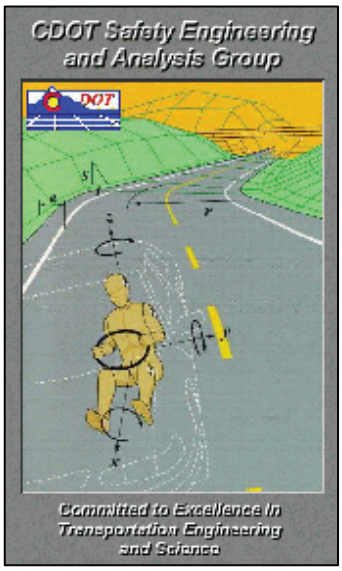
Appendix A:
Safety Assessment



A Statement of Philosophy

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

INTRODUCTION

The Transportation Equity Act for the 21st Century (TEA-21) of 1998 requires explicit consideration of safety in the transportation planning process. While this government mandate is well intentioned, little is known about how to accomplish it. In order to meet this requirement, we have employed a recently-developed concept of the Level of Service of Safety[2] (LOSS). The LOSS concept makes it possible to accomplish the following:

- Qualitatively describe the degree of safety or un-safety of a roadway segment.
- Effectively communicate the magnitude of the safety problem to other professionals or elected officials.
- Bring perception of roadway safety in line with reality of safety performance reflecting a specific facility.
- Provide a frame of reference from a safety perspective for planning major corridor improvements.

The scope of the safety chapter of the Environmental Assessment (EA) is as follows:

- Assess the magnitude and nature of the safety problem within the project limits.
- Relate accident causality to roadway geometrics, roadside features, traffic control devices, traffic operations, driver behavior, and vehicle type.
- Suggest counter measures to address identified problems.
- Provide guidance on how to identify the preferred alternative from a safety standpoint.

The safety chapter of the EA will prepare a framework for the evaluation of alternatives from a safety standpoint.

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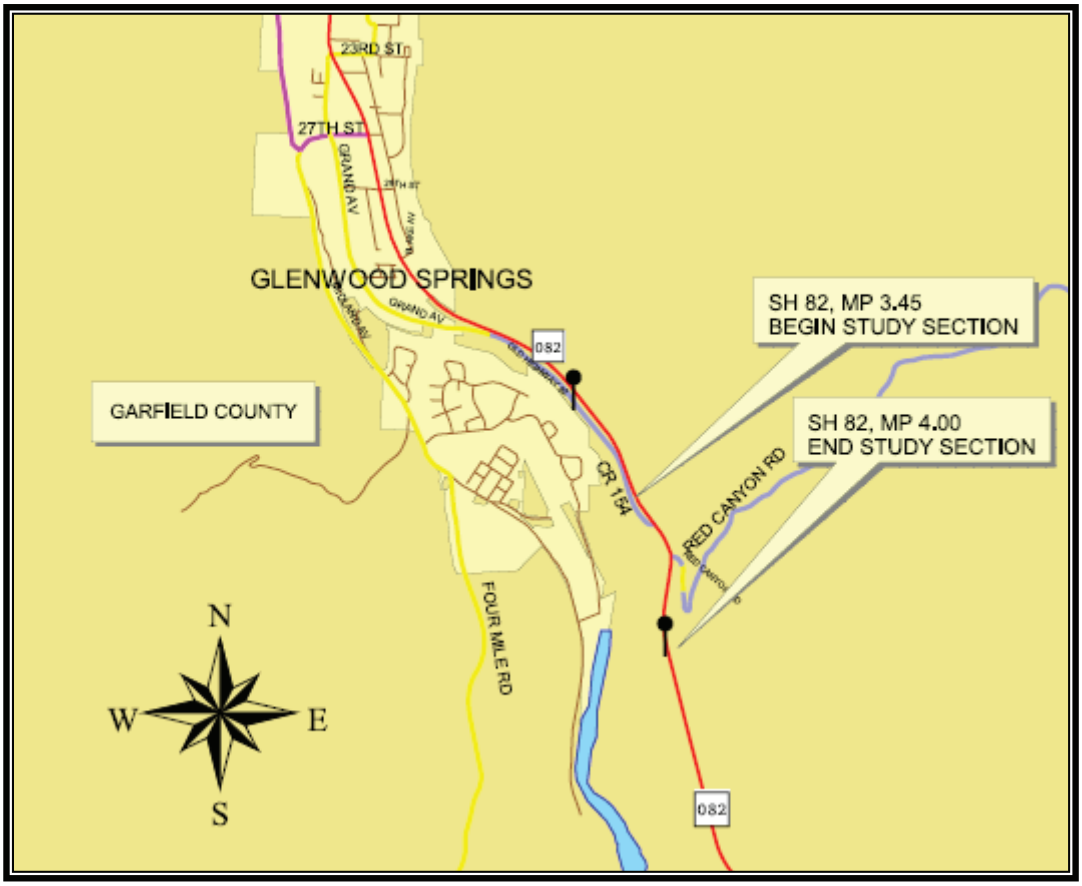
[1] Hauer, E., (1999) *Safety Review of Highway 407: Confronting Two Myths*. TRB

[2] Kononov, J. & Allery, B. (2003) *Level of Service of Safety-Conceptual Blueprint and Analytical Framework*. Presented at the TRB Annual Meeting, Washington D.C. (January 2003)

SITE LOCATION AND CONDITIONS

This study addresses SH 82 in Garfield County in the southern portion of the City of Glenwood Springs, beginning at MP 3.45 and continuing southeasterly to MP 4.00 (see **Figure 1**). The included distance is 0.55 miles. There is currently an existing County Road 154 intersection at approximately MP 3.55, one (1) existing private access intersections at approximately MP 3.67, MP 3.90 and 3.96; and the Red Canyon Road/private access to Holy Cross Electric at approximately MP 3.70. This study will also analyze the preferred alternate South Bridge Alignment/County Road 154 signalized intersection at approximately MP 3.88.

Figure 1



SH 82 is classified as an Urban Other Principal Arterial highway in mountainous terrain throughout the study section. The highway is a four-lane divided facility with a painted median from approximately MP 3.45 to 3.78, where the median changes to a raised curb median up to approximately MP 3.93, where the median is open, depressed and landscaped . According to the 2008 CORIS listing file, the 2008 Average Annual Daily Traffic (AADT) is 24,800 Vehicles per Day (VPD) throughout the entire study section, and the 2008 truck traffic rate is 4.1% of the total traffic. Keep in mind that these figures are historical and will be different from the current figures listed in other sections of this EA. The posted speed limit varies from 55 mph to 65 mph inside the City of Glenwood Springs.

SH 82 ACCIDENT HISTORY

The accident history for the five-year study period, from January 1st, 2004 to December 31st, 2008 was examined for the aforementioned study section to help locate accident clusters and identify accident causes. During the five-year study period, 55 accidents were reported on SH 82 between MP 3.45 and 4.00. Of these 55 accidents, 21 were located at intersections or were intersection-related, one (1) was located at a driveway access, and 33 were located in urban non-intersections. Of the 21 intersection and intersection-related accidents, 13 were located at the SH 82 / County Road (CR) 154 intersection, and eight (8) were located at the SH 82 / Red Canyon Road - Holy Cross Electric private access. Further analysis of these intersections are shown later in this report. In addition, eight (8) of the 55 total accidents resulted in **'Injuries'**, and none resulted in a **'Fatality'**.

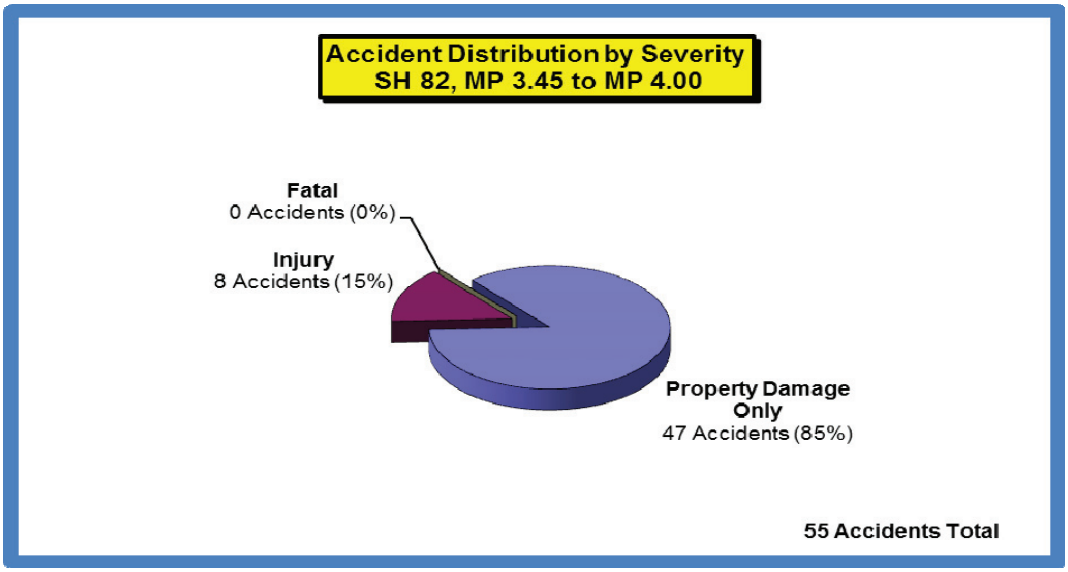
Table 1 summarizes the total accidents, annually, over the five-year study period, along with the Average Annual Daily Traffic Counts (AADT).

Table 1

Year	AADT	Accidents			
		PDO	Injury	Fatal	Total
2004	**22,600**	10	2	0	**12**
2005	**23,300**	7	3	0	**10**
2006	**23,700**	14	0	0	**14**
2007	**24,900**	5	2	0	**7**
2008	**24,800**	11	1	0	**12**
TOTAL		**47**	**8**	**0**	**55**

Figure 2 shows the accident severity distribution for the entire study section for the five-year study period.

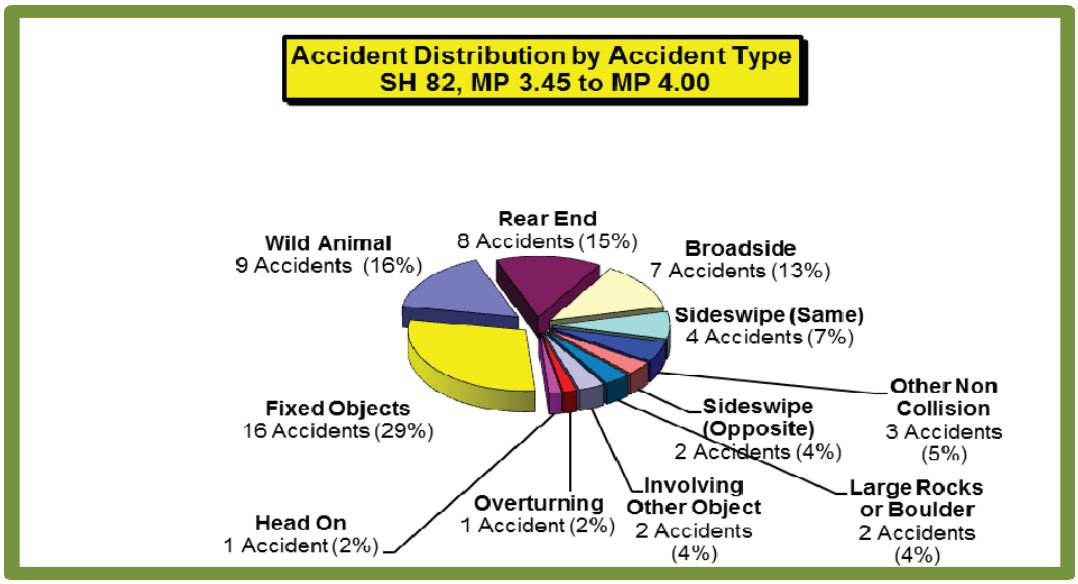
Figure 2



As **Figure 2** indicates, 15% (eight accidents) of the accidents during the study period resulted in **'Injuries'**, 85% (47 accidents) resulted in **'Property-Damage Only**, and none resulted in a **'Fatality'**. The **'Injury'** and **'Fatal'** rates are below statewide average when compared to similar facilities, so overall, the SH 82 study area has performed well, safety-wise.

Figure 3 shows the accident distribution, by accident type, for the SH 82 study section during the five-year study period.

Figure 3



As **Figure 3** indicates, 29% (16 accidents) of the accident types struck were **'Fixed Objects'**, 16% (nine accidents) were **'Wild Animal'**, 15% (eight accidents) were **'Rear-End'** accidents, and 13% (seven accidents) were **'Broadside'** accidents. The accidents rates for **'Wild Animal'**, **'Rear-End'** and **'Broadside'** are higher than the statewide average for similar facilities.

Most of the **'Wild Animal'** accidents (seven of nine) were located between MP 3.80 to the end of the study section. The animals being hit at this segment are deer and elk. While the problem of vehicles hitting wild animals, especially larger ones such as these, is a serious problem, it is also one of the most difficult to effectively address without incurring high costs and complex environmental considerations. The statewide increase in this accident type is possibly tied to what we hope are temporary drought conditions that have affected the state in recent years. The Region may want to consider adding wild animal advance warning signs (W11-3) at both ends of the study section.

None of the **'Rear-End'** accidents resulted in **'Injuries'** or a **'Fatality'**. Poor driver behavior or careless driving, not poor existing site conditions, were factors in five (5) of the **'Rear-End'** accidents. If these rear-end accidents were removed from the analysis, the rate of rear-end accidents would be slightly below the statewide average rate for similar facilities, and the number of these accidents would be very low for this study section over the five-year study period. Since the number of these accidents is low, no effective counter measure is warranted.

Five (5) of the **'Broadside'** accidents were located at the CR 154 intersection at MP 3.55, and the remaining two (2) accidents were located at the Red Canyon Road / Holy Cross Electric private access unsignalized intersection at MP 3.70. More detailed analysis of these accidents is described later in this report.

Figure 4 shows a breakdown of the fixed object accidents for the SH 82 study section during the five-year study period. **'Guard Rail'** was the most common object struck (five accidents), followed by **'Concrete Barrier'** (4 accidents), and **'Embankment'** (four accidents). There were very few secondary accident events that would cause additional safety concerns on this study section of SH 82. Therefore, no countermeasures are warranted.

Figure 4

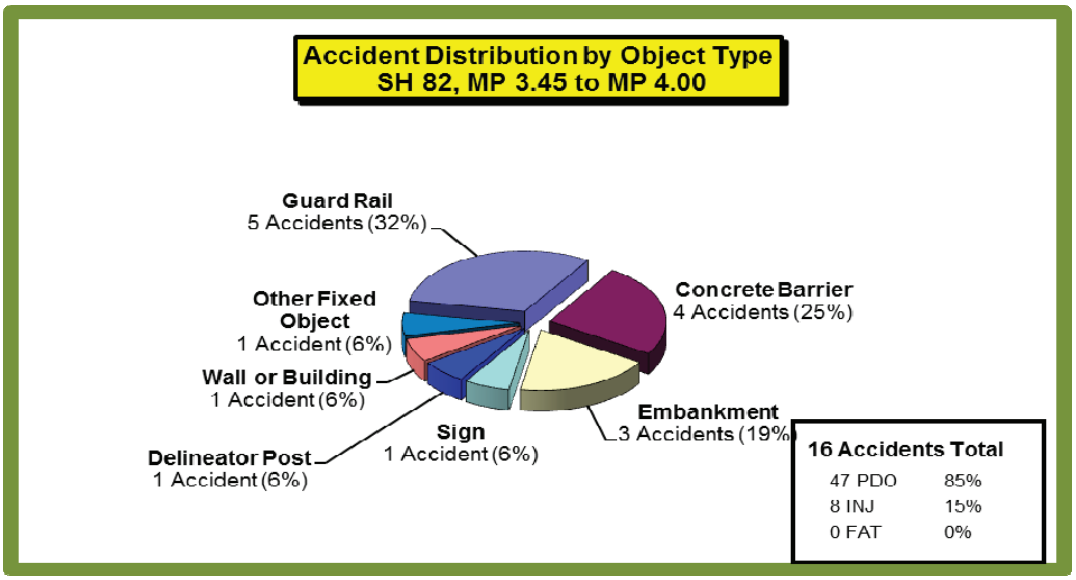


Figure 5 shows the accident distribution, by road conditions, for the SH 82 study section during the five-year study period. As the figure shows, road conditions did not appear to be a factor as most of the accidents occurred during **'Dry Road'** conditions.

Figure 5

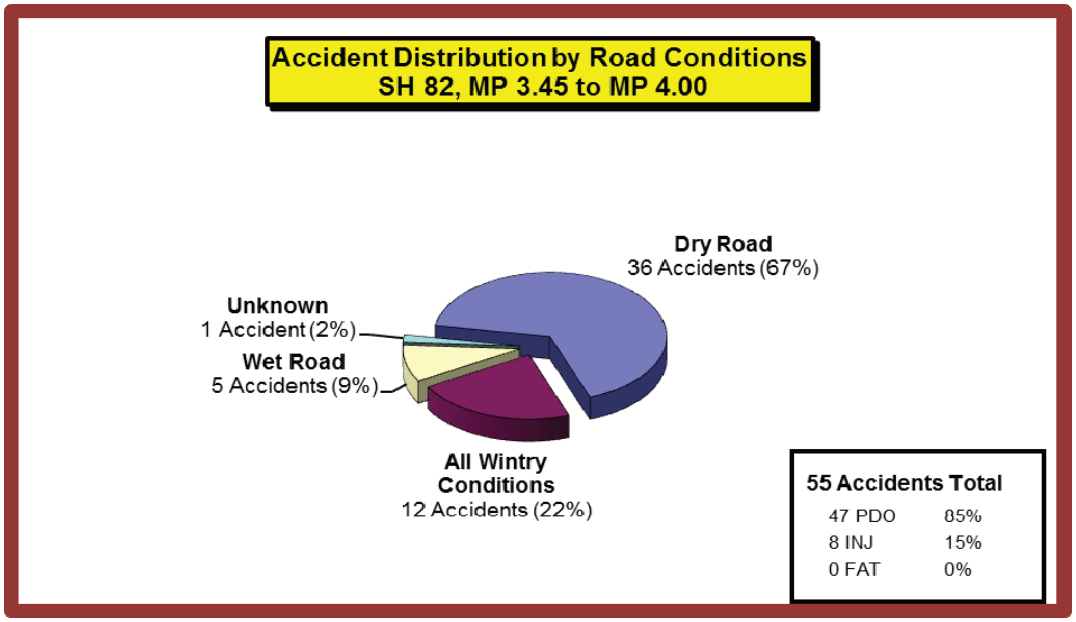
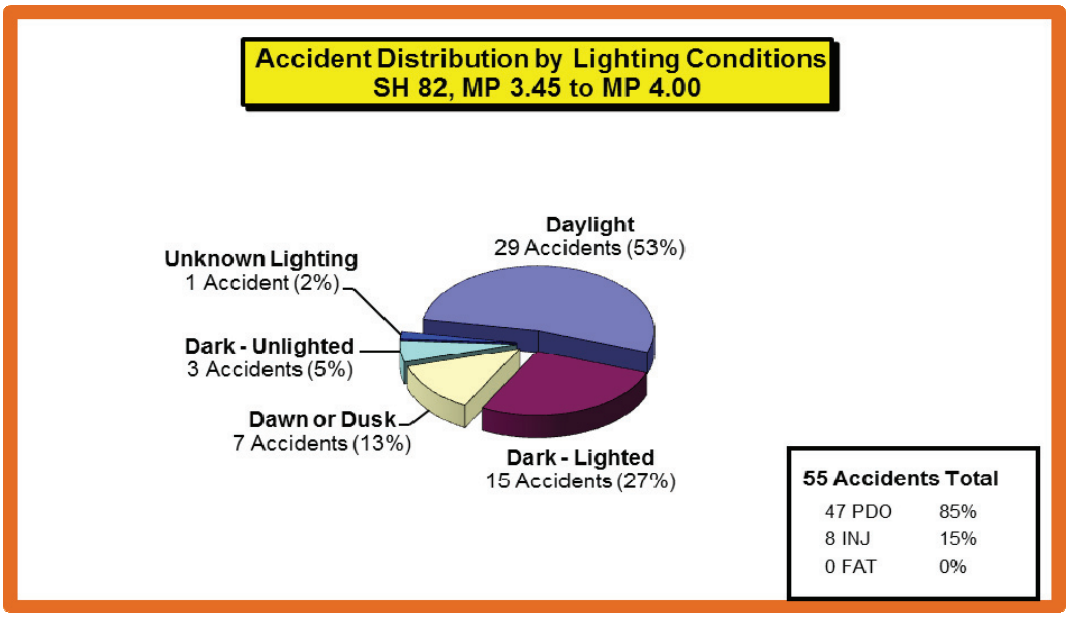


Figure 6 shows the accident distribution, by lighting conditions, for the SH 82 study section. As the figure shows, lighting conditions were not a factor as most of the accidents occurred under **'Daylight'** conditions. It should be noted that the accident rate of **'Dark-Lighted'** conditions is higher than the statewide average (0%) for similar facilities. However, the number of accidents that occurred under these **'Dark-Lighted'** conditions was 15; therefore, these small samples of accidents appear to skew the accident rate of this study section for the five-year study period, and no countermeasure is warranted.

Figure 6



SH 82 INTERSECTION ANALYSIS FOR 2008

SH 82 / CR 154 (Four-Leg Signalized Intersection)

SH082A, MP 3.55

SH 82 and County Road (CR) 154 is currently a four-leg signalized intersection. SH 82 is a four-lane, divided highway, with turn-lanes, while CR 154 is a two-lane undivided highway, as shown in **Figures 7 and 8**. The north leg is a minor street that parallels SH 82, giving the minor street the appearance of a frontage road in **Figure 7**.

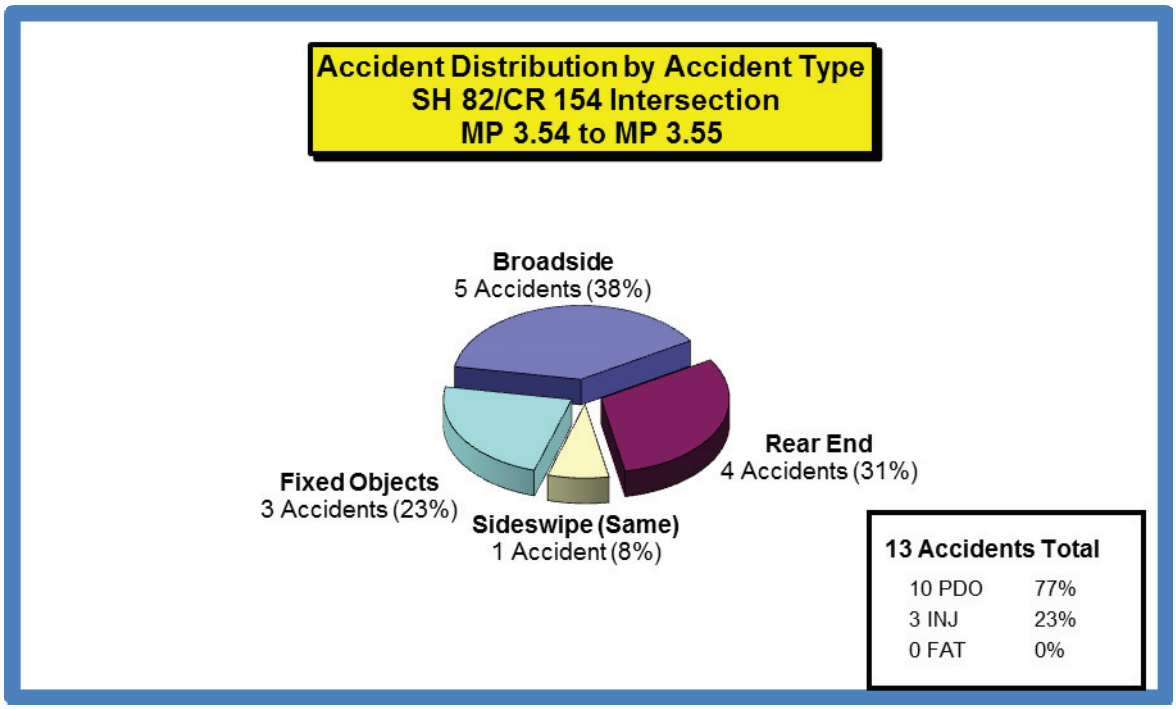
Figure 7

Figure 8

During most of the five-year study period (2004-2008), this intersection was unsignalized with a one-way stop-control sign at CR 154. Traffic signals were installed at this intersection in May 2008. Since then, only one (1) accident was reported during the remaining period of 2008.

During the five-year study period, there were 13 accidents located at or related to this intersection. **Figure 9** shows the accident distribution, by accident type, for the 13 accidents that occurred at this intersection.

Figure 9



There were 13 intersection-related accidents, of which most of the accident types were **'Broadside'** (five accidents), followed by **'Rear End'** (four accidents), and **'Fixed Objects'** (three accidents). The precipitating factors in the **'Rear End'** accidents vary and appeared to be due to random driver error that was not exacerbated by any design-related features of the intersection.

Distracted driving, driver unfamiliar with the area, or alcohol were factors in two (2) of the five (5) **'Broadside'** accidents at the intersection. The remaining three (3) accidents were caused when a vehicle on CR 154 failed to yield before making left or right turns onto SH 82. In addition, two (2) of the accidents resulted in **'Injuries'**.

The remaining three accidents involved striking **'Other Fixed Objects'** at this intersection, resulting from eastbound SH 82 vehicles making a sharp (greater than 90°) right turn onto northbound CR 154, and striking a concrete structure at the southwest corner of the intersection. These instances would indicate that this intersection is tightly confined geometrically, making a clean right-turn movement by a larger vehicle a difficult maneuver. No injuries or fatalities resulted from these accidents.

The assessment of the magnitude of safety problems on intersections has been 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 accident count for an intersection measured in accidents per year. The SPF models provide an estimate of the normal or expected accident frequency and severity for a range of ADT among similar facilities. Two kinds of Safety Performance Functions were calibrated. The first one addresses the total number of accidents, and the second one looks only at accidents involving an injury or fatality. It allows us to assess the magnitude of the safety problem from both the frequency and severity standpoint.

All of the dataset preparation was performed using the Colorado Department of Transportation (CDOT) accident databases. Accident history for each facility was prepared using the most recent five years of available accident data. ADT for each intersection approach (major and minor) over the five years was entered into the same dataset.

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 qualitative measures that characterize safety of a roadway segment in reference to its expected performance and severity. If the level of safety predicted by the SPF will represent a normal or expected number of accidents at a specific level of ADT, then the degree of deviation from the norm can be stratified to represent specific levels of safety as follows:

LOSS I - Indicates a Low Potential for Accident Reduction
LOSS II - Indicates a Better than Expected Safety Performance
LOSS III - Indicates a Less than Expected Safety Performance
LOSS IV - Indicates a High Potential for Accident Reduction

Gradual change in the degree of deviation of the LOSS boundary line from the fitted model mean reflects the observed increase of variability in accidents as ADT increases. LOSS reflects how the intersection is performing in regard to its expected accident frequency and severity at a specific level of ADT (major and minor). It only provides an accident frequency and severity comparison with the expected norm. 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 describes its magnitude from the frequency and severity standpoint. The nature of the problem is determined through diagnostic analysis using direct diagnostics and pattern recognition.

The accident history for the five-year study period within the SH 82/County Road 154 intersection has been plotted for evaluation. **Figure 10** addresses the *total number of accidents*, while **Figure 11** addresses *injury and fatal accidents-only*.

Figure 10

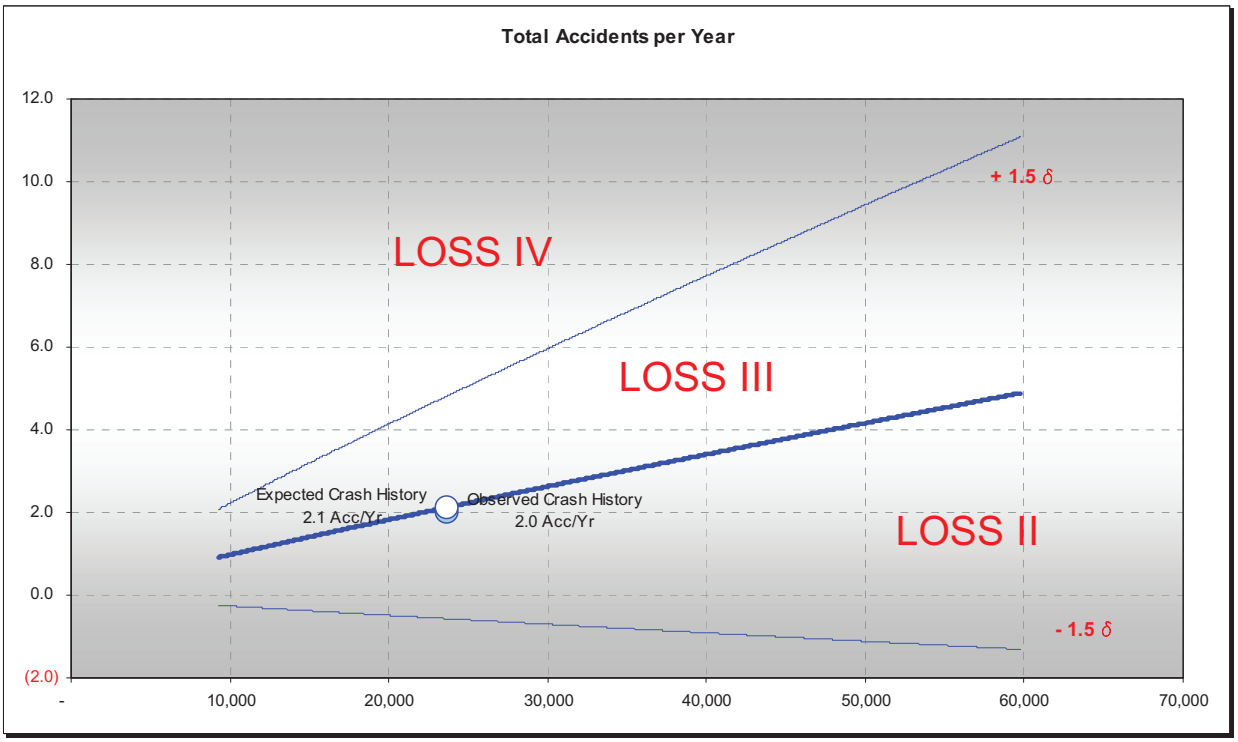
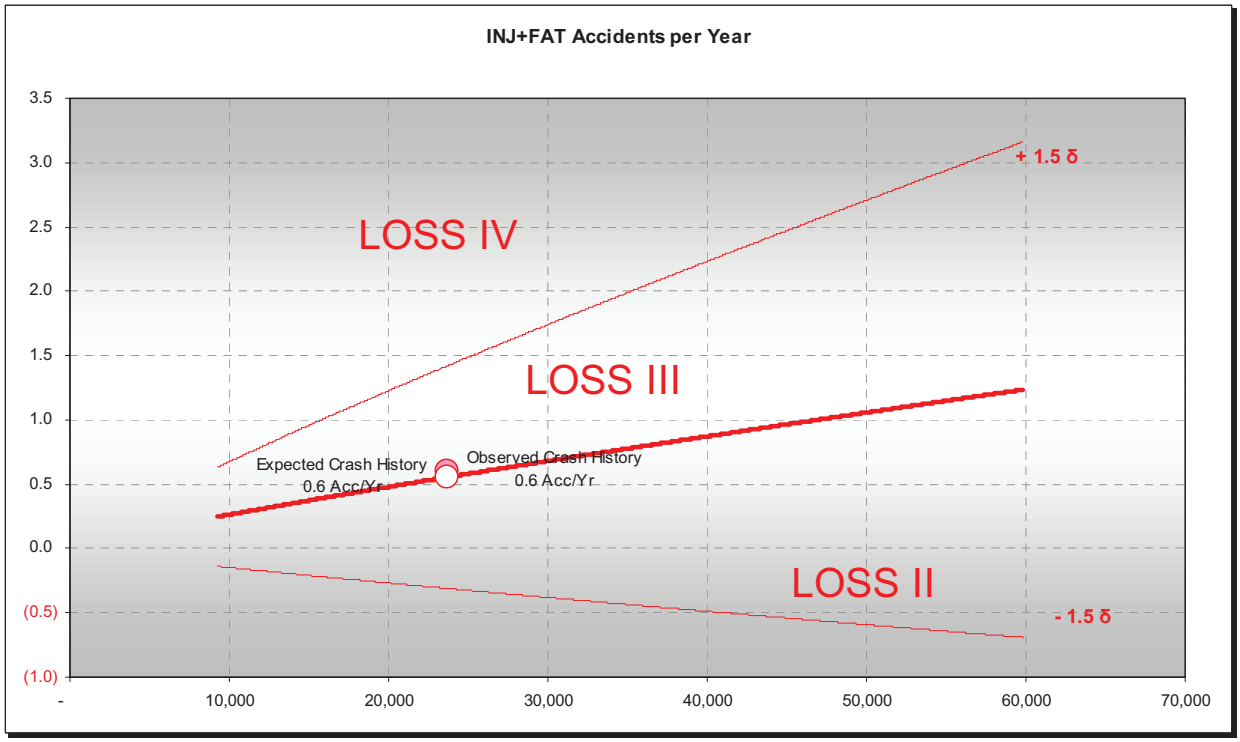


Figure 11



The SPF analysis for *total* and *injury and fatal accidents-only* accidents shown in **Figures 10 and 11**, respectively, indicates that the accident frequencies for the intersection are between LOSS II and LOSS III, which means the safety performance of the intersection is at the expected level when compared to other urban four-leg signalized intersections.

Private Accesses:

SH082A, MP 3.67, 3.90 and 3.96

There were no intersection-related accidents reported at the existing private accesses during the five year study period.

SH 82/CR Red Canyon Road – Holy Cross Electric Private Access Unsignalized Intersection:

SH082A, MP 3.70

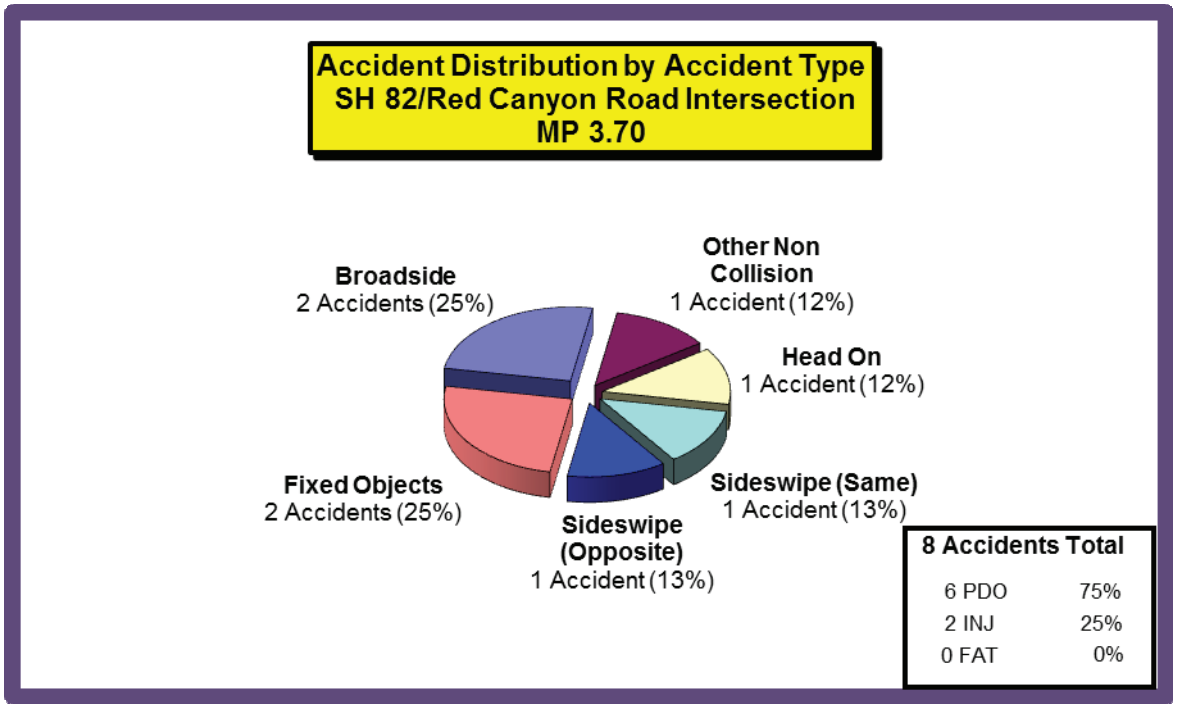
SH 82 and Red Canyon Road – Holy Cross Electric Private Access is currently a four-leg signalized intersection. SH 82 is a four-lane, undivided highway, with left-turn-lanes on both legs, while Red Canyon Road and Holy Cross Electric Private Access are two-lane undivided roads, as shown in **Figures 12 and 13**.

Figure 12

Figure 13

During the five-year study period, there were eight (8) accidents located at or related to this intersection. **Figure 14** shows the accident distribution, by accident type, for the eight (8) accidents that occurred at this intersection.

Figure 14



There were eight (8) intersection-related accidents, of which most of the accident types were **'Broadside'** and **'Fixed Objects'** (two accidents). The precipitating factors in the **'Rear End'** accidents vary and appeared to be due to random driver error that was not exacerbated by any design-related features of the intersection.

Distracted driving, driver unfamiliar with the area, or alcohol were factors in two (2) of the five (5) **'Broadside'** accidents at the intersection. The remaining three (3) accidents were caused when a vehicle on CR 154 failed to yield before making left or right turns onto SH 82. In addition, two (2) of the accidents resulted in **'Injuries'**.

The remaining three accidents involved striking **'Other Fixed Objects'** at this intersection, resulting from eastbound SH 82 vehicles making a sharp (greater than 90°) right turn onto northbound CR 154, and striking a concrete structure at the southwest corner of the intersection. These instances would indicate that this intersection is tightly confined geometrically, making a clean right-turn movement by a larger vehicle a difficult maneuver. No injuries or fatalities resulted from these accidents.

Once again, assessing the magnitude of safety problems on this intersection has been refined through the use of SPF. Two kinds of SPF were calibrated. The first one addresses the total number of accidents, and the second one looks only at accidents involving an injury or fatality. It allows us to assess the magnitude of the safety problem from both the frequency and severity standpoint.

The accident history for the five-year study period within the SH 82/County Road 154 intersection has been plotted for evaluation. **Figure 15** addresses the *total number of accidents*, while **Figure 16** addresses *injury and fatal accidents-only*.

Figure 15

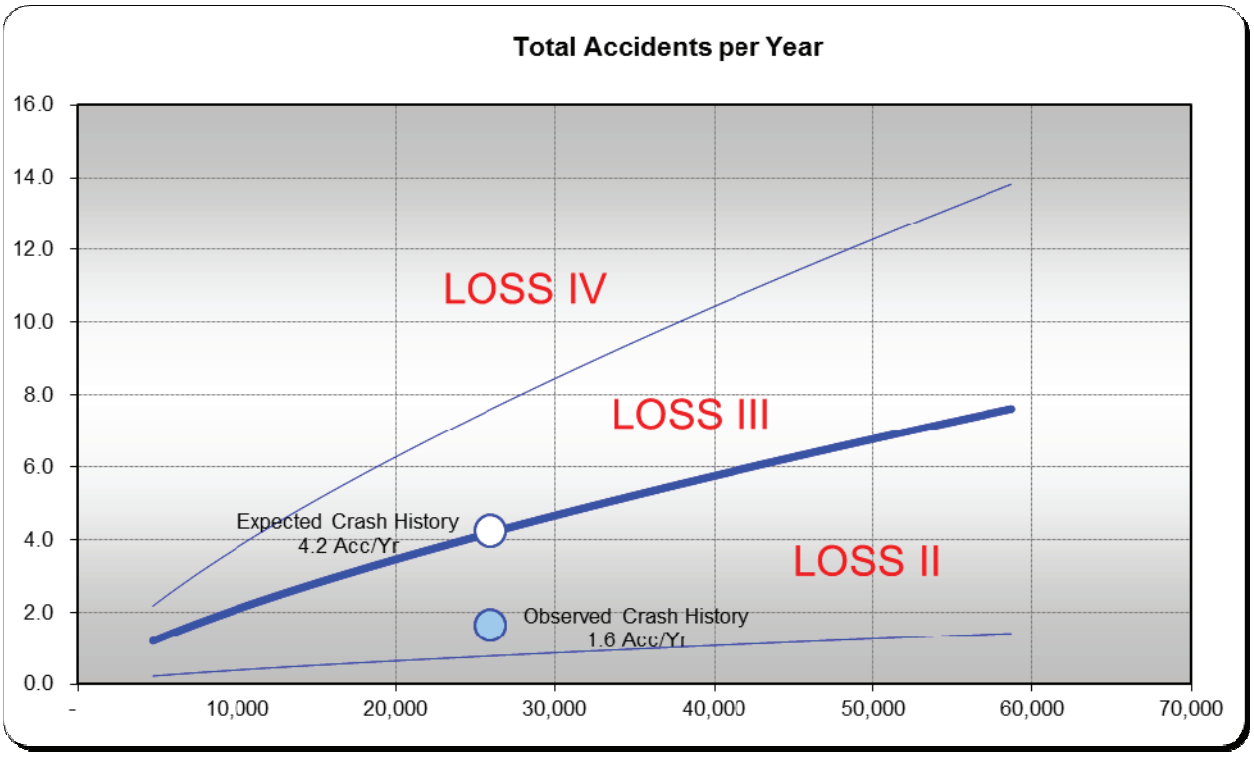
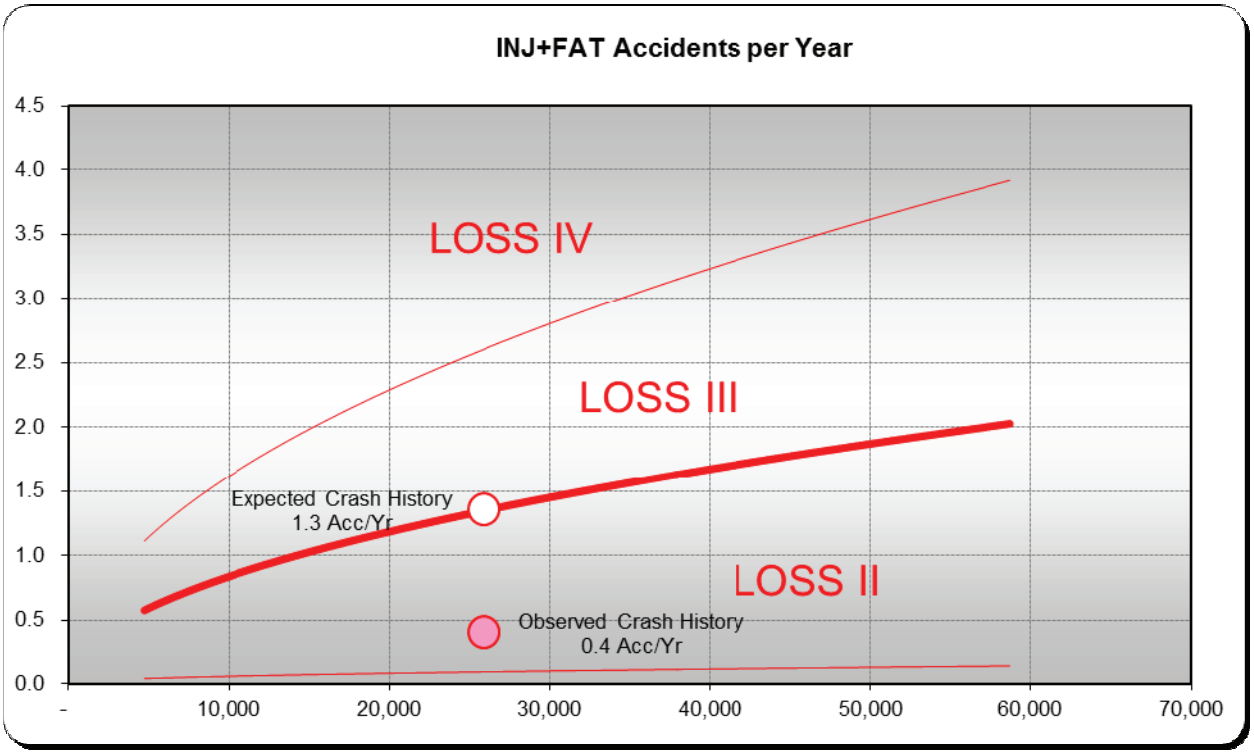


Figure 16



The SPF analysis for *total* and *injury and fatal accidents-only* accidents shown in **Figures 15 and 16**, respectively, indicates that the accident frequency for the intersection is LOSS III, which means the safety performance of the intersection is better-than-expected. This is evident where the eight (8) accidents in this intersection are small for a five-year time period; therefore, the intersection has performed well, safety-wise.

INTERSECTION ANALYSIS FOR 2035

The next set of accident projections will estimate accident reductions over the 29 years leading up to 2035 for the SH 82/CR 154 intersection. According to this environmental assessment report, there is a 1.7% annual growth in the SH 82 corridor area; therefore, there would be a 1.7% annual increase in the number of accidents due to increasing traffic.

SH 82/CR 154 Unsignalized Intersection:

SH082A, MP 3.55

This intersection is currently a four-leg, signalized intersection. If there are no improvements in the intersection, the projected annual accidents up to 2035 are shown in **Table 2** below:

Table 2 – No. of Projected Accidents – SH 82/CR 154 Intersection (No Action):

Year	Accidents	Year	Accidents	Year	Accidents	Year	Accidents	Year	Accidents	Year	Accidents
2008	2	2013	2	2018	2	2023	2	2028	2	2033	3
2009	2	2014	2	2019	2	2024	2	2029	2	2034	3
2010	2	2015	2	2020	2	2025	2	2030	2	2035	3
2011	2	2016	2	2021	2	2026	2	2031	2		
2012	2	2017	2	2022	2	2027	2	2032	2		

As you can see, the annual number of accidents is projected to be low without intersection improvements.

The preferred alternative described in this report would convert this intersection to an unsignalized, 'Florida-T' intersection, described in Chapter 2 of this report. The proposed intersection design would limit SH 82 access to right-in/right-out movements from the east leg, and right-in/right-out and left-in/left-out movements from the west leg of the intersection; which would be an effective countermeasure in eliminating future **'Broadside'** accidents, and it would effectively reduce the number of accidents by an estimated 35% - 40% since 38% of the total accidents at this intersection consisted of **'Broadside'** accident types in 2008.

SH 82 / Red Canyon Road – Holy Cross Electric Private Access:
SH082A, MP 3.70

This intersection is currently a four-leg, unsignalized intersection. If no improvements are done at this intersection, the projected annual accidents up to 2035 is shown in **Table 3** below:

Table 3 – No. of Projected Accidents – SH 82/Red Canyon Road – Holy Cross Electric Private Access Intersection (No Action):

Year	Accidents	Year	Accidents	Year	Accidents	Year	Accidents	Year	Accidents	Year	Accidents
2008	2	2013	2	2018	2	2023	2	2028	2	2033	3
2009	2	2014	2	2019	2	2024	2	2029	2	2034	3
2010	2	2015	2	2020	2	2025	2	2030	2	2035	3
2011	2	2016	2	2021	2	2026	2	2031	2		
2012	2	2017	2	2022	2	2027	2	2032	2		

Once again, the annual number of accidents is projected to be low without intersection improvements, and the intersection should continue to perform well through the year 2035.

The preferred alternative described in this report would eliminate this intersection, and traffic would be re-routed to a proposed SH 82 / Red Canyon Road – South Bridge Access signalized intersection, located at approximately MP 3.88. More details of this proposed intersection is described in the next subsection.

SH 82 / Red Canyon Road – Proposed South Bridge Access Intersection:
SH082A, MP 3.88

If the preferred alternative is chosen, this proposed intersection would be a four-leg, signalized intersection. SH 82 would remain a four-lane divided highway; and both legs would include left-turn lanes, and right-turn deceleration lanes, and acceleration lanes. The proposed South Bridge access road would represent the south leg of the intersection, and it would be a two-lane undivided road, with a right-turn deceleration lane. A re-routed Red Canyon Road would represent the north leg of the intersection, and it would be a two-lane undivided road.

There are two private accesses along SH 82, located just east of this intersection location, at MP 3.90 and 3.96, that would be relocated to the proposed South Bridge access road; therefore, maintaining smooth traffic flow and potentially reducing accidents along SH 82.

Traffic in this intersection is assumed to be coming from the existing SH 82 / Red Canyon Road – Holy Cross Electric private access intersection because of the close proximity of the two intersections. The number of accidents (three accidents) at the existing intersection (in 2035) will be the same at this proposed intersection. Even though the volume of traffic at this proposed intersection will be higher than at the existing SH 82 / Red Canyon Road intersection, the presence of the above-mentioned geometric improvements and safety features will mitigate the anticipated increase in traffic volume.