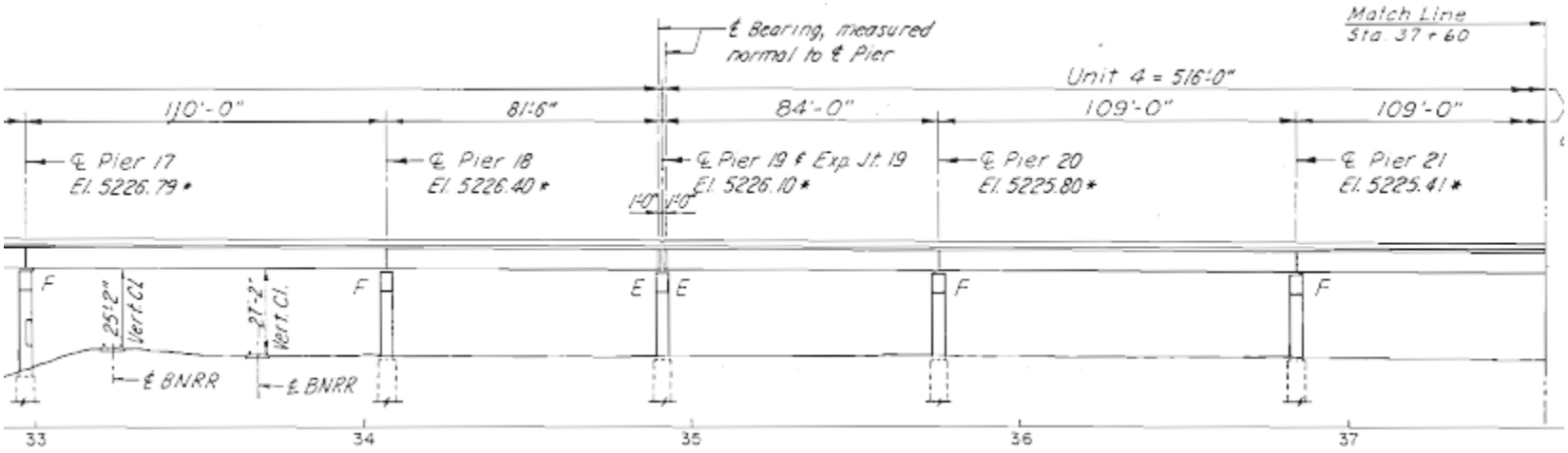
Elevation 1 - F-16-JX



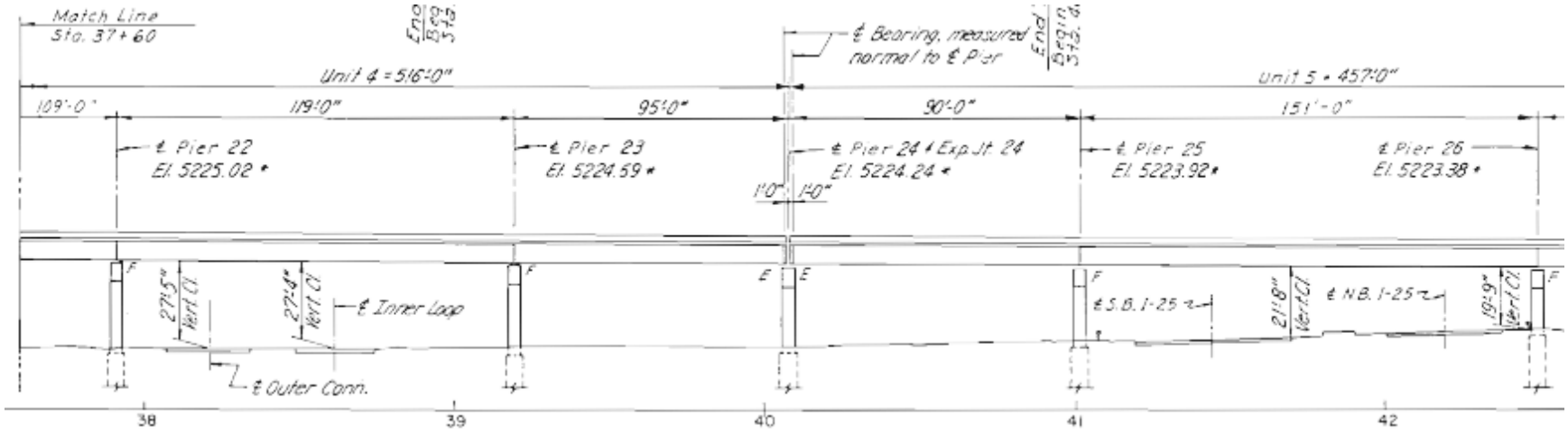
Elevation 2 - F-16-JX



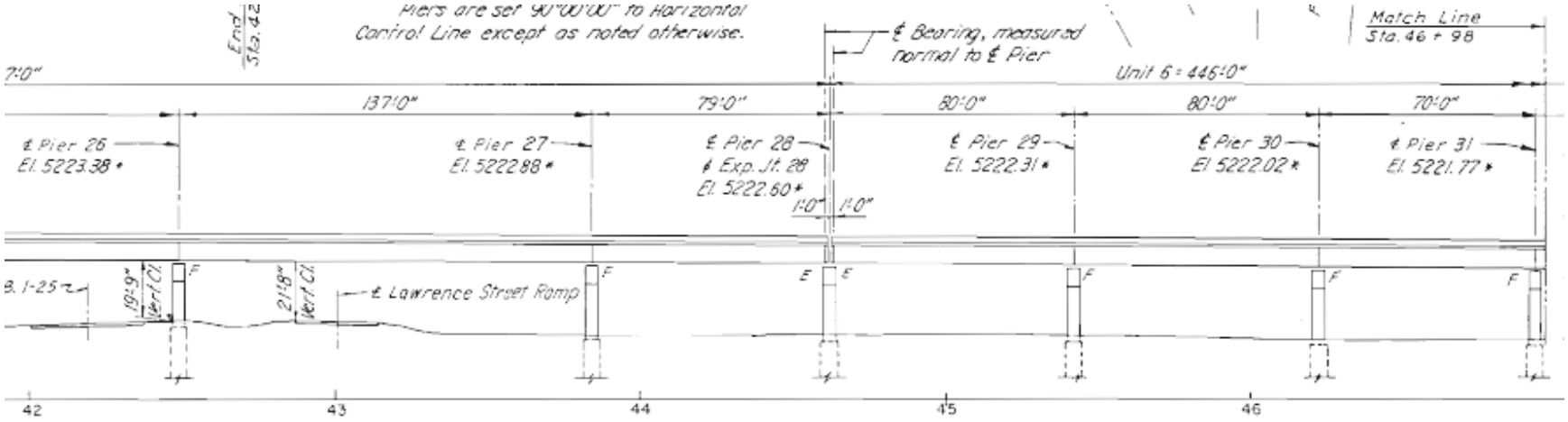
Elevation 3 - F-16-JX



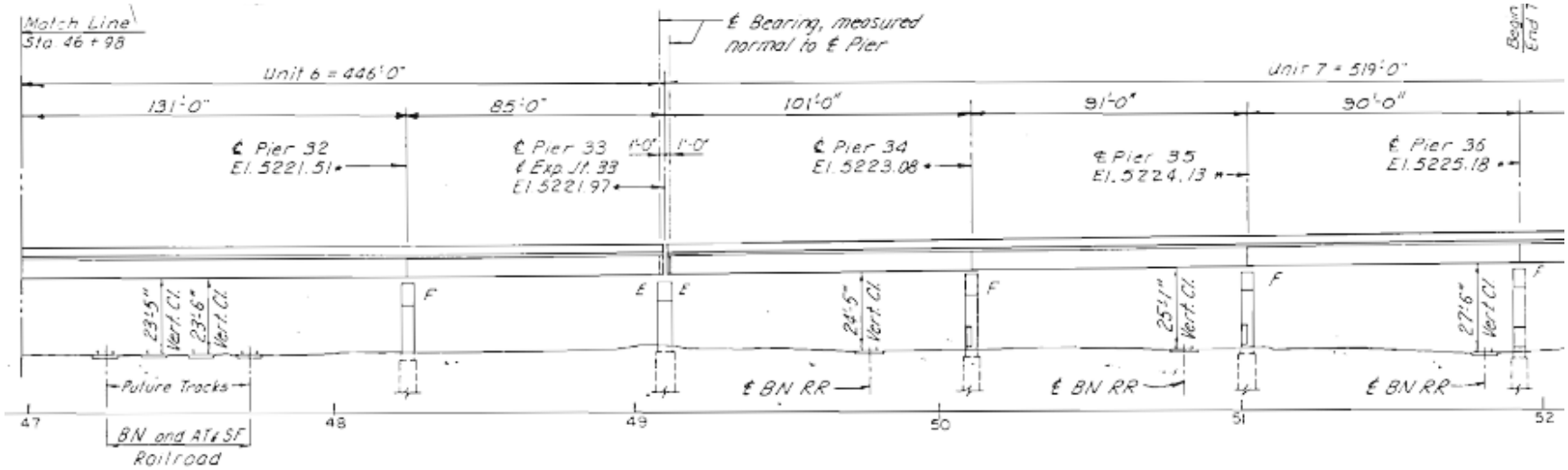
Elevation 4 - F-16-JX



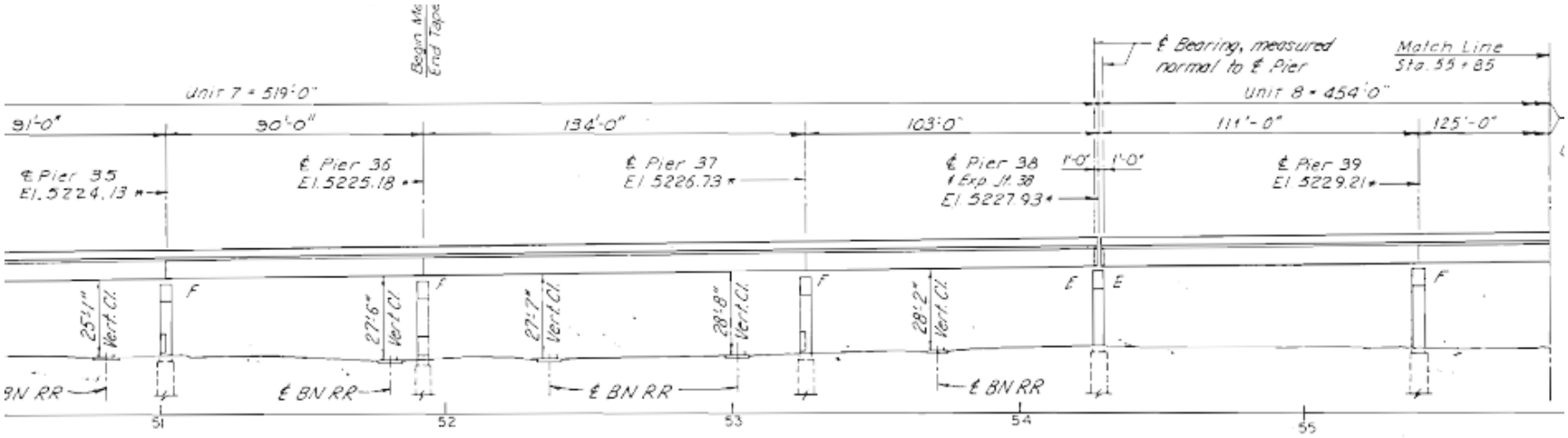
Elevation 5 - F-16-JX



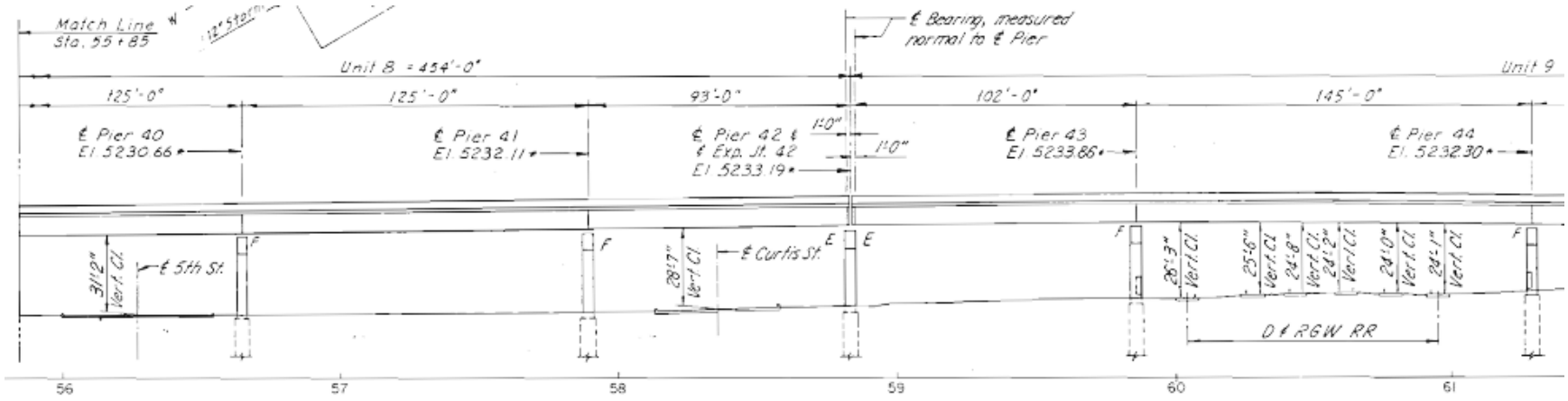
Elevation 6 - F-16-JX



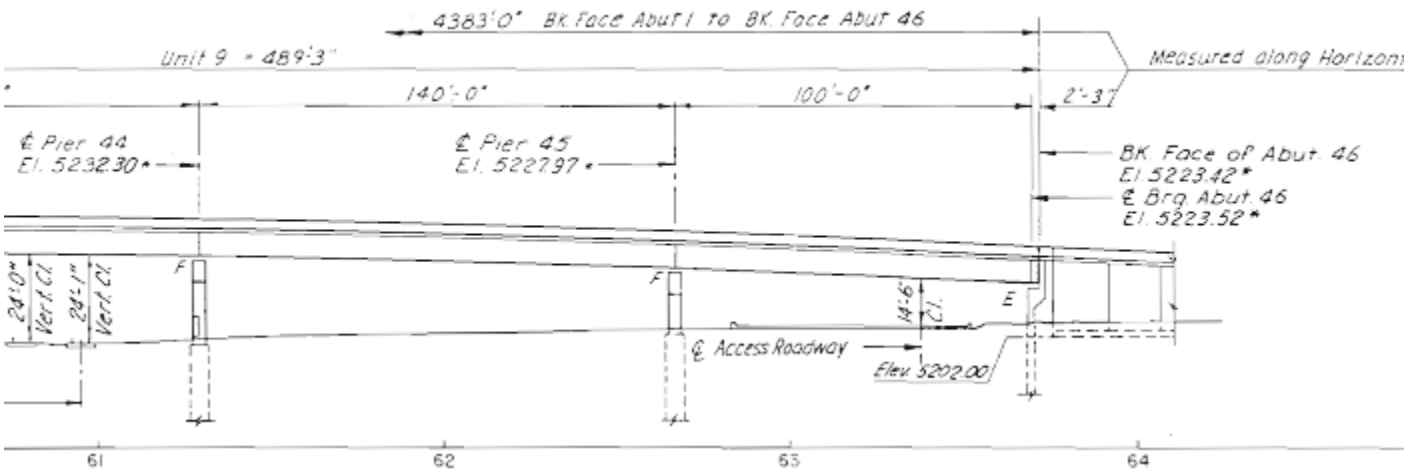
Elevation 7 - F-16-JX



Elevation 8 - F-16-JX



Elevation 9 - F-16-JX



Elevation 10 - F-16-JX

This Page Intentionally Left Blank.

EB Colfax Off Ramp to SB I-25

Structure Number: F-16-QJ **I-25 Milepost: 210.31**

Key Bridge Data	
Year Built	2003
Structure Type	Continuous Prestressed Concrete Box Girders
Spans	2
Length	326’
Width (out-to-out)	33’
Area of Deck	10,760 SF
Curb-to-Curb Width	30’-0”
Median	N/A
Sidewalks	N/A
Vert. Clear. over Walnut	22’-0”
Sufficiency Rating	91%
Deck Condition	8 out of 9
Superstructure Condition	8 out of 9
Substructure Condition	8 out of 9
Load Capacity	38.4 Tons (LFR Inventory)
Bridge Rail Type	Type 7
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	2 X 2” conduits (unknown owner)

Major Inspection Findings

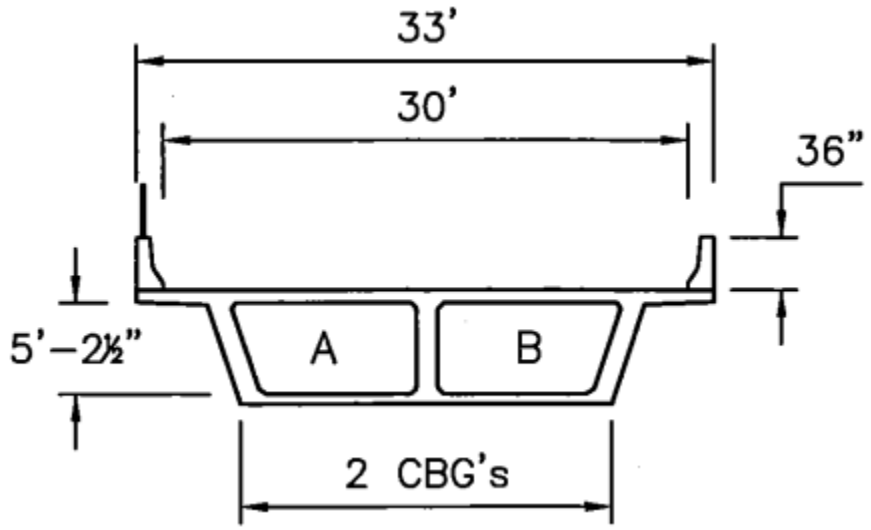
No major findings.

Rehabilitations/Widenings

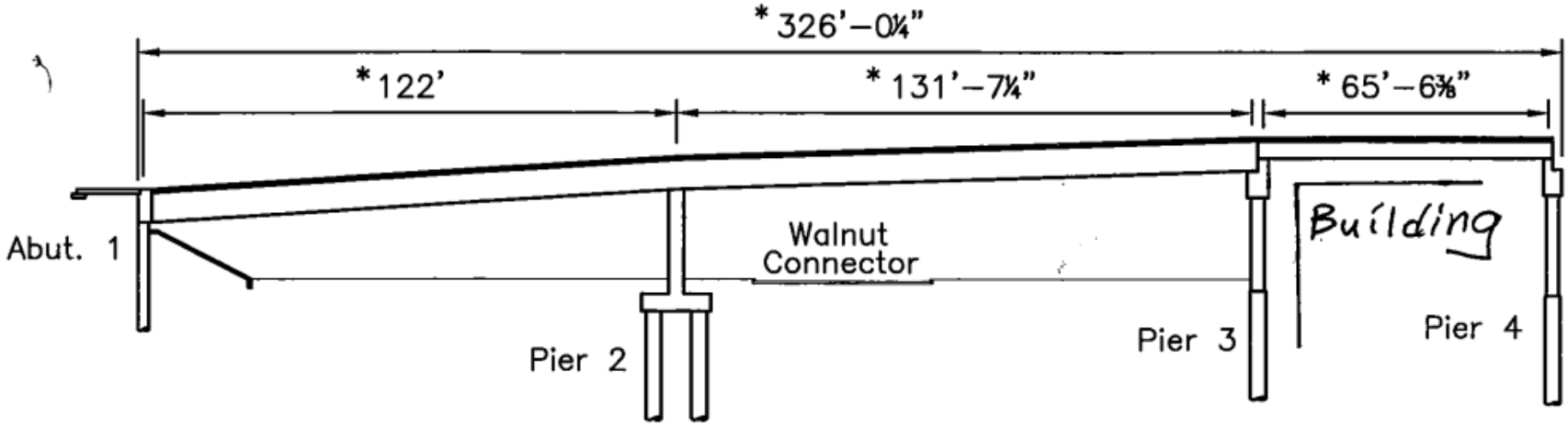
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-QJ



Elevation - F-16-QJ

EB Colfax Off Ramp to NB I-25

Structure Number: F-16-OB **I-25 Milepost: 210.31**

Key Bridge Data	
Year Built	1988
Structure Type	Continuous Prestressed Concrete Box Girders
Spans	3
Length	264’
Width (out-to-out)	37’
Area of Deck	9,770 SF
Curb-to-Curb Width	34’-0”
Median	N/A
Sidewalks	N/A
Vert. Clear. over I-25	N/A
Sufficiency Rating	100%
Deck Condition	6 out of 9
Superstructure Condition	6 out of 9
Substructure Condition	7 out of 9
Load Capacity	35.1 Tons (LFR Inventory) **(does not meet current standard)**
Bridge Rail Type	Type 7
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

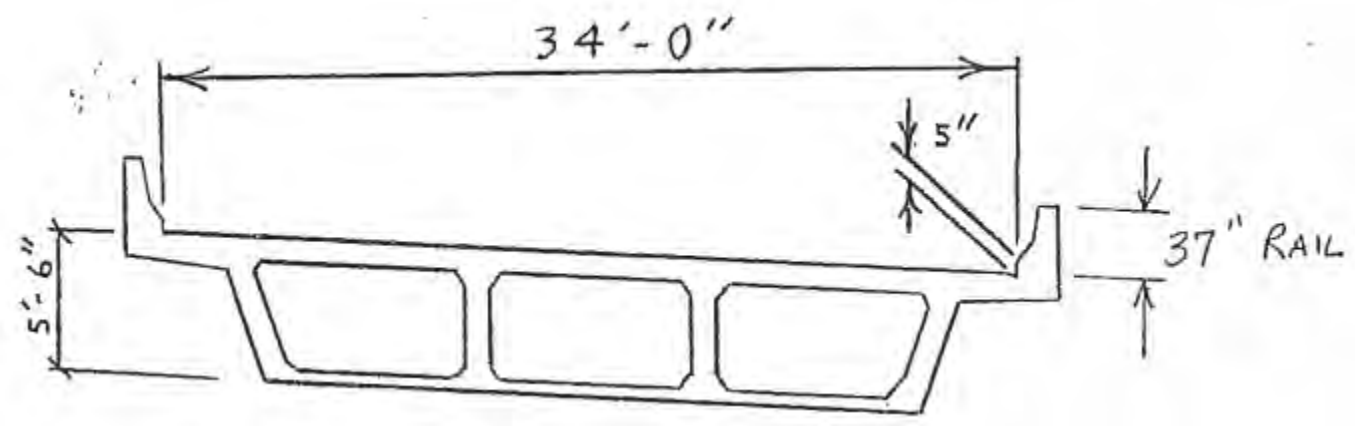
No major findings.

Rehabilitations/Widenings

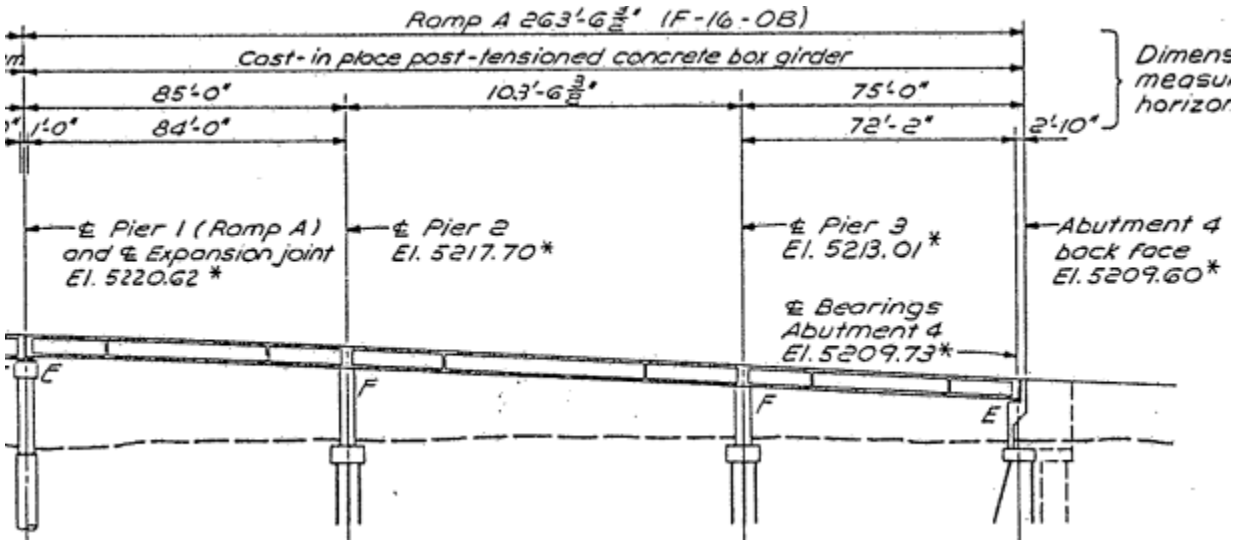
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-OB



Elevation - F-16-OB

NB I-25 Off Ramp to Colfax

Structure Number: F-16-RI **I-25 Milepost: 210.31**

Key Bridge Data	
Year Built	1991
Structure Type	Continuous Prestressed Concrete Box Girders
Spans	4
Length	443’
Width (out-to-out)	53’
Area of Deck	23,480 SF
Curb-to-Curb Width	50’-0”
Median	N/A
Sidewalks	N/A
Vert. Clear. over I-25	N/A
Sufficiency Rating	99%
Deck Condition	7 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	47.3 Tons (LFR Inventory)
Bridge Rail Type	Type 7
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	2.5” conduit (unknown owner)

Major Inspection Findings

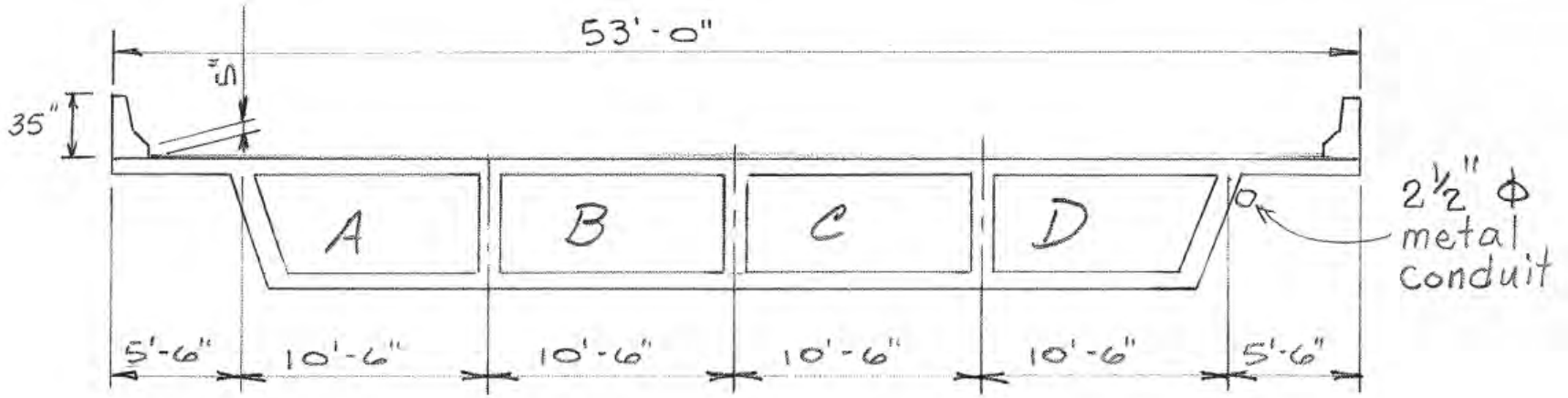
No major findings.

Rehabilitations/Widenings

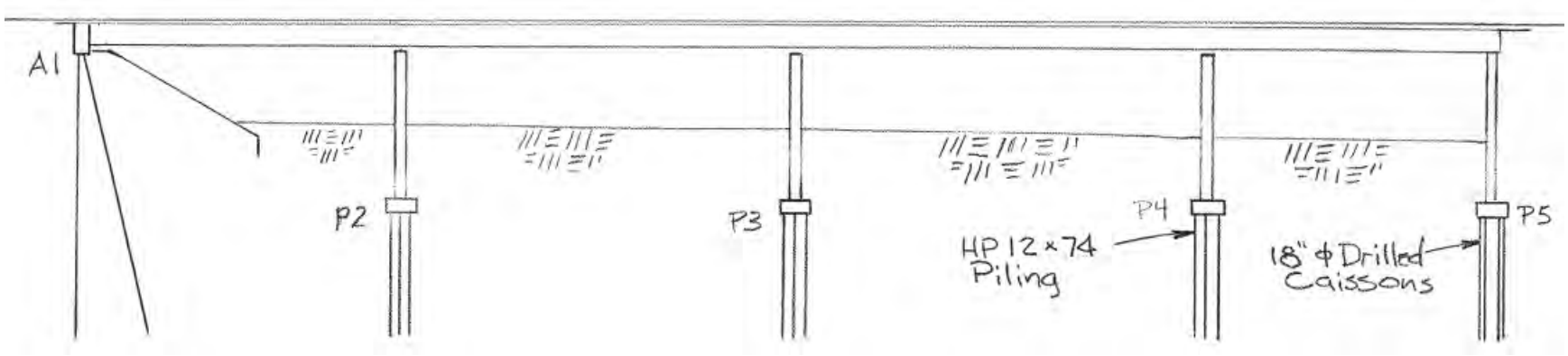
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-RI



Elevation - F-16-RI

SB I-25 Off Ramp to Colfax

Structure Number: F-16-NZ **I-25 Milepost: 210.31**

Key Bridge Data	
Year Built	1988
Structure Type	Continuous Prestressed Concrete Girders
Spans	3
Length	366’
Width (out-to-out)	47’
Area of Deck	17,200 SF
Curb-to-Curb Width	44’-0”
Median	N/A
Sidewalks	N/A
Vert. Clear. over Local Rd	17’-2”
Sufficiency Rating	80%
Deck Condition	7 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	38.0 Tons (LFR Inventory)
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

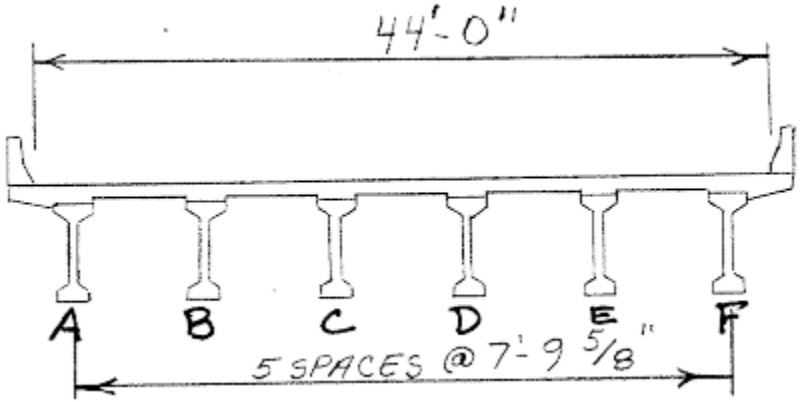
No major findings.

Rehabilitations/Widenings

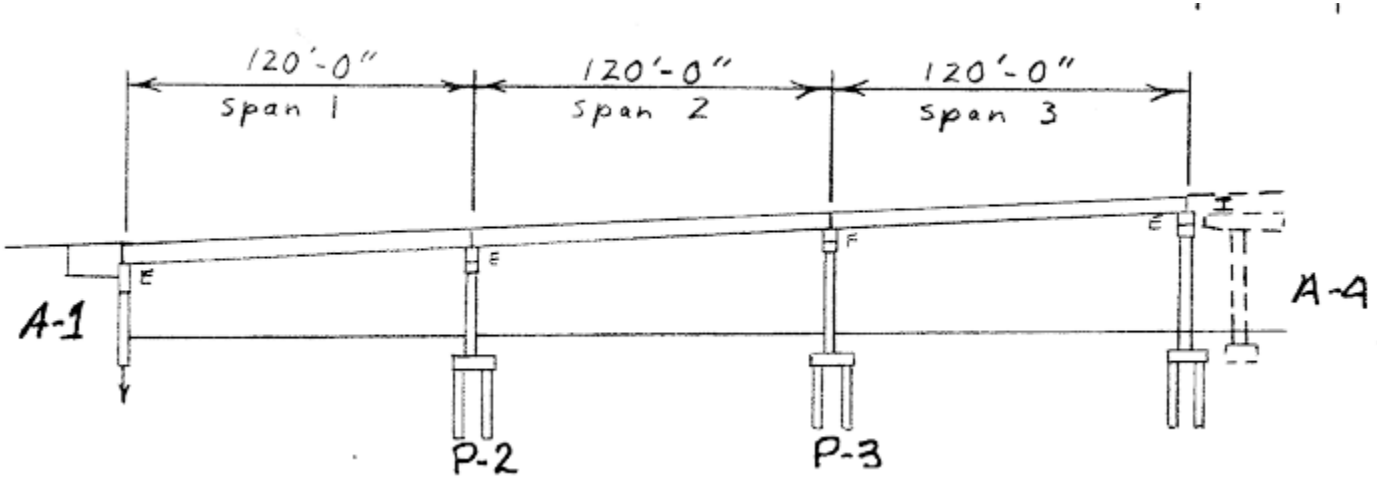
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-NZ



Elevation - F-16-NZ

WB Colfax Off Ramp over BNSF

Structure Number: F-16-OD **I-25 Milepost: 210.31**

Key Bridge Data	
Year Built	1988
Structure Type	Continuous Prestressed Concrete Box Girders
Spans	3
Length	363’
Width (out-to-out)	Varies 33’ to 87’
Area of Deck	21,780 SF
Curb-to-Curb Width	Varies 30’-4” to 83’-11”
Median	N/A
Sidewalks	N/A
Vert. Clear. over BNSF	24’-6”
Sufficiency Rating	80%
Deck Condition	7 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	44.0 Tons (LFR Inventory)
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

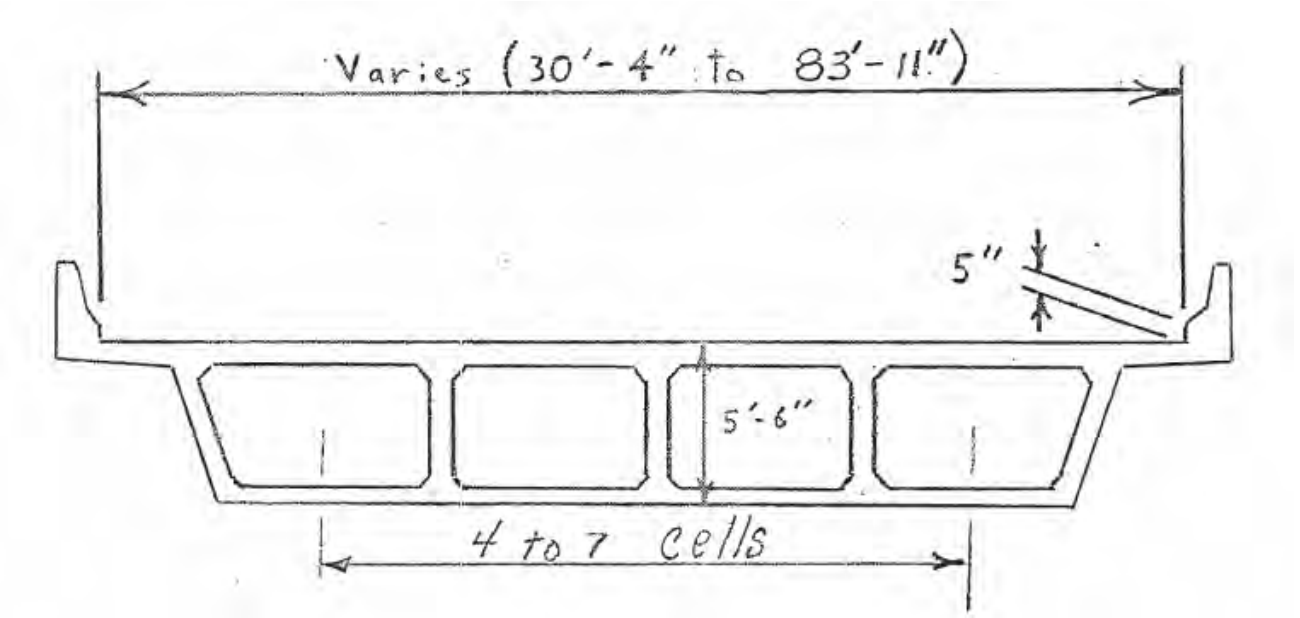
No major findings.

Rehabilitations/Widenings

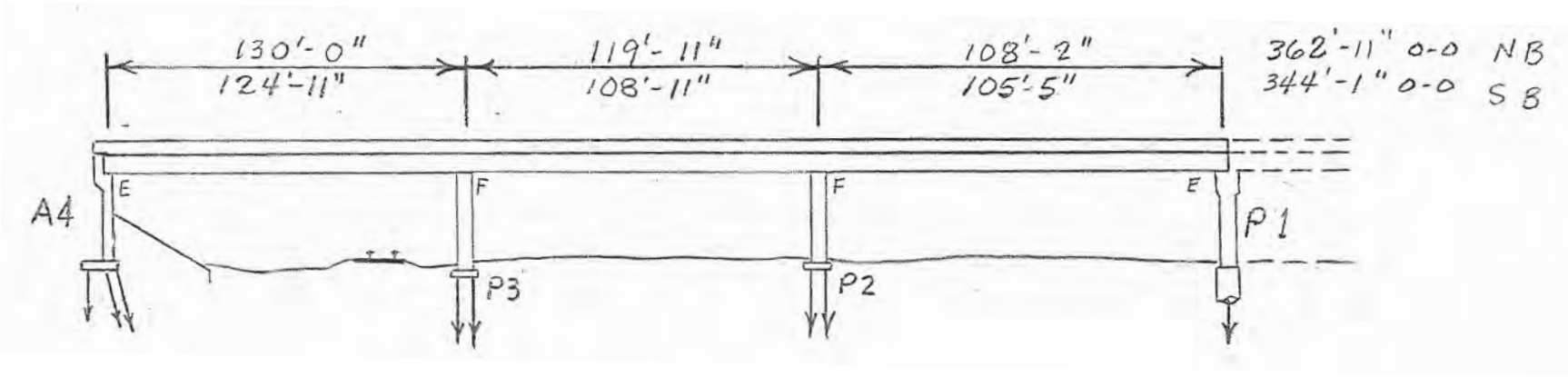
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-OD



Elevation - F-16-OD

WB Colfax Off Ramp to SB I-25

Structure Number: F-16-MX **I-25 Milepost: 210.31**

Key Bridge Data	
Year Built	1988
Structure Type	Prestressed Concrete Box Girders
Spans	1
Length	135’
Width (out-to-out)	33’
Area of Deck	4,460 SF
Curb-to-Curb Width	30’-0”
Median	N/A
Sidewalks	N/A
Vert. Clear. over Ramp	17’-10”
Sufficiency Rating	96%
Deck Condition	7 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	39.5 Tons (LFR Inventory)
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

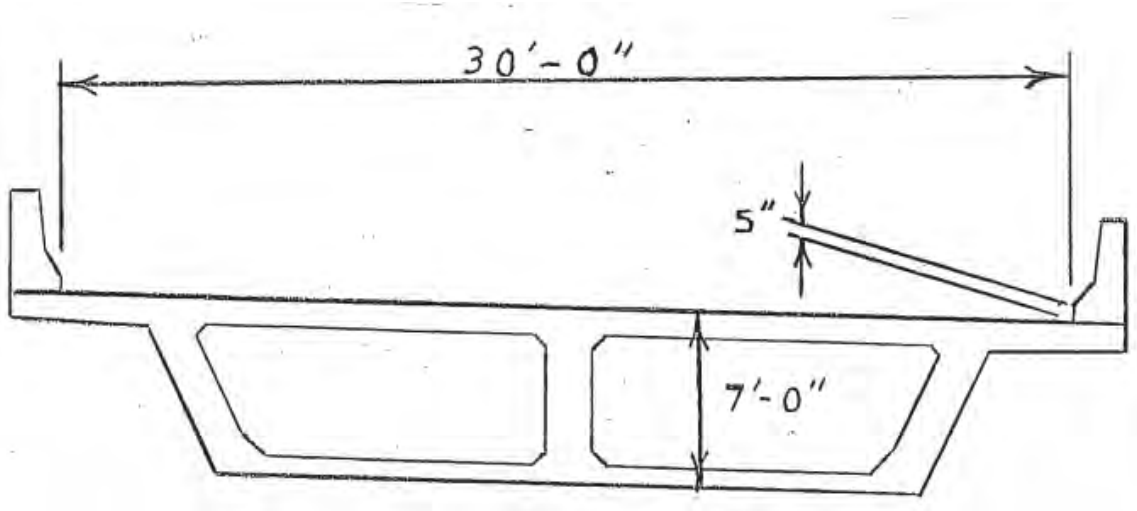
No major findings.

Rehabilitations/Widenings

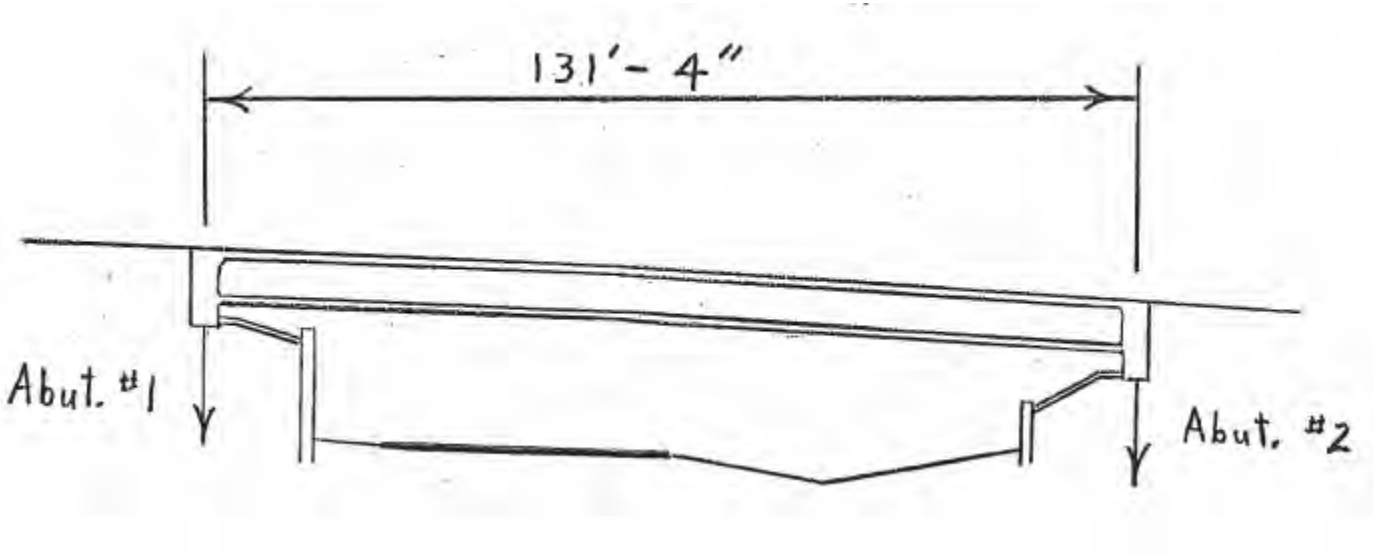
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-MX



Elevation - F-16-MX

EB/WB Colfax to NB I-25 On Ramp over Walnut St

Structure Number: D-03-V-210 **I-25 Milepost: 210.31**

Key Bridge Data	
Year Built	1988
Structure Type	Prestressed Concrete Girders
Spans	1
Length	78’
Width (out-to-out)	Varies 40’ to 44’
Area of Deck	3,040 SF
Curb-to-Curb Width	Varies 37’-3” to 41’-8”
Median	N/A
Sidewalks	N/A
Vert. Clear. over Walnut	16’-7”
Sufficiency Rating	92%
Deck Condition	8 out of 9
Superstructure Condition	8 out of 9
Substructure Condition	7 out of 9
Load Capacity	37.1 Tons (LFR Inventory)
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	2” electrical conduit

Major Inspection Findings

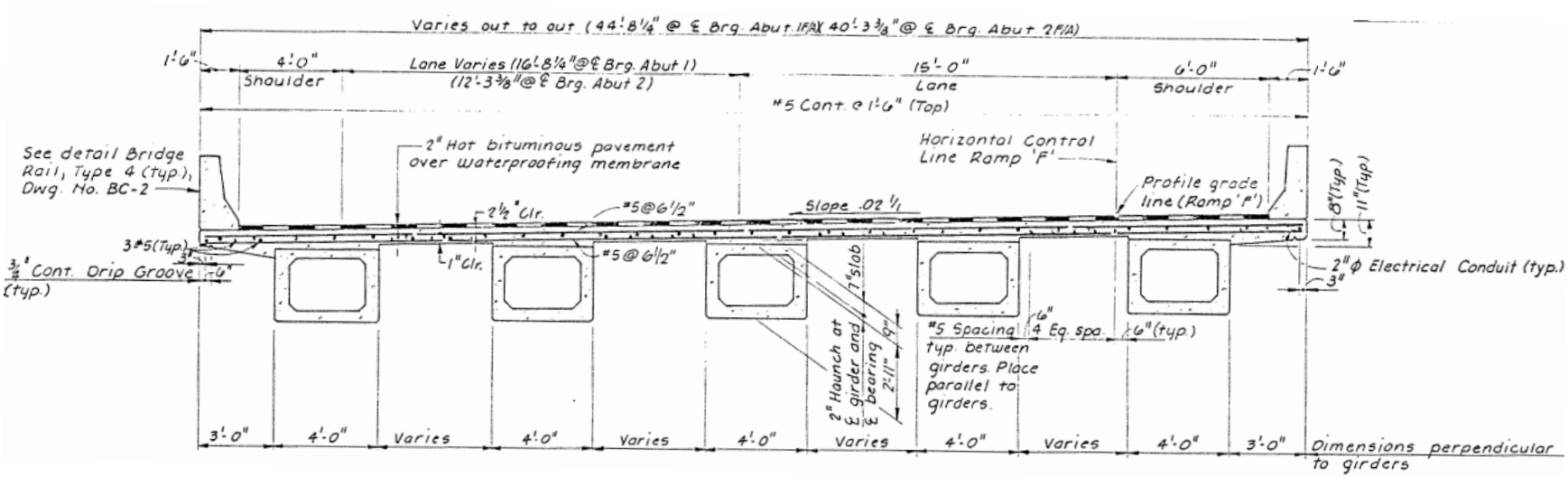
No major findings.

Rehabilitations/Widenings

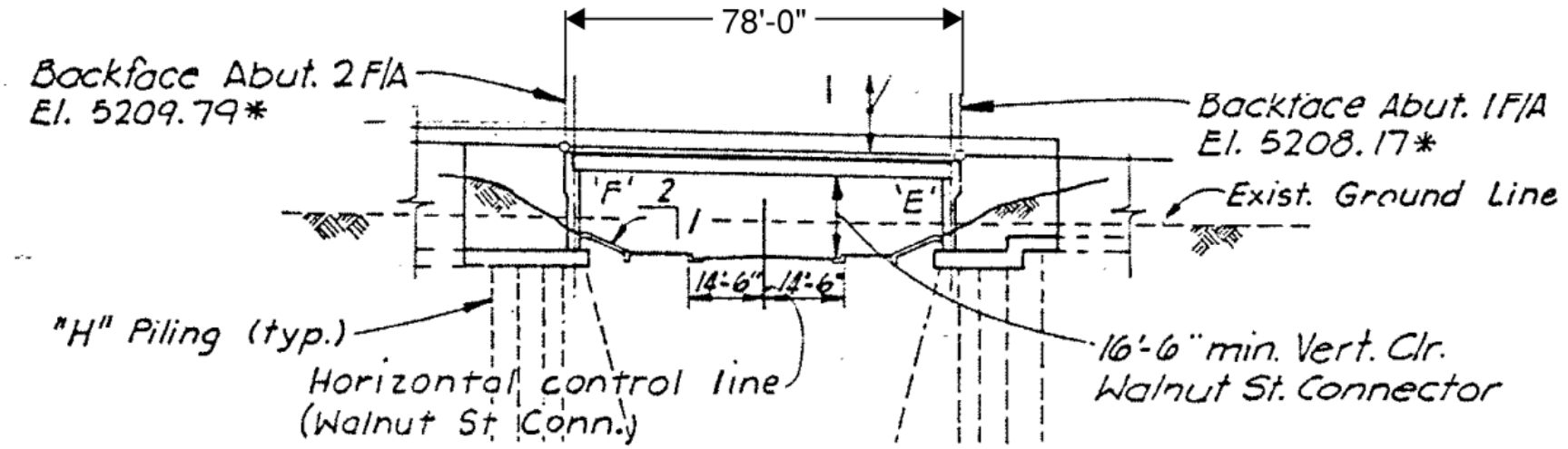
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-MW



Elevation - F-16-MW

I-25 NB Off Ramp to EB Auraria

Structure Number: F-16-NY **I-25 Milepost: 210.31**

Key Bridge Data	
Year Built	1988
Structure Type	Continuous Prestressed Concrete Box Girders
Spans	11
Length	1,252’
Width (out-to-out)	Varies 58’ to 43’
Area of Deck	63,230 SF
Curb-to-Curb Width	Varies 39’-9” to 55’-0”
Median	N/A
Sidewalks	N/A
Vert. Clear. over I-25 On Ramp	16’-5” **(does not meet current standard)**
Sufficiency Rating	76%
Deck Condition	6 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	35.5 Tons (LFR Inventory)
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	2” electrical conduit

Major Inspection Findings

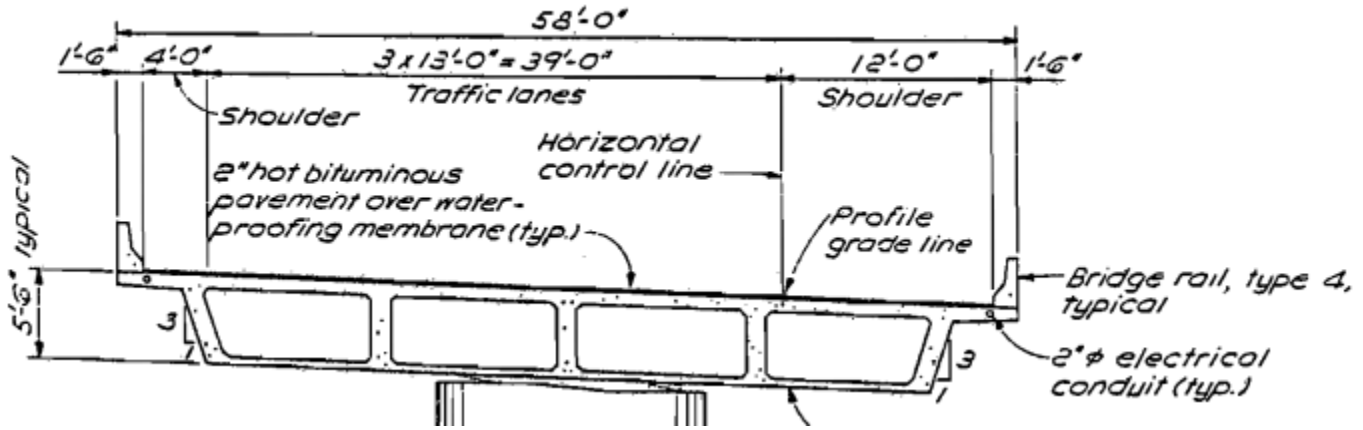
No major findings.

Rehabilitations/Widenings

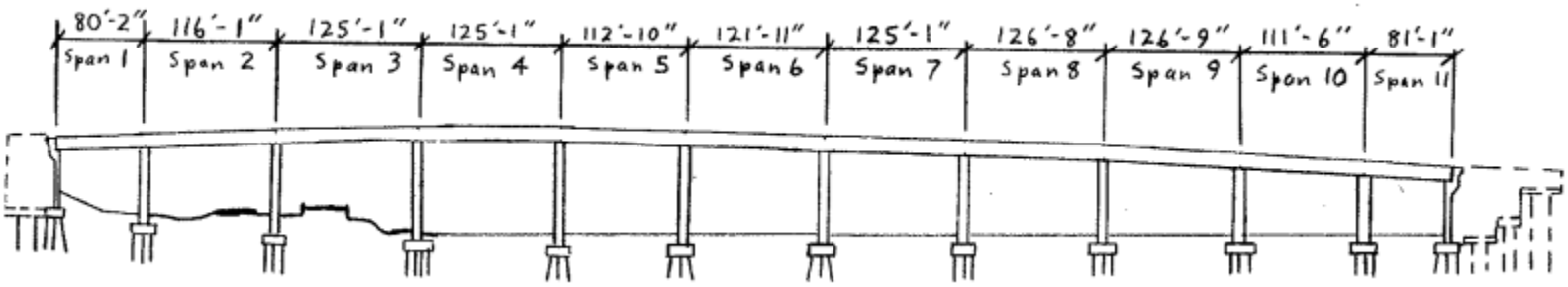
Concrete repair work has been completed in several cells.

Additional Notes

None.



Section - F-16-NY



Elevation - F-16-NY

WB Auraria Flyover Ramp to SB I-25

Structure Number: F-16-NX **I-25 Milepost: 210.31**

Key Bridge Data	
Year Built	1987
Structure Type	Continuous Steel Plate Girders
Spans	4
Length	587’
Width (out-to-out)	38’
Area of Deck	22,310 SF
Curb-to-Curb Width	35’-3”
Median	N/A
Sidewalks	N/A
Vert. Clear. over I-25	18’-2”
Sufficiency Rating	93%
Deck Condition	6 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	32.8 Tons (LFR Inventory) **(does not meet current standard)**
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

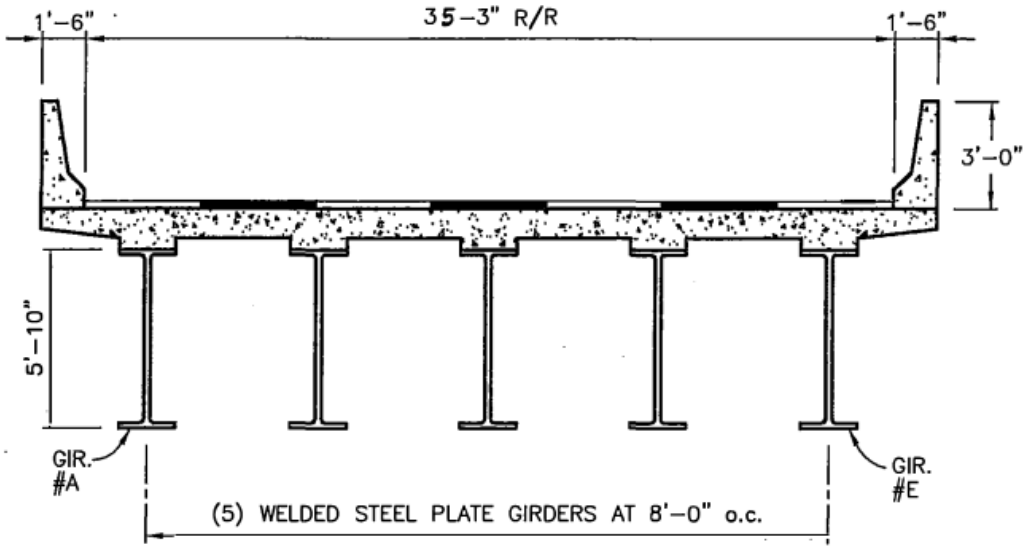
No major findings.

Rehabilitations/Widenings

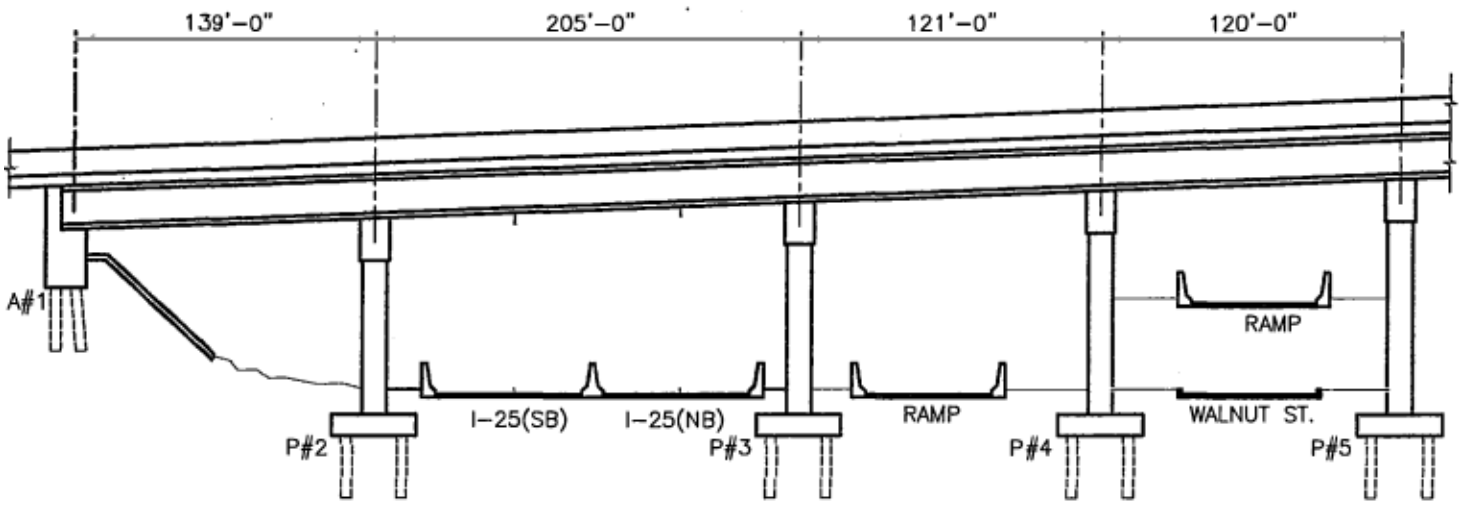
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-NX



Elevation - F-16-NX

WB Auraria Flyover Ramp to WB Colfax Ave

Structure Number: F-16-NW **I-25 Milepost: 210.31**

Key Bridge Data	
Year Built	1987
Structure Type	Continuous Prestressed Concrete Girders
Spans	13
Length	1,525’
Width (out-to-out)	33’
Area of Deck	50,330 SF
Curb-to-Curb Width	21’-0”
Median	1’-3”
Sidewalk	8’-0”
Vert. Clear. over I-25	17’-10”
Sufficiency Rating	60%
Deck Condition	7 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	7 out of 9
Load Capacity	13.9 Tons (LFR Inventory) **(does not meet current standard)**
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	2” electrical conduit

Major Inspection Findings

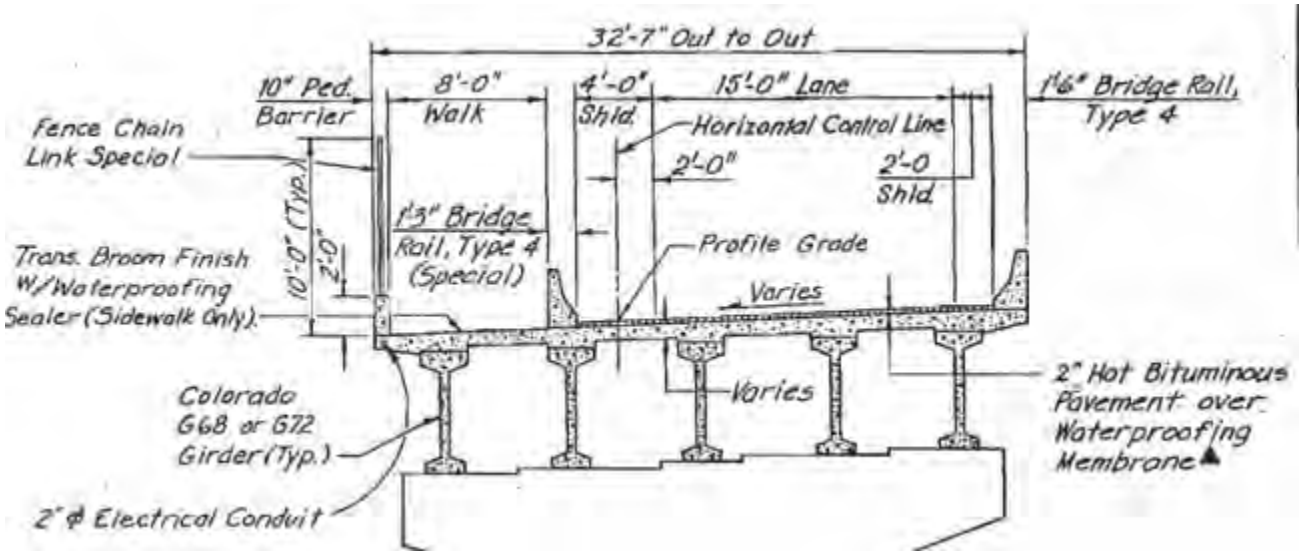
No major findings.

Rehabilitations/Widenings

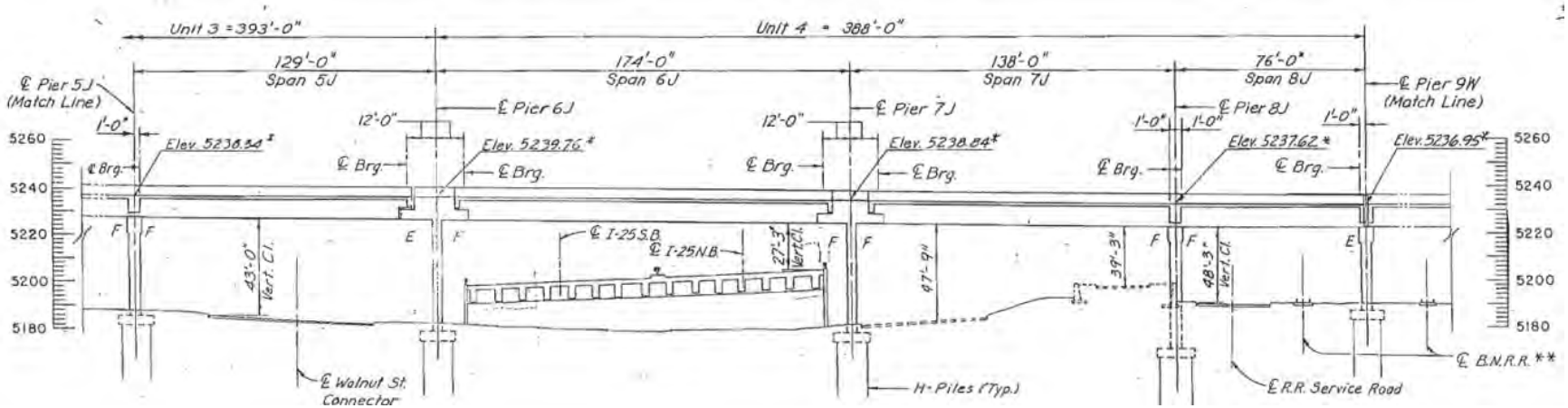
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-NW



Elevation - F-16-NW

I-25 over Walnut

Structure Number: F-16-DQ **I-25 Milepost: 210.31**

Key Bridge Data	
Year Built	1952
Structure Type	Concrete Rigid Frame
Spans	2
Length	202’
Width (out-to-out)	150’
Area of Deck	30,300 SF
Curb-to-Curb Width	72’-3” (NB), 72’-3” (SB)
Median	2’-0”
Sidewalk	N/A
Vert. Clear. over Walnut	17’-4”
Sufficiency Rating	72%
Deck Condition	5 out of 9
Superstructure Condition	5 out of 9
Substructure Condition	7 out of 9
Load Capacity	34.1 Tons (LFR Inventory) **(does not meet current standard)**
Bridge Rail Type	Type 4
Bridge Rail Height	3’-0” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

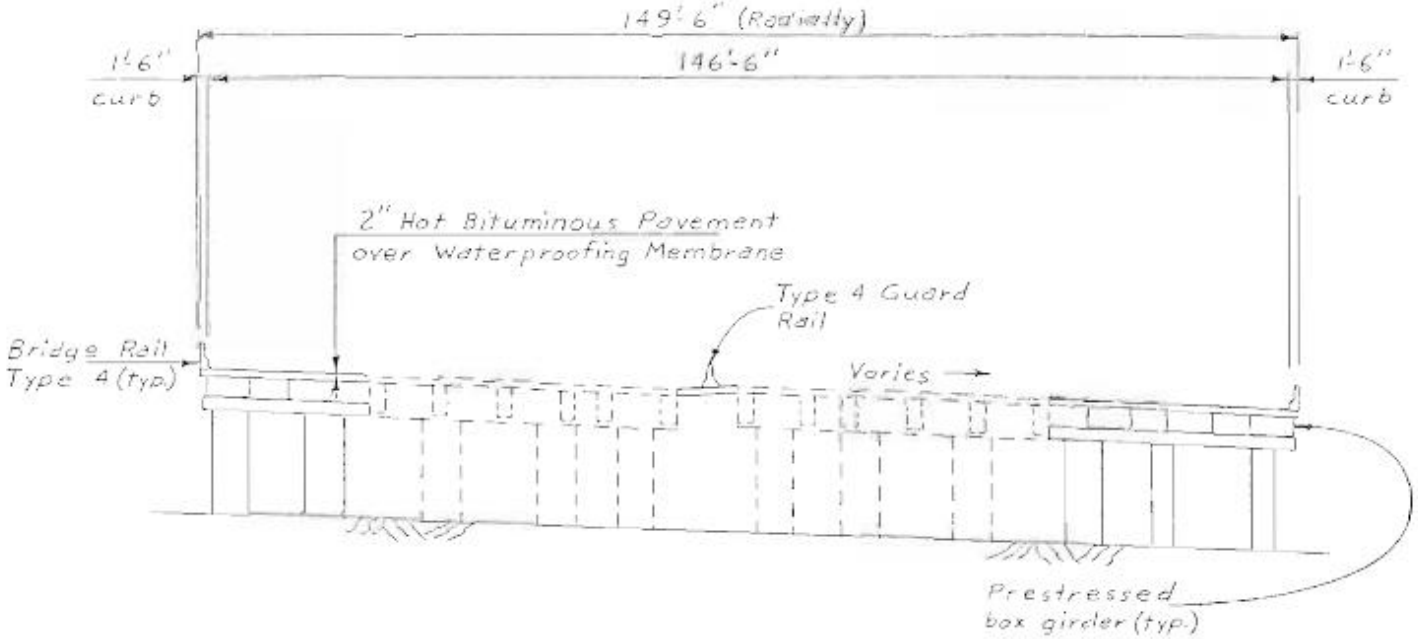
No major findings.

Rehabilitations/Widenings

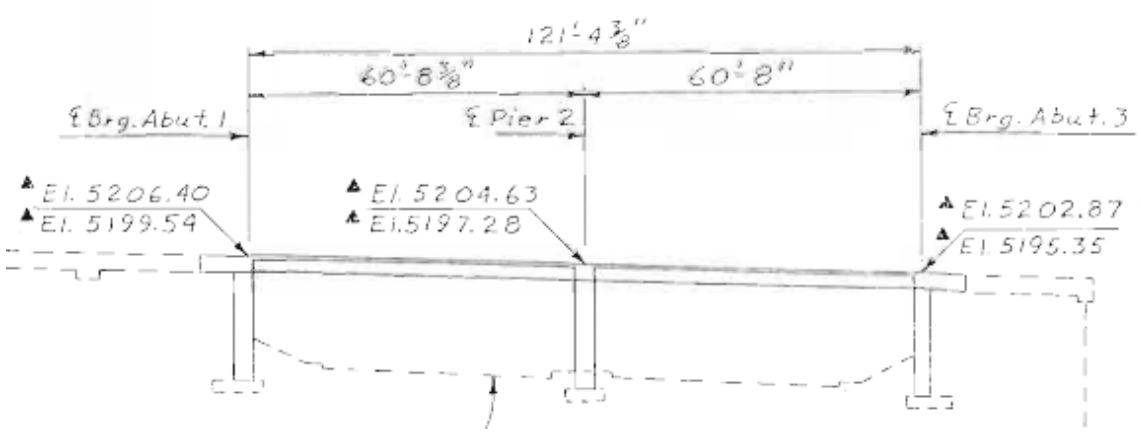
Original bridge consisted of two twin structures. A major widening was completed in 1972 to join the two bridges. Another widening was completed in 1987 to the outside to bring the structure width to what it is today.

Additional Notes

None.



Section - F-16-DQ



Elevation - F-16-DQ

I-25 over So Platte River

Structure Number: F-16-XB **I-25 Milepost: 210.56**

Key Bridge Data	
Year Built	2011
Structure Type	Continuous Prestressed Concrete Tub Girders
Spans	5 (3-main, 2-intermediate)
Length	371’
Width (out-to-out)	197’
Area of Deck	73,090 SF
Curb-to-Curb Width	96’-0” (NB), 96’-0” (SB)
Median	2’-0”
Sidewalks	N/A
Vert. Clear. over Local Rd	16’-6”
Sufficiency Rating	85%
Deck Condition	7 out of 9
Superstructure Condition	8 out of 9
Substructure Condition	7 out of 9
Load Capacity	39.6 Tons (LFR Inventory)
Bridge Rail Type	Type 7
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

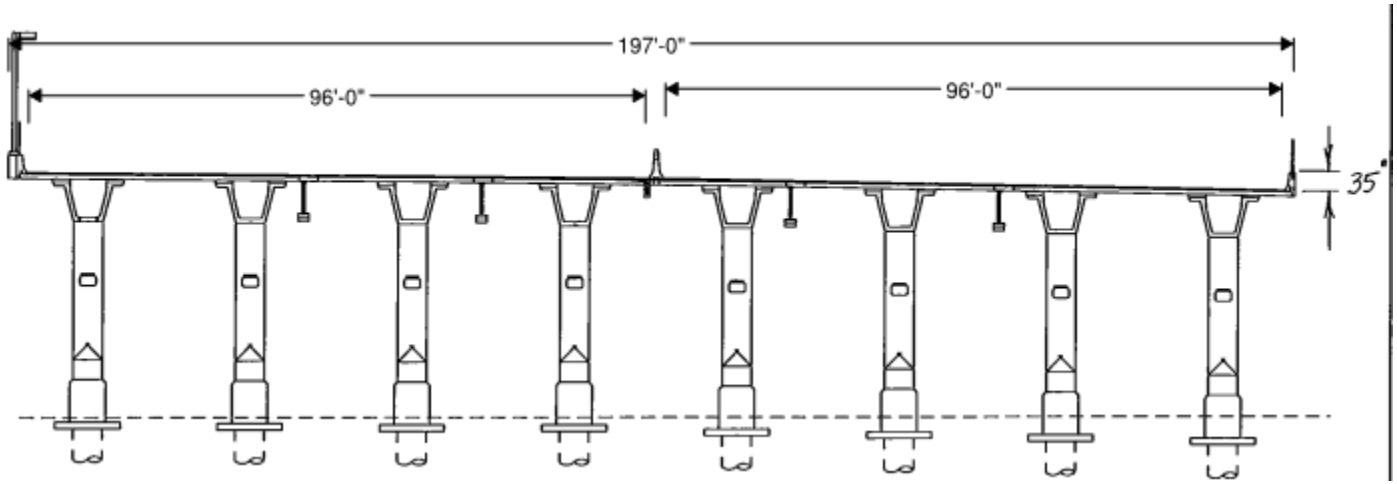
No major findings.

Rehabilitations/Widenings

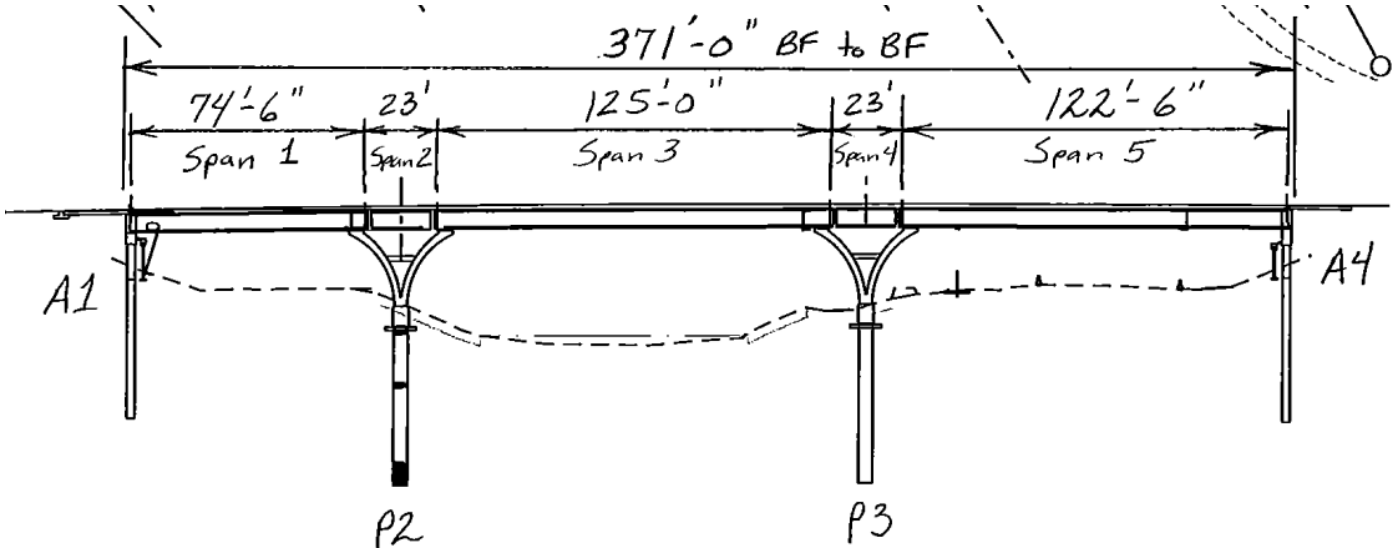
No rehabilitations nor widenings.

Additional Notes

Structure is wide enough to accommodate two additional lanes. There are currently two 24’-0” wide shoulders.



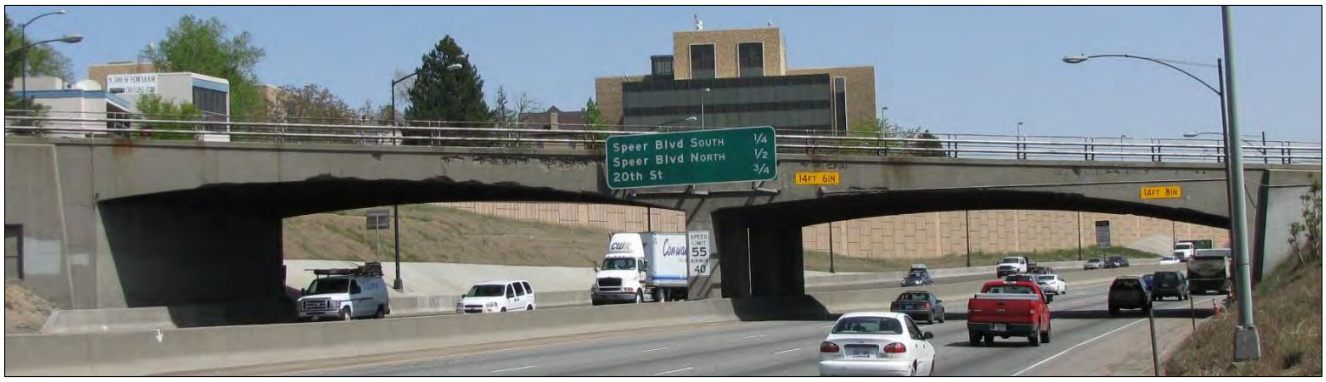
Section - F-16-XB



Elevation - F-16-XB

23rd Ave over I-25

Structure Number: F-16-DA **I-25 Milepost: 211.11**



Key Bridge Data	
Year Built	1952
Structure Type	Concrete Rigid Frame
Spans	2
Length	256’
Width (out-to-out)	44’
Area of Deck	11,260 SF
Curb-to-Curb Width	36’-0”
Median	N/A
Sidewalks	6’-2”
Vert. Clearance over I-25	13’-9” **(does not meet current standard)**
Sufficiency Rating	76%
Deck Condition	4 out of 9
Superstructure Condition	5 out of 9
Substructure Condition	5 out of 9
Load Capacity	33.1 Tons (LFR Inventory) **(does not meet current standard)**
Bridge Rail Type	Type 10R
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

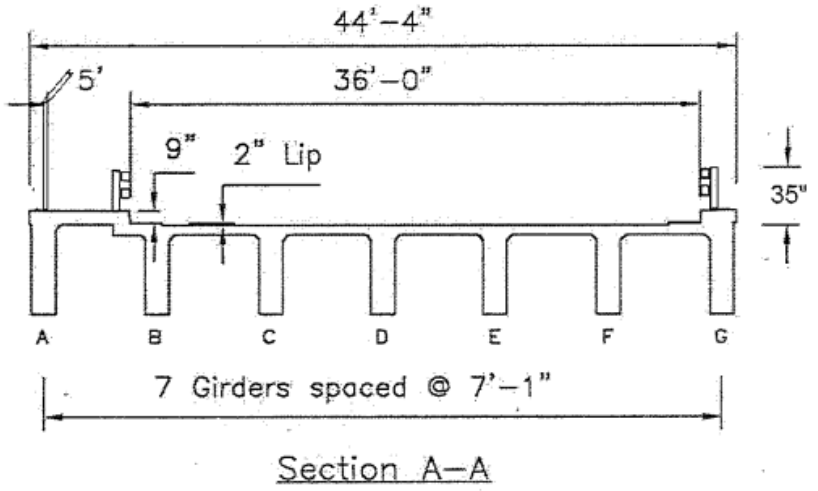
Structure has experienced multiple vehicular impacts resulting in damaged girders and exposed primary reinforcing. Cracking, heavy efflorescence, and spalled concrete with exposed rebar present throughout concrete deck.

Rehabilitations/Widenings

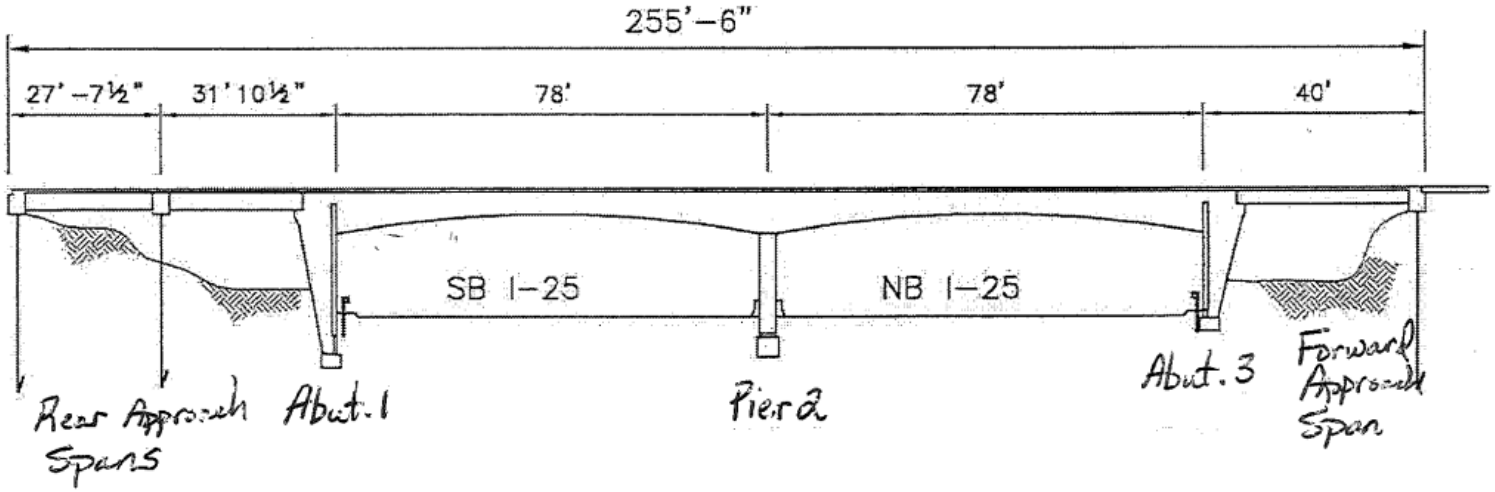
Girder concrete was previously patched where impacted by vehicles but additional vehicular impacts to the patched areas have caused spalling of the patch concrete.

Additional Notes

Low clearance is posted on exterior face of superstructure.



Section - F-16-DA



Elevation - F-16-DA

I-25 SB Off Ramp at 23rd St over I-25 SB On Ramp

Structure Number: F-16-IR **I-25 Milepost: 211.30**

Key Bridge Data	
Year Built	2010
Structure Type	Prestressed Concrete Girders
Spans	1
Length	124’
Width (out-to-out)	28’
Area of Deck	3,472 SF
Curb-to-Curb Width	25’-0”
Median	N/A
Sidewalks	N/A
Vert. Clearance over I-25	17’-10”
Sufficiency Rating	95%
Deck Condition	7 out of 9
Superstructure Condition	7 out of 9
Substructure Condition	8 out of 9
Load Capacity	93.6 Tons (LRFR Inventory)
Bridge Rail Type	Type 7
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

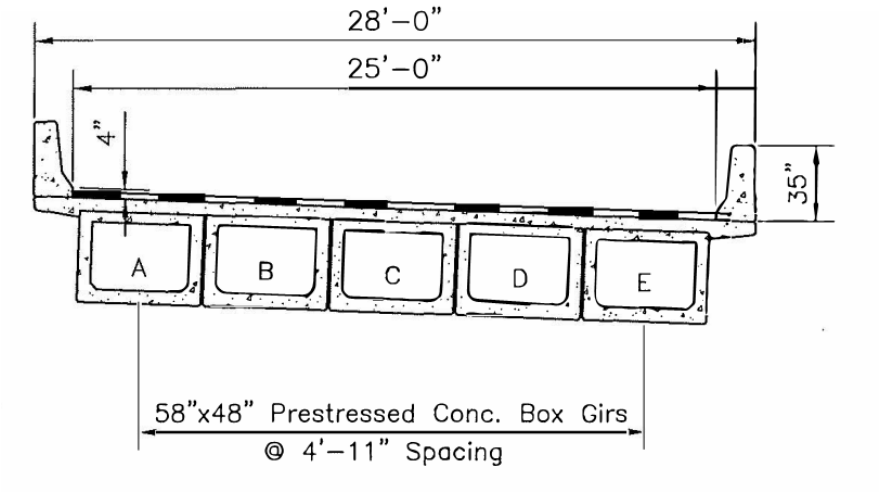
No major findings.

Rehabilitations/Widenings

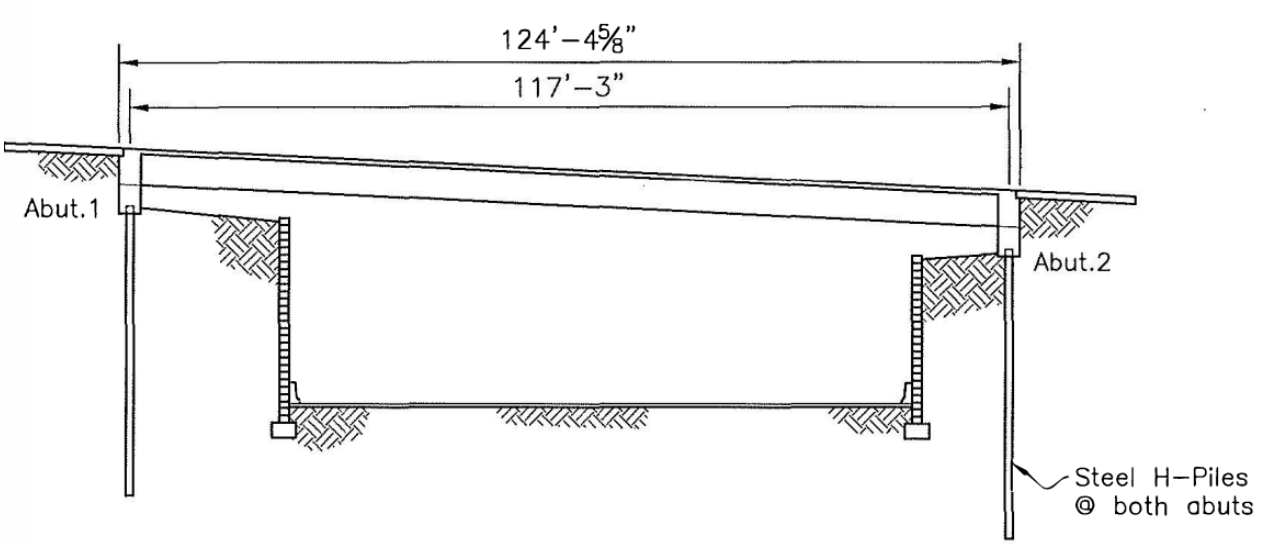
No rehabilitations nor widenings.

Additional Notes

None.



Section - F-16-IR



Elevation - F-16-IR

Speer Pedestrian Bridge over I-25

Structure Number: E-16-QR **I-25 Milepost: 211.45**

Key Bridge Data	
Year Built	1996
Structure Type	Steel Arch Truss
Spans	2
Length	240’
Width (out-to-out)	10.5’
Area of Deck	2,520 SF
Curb-to-Curb Width	9’-10”
Median	N/A
Sidewalks	N/A
Vert. Clearance over I-25	19’-9”
Sufficiency Rating	N/A
Deck Condition	7 out of 9
Superstructure Condition	6 out of 9
Substructure Condition	7 out of 9
Load Capacity	No Rating
Bridge Rail Type	N/A
Bridge Rail Height	N/A
Utilities Carried	3 X 1.25” electrical conduits

Major Inspection Findings

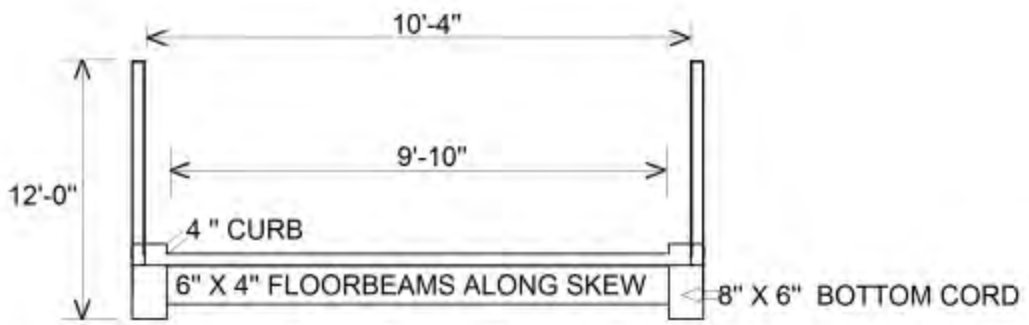
No major findings.

Rehabilitations/Widenings

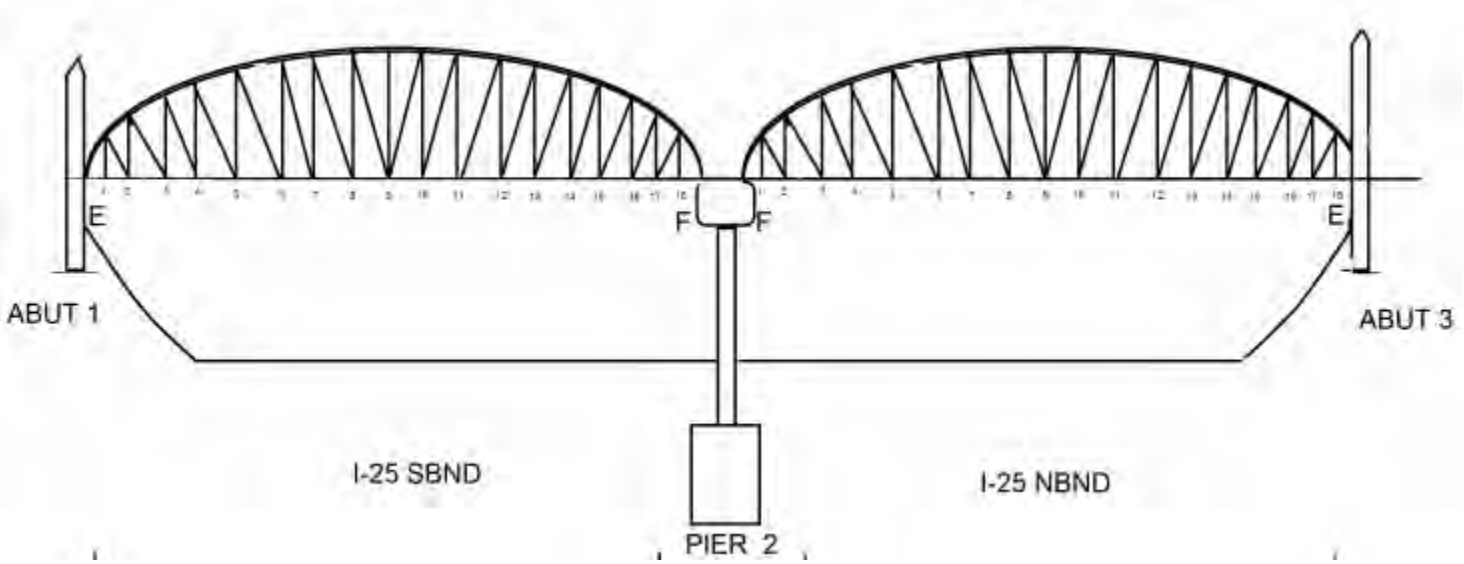
No rehabilitations nor widenings.

Additional Notes

None.



Section - E-16-QR



Elevation - E-16-QR

EB Speer Blvd over I-25

Structure Number: E-16-EO **I-25 Milepost: 211.46**

Key Bridge Data	
Year Built	1952
Structure Type	Concrete Rigid Frame
Spans	2
Length	259’
Width (out-to-out)	46’
Area of Deck	11,910 SF
Curb-to-Curb Width	40’-0”
Median	N/A
Sidewalks	N/A
Vert. Clearance over I-25	13’-5” **(does not meet current standard)**
Sufficiency Rating	59%
Deck Condition	4 out of 9
Superstructure Condition	5 out of 9
Substructure Condition	5 out of 9
Load Capacity	37.0 Tons (LFR Inventory)
Bridge Rail Type	Type 10R
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	N/A

Major Inspection Findings

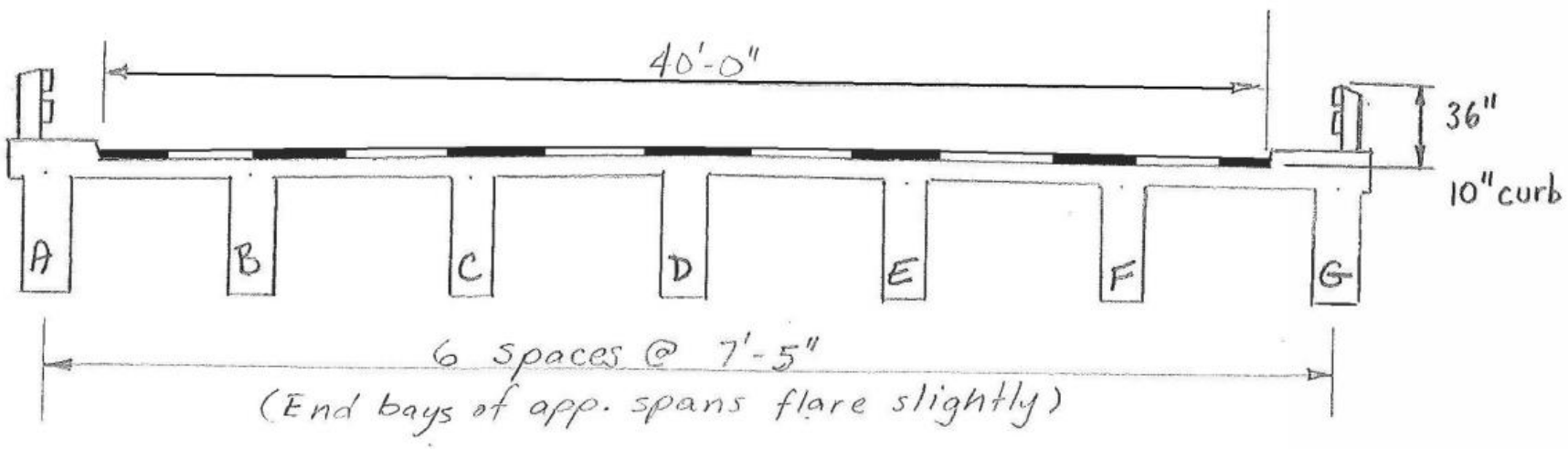
Structure has experienced multiple vehicular impacts resulting in damaged girders and exposed primary reinforcing. Cracking, efflorescence, and spalled concrete with exposed rebar present throughout concrete deck.

Rehabilitations/Widenings

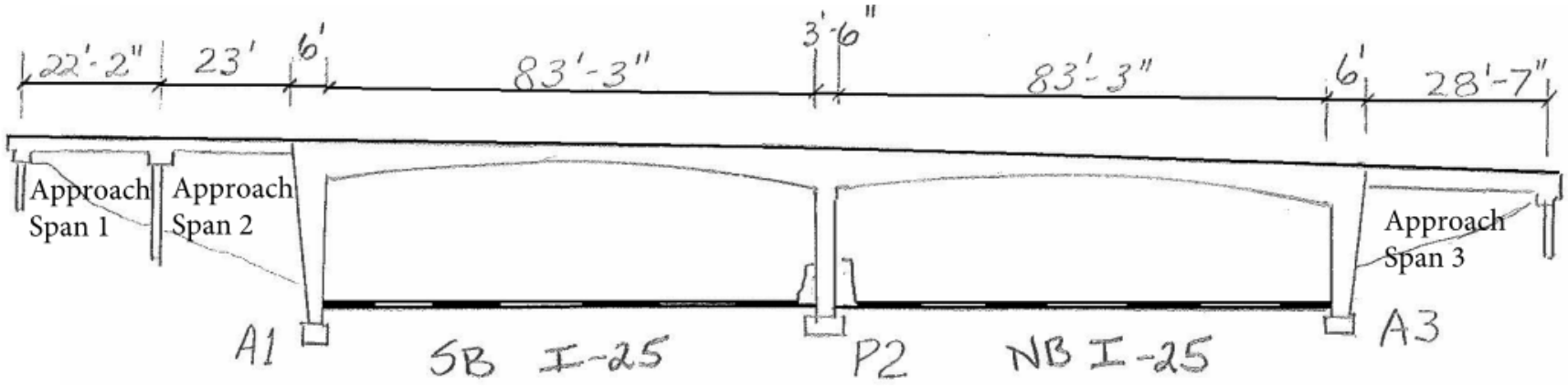
Bridge rail was replaced in 2008.

Additional Notes

Minimum vertical clearance over I-25 is posted as 14’-2” over I-25 northbound. Clearance reported here is 13’-5” and is located over I-25 on the inside of the southbound.



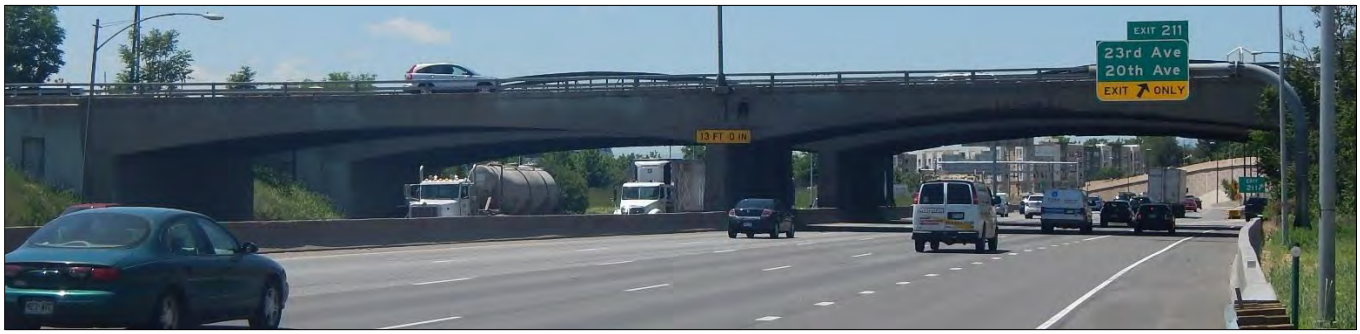
Section - E-16-EO



Elevation - E-16-EO

WB Speer Blvd over I-25

Structure Number: E-16-EW **I-25 Milepost: 211.46**



Key Bridge Data	
Year Built	1952
Structure Type	Concrete Rigid Frame
Spans	2
Length	234’
Width (out-to-out)	46’
Area of Deck	10,760 SF
Curb-to-Curb Width	40’-0”
Median	N/A
Sidewalks	N/A
Vert. Clearance over I-25	13’-0” **(does not meet current standard)**
Sufficiency Rating	56%
Deck Condition	4 out of 9
Superstructure Condition	5 out of 9
Substructure Condition	6 out of 9
Load Capacity	37.0 Tons (LFR Inventory)
Bridge Rail Type	Type 10R
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	12 X 4” Conduits (unknown owner)

Major Inspection Findings

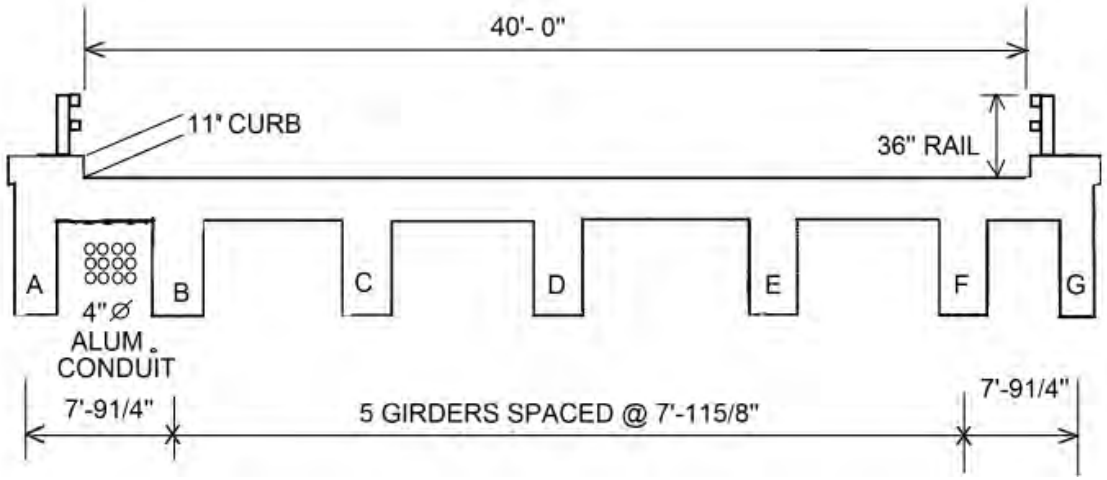
Structure has experienced multiple vehicular impacts resulting in damaged girders and exposed primary reinforcing. Cracking, efflorescence, and spalled concrete with exposed rebar present throughout concrete deck.

Rehabilitations/Widenings

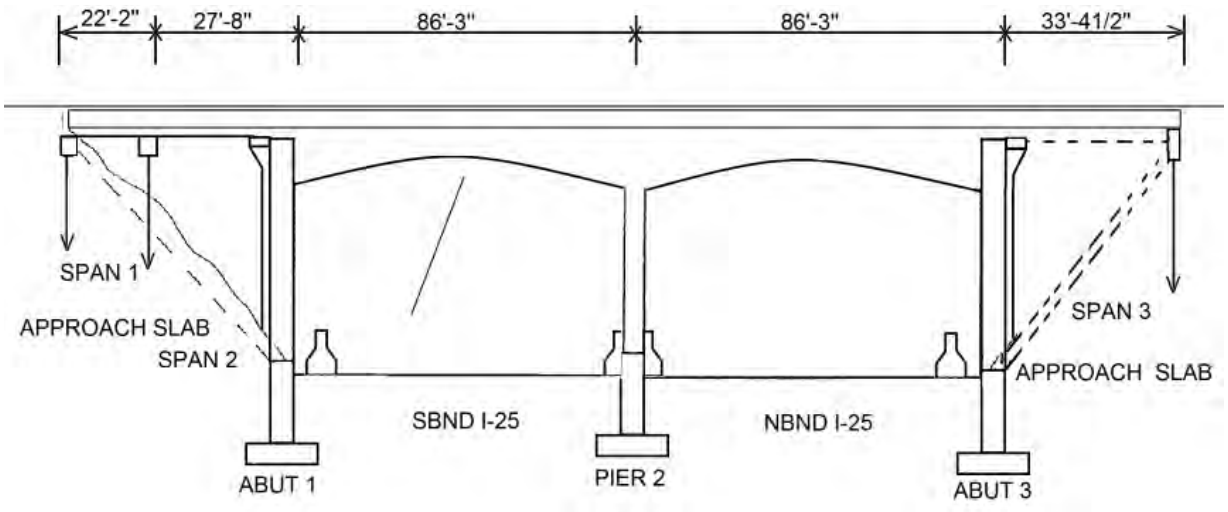
Bridge rail was replaced in 2008. Some concrete has been patched where vehicular impact damage occurred.

Additional Notes

None.



Section - E-16-EW



Elevation - E-16-EW

15th St over I-25

Structure Number: E-16-YA **I-25 Milepost: 211.67**

Key Bridge Data	
Year Built	2011
Structure Type	Continuous Steel Plate Girders
Spans	2
Length	239’
Width (out-to-out)	67’
Area of Deck	16,010 SF
Curb-to-Curb Width	45’-6”
Median	N/A
Sidewalks	10’-0” (WB side) 8’-0” (EB side)
Vert. Clearance over I-25	17’-0”
Sufficiency Rating	76%
Deck Condition	8 out of 9
Superstructure Condition	8 out of 9
Substructure Condition	8 out of 9
Load Capacity	39.6 Tons (LRFR Inventory)
Bridge Rail Type	Type 10M (Special)
Bridge Rail Height	2’-11” (meets current standard)
Utilities Carried	4 X 8” Xcel conduits 4 X 4” Comcast conduits 8 X 4” Qwest conduits

Major Inspection Findings

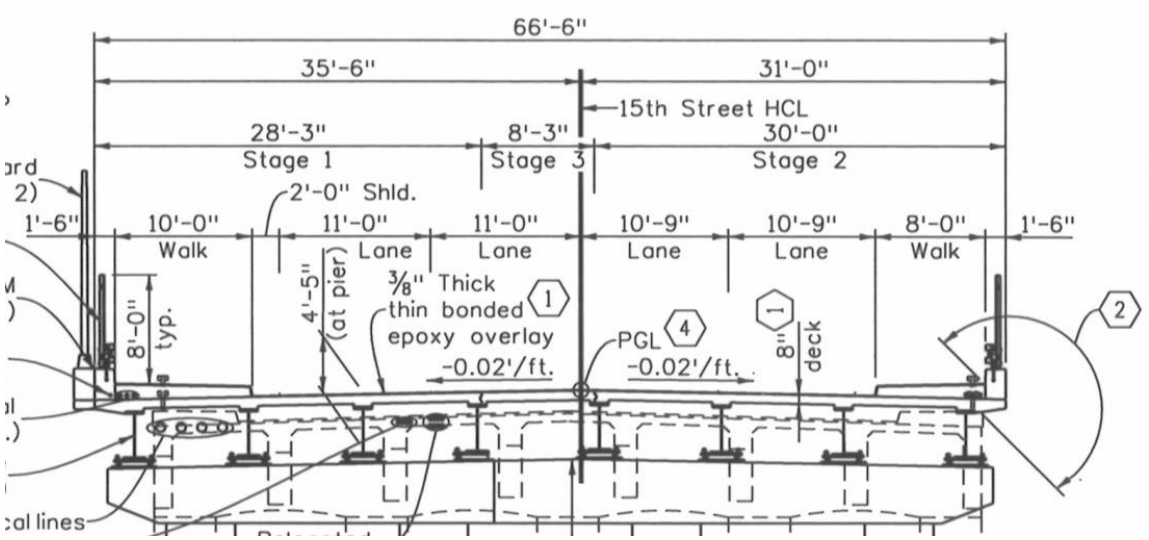
No major findings.

Rehabilitations/Widenings

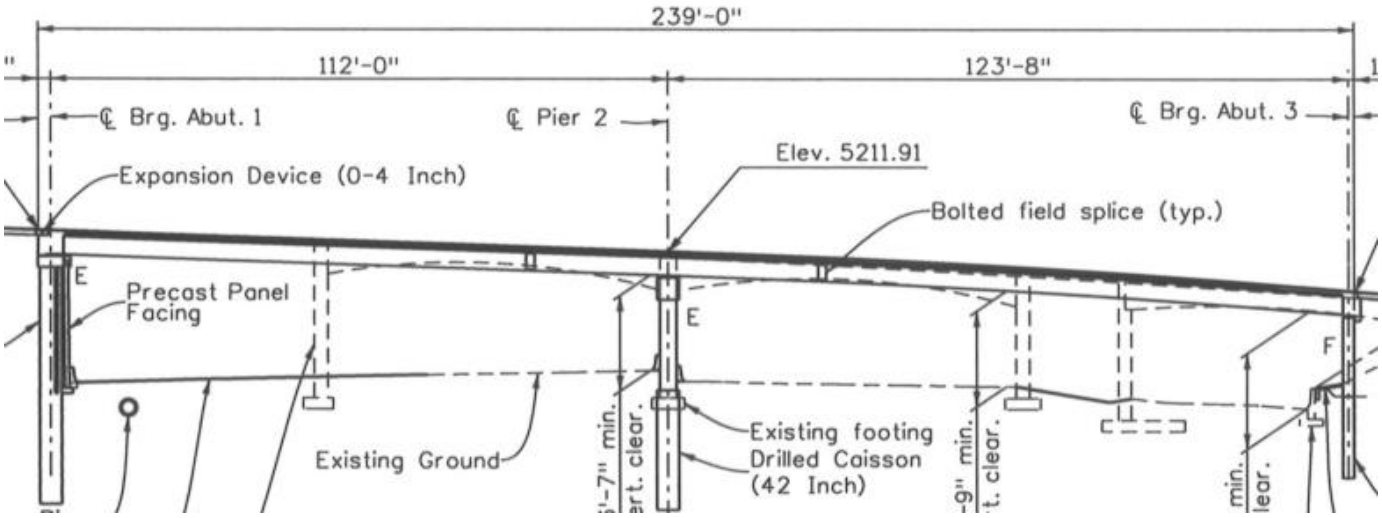
No rehabilitations nor widenings.

Additional Notes

None.



Section - E-16-YA



Elevation - E-16-YA

Highland Pedestrian Bridge over I-25

Structure Number: E-16-WB **I-25 Milepost: 211.72**

Key Bridge Data	
Year Built	2005
Structure Type	Steel Arch
Spans	2
Length	234’
Width (out-to-out)	10’
Area of Deck	2,340 SF
Curb-to-Curb Width	10’-0”
Median	N/A
Sidewalks	10’-0”
Vert. Clearance over I-25	18’-1”
Sufficiency Rating	N/A
Deck Condition	8 out of 9
Superstructure Condition	8 out of 9
Substructure Condition	8 out of 9
Load Capacity	No Rating
Bridge Rail Type	N/A
Bridge Rail Height	N/A
Utilities Carried	N/A

Major Inspection Findings

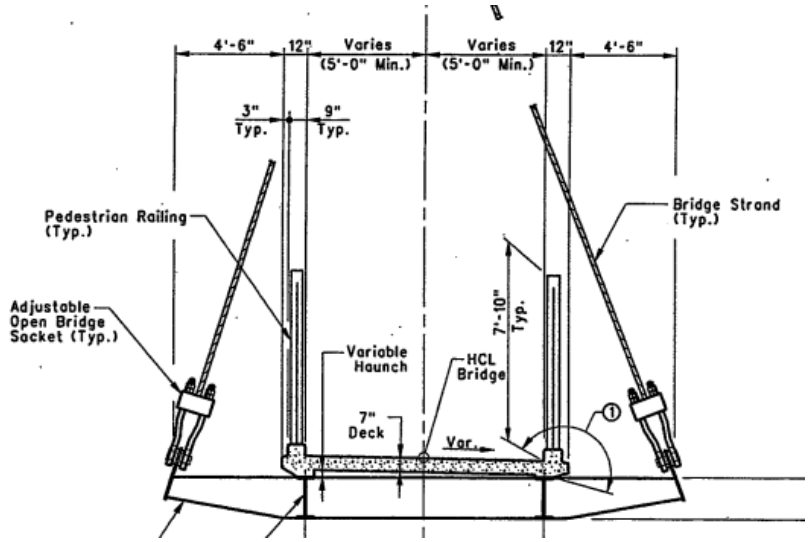
No major findings.

Rehabilitations/Widenings

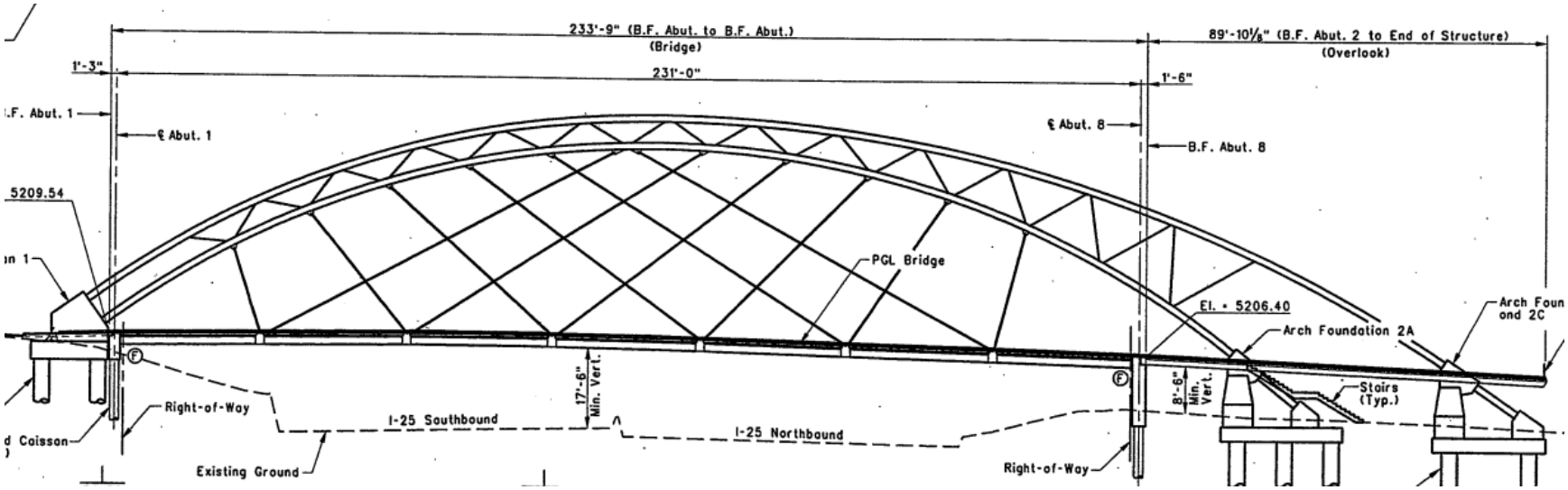
No rehabilitations nor widenings.

Additional Notes

None.



Section - E-16-WB



Elevation - E-16-WB

20th St over I-25

Structure Number: E-16-OO **I-25 Milepost: 212.10**

Key Bridge Data	
Year Built	1994
Structure Type	Continuous Steel Box Girders
Spans	2
Length	281’
Width (out-to-out)	83’
Area of Deck	23,320 SF
Curb-to-Curb Width	58’-0”
Median	N/A
Sidewalks	6’-6” (WB side) 13’-6” (EB side)
Vert. Clearance over I-25	17’-4”
Sufficiency Rating	94%
Deck Condition	6 out of 9
Superstructure Condition	6 out of 9
Substructure Condition	7 out of 9
Load Capacity	47.1 Tons (LFR Inventory)
Bridge Rail Type	Type 8 (Special)
Bridge Rail Height	3’-6” (meets current standard)
Utilities Carried	Telephone Conduit

Major Inspection Findings

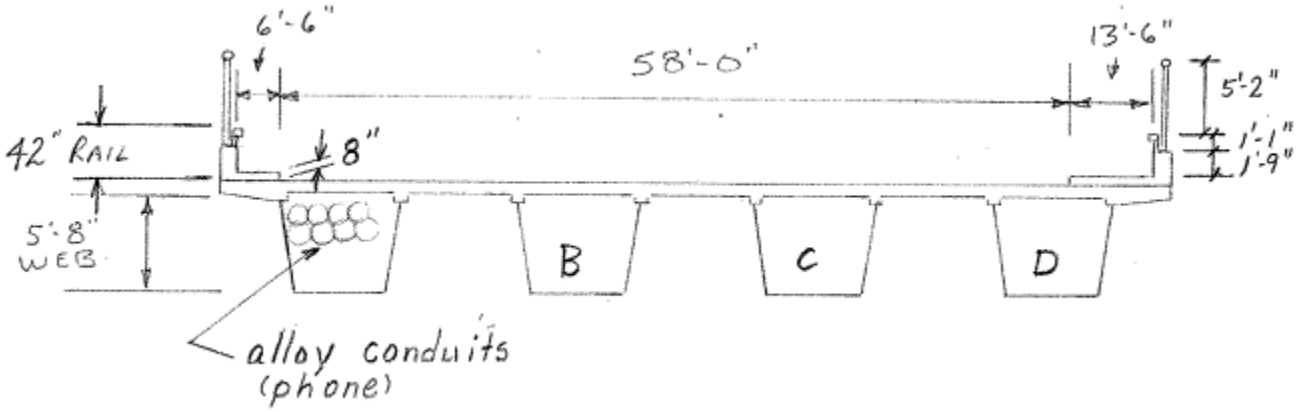
No major findings.

Rehabilitations/Widenings

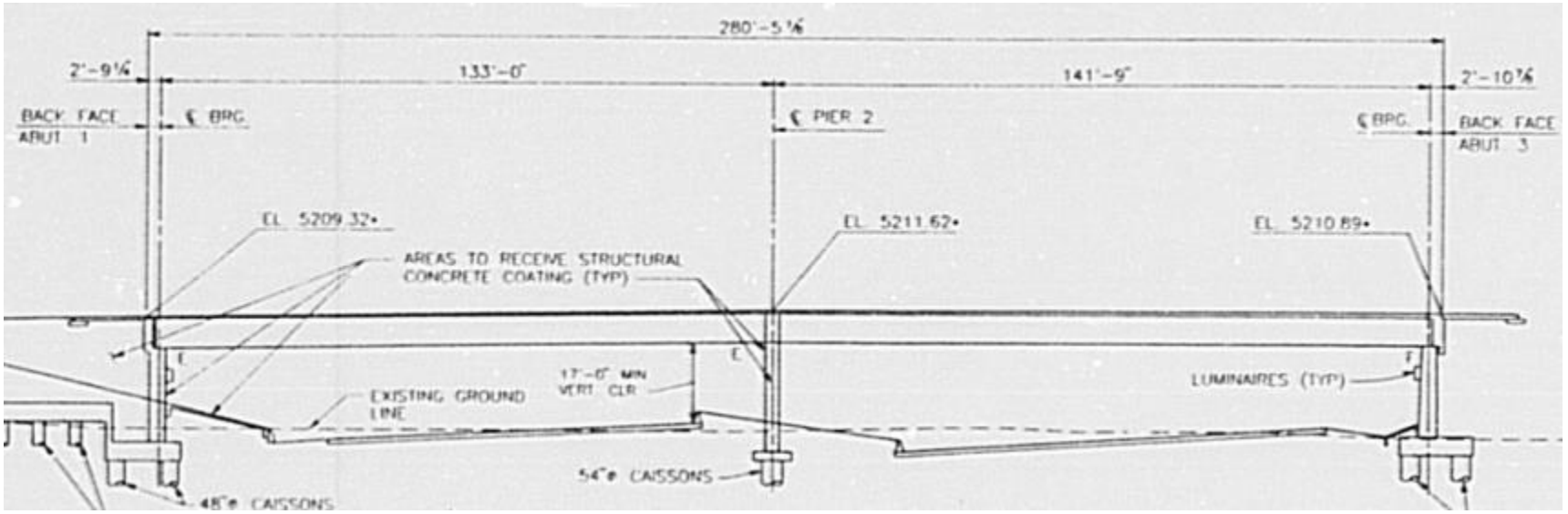
No rehabilitations nor widenings.

Additional Notes

None.



Section - E-16-00



Elevation - E-16-00

Drainage & Water Quality

July 6, 2018

1. Resource Description

Drainage and water quality resources include consideration of surface water, groundwater, climate, topography, geology, land use, and beneficial uses as defined by the Water Quality Control Commission (WQCC). Because these components are complex and interrelated, their assessment is best accomplished by evaluation on a watershed scale.

Transportation projects can impact drainage and water quality resources during construction and maintenance/operation phases of projects.

2. Potential Stakeholder and Agency Involvement

- Colorado Department of Transportation (CDOT)
- Federal Highway Administration (FHWA)
- Colorado Department of Public Health and Environment (CDPHE)
- U.S. Environmental Protection Agency (USEPA)
- Urban Drainage and Flood Control District (UDFCD)
- City and County of Denver (CCD)

3. Applicable Laws, Regulations, and Guidance

Regulation 31: The Basin Standards and Methodologies for Surface Water, CDPHE, Effective 3/1/17

Regulation 38: Classification and Numeric Standards for South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin, CDPHE, Effective 6/30/17

Regulation 41: The Basic Standards for Ground Water, CDPHE, Effective 12/30/16

Regulation 61: Colorado Discharge Permit System Regulation, CDPHE, Effective 4/30/17

Regulation 65: Regulations Controlling Discharges to Storm Sewer, CDPHE, Effective 5/30/08

Regulation 93: Colorado's Section 303(d) List of Impaired Waters and Monitoring and Evaluation List, Effective 11/30/16

Clean Water Act (401, 402)

Safe Drinking Water Act (40 CFR Parts 141-143)

Erosion and Sediment Control on Highway Construction Projects (25 CFR 650 Subpart B)

Colorado Water Quality Control Act (Colorado Revised Statues [CRS] Title 25, Article 8)

Colorado Senate Bill 15-212: Concerning a determination that water detention facilities design to mitigate the adverse effects of stormwater runoff do not materially injure water rights.

CDOT Drainage Design Manual

CDOT Municipal Separate Storm Sewer System (MS4) Permit

CDOT Erosion Control and Stormwater Quality Guide

FHWA Roadside Design Guidelines

Denver Storm Drainage Design and Technical Criteria Manual

UDFCD Urban Storm Drainage Criteria manual

4. Methodology for Resource Review

The CCD Master Plan was used to identify major offsite drainage flowing toward and across I-25 within the study area. These documents provide watershed delineations, characteristics, peak flows, and potential future projects.

The CDPHE website[1] includes a web viewer that provides Colorado Stream Segmentation. This map viewer identifies the South Platte River within the study area with a Water Body ID of COSPUS_14 and Assessment Unit ID COSPUS_14A.

[1] (http://cdphe.maps.arcgis.com/home/webmap/viewer.html?webmap=09478d4370d54c488530c5afff9ceed0

The USEPA website[2] provides information reported by Colorado about the conditions in surface waters. Colorado reports this information every two years in compliance with the Clean Water Act Section 305(b) and 303(d). This site also reports The Assessment and Total Maximum Daily Load (TMDL) Tracking and Implementation System (ATTAINS) and provides current status for impairments.

The United States Geological Survey (USGS) website[3] includes a web viewer that provides additional surface water and groundwater data. Sites include field groundwater level measurements and some sites include field/lab water quality samples.

Due to the nature of the study and potential additional investigations, resource agencies have not been contacted and site visits have not been performed.

5. Resource Findings

Offsite basins flow toward and across I-25 on their way to the South Platte River. Major offsite basins have been identified in the CCD Storm Drainage Master Plan. Four basins have been identified within the study area that include offsite flows directed toward or across I-25. Existing cross drains and storm drain systems convey these offsite flows through I-25 to the South Platte River. These CCD Basins include 5000-01, 0063-01, 0061-01, and 0061-02.

Surface water resources within the PEL Study area include segment COSPUS-14a of the South Platte River. This segment has a status of good for agriculture and aquatic life support. The status is impaired for recreation and water supply. The causes of impairment include arsenic, Escherichia Coli (E. Coli), and Nitrate. Arsenic is listed as a pollutant of concern for CDOT's permanent water quality program.

Table 1. Segment Impairment

Stream Segment	Use Group	Status	Cause of Impairment
COSPUS-14a	Agricultural	Good	Na
	Aquatic Life Support	Good	Na
	Recreation	Impaired	E. Coli
	Water Supply	Impaired	Arsenic, Nitrate

Groundwater resources within the PEL Study area include the Denver formation with shallow and deep water aquifers. Reported groundwater depths vary between 0.7 ft to 20 ft below ground. Shallow aquifers can be contaminated by urban and industrial sources. However, detailed reviews of available groundwater samples have not been conducted.

[2] https://ofmpub.epa.gov/tmdl_waters10/attains_index.home

[3] https://maps.waterdata.usgs.gov/mapper/index.html

CDOT drainage infrastructure has been identified within the study area. Major cross drains (greater than and equal to 48-inch diameter) are listed below and shown on Figure 1. Additional storm drains and cross drains are located within the study area but have not been reviewed due to their limited size and capacity. Sizes are provided in the Denver Storm Drainage Master Plan and provide diameter of crossing (in inches) or dimensions of box culverts and elliptical pipe (span/rise) in inches.

Table 2. Existing Major Drainage Infrastructure

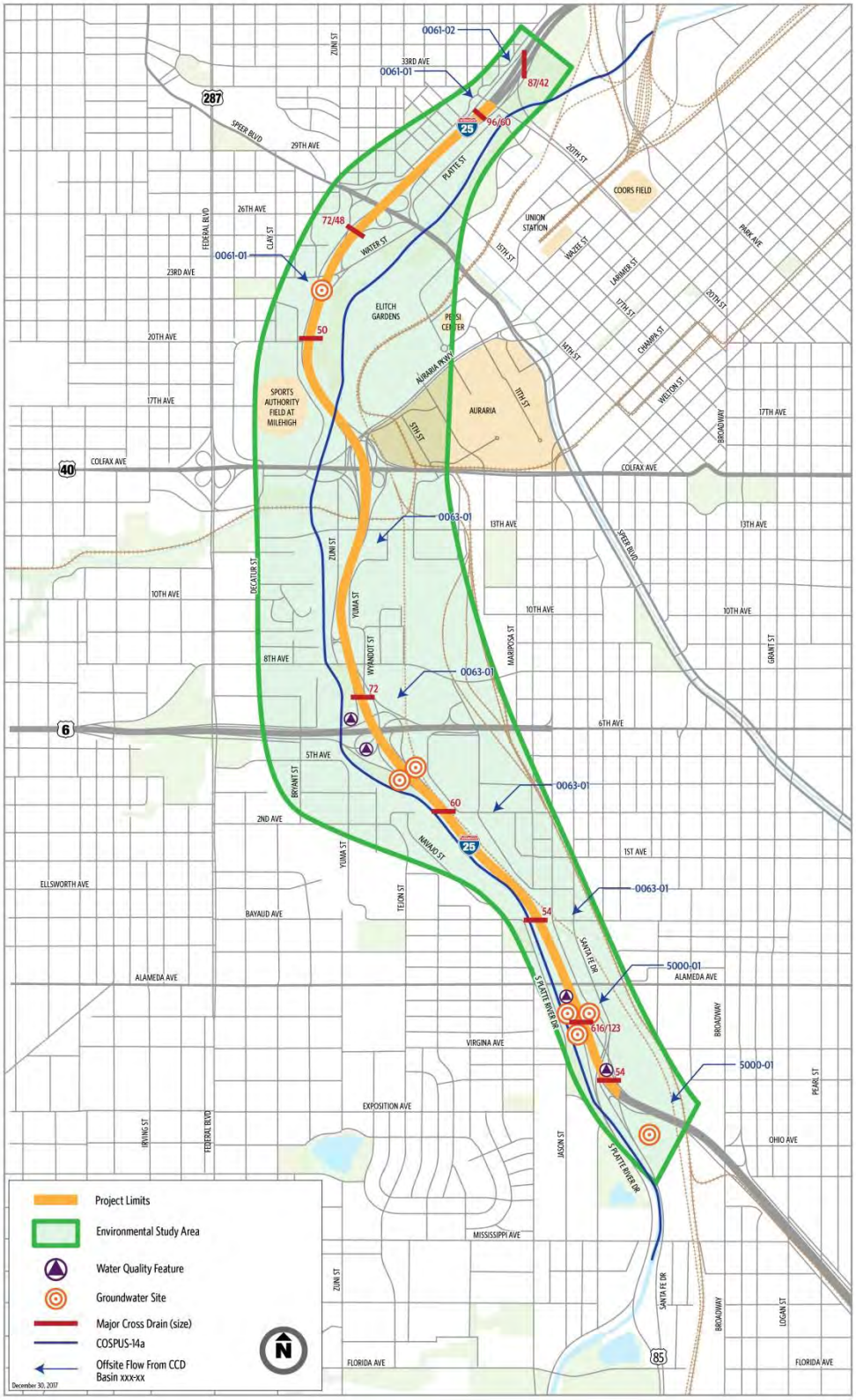
Cross Drain Location (Mile Post)	Approximate Cross Street	Size	Direction of Flow
207.4	E Center Ave	54-inch	East to West
207.7	E Dakota Ave	616/123-inch	East to West
208.2	W Bayaud Ave	54-inch	East to West
208.8	W 23rd Ave	60-inch	East to West
209.3	W 7th Ave	72-inch	East to West
210.8	W 20th St	50-inch	West to East
211.2	N Zuni St	72/48-inch	North to South
212.0	20th St	96/60-inch	Northwest to Southeast
212.2	N Lipan St	87/42	North to South

Existing CDOT water quality features have also been identified within the study area. These include extended detention pond (EDP) constructed with previous I-25 projects. Locations are listed below and shown on Figure 1.

Table 3. Existing Major Water Quality Infrastructure

Water Quality Location (Mile Post)	Approximate Cross Street	Control Measure
207.4	S Santa Fe Dr	EDP
207.8	E Dakota Ave	Lined holding pond
207.9	E Nevada Ave	EDP
209.1	6th Ave	EDP
209.2	6th Ave	EDP
211.4	N Speer Blvd	EDP
211.5	N Speer Blvd	EDP
212.0	20th Street	PWQ Vault

Figure 1: Environmental Study Area Map



6. NEPA Pre-scoping Considerations

Project alternatives should be reviewed to identify possible impacts to surface water, groundwater, and water quality. Mitigation measures for each should be reviewed and documented. Permitting requirements for potential project activities should be identified.

It is anticipated that the requirements of the CDOT MS4 permit will be applied throughout the study area; however, requirements of the CCD MS4 Permit may apply if project improvements extend outside of the CDOT right-of-way.

7. Critical Schedule Considerations

Drainage resources, including major cross drains, may require early coordination with local agencies to accommodate offsite flows crossing I-25. Master planning, design, funding, and construction of these major cross drains, outfall system plans, and capital improvement projects can take several years for the local agencies.

Water quality and groundwater resources do not include critical scheduled considerations.

8. Next Steps

To minimize impacts to drainage resources, CCD Capital Improvement Project status and UDFCD Outfall System Plans should be confirmed. Locations and expected capacity of major cross drains should be coordinated with CCD and UDFCD to minimize future construction impacts to I-25 from local agency drainage projects.

To minimize impacts to water quality resources, current design criteria and MS4 permit requirements should be confirmed. Opportunities for additional water quality features will be investigated during the design phase. Alternatives should be evaluated to determine impacts on the resource and mitigation commitments should be established. Alternatives should also be evaluated to determine potential impacts to shallow groundwater to identify the need for dewatering and to identify existing groundwater characteristics.

9. References

Waterbody Quality Assessment Report, 2016 Waterbody Report for COSPUS14_A. EPA

CDOT Permanent Water Quality Program Manual, 03/01/2017

CCD Storm Drainage Master Plan, September 2014

CDPHE Colorado Stream Segmentation, Map Viewer
http://cdphe.maps.arcgis.com/home/webmap/viewer.html?webmap=09478d4370d54c488530c5afff9ceed0

USGS National Water Information System Mapper;
https://maps.waterdata.usgs.gov/mapper/index.html

Appendix A

2016 Waterbody Quality Assessment Report

I-25 Central PEL

TECHNICAL MEMORANDUM

Roadway Geometrics Technical Memorandum

July 5, 2018

1. Introduction

The Interstate 25 (I-25) Central Planning and Environmental Linkages (PEL) Study includes approximately four and one-half miles of highway and nine interchanges through one of the most congested segments of interstate in Colorado. Many factors contribute to this congestion, including traffic volumes, vehicle mix (high truck percentage), and deficient roadway geometrics. Roadway geometrics include design elements such as horizontal alignment, vertical alignment, stopping sight distance, ramp spacing, etc. Deficient elements within the corridor can cause traffic operation and safety issues. An evaluation of the existing I-25 mainline and ramp conditions within the project limits has been performed and is documented in this technical memorandum.

Figure 1 through Figure 5 summarize all known roadway geometric deficiencies for the project. Deficiencies were identified using design criteria developed from industry standards, which are provided in the Design Criteria Tables, **Table 1 through Table 10**. All deficiencies have been highlighted in red. Subsequent subsections of this document discuss individual design elements (i.e., horizontal and vertical alignments, stopping sight distance, etc.), providing detail on existing conditions and any identified deficiencies.

Figure 1. I-25 Existing Geometric Deficiencies (20th Street to Santa Fe Drive)

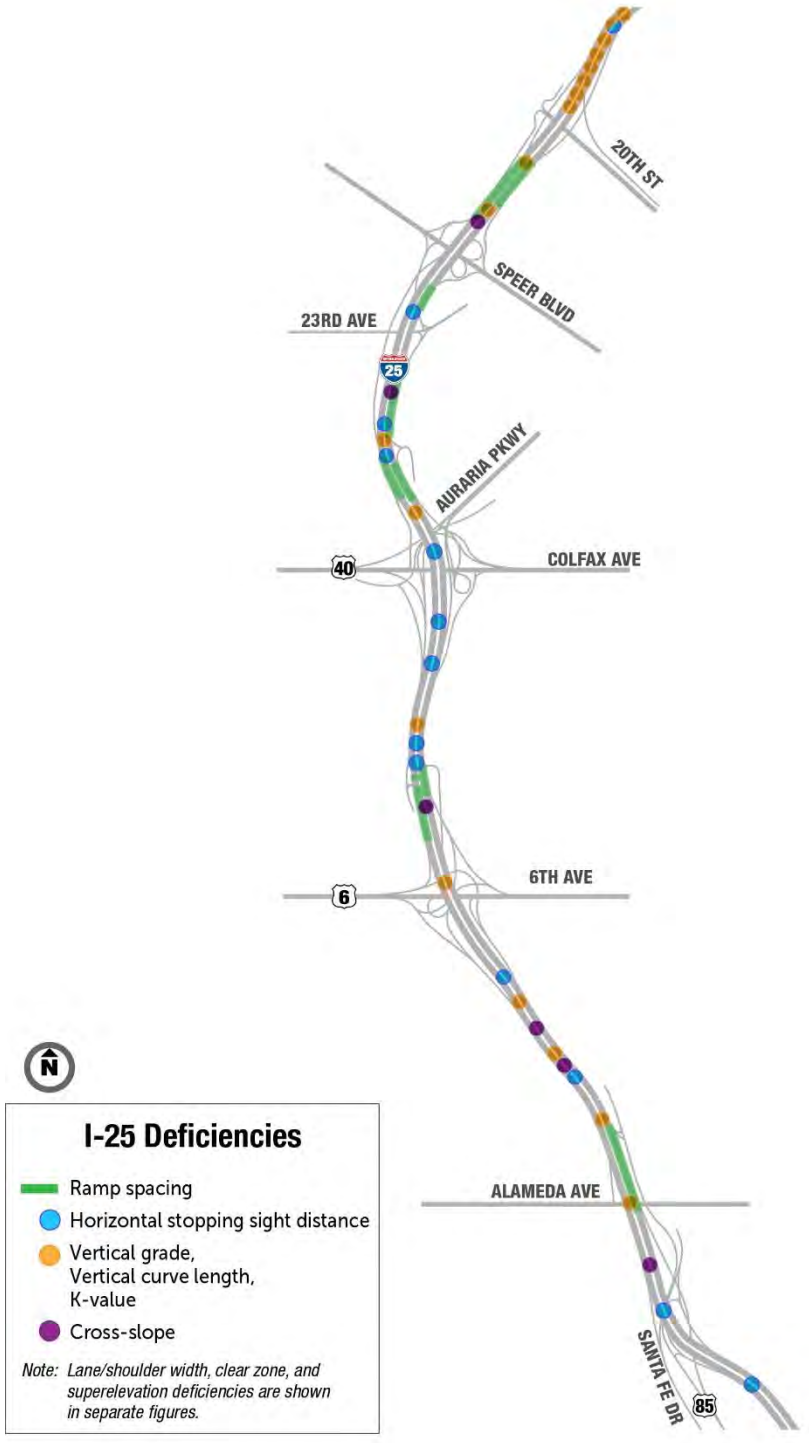


Figure 2. Ramp Existing Geometric Deficiencies (20th Street to Santa Fe Drive)

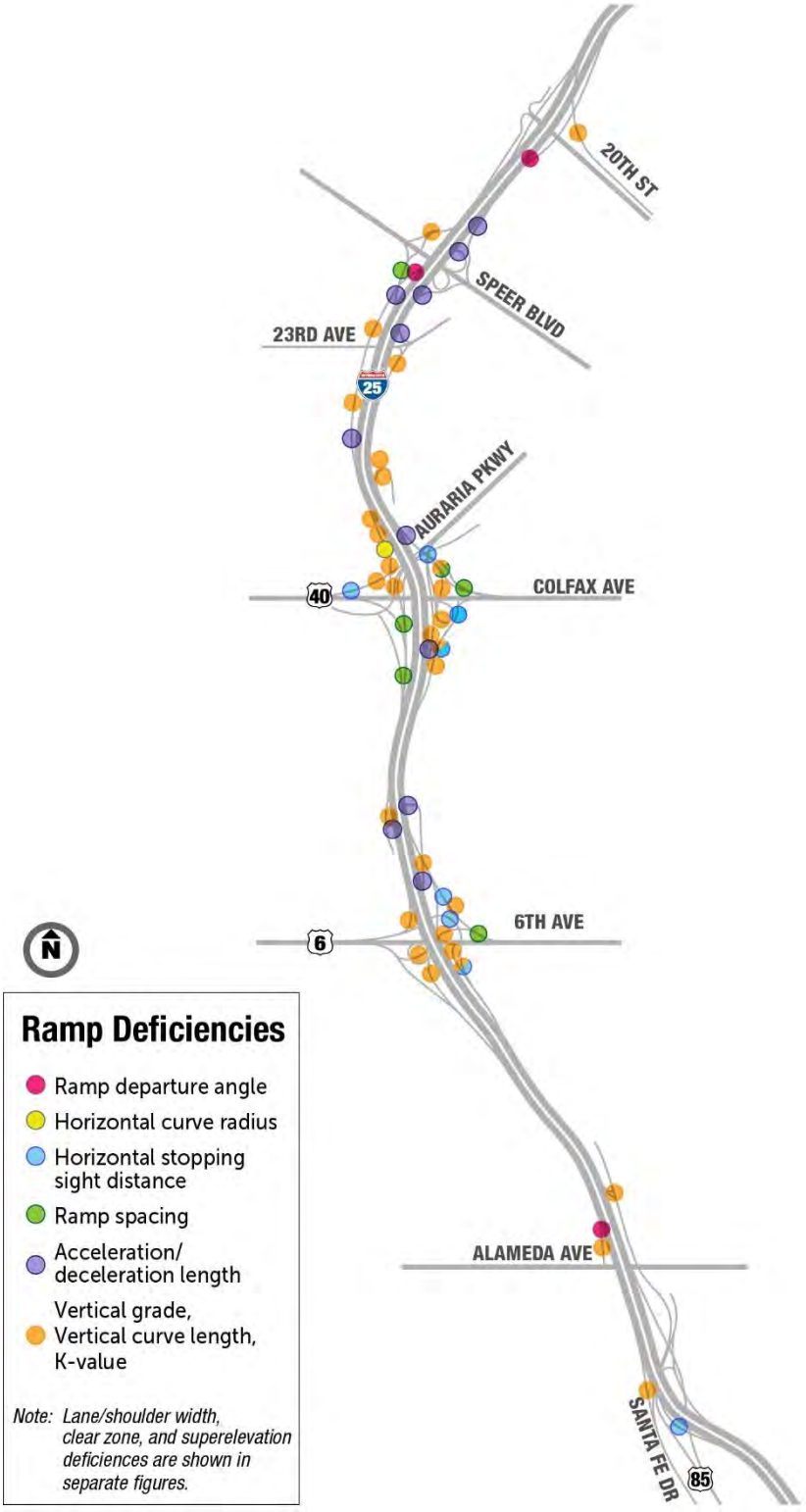


Figure 3. Existing Lane and Shoulder Width Deficiencies (20th Street to Santa Fe Drive)

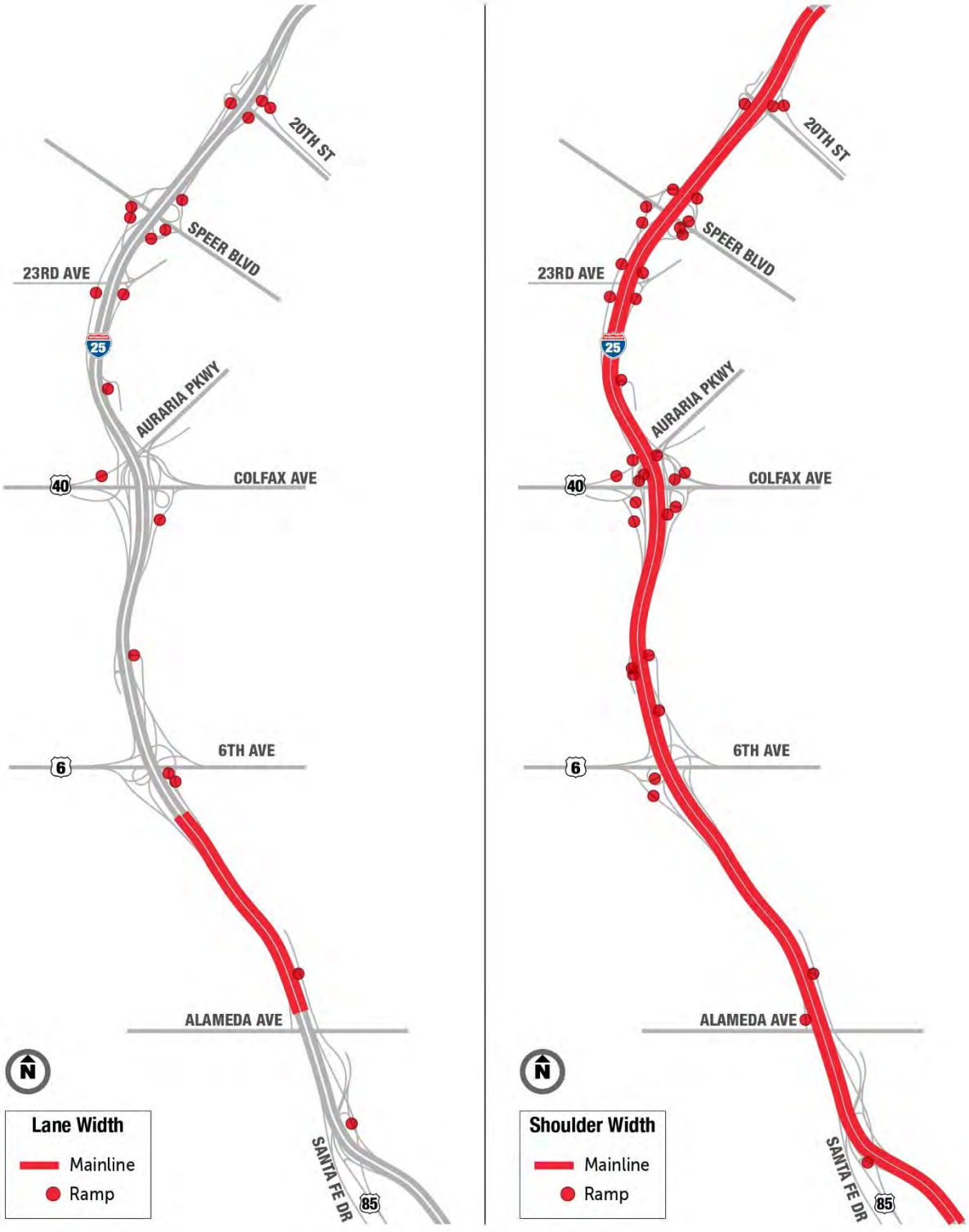


Figure 4. Existing Clear Zone Deficiencies (20th Street to Santa Fe Drive)

Figure 5. Existing Superelevation Deficiencies (20th Street to Santa Fe Drive)

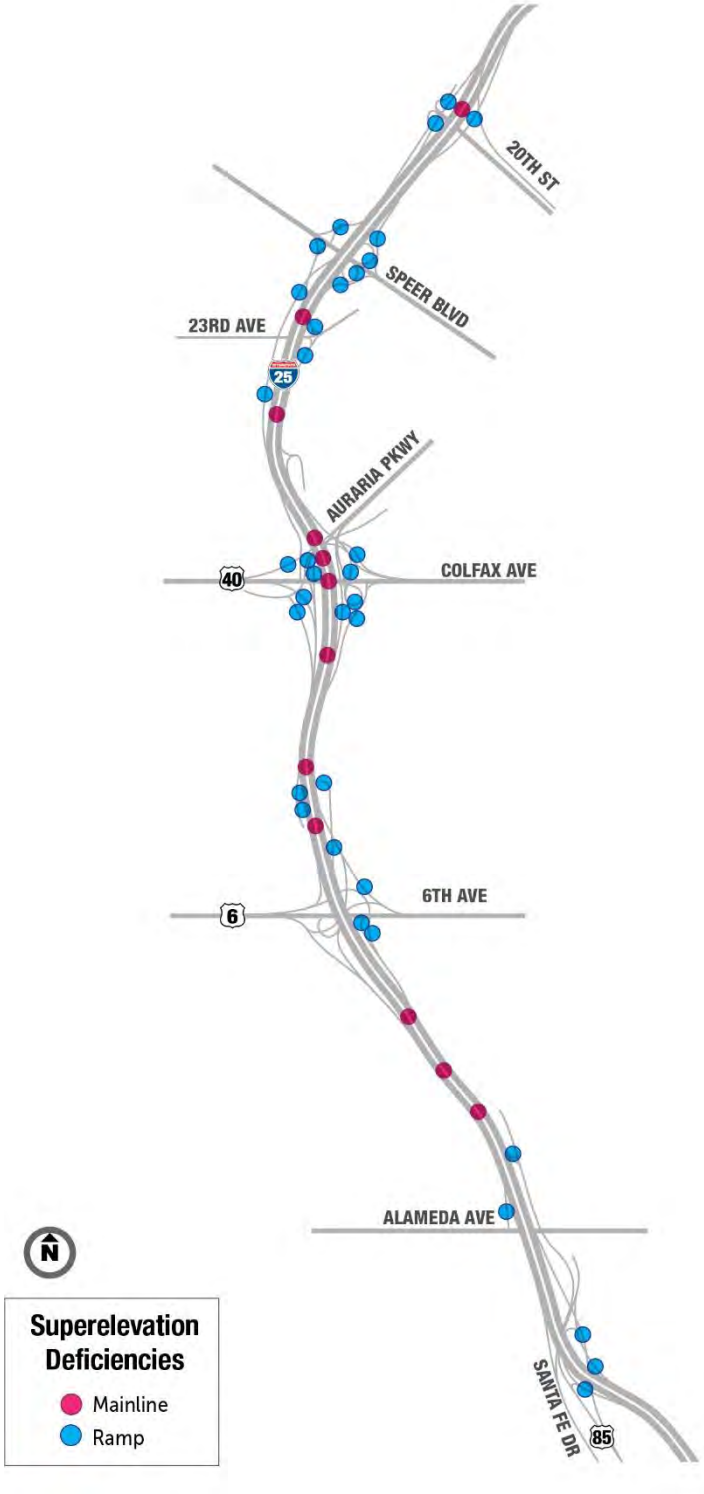


Table 1. Design Criteria Table — I-25 Mainline

= Deficient Existing Element

Design Element	Location	Design Criteria Reference
	I-25 Mainline	
Roadway Classification	Interstate	CDOT 2005, 1.1, pg. 1-2
Access Control Classification	Interstate (Full)	
Posted Speed Limit (Miles per hour) (MPH)	55	
Ramp Spacing on Mainline	Per figure specified in the Design Criteria Reference	PGDHS 2011, 10.9.6, Fig. 10-68, pg. 10-106
Horizontal Curve Radius (Feet)—Minimum	1,060	PGDHS 2011, 3.3.5, Table 3-9, pg. 3-45
Horizontal Curve Length (Feet)—Minimum	825	PGDHS 2011, 3.3.13, pg. 3-111
Horizontal Stopping Sight Distance (Feet)	495	PGDHS 2011, 3.2.2, Table 3-1, pg. 3-4; PGDHS 2011, 3.3.12, Fig. 3-22b, pg. 3-108
Cross Slope	2%	PDSIS 2005, pg. 4
Superelevation (e_{max})	6%	PGDHS 2011, 3.3.5, Table 3-9, pg. 3-45
Clear Zone (Feet)—Minimum	22	RDG 2011, Table 3-1, pg. 3-3
Lane Widths (Feet)	12	PDSIS 2005, pg. 3
Shoulder Widths		
Left Inside (Feet)	12	PDSIS 2005, pg. 3
Right Outside (Feet)	12	PDSIS 2005, pg. 3
Length of Vertical Curves (Feet)—Minimum		
Crest Vertical Curve	165	PGDHS 2011, 3.4.6, pg. 3-153
Sag Vertical Curve	165	PGDHS 2011, 3.4.6, pg. 3-161
K-Values		
Crest Vertical Curve	114	PGDHS 2011, 3.4.6, Table 3-34, pg. 3-155
Sag Vertical Curve	115	PGDHS 2011, 3.4.6, Table 3-36, pg. 3-161
Grade		
Maximum	4%	PDSIS 2005, pg. 3
Minimum	0.5%	PGDHS 2011, 3.4.2, pg. 3-119

CDOT 2005 = Colorado Department of Transportation Roadway Design Guide; PGDHS 2011 = A Policy on Geometric Design of Highways and Streets; PDSIS 2005 = A Policy on Design Standards Interstate System; RDG 2011 = Roadside Design Guide

Table 2. Design Criteria Table — US 85/Santa Fe Drive Ramps

= Deficient Existing Element

Design Element	Location				Design Criteria Reference
	SB I-25 to SB US 85/Santa Fe Dr	US 85/Santa Fe Dr to SB I-25	NB I-25 to US 85/Santa Fe Dr	NB US 85/Santa Fe Dr to NB I-25	
General					
Roadway Classification	Ramp	Ramp	Ramp	Ramp	
Recommended Design Speed (MPH) (Ramp Proper)	45 (Posted)	*50/35 (Posted)	25 (Posted)	35	
Horizontal Alignment Criteria					
Curve Radius (Feet)—Minimum	643	833/340	144	340	PGDHS 2011, 3.3.5, Table 3-9, pg. 3-45
Stopping Sigh Distance (Feet)—At level grade	360	425/250	155	250	PGDHS 2011, 3.2.2, Table 3-1, pg. 3-4; PGDHS 2011, 3.3.12, Fig. 3-22b, pg. 3-108
Minimum Acceleration Length (Feet)	N/A	600/ N/A	N/A	504	PGDHS 2011, 10.9.6, Table 10-3, pg. 10-110, Use grade adjustment factors if necessary.
Minimum Deceleration Length (Feet)	212	N/A	492	N/A	PGDHS 2011, 10.9.6, Table 10-5, pg. 10-115, Use grade adjustment factors if necessary.
Cross Slope	2%	2%	2%	2%	PGDHS 2011, 10.9.6, pg. 10-93
Superelevation (e max)	6%	6%	6%	6%	PGDHS 2011, 3.3.3, pg. 3-31
Clear Zone (Feet)—Minimum	20	16/12	14	14	RDG 2011, 3.1, Table 3-1 pg. 3-3
Lane Widths (Feet)	12	12	15	12	PGDHS 2011, 10.9.6, pg. 10-102
Shoulder Widths					
Left Inside (Feet)	4	4	4	4	PGDHS 2011, 10.9.6, pg. 10-102
Right Outside (Feet)	8	6	6	6	PGDHS 2011, 10.9.6, pg. 10-102
Ramp Departure Angle (degrees)	2 to 5	N/A	2 to 5	2 to 5	CDOT 2005, 10.7.8, Fig. 10-15, pg. 10-51
Vertical Alignment Criteria					
Length of Vertical Curves (Feet)—Minimum					
Crest Vertical Curves	135	150/105	75	105	PGDHS 2011, 3.4.6, pg. 3-153
Sag Vertical Curves	135	150/105	75	105	PGDHS 2011, 3.4.6, pg. 3-161
K-Values (at Exit/Entrance)					
Crest Vertical Curve	61	84/29	12	29	PGDHS 2011, 3.4.6, Table 3-34, pg. 3-155
Sag Vertical Curve	79	96/49	26	49	PGDHS 2011, 3.4.6, Table 3-36, pg. 3-161
Grade					
Maximum	6%	6%	6%	6%	PGDHS 2011, 10.9.6, pg. 10-93
Minimum	0.5%	0.5%	0.5%	0.5%	CDOT 2005, 3.3.3, pg. 3-32

*US 85/Santa Fe Dr to SB I-25 is stop controlled at a signalized intersection; therefore, a recommended design speed was chosen for both directions from the stop location.
SB = southbound; NB = northbound
CDOT 2005 = Colorado Department of Transportation Roadway Design Guide; PGDHS 2011 = A Policy on Geometric Design of Highways and Streets; RDG 2011 = Roadside Design Guide

Table 3. Design Criteria Table — Alameda Avenue Ramps

= Deficient Existing Element

Design Element	Location		Design Criteria Reference
	Kalamath/Cedar to NB I-25	SB I-25 to Alameda	
General			
Roadway Classification	Ramp	Ramp	
Recommended Design Speed (MPH) (Ramp Proper)	20	45 (Posted)	
Horizontal Alignment Criteria			
Curve Radius (Feet)—Minimum	81	643	PGDHS 2011, 3.3.5, Table 3-9, pg. 3-45
Stopping Sigh Distance (Feet)—At level grade	115	360	PGDHS 2011, 3.2.2, Table 3-1, pg. 3-4; PGDHS 2011, 3.3.12, Fig. 3-22b, pg. 3-108
Minimum Acceleration Length (Feet)	601	N/A	PGDHS 2011, 10.9.6, Table 10-3, pg. 10-110, Use grade adjustment factors if necessary.
Minimum Deceleration Length (Feet)	N/A	397	PGDHS 2011, 10.9.6, Table 10-5, pg. 10-115, Use grade adjustment factors if necessary.
Cross Slope	2%	2%	PGDHS 2011, 10.9.6, pg. 10-93
Superelevation (e max)	6%	6%	PGDHS 2011, 3.3.3, pg. 3-31
Clear Zone (Feet)—Minimum	14	20	RDG 2011, 3.1, Table 3-1 pg. 3-3
Lane Widths (Feet)	15	15	PGDHS 2011, 10.9.6, pg. 10-102
Shoulder Widths			
Left Inside (Feet)	4	4	PGDHS 2011, 10.9.6, pg. 10-102
Right Outside (Feet)	6	6	PGDHS 2011, 10.9.6, pg. 10-102
Ramp Departure Angle (degrees)	N/A	2 to 5	CDOT 2005, 10.7.8, Fig. 10-15, pg. 10-51
Vertical Alignment Criteria			
Length of Vertical Curves (Feet)—Minimum			
Crest Vertical Curves	60	135	PGDHS 2011, 3.4.6, pg. 3-153
Sag Vertical Curves	60	135	PGDHS 2011, 3.4.6, pg. 3-161
K-Values (at Exit/Entrance)			
Crest Vertical Curve	7	61	PGDHS 2011, 3.4.6, Table 3-34, pg. 3-155
Sag Vertical Curve	17	79	PGDHS 2011, 3.4.6, Table 3-36, pg. 3-161
Grade			
Maximum	6%	6%	PGDHS 2011, 10.9.6, pg. 10-93
Minimum	0.5%	0.5%	CDOT 2005, 3.3.3, pg. 3-32

CDOT 2005 = Colorado Department of Transportation Roadway Design Guide; PGDHS 2011 = A Policy on Geometric Design of Highways and Streets; RDG 2011 = Roadside Design Guide

Table 4. Design Criteria Table — US 6 Ramps

= Deficient Existing Element

Design Element	Location								Design Criteria Reference
	SB I-25 to WB US 6	EB US 6 to NB I-25	EB US 6 to SB I-25	SB I-25 to EB US 6	WB US 6 to SB I-25	NB I-25 to EB US 6	NB I-25 to WB US 6	WB US 6 to NB I-25	
General									
Roadway Classification	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	
Recommended Design Speed (MPH) (Ramp Proper)	25 (Posted)	35	25	25 (Posted)	35	*35 (Posted)/ 25 (Posted)	35 (Posted)	40	
Horizontal Alignment Criteria									
Curve Radius (Feet)—Minimum	144	340	144	144	340	340/144	340	485	PGDHS 2011, 3.3.5, Table 3-9, pg. 3-45
Stopping Sigh Distance (Feet)—At level grade	155	250	155	155	250	250/155	250	305	PGDHS 2011, 3.2.2, Table 3-1, pg. 3-4; PGDHS 2011, 3.3.12, Fig. 3-22b, pg. 3-108
Minimum Acceleration Length (Feet)—At level grade	N/A	960	600	N/A	N/A	N/A	N/A	N/A	PGDHS 2011, 10.9.6, Table 10-3, pg. 10-110, Use grade adjustment factors if necessary.
Minimum Deceleration Length (Feet)—At level grade	410	N/A	N/A	410	N/A	315/250	N/A	N/A	PGDHS 2011, 10.9.6, Table 10-5, pg. 10-115, Use grade adjustment factors if necessary.
Cross Slope	2%	2%	2%	2%	2%	2%	2%	2%	PGDHS 2011, 10.9.6, pg. 10-93
Superelevation (e max)	6%	6%	6%	6%	6%	6%	6%	6%	PGDHS 2011, 3.3.3, pg. 3-31
Clear Zone (Feet)—Minimum	14	14	14	14	12	12	14	12	RDG 2011, 3.1, Table 3-1 pg. 3-3
Lane Widths (Feet)	12	12	12	15	15	15	15	15	PGDHS 2011, 10.9.6, pg. 10-102
Shoulder Widths									
Left Inside (Feet)	4	4	4	4	4	4	4	4	PGDHS 2011, 10.9.6, pg. 10-102
Right Outside (Feet)	8	8	8	6	6	6	6	6	PGDHS 2011, 10.9.6, pg. 10-102
Ramp Departure Angle (degrees)	2 to 5	N/A	N/A	N/A	N/A	2 to 5	N/A	N/A	CDOT 2005, 10.7.8, Fig. 10-15, pg. 10-51
Vertical Alignment Criteria									
Length of Vertical Curves (Feet)—Minimum									
Crest Vertical Curves	75	105	75	75	105	105/75	105	120	PGDHS 2011, 3.4.6, pg. 3-153
Sag Vertical Curves	75	105	75	75	105	105/75	105	120	PGDHS 2011, 3.4.6, pg. 3-161
K-Values (at Exit/Entrance)									
Crest Vertical Curve	12	29	12	12	29	29/12	29	44	PGDHS 2011, 3.4.6, Table 3-34, pg. 3-155
Sag Vertical Curve	26	49	26	26	49	49/26	49	64	PGDHS 2011, 3.4.6, Table 3-36, pg. 3-161
Grade									
Maximum	6%	6%	6%	6%	6%	6%	6%	6%	PGDHS 2011, 10.9.6, pg. 10-93
Minimum	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	CDOT 2005, 3.3.3, pg. 3-32

*NB I-25 to EB US 6 has a speed drop within the ramp proper; therefore, two recommended design speeds are shown for this ramp.
WB = westbound; EB = eastbound
CDOT 2005 = Colorado Department of Transportation Roadway Design Guide; PGDHS 2011 = A Policy on Geometric Design of Highways and Streets; RDG 2011 = Roadside Design Guide

Table 5. Design Criteria Table — 8th Avenue Ramps

= Deficient Existing Element

Design Element	Location				Design Criteria Reference
	SB I-25 to Zuni St	Zuni St to SB I-25	NB I-25 to 8th Ave	8th Ave to NB I-25	
General					
Roadway Classification	Ramp	Ramp	Ramp	Ramp	
Recommended Design Speed (MPH) (Ramp Proper)	15 (Posted)	20	35 (Posted)	20	
Horizontal Alignment Criteria					
Curve Radius (Feet)—Minimum	39	81	340	81	PGDHS 2011, 3.3.5, Table 3-9, pg. 3-45
Stopping Sigh Distance (Feet)—At level grade	80	115	250	115	PGDHS 2011, 3.2.2, Table 3-1, pg. 3-4; PGDHS 2011, 3.3.12, Fig. 3-22b, pg. 3-108
Minimum Acceleration Length (Feet)	N/A	1392	N/A	960	PGDHS 2011, 10.9.6, Table 10-3, pg. 10-110, Use grade adjustment factors if necessary.
Minimum Deceleration Length (Feet)	455	N/A	350	N/A	PGDHS 2011, 10.9.6, Table 10-5, pg. 10-115, Use grade adjustment factors if necessary.
Cross Slope	2%	2%	2%	2%	PGDHS 2011, 10.9.6, pg. 10-93
Superelevation (e max)	6%	6%	6%	6%	PGDHS 2011, 3.3.3, pg. 3-31
Clear Zone (Feet)	14	12	12	12	RDG 2011, 3.1, Table 3-1 pg. 3-3
Lane Widths (Feet)	15	15	15	15	PGDHS 2011, 10.9.6, pg. 10-102
Shoulder Widths					
Left Inside (Feet)	4	4	4	4	PGDHS 2011, 10.9.6, pg. 10-102
Right Outside (Feet)	6	6	6	6	PGDHS 2011, 10.9.6, pg. 10-102
Ramp Departure Angle (degrees)	2 to 5	N/A	2 to 5	N/A	CDOT 2005, 10.7.8, Fig. 10-15, pg. 10-51
Vertical Alignment Criteria					
Length of Vertical Curves (Feet)—Minimum					
Crest Vertical Curves	45	60	105	60	PGDHS 2011, 3.4.6, pg. 3-153
Sag Vertical Curves	45	60	105	60	PGDHS 2011, 3.4.6, pg. 3-161
K-Values (at Exit/Entrance)					
Crest Vertical Curve	3	7	29	7	PGDHS 2011, 3.4.6, Table 3-34, pg. 3-155
Sag Vertical Curve	10	17	49	17	PGDHS 2011, 3.4.6, Table 3-36, pg. 3-161
Grade					
Maximum	6%	6%	6%	6%	PGDHS 2011, 10.9.6, pg. 10-93
Minimum	0.5%	0.5%	0.5%	0.5%	CDOT 2005, 3.3.3, pg. 3-32

CDOT 2005 = Colorado Department of Transportation Roadway Design Guide; PGDHS 2011 = A Policy on Geometric Design of Highways and Streets; RDG 2011 = Roadside Design Guide

Table 6. Design Criteria Table — Colfax Avenue Ramps

= Deficient Existing Element

Design Element	Location											Design Criteria Reference
	SB I-25 to Colfax Ave	WB Colfax Ave to SB I-25	EB Colfax Ave to SB I-25	Walnut St to SB I-25	NB I-25 to Colfax Ave	NB I-25 to EB Auraria Pkwy	WB Colfax Ave to EB Auraria Pkwy	EB Colfax Ave to NB I-25	WB Colfax Ave to NB I-25	WB Auraria Pkwy to SB I-25	WB Auraria Pkwy to WB Colfax Ave	
General												
Roadway Classification	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	
Recommended Design Speed (MPH) (Ramp Proper)	40 (Posted)	25	25	30	45 (Posted)	*45 (Posted)/ 40 (Posted)	25	25	25	30	40	
Horizontal Alignment Criteria												
Curve Radius (Feet)—Minimum	485	144	144	231	643	643/485	144	144	144	231	485	PGDHS 2011, 3.3.5, Table 3-9, pg. 3-45
Stopping Sight Distance (Feet)—At level grade	305	155	155	200	360	360/305	155	155	155	200	305	PGDHS 2011, 3.2.2, Table 3-1, pg. 3-4; PGDHS 2011, 3.3.12, Fig. 3-22b, pg. 3-108
Minimum Acceleration Length (Feet)	N/A	N/A	550	N/A	N/A	N/A	N/A	960	N/A	N/A	N/A	PGDHS 2011, 10.9.6, Table 10-3, pg. 10-110, Use grade adjustment factors if necessary.
Minimum Deceleration Length (Feet)	285	N/A	N/A	N/A	N/A	341	N/A	N/A	N/A	N/A	N/A	PGDHS 2011, 10.9.6, Table 10-5, pg. 10-115, Use grade adjustment factors if necessary.
Cross Slope	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	PGDHS 2011, 10.9.6, pg. 10-93
Superelevation (e max)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	PGDHS 2011, 3.3.3, pg. 3-31
Clear Zone (Feet)—Minimum	14	14	12	10	20	20/14	14	14	14	14	12	RDG 2011, 3.1, Table 3-1 pg. 3-3
Lane Widths (Feet)	15	15	15	15	15	12	15	15	15	12	15	PGDHS 2011, 10.9.6, pg. 10-102
Shoulder Widths												
Left Inside (Feet)	4	4	4	4	4	4	4	4	4	4	4	PGDHS 2011, 10.9.6, pg. 10-102
Right Outside (Feet)	6	6	6	6	6	8	6	6	6	8	6	PGDHS 2011, 10.9.6, pg. 10-102
Ramp Departure Angle (degrees)	2 to 5	2 to 5	2 to 5	N/A	2 to 5	2 to 5	N/A	N/A	2 to 5	N/A	2 to 5	CDOT 2005, 10.7.8, Fig. 10-15, pg. 10-51
Vertical Alignment Criteria												
Length of Vertical Curves (Feet)—Minimum												
Crest Vertical Curves	120	75	75	90	135	135/120	75	75	75	90	120	PGDHS 2011, 3.4.6, pg. 3-153
Sag Vertical Curves	120	75	75	90	135	135/120	75	75	75	90	120	PGDHS 2011, 3.4.6, pg. 3-161
K-Values (at Exit/Entrance)												
Crest Vertical Curve	44	12	12	19	61	61/44	12	12	12	19	44	PGDHS 2011, 3.4.6, Table 3-34, pg. 3-155
Sag Vertical Curve	64	26	26	37	79	79/64	26	26	26	37	64	PGDHS 2011, 3.4.6, Table 3-36, pg. 3-161
Grade												
Maximum	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	PGDHS 2011, 10.9.6, pg. 10-93
Minimum	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	CDOT 2005, 3.3.3, pg. 3-32

*NB I-25 to EB Auraria has a speed drop within the ramp proper; therefore, two recommended design speeds are shown for this ramp.
CDOT 2005 = Colorado Department of Transportation Roadway Design Guide; PGDHS 2011 = A Policy on Geometric Design of Highways and Streets; RDG 2011 = Roadside Design Guide

Table 7. Design Criteria Table — Mile High Stadium Circle Ramps

= Deficient Existing Element

Design Element	Location		Design Criteria Reference
	Mile High to NB I-25	NB I-25 to Mile High	
General			
Roadway Classification	Ramp	Ramp	
Recommended Design Speed (MPH) (Ramp Proper)	25	25 (Posted)	
Horizontal Alignment Criteria			
Curve Radius (Feet)—Minimum	144	144	PGDHS 2011, 3.3.5, Table 3-9, pg. 3-45
Stopping Sigh Distance (Feet)—At level grade	155	155	PGDHS 2011, 3.2.2, Table 3-1, pg. 3-4; PGDHS 2011, 3.3.12, Fig. 3-22b, pg. 3-108
Minimum Acceleration Length (Feet)—At level grade	960	N/A	PGDHS 2011, 10.9.6, Table 10-3, pg. 10-110, Use grade adjustment factors if necessary.
Minimum Deceleration Length (Feet)—At level grade	N/A	410	PGDHS 2011, 10.9.6, Table 10-5, pg. 10-115, Use grade adjustment factors if necessary.
Cross Slope	2%	2%	PGDHS 2011, 10.9.6, pg. 10-93
Superelevation (e max)	6%	6%	PGDHS 2011, 3.3.3, pg. 3-31
Clear Zone (Feet)—Minimum	12	10	RDG 2011, 3.1, Table 3-1 pg. 3-3
Lane Widths (Feet)	15	15	PGDHS 2011, 10.9.6, pg. 10-102
Shoulder Widths			
Left Inside (Feet)	4	4	PGDHS 2011, 10.9.6, pg. 10-102
Right Outside (Feet)	6	6	PGDHS 2011, 10.9.6, pg. 10-102
Ramp Departure Angle (degrees)	N/A	N/A	CDOT 2005, 10.7.8, Fig. 10-15, pg. 10-51
Vertical Alignment Criteria			
Length of Vertical Curves (Feet)—Minimum			
Crest Vertical Curves	75	75	PGDHS 2011, 3.4.6, pg. 3-153
Sag Vertical Curves	75	75	PGDHS 2011, 3.4.6, pg. 3-161
K-Values (at Exit/Entrance)			
Crest Vertical Curve	12	12	PGDHS 2011, 3.4.6, Table 3-34, pg. 3-155
Sag Vertical Curve	26	26	PGDHS 2011, 3.4.6, Table 3-36, pg. 3-161
Grade			
Maximum	6%	6%	PGDHS 2011, 10.9.6, pg. 10-93
Minimum	0.5%	0.5%	CDOT 2005, 3.3.3, pg. 3-32

CDOT 2005 = Colorado Department of Transportation Roadway Design Guide; PGDHS 2011 = A Policy on Geometric Design of Highways and Streets; RDG 2011 = Roadside Design Guide

Table 8. Design Criteria Table — 23rd Avenue Ramps

= Deficient Existing Element

Design Element	Location				Design Criteria Reference
	SB I-25 to 23rd Ave	23rd Ave to SB I-25	NB I-25 to 23rd Ave	23rd Ave to NB I-25	
General					
Roadway Classification	Ramp	Ramp	Ramp	Ramp	
Recommended Design Speed (MPH) (Ramp Proper)	40 (Posted)	40	35 (Posted)	15	
Horizontal Alignment Criteria					
Curve Radius (Feet)—Minimum	485	485	340	39	PGDHS 2011, 3.3.5, Table 3-9, pg. 3-45
Stopping Sigh Distance (Feet)—At level grade	305	305	250	80	PGDHS 2011, 3.2.2, Table 3-1, pg. 3-4; PGDHS 2011, 3.3.12, Fig. 3-22b, pg. 3-108
Minimum Acceleration Length (Feet)—At level grade	N/A	960	N/A	960	PGDHS 2011, 10.9.6, Table 10-3, pg. 10-110, Use grade adjustment factors if necessary.
Minimum Deceleration Length (Feet)—At level grade	285	N/A	350	N/A	PGDHS 2011, 10.9.6, Table 10-5, pg. 10-115, Use grade adjustment factors if necessary.
Cross Slope	2%	2%	2%	2%	PGDHS 2011, 10.9.6, pg. 10-93
Superelevation (e max)	6%	6%	6%	6%	PGDHS 2011, 3.3.3, pg. 3-31
Clear Zone (Feet)—Minimum	12	14	12	12	RDG 2011, 3.1, Table 3-1 pg. 3-3
Lane Widths (Feet)	15	12	15	15	PGDHS 2011, 10.9.6, pg. 10-102
Shoulder Widths					
Left Inside (Feet)	4	4	4	4	PGDHS 2011, 10.9.6, pg. 10-102
Right Outside (Feet)	6	8	6	6	PGDHS 2011, 10.9.6, pg. 10-102
Ramp Departure Angle (degrees)	2 to 5	N/A	N/A	N/A	CDOT 2005, 10.7.8, Fig. 10-15, pg. 10-51
Vertical Alignment Criteria					
Length of Vertical Curves (Feet)—Minimum					
Crest Vertical Curves	120	120	105	45	PGDHS 2011, 3.4.6, pg. 3-153
Sag Vertical Curves	120	120	105	45	PGDHS 2011, 3.4.6, pg. 3-161
K-Values (at Exit/Entrance)					
Crest Vertical Curve	44	44	29	3	PGDHS 2011, 3.4.6, Table 3-34, pg. 3-155
Sag Vertical Curve	64	64	49	10	PGDHS 2011, 3.4.6, Table 3-36, pg. 3-161
Grade					
Maximum	6%	6%	6%	6%	PGDHS 2011, 10.9.6, pg. 10-93
Minimum	0.5%	0.5%	0.5%	0.5%	CDOT 2005, 3.3.3, pg. 3-32

CDOT 2005 = Colorado Department of Transportation Roadway Design Guide; PGDHS 2011 = A Policy on Geometric Design of Highways and Streets; RDG 2011 = Roadside Design Guide

Table 9. Design Criteria Table — Speer Boulevard Ramps

= Deficient Existing Element

Design Element	Location							Design Criteria Reference
	SB I-25 to WB Speer	EB Speer to SB I-25	WB Speer to SB I-25	NB I-25 to EB Speer	EB Speer to NB I-25	WB Speer to NB I-25	NB I-25 to WB Speer	
General								
Roadway Classification	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	Ramp	
Recommended Design Speed (MPH) (Ramp Proper)	40 (Posted)	40	30	30 (Posted)	25	25	20 (Posted)	
Horizontal Alignment Criteria								
Curve Radius (Feet)—Minimum	485	485	231	231	144	144	81	PGDHS 2011, 3.3.5, Table 3-9, pg. 3-45
Stopping Sigh Distance (Feet)—At level grade	305	305	200	200	155	155	115	PGDHS 2011, 3.2.2, Table 3-1, pg. 3-4; PGDHS 2011, 3.3.12, Fig. 3-22b, pg. 3-108
Minimum Acceleration Length (Feet)—At level grade	N/A	N/A	960	N/A	960	960	N/A	PGDHS 2011, 10.9.6, Table 10-3, pg. 10-110, Use grade adjustment factors if necessary.
Minimum Deceleration Length (Feet)—At level grade	285	N/A	N/A	380	N/A	N/A	440	PGDHS 2011, 10.9.6, Table 10-5, pg. 10-115, Use grade adjustment factors if necessary.
Cross Slope	2%	2%	2%	2%	2%	2%	2%	PGDHS 2011, 10.9.6, pg. 10-93
Superelevation (e max)	6%	6%	6%	6%	6%	6%	6%	PGDHS 2011, 3.3.3, pg. 3-31
Clear Zone (Feet)	14	14	14	12	12	14	12	RDG 2011, 3.1, Table 3-1 pg. 3-3
Lane Widths (Feet)	15	15	12	15	15	15	15	PGDHS 2011, 10.9.6, pg. 10-102
Shoulder Widths								
Left Inside (Feet)	4	4	4	4	4	4	4	PGDHS 2011, 10.9.6, pg. 10-102
Right Outside (Feet)	6	6	8	6	6	6	6	PGDHS 2011, 10.9.6, pg. 10-102
Ramp Departure Angle (degrees)	2 to 5	N/A	N/A	2 to 5	2 to 5	N/A	2 to 5	CDOT 2005, 10.7.8, Fig. 10-15, pg. 10-51
Vertical Alignment Criteria								
Length of Vertical Curves (Feet)—Minimum								
Crest Vertical Curves	120	120	90	90	75	75	60	PGDHS 2011, 3.4.6, pg. 3-153
Sag Vertical Curves	120	120	90	90	75	75	60	PGDHS 2011, 3.4.6, pg. 3-161
K-Values (at Exit/Entrance)								
Crest Vertical Curve	44	44	19	19	12	12	7	PGDHS 2011, 3.4.6, Table 3-34, pg. 3-155
Sag Vertical Curve	64	64	37	37	26	26	17	PGDHS 2011, 3.4.6, Table 3-36, pg. 3-161
Grade								
Maximum	6%	6%	6%	6%	6%	6%	6%	PGDHS 2011, 10.9.6, pg. 10-93
Minimum	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	CDOT 2005, 3.3.3, pg. 3-32

CDOT 2005 = Colorado Department of Transportation Roadway Design Guide; PGDHS 2011 = A Policy on Geometric Design of Highways and Streets; RDG 2011 = Roadside Design Guide

Table 10. Design Criteria Table — 20th Street Ramps

= Deficient Existing Element

Design Element	Location					Design Criteria Reference
	SB I-25 to 20th St	20th St to SB I-25	NB I-25 to 20th St	20th St to NB I-25	Ramp to I-25 NB HOV	
General						
Roadway Classification	Ramp	Ramp	Ramp	Ramp	Ramp	
Recommended Design Speed (MPH) (Ramp Proper)	40	45	30 (Posted)	40	35	
Horizontal Alignment Criteria						
Curve Radius (Feet)—Minimum	485	463	231	485	340	PGDHS 2011, 3.3.5, Table 3-9, pg. 3-45
Stopping Sigh Distance (Feet)—At level grade	305	360	200	305	250	PGDHS 2011, 3.2.2, Table 3-1, pg. 3-4; PGDHS 2011, 3.3.12, Fig. 3-22b, pg. 3-108
Minimum Acceleration Length (Feet)	N/A	960	N/A	960	N/A	PGDHS 2011, 10.9.6, Table 10-3, pg. 10-110, Use grade adjustment factors if necessary.
Minimum Deceleration Length (Feet)	480	N/A	480	N/A	N/A	PGDHS 2011, 10.9.6, Table 10-5, pg. 10-115, Use grade adjustment factors if necessary.
Cross Slope	2%	2%	2%	2%	2%	PGDHS 2011, 10.9.6, pg. 10-93
Superelevation (e max)	6%	6%	6%	6%	6%	PGDHS 2011, 3.3.3, pg. 3-31
Clear Zone (Feet)—Minimum	14	20	14	14	14	RDG 2011, 3.1, Table 3-1 pg. 3-3
Lane Widths (Feet)	12	15	15	15	15	PGDHS 2011, 10.9.6, pg. 10-102
Shoulder Widths						
Left Inside (Feet)	4	4	4	4	4	PGDHS 2011, 10.9.6, pg. 10-102
Right Outside (Feet)	8	6	6	6	6	PGDHS 2011, 10.9.6, pg. 10-102
Ramp Departure Angle (degrees)	2 to 5	N/A	2 to 5	N/A	N/A	CDOT 2005, 10.7.8, Fig. 10-15, pg. 10-51
Vertical Alignment Criteria						
Length of Vertical Curves (Feet)—Minimum						
Crest Vertical Curves	120	135	90	120	105	PGDHS 2011, 3.4.6, pg. 3-153
Sag Vertical Curves	120	135	90	120	105	PGDHS 2011, 3.4.6, pg. 3-161
K-Values (at Exit/Entrance)						
Crest Vertical Curve	44	61	19	44	29	PGDHS 2011, 3.4.6, Table 3-34, pg. 3-155
Sag Vertical Curve	64	79	37	64	49	PGDHS 2011, 3.4.6, Table 3-36, pg. 3-161
Grade						
Maximum	6%	6%	6%	6%	6%	PGDHS 2011, 10.9.6, pg. 10-93
Minimum	0.5%	0.5%	0.5%	0.5%	0.5%	CDOT 2005, 3.3.3, pg. 3-32

CDOT 2005 = Colorado Department of Transportation Roadway Design Guide; PGDHS 2011 = A Policy on Geometric Design of Highways and Streets; RDG 2011 = Roadside Design Guide

2. Typical Section

Typical sections for each segment of the highway are provided in the *Existing Conditions Assessment*. Critical typical section elements include number of lanes, lane width, shoulder width, and cross slope. The number of lanes for I-25 vary by way of adding and dropping auxiliary lanes; however, the corridor does maintain four through lanes from the Santa Fe Drive interchange to the 20th Street interchange. **Table 11 and Table 12** show existing lane and shoulder widths for the mainline study area. Deficient lane widths have been highlighted in red. Station ranges for I-25 were chosen based on changes in lane width or shoulder width. A new station range was used when the lane or shoulder width transitioned to a new typical width. At the time of publication of this document, FHWA is reviewing the standard inside and outside shoulder width for metro area interstate facilities from 12' to 10'.

According to AASHTO's *A Policy on Design Standards Interstate System*, the appropriate interstate lane width and shoulder width are 12 feet. In most locations a 12-foot lane width is maintained, though in locations between Santa Fe Drive and US 6 the lane width has been reduced to 11 feet. Throughout the entirety of the corridor, shoulder widths vary and most locations are less than 12 feet. In extreme cases, the shoulder width is reduced to one foot, causing significant safety and driver comfort issues.

Ramp lane widths and shoulder widths are provided in **Table 13**, with any deficiencies highlighted in red. According to AASHTO's *A Policy on Geometric Design of Highways and Streets*, single-lane ramps should have a 15-foot lane width with a four-foot left shoulder width and a six-foot right shoulder width. Multiple-lane ramps should have a 12-foot lane width with a four-foot left shoulder width and an eight-foot right shoulder width.

Cross-slope within the roadway typical section allows for drainage to sufficiently sheet flow across the roadway, reducing icy roads and ponding. According to AASHTO's *A Policy on Design Standards Interstate System,* a typical cross slope for a highway is 2 percent. Multiple cross sections throughout the corridor were evaluated to determine the approximate cross-slope for various locations on I-25. Cross-slope deficiencies can be seen in **Table 14**.

Table 11. I-25 NB Existing Lane and Shoulder Width Inventory

= Deficient Existing Element

Begin Station	End Station	Left Shoulder Width (ft)	Lane Width (ft)	No. of Lanes	Aux Lane	Right Shoulder Width (ft)	Remarks
1000+00	1008+00	8.5	12	5	Yes	11.5 to 12.5	
1008+00	1014+00	8 to 12	12	4	No	10.5	
1014+00	1020+00	12.5	12	5	Yes	10.5	
1020+00	1038+75	11 to 11.5	12.5	5	Yes	12	
1038+75	1063+00	10 to 11	12	4	No	12	
1063+00	1072+25	11	12	4	No	10 to 30	Gore area with entrance ramp from Santa Fe Dr
1072+25	1080+00	4 to 11	11	5	No	3.5 to 27	Transition from between Alameda Ave and Cedar Ave
1080+00	1090+00	3	11	6	Yes	1	10-foot aux lane
1090+00	1093+00	3	11	5	Yes	1.5	
1093+00	1100+00	3	11	5	Yes	2 to 7.5	11.5-foot aux lane
1100+00	1114+50	3	11	5	Yes	2 to 5.5	12-foot aux lane
1114+50	1118+00	3	12	5	Yes	3	11-foot aux lane
1118+00	1125+00	5	12	4	No	19	
1125+00	1131+00	5 to 10	12	4	No	12.5 to 19	
1131+00	1140+00	9 to 10.5	12	4	No	12	
1140+00	1146+00	2 to 4.5	12	4	No	11 to 24	Gore area at US 6
1146+00	1155+50	4.5	12	4	No	24	Gore area at US 6
1155+50	1159+00	2 to 3.5	12	5	No	7.5 to 9	Lane drop at entrance ramp from US 6
1159+00	1162+00	4.5	12	6	Yes	9	10-foot aux lane
1162+00	1165+00	6.5	12	6	Yes	7.5	11-foot aux lane
1165+00	1169+00	8	12	6	Yes	6	13.5-foot aux lane
1169+00	1172+00	7	12	6	Yes	7	
1172+00	1180+00	5.5	12	5	No	9.5	Gore area with exit ramp to Colfax Ave

= Deficient Existing Element

Begin Station	End Station	Left Shoulder Width (ft)	Lane Width (ft)	No. of Lanes	Aux Lane	Right Shoulder Width (ft)	Remarks
1180+00	1187+00	5.5 to 7.5	12	4	No	15.5	Gore area with exit ramp to Colfax Ave
1187+00	1200+00	7.5 to 9.5	12	4	No	12.5 to 21	
1200+00	1203+50	9.5 to 12.5	12	4	No	12.5	
1203+50	1211+00	12.5	12	5	Yes	13 to 24	
1211+00	1212+50	11.5	12	5	Yes	13.5	Exit ramp to Mile High Stadium
1212+50	1217+50	10.5	12	4	No	17.5	
1217+50	1223+00	8.5	12	5	Yes	5 to 6.5	
1223+00	1229+00	4.5 to 8.5	12	5	Yes	4.5 to 5	
1229+00	1242+00	5	12	4	No	4.5 to 7.5	Off-ramp to 23rd Ave
1242+00	1246+00	7	12	5	Yes	0.5	10-foot aux lane
1246+00	1253+00	5.5	12	4	No	5.5	
1253+00	1257+00	5	12	5	Yes	0.5	11-foot aux lane
1257+00	1268+50	5 to 5.5	12	4	No	5.5 to 9.5	
1268+50	1275+00	5	12	5	No	9 to 9.5	
1275+00	1278+00	8	12	5	No	0 to 9.5	
1278+00	1283+00	8 to 8.5	12	6	Yes	9.5 to 11	
1283+00	1298+50	10.5	12	6	Yes	0 to 18	
1298+50	1315+50	9 to 10.5	12	6	Yes	9 to 9.5	
1315+50	1322+00	7.5 to 9	12	5	Yes	0 to 21	

Table 12. I-25 SB Existing Lane and Shoulder Width Inventory

= Deficient Existing Element

Begin Station	End Station	Left Shoulder Width (ft)	Lane Width (feet)	No. of Lanes	Aux Lane	Right Shoulder Width (ft)	Remarks
1000+00	1010+50	8	12	4	No	9	
1010+50	1036+00	11.5	12	5	Yes	12.5	
1036+00	1069+00	11.5	12	4	No	12	
1069+00	1073+00	9.5	12	5	Yes	28	
1073+00	1078+00	4 to 9.5	11	5	Yes	8 to 33	
1078+00	1100+00	2.5 to 3.5	11	5	No	8 to 9.5	
1100+00	1103+00	3	11.5	5	No	9.5	
1103+00	1111+00	3	11.5	5	No	6	
1111+00	1115+00	3 to 5.5	11.5	5	No	3 to 6	
1115+00	1125+00	3.5 to 5.5	12	4	No	0 to 17.5	
1125+00	1135+00	3.5 to 10.5	12	4	No	7.5 to 17.5	
1135+00	1140+00	7.5 to 10	12	5	Yes	12.5 to 13.5	
1140+00	1145+00	3 to 7.5	12	5	Yes	13.5 to 16.5	
1145+00	1154+00	5.5 to 6.5	12	6	Yes	6 to 11.5	
1154+00	1157+00	4	12	5	No	12	
1157+00	1166+00	2 to 4	12	5	Yes	10.5	
1166+00	1172+00	2 to 3	12	5	Yes	7 to 7.5	
1172+00	1180+00	6	12	6	Yes	4 to 7	Entrance ramp from Colfax Ave
1180+00	1189+00	4	12	4	No	7 to 7.5	
1189+00	1197+00	7 to 10	12	4	No	8.5 to 9	
1197+00	1202+00	11	12 to 12.5	4	No	0 to 11.5	
1202+00	1208+00	11 to 12.5	12 to 12.5	5	Yes	18 to 23	
1208+00	1212+00	11 to 12.5	12	5	Yes	14.5 to 18	
1212+00	1220+00	8.5 to 10.5	12	4	No	15 to 17	

= Deficient Existing Element

Begin Station	End Station	Left Shoulder Width (ft)	Lane Width (feet)	No. of Lanes	Aux Lane	Right Shoulder Width (ft)	Remarks
1220+00	1224+00	8.5	12	4	No	17	
1224+00	1227+50	5	12	4	No	7	
1227+50	1240+00	5.5 to 7.5	12	4	No	2 to 9	
1240+00	1248+00	4.5	12 to 12.5	4	No	10.5	
1248+00	1253+00	5 to 8	12	4	Yes	8 to 11.5	
1253+00	1260+00	11 to 13.5	12	5	Yes	4 to 13	
1260+00	1265+00	13.5 to 19.5	12	5	Yes	0 to 13	
1265+00	1272+00	9 to 19	12	6	Yes	10	
1272+00	1275+00	9.5	12	5	No	0	
1275+00	1281+00	8 to 12.5	12	6	Yes	6.5 to 7	
1281+00	1295+00	10	12	5	No	6.5 to 9.5	
1295+00	1322+00	9 to 10	12	6	Yes	9 to 13	

Table 13. I-25 Ramp Existing Lane and Shoulder Width Inventory

= Deficient Existing Element

Interchange	Ramp	Left Shoulder Width (ft)	No. of Lanes	Lane Width (ft)	Right Shoulder Width (ft)	Remarks
US 85/ Santa Fe Dr	A: SB I-25 to SB US 85/Santa Fe Dr	4	2	12	8	
	B: US 85/Santa Fe Dr to SB I-25	2	2	12	2	
	C: NB I-25 to US 85/Santa Fe Dr	5	1	14	8	
	D: NB US 85/Santa Fe Dr to NB I-25	4	2	12	8	
Alameda Ave	A: Kalamath St/Cedar Ave to NB I-25	0	1	14	1	Cedar Ave, left side includes curb and gutter
	B: SB I-25 to Alameda Ave	4	1	15.5	1	
US 6	A: SB I-25 to WB US 6	5.5	2	12	8	
	B: EB US 6 to NB I-25	7	2	12.5 to 13	7	
	C: EB US 6 to SB I-25	10	2	18	4	
	D: SB I-25 to EB US 6	4	1	15	6	
	E: WB US 6 to SB I-25	8	1	15	8.5	
	F: NB I-25 to EB US 6	6	1	13.5	7	
	G: NB I-25 to WB US 6	4	1	14.5	6.5	
	H: WB US 6 to NB I-25	4	1	15.5	7	
8th Ave	A: SB I-25 to Zuni St	0.5	1	18	9	
	B: Zuni St to SB I-25	0.5	1	24 to 28	2-5	
	C: NB I-25 to 8th Ave	3	1	26	3.5	Variable lane width
	D: 8th Ave to NB I-25	2	1	10 to 24	2	

= Deficient Existing Element

Interchange	Ramp	Left Shoulder Width (ft)	No. of Lanes	Lane Width (ft)	Right Shoulder Width (ft)	Remarks
Colfax Ave	A: SB I-25 to Colfax Ave	4	1	15 to 36	0 to 6	
	B: WB Colfax Ave to SB I-25	2-6	1	18 to 20	4 to 6	
	C: EB Colfax Ave to SB I-25	3.5	1	15	10	
	D: Walnut St to SB I-25	2.5	1	15.5	3	
	E: NB I-25 to Colfax Ave	6.5	2	11 to 13.5	6	
	F: NB I-25 to EB Auraria Pkwy	2.5	2	12	0 to 6	
	G: WB Colfax Ave to EB Auraria Pkwy	1	1	24	4.5	
	H: EB Colfax Ave to NB I-25	4.5	1	17	2	
	I: WB Colfax Ave to NB I-25	4	1	21	3.5	
	J: WB Auraria Pkwy to SB I-25	3	2	12.5 to 14	3	Left lane width varies from 12 feet to 14 feet
	K: WB Auraria Pkwy to WB Colfax Ave	2	1	13.5	3.5	
Mile High Stadium	A: Mile High Stadium to NB I-25	4	1	15	4	
	B: NB I-25 to Mile High Stadium	5	1	14.5	7	
23rd Ave	A: SB I-25 to 23rd Ave	3.5	1	15	3.5	
	B: 23rd Ave to SB I-25	2	1	12	6	
	C: NB I-25 to 23rd Ave	1.5	1	12	3.5	
	D: 23rd Ave to NB I-25	3	1	18	1	
Speer Blvd	A: SB I-25 to WB Speer Blvd	3.5	1	15.5	7.5	
	B: EB Speer Blvd to SB I-25	4	1	14	4	
	C: WB Speer Blvd to SB I-25	3	2	11 to 14	2.5	Left lane width is 14 feet
	D: NB I-25 to EB Speer Blvd	3.5 to 4.5	1	13 to 23.5	1	
	E: EB Speer Blvd to NB I-25	1 to 1.5	1	11 to 22	0.5 to 1	
	F: WB Speer Blvd to NB I-25	1 to 4.5	1	11 to 23	5 to 8	
	G: NB I-25 to WB Speer Blvd	1 to 4.5	1	17.5 to 23.5	1	

= Deficient Existing Element

Interchange	Ramp	Left Shoulder Width (ft)	No. of Lanes	Lane Width (ft)	Right Shoulder Width (ft)	Remarks
20th St	A: SB I-25 to 20th St	4.5	1	22.5	8	
	B: 20th St to SB I-25	4.5	2	10 to 12	3 to 8	
	C: NB I-25 to 20th St	4	1	14	8	
	D: 20th St to NB I-25	3.5	2	11 to 12	8	
I-25 HOV	A: SB HOV	10	1	14	3.5	
	B: NB HOV	8 to 10	1	14.5	8	
	C: 20th St to NB HOV	0 to 6	1	12	14	

Table 14. Cross-Slope Deficiencies

Location	Required Cross-Slope (%)	Existing Cross-Slope (%)
I-25 SB, Station 1056+00	2.00	0.94
I-25 NB, Station 1095+00	2.00	0.67
I-25 NB, Station 1110+00	2.00	1.15
I-25 NB, Station 1149+00	2.00	0.39
I-25 SB, Station 1231+00	2.00	0.22
I-25 SB, Station 1262+00	2.00	1.43

3. Horizontal Alignment

The horizontal alignment design criterion is linked to the design speed of the facility, the radius of horizontal alignment, and the superelevation of the roadway. Within a given design speed, the greater the superelevation is on the curve, the tighter the curve radius that is permitted. Existing superelevations were evaluated using recent survey surface and topographic information. Existing superelevation deficiencies are shown in **Table 15**. Mainline and ramp design speeds were considered the same as posted speeds. Existing ramp design speeds were determined by utilizing posted warning signs on exit ramp approaches, while entrance ramp design speeds were determined by evaluating horizontal and vertical curvature. All ramp speeds shown in **Table 2 through Table 10** are for the ramp proper only. Existing superelevation, vertical curve lengths, and horizontal stopping sight distance were not considered in determining the appropriate ramp design speed, but were evaluated separately based on the design speeds as determined by the methodology provided above. Study area locations, on both I-25 and on the ramps, with deficient horizontal curvature are summarized in the following tables. Horizontal curve lengths were only evaluated for I-25, and no horizontal alignment radius deficiencies were identified on I-25.

Table 15. Superelevation Deficiencies[1]

Location	Required Superelevation (%)	Existing Superelevation (%)
I-25 NB, Station 1088+84	5.2	4.6
I-25 SB, Station 1088+84	5.2	4.0
I-25 SB, Station 1102+07	3.2	2.0
I-25 NB, Station 1118+23	3.8	1.3
I-25 SB, Station 1118+23	3.8	2.0
I-25 NB, Station 1157+67	4.2	2.7

Location	Required Superelevation (%)	Existing Superelevation (%)
I-25 SB, Station 1157+67	4.2	1.8
I-25 NB, Station 1165+60	4.6	3.1
I-25 SB, Station 1165+60	4.6	2.9
I-25 NB, Station 1179+31	4.0	1.6
I-25 SB, Station 1179+31	4.0	3.4
I-25 NB, Station 1192+00	4.6	3.1
I-25 SB, Station 1192+00	4.6	2.9
I-25 NB, Station 1195+24	5.6	4.4
I-25 SB, Station 1195+24	5.6	4.8
I-25 NB, Station 1199+33	4.6	1.9
I-25 SB, Station 1199+33	4.6	3.2
I-25 NB, Station 1221+29	5.2	4.3
I-25 NB, Station 1240+69	4.0	3.3
I-25 SB, Station 1240+69	4.0	2.1
I-25 NB HOV, Station 1286+50	5.0	4.1
I-25 SB HOV, Station 3005+00	4.0	3.4
I-25 NB HOV from 20th St	4.2	3.7
US 85/Santa Fe Dr Ramp, SB I-25 to SB US 85/Santa Fe Dr	5.6, 3, 3	1.7, 0.9, 1.6
US 85/Santa Fe Dr Ramp, US 85/Santa Fe Dr to SB I-25	4.4, 5.8, 6.0, 6.0, 5.0	1.9, 2.5, 2.0, 3.1, 1.8
US 85/Santa Fe Dr Ramp, NB I-25 to US 85/Santa Fe Dr	3.4	1.3
US 85/Santa Fe Dr Ramp, NB US 85/Santa Fe Dr to NB I-25	2.8, 3.8	1.1, 2.6
Alameda Ave Ramp, Kalamath St/Cedar Ave to NB I-25	6.0	2.4
Alameda Ave Ramp, SB I-25 to Alameda Ave	2.4	1.3
US 6 Ramp, WB US 6 to SB I-25	6.0	4.4
US 6 Ramp, NB I-25 to EB US 6	4.0	2.8
US 6 Ramp, NB I-25 to WB US 6	6.0, 6.0	4.4, 5.4
8th Ave Ramp, SB I-25 to Zuni St	5.0	2.4
8th Ave Ramp, Zuni St to SB I-25	5.6	3.4
8th Ave Ramp, NB I-25 to 8th Ave	2.6	2.1
8th Ave Ramp, 8th Ave to NB I-25	5.8	2.0
Colfax Ave Ramp, WB Colfax Ave to SB I-25	6.0	2.3
Colfax Ave Ramp, EB Colfax Ave to SB I-25	3.2, 4.2, 4.2	2.8, 1.7, 2.1
Colfax Ave Ramp, Walnut St to SB I-25	5.2, 5.0	2.0, 2.2

Location	Required Superelevation (%)	Existing Superelevation (%)
Colfax Ave Ramp, NB I-25 to Colfax Ave	3.8, 4.2, 5.8, 6.0	2.3, 3.1, 3.5, 3.9
Colfax Ave Ramp, NB I-25 to EB Auraria Pkwy	4.8, 4.2, 5.2	2.0, 2.9, 3.9
Colfax Ave Ramp, WB Colfax Ave to EB Auraria Pkwy	4.4, 5.6, 6.0, 3.0	2.0, 2.0, 5.1, 0.3
Colfax Ave Ramp, EB Colfax Ave to NB I-25	2.0	0.6
Colfax Ave Ramp, WB Colfax Ave to NB I-25	3.4, 4.4	2.8, 0.3
Colfax Ave Ramp, WB Auraria Pkwy to SB I-25	2.8	2.3
Colfax Ave Ramp, WB Auraria Pkwy to WB Colfax Ave	6.0	4.5
23rd Ave Ramp, SB I-25 to 23rd Ave	3.2	2.8
23rd Ave Ramp, 23rd Ave to SB I-25	5.0, 3.8, 4.4	2.0, 2.3, 1.5
23rd Ave, NB I-25 to 23rd Ave	5.4	3.7
23rd Ave Ramp, 23rd Ave to NB I-25	3.6	2.0
Speer Blvd Ramp, SB I-25 to WB Speer Blvd	5.6, 6.0, 6.0, 6.0	4.6, 0.6, 3.2, 5.1
Speer Blvd Ramp, EB Speer Blvd to SB I-25	5.2, 5.6	3.1, 2.3
Speer Blvd Ramp, NB I-25 to EB Speer Blvd	4.0	3.1
Speer Blvd Ramp, EB Speer Blvd to NB I-25	4.4, 6.0, 6.0, 6.0	3.3, 3.9, 4.6, 5.2
Speer Blvd Ramp, WB Speer Blvd to NB I-25	6.0, 5.8, 5.8	4.0, 3.1, 4.6
Speer Blvd Ramp, NB I-25 to WB Speer Blvd	5.4, 4.8, 5.4, 4.4	0.3, 0.7, 0.9, 2.4
20th St Ramp, SB I-25 to 20th St	3.0, 2.8	1.9, 2.3
20th St Ramp, 20th St to SB I-25	4.2, 3.2	0.1, 1.5
20th St Ramp, 20th St to NB I-25	4.6, 5.4	3.0, 3.3

1. Ramps with multiple deficiencies are shown with the required superelevation percentages and the corresponding existing superelevation percentages.

Table 16. Horizontal Alignment Radius Deficiencies

Location	Required Curve Radius (ft)	Existing Curve Radius (ft)
Colfax Ave Ramp, SB I-25 to Zuni St	485	460

Table 17. I-25 Horizontal Alignment Curve Length Deficiencies

Location	Required Curve Length (ft)	Existing Curve Length (ft)
I-25 NB/SB, Station 1025+64	825	681
I-25 NB/SB, Station 1063+13	825	699
I-25 NB/SB, Station 1077+39	825	389
I-25 NB/SB, Station 1088+84	825	683
I-25 NB/SB, Station 1102+07	825	628
I-25 NB/SB, Station 1118+23	825	461
I-25 NB/SB, Station 1157+67	825	574
I-25 NB/SB, Station 1192+00	825	348
I-25 NB/SB, Station 1195+24	825	480
I-25 NB/SB, Station 1199+33	825	339
I-25 NB/SB, Station 1221+29	825	476
I-25 NB/SB, Station 1225+73	825	412
I-25 NB, Station 1276+87	825	365
I-25 NB, Station 1281+66	825	370

4. Horizontal Stopping Sight Distance

Horizontal stopping sight distance is a calculation that determines the necessary distance to safely stop a vehicle in a sudden stop condition. The equation to determine the distance includes driver reaction time and the distance to stop a vehicle from a given design speed. Obstructions often infringe upon the sight distance lines, reducing driver safety. Based on the design speed of the mainline and respective ramps, the following horizontal stopping sight distance deficiencies have been identified.

Table 18. I-25 Horizontal Stopping Sight Distance Deficiencies

Location	Design Speed (mph)	Required Distance (ft)	Existing Distance (ft)	Obstruction
I-25 NB, Station 1088+84	55	495	335	Barrier
I-25 NB, Station 1118+84	55	495	426	Sign structure
I-25 SB, Station 1159+64	55	495	403	Sign structure
I-25 SB, Station 1165+60	55	495	357	Barrier
I-25 NB, Station 1175+22	55	495	432	Sign structure
I-25 NB, Station 1182+69	55	495	415	Sign structure
I-25 NB, Station 1195+17	55	495	475	Barrier
I-25 SB, Station 1212+96	55	495	422	Sign structure
I-25 SB, Station 1220+13	55	495	458	Sign structure
I-25 SB, Station 1241+90	55	495	466	Barrier
I-25 SB, Station 1306+32	55	495	432	Sign structure

Table 19. Ramp Horizontal Stopping Sight Distance Deficiencies

Ramp	Approx. Station	Design Speed (mph)	Required Distance (ft)	Existing Distance (ft)	Obstruction
US 85/Santa Fe Dr, US 85/Santa Fe Dr to SB I-25	205+00	50	425	305	Guardrail
US 6, WB US 6 to NB I-25	807+00	40	305	283	Barrier
Colfax Ave, NB I-25 to Colfax Ave	514+00	45	360	270	Barrier
Colfax Ave, NB I-25 to Colfax Ave	518+00	45	360	146	Barrier
Colfax Ave, NB I-25 to EB Auraria Pkwy	614+00	40	305	236	Barrier
Colfax Ave, WB Auraria Pkwy to WB Colfax Ave	1103+00	40	305	210	Barrier

5. Acceleration/Deceleration

Acceleration distance provides space for vehicles to get up to speed and safely enter the highway. This distance can be provided on the ramp proper or on the highway, through use of an auxiliary lane. The acceleration length required is determined by the design speed of both the ramp and the mainline, and is adjusted according to the vertical grades associated with each. Similarly, deceleration provides sufficient space for vehicles leaving the highway to safely reduce speed away from the mainline traffic. Existing acceleration lengths for entrance ramps were measured from the metering location to the merge point, as this would provide the worst-case scenario. Acceleration and deceleration distance deficiencies are documented in **Table 20**, in accordance with the existing ramp configuration and posted speeds.

Table 20. Acceleration/Deceleration Distance Deficiencies

Ramp Location	Acceleration/ Deceleration	Required Distance (ft)	Existing Distance (ft)
8th Ave Ramp, Zuni St to SB I-25	Acceleration	1,392	365
8th Ave Ramp, NB I-25 to 8th Ave	Deceleration	350	0
8th Ave Ramp, 8th Ave to NB I-25	Acceleration	960	839
Colfax Ave Ramp, NB I-25 to EB Auraria Pkwy	Deceleration	341	167
Colfax Ave Ramp, EB Colfax Ave to NB I-25	Acceleration	960	815
23rd Ave Ramp, 23rd Ave to SB I-25	Acceleration	960	851
23rd Ave Ramp, 23rd Ave to NB I-25	Acceleration	960	264
Speer Blvd Ramp, WB Speer Blvd to SB I-25	Acceleration	960	516
Speer Blvd Ramp, NB I-25 to EB Speer Blvd	Deceleration	380	83
Speer Blvd Ramp, WB Speer Blvd to NB I-25	Acceleration	960	312
Speer Blvd Ramp, NB I-25 to WB Speer Blvd	Deceleration	440	128

6. Ramp Spacing

Adequate ramp separation distance permits safe weaving operation between interchanges. Proper ramp spacing gives suitable distance for vehicles to accelerate along entrance ramps and weave into the through lanes, while permitting sufficient distance for vehicles leaving the highway to decelerate and weave onto exit ramps. As ramp spacing is reduced, strain is placed on operations through insufficient acceleration/deceleration distances and associated weaving. Inadequate ramp spacing for the corridor is shown in **Table 21**.

Table 21. Ramp Spacing Deficiencies

Ramp to Ramp	Type	Required Distance (ft)	Existing Distance (ft)
I-25 NB, US 85/Santa Fe Dr to Alameda Ave	EN-EN (EX-EX)	1,000	864
I-25 SB, 8th Ave to US 6	EN-EX (System to Service Interchange)	2,000	900
I-25 NB, US 6 to 8th Ave	EN-EN (EX-EX)	1,000	487
I-25 SB, 8th Ave to 8th Ave	EX-EN	500	185
I-25 NB, Mile High to 23rd Ave	EN-EX (System to Service Interchange)	1,600	1,272
I-25 NB, Colfax Ave to Mile High	EN-EX (Service to System Interchange)	1,600	933
I-25 NB, Mile High to Mile High	EX-EN	500	440
I-25 SB, 23rd Ave to Colfax Ave	EN-EX (Service to System Interchange)	1,600	1,060
I-25 NB, 23rd Ave to Speer Blvd	EN-EX (Service to System Interchange)	1,600	385
I-25 NB, Speer Blvd to 20th St	EN-EX (Service to System Interchange)	1,600	853
I-25 SB, 20th St to Speer Blvd	EN-EX (Service to System Interchange)	1,600	790
US 6 to US 6	Turning Roadways (Service Interchange)	800	330
Colfax Ave to Colfax Ave	Turning Roadways (Service Interchange)	800	446
Colfax Ave to Colfax Ave	Turning Roadways (Service Interchange)	800	630
Colfax Ave to Colfax Ave	Turning Roadways (Service Interchange)	800	679
Colfax Ave to Colfax Ave	Turning Roadways (Service Interchange)	800	93
Speer Blvd to I-25 SB	Turning Roadways (Service Interchange)	800	643

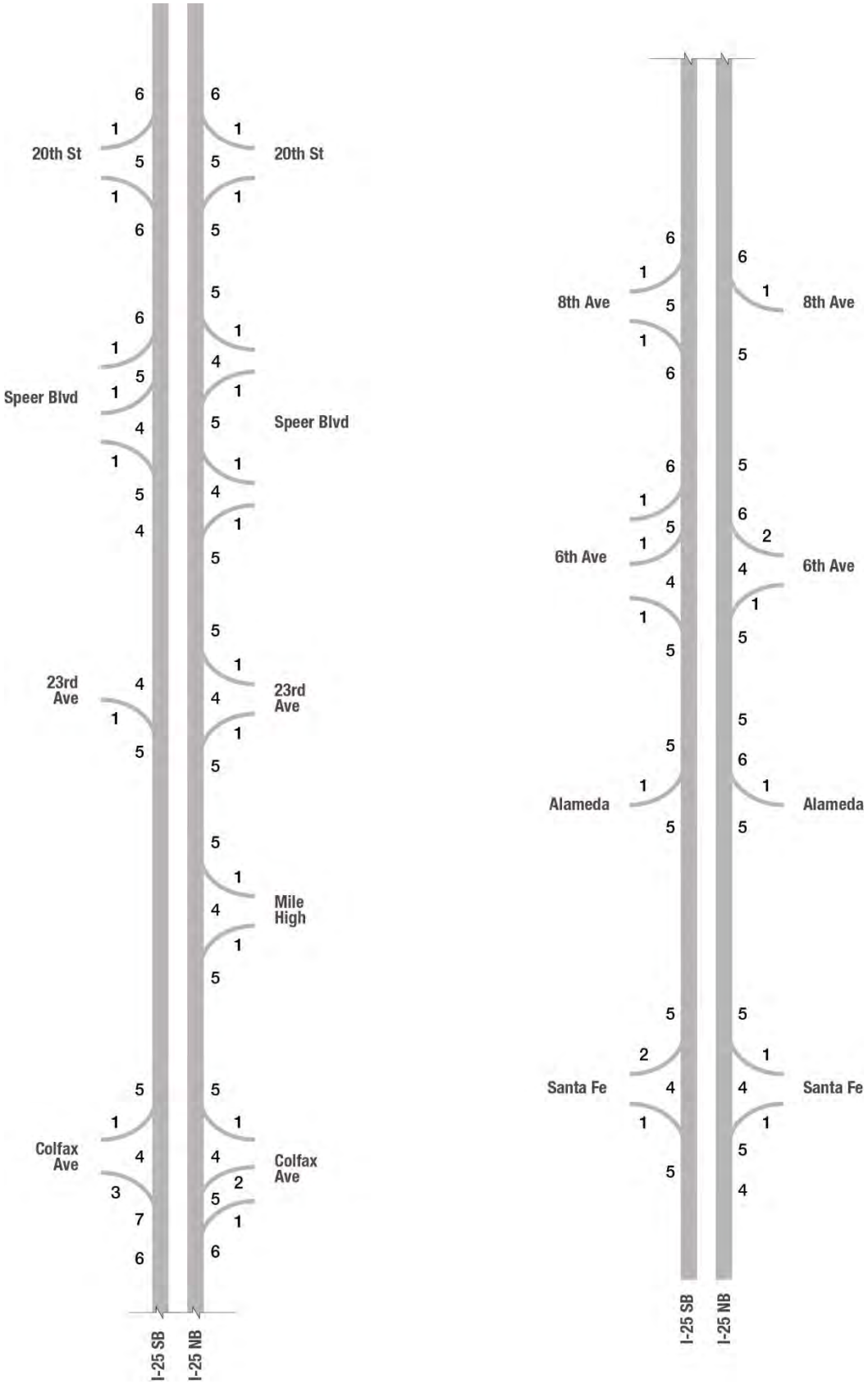
EN = entrance; EX = exit

7. Lane Balance and Route Continuity

Weaves in advance of an interchange cause friction within the facility, slowing traffic operations and causing safety issues. To reduce the number of weaves required at an interchange, designers implement the principle of lane balance. Lane balance properly aligns the number of lanes entering an interchange, allowing for the efficient exiting of vehicles leaving the highway. **Figure 6** shows lane balance for each interchange along the corridor. No improper lane balance has been identified in this corridor.

Route continuity is a traffic operations concept referring to a continuous directional path along a designated route where lane changes on the route are not necessary. Maintaining route continuity provides a straightforward route for drivers traveling through a corridor by way of reduced decision points, fewer lane changes, and simplified signing. The corridor covered in this study maintains four through lanes and all exit lanes terminate on the right.

Figure 6. I-25 Lane Balance



8. Clear Zone

Clear zone is the design concept of providing adequate "buffer" between the travel lane and the nearest obstruction. Obstructions include manmade objects (i.e., bridge piers, sign structures, culverts, etc.), as well as natural features (i.e., trees, rocks, etc.). Both the mainline and the ramps mostly provide barrier separation for objects within the clear zone. **Table 22** identifies locations where clear zone is not met.

Table 22. Clear Zone Deficiencies

Location	Design Speed (mph)	Minimum Clear Zone (ft)	Desirable Clear Zone (ft)	Existing Clear Zone (ft)	Obstruction
I-25 NB, Station 1093+20 to Station 1112+50	55	22	24	10	Light poles and sign structure
I-25 SB, Station 1155+00 to Station 1155+60	55	22	24	14	Curb and gutter
I-25 NB, Station 1156+40 to Station 1158+15	55	22	24	6	Curb and gutter
I-25 SB, Station 1183+30 to Station 1190+50	55	22	24	10	Curb and gutter
I-25 NB, Station 1199+65 to Station 1200+60	55	22	24	13	Curb and gutter
I-25 NB, Station 1213+50 to Station 1240+60	55	22	24	2	Light poles, curb and gutter
I-25 NB, Station 1241+30 to Station 1246+20	55	22	24	8	Light poles
I-25 NB, Station 1246+50 to Station 1256+60	55	22	24	1	Light poles, curb and gutter
I-25 NB, Station 1257+90 to Station 1258+90	55	22	24	13	Light poles

9. Ramp Departure Angle

Ramp departure angle refers to the change in direction drivers are required to maneuver to merge onto the interstate exit ramp. The departure angle should be between two degrees and five degrees, which allows drivers to exit the interstate while maintaining a higher speed onto the ramp. **Table 23** identifies areas where the ramp departure angles are greater than five degrees.

Table 23. Ramp Departure Angle Deficiencies

Location	Approx. Station	Required Angle (deg)	Existing Angle (deg)
Alameda Ramp, SB I-25 to Alameda Ave	210+90	2 to 5	5.6
23rd Ave Ramp, SB I-25 to 23rd Ave	118+13	2 to 5	8.0
20th St Ramp, NB I-25 to 20th St	300+00	2 to 5	7.6

10. Vertical Alignment

Vertical alignment refers to tangents on grade transitioned with vertical curves. On the I-25 mainline, profile grades should remain between 0.5 percent and 4 percent to provide for sufficient drainage while maintaining driver comfort and safety. Ramp grades may be increased to 6 percent, as necessary. Profile grades outside of these parameters are identified in **Table 24**.

Table 24. Vertical Grade Deficiencies

Location	Existing Vertical Grade (%)
I-25, Station 1078+89 to Station 1080+41	0.2%
I-25, Station 1083+91 to Station 1106+57	0.3%
I-25, Station 1108+57 to Station 1111+40	0.4%
I-25, Station 1137+16 to Station 1137+93	0.0%
I-25, Station 1162+58 to Station 1168+53	0.4%
I-25, Station 1218+47 to Station 1219+26	0.3%
I-25, Station 1263+23 to Station 1267+02	0.1%
I-25 SB, Station 1277+49 to Station 1278+71	0.4%
I-25 SB, Station 1295+94 to Station 1298+82	0.1%
I-25 NB HOV, Station 1290+61 to Station 1292+27	0.2%
I-25 SB HOV, Station 3015+33 to Station 3018+64	0.0%
Alameda Ave Ramp, Kalamath St/Cedar Ave to NB I-25	0.0%
Alameda Ave Ramp, SB I-25 to Alameda Ave	0.3%, 0.1%
US 6 Ramp, SB I-25 to WB US 6	0.4%
US 6 Ramp, WB US 6 to SB I-25	0.0%
US 6 Ramp, NB I-25 to EB US 6	7.1%
Colfax Ave Ramp, SB I-25 to Colfax Ave	0.3%
Colfax Ave Ramp, WB Colfax Ave to SB I-25	7.2%
Colfax Ave Ramp, NB I-25 to Colfax Ave	0.4%, 0.3%
Colfax Ave Ramp, WB Colfax Ave to EB Auraria Pkwy	6.7%
Colfax Ave Ramp, EB Colfax Ave to NB I-25	0.3%
Colfax Ave Ramp, WB Colfax Ave to NB I-25	0.3%
Colfax Ave Ramp, WB Auraria Pkwy to SB I-25	6.6%
Colfax Ave Ramp, WB Auraria Pkwy to WB Colfax Ave	0.4%
Mile High Ramp, Mile High to NB I-25	0.3%, 0.1%
Mile High Ramp, NB I-25 to Mile High	0.3%
23rd Ave Ramp, 23rd Ave to SB I-25	0.4%
20th St to NB I-25 HOV	6.5%, 0.2%

Vertical curves are used to effect gradual changes in different profile grades. Curves are classified as either a sag curve or a crest curve. A sag curve has a point of intersection at the lowest elevation, while a crest curve has a point of intersection at the highest elevation. Curves have various design elements, including curve length and K-values. Minimum vertical curve length should be no less than three times the design speed for driver comfort. The following vertical curves have been identified as having insufficient curve length.

Table 25. Vertical Curve Length Deficiencies[1,2]

Location	Required Curve Length (ft)	Existing Curve Length (ft)
I-25 SB, Station 1303+07	165	150
I-25 SB, Station 1304+64	165	150
I-25 NB HOV, Station 1290+16	165	90
I-25 NB HOV, Station 1292+64	165	75
I-25 NB HOV, Station 1293+52	165	100
I-25 SB HOV, Station 3023+47	165	100
US 85/Santa Fe Dr Ramp, SB I-25 to SB US 85/Santa Fe Dr	135	110, 60, 100, 125
Alameda Ave Ramp, Kalamath St/Cedar Ave to NB I-25	60	35, 35, 50
Alameda Ave Ramp, SB I-25 to Alameda Ave	135	120
US 6 Ramp, EB US 6 to NB I-25[2]	105	75, 75, 80
US 6 Ramp, WB US 6 to SB I-25	105	80
US 6 Ramp, WB US 6 to NB I-25	120	100
8th Ave Ramp, Zuni St to SB I-25	60	50
8th Ave Ramp, NB I-25 to 8th Ave	105	50
Colfax Ave Ramp, SB I-25 to Colfax Ave	120	100, 100
Colfax Ave Ramp, NB I-25 to Colfax Ave	135	100, 100, 100, 100, 100, 125, 125, 100
Colfax Ave Ramp, NB I-25 to EB Auraria Pkwy	135, 120, 120	100, 95, 95
Colfax Ave Ramp, EB Colfax Ave to NB I-25	75	55, 55
Colfax Ave Ramp, WB Colfax Ave to NB I-25	75	50
Colfax Ave Ramp, WB Auraria Pkwy to WB Colfax Ave	120	100, 100

1. NB I-25 to EB Auraria Pkwy has a speed drop within the ramp proper; therefore, multiple required and existing curve lengths are shown.
2. Ramps with multiple deficiencies are shown with the required curve length and the corresponding existing curve lengths.

K-values are determined by dividing the length of the vertical curve by the algebraic difference in grades. K-values are tightly related to the necessary curve length and vertical stopping sight distance. Curves are designed to allow sufficient sight lines along the roadway, permitting the user to identify an object in the road and come to a complete stop in a sudden stop situation. Vertical curves that do not meet stopping sight distance criteria pose a safety risk to drivers. The following vertical curves have been identified as having insufficient K-values.

Table 26. K-Value Deficiencies[1]

Location	Required K-Value	Existing K-Value
I-25 NB/SB, Station 1068+79	115 (Sag)	81
I-25 NB/SB, Station 1201+52	114 (Crest)	96
I-25 NB HOV, Station 1290+16	114 (Crest)	56
I-25 NB HOV, Station 1293+52	115 (Sag)	83
I-25 NB HOV, Station 3020+02	115 (Sag)	78
US 85/Santa Fe Dr, SB I-25 to SB US 85/Santa Fe Dr	79 (Sag)	58
US 6 Ramp, EB US 6 to NB I-25	49 (Sag)	41
US 6 Ramp, NB I-25 to EB US 6	26 (Sag)	20
US 6 Ramp, NB I-25 to WB US 6	49 (Sag)	39
8th Ave Ramp, NB I-25 to 8th Ave	49 (Sag)	42, 39
Colfax Ave Ramp, SB I-25 to Colfax Ave	64 (Sag)	53, 24
Colfax Ave Ramp, NB I-25 to EB Auraria Pkwy	79 (Sag)	64, 28
23rd Ave Ramp, SB I-25 to 23rd Ave	44 (Crest), 64 (Sag)	21 (Crest), 43 (Sag)
23rd Ave Ramp, NB I-25 to 23rd Ave	49 (Sag), 29 (Crest)	13 (Sag), 13 (Crest)
Speer Blvd Ramp, SB I-25 to WB Speer Blvd	64 (Sag)	43

1. Ramps with multiple deficiencies are shown with the required K-value and the corresponding existing K-values.

11. References

American Association of State Highway and Transportation Officials (AASHTO). (2005). *A Policy on Design Standards—Interstate System*. Washington, DC: AASHTO.

American Association of State Highway and Transportation Officials (AASHTO). (2011). *A Policy on Geometric Design of Highways and Streets*. Washington, DC: AASHTO.

American Association of State Highway and Transportation Officials (AASHTO). (2011). *Roadside Design Guide*. Washington, DC: AASHTO.

Colorado Department of Transportation (CDOT). (2005). *Roadway Design Guide*. Denver, CO: CDOT.

I-25 Central PEL

Traffic Safety Technical Memorandum

July 2018

1. Introduction

Interstate 25 (I-25) serves as a critical transportation link connecting people and commerce across the Denver metropolitan region, the state of Colorado, and the country. Through the Denver metropolitan area, I-25 is part of a multimodal corridor with close connections to downtown Denver and major urban activities related to city life.

This Traffic Safety Analysis Technical Memorandum for the I-25 Central Planning and Environmental Linkages (PEL) Study provides a baseline evaluation of existing traffic safety conditions for the I-25 Central corridor—extending from 20th Street to U.S. Highway 85 (US 85)/Santa Fe Drive—in Denver, Colorado. This assessment was conducted to establish a baseline of existing crash patterns along the corridor and to determine the presence of causal relationships, if any, among each facility type and road users. As such, this report includes the following information:

- Traditional crash analysis based on crash occurrence and distribution for each facility type in the project limits
- Assessment to identify areas with potential safety issues using Safety Performance Functions and Crash Modification Factors from the American Association of State Highway and Transportation Officials (AASHTO) *Highway Safety Manual* (HSM) and Colorado Department of Transportation (CDOT) guidance.

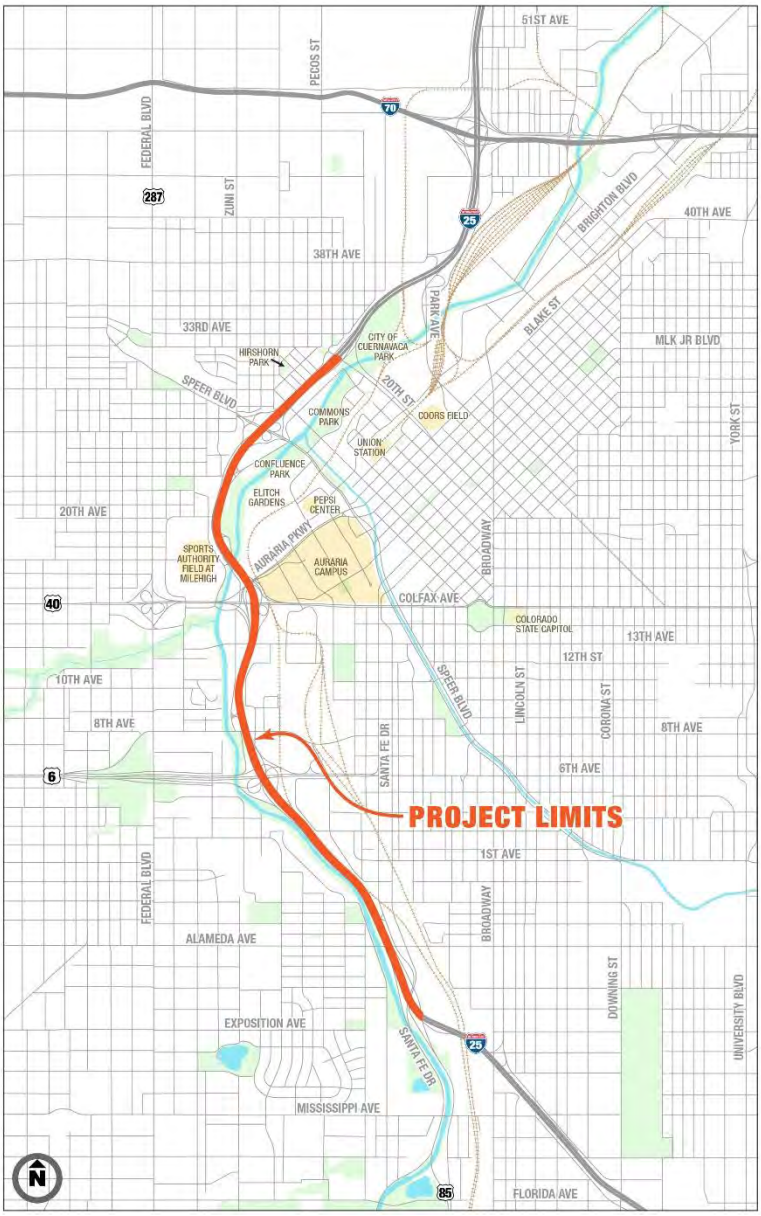
Ultimately, the findings provided in this assessment will assist the project team with identifying and selecting the appropriate design alternatives as part of the I-25 Central PEL Study.

1.1. Background

The study area includes three facility types: mainline freeway segments, ramp segments, and controlled ramp terminals. Mainline freeway segments are the main roadway of I-25 itself. Ramp segments are the on-ramps and off-ramps to I-25. A ramp terminal is the point where an on-ramp or off-ramp from I-25 intersects a local street or frontage road.

As shown in Figure 1, project limits extend along I-25 from 20th Street in the north to US 85/Santa Fe Drive in the south.

Figure 1: I-25 Central PEL Study Area Limits



The total corridor length as measured along the mainline is approximately 4.5 miles, with traffic volumes along the mainline corridor ranging from 178,000 vehicles per day (vpd) to 260,000 vpd. The greatest concentration of traffic exists on the mainline section between Colfax Avenue and U.S. Highway 6 (US 6), where the maximum average daily traffic (ADT) value was observed. For ramp segments, ADT values ranged from a minimum of approximately 900 vpd up to a maximum of 34,200 vpd. Cross streets at ramp terminals had ADTs ranging between 580 vpd and 58,000 vpd.

1.2. Analysis Methodology

The analysis methodology used for this project is based on the AASHTO *Highway Safety Manual* (AASHTO 2010) Empirical Bayes methodology. This methodology relies on the

comparison of three values to identify locations where safety improvements are most needed. These values include observed crashes, predicted crashes, and expected crashes.

1.2.1. Observed Crashes

Observed crashes are those that occurred in the field. These data were obtained from CDOT crash records and included three years of information from January 2013 to December 2015.

1.2.2. Predicted Crashes

Predicted crashes is a derived value that examines facilities of a similar type and calculates the average number of crashes observed across those facilities. The values are calculated using safety performance functions (SPFs). “SPFs are regression equations that estimate the average crash frequency for a specific site type (with specific base conditions) as a function of annual average daily traffic (AADT) and, in the case of roadway segments, the segment length.” (AASHTO 2010, 3-17)

For mainline freeway segments, CDOT data were used and the predicted crash value is specifically calibrated for conditions and facilities in Colorado. However, CDOT only maintains this information for mainline freeway facilities; therefore, CDOT data could not be used for the analysis of ramps or ramp terminals. For this reason, FHWA information was used to supplement CDOT data as necessary. FHWA provides base SPFs that are created using data collected from across the United States. Although these SPFs are not specifically calibrated for conditions in Colorado, they provide an adequate alternative in the absence of calibrated data.

1.2.3. Expected Crashes

Expected crashes is another derived value that blends the observed crashes and the predicted crashes to provide a more balanced number of crashes likely to occur on a facility. Expected crash calculations are important because they help account for the natural variations in observed crashes. In general, the number of observed crashes fluctuates over time, with some periods having more crashes and some having less. Based on this paradigm, it is possible that the three years of crash data collected and analyzed for this study could represent years where crashes were higher or lower than the long-term average. By comparing the observed crashes to the predicted crashes—the average of crashes observed at similar facilities—the expected crashes provide a more balanced representation of existing conditions.

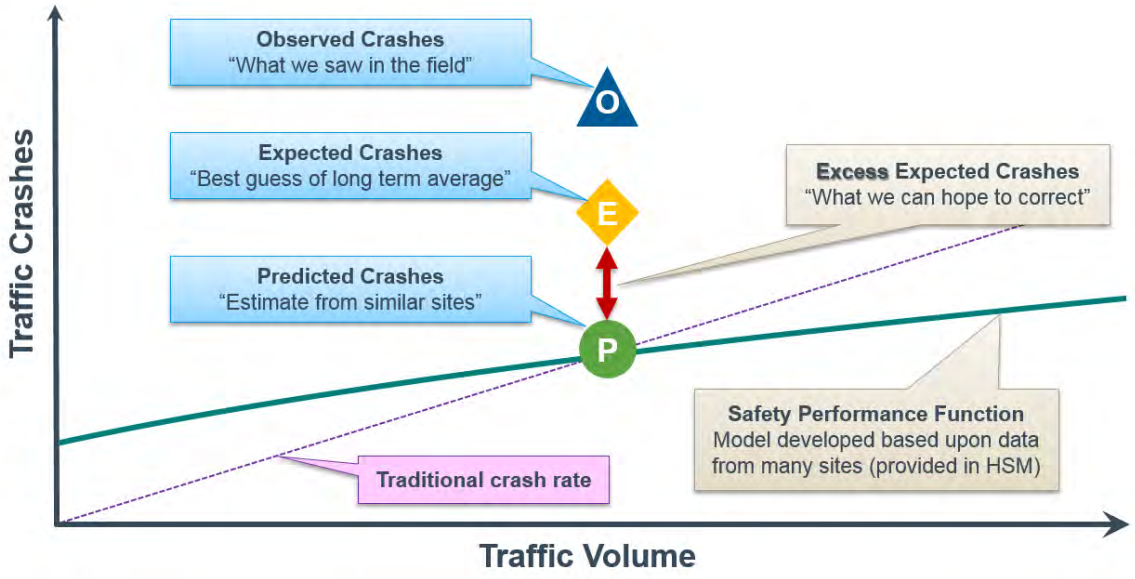
1.2.4. Benefits of the *Highway Safety Manual* Methodology

A traditional safety analysis examines the observed crash data and applies a linear interpolation to forecast future conditions given projected traffic growth. This often results in an overly simplified conclusion that crashes are correlated primarily to traffic volumes. Although traffic volumes do influence crashes, it is not the only factor. By comparing facilities of a similar type to each other and accounting for natural variations in crash data, the HSM methodology better accounts for more factors that influence crashes.

The final results of the HSM methodology compare the expected crashes to the predicted crashes. This comparison can be used to identify if a facility has excess crashes, or more

crashes than what one would expect to see on a facility of that type. The larger the number of excess crashes, the greater the opportunity to improve safety at that location. Figure 2 shows this concept in more detail.

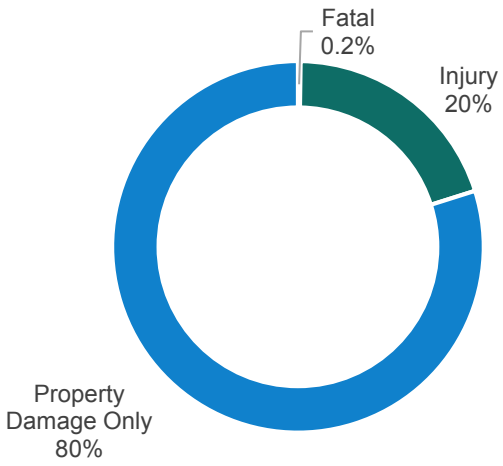
Figure 2: Empirical Bayes Methodology Overview



2. Overview of Crashes

During the three-year analysis period, there were a total of 3,034 documented crashes along the I-25 Central corridor, including those on the mainline, on the ramps, and at the ramp terminals. This total includes seven fatal crashes (0.2 percent), 604 injury crashes (20 percent), and 2,423 property damage only (PDO) crashes (80 percent). A summary of the crash severity is shown in Figure 3.

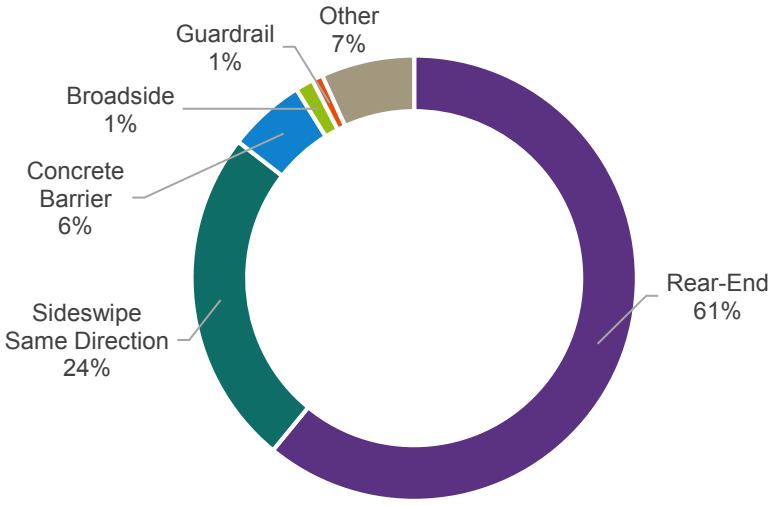
Figure 3: Crash Severity



Note: Percentages may not add up to 100 due to rounding.

The most common crash types observed included rear-end collisions (61 percent), sideswipes by vehicles moving in the same direction (24 percent), concrete barrier collisions (6 percent), broadside crashes (1 percent), and colliding with the guardrail (1 percent). The remaining crashes (7 percent) were a combination of other crash types, including colliding with vehicle cargo or debris, overturning, hitting the crash cushion, becoming involved in an approach turn, or other non-collision events. Figure 4 summarizes the most common crash types observed.

Figure 4: Most Common Crash Types



Crash types and severity often are influenced by the type of facility on which they occur. To better understand the crash patterns observed along the I-25 Central corridor, crash data were separated by facility type, which included mainline freeway segments, ramps, and ramp terminals. Of the total 3,034 observed crashes, 2,438 (80 percent) occurred on the mainline freeway, 425 (14 percent) occurred on ramps, and 171 (6 percent) occurred at ramp terminals. Figure 5 shows the crashes by facility type. Table 1 summarizes crashes by facility type and severity.

Figure 5: Crashes by Facility Type

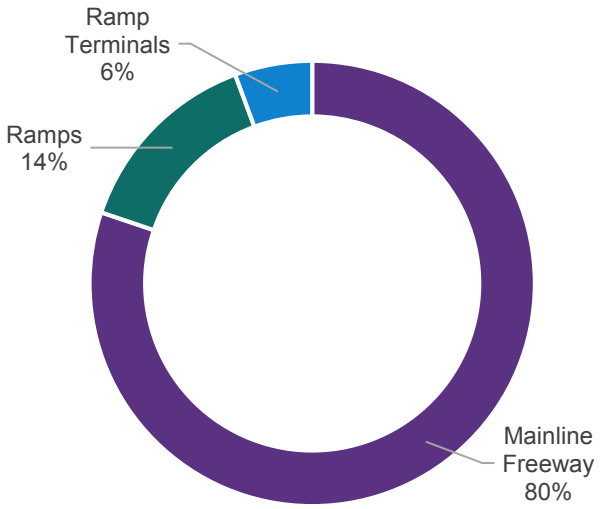


Table 1: Overall Crash Frequency by Facility

Facility	Fatal	Injury	PDO	Total
Mainline Freeway	4	473	1,961	2,438
Ramps	2	87	336	425
Ramp Terminals	1	44	126	171
Total	**7**	**604**	**2,423**	**3,034**

The specific details of each fatal crash are discussed in subsequent sections of this report. In addition, a complete record of the crash data organized by facility type is provided in the appendixes to this memorandum. These appendixes include:

- Appendix A, Mainline Crash Data
- Appendix B, Ramp Crash Data
- Appendix C, Ramp Terminal Crash Data
- Appendix D, HSM Results

2.1. Inconsistencies During the Data Collection Period

During the three years for which crash data were collected and analyzed, numerous roadside activities may have influenced crash patterns. Most of these activities—such as road repaving, landscaping work, or other general maintenance—represent typical activities and, therefore, do not adversely skew the crash data. However, some activities that do not represent typical conditions, such as major construction work, did occur; these atypical activities may have an impact on crash pattern results identified in this study.

Because only three years of crash data were analyzed as part of this study, no correlation between these construction activities and their potential impact has been made. Furthermore, use of the HSM methodology, which works to normalize a short range of temporal data

collection into a longer-term trend, reduces the amount by which these abnormal conditions influence the overall results. However, these activities are listed and described to record their occurrence and should be considered when interpreting the crash analysis results.

2.1.1. US 85/Santa Fe Drive Interchange Construction

During 2013 and the summer of 2014, major construction activities at the I-25 and US 85/ Santa Fe Drive interchange disrupted traffic flow on I-25 and the surrounding ramps. Activities that most impacted I-25 and potentially affected crash patterns include:

- The new northbound US 85/Santa Fe Drive to northbound I-25 ramp was opened in January of 2013. Although the new ramp was the same type of ramp as the old ramp (both were/are flyover ramps), the new ramp brought traffic in from the right side whereas the old ramp brought traffic in on the left side of the mainline.
- The northbound and southbound US 85/Santa Fe Drive ramps to southbound I-25 were closed from the start of the crash data collection period (January 2013) until late 2013. During this time, on-ramp traffic was diverted to Broadway.
- The northbound I-25 off-ramp to US 85/Santa Fe Drive was temporarily realigned multiple times throughout 2013.
- Between early 2013 and fall of 2013, the mainline of southbound I-25 had lane shifts to temporarily use the same bridge structure as northbound I-25 while the southbound structure was resurfaced.
- Prior to August 2013, the northbound I-25 mainline had some additional curves through the US 85/Santa Fe Drive interchange. During construction, lanes were reduced from 12 to 11 feet to accommodate construction of new wall structures.

2.1.2. US 6 Interchange Construction

Between 2013 and 2015, the US 6 interchange with I-25 was reconstructed. A majority of the activities were focused on US 6 between I-25 and Knox Court and, therefore, resulted in few major activities on I-25. Construction activities on I-25 resulted in mostly temporary lane closures—primarily done during off-peak travel times—as well as a few major freeway closures in August of 2014. Additionally, between the fall of 2013 and the spring of 2015, the northbound I-25 ramp to westbound US 6 experienced extended closures and temporary configurations to accommodate construction needs.

3. Mainline Freeway Crashes

As discussed in Section 1.2.2, CDOT maintains its own set of SPFs for freeway segments that are calibrated to local conditions. Outputs from the CDOT SPFs consist of crashes per mile per year, which represents the expected crashes for a given facility in any year. These expected crashes for specific facility types are reported in the form of level of service of safety (LOSS).

LOSS compares the facility being studied to other, similar facilities in Colorado. Elements of similar facilities would include those that are comparable in terms of daily traffic volumes, access control, urban or rural character, terrain, and geometry. By comparing one facility to others of a similar type, the LOSS methodology can help identify if the corridor is operating

better or worse than expected, or as expected. This information then can be used to help identify locations with the greatest opportunity to improve safety.

LOSS is measured on a scale from one to four with a lower LOSS value correlating to better safety. A description of each LOSS category is provided below.

LOSS I—a facility with a crash frequency and typical crash severity below the 20th percentile among similar facilities. This type of facility has a low potential for crash reductions.

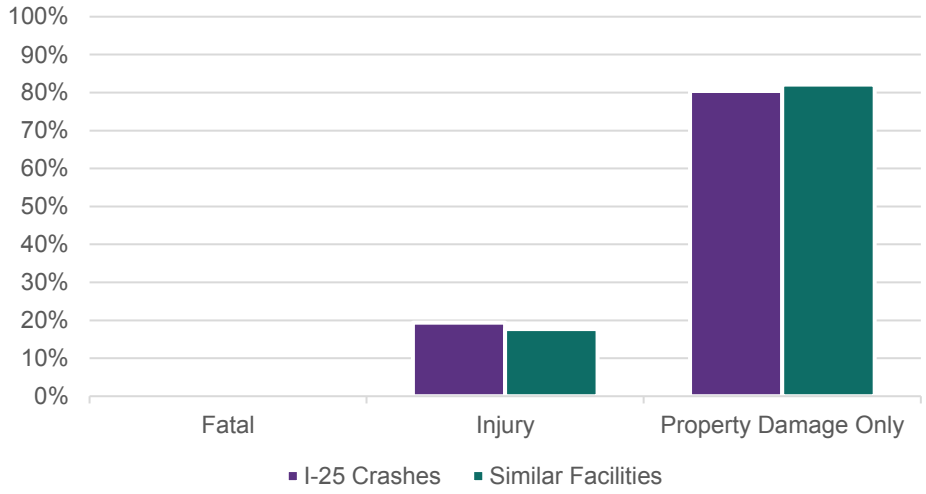
LOSS II—a facility with a crash frequency and typical crash severity between the 20th percentile and the mean among similar facilities. This type of facility has a low to moderate potential for crash reduction.

LOSS III—a facility with a crash frequency and typical crash severity between the mean and the 80th percentile among similar facilities. This category indicates a moderate to high potential for crash reduction.

LOSS IV—a facility with a crash frequency and typical crash severity above the 80th percentile among similar facilities. This type of facility has a high potential for crash reduction.

During the three years for which data were analyzed, there were a total of 2,438 crashes on the mainline freeway. Of these crashes, four (0.16 percent) resulted in a fatality, 473 (19 percent) resulted in an injury, and 1,961 (80 percent) had only property damage. Comparing these numbers to other eight-lane freeway facilities with average annual daily traffic (AADT) counts greater than 222,000 shows that there are slightly more injury crashes than average on this portion of I-25. Figure 6 shows both the observed mainline freeway crash severity and the statewide average for similar facilities.

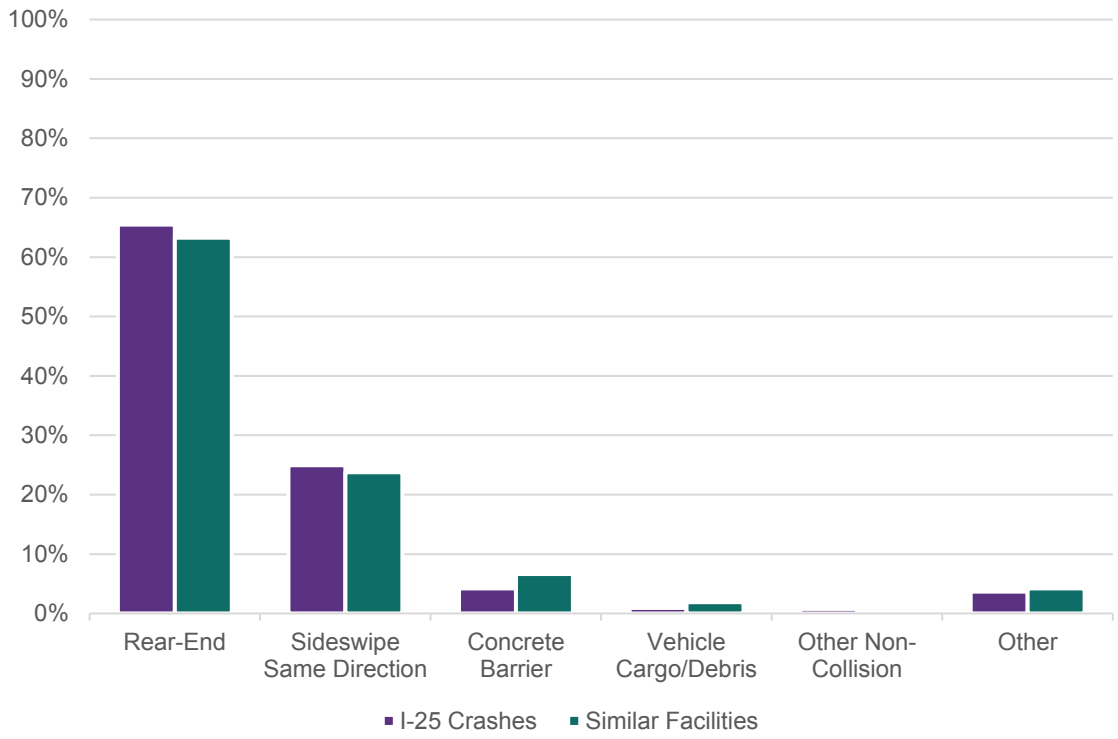
Figure 6: Mainline Freeway Crashes by Severity



The most common crash types observed on the mainline freeway include rear-end collisions (65 percent), sideswipes by cars going in the same direction (25 percent), collisions with the concrete barrier (4 percent), colliding with vehicle cargo/debris (1 percent), and other non-collision incidents (1 percent). The remaining crashes (4 percent) are a combination of other

crash types. This crash type distribution closely parallels the crash types of similar facilities. The primary difference is the 3 percent fewer concrete barrier crashes on I-25 Central than on similar facilities. Additionally, the fifth most common crash type on I-25 Central is other non-collision incidents, which represents 1 percent of crashes, whereas this crash type ranks 11th for similar facilities and typically represents 0.2 percent of crashes. Figure 7 shows the mainline freeway crashes on I-25 Central, as well as the average freeway crash types for similar facilities in the state.

Figure 7: Mainline Freeway Crashes by Type



To perform a more detailed analysis of mainline freeway crashes, I-25 was divided into four segments, which were analyzed individually. These segments include I-25 between:

- 20th Street and Speer Boulevard (Segment 1)
- Speer Boulevard and Colfax Avenue (Segment 2)
- Colfax Avenue and US 6 (Segment 3)
- US 6 and US 85/Santa Fe Drive (Segment 4)

3.1. Segment 1: 20th Street to Speer Boulevard

Segment 1 extends from 20th Street to Speer Boulevard, approximately 0.6 mile, and has an ADT of approximately 242,000 vpd. Over the three years for which data were analyzed, a total of 321 crashes occurred on this segment of I-25, or 13 percent of all the mainline freeway crashes. These crashes included 67 injury crashes and 254 PDO crashes. There were no fatalities on this segment within the three-year analysis period. Compared to similar

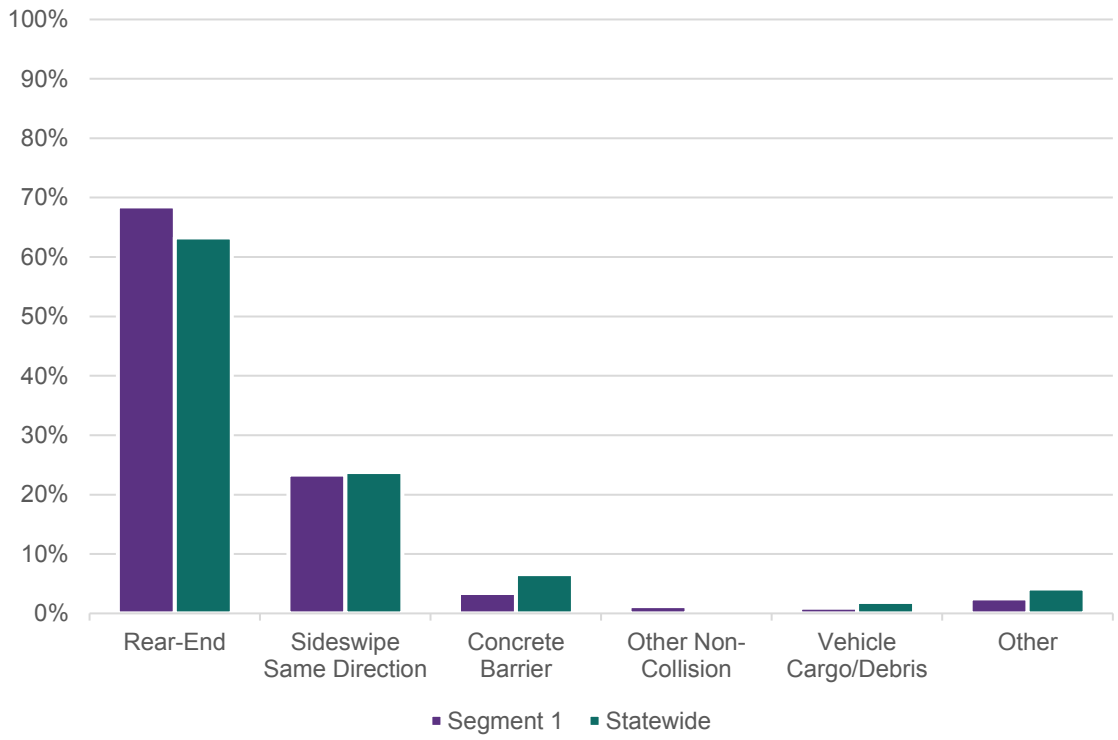
facilities, this freeway segment has slightly more injury crashes than the average. Table 2 compares the observed crashes on this segment to similar facilities.

Table 2: Segment 1 Crashes by Severity

	Fatal	Injury	PDO
Observed	0.0%	20.9%	79.1%
Statewide Average	0.2%	17.7%	82.1%
Difference	-0.2%	+3.2%	-3.0%

The most common crash types in this segment include rear-end collisions and sideswipes by vehicles moving in the same direction. Rear-end crashes occurred about 6 percent more frequently than the statewide average, whereas sideswipe same direction crashes occurred at approximately the average rate. Figure 8 summarizes the most common crash types within this segment and compares them to statewide averages for similar facilities.

Figure 8: Segment 1 Crash Types Compared to Statewide Averages



Based on an ADT of 242,000 vpd, CDOT SPFs predict a total of approximately 120 crashes per mile per year, with about 21 of them being injury or fatality crashes. Using this information, expected crashes for Segment 1 were calculated to be approximately 180 total crashes per mile per year, with 37 being injury or fatality crashes. Table 3 summarizes the observed, predicted, and expected crashes for Segment 1.

Table 3: Segment 1 Observed, Predicted, and Expected Crashes

	Observed Crashes per Mile per Year	Predicted Crashes per Mile per Year	Expected Crashes per Mile per Year	Excess Crashes per Mile per year
Total Crashes	180.4	120.0	179.9	59.9
Fatal and Injury Crashes	37.2	21.4	36.6	15.2

Applying the LOSS methodology to this segment shows that it falls into the LOSS IV category. This means that this portion of I-25 experiences more crashes than 80 percent of similar facilities. When examining only the fatal and injury crashes, Segment 1 also is categorized as LOSS IV. Figure 9 and Figure 10 show the Segment 1 LOSS results for all crashes and for fatal and injury crashes.

Figure 9: Segment 1 LOSS

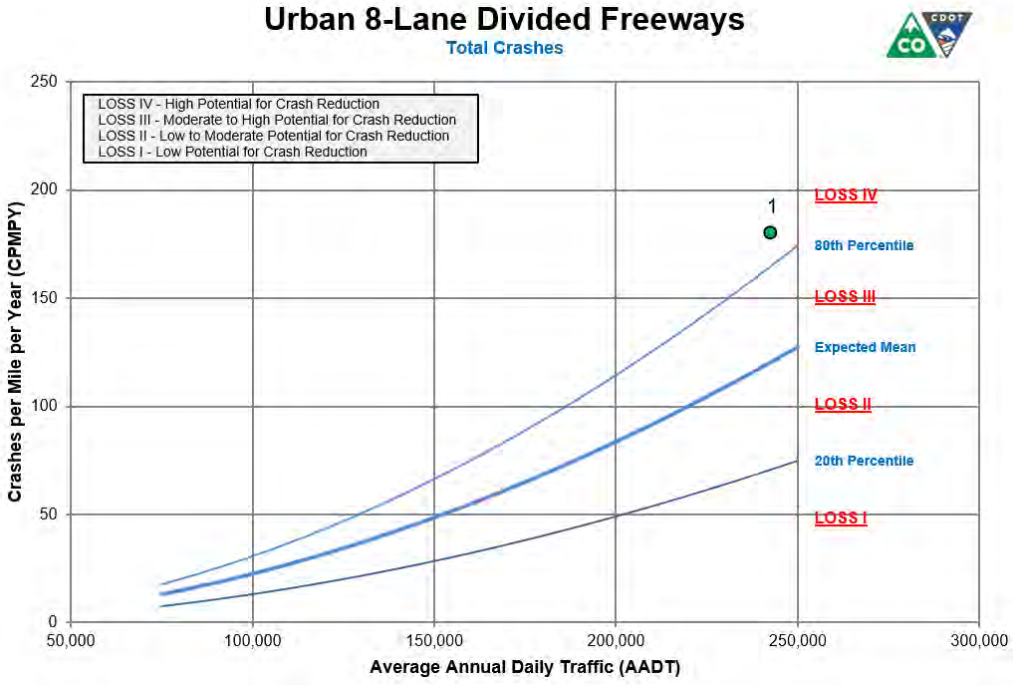
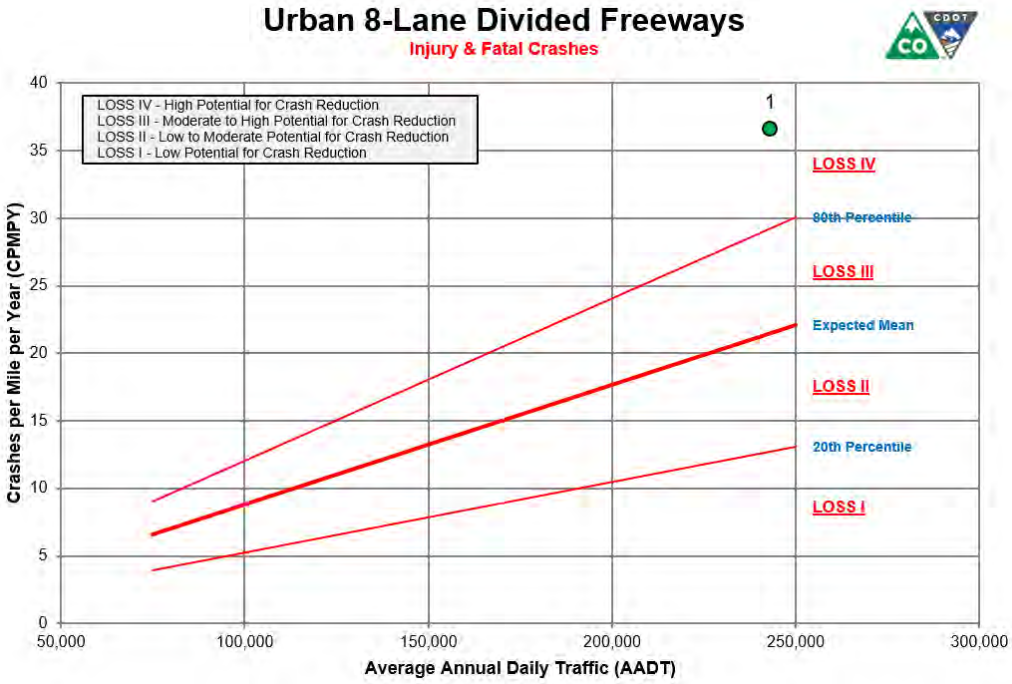


Figure 10: Segment 1 Fatality and Injury LOSS



3.2. Segment 2: Speer Boulevard to Colfax Avenue

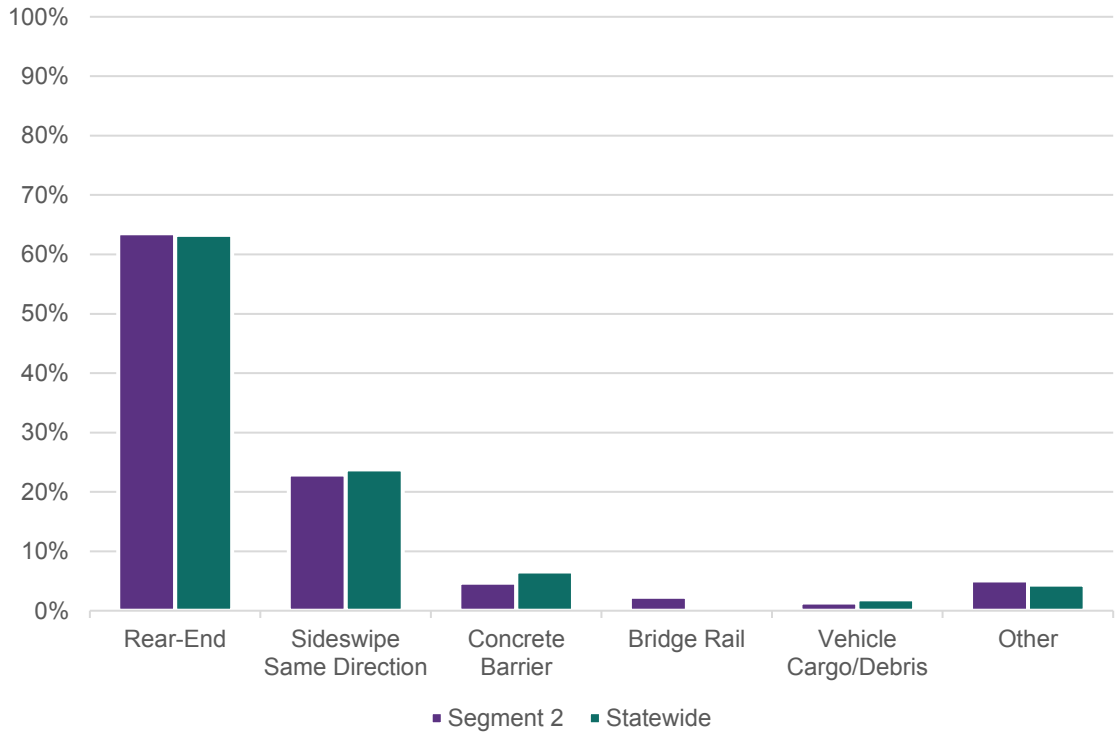
Segment 2 extends from Speer Boulevard to Colfax Avenue, approximately 1.2 miles, and has an ADT of approximately 224,000 vpd. Over the three years for which data were analyzed, a total of 510 crashes occurred on this segment of I-25, or 21 percent of all the mainline freeway crashes. These crashes included 99 injury crashes and 411 PDO crashes. There were no fatalities on this segment within the three-year analysis period. Compared to similar facilities, this freeway segment has slightly more injury crashes than the average. Table 4 compares the observed crashes on this segment to similar facilities.

Table 4: Segment 2 Crashes by Severity

	Fatal	Injury	PDO
Observed	0.0%	19.4%	80.6%
Statewide Average	0.2%	17.7%	82.1%
Difference	-0.2%	+1.7%	-1.5%

The most common crash types in this segment include rear-end crashes and sideswipes moving in the same direction. Both crash types occurred at a rate about average for similar facilities. Figure 11 summarizes the most common crash types within this segment and compares them to statewide averages.

Figure 11: Segment 2 Crash Types Compared to Statewide Averages



It should be noted that this segment of the corridor has low-clearance bridges—bridges with vertical clearances less than the CDOT standard of 16.5 feet—at 23rd Avenue and Speer Boulevard. Over the three years for which data were analyzed, these low-clearance bridges resulted in four bridge strikes. In all four cases, the bridges required repairs.

Based on an ADT of 224,000 vpd, CDOT SPFs predict a total of approximately 104 crashes per mile per year, with about 20 of them being injury or fatality crashes. Using this information, expected crashes for Segment 2 were calculated to be approximately 145 total crashes per mile per year, with 28 being injury or fatality crashes. Table 5 summarizes the observed, predicted, and expected crashes for Segment 2.

Table 5: Segment 2 Observed, Predicted, and Expected Crashes

	Observed Crashes per Mile per Year	Predicted Crashes per Mile per Year	Expected Crashes per Mile per Year	Excess Crashes per Mile per year
Total Crashes	145.0	103.8	144.6	40.8
Fatal and Injury Crashes	28.1	19.8	27.6	7.8

Applying the LOSS methodology to this segment shows that it falls into the LOSS IV category for both total crashes and fatal and injury crashes. This means that this portion of I-25 is in the 80th percentile for the total number of crashes as compared to similar facilities. Figure 12

and Figure 13 show the Segment 2 LOSS results for total crashes and fatal and injury crashes, respectively.

Figure 12: Segment 2 LOSS

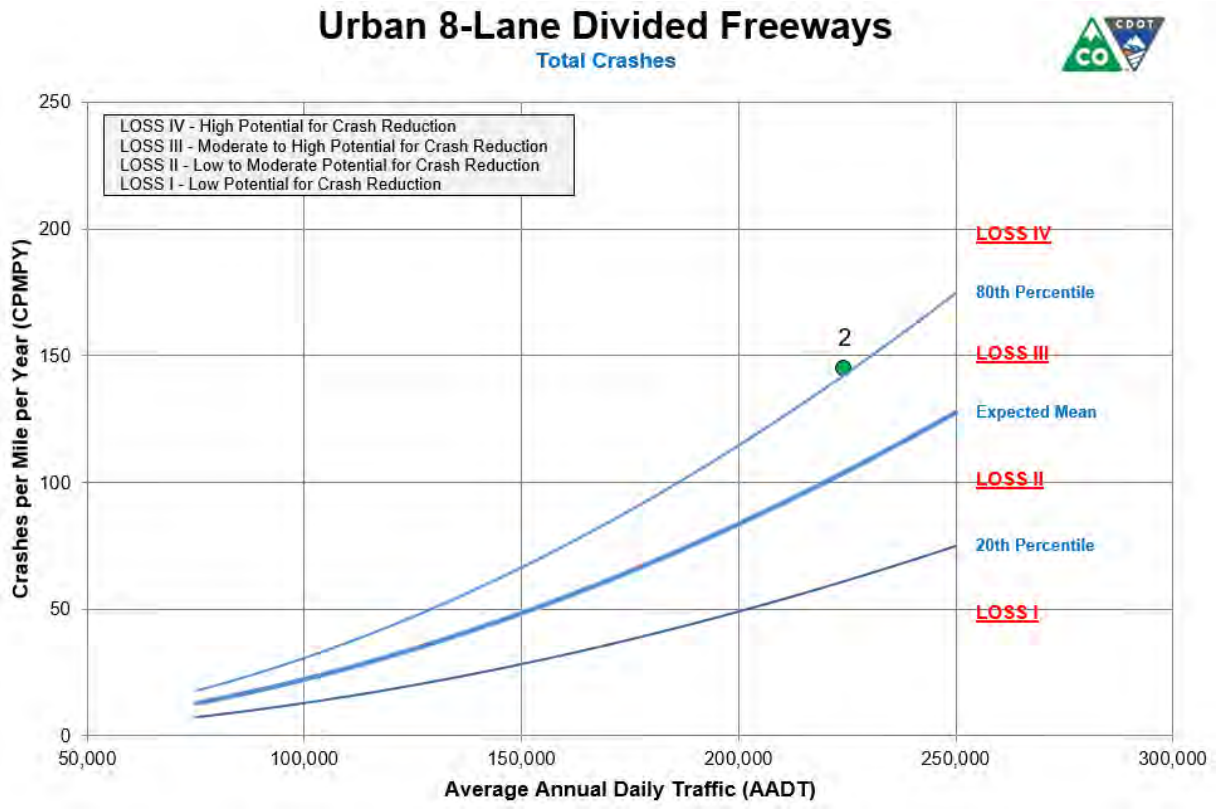
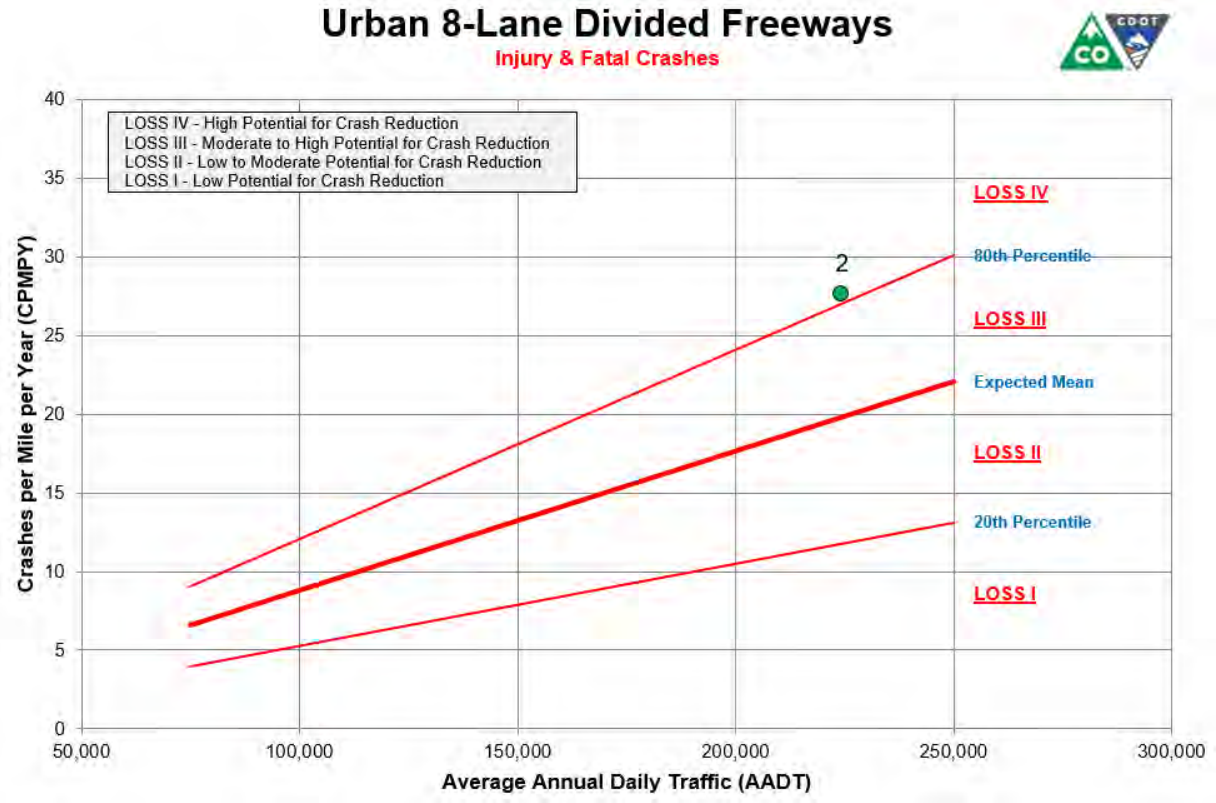


Figure 13: Segment 2 Fatality and Injury LOSS



3.3. Segment 3: Colfax Avenue to US 6

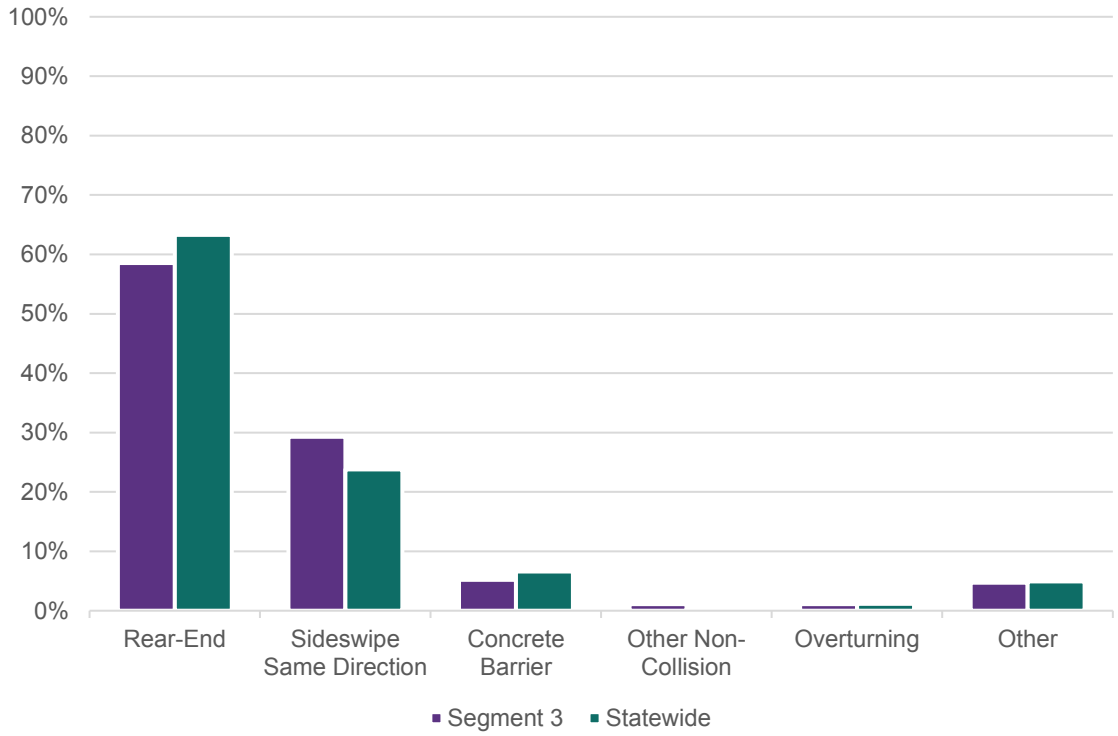
Segment 3 extends from Colfax Avenue to US 6, approximately 1.0 mile, and has an ADT of approximately 248,000 vpd. Over the three years for which data were analyzed, a total of 444 crashes happened on this segment of I-25, or 18 percent of all the mainline freeway crashes. These crashes included 367 PDO crashes, 74 injury crashes, and 3 fatal crashes. Compared to similar facilities, this freeway segment has slightly more fatal and PDO crashes than the average. Table 6 compares the observed crashes on this segment to similar facilities.

Table 6: Segment 3 Crashes by Severity

	Fatal	Injury	PDO
Observed	0.7%	16.7%	82.7%
Statewide Average	0.2%	17.7%	82.1%
Difference	+0.5%	-1.0%	+0.6%

The most common crash types in this segment include rear-end crashes, sideswipes with vehicles moving in the same direction, and concrete barrier crashes. Both rear-end and concrete barrier crashes occurred at a rate lower than the average for similar facilities, but sideswipe same direction crashes were 5 percent higher than the statewide average for similar facilities. Figure 14 summarizes the most common crash types within this segment and compares them to statewide averages for similar facilities.

Figure 14: Segment 3 Crash Types Compared to Statewide Averages



The three fatal crashes that occurred on this freeway segment included an overturning, a pedestrian, and a sideswipe same direction type crash. A brief description of each fatal crash is discussed below.

MP 209.45; January 11, 2014; 4:19 p.m. A southbound motorcycle overturned under dry, dusk conditions.

MP 210.16; April 13, 2014; 2:26 a.m. A pedestrian under the influence of alcohol or drugs was struck in the northbound direction on the highway under dry, dark-lighted conditions.

MP 210.31; December 24, 2015; 1:50 a.m. A southbound passenger vehicle sideswiped another car under dry, dark-lighted conditions.

Based on an ADT of 248,000 vpd, CDOT SPFs predict a total of approximately 125 crashes per mile per year, with approximately 22 of them being injury or fatality crashes. Using this information, expected crashes for Segment 3 were calculated to be approximately 146 total crashes per mile per year, with 25 being injury or fatality crashes. Table 7 summarizes the observed, predicted, and expected crashes for Segment 3.

Table 7: Segment 3 Observed, Predicted, and Expected Crashes

	Observed Crashes per Mile per Year	Predicted Crashes per Mile per Year	Expected Crashes per Mile per Year	Excess Crashes per Mile per year
Total Crashes	146.1	125.3	146.0	20.7
Fatal and Injury Crashes	25.7	21.9	25.1	3.2

Applying the LOSS methodology to this segment shows that it falls into the LOSS III category for both total crashes and fatal and injury crashes. This means that this portion of I-25 is above the expected mean for crashes as compared to similar facilities. Figure 15 and Figure 16 show the Segment 3 LOSS results for total crashes and fatal and injury crashes respectively.

Figure 15: Segment 3 LOSS

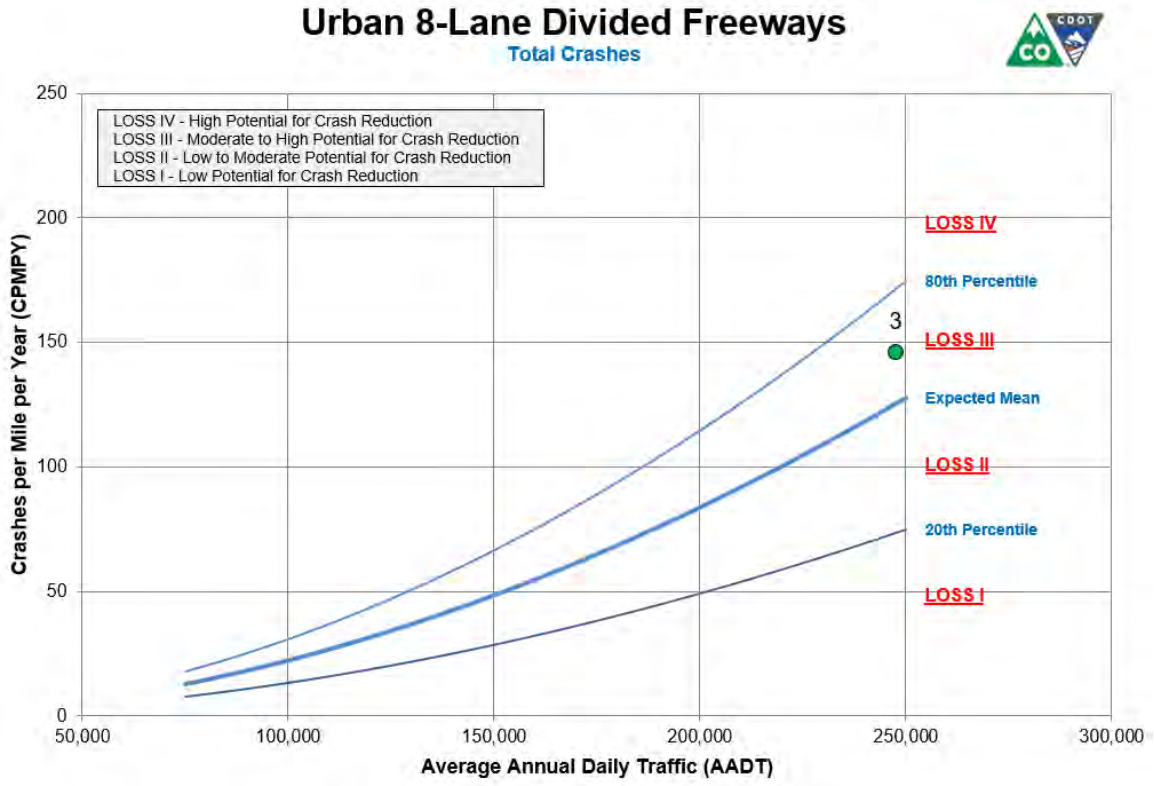
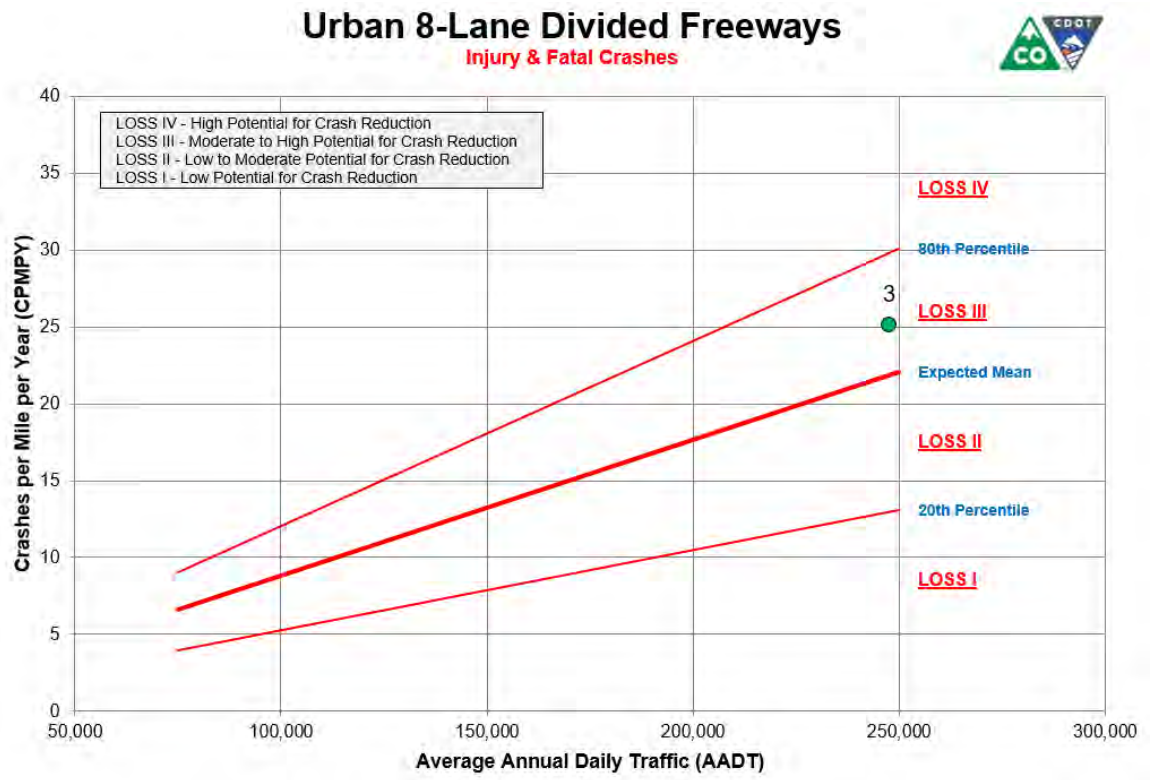


Figure 16: Segment 3 Fatality and Injury LOSS



3.4. Segment 4: US 6 to US 85/Santa Fe Drive

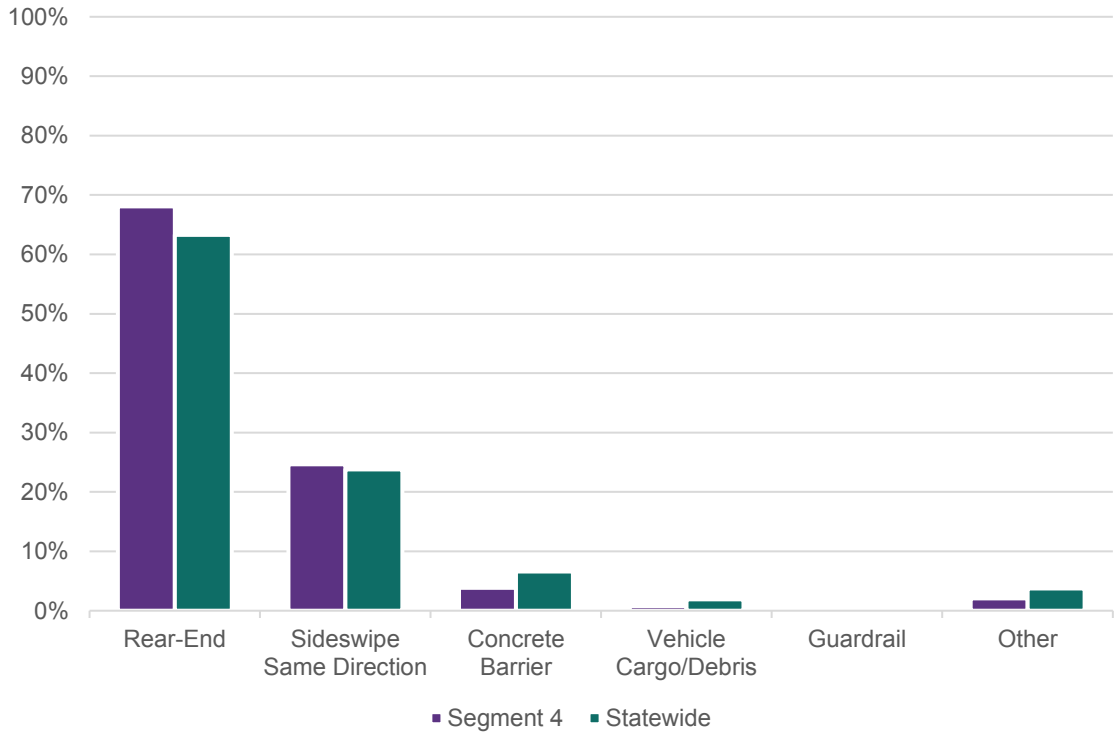
Segment 4 extends from US 6 to US 85/Santa Fe Drive, approximately 1.7 miles, and has an ADT of approximately 244,000 vpd. Over the three years for which data were analyzed, a total of 1,163 crashes occurred on this segment of I-25, or 48 percent of all the mainline freeway crashes. These crashes included 929 PDO crashes, 233 injury crashes, and one fatal crash. This freeway segment has more injury crashes than other, similar facilities. Table 8 compares the observed crashes on this segment to similar facilities.

Table 8: Segment 3 Crashes by Severity

	Fatal	Injury	PDO
Observed	0.1%	20.0%	79.9%
Statewide Average	0.2%	17.7%	82.1%
Difference	-0.1%	2.3%	-2.2%

The most common crash types in this segment include rear-end collisions, sideswipes by vehicles moving in the same direction, and concrete barrier crashes. Both rear-end and sideswipe same direction crashes occurred more frequently than similar facilities. Figure 17 summarizes the most common crash types within this segment and compares them to statewide averages for similar facilities.

Figure 17: Segment 4 Crash Types Compared to Statewide Averages



The single fatal crash that occurred on this segment over the three-year analysis involved a motorcycle overturning on a treated icy road in dark-lighted conditions at milepost 208.8. This crash occurred on December 2, 2015, at 4:18 a.m.

Based on an ADT of 244,000 vpd, CDOT SPFs predict a total of approximately 122 crashes per mile per year, with about 22 of them being injury or fatality crashes. Using this information, expected crashes for Segment 4 were calculated to be approximately 229 total crashes per mile per year, with 44 being injury or fatality crashes. Table 9 summarizes the observed, predicted, and expected crashes for Segment 4.

Table 9: Segment 4 Observed, Predicted, and Expected Crashes

	Observed Crashes per Mile per Year	Predicted Crashes per Mile per Year	Expected Crashes per Mile per Year	Excess Crashes per Mile per year
Total Crashes	232.3	121.9	228.5	106.6
Fatal and Injury Crashes	46.7	21.5	43.9	22.4

Applying the LOSS methodology to this segment shows that it falls into the LOSS IV category for both total crashes and fatal and injury crashes. This means that this portion of I-25 is in the 80th percentile for crashes as compared to similar facilities. Figure 18 and Figure 19 show the Segment 3 LOSS results for total crashes and fatal and injury crashes, respectively.

Figure 18: Segment 4 LOSS

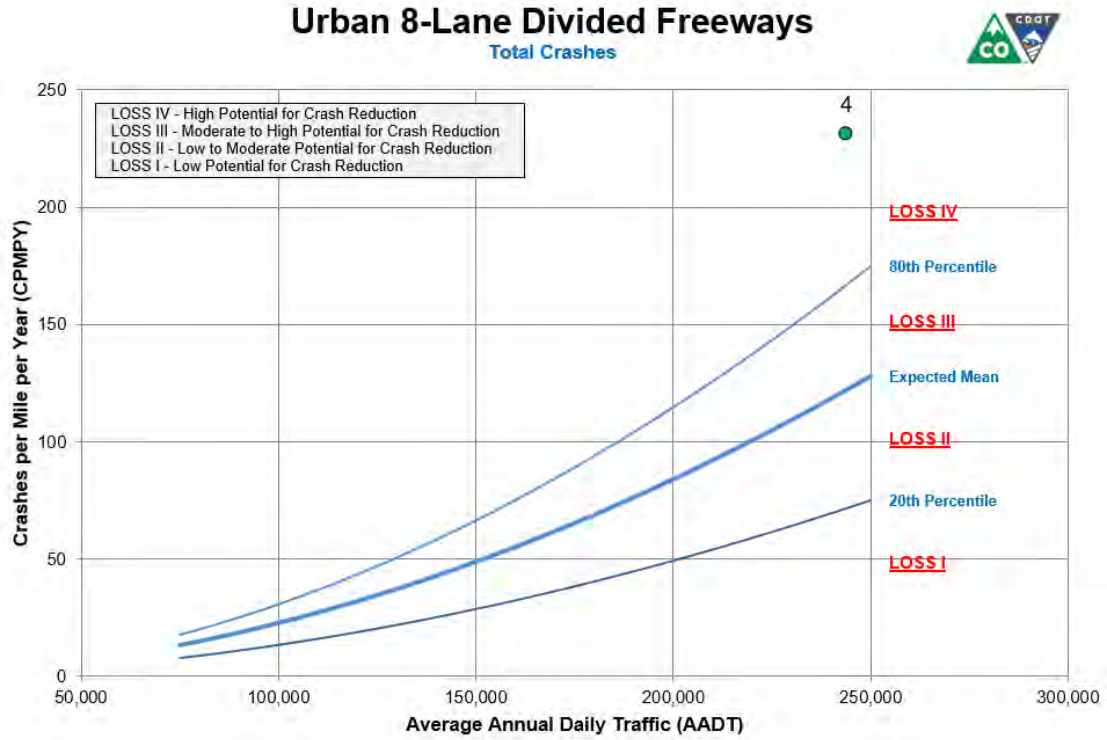
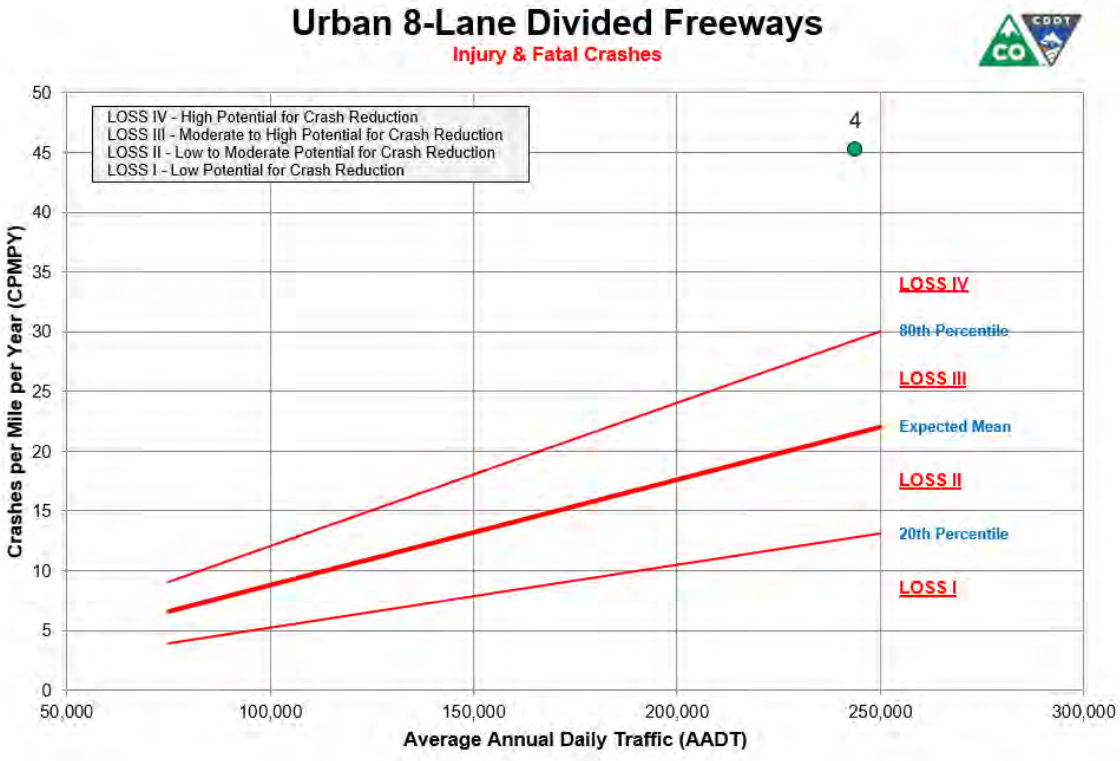


Figure 19: Segment 4 Fatality and Injury LOSS



3.5. Interpretation of Mainline Analysis

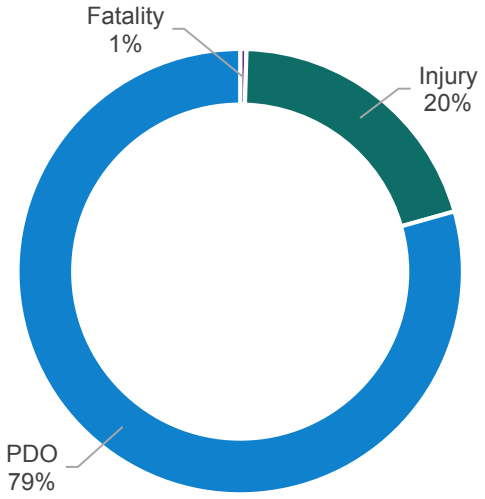
In general, crashes are occurring more frequently on the I-25 Central mainline freeway segments than for other similar facilities in Colorado. This is indicated by the analysis of all four mainline freeway segments being categorized as LOSS III or LOSS IV. These determinations indicate that there is a high potential to reduce crashes on this portion of I-25.

Overall crash patterns on the mainline freeway segments match those of similar facilities in Colorado, with most of the crashes being rear-end or sideswipe same direction crashes. Although exact causes of crashes are influenced by numerous factors, rear-end crashes typically are correlated to congestion. Congestion causes drivers to stop in areas where other drivers may not be expecting them to, such as the back of a queue or in stop-and-go traffic conditions. Similarly, sideswipe same direction crashes usually are correlated to merging and weaving areas, especially in congested conditions. Anytime vehicles are required to change lanes, there is an increased likelihood of a sideswipe same direction type crash occurring. This chance is exacerbated in locations where merging and/or weaving segments may be short in length, or where vehicles are required to change multiple lanes to get on or off the mainline.

4. Ramp Crashes

A total of 425 crashes occurred on ramps within the I-25 Central study area. Of these crashes, two (1 percent) resulted in a fatality, 87 (20 percent) resulted in an injury, and 336 (79 percent) had only property damage. As discussed in Section 1.2.2, CDOT does not maintain SPFs for ramps; therefore, no comparison to similar facilities in the state of Colorado can be made. Figure 20 shows the observed ramp crashes by severity.

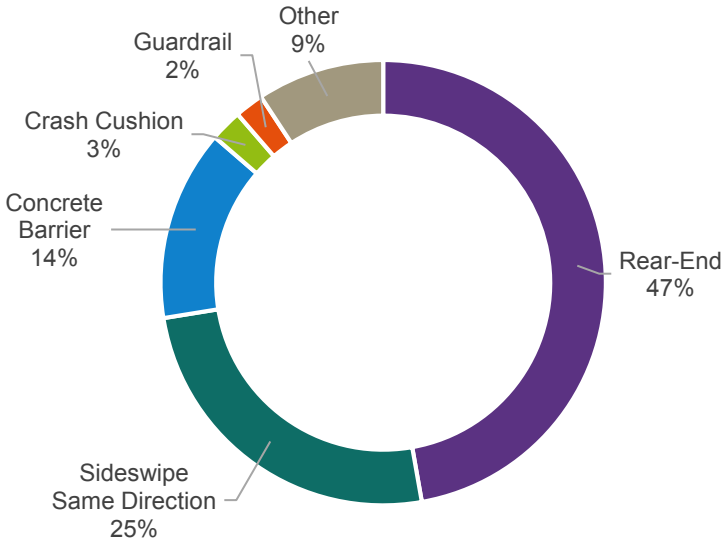
Figure 20: Ramp Crashes by Severity



The most common crash types observed on ramps include rear-end collisions (47 percent), sideswipes by vehicles moving in the same direction (25 percent), concrete barrier crashes (14 percent), crash cushion collisions (3 percent), and guardrail crashes (2 percent). The

remaining crashes (9 percent) are a combination of other crash types. Figure 21 summarizes the ramp crash types.

Figure 21: Ramp Crashes by Type



By applying default SPFs from the HSM, predicted and expected crash values were calculated for each ramp. These calculations show that, overall, ramps along the I-25 Central corridor experience more fatal and injury crashes than would be predicted for similar facilities across the country. Table 10 shows the observed, predicted, and expected crashes for ramps along the I-25 Central corridor. Individual ramp segments are discussed below by interchange.

Table 10: Ramp Segment Observed, Predicted, and Expected Crashes

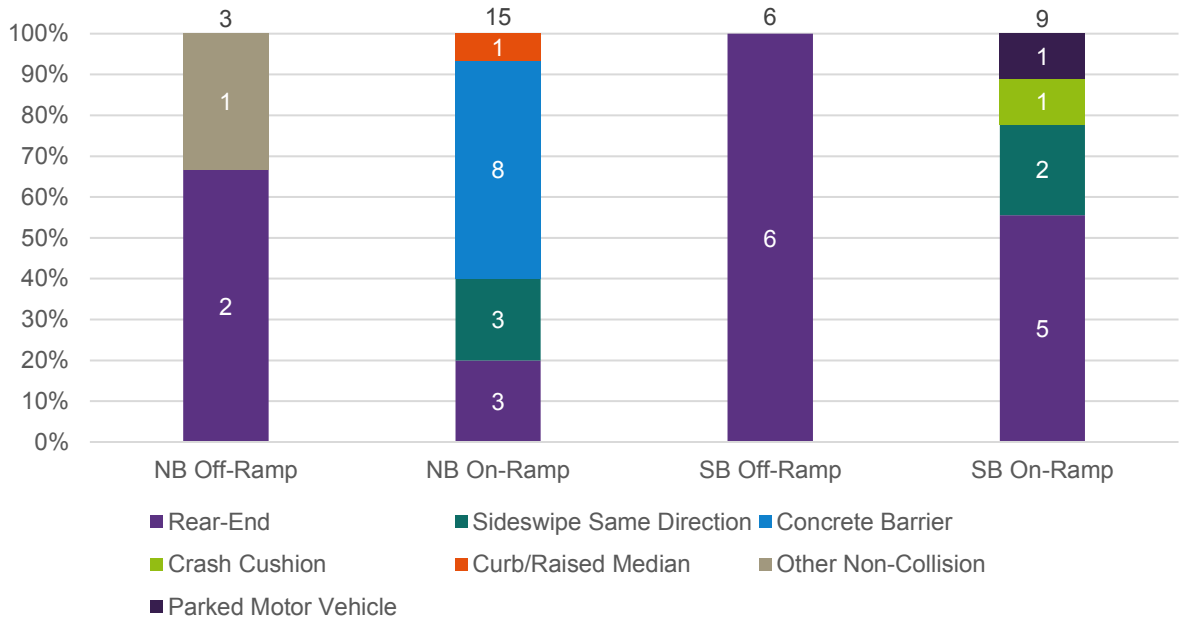
	PDO Crashes per Year	Fatal and Injury Crashes per year	Total Crashes per Year
Observed	112.0	29.7	141.7
Predicted	34.9	20.3	55.2
Expected	43.4	15.9	59.3
Excess Crashes	+8.5	-4.4	+4.1

4.1. 20th Street Interchange

The 20th Street interchange is a traditional diamond interchange and has one on-ramp and one off-ramp for each direction of travel on I-25. This results in a total of four ramps. Over the three-year analysis period, there were 21 PDO crashes, 11 injury crashes, and 1 fatal crash—adding to a total of 33 crashes across all four ramps. The most common crash types were rear-end collisions, concrete barrier impacts, and sideswipe same directions. The only ramp for which rear-end crashes did not represent the majority crash type was the northbound on-

ramp. The majority of crashes at this ramp were comprised of concrete barrier crashes. Figure 22 shows the crash types for each ramp.

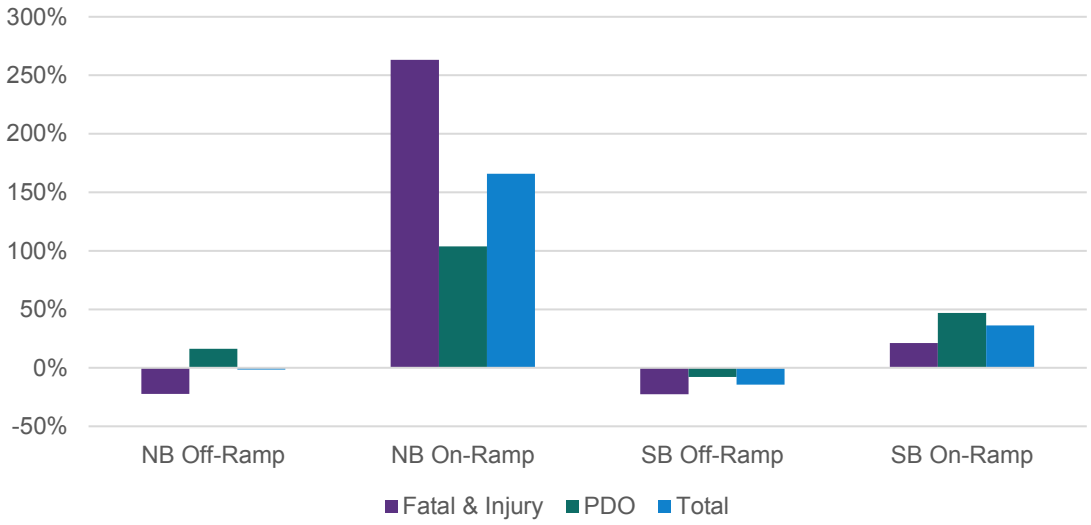
Figure 22: 20th Street Interchange Crash Types by Ramp



Over the three years for which data were analyzed, there was one fatal crash on the northbound on-ramp from 20th Street. This crash occurred on December 27, 2013, at 1:08 a.m. and involved a single passenger car crashing into the concrete barrier under dry, dark-lighted conditions.

The results of the HSM analysis show the northbound on-ramp having the highest number of excess crashes. This analysis predicts this ramp should have 0.538 crashes per year, but expects 1.431 crashes per year. This is an excess of 0.893 crashes per year, or 166 percent more crashes than predicted. Figure 23 shows the percent difference between the predicted and expected crashes for each of the 20th Street ramps. A full list of the observed, predicted, and expected crashes for these ramps can be found in Appendix B.

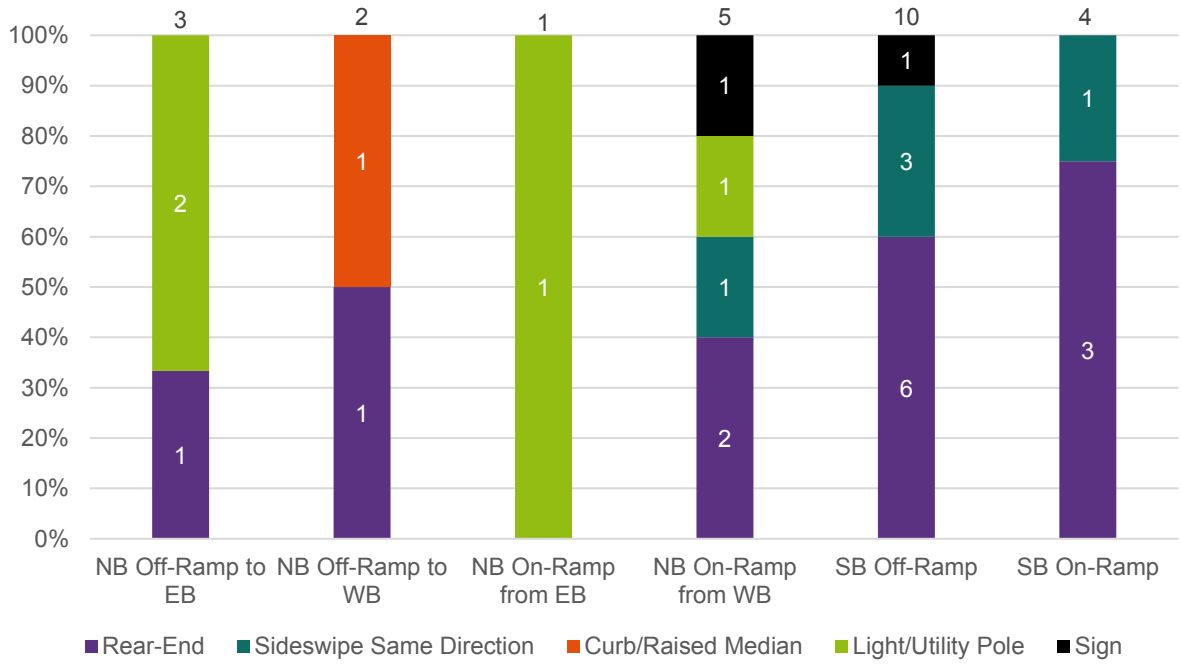
Figure 23: Percent of Excess Crashes at the 20th Street Ramps



4.2. Speer Boulevard Interchange

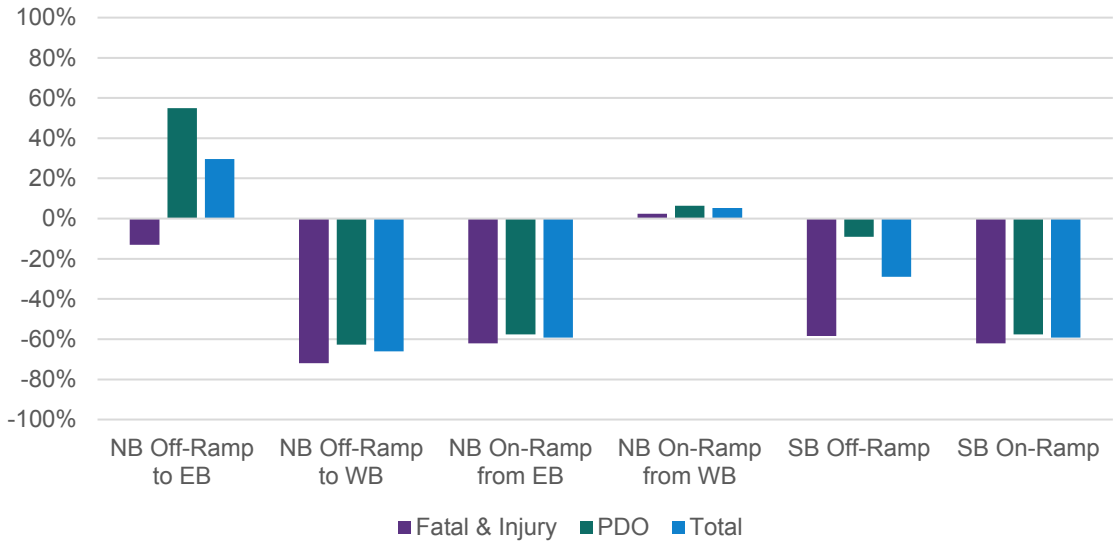
The Speer Boulevard interchange is a partial cloverleaf with a total of six ramps. Over the three-year analysis period, a total of 25 crashes (22 PDO and three injury) occurred across all ramps. The most common crash types were rear-end collisions, sideswipes by vehicles moving in the same direction, and impacts with light/utility poles. Figure 24 shows the crash types for each ramp.

Figure 24: Speer Boulevard Interchange Crash Types by Ramp



The results of the HSM analysis show the northbound off-ramp to eastbound Speer Boulevard having the highest number of excess crashes. This analysis predicts this ramp should have 0.260 crashes per year, but expects 0.337 crashes per year. This is an excess of 0.077 crashes per year, or 30 percent more crashes than predicted. Figure 25 shows the percent difference between the predicted and expected crashes for each of the Speer Boulevard ramps. A full list of the observed, predicted, and expected crashes for these ramps can be found in Appendix B.

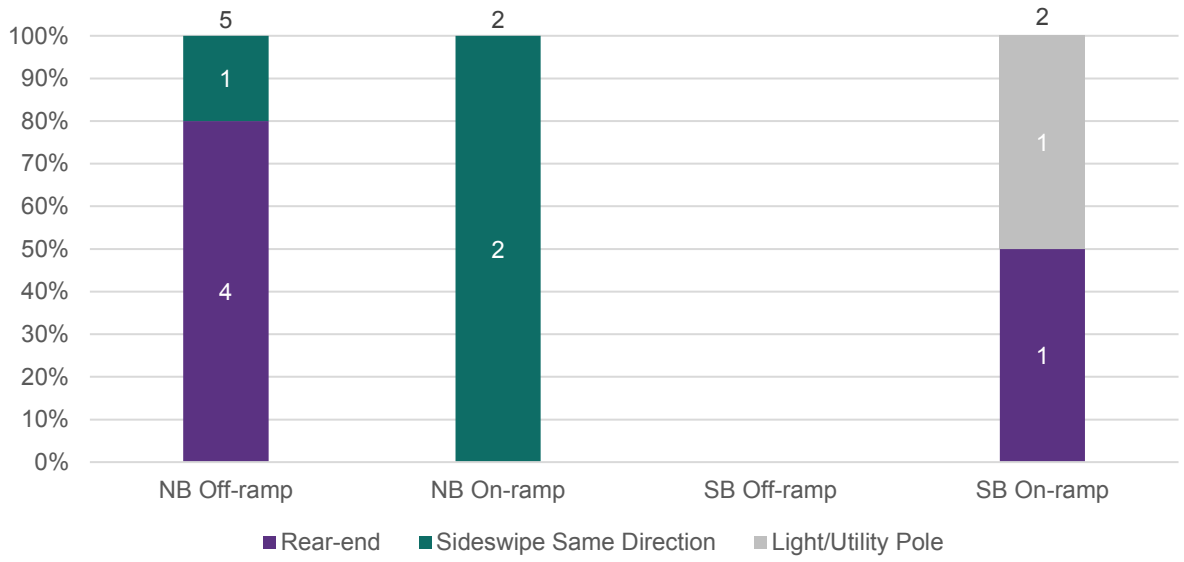
Figure 25: Percent of Excess Crashes at the Speer Boulevard Ramps



4.3. 23rd Avenue Interchange

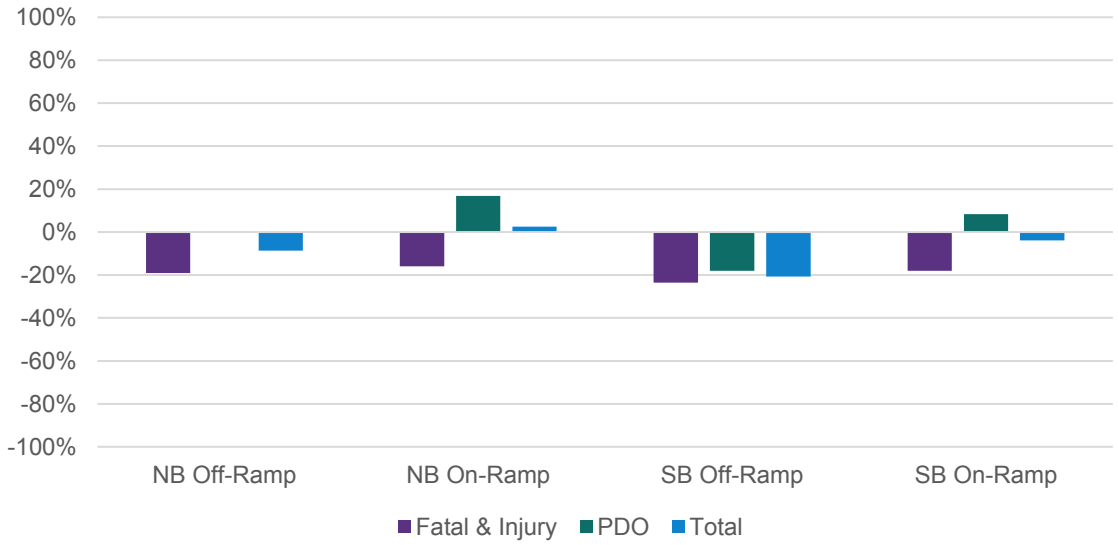
The 23rd Avenue interchange is a traditional diamond interchange and has a total of four ramps. Over the three-year analysis period, a total of nine crashes (eight PDO, and one injury) happened across all ramps. The only three crash types observed on these ramps were rear-end crashes, sideswipes by vehicles moving in the same direction, and impacts with light/utility poles. Figure 26 shows the crash types for each ramp. It should be noted that there were no crashes observed on the southbound off-ramp over the three years for which data were collected.

Figure 26: 23rd Avenue Interchange Crash Types by Ramp



The results of the HSM analysis show most of the ramps at this interchange performing better than predicted. Figure 27 shows the percent difference between the predicted and expected crashes for each of the 23rd Avenue ramps. A full list of the observed, predicted, and expected crashes for these ramps can be found in Appendix B.

Figure 27: Percent of Excess Crashes at the 23rd Avenue Ramps



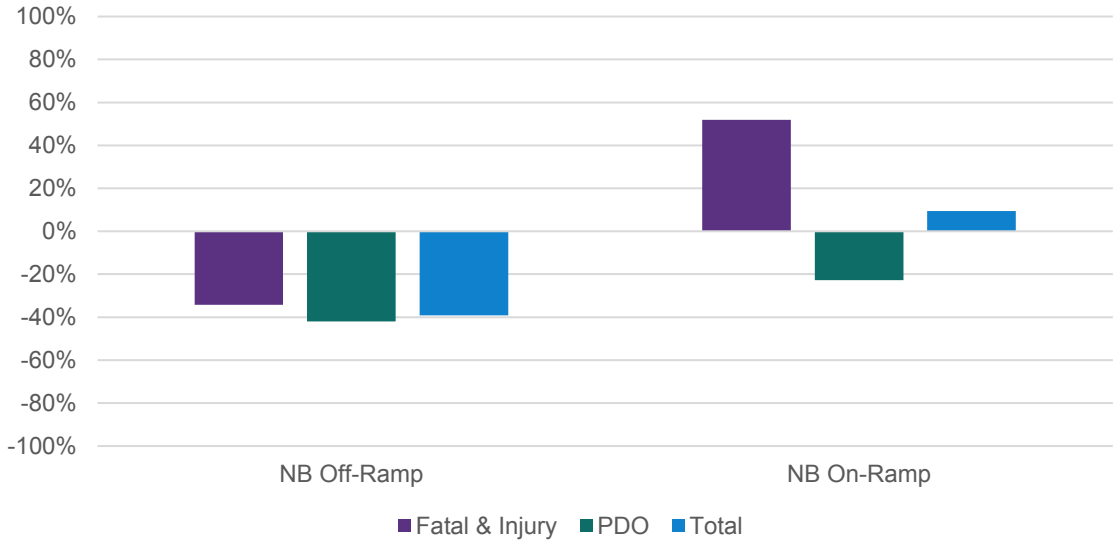
4.4. 17th Avenue Interchange

The 17th Avenue interchange is a half diamond interchange and has a total of two ramps. Over the three-year analysis period, a total of two crashes (one PDO and one injury)

happened, both of which occurred on the northbound on-ramp. One of these was a rear-end crash and the other was a collision with a fence.

The results of the HSM analysis show the northbound off-ramp at this interchange performs better than predicted, but the northbound on-ramp has more injury and fatality crashes than predicted. Figure 28 shows the percent difference between the predicted and expected crashes for each of the 17th Avenue ramps. A full list of the observed, predicted, and expected crashes for these ramps can be found in Appendix B.

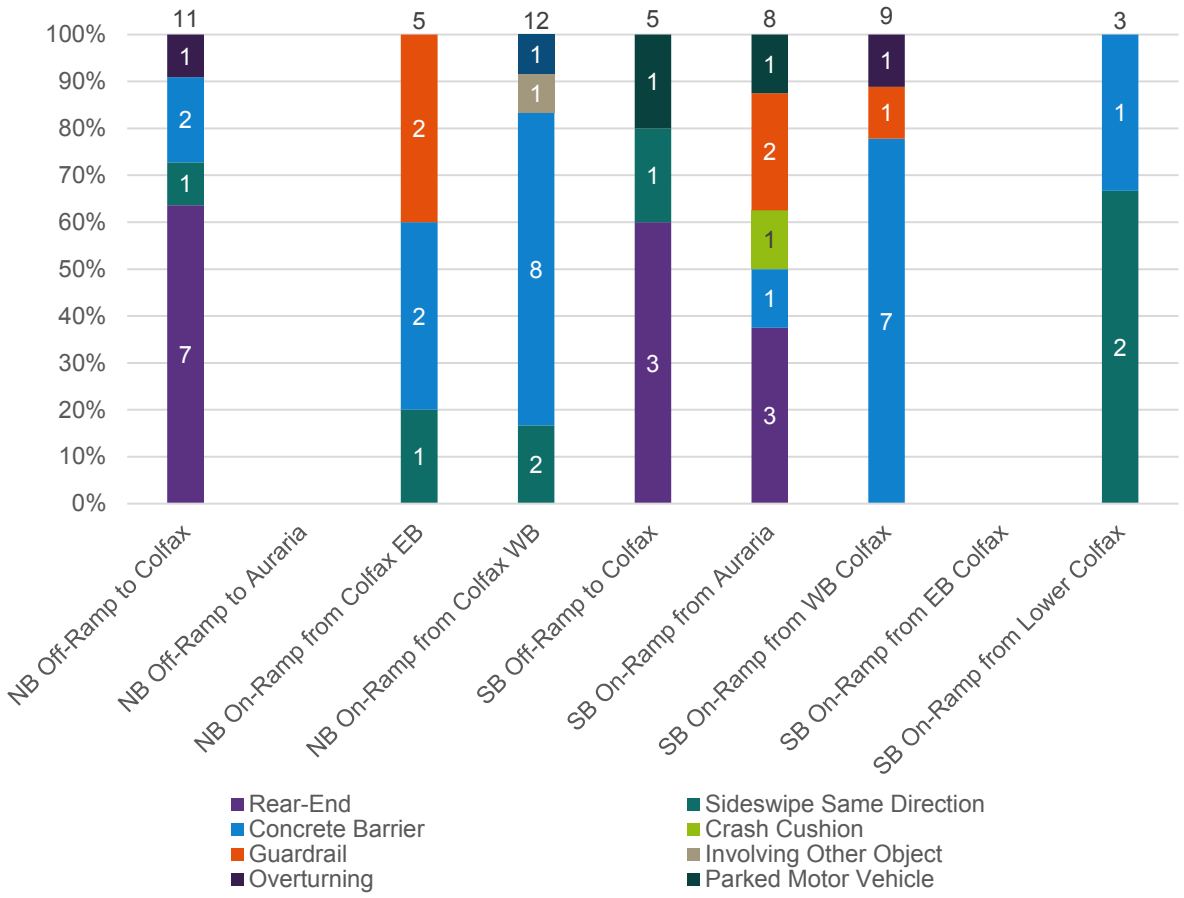
Figure 28: Percent of Excess Crashes at the 17th Avenue Ramps



4.5. Colfax Avenue/Auraria Parkway Interchange

The Colfax Avenue/Auraria Parkway interchange is a combination of directional ramps and has a total of nine ramps. Over the three-year analysis period, a total of 53 crashes (37 PDO, 15 injury, and one fatal) happened across all ramps. The most common crash types included rear-end and concrete barrier crashes. Figure 29 shows the crash types for each ramp. It should be noted that there were no crashes observed on the northbound off-ramp to Auraria Parkway or the southbound on-ramp from eastbound Colfax Avenue over the three years for which data were collected.

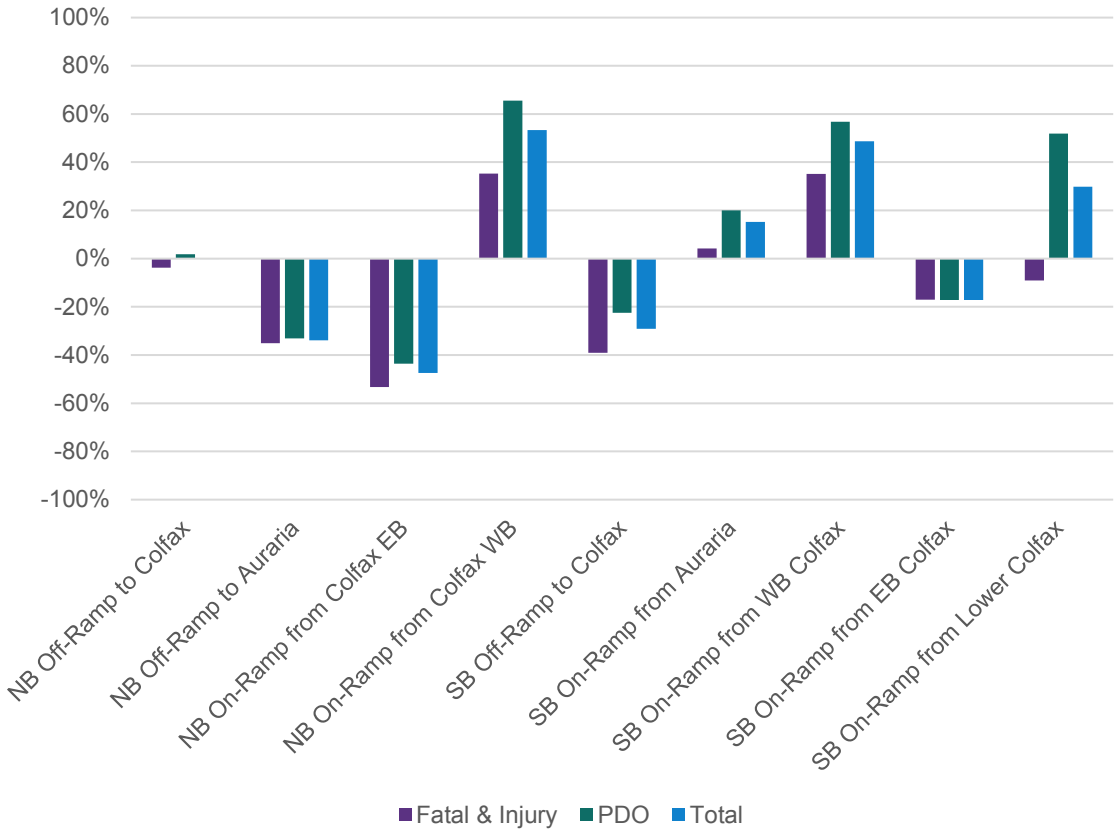
Figure 29: Colfax Avenue/Auraria Parkway Interchange Crash Types by Ramp



During the analysis period, there was one fatal crash at this interchange. It occurred on the southbound on-ramp from Lower Colfax Avenue on October 16, 2015, at 11:50 a.m. and involved a single motorcycle crashing into the crash cushion under dry, daylight conditions.

The results of the HSM analysis show the worst-performing ramps to be the northbound on-ramp from westbound Colfax Avenue, the southbound on-ramp from westbound Colfax Avenue, and the southbound on-ramp from Lower Colfax Avenue. Figure 30 shows the percent difference between the predicted and expected crashes for each of the Colfax Avenue/Auraria Parkway ramps. A full list of the observed, predicted, and expected crashes for these ramps can be found in Appendix B.

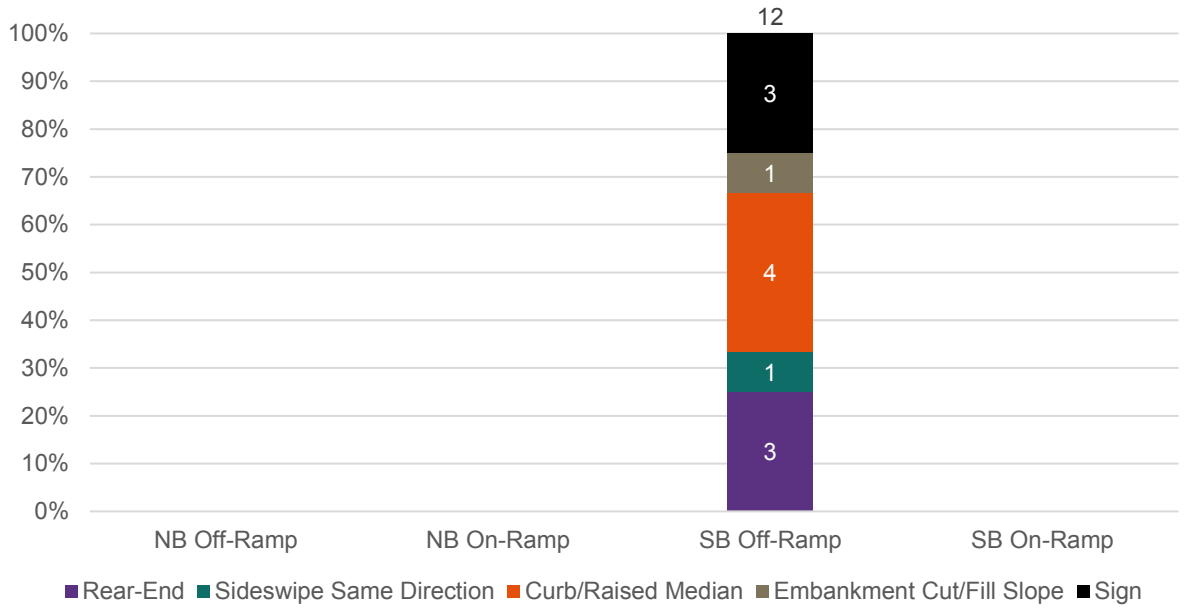
Figure 30: Percent of Excess Crashes at the Colfax Avenue/Auraria Parkway Ramps



4.6. 8th Avenue Interchange

The 8th Avenue interchange is an offset diamond interchange and has a total of four ramps. This interchange is in close proximity to the US 6 interchange, with less than 1,000 feet between the merge/diverge of the 8th Avenue ramps and the merge/diverge of the US 6 ramps. Over the three-year analysis period, a total of 12 crashes (nine PDO and three injury) occurred on the 8th Avenue interchange ramps, all of which occurred on the southbound off-ramp. The most common crash types included impacts with the curb/raised median, rear-end collisions, and sign crashes. Figure 31 shows the crash types for each ramp.

Figure 31: 8th Avenue Interchange Crash Types by Ramp



The results of the HSM analysis show that the southbound off-ramp is performing much worse than predicted. This is likely a result of the sharp right turn located at the end of this ramp. The ramp requires drivers to slow from the mainline posted speed limit of 55 mph to a speed of 15 mph to safely make the turn. Figure 32 shows the percent difference between the predicted and expected crashes for each of the 8th Avenue ramps, and Figure 33 shows an image of the southbound off-ramp configuration. A full list of the observed, predicted, and expected crashes for these ramps can be found in Appendix B.

Figure 32: Percent of Excess Crashes at the 8th Avenue Ramps

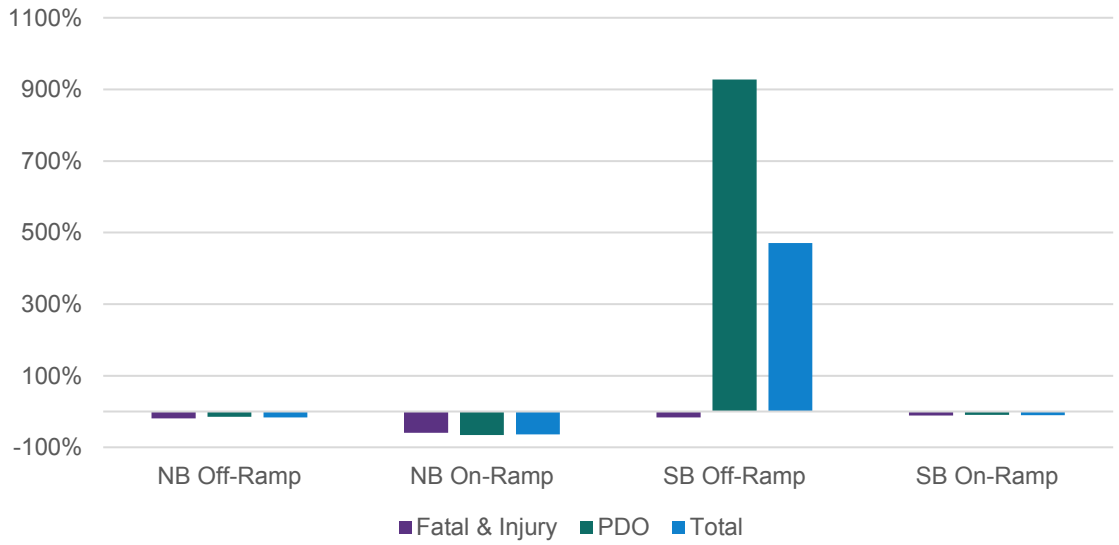


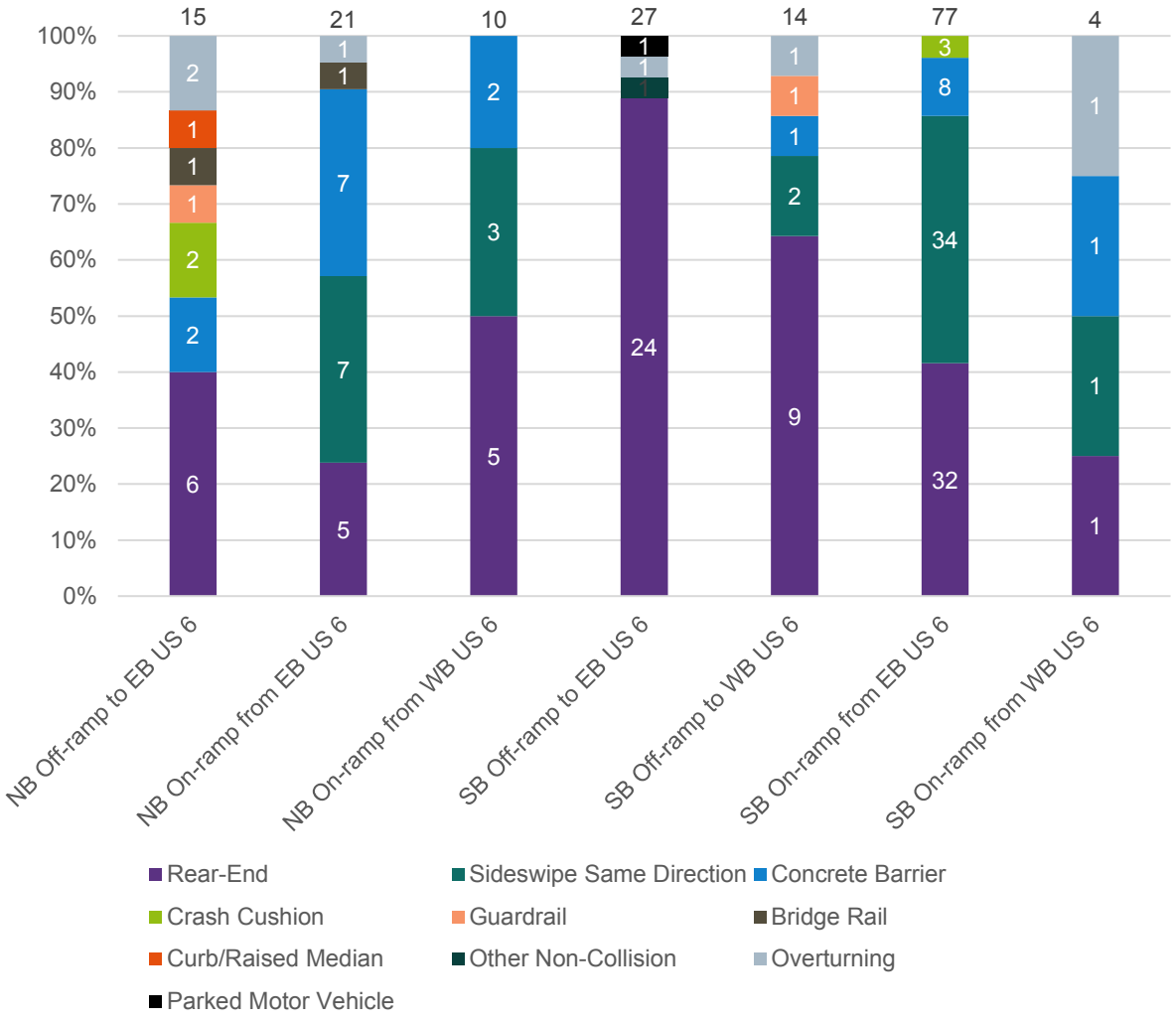
Figure 33: Southbound I-25 Off-Ramp to 8th Avenue

4.7. US 6 Interchange

The US 6 interchange is a directional ramp interchange with a total of eight ramps. It should be noted that, during this period of the crash analysis, construction at this interchange altered the geometric configuration of the northbound I-25 to westbound US 6 ramp; therefore, crash data collected for this time period is only partially reflective of the new ramp design. For consistency, this ramp was removed from the analysis.

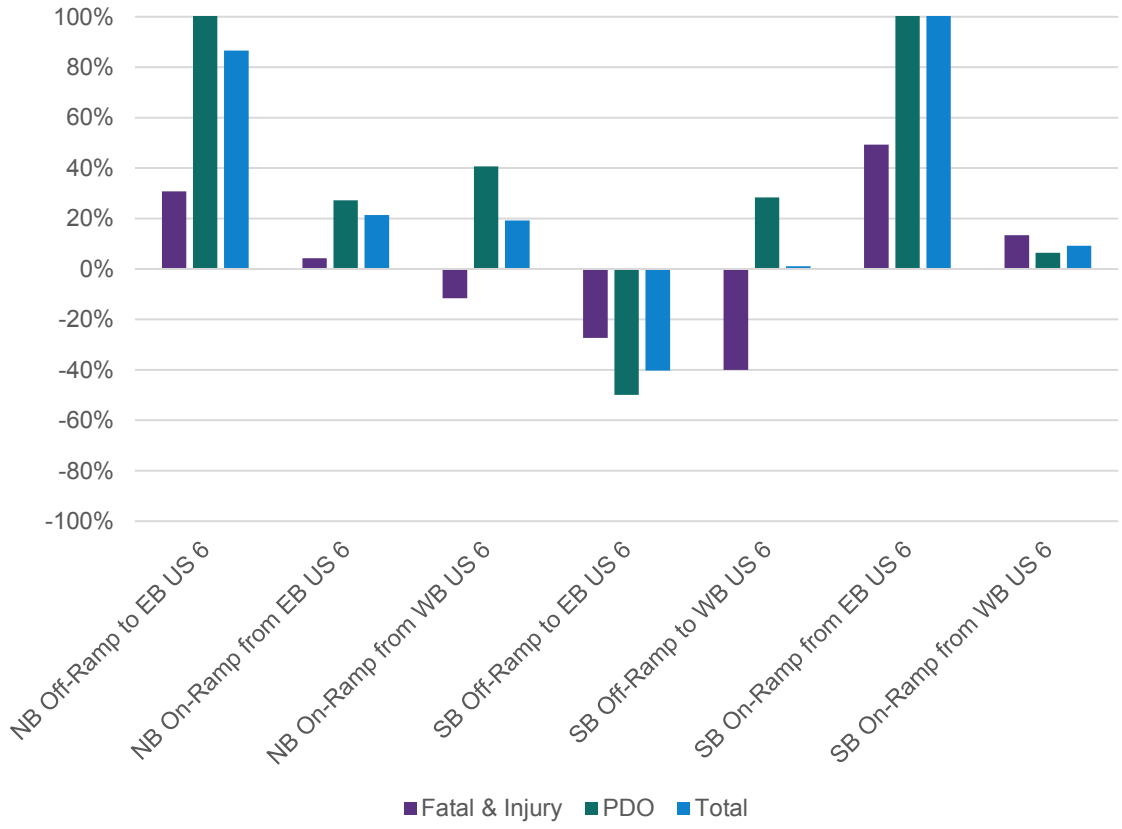
Over the three-year analysis period, a total of 168 crashes (132 PDO and 36 injury) occurred on the US 6 interchange ramps. The most common crash types included rear-end crashes, sideswipes by vehicles moving in the same direction, and concrete barrier crashes. Figure 34 shows the crash types for each ramp.

Figure 34: US 6 Interchange Crash Types by Ramp



The results of the HSM analysis show that the southbound on-ramp from eastbound US 6 and the northbound off-ramp to eastbound US 6 are performing worse than predicted. Figure 35 shows the percent difference between the predicted and expected crashes for each of the US 6 ramps. A full list of the observed, predicted, and expected crashes for these ramps can be found in Appendix B.

Figure 35: Percent of Excess Crashes at the US 6 Ramps



4.8. Alameda Avenue/Kalamath Street Interchange

The Alameda Avenue/Kalamath Street interchange is a half diamond interchange with a total of two ramps. It should be noted that, due to the geometric configuration of the northbound on-ramp from Kalamath Street, that ramp has been divided into two segments which were analyzed individually. The first segment is comprised of the ramp originating from West Cedar Avenue and continuing to the merge point with I-25. The second segment consists of the right-turn movement from southbound Kalamath Street and extends to the merge point with the primary on-ramp. Figure 36 depicts the extents of the two segments. Over the three-year analysis period, a total of 19 crashes (18 PDO and one injury) happened on these ramps. The most common crash types included sideswipes by vehicles moving in the same direction and rear-end crashes. Figure 37 shows the crash types for each ramp/ramp segment.

Figure 36: Kalamath Street On-Ramp Segments

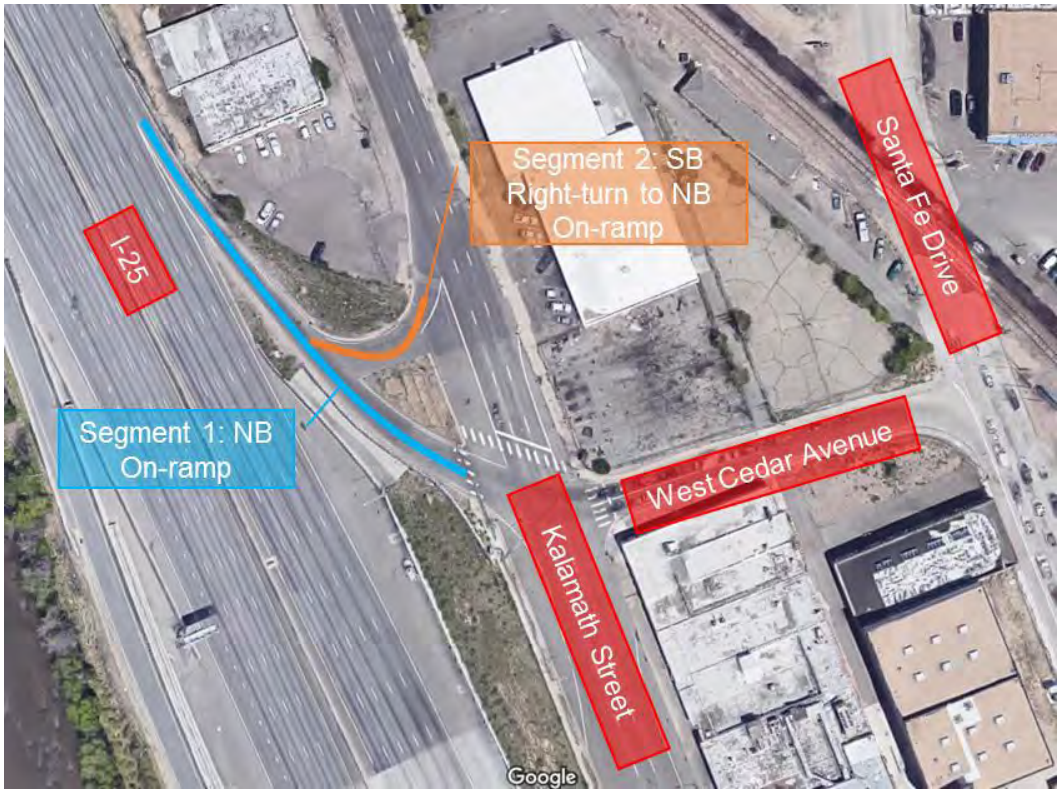
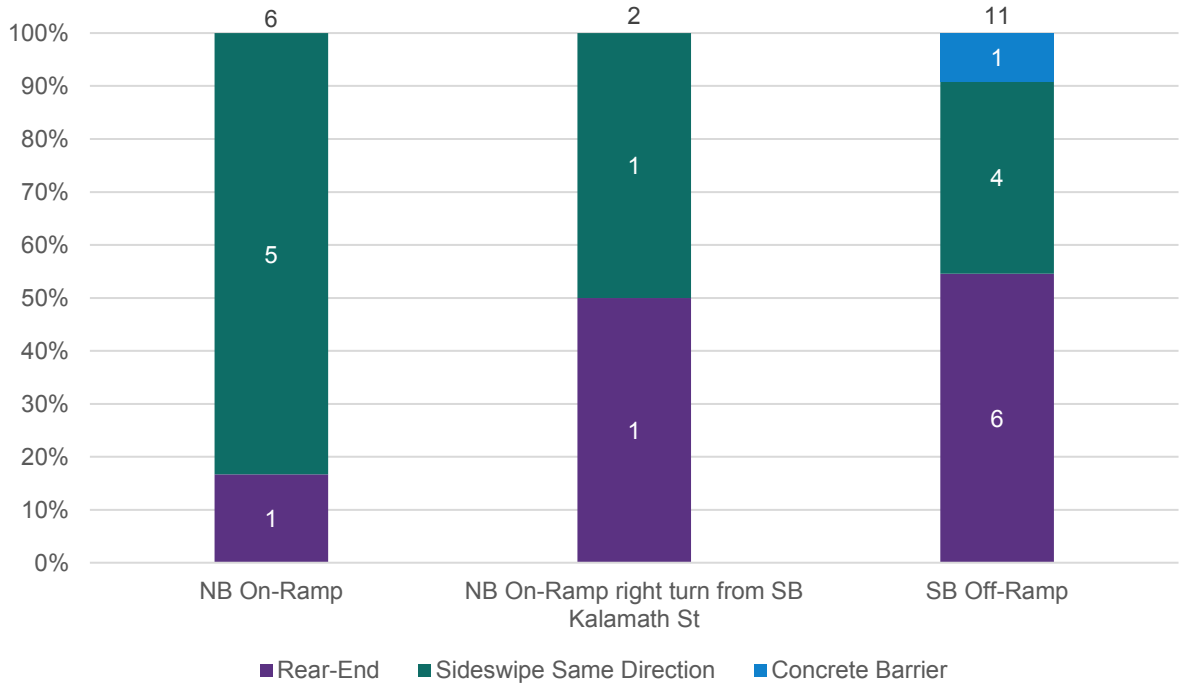
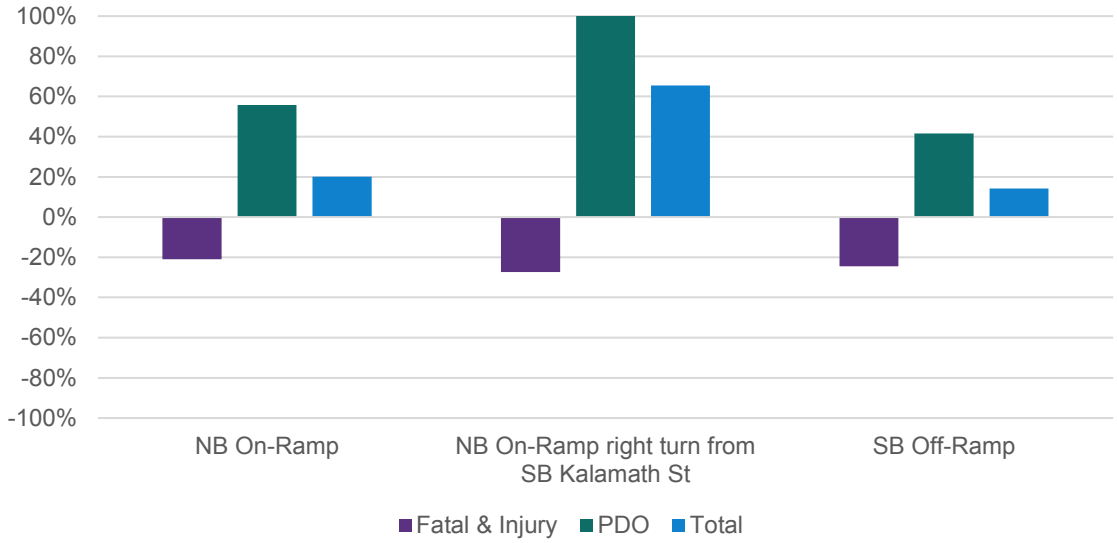


Figure 37: Alameda Avenue/Kalamath Street Interchange Crash Types by Ramp



The results of the HSM analysis show that all three ramp/ramp segments have more PDO crashes than predicted. Figure 38 shows the percent difference between the predicted and expected crashes for each of the Alameda Avenue/Kalamath Street ramps/ramp segments. A full list of the observed, predicted, and expected crashes for these ramps can be found in Appendix B.

Figure 38: Percent of Excess Crashes at the Alameda Avenue/Kalamath Street Ramps

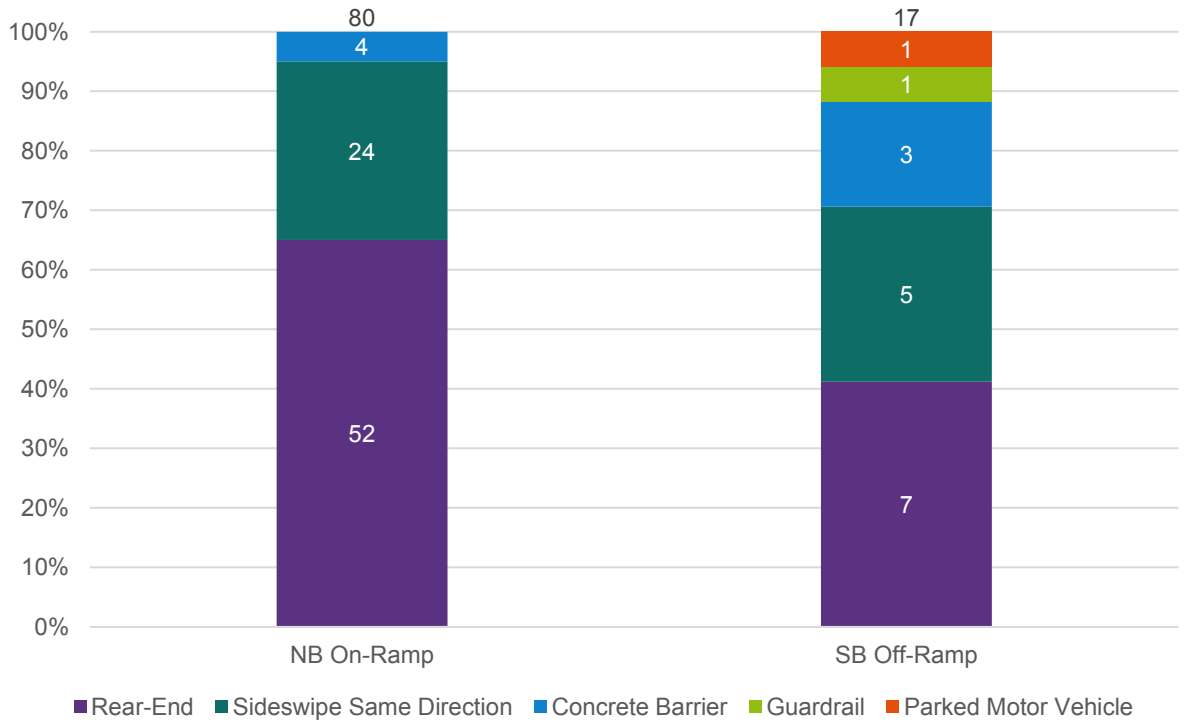


4.9. US 85/Santa Fe Drive Interchange

The US 85/Santa Fe Drive interchange is a partial single-point urban interchange (SPUI) with a flyover ramp. During the three years for which crash data were collected, this interchange was reconstructed into this new SPUI configuration. These changes invalidate the crash data collected and, therefore, no analysis could be performed for the new ramps. However, two of the ramps—the ramp from northbound US 85/Santa Fe Drive to northbound I-25 and the southbound I-25 to southbound US 85/Santa Fe Drive—were completed prior to 2013; therefore, analysis was performed for these two ramps.

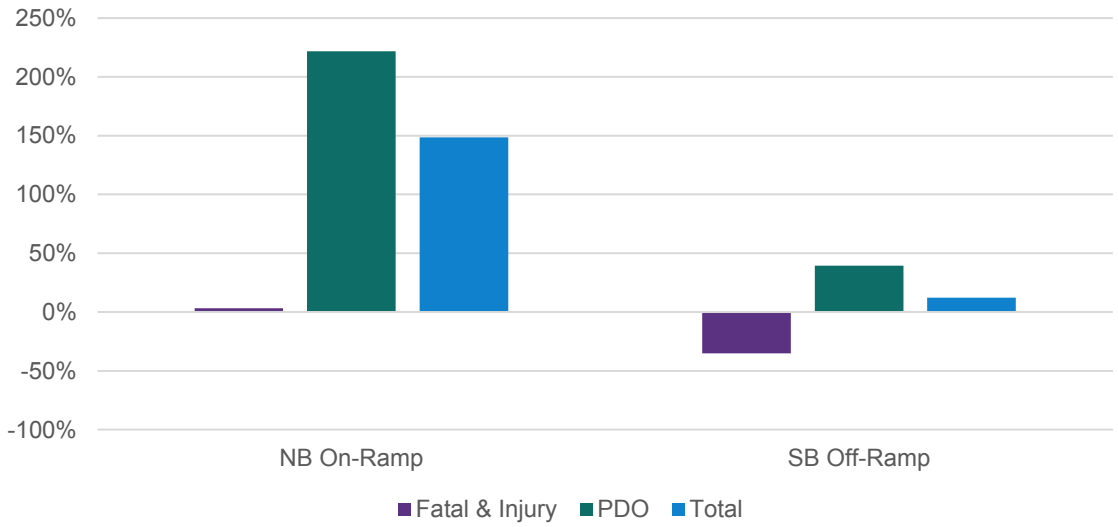
Over the three-year analysis period, a total of 97 crashes (84 PDO and 13 injury) occurred on the two ramps. The most common crash types included rear-end collisions and sideswipes by vehicles moving in the same direction. Figure 39 shows the crash types for each ramp.

Figure 39: US 85/Santa Fe Drive Interchange Crash Types by Ramp



The results of the HSM analysis show that the northbound on-ramp to I-25 has significantly more PDO crashes than predicted. Figure 40 shows the percent difference between the predicted and expected crashes for each of the US 85/Santa Fe Drive ramps. A full list of the observed, predicted, and expected crashes for these ramps can be found in Appendix B.

Figure 40: Percent of Excess Crashes at the US 85/Santa Fe Drive Ramps



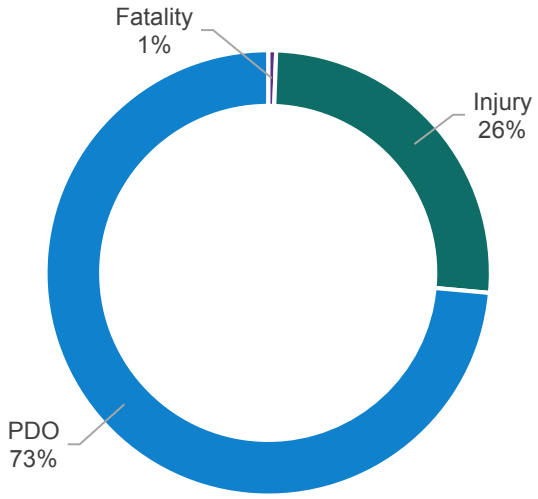
4.10. Interpretation of Ramp Analysis

Although many ramp segments are performing as predicted or better than predicted, some ramp segments in the I-25 Central corridor experience more crashes than predicted. The most common crash types across all ramps include rear-end collisions and sideswipes by vehicles moving in the same direction. Some ramps also experience a significant number of concrete barrier crashes. Although crashes are the result of many different factors, the most common characteristics that result in these types of crashes include congestion for rear-end crashes, short merging and weaving areas for sideswipe same direction crashes, and poor geometry for concrete barrier crashes.

5. Ramp Terminal Crashes

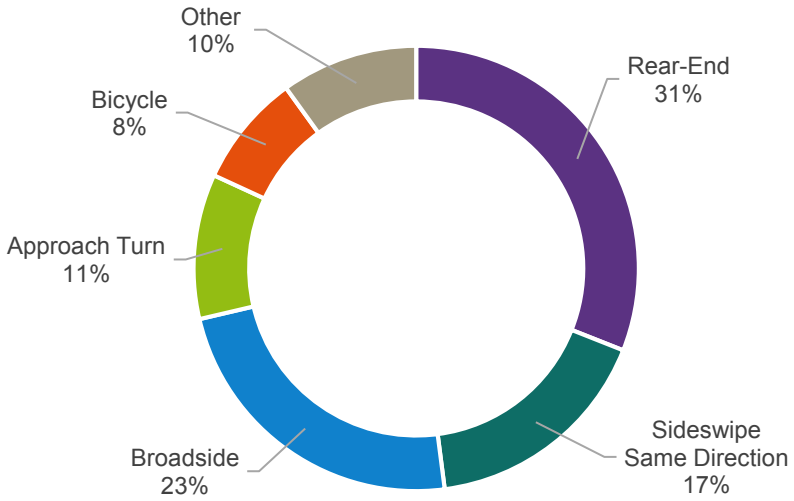
A total of 171 crashes occurred at ramp terminals within the I-25 Central study area. Of these crashes, one (1 percent) resulted in a fatality, 44 (26 percent) resulted in injury, and 126 (73 percent) had only property damage. As discussed in Section 1.2.2, CDOT does not maintain SPFs for ramp terminals; therefore, no comparison to similar facilities in Colorado can be made. Figure 41 shows the observed ramp terminal crashes by severity.

Figure 41: Ramp Terminal Crashes by Severity



The most common crash types observed at ramp terminals include rear-end collisions (31 percent), broadside crashes (23 percent), sideswipes by vehicles moving in the same direction (17 percent), approach turn crashes (11 percent), and bicycle (8 percent) crashes. The remaining 10 percent of crashes are a combination of other crash types. Figure 42 summarizes the ramp terminal crash types.

Figure 42: Ramp Terminal Crashes by Type



By applying default SPFs from the HSM, predicted and expected crash values were calculated for each ramp terminal. These calculations show that, overall, ramp terminals along the I-25 Central corridor experience fewer crashes—both injury and fatality and PDO crashes—than predicted for similar facilities across the country. Table 11 shows the observed, predicted, and expected crashes for ramps along the I-25 Central corridor. Individual ramp terminals are discussed below by interchange.

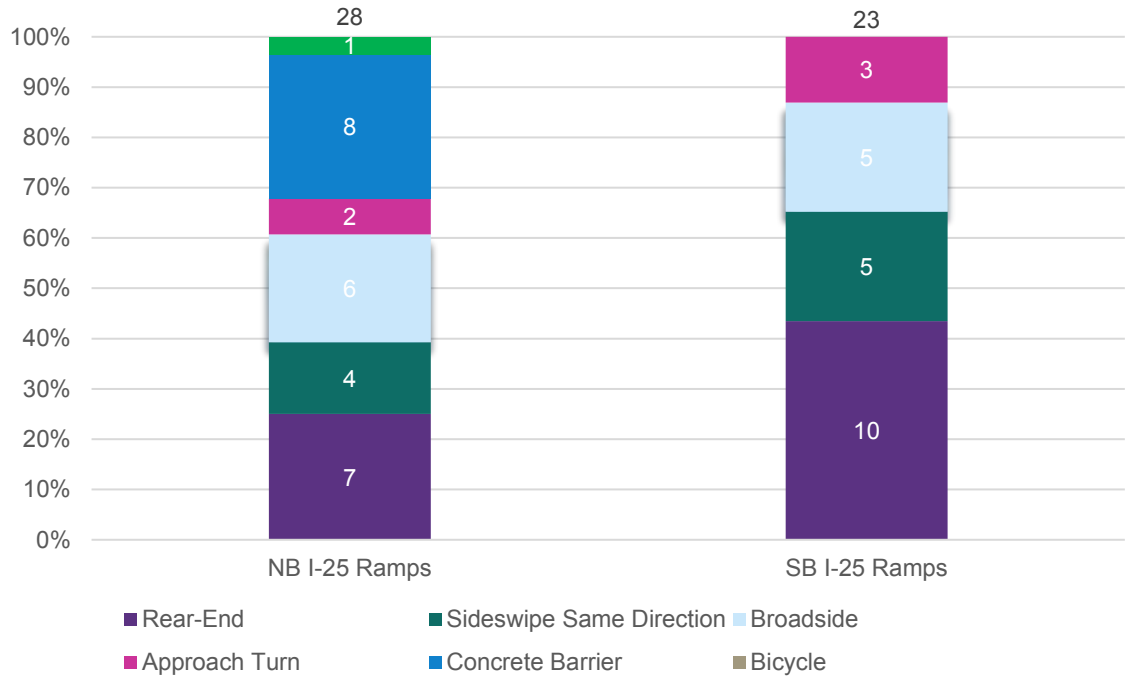
Table 11: Ramp Terminal Observed, Predicted, and Expected Crashes

	PDO Crashes per Year	Fatal and Injury Crashes per year	Total Crashes per Year
Observed	42.0	15.0	57.0
Predicted	41.8	29.3	71.1
Expected	41.4	21.1	63.7
Excess Crashes	-0.4	-8.2	-7.4

5.1. 20th Street Interchange

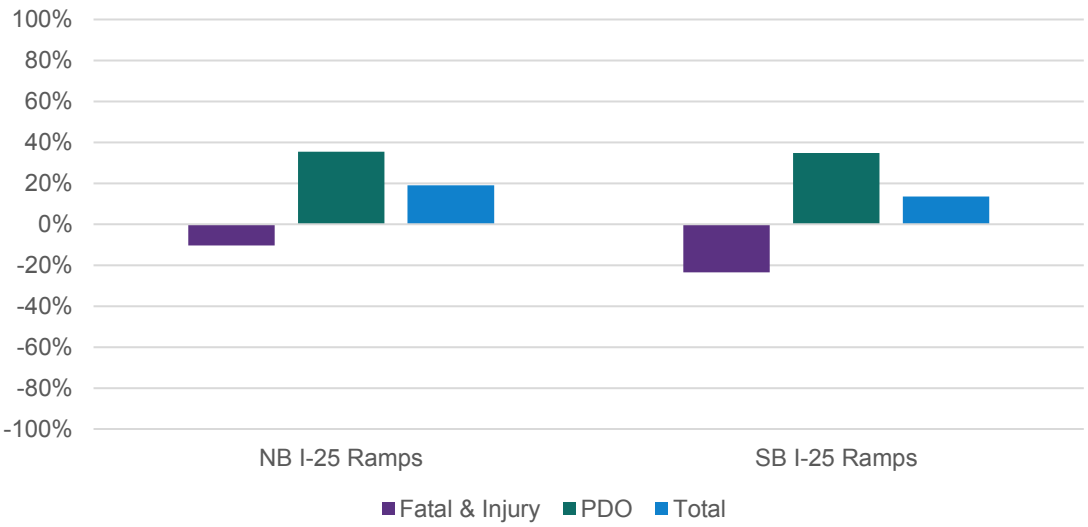
The 20th Street interchange has a total of two ramp terminals, both of which are signalized intersections. During the three-year data collection period, the 20th Street and northbound I-25 ramp intersection had a total of 28 crashes (22 PDO and six injury) and the 20th Street and southbound I-25 ramp intersection experienced 23 crashes (20 PDO and three injury). The most common crash types observed at these ramp terminals included rear-end collisions, broadside collisions, sideswipes by vehicles moving in the same direction, and concrete barrier crashes. Figure 43 shows the percent of each crash type observed at each ramp terminal.

Figure 43: 20th Street Ramp Terminal Crash Types



The results of the HSM analysis show that both ramp terminals experience slightly more PDO crashes than predicted. Figure 44 shows the percent difference between the predicted and expected crashes for both 20th Street ramp terminals. A full list of the observed, predicted, and expected crashes for these ramp terminals can be found in Appendix B.

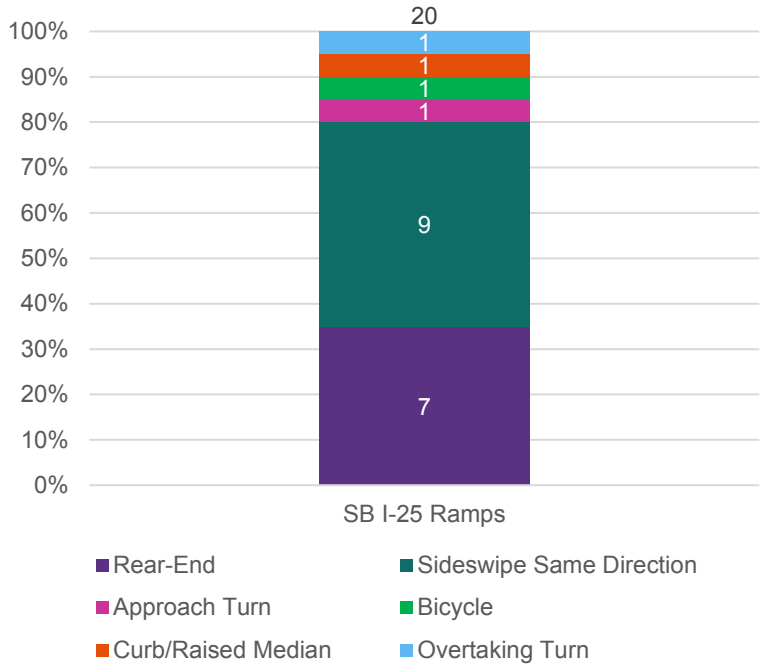
Figure 44: Percent of Excess Crashes at the 20th Street Ramp Terminals



5.2. Speer Boulevard Interchange

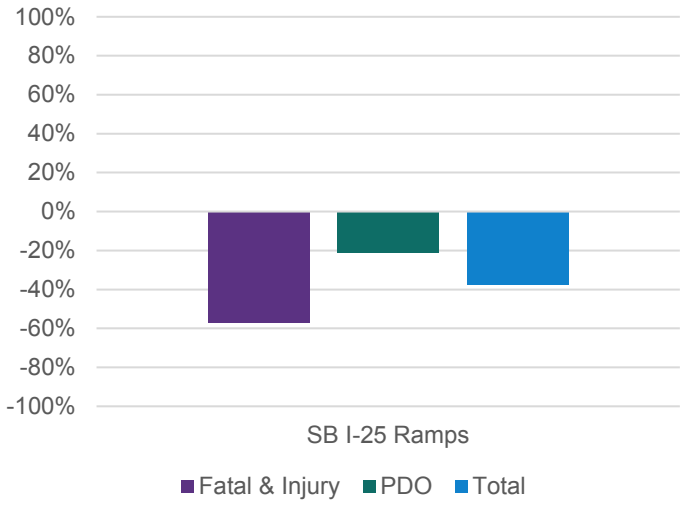
The Speer Boulevard interchange has one controlled intersection, which is a traffic signal located at the terminal of the southbound I-25 on/off-ramps. During the three-year data collection period, this intersection experienced a total of 20 crashes (18 PDO and two injury). The most common crash types observed at this ramp terminal included sideswipes by vehicles moving in the same direction and rear-end crashes. Figure 45 shows the percent of each crash type observed at the ramp terminal.

Figure 45: Speer Boulevard Ramp Terminal Crash Types



The results of the HSM analysis show the ramp terminal experiences fewer crashes than predicted. Figure 46 shows the percent difference between the predicted and expected crashes for the Speer Boulevard ramp terminal. A full list of the observed, predicted, and expected crashes for this ramp terminal can be found in Appendix B.

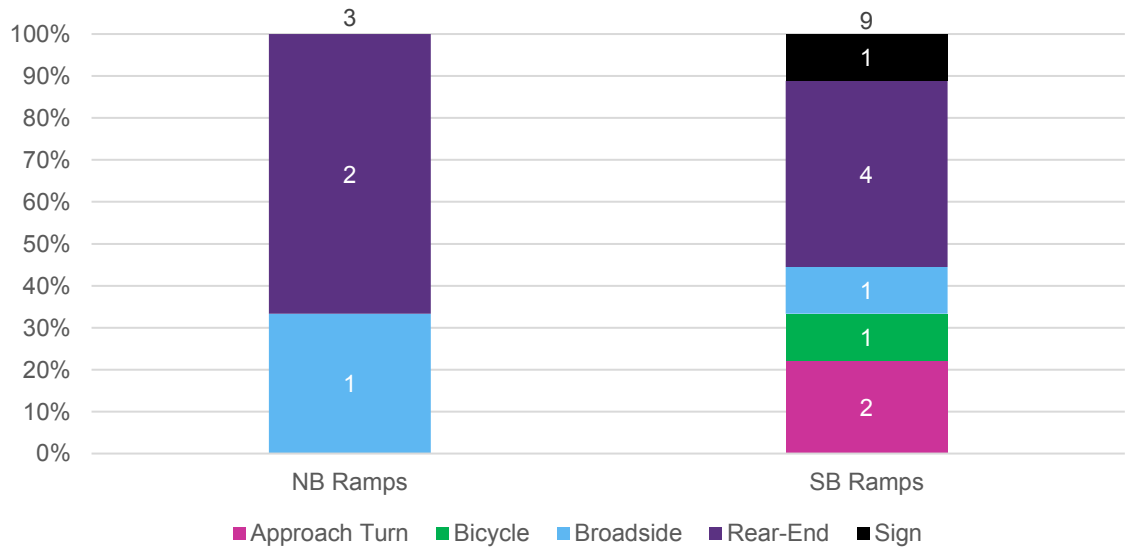
Figure 46: Percent of Excess Crashes at the Speer Boulevard Ramp Terminal



5.3. 23rd Avenue Interchange

The 23rd Avenue interchange has two controlled intersections, one of which is a traffic signal located at the termini of the southbound I-25 on-/off-ramps and the other is a one-way stop-controlled intersection for the left-turn at the end of the northbound off-ramp. During the three-year data collection period, this interchange experienced a total of 12 crashes (nine PDO and three injury) between the two ramp terminals. The most common crash types observed at these ramp terminals included rear-end crashes, broadside collisions, and approach turn crashes. Figure 47 shows the percent of each crash type observed at each ramp terminal.

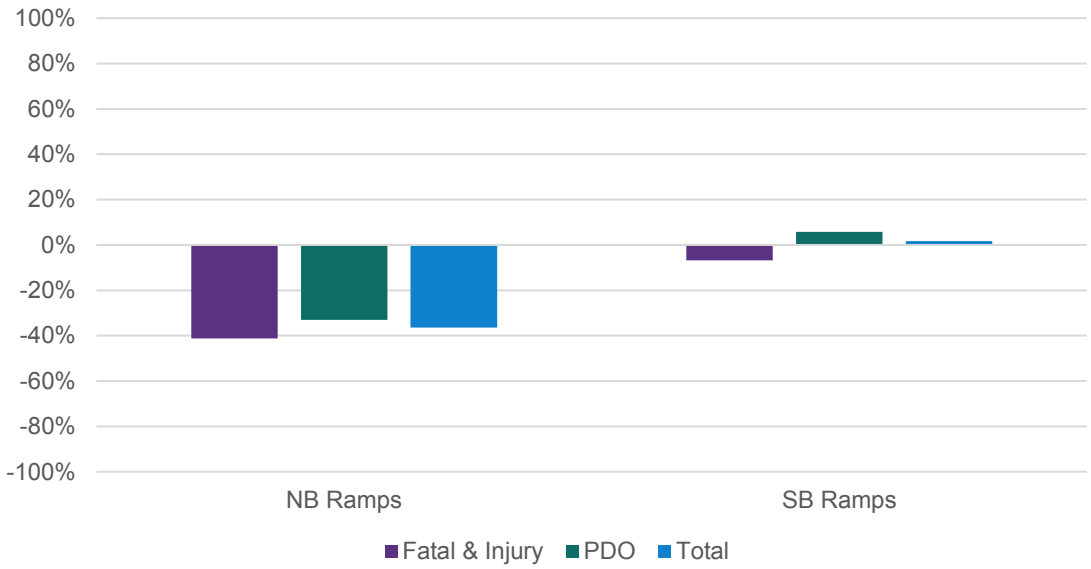
Figure 47: 23rd Avenue Ramp Terminal Crash Types



The results of the HSM analysis show the northbound 23rd Avenue ramp terminal experiences fewer crashes than predicted, and the southbound ramp terminal experiences

about the same number of crashes as predicted. Figure 48 shows the percent difference between the predicted and expected crashes for the 23rd Avenue ramp terminals. A full list of the observed, predicted, and expected crashes for this ramp terminal can be found in Appendix B.

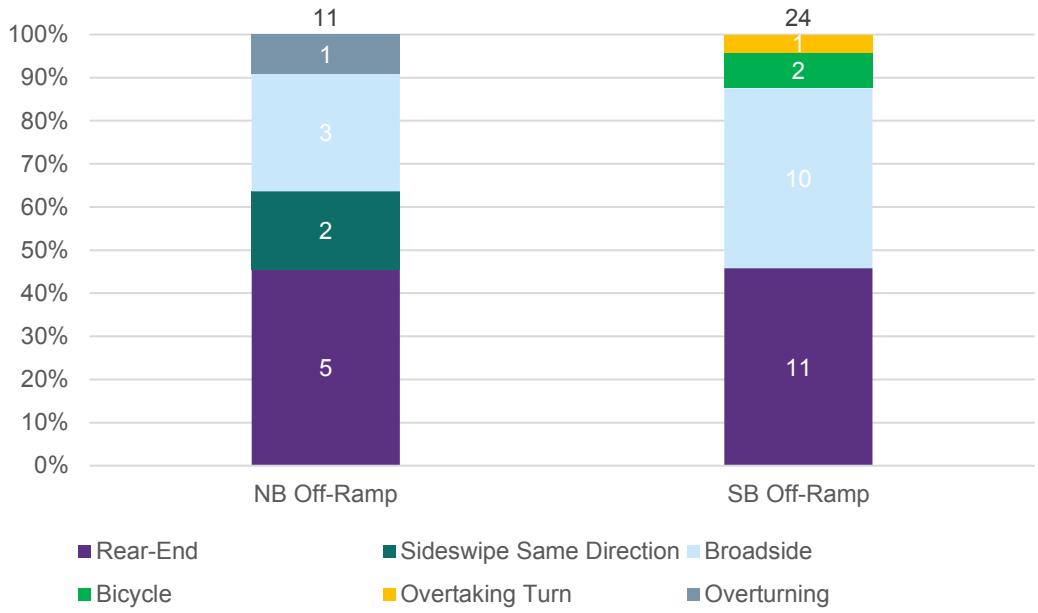
Figure 48: Percent of Excess Crashes at the 23rd Avenue Ramp Terminals



5.4. Colfax Avenue Interchange

The Colfax Avenue interchange has two controlled intersections, both of which are traffic signals located at the terminals of the I-25 off-ramps. During the three-year data collection period, there were 35 crashes (24 PDO, 10 injury, and one fatal) across these two ramp terminals. The most common crash types include rear-end collisions and broadside crashes. Figure 49 summarizes the crashes by type at each ramp terminal location.

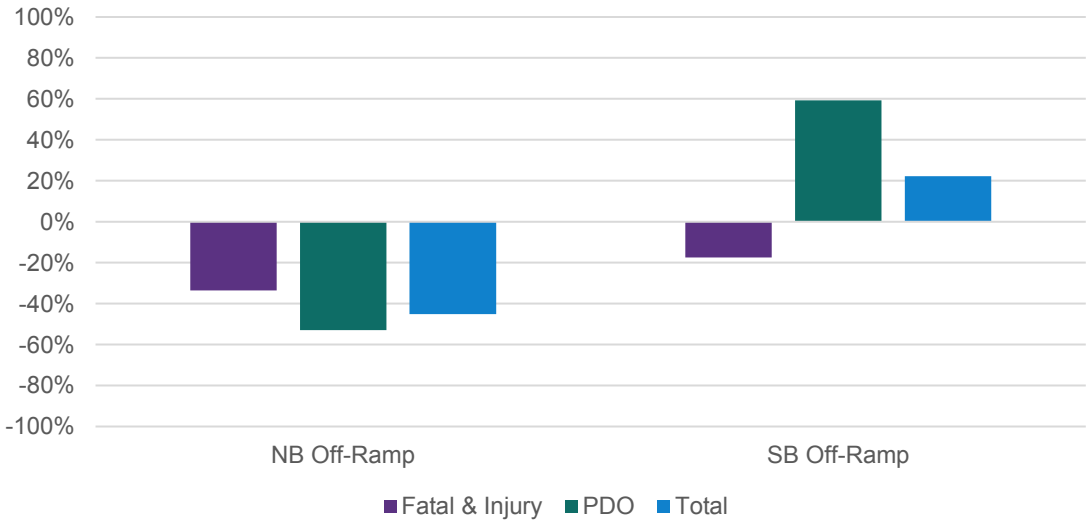
Figure 49: Colfax Avenue Ramp Terminal Crash Types



During the data analysis period, there was one fatal crash at the southbound I-25 off-ramp to the Colfax Avenue intersection. It occurred on October 11, 2015, at 7:27 p.m. and involved a motorcycle being broadsided by a vehicle under dry, dark-lighted conditions.

The results of the HSM analysis show that the southbound Colfax Avenue ramp terminal is expected to experience more crashes than predicted. Figure 50 shows the percent difference between the predicted and expected crashes for the Colfax Avenue ramp terminals. A full list of the observed, predicted, and expected crashes for this ramp terminal can be found in Appendix B.

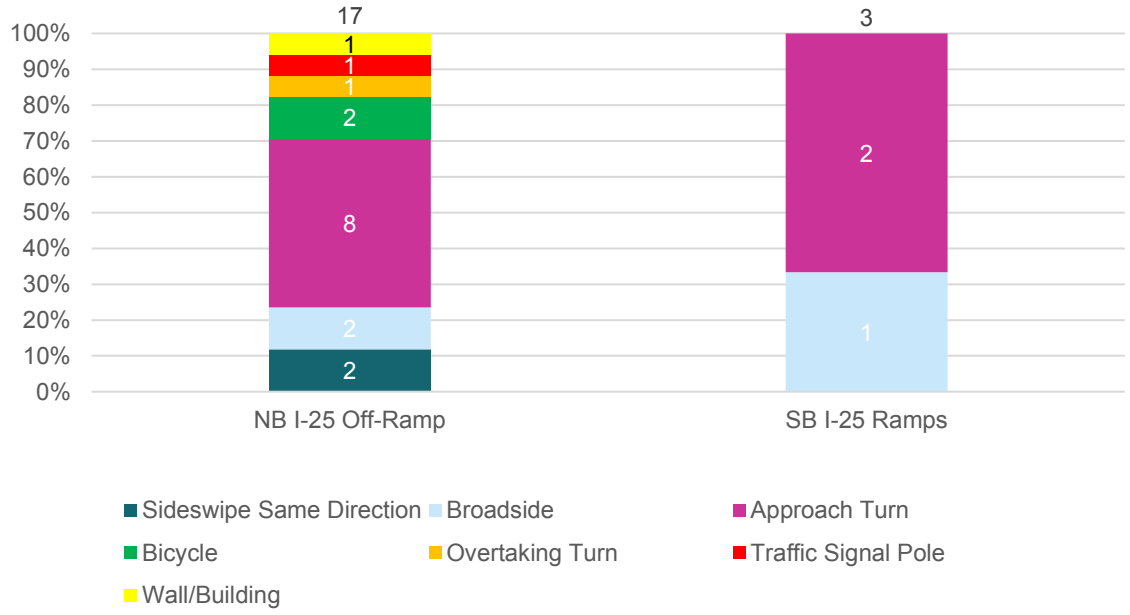
Figure 50: Percent of Excess Crashes at the Colfax Avenue Ramp Terminals



5.5. 8th Avenue Interchange

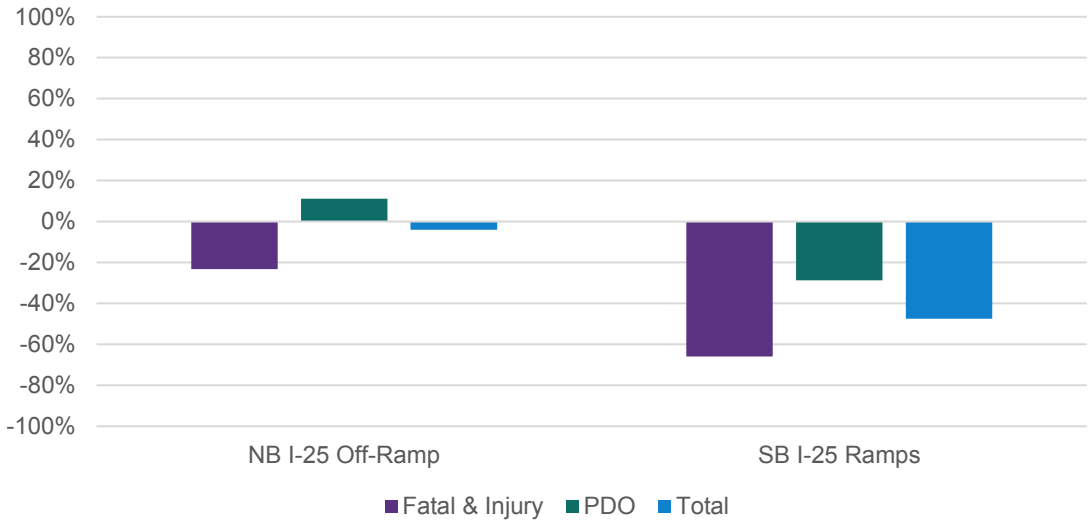
The 8th Avenue interchange has two controlled intersections. These include one signalized intersection at 8th Avenue and the northbound I-25 off-ramp and one stop-controlled intersection at the southbound I-25 ramps and Zuni Street. During the three-year data collection period, these ramp terminals experienced a total of 20 crashes (16 PDO and four injury). The most common crash type observed at these ramp terminals was approach turn crashes. Figure 51 shows the percent of each crash type observed at each ramp terminal.

Figure 51: 8th Avenue Ramp Terminal Crash Types



The results of the HSM analysis show these ramp terminals operate as expected or better in terms of predicted crashes. Figure 52 shows the percent difference between the predicted and expected crashes for the 8th Avenue ramp terminals. A full list of the observed, predicted, and expected crashes for this ramp terminal can be found in Appendix B.

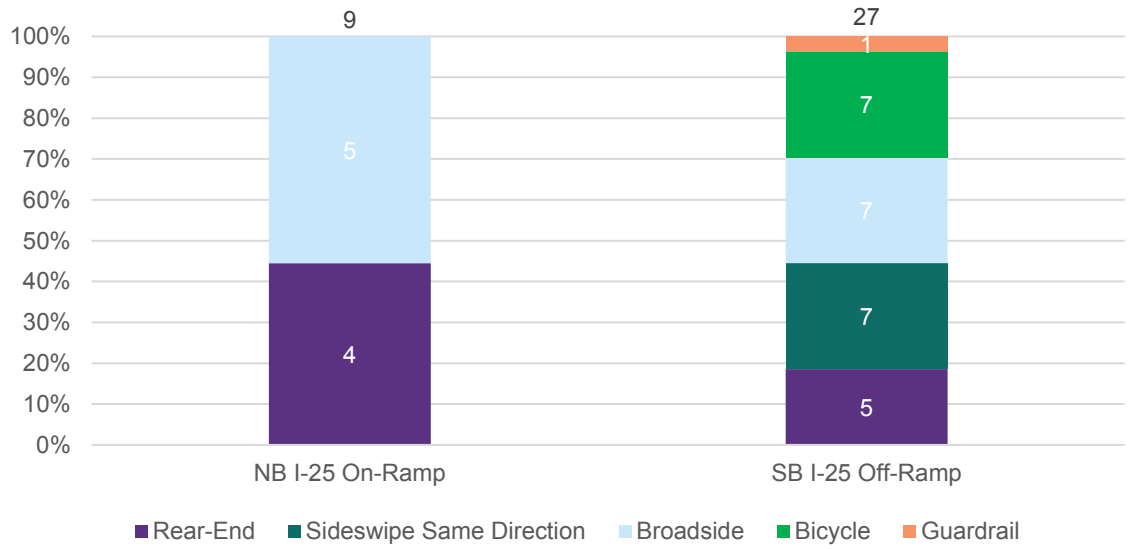
Figure 52: Percent of Excess Crashes at the 8th Avenue Ramp Terminals



5.6. Alameda Avenue/Kalamath Street Interchange

The Alameda Avenue/Kalamath Street interchange has two signal-controlled intersections—one for the northbound on-ramp to I-25 and one for the southbound off-ramp from I-25. During the three-year data collection period, these intersections had a total of 36 crashes (19 PDO and 17 injury). The most common crash types observed at these ramp terminals included broadside crashes, rear-end collisions, sideswipes by vehicles moving in the same direction, and bicycle crashes. Figure 53 shows the percent of each crash type observed at each ramp terminal.

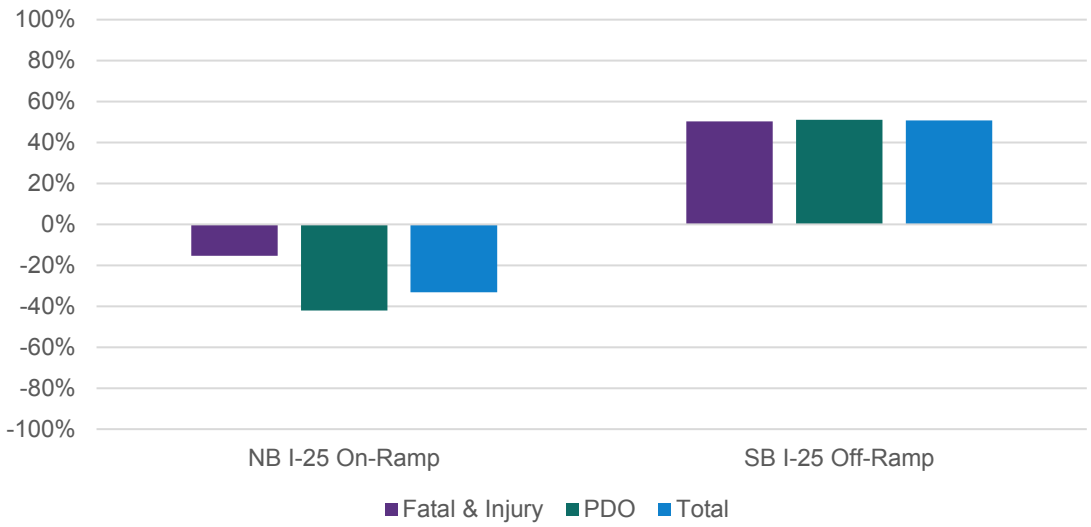
Figure 53: Alameda Avenue/Kalamath Street Ramp Terminal Crash Types



During the data collection period, the southbound I-25 off-ramp to Alameda Avenue had the most bicycle crashes out of all the ramp terminals analyzed, with a total of seven. All seven of these bicycle crashes involved vehicles making a southbound right-turn onto Alameda Avenue. Of these seven, six resulted in injuries.

The results of the HSM analysis show the southbound I-25 off-ramp to Alameda Avenue intersection has more crashes expected than predicted. This is true for both PDO and injury and fatality crashes. Figure 54 shows the percent difference between the predicted and expected crashes for the Alameda Avenue/Kalamath Street ramp terminals. A full list of the observed, predicted, and expected crashes for these ramp terminals can be found in Appendix B.

Figure 54: Percent of Excess Crashes at the Alameda Avenue/Kalamath Street Ramp Terminals



5.7. Interpretation of Ramp Terminal Analysis

The most common crash types at ramp terminals along the I-25 Central corridor include rear-end crashes, broadside collisions, sideswipes by vehicles moving in the same direction, and approach turn crashes. Rear-end crashes are most common in areas where drivers are not expecting stopped traffic, such as in congested, stop-and-go conditions. At ramp terminals, rear-end crashes can be indicative of a lack of upstream warnings for approaching traffic control devices, or excess congestion at intersections that results in extended vehicle queues.

Broadside impacts and approach turn crashes are the result of poor driver judgement and a failure to yield. However, they also can be influenced by engineering factors such as sight distances, protected versus permitted left-turn signal operations, and advanced warning of upcoming traffic control devices.

Sideswipe crashes usually are the result of short merging and weaving areas, as well as poor upstream signage. Short merging and weaving areas result in drivers needing to make sudden lane changes that result in sideswipe crashes. A lack of upstream signage can result in drivers being in the wrong lane to make a turn at a ramp terminal. This causes drivers to

make sudden, last-minute lane changes in an attempt to make a turn, which can result in sideswipe crashes.

6. Summary of Results

In general, the mainline freeway and ramps along the I-25 Corridor experience more crashes than would be predicted based on HSM analysis, while the ramp terminals are expected to experience fewer crashes than predicted. Table 12 shows the overall HSM results. These results indicate there are likely opportunities to improve safety throughout the corridor.

Table 12: Overall I-25 Central HSM Results

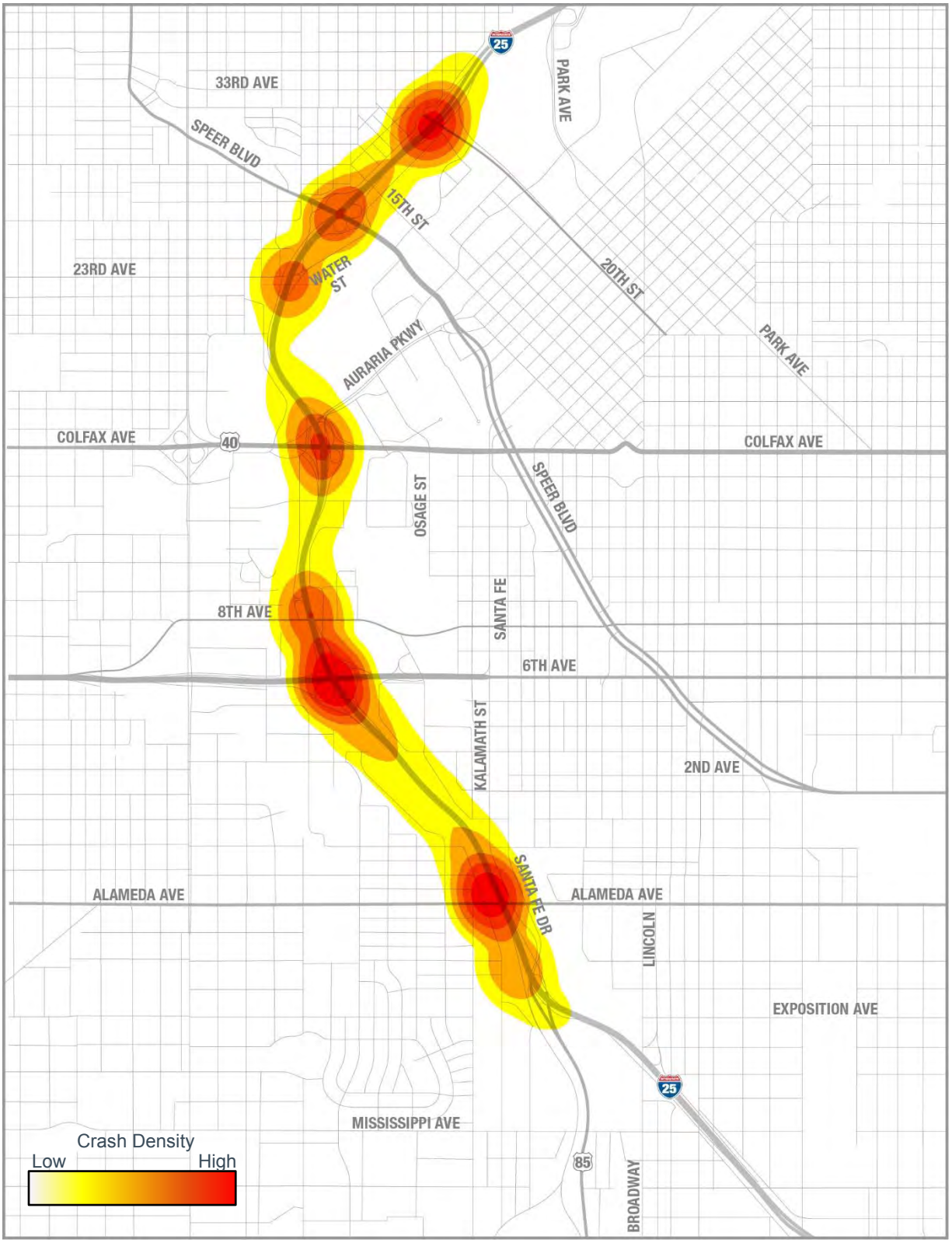
Facility	Crash Severity[1]	Observed Crashes (crashes per year)	Predicted Crashes (crashes per year)	Expected Crashes (crashes per year)	Excess Crashes (crashes per year)
Mainline Freeway[2]	FI	159.0	94.0	133.3	+39.3
	PDO	653.7	429.4	565.7	+136.3
	Total	812.7	523.4	699.0	+175.6
Ramp Terminals	FI	15.0	29.3	21.1	-8.2
	PDO	42.0	41.8	41.4	-0.4
	Total	57.0	71.1	62.5	-8.6
Ramp Segments	FI	29.7	19.0	15.3	-3.7
	PDO	112.0	33.2	42.5	+9.3
	Total	141.7	52.1	57.8	+5.7
Overall	FI	203.7	142.3	169.7	+27.4
	PDO	807.7	504.4	649.5	+145.1
	Total	1011.3	646.6	819.3	+172.7

*[1]**FI =** Fatality and/or Injury; PDO = Property Damage Only*

[2]Mainline freeway segment crash results were reported in crashes per mile per year in Chapter 3 of this report. To provide a standard comparison between the mainline freeway segments, the ramps, and the ramp terminals, crashes in this table are reported as crashes per year and are not normalized by length of the freeway.

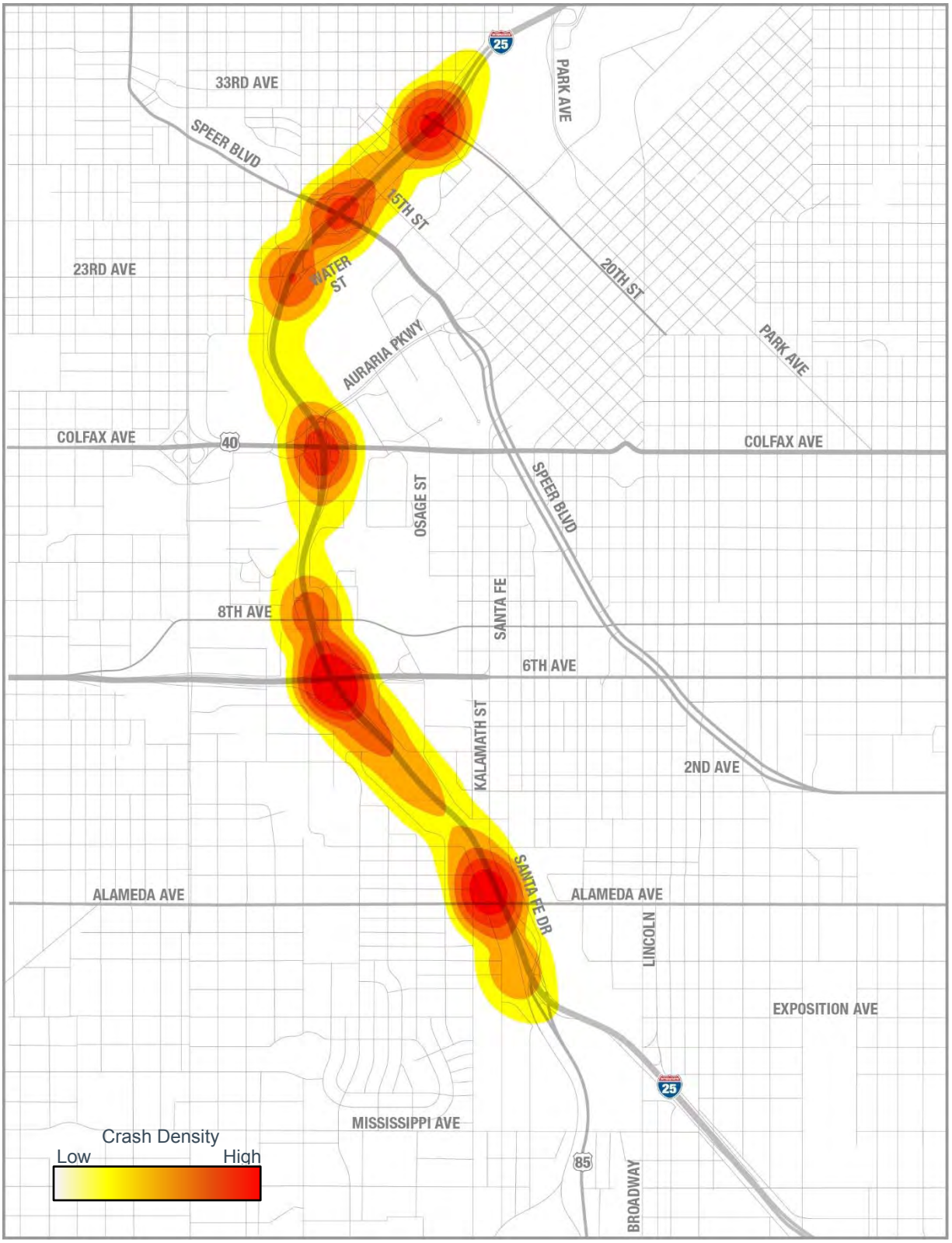
In addition to the HSM analysis, crashes also were mapped using geographic information system (GIS) software. Using GIS, crash density analysis was performed to identify crash hotspots. The results of this analysis show that interchanges represent the areas with the highest crash density. This is typical for freeway facilities because interchange areas are where drivers are most likely to weave, merge, or diverge, increasing the likelihood of a crash occurring. Figure 55 shows the density analysis results for all crashes on the I-25 Central corridor.

Figure 55: Crash Density



Excluding PDO crashes shows that the distribution of fatal and injury crashes is similar to the overall crash density patterns, with a majority of fatal and injury crashes occurring near interchange locations. The primary difference between the crash densities of all crashes combined and the crash density of only fatal and injury crashes is the distribution between Alameda Avenue and US 6. Between these two locations, there is a higher density of fatal and injury crashes whereas the overall crash density shows a higher concentration of crashes at the interchanges. Figure 56 shows the crash density analysis results for fatal and injury crashes.

Figure 56: Fatal and Injury Crash Density



7. References

American Association of State Highway and Transportation Officials (AASHTO). (2010). *Highway Safety Manual*. Washington, DC: AASHTO. Page 3-17.