SH 83 Safety and Operations Analysis:
Bayou Gulch to El Paso County Line
MP 30.20 – MP 53.88
Project Code 23008

Appendix A - Safety Assessment Report

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March 2022

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SH 83 CRASH HISTORY AND PROBLEM ANALYSIS

Crash History

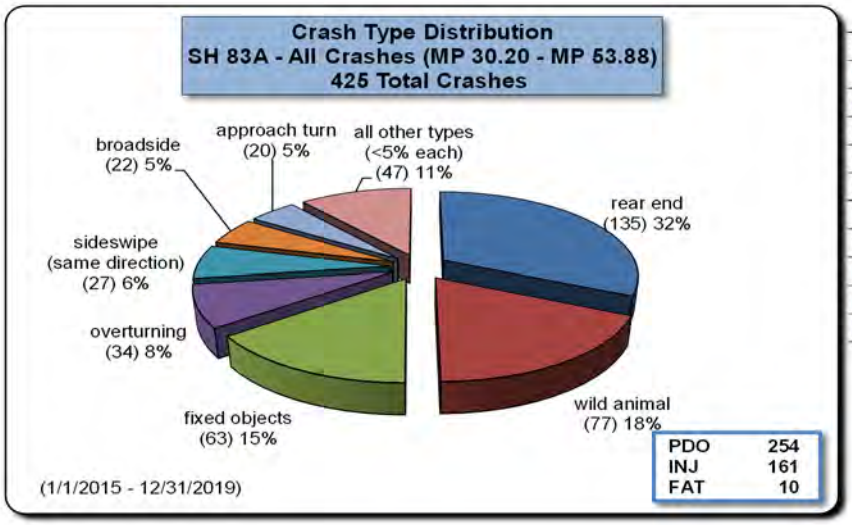
The SH 83 crash history for the five-year period, January 1, 2015, through December 31, 2019 was examined between East Palmer Divide Road (MP 32.20) and Bayou Gulch Road (MP 53.88) to locate clusters and identify crash causes. Four hundred twenty-five (425) crashes were reported along this section of SH 83 during the study period; 161 crashes resulted in 268 injuries and ten (10) crashes resulted in thirteen (13) fatalities. **Table A1** summarizes the crash totals for this segment of SH 83 over the five-year study period.

Table A1: SH 83 Crash History from MP 30.20 to MP 53.88

Year	Crashes				Persons	
	PDO*	Injury	Fatal	Total	Injured	Killed
1/1/2015 to 12/31/2015	41	24	1	66	31	2
1/1/2016 to 12/31/2016	52	35	2	89	59	3
1/1/2017 to 12/31/2017	48	28	1	77	47	1
1/1/2018 to 12/31/2018	56	29	4	89	48	5
1/1/2019 to 12/31/2019	57	45	2	104	83	2
Total	**254**	**161**	**10**	**425**	**268**	**13**
Average/Yr	**50.8**	**32.2**	**2.0**	**85.0**	**53.6**	**2.6**
***PDO – Property Damage Only**						

Rear end crashes were the most common crash type observed, accounting for 32% of the total crashes; followed by *wild animal* crashes at 18%, and fixed object crashes at 15%. **Figure A1** displays the crash distribution, by type, for the study segment.

Figure A1: SH 83 Crash Distribution by Type



All Other Types (47)	
sideswipe (opposite dir.)	14
head on	10
vehicle debris or cargo	4
overtaking turn	4
other non-collision	4
domestic animal	4
large rocks/boulder	2
involving other object	2
road maintenance equipment	1
parked motor vehicle	1
bicycle	1

Relationship to Previous Study

A comprehensive Safety Assessment Report was completed in January 2019 along the study corridor. The 2019 Safety Assessment analyzed crashes for the five-year period from January 1, 2012 through December 31, 2016. This analysis is intended as an update to the previous analysis

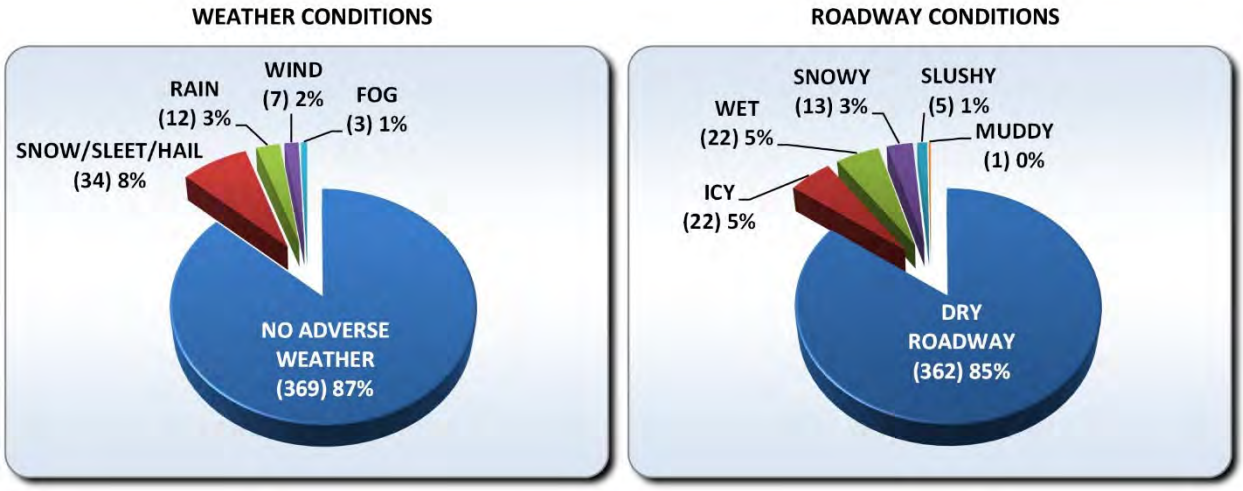
to evaluate any changes in crash patterns based on the additional three years of crash data; the current study includes the two-year overlap (2015, 2016).

Weather and Roadway Conditions

Most crashes occurred with no adverse weather conditions noted (369 of 425, 87%), followed by crashes under snow/sleet/hail conditions (34 of 425, 8%). There was a similar frequency of crashes when the roadway condition was dry (362 of 425, 85%). This breakdown is shown in

Figure A2. As wet roadway conditions can occur during snowy weather depending on the temperature, crashes with poor roadway conditions appear to match up with adverse weather conditions.

Figure A2: Weather and Roadway Conditions

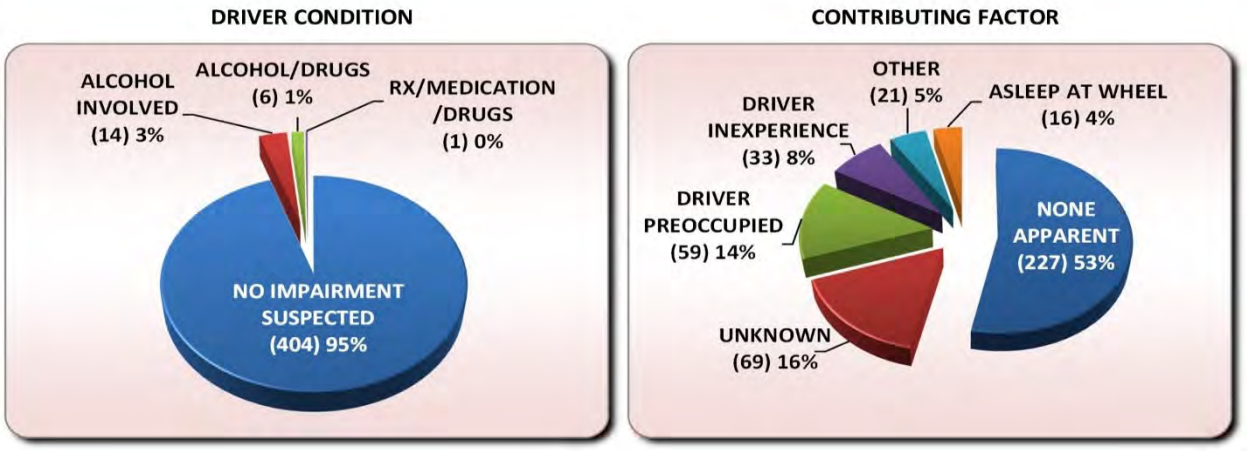


While this suggests that there is adequate drainage and that snow-removal is generally good, there may still be the potential to reduce the frequency of adverse weather/roadway crashes through improved maintenance response times or other mitigation measures.

Driver Conditions and Contributing Factors

Figure A3 shows the breakdown of driver conditions (driver #1) and general contributing factors as indicated on the crash reports for the corridor as a whole. There were 21 crashes (5%) crashes where drugs or alcohol were cited as causal factors for driver conditions along the corridor, including two (2) of the ten fatal crashes along the corridor. While most crashes were listed with no apparent contributing factor or an unknown contributing factor (53% and 16%, respectively), distracted driving was a factor in many of the crashes along the corridor.

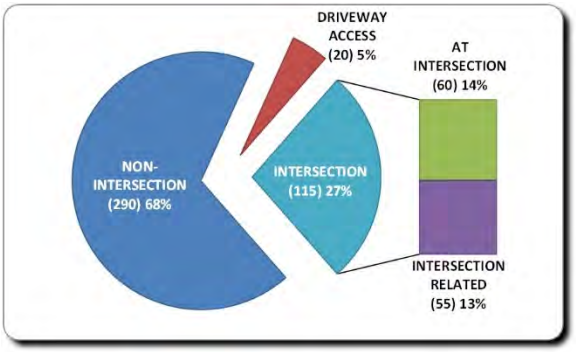
Figure A3: Driver Condition and Contributing Factors



Crash Locations

The majority of the crashes along the SH 83 corridor occurred at non-intersection locations (290 of 425, 68%), followed by crashes that occurred at or in the vicinity of intersections (115 of 425, 27%), and driveway accesses (20 of 425, 5%). This breakdown is shown in **Error! Reference source not found.**. The magnitude of safety problems at intersections was assessed using Safety Performance Functions, and specific patterns were determined using direct diagnostic analysis techniques. The complete listing and detailed crash summary sheets for the study corridor of SH 83 are provided in the **Appendix B**.

Figure A4: Crashes by Location



Safety Performance Function

The assessment of the magnitude of safety problems is refined through the use of Safety Performance Functions (SPF). The SPF reflects the complex relationship between traffic exposure measured in Average Daily Traffic (ADT), and crash count measured in crashes per year. The SPF model provides an estimate of the normal or expected crash frequency and severity for a range of ADT among similar facilities. Two kinds of SPF's were calibrated. The first addresses the total number of crashes, and the second addresses crashes involving an injury or fatality, allowing the assessment of the magnitude of the safety problem from the frequency and severity standpoint.

Development of the SPF lends itself well to the conceptual formulation of the Level of Service of Safety (LOSS). The concept of level of service uses quantitative measures and qualitative description that characterize safety of a roadway segment in reference to its expected frequency and severity. LOSS boundaries are calibrated by computing the 20th and the 80th percentiles using the Gamma Distribution Probability Density Function. Gradual change in the degree of deviation of the LOSS boundary line from the fitted model mean reflects the observed increase of variability in crashes/mile as AADT increases.

- LOSS I – Below 20th Percentile

Indicates a low potential for crash reduction.

- LOSS II – 20th Percentile to Mean
  Indicates a low to moderate potential for crash reduction.
- LOSS III – Mean to 80th Percentile
  Indicates a moderate to high potential for crash reduction.
- LOSS IV – Above 80th Percentile
  Indicates a high potential for crash reductions.

LOSS reflects how the roadway or intersection is performing in regard to its expected crash frequency at a specific level of ADT (major and minor). It does not, however, provide any information related to the nature of the safety problem itself. If a safety problem is present, LOSS will only describe its magnitude from the frequency and severity standpoints. The nature of the problem is determined through diagnostic analysis using direct diagnostic and pattern recognition techniques discussed later in this assessment.

Correcting for Regression to the Mean Bias using the Empirical Bayes Method

In road safety the average of several years of crash history of a highway segment or of an intersection provides us with an estimate of what is likely to be observed in the future. The precision of this estimate, however, can be improved upon by correcting it for the Regression to the Mean (RTM) bias. RTM phenomenon reflects the tendency for random events, such as vehicle crashes to move toward the average during the course of an experiment or over time. For instance, if a segment or an intersection exhibits unusually high or unusually low crash frequency in a particular year, because of RTM we need to be aware that over the long run its true average is closer to the mean representing safety performance of similar facilities. The existence of the RTM bias has been long recognized and is now effectively addressed by using the Empirical Bayes (EB) method[1]. The use of the EB method is particularly effective when it takes a long time for a few crashes to occur, as is often the case on Colorado rural roads.

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

Pattern Recognition Analysis

Pattern recognition analysis for the study corridors was performed using normative percentages for diagnostics of safety problems for comparable roadways and intersections. Patterns are reviewed further if the direct diagnostic analysis indicates a greater than 90% significance when compared to similar facilities statewide, and the pattern is based on at least three (3) crashes during the five-year study period (unless otherwise noted).

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

SH 83 NON-INTERSECTION CRASH ANALYSIS

There were 290 non-intersection crashes during the five-year study period on SH 83. To remain consistent with the 2019 Safety Assessment, the study corridor was divided into six segments for the purpose of the analysis. The study corridor can be generally described as an undivided 2-lane highway through rolling terrain for the purpose of SPF and diagnostic analysis; however, it should be noted that the higher frequency of access points and side-streets in Segment 6 (north of the SH 86 intersection) is less consistent with the data used as the basis for the SPF or diagnostic foundation.

Table A2 provides a breakdown of the non-intersection crashes by study segment along with the number of lanes, 2019 AADT, and results of the segment-wide SPF analysis for total crashes and severe crashes (injury and fatal).

Table A2: Non-Intersection Crashes by Location

ID	MP Range	Length	Segment Description	Lanes	AADT	LOSS[2]	Number of Crashes[1]			
							PDO	INJ	FAT	TOT
1	30.20 - 33.50	3.28	El Paso Line to South of Jones Road	2	4,800	IV / IV	29	19	2	50
2	33.50 - 37.82	4.31	South of Jones Road to Gillian Avenue	2	4,700	III / III	22	13	2	37
3	37.82 - 42.33	4.51	Gillian Avenue to Lake Gulch Road	2	4,700	III / II	17	12	1	30
4	42.33 - 45.30	2.96	Lake Gulch Road to MP 45.30	2	7,700	II / II	19	7	1	27
5	45.30 - 50.75	5.62	MP 45.30 to SH 86	2	7,900	III / III	45	19	0	64
6	50.75 - 53.88	3.12	SH 86 to Bayou Gulch Road	2	14,200	N/A	50	32	0	82
						Total	**182**	**102**	**6**	**290**
						Average/Year	**36.4**	**20.4**	**1.2**	**58**

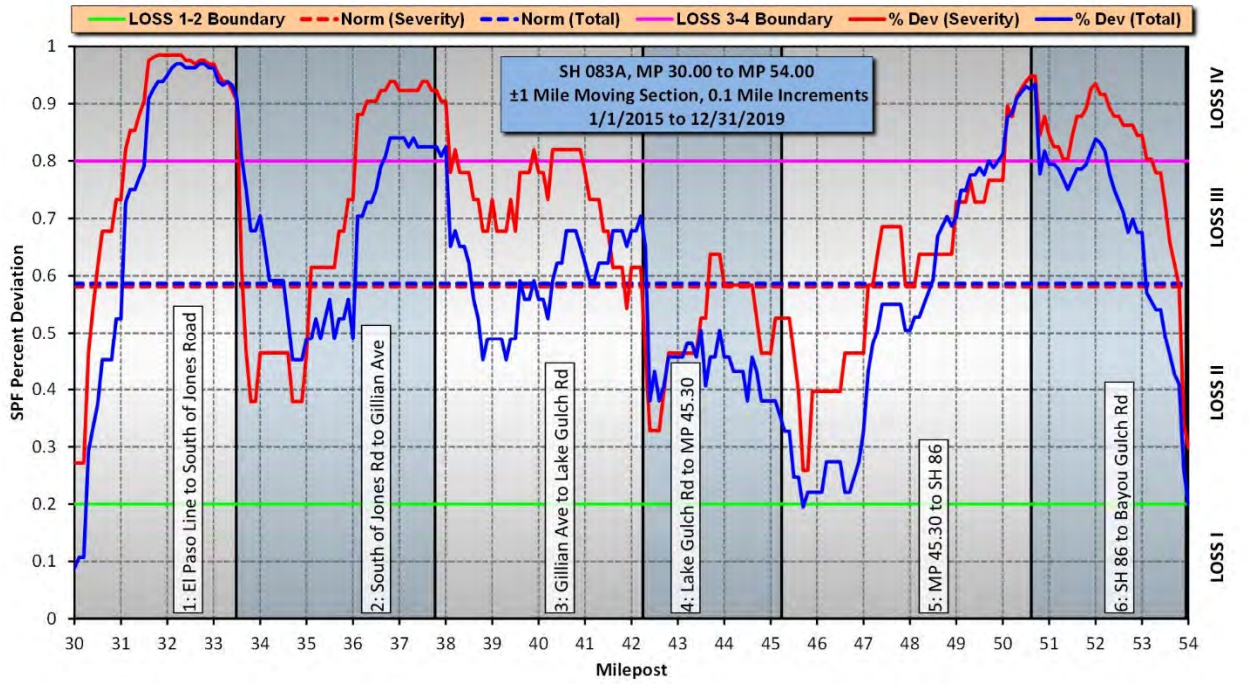
[1] **PDO – Property Damage Only, INJ – Injury, FAT – Fatal, TOT - Total**
[2] **Level of Service of Safety: Total/Severe**

There were between one (1) and three (3) crashes per mile per year on Segments 1 through 5, with a higher frequency of five (5) crashes per mile per year in Segment 6. The SPF results indicated a higher than expected crash frequency (LOSS III or IV) for total crashes on four of the five segments and was also above the norm for severe crashes on three of the five segments. This indicates a moderate to high potential to reduce crash frequency along most of the study corridor. Segment 6 was excluded from the segment SPF analysis due to the higher frequency of access points and side-streets, as noted.

Corridor Safety Performance Function Analysis

A graph representing the change in safety performance for total crashes and for severe crashes (injury and fatal) is shown in **Figure A5.** This continuous graph uses a ±1.0-mile moving section in 0.10-mile increments for Rural Flat and Rolling 2-Lane Undivided Highways.

Figure A5: SH 83 Corridor Safety Performance Function

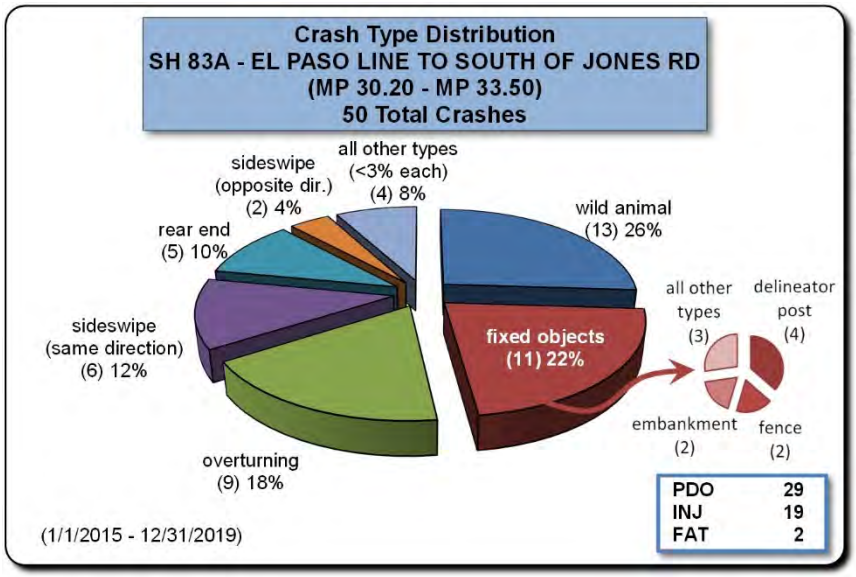


Locations with high crash concentrations indicate locations with a moderate to high potential for crash reduction (LOSS III and IV, respectively), and provide insight into where to focus analysis and mitigation efforts, further refined through the use of direct diagnostic analysis techniques as outlined in the following sections.

Segment 1: El Paso Line to South of Jones Road

There were 50 crashes along this segment during the five-year study period: 29 PDO crashes (58%), 19 injury crashes (38%) with 40 injured, and two (2) fatal crashes (4%) with 3 killed. **Figure A6** shows the crash type distribution for this segment. *Wild animal* type crashes were predominant (26%), followed by fixed object crashes and *overturning* type crashes (22% and 18%, respectively). A graphic showing the location, frequency, and severity of crashes is shown in **Figure A8** on page 12.

Figure A6: Segment 1 Crash Type Distribution



All Other Types (4)	
other non-collision	1
involving other object	1
head on	1
domestic animal	1

Relationship to Previous Study: There were 34 crashes reported in the 2019 Safety Assessment. The proportion of *wild animal* and fixed object crashes were similar, but there was only one *sideswipe (same direction)* crash and no *rear end* crashes reported in the 2012 to 2016 data.

Fatal Crashes

There were two fatal non-intersection crashes along this segment during the five-year study period: one *head-on* crash, and one *sideswipe (same direction)* crash. Both fatal crashes occurred during the day with no adverse weather or roadway conditions.

The *head-on* collision occurred in May 2018 at MP 32.53. A southbound vehicle (Pick-Up) attempted to pass multiple southbound vehicles in a no-passing zone approaching a left-hand curve and struck a northbound vehicle head on. The northbound vehicle (SUV) was pushed backward and rolled onto its roof after impact, two of the three occupants were killed. Alcohol/Drugs were indicated as a possible contributing factor.

The *sideswipe (same direction)* type crash occurred in April 2017 at MP 31.35. Two motorcycles were travelling in the southbound direction approaching milepost 31 and had just entered a passing zone. The lead rider moved toward the centerline (but did not cross) to see if it was safe to pass a slower vehicle but did not begin a passing maneuver and moved back to the right. The trailing rider had moved up into the empty space and collided with the lead motorcycle. The trailing motorcycle then lost control and overturned, sliding along the southbound lanes and ejecting the rider, who was not wearing a helmet at the time of the collision and died after being transported to the hospital.

Off-Right Collisions

The frequency of crashes involving vehicles running off of the right-side of the roadway was higher than expected compared to similar facilities, statewide. Of the 21 off-right crashes, nine (9) involved southbound vehicles and 12 involved northbound vehicles. The highest concentration of crashes (8 of 21) occurred in the vicinity of the reverse curves located between MP 32.25 and MP 32.50 (approximate): five (5) northbound, three (3) southbound.

There is a slight downhill grade in the northbound direction (about 2%) and the roadway is generally marked as a no-passing zone. Most occurred during daylight conditions (7 of 8) with no adverse weather or roadway conditions (7 of 8). Alcohol was involved in two of the crashes. There are advance curve warning signs with speed advisory plaques in both directions and curve chevrons in both directions. The shoulders are stabilized with approximately 1-ft of paved material as shown in **Figure A7**; there is a bit of a drop-off between the edge of pavement and stabilized material and the safety edge may be worn down in places.

Figure A7: Northbound SH 83A at MP 32.25

Recommendation

Shoulder widening through the reverse curves would allow vehicles more opportunity to recover when running off of the right-side of the road and help reduce the frequency of run-off-road collisions. In addition, wider shoulders would allow for outside shoulder rumble strips which would further help improve safety through this area.

Sideswipe (Same Direction) Collisions

There were six (6) *sideswipe (same direction)* type crashes during the five-year study period. The crashes were split evenly between the northbound and southbound directions. A review of the crash data indicates that most of the crashes likely involved vehicles attempting a passing maneuver of some kind and included one fatality. Most occurred outside of passing zones (5 of 6).

Recommendation

The "Swedish 2+1" passing lane configuration recommended in the 2019 Safety Assessment could potentially help reduce the frequency of *sideswipe (same direction)* type crashes. However, it may not be feasible from a geometric perspective given the presence of access points and the space required for the tapers per CDOT. The impact of the recent modifications to the passing zones should be evaluated in the future and additional mitigation measures considered if the pattern persists or worsens.

Rear End Collisions

There were five (5) *rear end* type crashes during the current five-year study period. A review of the crash data indicates that several of these crashes may have involved vehicles slowing to turn from SH 83 at different driveway or side-street locations (no concentrations). Adverse weather or roadway conditions may have also been a contributing factor in several crashes.

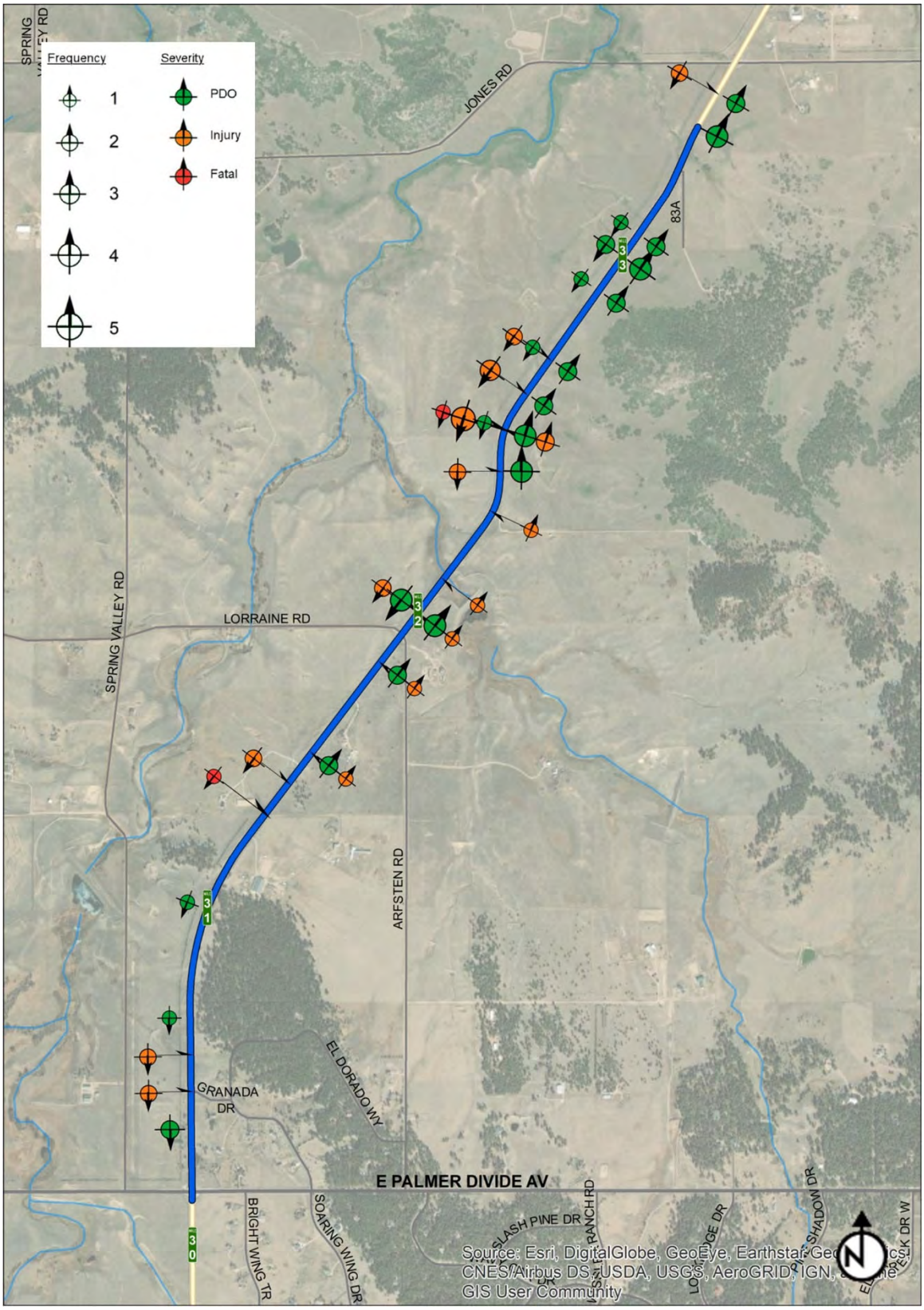
Recommendations

Shoulder widening in the vicinity of driveways or approaching side-streets where turn lanes are not feasible should help reduce the likelihood of a *rear end* collision due to vehicles slowing to turn. The *rear end* crashes that may be associated with turning traffic occurred at MP 30.50, MP 31.89, and MP 32.10.

Wild Animal Collisions

There were 13 *wild animal* crashes during the five-year study period through this 3.28-mile segment. There were no notable concentrations of *wild animal* crashes that would suggest a significant migration pattern and only 0.79 crashes per mile per year. There are no recommendations specific to this crash type at this time.

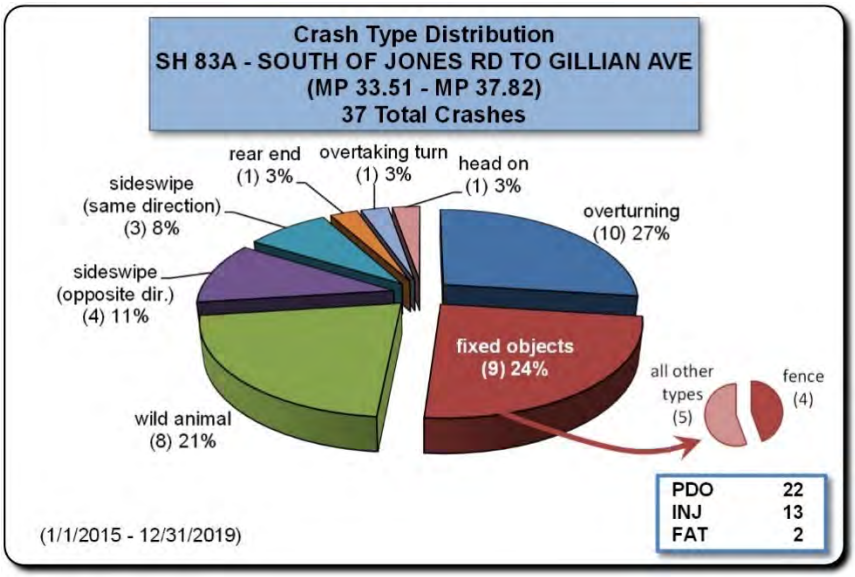
Figure A8: Segment 1 Crashes by Frequency and Severity



Segment 2: South of Jones Road to Gillian Avenue

There were 37 crashes along this segment during the five-year study period: 22 PDO crashes (60%), 13 injury crashes (35%) with 20 injured, and two (2) fatal crashes (5%) with two killed. **Figure A9** shows the crash type distribution for this segment. *Overturning* type crashes were predominant (27%), followed by fixed object crashes (24%) and *wild animal* crashes (21%). A graphic showing the location, frequency, and severity of crashes is shown in **Figure A8**.

Figure A9: Segment 2 Crash Type Distribution



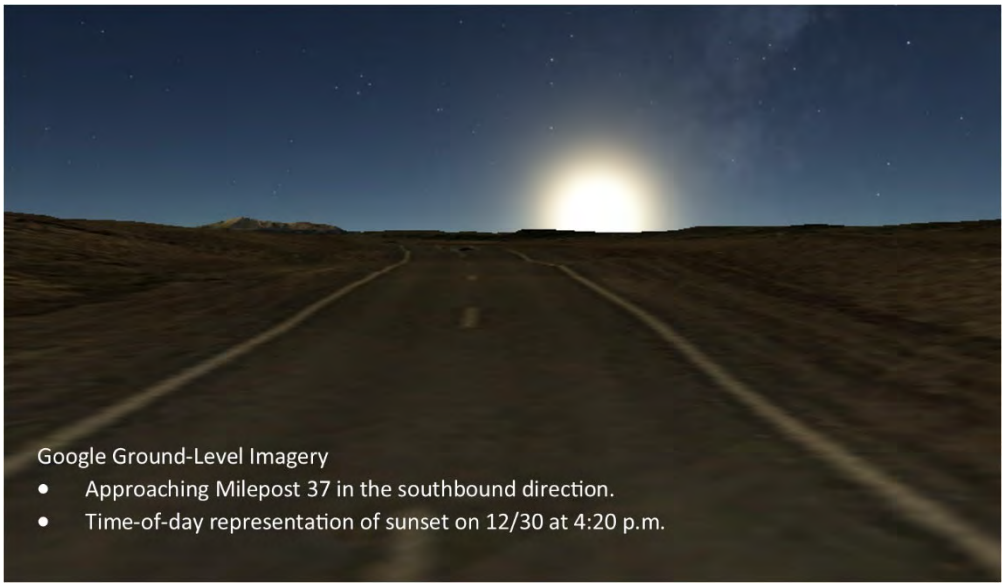
Relationship to Previous Study: There were 24 crashes reported in the 2019 Safety Assessment. The proportion of *overturning* type, *wild animal* type, and *sideswipe (opposite direction)* type crashes were similar, with a slightly higher proportion of fixed object crashes.

Fatal Crashes

There were two fatal *sideswipe (opposite direction)* type crashes along this segment. Both crashes occurred with no adverse weather or roadway conditions.

One *sideswipe (opposite direction)* fatal crash occurred in December 2018 at MP 37.04. A southbound vehicle travelled off of the right-side of the road, overcorrected then lost control, crossing into the northbound lane and colliding with a northbound vehicle. A review of the crash data suggests that the crash occurred just after a slight left-hand curve in the southbound direction, on a short tangent before a second left-hand curve. Lighting was listed as “dawn or dusk” in the report and it is possible that sun-glare was a contributing factor given the date, time and direction as illustrated in **Figure A10**. The driver of the southbound vehicle was not wearing a seat-belt at the time of the collision and died after being transported to the hospital.

Figure A10: Ground Level Representation – Late December Sunset



The other *sideswipe (opposite direction)* type crash occurred in August 2019 at MP 36.60. A southbound vehicle travelled off of the right-side of the road, overcorrected, and crossed over into the northbound lane. A motorcycle travelling northbound was struck by the errant vehicle and tumbled off of the east side of the road, ejecting the rider. A review of the crash data did not provide sufficient information to identify the proximate cause of the crash.

Run-Off-Road Collisions

Most of the crashes along this segment were run-off-road (19 of 37), which is higher than expected for this type of facility. There was a concentration of crashes in the vicinity of the reverse curves starting around mile marker 37 during the study period (10 of 19), including one fatal *sideswipe (opposite direction)* type crash. These crashes predominately occurred when there were no adverse weather or roadway conditions and only a few could be attributed to attempted passing maneuvers. Drivers asleep at the wheel were identified as a causal factor in four (4) of these crashes, and alcohol was suspected in one (1) crash.

Recommendation

A recent project revised the passing zone striping through this area, eliminating the passing zone through the reverse curve area. Shoulder widening through the reverse curves along with rumble strips (centerline and shoulder) would help reduce the likelihood of run-off-road crashes by alerting drivers that are departing the road and allow for safer recovery prior to running off of the roadway and overturning. In addition, improved delineation using oversized reflectors would improve both daytime and nighttime visibility on curves that may not warrant chevron signs to provide an additional visual cue to drivers approaching the curve.

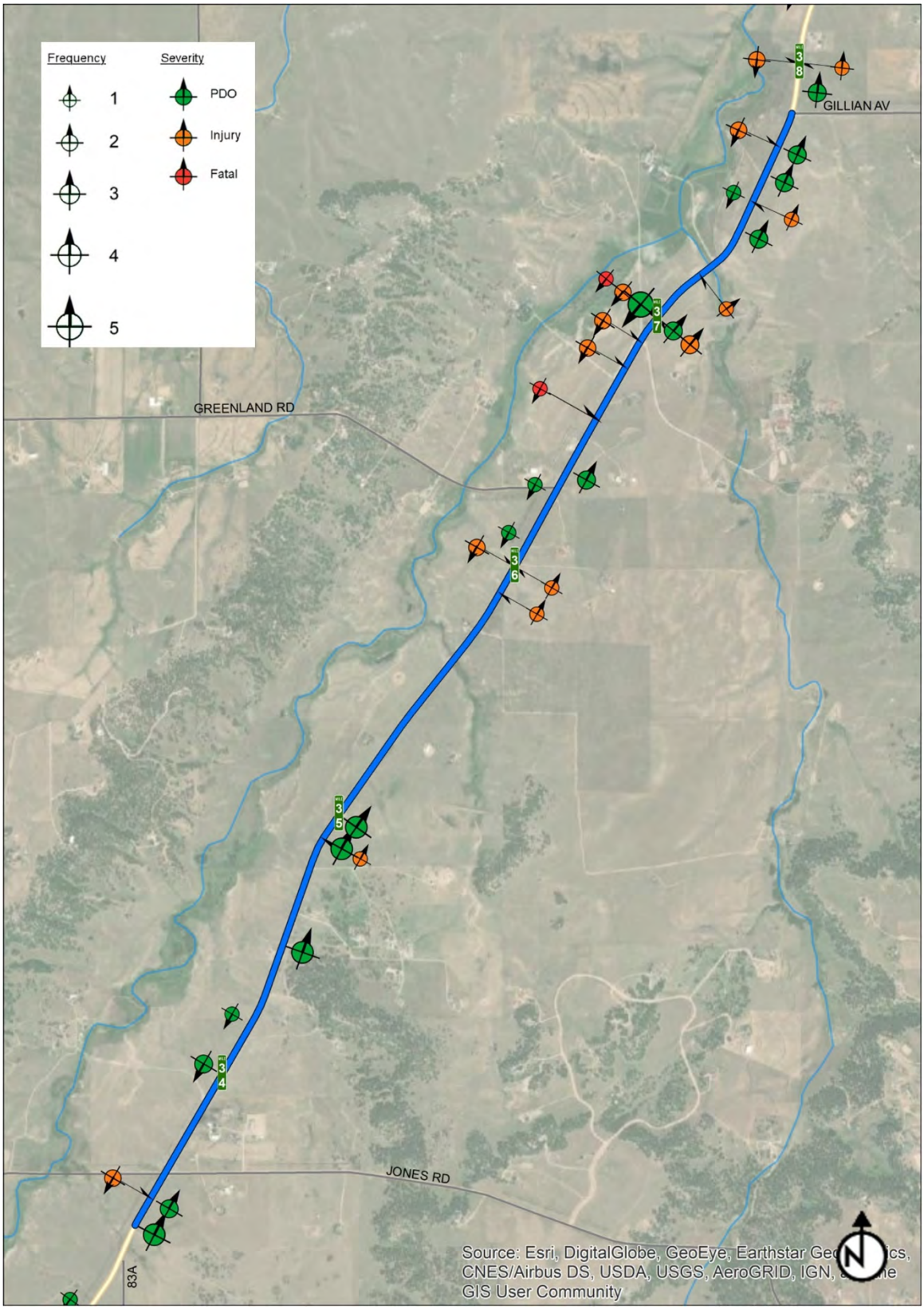
Overturning Collisions

There was a higher frequency of *overturning* type crashes along this segment compared to similar facilities statewide. Most of the *overturning* crashes along this segment occurred between MP 36.90 and MP 37.70 (6 of 10). A review of the crash data indicates that these crashes were influenced by the reverse curves starting around mile marker 37 combined with factors such as drivers asleep at the wheel (3 of 6), alcohol (1 of 6), or passing maneuvers (1 of 6). The recommended shoulder widening with rumble strips through the reverse curves should also help reduce the likelihood of *overturning* type crashes in the packagearea.

Sideswipe (Opposite Direction) Collisions

The frequency of *sideswipe (opposite direction)* type crashes was higher than expected, two of these were fatal crashes. There was a concentration of these crashes between MP 36.60 and MP 37.10 (3 of 4). One of the crashes (fatal) may have been influenced by sun glare, another involved a driver crossing the centerline outside of a passing zone, while the cause of the third crash (fatal) was not clear. The recommended shoulder widening with rumble strips through the reverse curves should also help reduce the likelihood of *sideswipe (opposite direction)* type crashes in the packagearea.

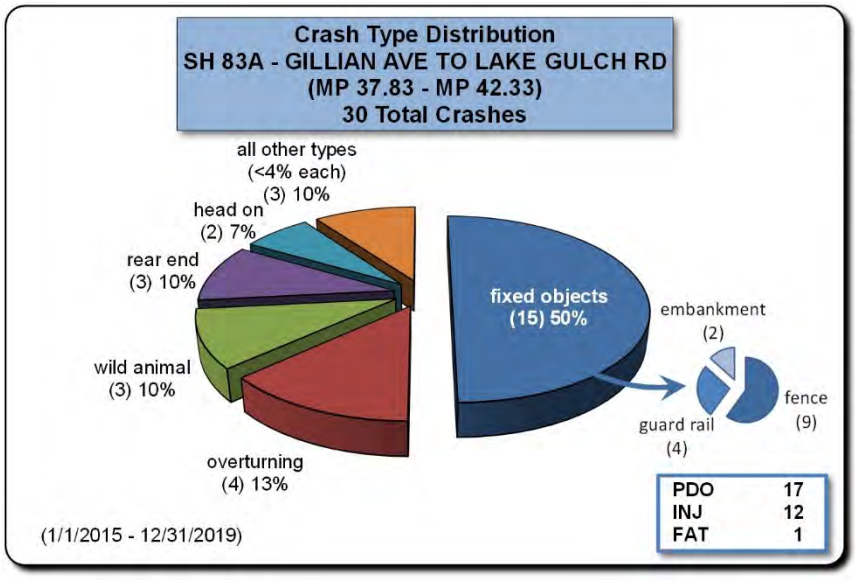
Figure A11: Segment 2 Crashes by Frequency and Severity



Segment 3: Gillian Avenue to Lake Gulch Road

There were 30 crashes along this segment during the five-year study period: 17 PDO crashes (57%), 12 injury crashes (40%) with 18 injured, and one (1) fatal crash (3%) with 2 killed. **Figure A12** shows the crash type distribution for this segment. Fixed object crashes were predominant (50%), followed by *overturning* and *wild animal* type crashes (13% and 10%, respectively). A graphic showing the location, frequency, and severity of crashes is shown in **Figure A11**.

Figure A12: Segment 3 Crash Type Distribution



All Other Types (3)	
vehicle debris or cargo	1
sideswipe (opposite dir.)	1
domestic animal	1

Relationship to Previous Study: There 30 crashes reported in the 2019 Safety Assessment. The proportion of fixed object and *overturning* type crashes were similar, but the frequency of *wild animal* type crashes (8 of 30) was much higher in the 2012 to 2016 data.

Fatal Crash

There was one fatal *head on* crash along this segment that occurred in February 2016 at MP 40.39. A southbound driver crossed over the centerline while travelling around the right-hand curve south of Russelville Road and struck a northbound motorcycle in the northbound lane. Both riders were ejected, the driver (no helmet) was killed on the scene and the passenger (helmet) died after being transported to the hospital. The driver of the southbound vehicle was charged with vehicular homicide while driving under the influence.

Run-Off-Road Collisions

Most of the crashes along this segment were run-off-road collisions (19 of 30), the majority of which were off-right (16 of 19) and involved a high proportion of injury crashes (7 of 16). Though adverse weather or roadway conditions were noted in several crashes (3 PDO, 2 INJ), dry pavement conditions were more common. A review of the crash data did not indicate location-specific crash patterns. The causal factors included multiple DUIs, asleep at the wheel, loss of control during adverse weather, and crash avoidance maneuvers due to passing vehicles. However, many crashes involved vehicles overcorrecting after running off of the right-side of the roadway.

Recommendations

Centerline rumble strips are a potential countermeasure to help address the run-off-road crashes that involved vehicles crossing the centerline. Outside shoulder widening sufficient to provide

rumble-strips would be an effective countermeasure, in general, to warn drivers of lane departure and reduce the likelihood of drivers overcorrecting when attempting to re-enter the roadway. Targeting these improvements to curve locations or near intersections or higher-volume driveways should be considered if segment-wide widening is not feasible.

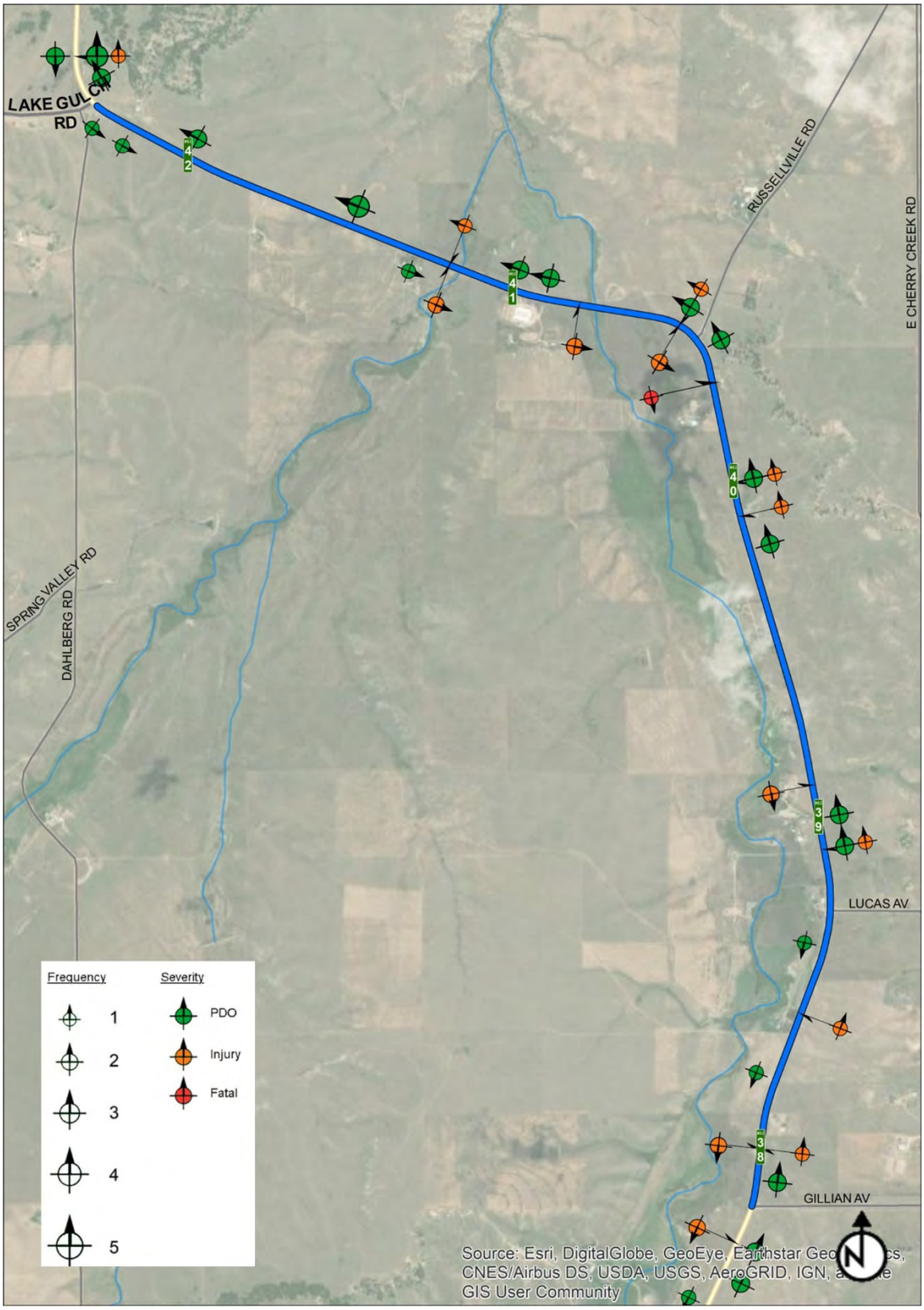
Head-On Collisions

There were two (2) *head on* collisions during the study period, one resulted in multiple fatalities due to an intoxicated driver. The second *head on* collision occurred at MP 39.16, however, there was not sufficient information to determine the proximal cause. There are no recommendations specific to this crash type at this time.

Cherry Valley School Zone

The 2019 Safety Assessment noted the unconventional school zone signing near the Cherry Valley Elementary School, which is located at MP 38.08 just north of Gillian Avenue. There were four (4) crashes within approximately ¼ mile of the school in the current data, only one of which occurred in a timeframe that might coincide with typical school pick-up or drop-off times (2:20 p.m. in May 2018). However, this remains an area of concern and the previous recommendation for an enforceable school zone speed limit should be considered.

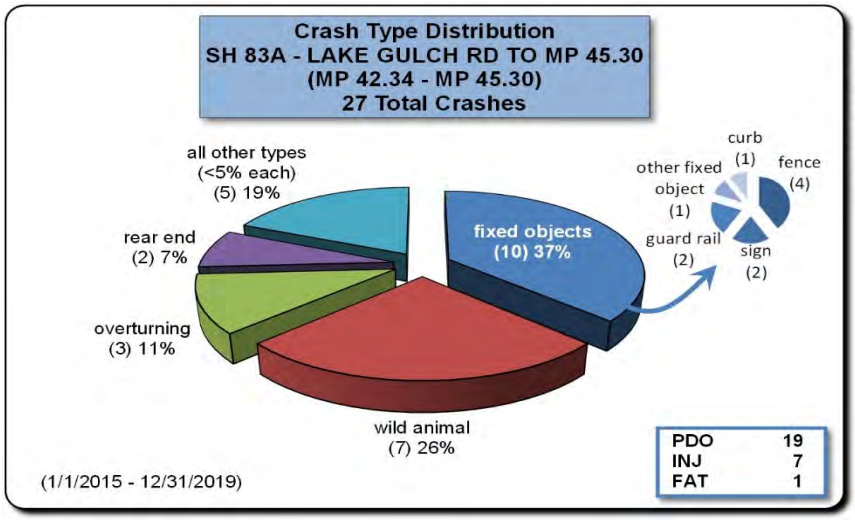
Figure A13: Segment 3 Crashes by Frequency and Severity



Segment 4: Lake Gulch Road to MP 45.30

There were 27 crashes along this segment during the five-year study period: 19 PDO crashes (70%), seven (7) injury crashes (26%) with 12 injured, and one (1) fatal crash (4%) with 2 killed. **Figure A14** shows the crash type distribution for this segment. Fixed object crashes were predominant (37%), followed by *wild animal* type crashes (26%). A graphic showing the location, frequency, and severity of crashes is shown in **Figure A15**.

Figure A14: Segment 4 Crash Type Distribution



All Other Types (5)	
sideswipe (same direction)	1
sideswipe (opposite dir.)	1
other non-collision	1
head on	1
domestic animal	1

Relationship to Previous Study: There were 31 crashes reported in the 2019 Safety Assessment. In general, the proportions were similar in the 2012 to 2016 data compared to those reported in the current five-year study period.

Fatal Crash

There was a fatal *head on* type crash in December 2018 at MP 44.67. There were no adverse weather or roadway conditions; the crash occurred just after dusk. A northbound vehicle crossed the centerline within a passing zone and struck a southbound vehicle head-on; the impact focused on the driver's side of both vehicles. Though wearing seatbelts at the time of the collision, the drivers of both vehicles were killed as a result of this high-speed collision.

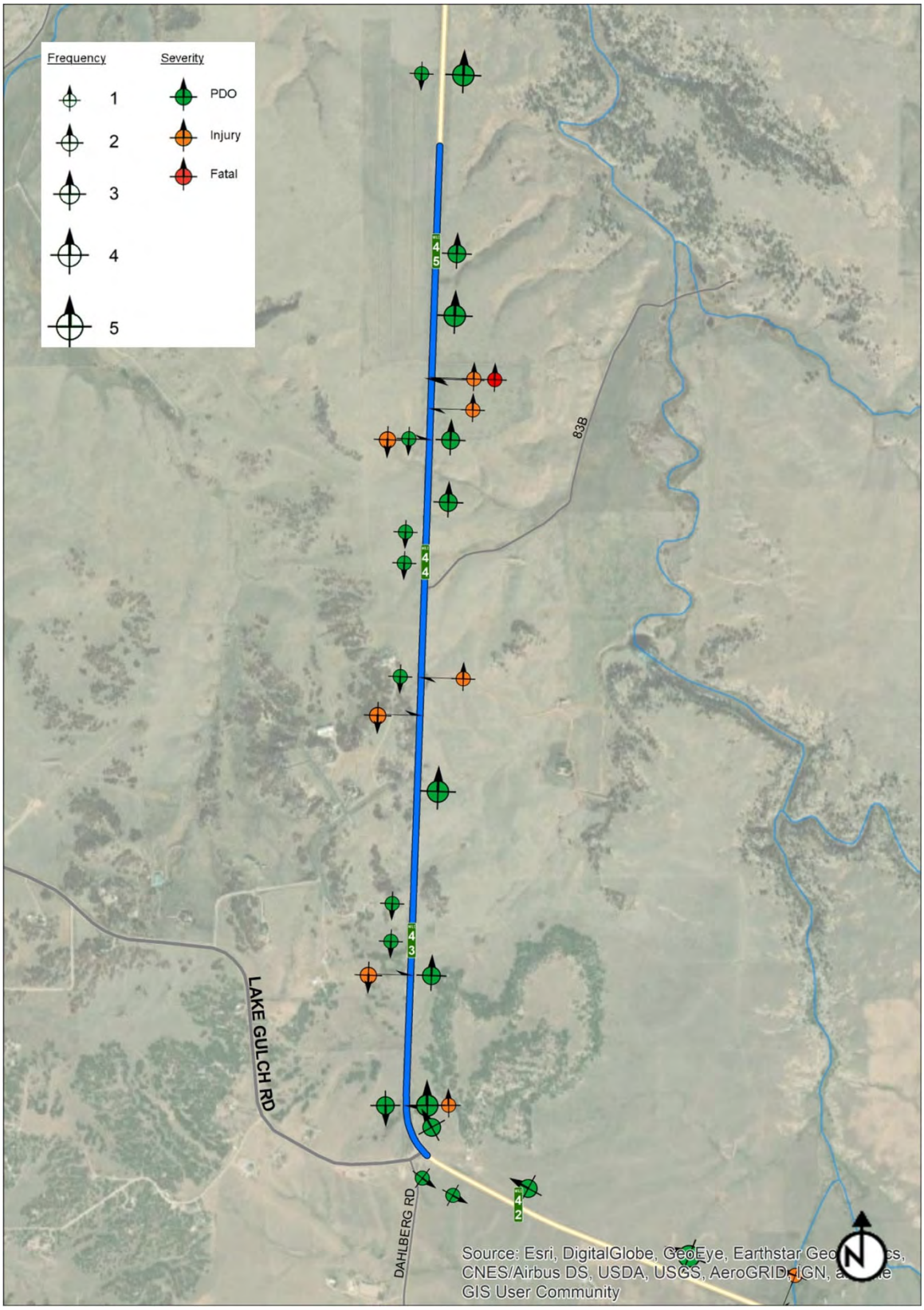
Run-Off-Road Collisions

The proportion of run-off-road crashes (13 of 27) was higher than expected: nine (9) PDO crashes and four (4) injury crashes. The crashes were close to evenly split between off-left (6 of 13) and off-right (7 of 13), and by direction between northbound (7 of 13) and southbound (6 of 13). There was a minor concentration of crashes on the southern end of the segment associated with the curve north of Lake Gulch Road where two northbound off-right crashes and two southbound off-left crashes, all went off of the east side of the roadway. Poor roadway conditions were cited for both of the southbound crashes, the slope of the roadway likely contributing to them travelling off of the inside of the curve after losing control.

Recommendations

There were no clear patterns observed in the crash data for the run-off-road crashes in terms of location or causal factors that would support targeted safety improvements along this segment. Shoulder widening and rumble strips (centerline and shoulder) along the length of the segment would help reduce the frequency of run-off-road collisions, in general, by warning drivers of lane departure and allowing for safer recovery.

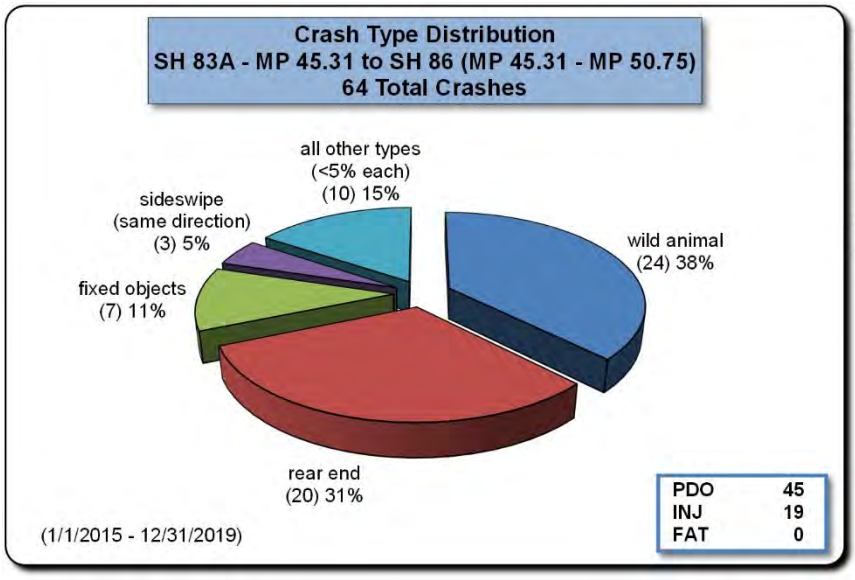
Figure A15: Segment 4 Crashes by Frequency and Severity



Segment 5: MP 45.30 to SH 86

There were 64 crashes along this segment during the five-year study period: 45 PDO crashes (70%), 19 injury crashes (30%) with 24 injured, and no fatal crashes. **Figure A16** shows the crash type distribution for this segment. *Wild animal* type crashes were predominant (38%), followed by *rear end* type crashes (31%). A graphic showing the location, frequency, and severity of crashes is shown in **Figure A17**.

Figure A16: Segment 5 Crash Type Distribution



All Other Types (10)	
sideswipe (opposite dir.)	2
large rocks/boulder	2
head on	2
vehicle debris or cargo	1
overturning	1
other non-collision	1
domestic animal	1

Relationship to Previous Study: There were 42 crashes reported in the 2019 Safety Assessment. There was a significantly lower frequency of non-intersection *rear end* collisions reported in the previous study (7 of 42), but conversely there were more fixed object crashes (12 of 42). The proportion of *wild animal* type crashes was similar in the 2012 to 2016 data.

Wild Animal Collisions

The frequency of *wild animal* type crashes (24 of 64) was within the expected norms for this type of roadway when compared to similar facilities statewide. There was a concentration of about 2.0 crashes per mile per year between MP 49.10 and MP 50.70 (13 of 24). Mitigation measures such as wild animal fencing may not be warranted given the relatively low frequency, though it could be beneficial if an environmental review identifies an appropriate location relative to the migratory patterns. While likely outside the scope of the current project, consider a wild animal underpass at MP 49.56 as part of a future package or when the bridge structure is due for replacement.

MP 47.00 to MP 49.00 Crash Concentration

There was a concentration of crashes (19 of 64) between MP 47.00 and MP 49.00 along a portion of the segment with several curves and a 2.5% downhill grade in the northbound direction. The clear zone is limited through this section due to steep side-slopes and rocky terrain. Guard rail is present along much of the section where there is a significant drop-off. Most of the crashes along this segment were located on the roadway (13 of 19), which is a much higher proportion than expected for this type of facility. *Guard rail* type crashes were notably absent, though there were four other fixed object crashes along the section.

Excluding the six (6) *wild animal* type crashes and one (1) *domestic animal* type crash (successfully avoiding a dog in the road), all six (6) of the remaining on-road crashes occurred in

the southbound direction on the uphill grade. A couple of crashes (2 of 6) involved unusual circumstances such as an oversized load, or vehicle cargo/debris from a large truck, and there were two crashes (2 of 6) that were likely related to passing maneuvers. The last two crashes (2 of 6) were *rear end* crashes that cited stopped traffic downstream of the collision; both crashes occurred just before 4 p.m., near MP 48.00, downstream of a "School Bus Stop Ahead" sign.

Recommendations

This location has been considered for a southbound passing or climbing lane due to the grade and there is public interest in this type of improvement. The low frequency of crashes that would be considered correctable by the additional lane suggests that this mitigation is unlikely to be cost effective given the terrain and its impact on the cost of such a package in this section. However, there are indirect benefits to providing passing opportunities and sorting out high and low speed traffic that can extend well beyond the immediate vicinity of the installation that may be worth pursuing as part of a larger package.

Rear End Collisions

The frequency of *rear end* collisions (20 of 64) was higher than expected for this type of facility. Half of the *rear end* type crashes occurred in the last mile of the segment approaching the SH 86 intersection in Franktown: nine (9) northbound, one (1) southbound. All occurred between 2:30 p.m. and 5:30 p.m., most often on weekends (8 of 10). This suggests that drivers may be less familiar with the area and could be caught off-guard by the transition into Franktown where there is a higher frequency of access points, a lower speed limit, and stop conditions at the SH 86 intersection.

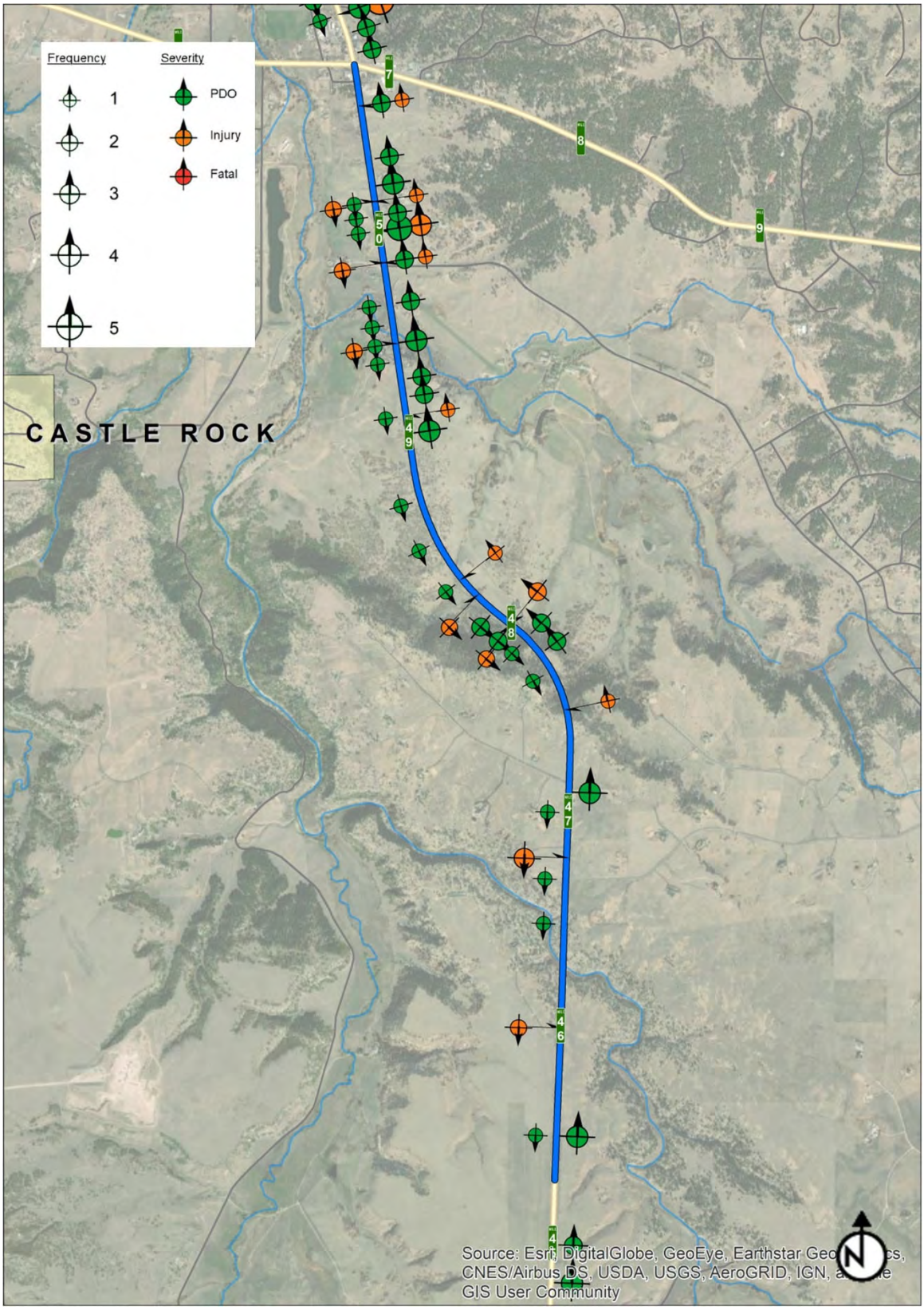
Recommendation

There is a median to provide a southbound left-turn lane at the Franktown Elementary School access (MP 50.30), and the two-way left-turn lane (TWLTL) approaching the SH 86 intersection begins around MP 50.60, south of Kelty Road. Extending the TWLTL median to connect these two locations, starting near MP 50.00, would provide a clearer indication of the change in roadway condition associated with the speed limit drop to 45-mph. In addition, the TWLTL would better serve the higher access frequency approaching SH 86 and reduce the potential for conflicts with turning vehicles. The clear distinction in roadway environment and reduction in conflicts should help lower driver speeds and reduce the likelihood of *rear end* type crashes (along with other crashes). In addition, the TWLTL would provide additional storage for left-turns during school pick-up/drop-off times at Franktown Elementary School.

Franktown Elementary School Zone

There were eight (8) crashes within approximately ¼ mile of the school in the current data, but none occurred on weekdays in a timeframe that would coincide with typical school pick-up or drop-off time. In addition, most were *wild animal* crashes (5 of 8); there were two (2) *rear end* crashes and one (1) *head on* crash that occurred north of the school access point. However, this remains an area of concern and providing an enforceable school zone speed limit should be considered.

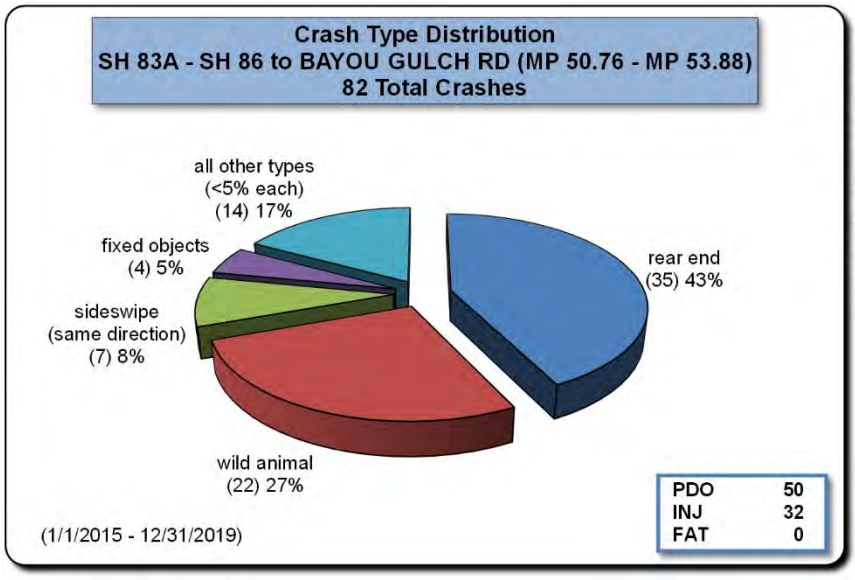
Figure A17: Segment 5 Crashes by Frequency and Severity



Segment 6: SH 86 to Bayou Gulch Road

There were 82 crashes along this segment during the five-year study period: 50 PDO crashes (61%), 32 injury crashes (39%) with 51 injured, and no fatal crashes. **Figure A18** shows the crash type distribution for this segment. *Rear end* type crashes were predominant (43%), followed by *wild animal* type crashes (27%). A graphic showing the location, frequency, and severity of crashes is shown in **Figure A19**.

Figure A18: Segment 6 Crash Type Distribution



All Other Types (14)	
sideswipe (opposite dir.)	3
overturning	3
head on	3
vehicle debris or cargo	1
road maintenance equipment	1
parked motor vehicle	1
involving other object	1
bicycle	1

Relationship to Previous Study: There were 56 crashes reported in the 2019 Safety Assessment. The frequency of *rear end* and *wild animal* type crashes was significantly lower in the previous study (15 of 56 and 11 of 56, respectively). The general proportion of other crash types as similar in the 2012 to 2016 data.

Rear End Collisions

The frequency of *rear end* type crashes (35 of 82) was higher than expected for this type of facility. Most of these crashes resulted in injury (20 of 35), which isn't typical for *rear end* crash patterns. The average speed differential between the stated speeds was over 20-mph, on average, which is likely a contributing factor in the increased severity observed in the data. There was a relatively even split between northbound and southbound crashes (18 and 17, respectively). Most of the northbound crashes occurred between SH 86 and Lost Lake Drive (13 of 18), while southbound crashes were more concentrated between Rafter Road and Castle Oaks Drive (9 of 17). Often, non-intersection *rear end* crashes are more prevalent approaching signalized intersections, which is not the case here.

Recommendation

There is a separate project to widen SH 83 and add left-turn and right-turn lanes between the Rafter Road intersection and the Lost Lake Drive intersection, providing turn lanes for all non-driveway connections between SH 86 and Castle Oaks Drive. Only a short segment between Rafter Road and SH 86 (approximately ¼ mile) will remain undivided once this project is completed. Consider extending the median through this segment to maintain a more consistent cross section.

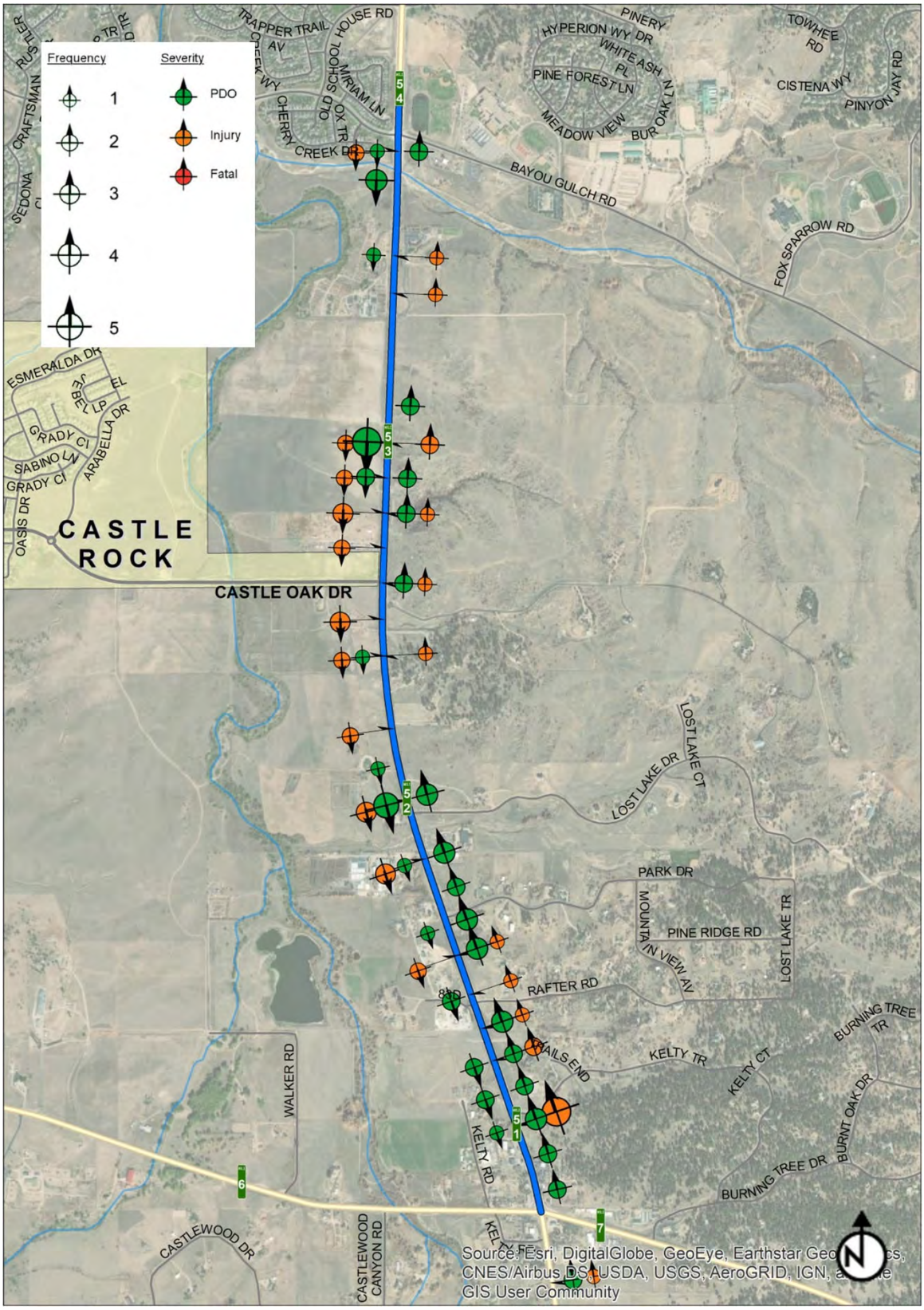
Bicycle Collision

There was one (1) *bicycle* type crash during the five-year study period in September 2016 at MP 52.91. A southbound vehicle was passing the cyclist on the left and struck the cyclist in the process, then fled the scene.

Recommendation

Consider shoulder widening through this segment to provide a safer environment for cyclists and encourage multi-modal use in the area. Wider shoulders would also help reduce the overall crash frequency through this segment.

Figure A19: Segment 6 Crashes by Frequency and Severity



SH 83 INTERSECTION CRASH ANALYSIS

Crashes that can be attributed to intersections (located at intersections or that are intersection related) account for 27% of the total crashes (115 of 425). **Table A3** lists the intersection, number of legs, signalization, crash frequency, and LOSS.

Table A3: Intersection Crashes by Location

MP	Description	Legs	Signal	Number of Crashes				LOSS Total	LOSS Severe
				PDO[1]	Injury	Fatal	Total		
30.24	E. PALMER DIVIDE RD	4	No	6	6	0	12	**IV**	**IV**
31.90	LORRAINE RD, CR 82	4	No	1	2	1	4	**III**	**IV**
33.69	JONES RD, CR 80	4	No	0	1	0	1	II	II
36.33	GREENLAND RD, CR74	3	No	0	0	0	0	I	I
37.82	GILLIAN ST, CR 78	3	No	5	7	1	13	**IV**	**IV**
38.70	LUCAS RD, CR 69	4	No	0	0	0	0	I	I
40.43	S. RUSSELVILLE RD, CR 69	3	No	2	1	0	3	**III**	**III**
42.34	LAKE GULCH RD, CR 63	3	No	2	1	0	3	II	II
43.94	CR 83B	3	No	0	0	0	0	I	I
47.16	NEW DEVELOPMENT	3	No	0	0	0	0	I	I
49.89	N. RUSSELVILLE RD, CR 69	3	No	1	0	0	1	II	II
50.30	FRANKTOWN ELEMENTARY	3	No	0	0	0	0	I	I
50.70	KELTY RD	3	No	0	0	0	0	I	I
50.76	JCT SH 86	4	Yes	17	12	1	30	II	**III**
51.03	KELTY TRAIL	3	No	0	0	0	0	I	I
51.37	RAFTER RD	4	No	0	2	0	2	II	II
51.63	PARK DR	3	No	3	3	0	6	**IV**	**III**
52.60	CASTLE OAKS DR	3	Yes	6	4	0	10	II	**III**
53.86	BAYOU GULCH RD, CR 28	4	Yes	14	7	0	21	**III**	**III**
Non-Specific Intersection Crashes (>100-ft from intersection)				6	3	0	9		
Total				**63**	**49**	**3**	**115**		
Average / Year				**12.6**	**9.8**	**0.6**	**23.0**		

[1] PDO – Property Damage Only crashes
[2] 4-lane signalized intersection data used to calculate LOSS for 2-lane signalized intersections.

There were four intersections where either the total or severe crashes were in the LOSS IV category, indicated a high potential for crash reduction. Four other intersections indicated a higher-than-expected crash frequency for either total or severe crashes (LOSS III). These locations are discussed in greater detail in the following sections.

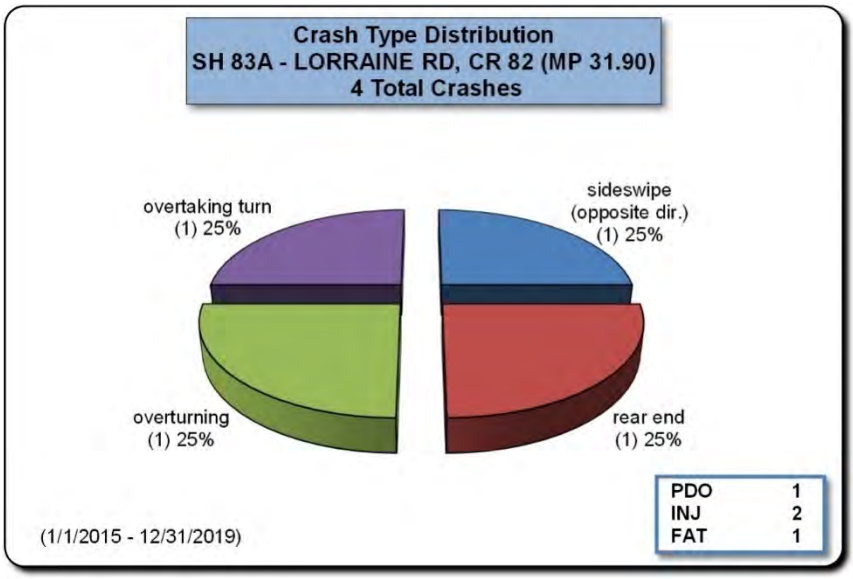
Palmer Divide Road (MP 30.24)

A total of 12 crashes occurred at this 2-lane undivided unsignalized 4-leg intersection during the study period: eight (8) *broadside* type, two (2) *rear end* type, and two (2) *approach turn* type crashes. The SPF analysis indicated LOSS IV conditions for both total and severe crashes. There is an existing project in the planning/design stages to reconstruct this intersection to a high-speed roundabout based on previous analysis efforts at this location. As such, there are no additional recommendations at this time.

Lorraine Road (MP 31.90)

There were four (4) crashes at this 2-lane undivided unsignalized 4-leg intersection, including one (1) fatal crash. The SPF analysis indicated LOSS IV for severe crashes and LOSS III for total crashes. The crash type distribution is shown in **Figure A20**.

Figure A20: Lorraine Road Crash Type Distribution



Relationship to Previous Study: There were only two (2) crashes reported in the 2019 Safety Assessment, both occurred in 2016 and are therefore also represented in the current crash data. The previous recommendation was to monitor the safety performance at this intersection.

Fatal Collision

There was a fatal *sideswipe (opposite direction)* type crash that occurred in August 2018. A northbound vehicle lost control while braking to avoid a collision with a northbound (non-contact) vehicle that was waiting to turn left-onto Lorraine Road, then crossed the centerline into the southbound lane and collided with a southbound vehicle. The southbound vehicle went off of the right-side of the road in a broadside skid and rolled 1 ¼ times, ejecting then coming to rest atop an unrestrained passenger who died on the scene.

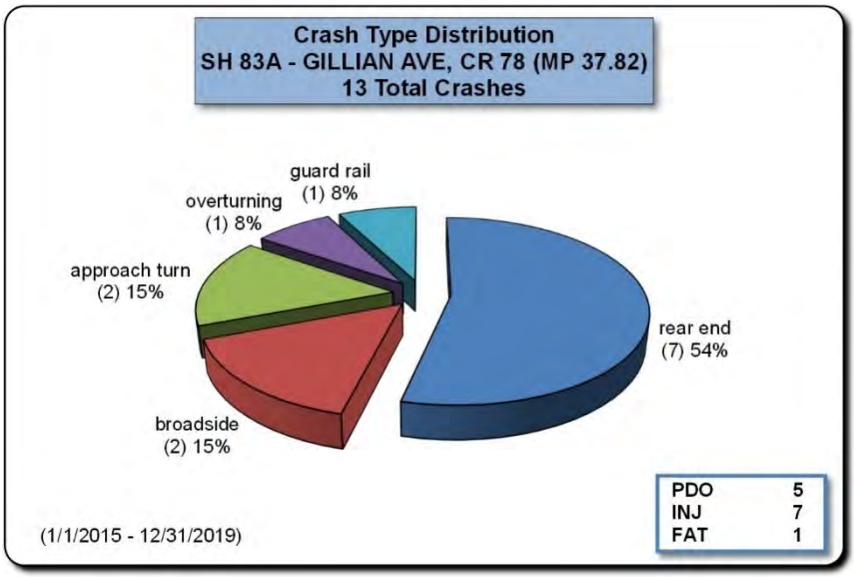
Recommendation

A review of the crash data indicated that all four crashes involved northbound vehicles turning at the Lorraine Road intersection, including the fatal crash. Due to the consistency of the underlying cause of the crashes and worsening pattern at this location, consider adding left-turn lanes to allow for safer deceleration and storage for vehicles turning left at this intersection. While none of the crashes involved right-turns at this time, consider collecting traffic counts to determine if the volumes meet access code requirements for right-turn lanes and widening the shoulders in the vicinity of the intersection if the volumes are not sufficient.

Gillian Avenue (MP 37.82)

There were 13 crashes at this 2-lane undivided unsignalized 3-leg intersection, including one (1) fatal crash. The SPF analysis indicated LOSS IV for both severe and total crashes. The crash type distribution is shown in **Figure A21**.

Figure A21: Gillian Avenue Crash Type Distribution



Relationship to Previous Study: There were eight (8) crashes reported in the 2019 Safety Assessment. There were fewer *rear end* and *broadside* crashes (4 and 1, respectively), and there were no *approach turn* type crashes reported in the 2012 to 2016 data. The recommended improvements included adding left-turn deceleration and acceleration lanes in the southbound direction, or alternatively converting the intersection to a roundabout.

Fatal Crash

There was a fatal *broadside* type crash that occurred in May 2019. A westbound vehicle on Gillian Avenue failed to stop at the stop sign and skidded into the intersection where it was struck by a northbound vehicle at an approximate speed of 65-mph. All parties were wearing seatbelts at the time of the crash, but a passenger in the rear of the northbound vehicle died after being transported to the hospital.

Recommendation

A review of the crash data indicated that most of the crashes at this intersection were caused by southbound vehicles including all seven *rear end* crashes, both *approach turn* crashes, and the *overturning* type crash. Slowed or stopped traffic due to vehicles turning left onto Gillian Avenue was a significant contributing factor. Adding a southbound left-turn lane would provide space to allow for deceleration and storage for turning vehicles. This will allow vehicles to complete their turns in a safer manner and should help reduce the frequency of *rear end* crashes and reduce the likelihood of *approach turn* type crashes as drivers can focus on gaps in oncoming traffic with less risk of being struck from behind while waiting.

Also consider reviewing the traffic volumes to determine if a left-turn acceleration lane is warranted as per the access code for this type of facility. This would help improve the safety and operation for westbound vehicles turning left from Gillian Avenue though only one of the *broadside* type crashes occurred due to a vehicle failing to yield the right-of-way. Stop sign enhancements, such as flashing LED borders, should also be considered as the fatal *broadside* type crash occurred when a vehicle failed to stop for the stop-sign.

Secondary Recommendation

The recommended left-turn deceleration lane is expected to result in a significant reduction in crashes at this location based on a review of the crash patterns. Replacing the unsignalized

intersection with a high-speed roundabout would also address the observed crash patterns and would additionally provide some degree of traffic calming by slowing approaching vehicles. However, the additional benefits are unlikely to offset the higher cost, and there are additional impacts associated with a roundabout project. This should only be considered if there is sufficient public or local agency support for such a measure.

South Russelville Road (MP 40.43)

There were only three (3) crashes at the South Russelville Road intersection during the five-year study period: one each of *sign*, *overturning*, and *broadside* type crashes. While the SPF analysis indicated LOSS III for both severe and total crashes, a review of the crash data did not indicate a correctable pattern. No recommendations for improvement are made at this time.

North Russelville Road (MP 49.89)

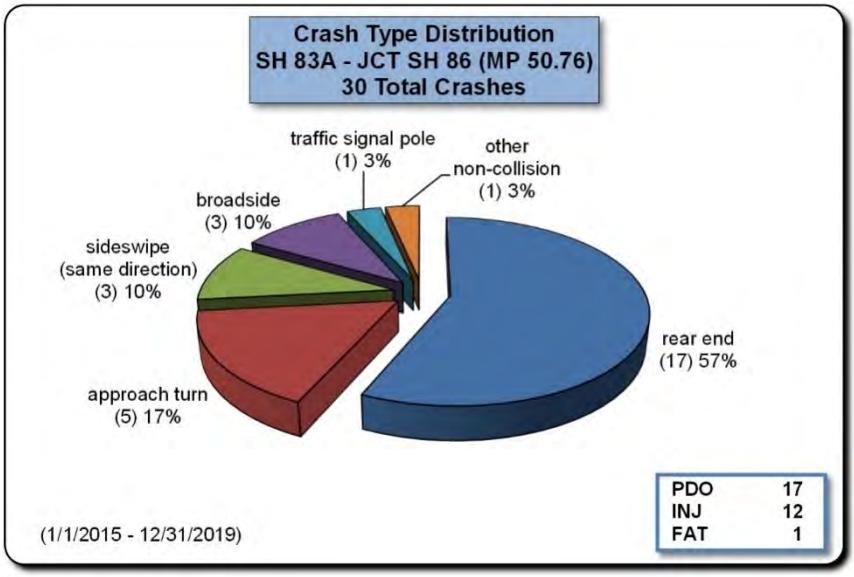
There were nine (9) crashes reported in the 2019 Safety Assessment based on the 2012 to 2016 crash data. Southbound left-turn lanes were added at this intersection in the 2013-2014 timeframe, about halfway through the previous reporting period.

There was only one (1) crash at the North Russelville Road intersection during the current five-year study period (2015-2019) and the SPF analysis indicated better than expected safety performance for both severe and total crashes (LOSS II). Due to the significant decrease in crash experience observed between the two datasets, no additional recommendations for improvement are made at this time.

SH 86 (MP 50.76)

There were 30 crashes at this 2-lane divided signalized 4-leg intersection, including one (1) fatal crash. The SPF analysis indicated LOSS III for severe crashes and LOSS II for total crashes. The crash type distribution is shown in **Figure A22**.

Figure A22: SH 86 Crash Type Distribution



Relationship to Previous Study: There were 28 crashes reported in the 2019 Safety Assessment. The proportions of *rear end* and *approach turn* type crashes were shifted somewhat, with only 42% *rear end* and 32% *approach turn* in the 2012 to 2016 data. The previous study

recommended changing the northbound and southbound signal phasing to protected-only operations to help reduce the frequency of *approach turn* type crashes.

Fatal Crash

There was a fatal *rear end* type crash that occurred in October 2018. The collision occurred in the southbound left-turn lane when the leading vehicle stopped for the light and was struck from behind as the trailing vehicle traveled into the left-hand lane at an estimated speed of 60-mph. The crash occurred around midday during adverse weather with wet roadway conditions. It is possible that the trailing vehicle did not intend to drive into the left-turn lane, and the driver of the vehicle was killed.

Rear End Collisions

The proportion of *rear end* type crashes (17 of 30, 57%) was higher than expected when compared to similar intersections. Northbound and southbound crashes were more common (5 and 6, respectively) while the remaining five crashes occurred in the eastbound and westbound directions (4 and 1, respectively). Most of the crashes occurred during the day with no adverse weather or roadway conditions noted.

Recommendation

General signal visibility improvements should help reduce the frequency of *rear end* type crashes at this intersection. Consider replacing the current span wire signals with a mast-arm signal installation including LED lenses with backplates and highly reflective borders.

Approach Turn Collisions

The *approach turn* crashes occurred in the northbound and southbound directions (3 and 2, respectively); these approaches operate with protected/permitted phasing. While the proportion of *approach turn* crashes was within the expected norm for this type of intersection, most of the crashes involved injury (4 of 5).

Recommendation

The recommended protected only phasing from the 2019 Safety Assessment would still be appropriate given the high proportion of injury crashes. If the operations assessment determines a need to maintain the protected/permitted phasing, the left-turn signals should be upgraded to Flashing Yellow Arrow (FYA) signal heads to help reduce the frequency of *approach turn* type crashes.

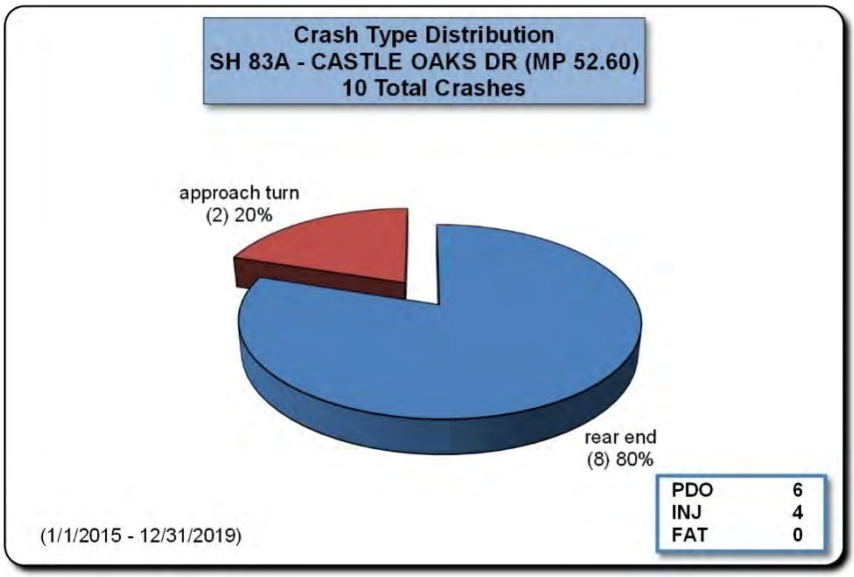
Park Drive (MP 51.63)

There were six (6) crashes at this 2-lane undivided unsignalized 3-leg intersection: four (4) *rear end* type crashes, one (1) *broadside* type crash, and one (1) *approach turn* type crash. The SPF analysis indicated LOSS IV for total crashes and LOSS III for severe crashes. There is a current project planned for this location that would add turn lanes at this intersection; no additional recommendations are made at this time.

Castle Oaks Drive (MP 52.60)

There were 10 crashes at this 2-lane divided signalized 3-leg intersection. The SPF analysis indicated LOSS III for severe crashes and LOSS II for total crashes. The crash type distribution is shown in **Figure A23**.

Figure A23: Castle Oaks Drive Crash Type Distribution



Relationship to Previous Study: There were nine (9) crashes reported in the 2019 Safety Assessment. Some of the crashes (two *broadside*) occurred prior to the signal installation and desisted afterward. In addition to monitoring the crash patterns in the future, the previous study recommended adding advance street name plaques to the intersection warning sign for northbound traffic and to provide a similar warning sign with name plaque in the southbound direction.

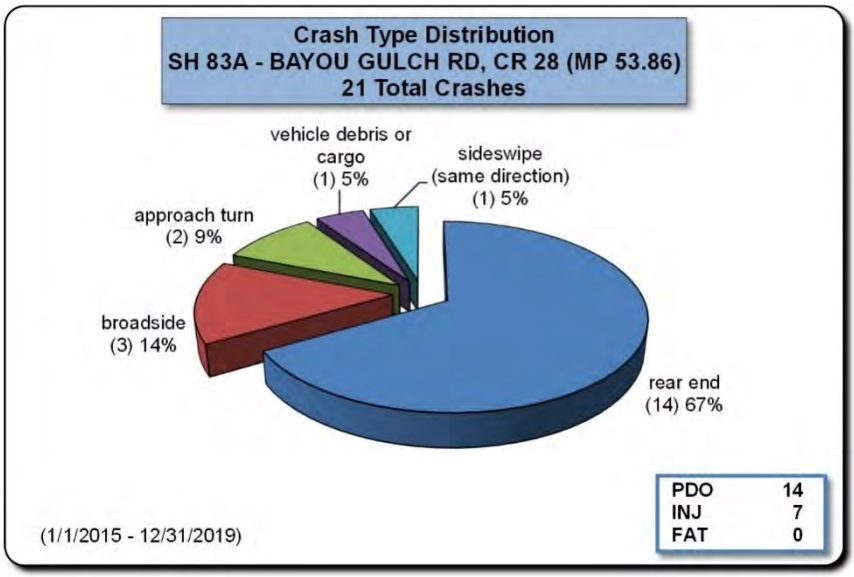
Rear End Collisions

The proportion of *rear end* type crashes (8 of 10, 80%) was higher than expected for this type of intersection, most occurring in the northbound direction (7 of 8). The signal was installed in 2015 and most of the crashes occurred earlier in the study period: six (6) crashes from 2015 through 2017 (2 per year), one (1) crash in 2018 and no crashes in 2019. The decreasing trend could indicate a change in driver behavior (or timing adjustments) that should be monitored before committing to additional geometric improvements.

Bayou Gulch Road (MP 53.86)

There were 21 crashes at this 2-lane divided signalized 4-leg intersection. The SPF analysis indicated LOSS III for both severe and total crashes. The crash type distribution is shown in **Figure A24**.

Figure A24: Bayou Gulch Road Crash Type Distribution



Relationship to Previous Study: There were 18 crashes reported in the 2019 Safety Assessment. There were no recommendations for improvement based on the 2012 to 2016 crash data.

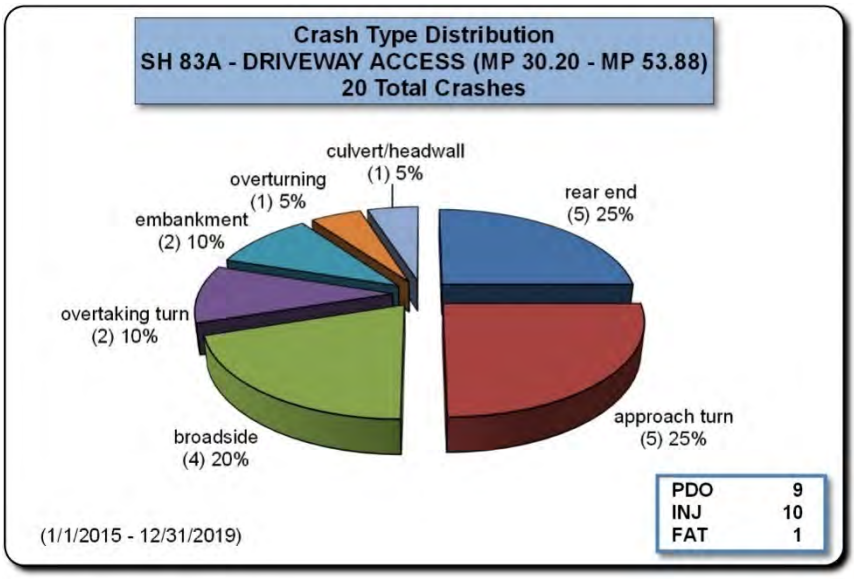
Rear End Collisions

The proportion of *rear end* crashes was somewhat higher than expected but not significant when compared to similar facilities. There was a minor concentration of crashes between 2 p.m. and 4 p.m. which could coincide with school egress. While no geometric improvements are recommended at this time, a review of the signal timing during this afternoon peak should be considered.

SH 83 DRIVEWAY ACCESS CRASHES

Crashes that occurred at driveway access locations accounted for 5% of the total crashes (20 of 425). There are no SPF analysis methodologies that apply directly to driveway access crashes. **Figure A25** shows the crash type distribution for the driveway access crashes during the study period. A graphic displaying the approximate location and severity of driveway crashes, by direction, is shown in **Figure A26**.

Figure A25: Driveway Access Crash Type Distribution



Relationship to Previous Study: There were 15 crashes reported in the 2019 Safety Assessment, one (1) resulted in a fatality. There were no recommendations for improvement specific to driveway access crashes based on the 2012 to 2016 data.

Fatal Crash

There was one (1) fatal *rear end* crash that occurred in September 2016 at MP 44.03. Details were limited, but it appears that a southbound passenger car and a southbound motorcycle were both stopped in traffic, presumably due to a vehicle waiting to turn left into the nearby driveway. A third vehicle failed to stop and collided with the stopped vehicle at a high rate of speed. The chain collision resulted in the death of the motorcycle rider.

South of Franktown (East Palmer Divide Road to SH 86)

Eight (8) of the 20 driveway crashes occurred south of the Franktown area (near SH 86) and included the fatal driveway crash. A review of the crash data did not indicate that any specific driveway access was more prone to crashes than other locations. Crashes could occur at any driveway location when drivers slow or stop to turn into the driveway from this high-speed facility.

Recommendation

It is generally not feasible to provide a median or left-turn lanes for individual driveway accesses unless the turning movements meet the requirements as per the CDOT access code. However, providing wider shoulders in the immediate vicinity of higher use driveways should help reduce the likelihood of multi-vehicle crashes.

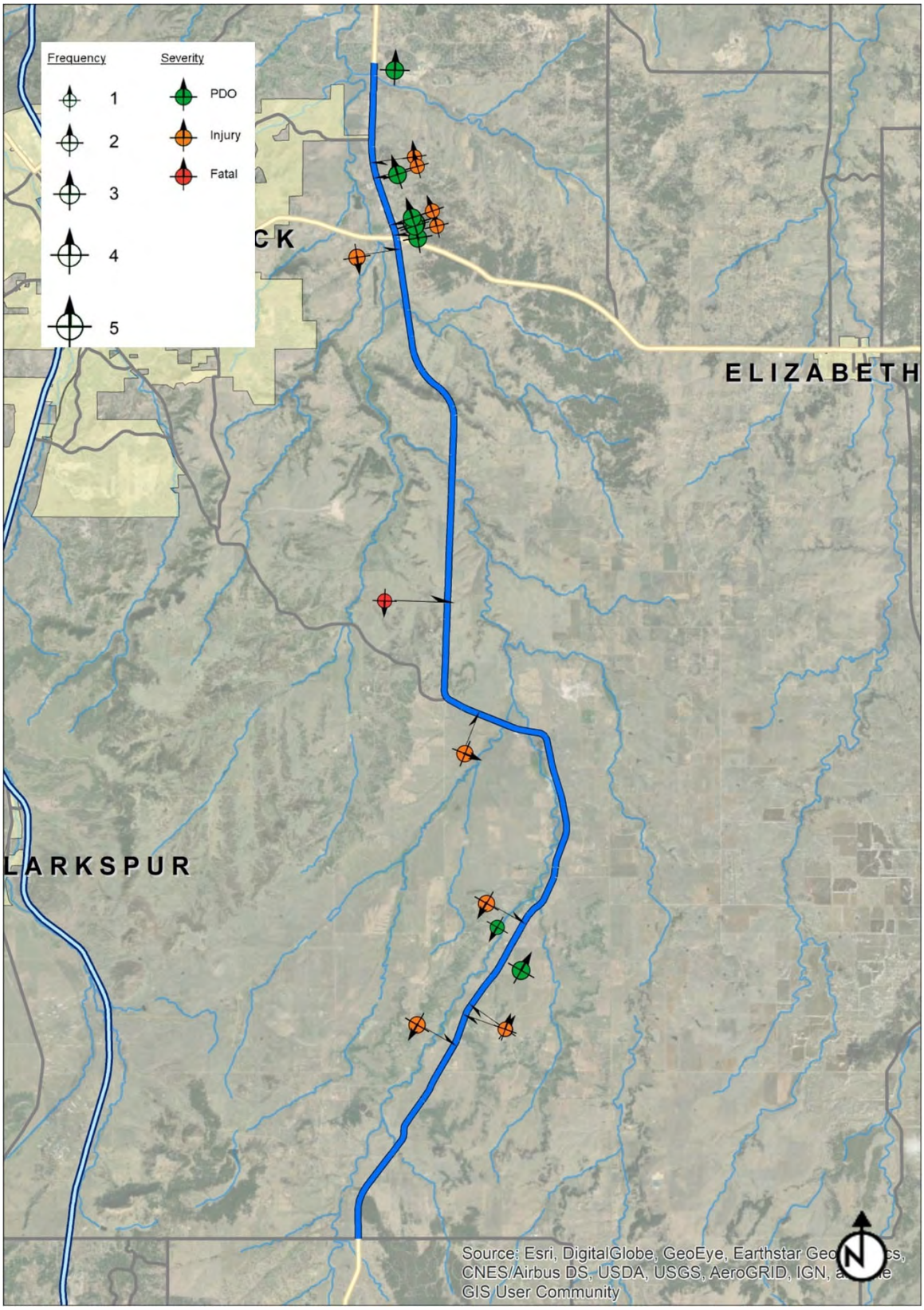
North of (and including) Franktown (SH 86 to Bayou Gulch Road)

Most of the driveway access crashes (12 of 20) occurred either just south of the SH 86 intersection or to the north. Of these, most occurred in the immediate vicinity of SH 86 (8 of 12) where the access density is highest.

Recommendation

As per the access control plan, combine or limit access to identified locations as development occurs to enhance the safety and operations of the SH 86 corridor. In particular in the Franktown area and to the north along SH 83 toward the end of the study segment at Bayou Gulch Road due to the higher frequency of driveway related crashes.

Figure A26: Driveway Crashes by Frequency and Severity



SUMMARY OF RECCOMENDATIONS

The intent of this Safety Study is to identify, as much as possible, specific locations for safety improvements along SH 83 between East Palmer Divide Road and Bayou Gulch Road. These recommendations are made as an extension of those in the 2019 Safety Assessment, except where the differences in crash patterns dictate different mitigation measures. However, it should be noted that some of the previous recommendations require systemic changes or would require additional study and do not fit the current funding opportunities.

General Recommendations

The following features typically associated with construction projects should be provided:

- Good skid resistance and drainage of the roadway surface.
- Adjustment, repair, and upgrade of existing guardrail to meet current standards.
- Elimination of pavement edge drop-offs (Safety Edge Application).
- Crown correction where required.
- Appropriate advance warning signing of curves, interchanges, and intersections.
- Replace all button reflectors and guardrail reflectors to ensure good nighttime and inclement weather (fog, snow, rain, etc.) delineation.
- Upgrade pavement markings to meet current retroreflectivity standards.
- Review signal timing plans to ensure appropriate signal change period.

Additional recommendations that should be considered for the corridor as a whole:

- Install centerline rumble strips.
- Widen shoulders and install rumble strips.
- Add intersection name plaques to all intersection ahead signs.
- Consider a pilot package to install oversized delineator reflectors along the corridor.

Non-Intersection Recommendations

Segment 1: El Paso Line to South of Jones Road (MP 30.20 to MP 33.50)

- **Run-Off-Road, Off-Right Collisions:** Widen shoulders through the reverse curves (near MP 32.50) and install rumble strips.
- **Sideswipe (Same Direction) Collisions:** Monitor the impact of the recent modifications to the passing zones to determine if additional mitigation measures should be considered.
- **Rear End Collisions:** Widen shoulders in the vicinity of driveways and side-streets where turn-lanes are not feasible; specifically around MP 30.50, MP 31.89, and MP 32.10.

Segment 2: South of Jones Road to Gillian Avenue (MP 33.50 to MP 37.82)

- **Run-Off-Road Collisions:** Widen shoulders and install rumble strips through the reverse curves (near MP 37.00) and curve locations in general, where possible.
- **Run-Off-Road Collisions:** Consider installing oversized delineator reflectors through the curves in this segment where chevrons are not warranted to evaluate effectiveness.

Segment 3: Gillian Avenue to Lake Gulch Road (MP 37.82 to MP 42.33)

- **Run-Off-Road Collisions:** Widen shoulders and install rumble strips along this segment, focusing on curves as breakout packages if necessary.
- **Cherry Valley School Zone:** Consider replacing the school zone warning signs with enforceable school zone speed limit signage.

Segment 4: Lake Gulch Road to MP 45.30 (MP 42.33 to MP 45.30)

- **Run-Off-Road Collisions:** Widen shoulders and install rumble strips along this segment.

Segment 5: MP 45.30 to SH 86 (MP 45.30 to MP 50.75)

- **Wild Animal Collisions:** Consider a review of wild animal migration patterns to determine if wild animal fencing along with a wild animal underpass would be appropriate as a future package.
- **Grade from MP 47.00 to MP 49.00 Concentration:** A southbound climbing lane along this 2.5% grade would be cost-prohibitive but should be considered as part of a future package.
- **Rear End Collisions:** Extend the two-way left-turn lane (TWLTL) to provide a consistent median from the Franktown Elementary School access (MP 50.30) through the SH 86 intersection.
- **Franktown Elementary School Zone:** Consider enforceable school zone speed limit signage.

Segment 6: SH 86 to Bayou Gulch Road (MP 50.75 to MP 53.88)

- **Rear End Collisions:** Extend the median as a TWLTL to connect the median north of SH 86 to the median being added near Rafter Road as part of a separate project.
- **Bicycle Collision:** Shoulder widening through this segment would provide a safer environment for cyclists and encourage multi-modal use.

Intersection Recommendations

Lorraine Road (MP 30.24)

- Add left-turn deceleration lanes on SH 86 at this intersection.
- Review volumes to determine if right-turn acceleration/deceleration lanes are warranted.
  - If not warranted, consider shoulder widening in the vicinity of the intersection.

Gillian Avenue (MP 37.82)

- Add a southbound left-turn deceleration lane.
- Add a westbound to southbound left-turn acceleration lane if warranted.
- Consider stop-sign enhancements such as flashing LED borders.
- As an alternative, consider replacing the intersection with a high-speed roundabout if there is sufficient public or local agency support for the package.

SH 86 (MP 50.75)

- Replace with mast-arm signal installation.
- Provide LED lenses and backplates with highly reflective borders, in general.
- Convert northbound and southbound left-turns to protected-only phasing.
  - If protected/permitted phasing is desired for operations, replace the left-turn signal heads with Flashing Yellow Arrow signal heads and appropriate signing.

Driveway Access Recommendations

- **South of SH 86:** Widen shoulders in the vicinity of driveways where turn-lanes are not warranted.
- **North of SH 86:** As per the access control plan, combine or limit access to identified locations as development occurs.