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MEMORANDUM

DATE:	December 12, 2019
TO:	Stephen Johnson, Garver
FROM:	Brian Chandler, DKS Associates Tom Williams, DKS Associates
SUBJECT:	Bastrop Corridor Study – Analysis of Safety Performance

This memorandum provides a summary of the collision data and field observations collected during a road safety inspection of SH 71 at McAllister Road/Pine Hill Loop, FM 969, FM 1209, and Loop 150 in Bastrop County, Texas. The high-risk collision trends and hot-spot locations throughout the corridor are identified as well as systemic and location-specific recommendations to improve overall safety performance.

CORRIDORS

This safety study includes analysis of crashes along the following corridors:

- **FM 969** is a 2-lane undivided roadway that serves as a major collector. It is approximately 4.57 miles long in the study area.
- **FM 1209** is a 2-lane undivided roadway that serves as a minor collector. It is approximately 3.65 miles long in the study area.
- **State Loop 150** (SL 150) is a 2-lane undivided roadway throughout; it transitions to a 4-lane undivided highway between Highway 95 and SH 21. This route serves as a principal arterial between SH 71 (West) and SH 21 and a minor arterial between SH 21 and SH 71 (East). It is approximately 3.06 miles long.

Figure 1 below shows the relative location of the corridors studied.

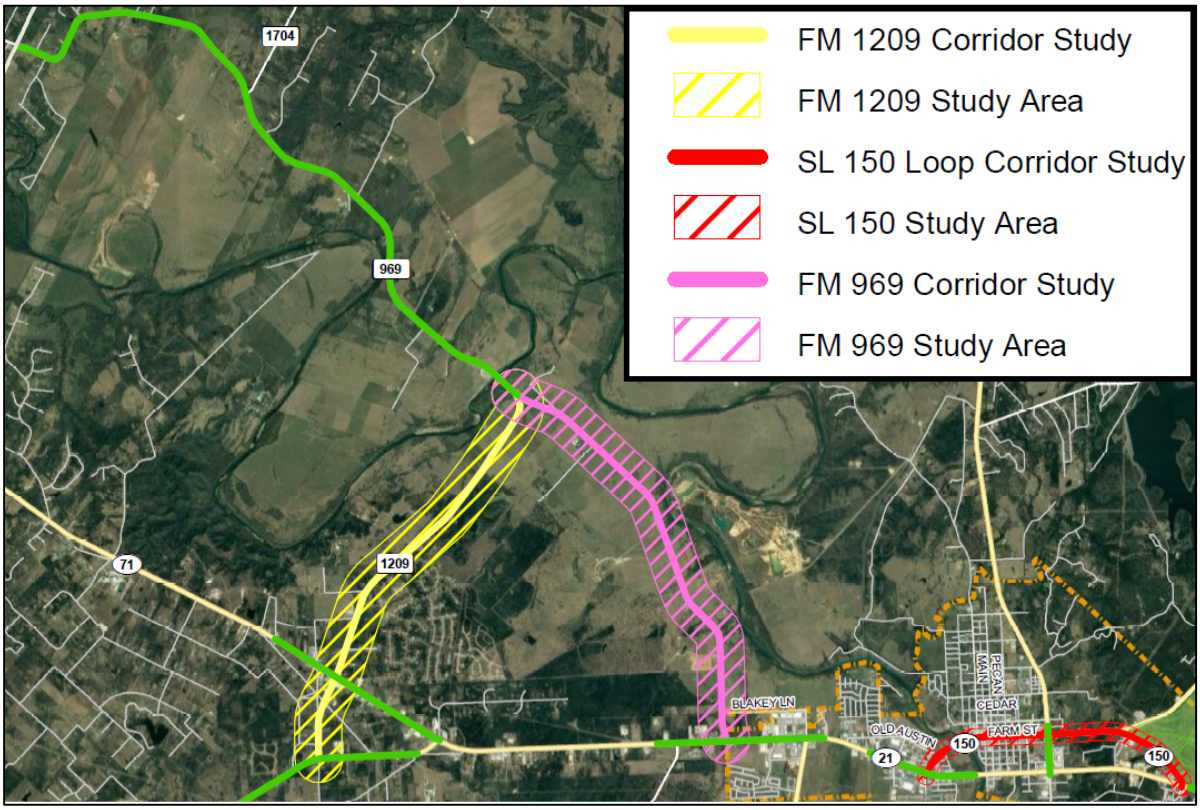

Figure 1: Bastrop Area Study Corridors

Collision Analysis

The project team analyzed crash data received from the Texas Department of Transportation's (TxDOT) automated statewide Crash Records Information System (CRIS) for the most recent 8 years (1/1/2011-7/30/2019). All available crash data using this tool represents reportable data collected from Texas Peace Officer's Crash Reports (CR-3) received and processed by TxDOT as of 07/30/2019.

Table 1: Collision and Crash Rate by Location

Location	Total Collisions	AADT[1]	Crash Rate per 1M VMT
FM 969	216	3,623	4.46
FM 1209	47	4,483	0.98
SL 150	377	12,595[2]	3.35

[1] AADT was found using 2018 TxDOT District Traffic and Urban Saturation Web Map: http://txdot.maps.arcgis.com/apps/webappviewer/index.html?id=75e148d784554d99bea6e8602986bfd2

[2] The AADT was averaged along Loop 150 because of the varying number of counts collected by TxDOT.

Of the segments studied, FM 969 experienced the highest rate of collisions per vehicle miles traveled.

SH 71 AT MCALLISTER ROAD/PINE HILL LOOP

This is a two-way stop-controlled intersection with a 75 mph speed limit on the mainline (SH 71).

Collision Analysis

Collision data was retrieved from CRIS for collisions along SH 71 at McAllister Road/Pine Hill Loop for the most recent 8 years (1/1/2011-7/30/2019). The dataset provides details for each collision including date, time, location, traffic control, weather, severity, primary collision factor, and lighting.

Correctly assigning crashes to the corridor, study intersections, and study segments is critical to accurately evaluating safety performance. Initial data processing was required prior to beginning the analysis. This processing effort involved standardizing street names from the CRIS data and verifying the accuracy of location information.

All collisions were classified as intersection or segment collisions based on the distance to the nearest intersection. All collisions within 100 feet of an intersection were considered intersection collisions; all collisions greater than 250 feet from an intersection were considered segment collisions; collisions in between 100-250 feet of an intersection were individually evaluated based on the other collision details (collision type, vehicle movement, etc.) prior to being classified. Additionally, all collisions reported as occurring at a specific address, utility/light pole, jurisdiction line, or other non-intersection reference were categorized as segment collisions.

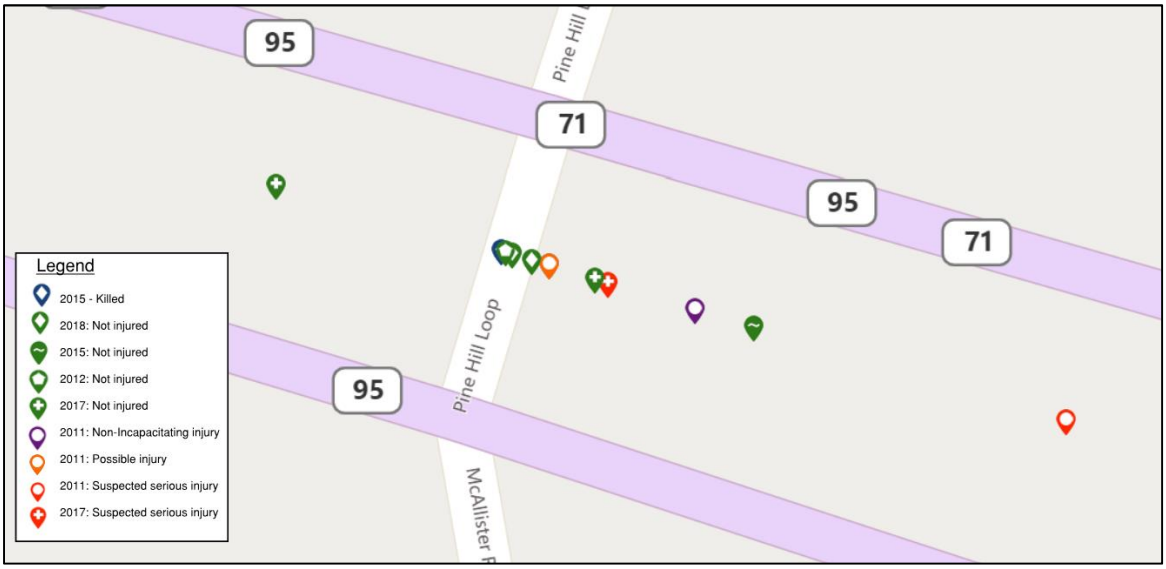

Figure 2 below illustrates the location of collisions in the area via the CRIS mapping tool.

Figure 2: Collisions at SH71 and McAllister Road/Pine Hill Loop, 1/1/11-7/30/19 (Source: CRIS)

During the study period, 11 collisions occurred in the vicinity of SH 71 and McAllister Road/Pine Hill Loop. Two of these were injury crashes and one was a fatal crash.[3] The fatal collision occurred on a Wednesday around 9:00 pm due to a northbound motorist at the McAllister Road stop sign failing to yield the right-of-way to an eastbound SH 71 vehicle.

Table 2. Collisions by Year and Severity, SH71 at McAllister Road/Pine Hill Loop

Collisions by Severity				
Year	**Fatal**	**Injury**	**PDO**	**Total Collisions**
2011	0	1	0	1
2012	0	0	1	1
2013	0	0	0	0
2014	0	0	0	0
2015	1	0	3	4
2016	0	0	0	0
2017	0	1	2	3
2018	0	0	2	2
2019	0	0	0	0
TOTAL	1	2	8	11

The study team made the following observations of this dataset:[4]

- Approximately 91% of all crashes occurred under clear and cloudy skies as well as dry pavement conditions, where only one crash occurred while it was raining.
- Approximately 55% of all crashes were non-intersection related
- 55% of crashes occurred due to overturning or losing control over the vehicle.
- 45% of crashes were angled related.
- Just over 36% of crashes occurred in the dark at locations where street lighting was not present.
- Nearly 63% of crashes occurred on a Sunday between 1:30 am and 4:00 pm.

[3] CRIS data included contradictory information regarding the location of this fatal crash. Latitude and longitude and posted speed limit indicated McAllister Road. The cross-street provided in CRIS was Loop 150. Researchers concluded that McAllister Road is the more likely location.

[4] Note that these observations are not mutually exclusive. For example, a crash occurring on a Sunday in dark conditions at an intersection would be counted in multiple bullets.

Field Observations

In order to understand the conditions in the field and supplement collision data, DKS conducted a road safety inspection on July 22, 2019. The road safety assessment consisted of driving along the SH 71, McAllister Road, and Pine Hill Loop roadways and walking the intersection to inspect conditions, note roadway characteristics, and observe driver behaviors. Findings and recommendations from the field observations are summarized below.

- Two ONE WAY (R6-1) signs appear to be missing below the Yield signs within the median. Refer to **Figure 3** for a photo at this location and **Figure 5** in the next section for the TMUTCD standard sign package.
- The DO NOT ENTER (R5-1) signs for McAllister Road motorists looking left along SH 71 are faded (see **Figure 4**).
- Both side street approaches have potential sight distance issues based on the vertical curve and current 75 mph posted speed limit of SH 71 (see **Figure 4**). Current TxDOT Roadway Design Manual standards require 820 feet of design stopping sight distance at 75 mph.[5]

Figure 3. Existing signs at the SH 71 & McAllister Rd intersection

[5] TxDOT Roadway Design Manual (Rev. April 2018) Table 2-1

Figure 4. View looking left/west from NB McAllister Rd approach to SH 71 showing faded DO NOT ENTER signs, deceleration area striped into the previous10' shoulder (leaving no shoulder), and sight distance limitation.

Northbound McAllister Road at SH 71

Eastbound mainline traffic on SH 71 emerges from a combined vertical/horizontal curve as it approaches the intersection. Vehicles are not visible from McAllister Road until they emerge from the curve along SH 71 eastbound. A field-observed count of 8 to 10 seconds was made for most vehicles approaching the intersection from the west as they became visible at approximately 750-800 feet. Additionally, leading to the McAllister Road intersection, eastbound traffic does have a deceleration area where the shoulder should be, per TxDOT's RDM. The existing deceleration area is 10' wide, 600' long, with a 150' taper and no shoulder, which falls below the guidelines set forth in Table 3-13 of the TxDOT RDM, which require a 950' long lane at 12' wide with a 4' shoulder.

Northbound traffic at the STOP sign is stopped on older pavement and loose gravel with a slight vertical grade. The team observed some motorists struggling for traction, causing tires to spin as they attempted to enter the roadway and avoid oncoming traffic on SH 71.

The McAllister Road street name sign is missing. Historic Google Maps images show there were former street name signs at this location.

Southbound Pine Hill Loop at SH 71

Westbound mainline traffic on SH 71 (approaching from east of the intersection) travels through a sag vertical curve as it approaches the Pine Hill Loop intersection, then emerges near the Pine

Hill Loop. This vertical curve begins approximately 1,200' east of the Pine Hill Loop intersection. Vehicles are not visible at the bottom of this sag curve along SH 71 westbound and become visible again at approximately 630 feet from the Pine Hill Loop intersection. A count of 8 to 10 seconds was made for most vehicles approaching the intersection from the east as they became visible.

Median Openings East of Intersection

The existing turnaround east of the McAllister Road intersection is approximately 1190' from the McAllister Road/Pine Hill Loop intersection. This is less than recommended minimum of a quarter mile (1320') spacing between median openings, per TxDOT RDM, page 3-42.

This existing median opening as well as the existing Harmon Rd turnaround (approximately 3300' east of McAllister) each provide eastbound drivers with a 150' deceleration lane with 150' taper. This does not meet the 950' minimum deceleration length, per TxDOT RDM Table 3-13.

Recommendations

Short Term

- Install street name sign at SH 71 / McAllister Road intersection
- Install/replace ONE WAY signing for divided highways in accordance with TMUTCD per **Figure 5**. Utilize larger ONE WAY signs (54" x 18") due to the distance from the intersection to the median and approach speeds along SH 71.

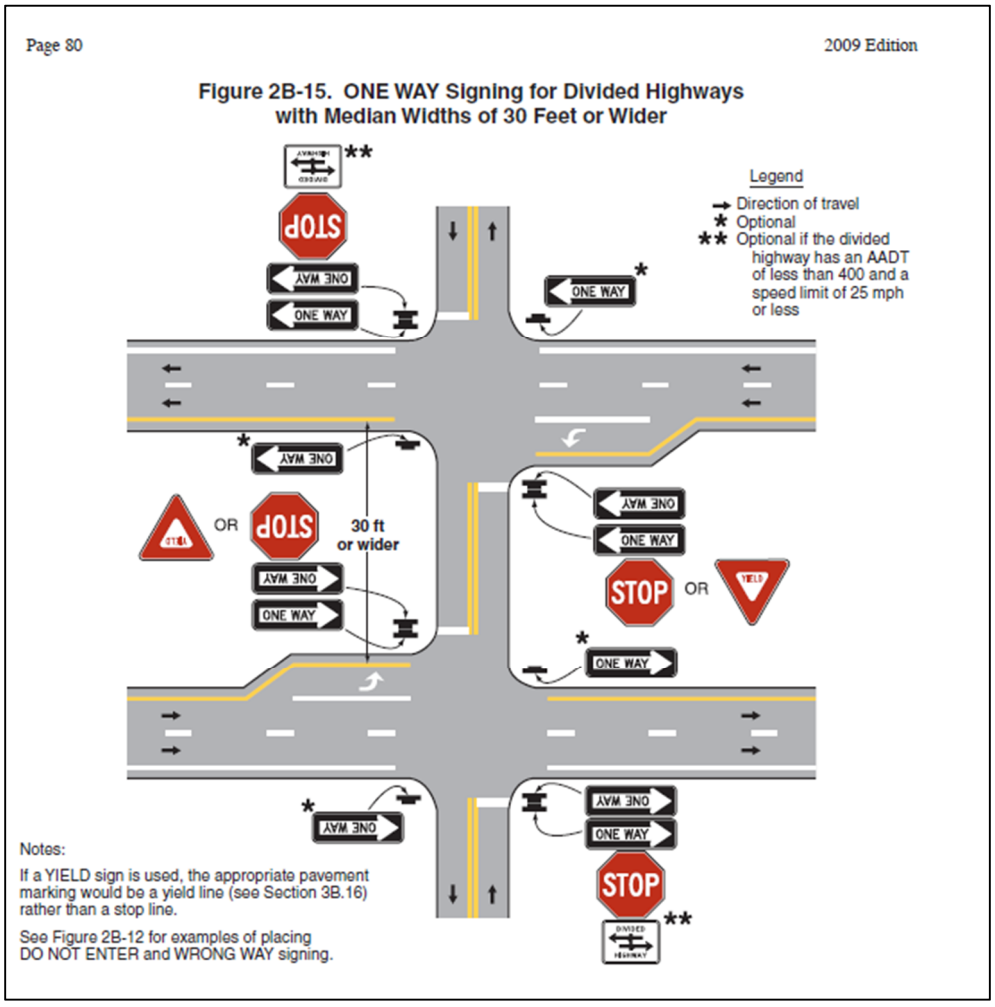

Figure 5: ONE WAY Signing for Divided Highways (Source: TMUTCD, 2011 Edition, Revision 2)

- Add intersection warning signs (W2-1) at each approach along SH 71.
    - Add supplemental black-on-yellow street name plaques below each intersection warning sign.
    - Add yellow retroreflective post sleeves to each warning sign
    - Add LEDs around the outside of the intersection warning signs. Include flashing beacons.
- Reconstruct the northbound McAllister Road intersection approach, or mill/overlay the existing asphalt with a High Friction Surface Treatment for northbound motorists at McAllister Road to address slippage.

- Install additional intersection illumination for eastbound and westbound approaches along SH 71 to improve visibility in dark conditions.
- Reconstruct existing eastbound deceleration area to full deceleration lane (12') with shoulder (4')

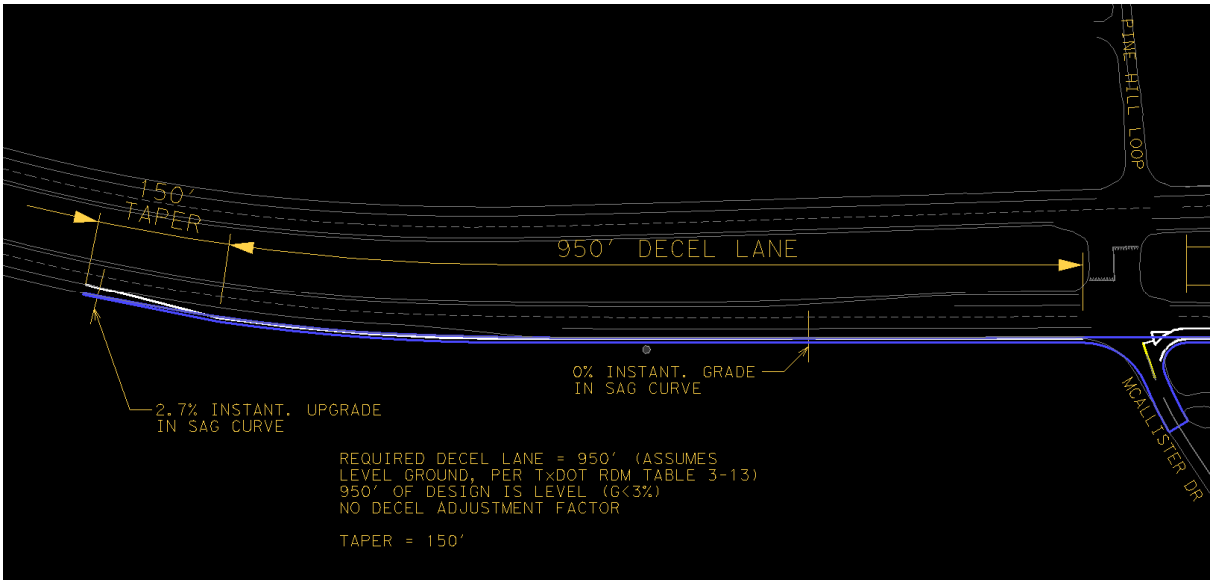

Figure 6: Eastbound SH 71 to southbound McAllister Road deceleration lane

- Construct northbound to eastbound acceleration lane with 4' shoulder.
    - Recommend installing channelizing devices along acceleration lane to prevent unsafe weaving operations to adjacent median opening.

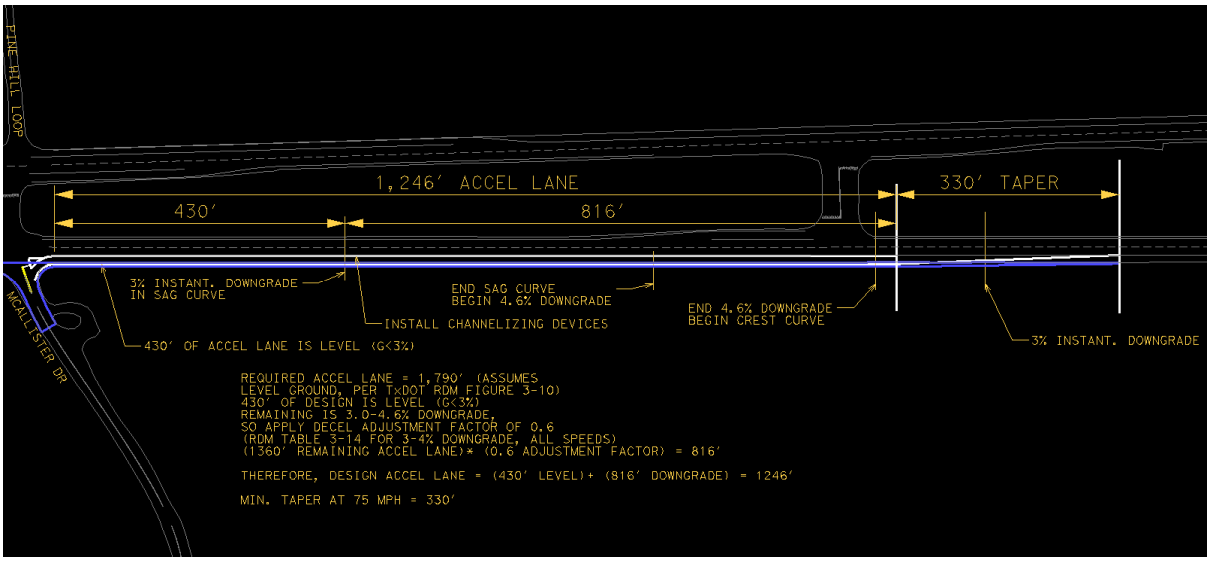

Figure 7: Northbound McAllister Road to eastbound SH 71 acceleration lane

- Reconstruct the existing eastbound left-turn deceleration lane and taper at the Harmon Rd median opening to meet Current TxDOT RDM design standards. This improvement combined with eastbound acceleration lane at McAllister Road would result in approximately 540' weaving distance between the end of the eastbound acceleration lane and beginning of the eastbound deceleration lane taper, as shown in **Figure 8**, below, which is sufficient to accommodate a lane change maneuver, and will therefore not preclude the J-turn Medium-term solution described below

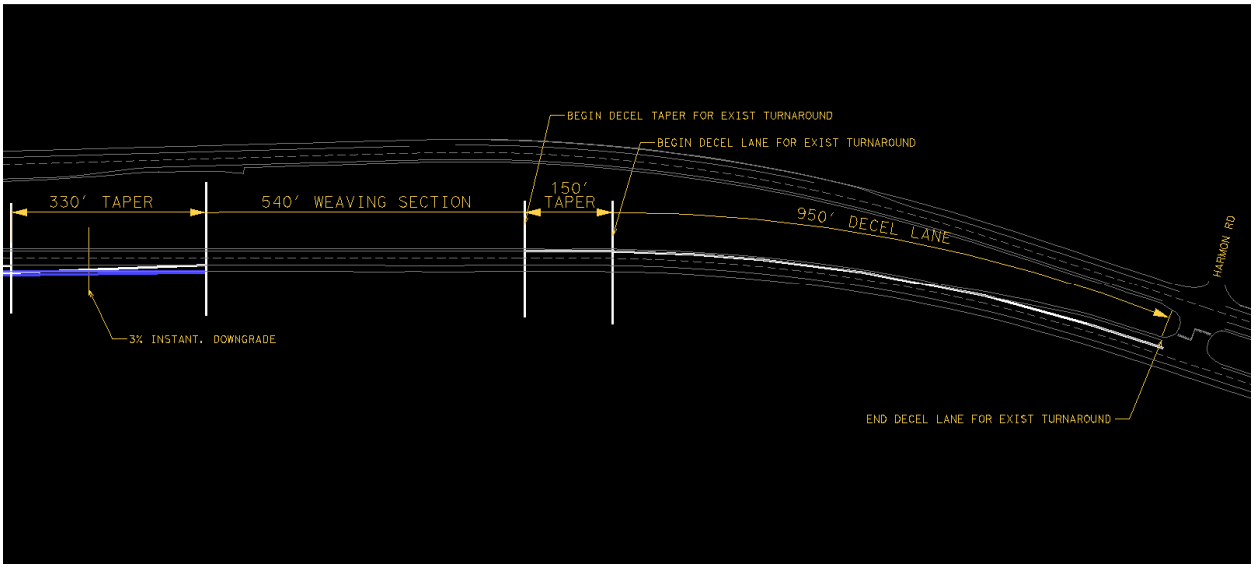

Figure 8: Weaving Section between eastbound acceleration lane and Harmon Rd deceleration lane

- Install an Intersection Conflict Warning Systems (ICWS). ICWSs have been implemented across several states (including Missouri – below, and Minnesota: https://www.lrrb.org/media/reports/2016RIC10.pdf) to warn drivers on the mainline and/or side street of the presence of traffic on conflicting roadways.[6] ICWSs illustrated in the **Figure 9** and **Figure 10** below have been evaluated in recent research studies; results include a 20% reduction in the number of fatal and injury crashes at 4-lane/2-lane intersections when the ICWS is installed.[7]

[6] Vaughan W. Inman and Steven Jackson. "Intersection Conflict Warning System Human Factors: Final Report." November 2016: https://www.fhwa.dot.gov/publications/research/safety/16061/16061.pdf

[7] Scott Himes, Frank Gross, Kimberly Eccles, and Bhagwant Persaud. "Safety Evaluation of Intersection Conflict Warning Systems." https://www.fhwa.dot.gov/publications/research/safety/16035/16035.pdf
[8] Additional information available via FHWA's Median U-Turn Intersection tech brief. https://www.fhwa.dot.gov/publications/research/safety/09057/index.cfm

Figure 9: Example of ICWS installation of mainline signing, Missouri (Source: Google Maps, 2016)

Figure 10: Example of an Intersection Conflict Warning System, Missouri (Source: Google Maps, 2016)

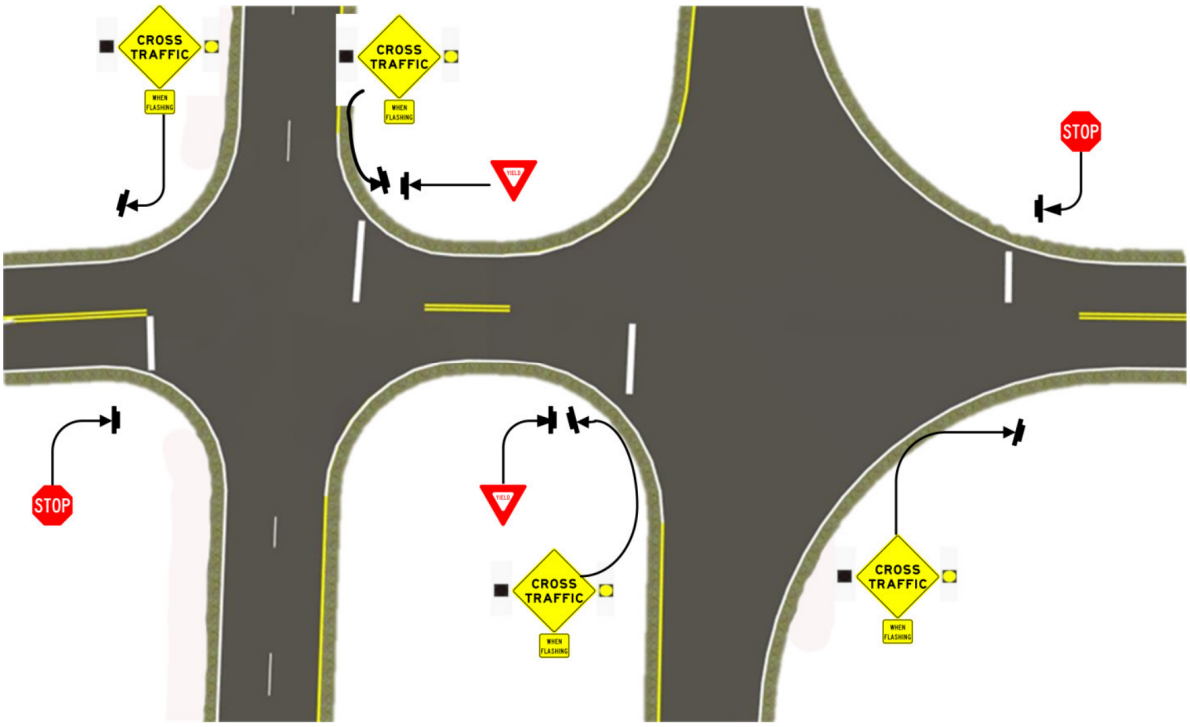

Figure 11. ICWS Recommended Sign Message and Placement for Minor Street Traffic[8]

Medium Term

- Re-profile SH 71 west of the intersection to improve intersection sight distance related to the current vertical curve.
- Convert to a J-turn intersection/median U-turn by redesigning the SH 71 and McAllister Road/Pine Hill Loop intersection to right-in, right-out only and modifying median U-turns upstream and downstream.[9]
    - This may require additional pavement at the U-turn locations to ensure large vehicles can make the turning movements.
    - Proposed J-turn configuration, with short-term acceleration/deceleration lane improvements, provide adequate weaving distance and spacing
    - The Missouri Department of Transportation (MoDOT) has implemented several J-turn configurations. An example of their latest preferred signing layout is shown on their US 50 at Route W/Route Z intersection, which is provided in the attached appendix.

[9] https://www.fhwa.dot.gov/publications/research/safety/16061/006.cfm

Long-term

- Design and install a grade-separated interchange to eliminate interaction of high and low-speed traffic.

Estimated Costs and Benefits

The table below shows the estimated countermeasure costs and safety benefits of each recommended treatment at this location; in some cases, the treatment has an established entry in TxDOT's Work Codes Table. Calculations were conducted using TxDOT's Safety Improvement Index (SII) Calculator, and planning-level estimates for implementation cost were used.[10] The SII Calculator limits analysis to 3 years – 2015, 2016, and 2017 – to calculate the benefit-cost ratio.

In its most basic form, the SII is the ratio of the cost of crashes that have occurred at a location to the cost of constructing the proposed improvement.[11] The SII incorporates adjustments to provide additional benefit for the following:

- Locations experiencing increasing traffic over the project life.
- Improvements that will reduce maintenance costs.
- Projects expected to have long service lives over which construction costs can be amortized.

A project **with an SII greater than or equal to 1.0** is considered cost effective.

[10] Each row in the table is supported by an Excel worksheet from TxDOT's 2018 SII Calculator.
[11] http://onlinemanuals.txdot.gov/txdotmanuals/hsi/using_the_safety_improvement_index.htm

Table 3. Benefits and Costs of Recommended Treatments at SH 71 / McAllister Intersection

Treatment	Crash Reduction Factor and type affected [12]	Estimated Implementation Cost [13]	Estimated Maintenance Cost (per year)	SII
124 - Install Advance Intersection Warning Signals and Signs	15% Intersection-related	$160,000	$1300	10.48
307 - High Friction Surface Treatment at Intersection	20% intersection-related	$35,000	N/A	37.07
305 - Safety Lighting at Intersection	45% dark conditions	$150,000	$400 (4 luminaires)	38.70
521 - Add Right Turn Lane	25% intersection-related	$194,000	N/A	14.66
J-Turn [14]	42% fatal and injury crashes	$618,000	N/A	7.65
505 - Improve Vertical Alignment	50% intersection-related	$600,000	N/A	9.38
ICWS [15]	20% fatal and injury crashes	$300,000	$625	7.49
515 - Construct Interchange	65% intersection-related	$10,000,000	N/A	0.96

[12] http://onlinemanuals.txdot.gov/txdotmanuals/hsi/preventable_crash_decoding.htm
[13] Preliminary, planning-level estimate to be reviewed for each treatment to incorporate recent TxDOT bids.
[14] Crash Reduction Factor and cost information per FHWA.
https://safety.fhwa.dot.gov/intersection/alter_design/pdf/fhwasa14070_rcut_infoguide.pdf
[15] Crash Reduction Factor and cost information per FHWA.
https://www.fhwa.dot.gov/publications/research/safety/16035/index.cfm

SL 150

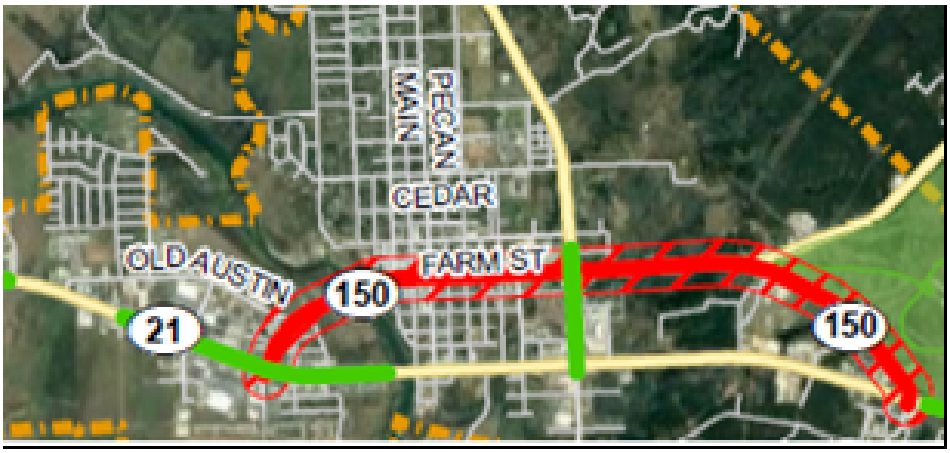

Figure 12. SL 150 Study Area

Collision Analysis

The collision data was retrieved from the CRIS for collisions along SL 150 in the study area for the most recent 8 years (1/1/2011-12/31/2018). The dataset provides details for each collision including date, time, location, traffic control, weather, severity, primary collision factor, and lighting.

This segment's characteristics differ from the others in this safety study. In particular, the western half of SL150 is a lower speed city arterial with a high number of intersections and private entrances serving commercial properties (see **Figure 13**).

Figure 13. Typical cross section of SL 150 through Bastrop (Google Maps)

Vulnerable Road User Collisions

Given the more urban nature of this route and intersections, the study team identified the number of reported crashes along SL 150 during the study period that involved pedestrians or bicyclists. Of the 377 collisions reported, three involved pedestrian and two involved a bicycle. However, it is common for pedestrian and bicycle collisions to go unreported. It may be possible that additional pedestrian- or bicycle-related incidents have occurred along this segment.

SL 150 and SH 21 / SH 95 Intersection

The intersections of SL 150 with SH 21 / SH 95 serve motorists traveling through Bastrop, east to Bastrop State Park, north of the city, and south toward Buc-ee's and the SH 21/71 highway.

Figure 14. SL 150 at SR 95 / SR 21, Facing West (Google Maps)

During the study period (2011-2018), this intersection experienced 41 collisions as shown in **Table 4**. In 2013. a fatal crash occurred involving two vehicles in an angle collision, during a rainy day on wet pavement. The police officer cited driver distraction as a contributing factor.

Table 4. Collisions by Year and Severity, SL 150 at SH 21 / SH 95 Intersection

Collisions by Severity				
Year	**Fatal**	**Injury**	**PDO**	**Total Collisions**
2011	0	0	4	4
2012	0	0	7	7
2013	1	2	4	7
2014	0	2	3	5
2015	0	0	5	5
2016	0	0	2	2
2017	0	1	6	7
2018	0	0	4	4
TOTAL	1	5	35	41

Crashes at this intersection included the following common contributing factors during the study period:

- 7 crashes occurred in dark conditions
- 9 crashes occurred in wet pavement conditions
- 11 were angle crashes
- 25 were rear-end crashes
- 19 crashed included “Failed to Control Speed” as a driver-related contributing factor.

Recommendations

Short Term

- Due to the number of rear-end crashes and the proportion of crashes occurring in wet conditions, the team recommends High Friction Surface Treatment for all approaches.
- Evaluate signal phasing, including ensuring established clearance interval timing and advance warning.[16]

[16] https://safety.fhwa.dot.gov/intersection/other_topics/fhwasa09020/

- ITS-enabled advance warning signs connected to signal timing can be activated when the indication turns red for each approach.

Medium Term

- To address the right-turn, rear-end crashes at the existing channelized right turn islands (which are designed for a higher speed right turn), the team recommends a redesign of each to the "Australian Right Turn". The main objective of this design is to reduce the angle that drivers must turn their heads to check approaching traffic to their left. See **Figure 15** that illustrates the treatment.

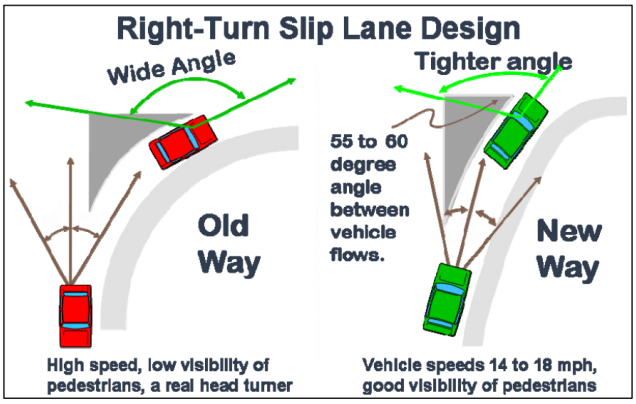

Figure 15. Australian Right Turn Design

Source: Missouri Department of Transportation, Implementing MoDOT's Access Management Guidelines Along Route 763

Long Term

- Roadway reconfigurations (i.e., "Road Diets") have been proven to reduce crashes and improve livability in urban areas. A traditional Road Diet repurposes one lane of general-purpose vehicle traffic to allow for on-street parking, bicycle facilities, and/or pedestrian facilities. [17] On November 12, 2019, the City of Bastrop adopted a new Land Development code entitled the "Building Bastrop Block (B3) Code, Technical Manual, and Pattern Book." This code advocates for a more dense, walkable environment. Further coordination with the City of Bastrop is required to evaluate SL 150.

Benefits and Costs of Recommendations

The table below shows the estimated countermeasure costs and safety benefits of each recommended treatment at this location; in some cases, the treatment has an established entry in TxDOT's Work Codes Table.

[17] Additional information is available in FHWA's Road Diet Informational Guide, https://safety.fhwa.dot.gov/road_diets/guidance/info_guide/

Table 5. Benefits and Costs of Recommended Treatments at SL 150 / SH 95, SH 21 Intersections

Treatment	Crash Reduction Factor and type affected [18]	Estimated Implementation Cost [19]
307 - High Friction Surface Treatment at Intersection	20% intersection-related	$35,000
Signal Timing/Phasing Improvements	8% intersection-related	$10,000
124 Install Advance Intersection Warning Signals and Signs	15% Intersection-related	$160,000
Redesign right turns to "Australian Right Turn" design	50% right-turn collisions [20]	$192,000 per right-turn lane
Roadway reconfiguration (i.e., "Road Diet")	19-47% reduction in all crashes	$100,000 per mile [21]

FM 1209 AND FM 969

The intersection of FM 1209 and FM 969 is a large, Y- intersection, as illustrated in the figures below.

Figure 16: FM 1209 at FM 969 South Leg, facing Northeast (Google Maps, 2017)

[18] http://onlinemanuals.txdot.gov/txdotmanuals/hsi/preventable_crash_decoding.htm
[19] Preliminary, planning-level estimate to be reviewed for each treatment to incorporate recent TxDOT bids. Sources include FHWA, Oregon DOT.
[20] https://safety.fhwa.dot.gov/intersection/conventional/signalized/fhwasa13027/ch11.cfm
[21] https://safety.fhwa.dot.gov/road_diets/resources/fhwasa16100/

Figure 17: FM 1209 at FM 969 Northwest Leg, facing South (Google Maps, 2019)

Figure 18: FM 1209 at FM 969 East Leg, facing West (Google Maps, 2019)

Collision Analysis

The collision data was retrieved from the CRIS for collisions at FM 1209 and FM 969 for the most recent 8 years (1/1/2011-7/30/2019). **Figure 19** below illustrates the location of collisions in the area via the CRIS mapping tool.

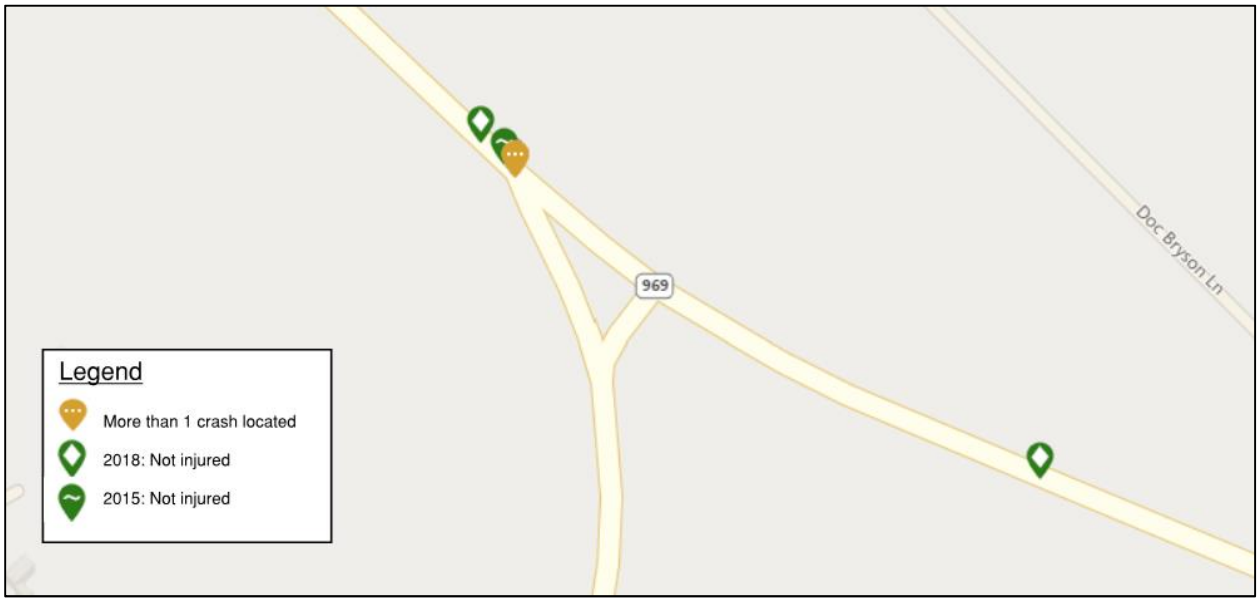

Figure 19: Collisions at FM 1209 and FM 969 Intersection, 1/1/11-7/30/19.[22] (Source: CRIS)

Between January 2011 and July 2019, 34 collisions have occurred in the vicinity of FM 1209 and FM 969, where 24 of them were intersection related. One collision that resulted in multiple fatalities was non-intersection related. **Table 6** provides an overall summary of the collision data by year and severity.

[22] Several overlapping crashes are "stacked" in this figure.

Table 6. Collisions by Year and Severity, FM 1209 at FM 969

Collisions by Severity				
Year	**Fatal**	**Injury**	**PDO**	**Total Collisions**
2011	0	1	0	1
2012	0	1	0	1
2013	0	1	1	2
2014	0	3	1	4
2015	0	1	4	5
2016	0	1	4	5
2017	1	3	2	6
2018	0	1	4	5
2019	0	2	3	5
TOTAL	1	14	19	34

The frequency of collisions is relatively consistent over the study period, averaging five (5) collisions per year.

Fatal and Injury Related Collisions

Most injury-involved collisions occurred during night-time conditions. There is no existing street/intersection lighting present. There were no distinct patterns in collision type, contributing factors, or roadway characteristics for injury related and fatal collisions. According to the online crash data, there was one fatal collision in 2017, where a motorist swerved and hit a nearby fence.

Intersection vs Segment Collisions

Approximately 71% of the collisions occurred at intersections (29% occurred on roadway segments). Most intersection-related collisions were caused by motorists losing control, slowing-or-stopping, and/or overturning. The Y-intersection design may contribute to higher-than-typical speeds for turning vehicles (compared to orthogonal designs) within the intersection.

Weather and Pavement Conditions

In general, there were no significant trends related to the weather or pavement conditions at the time corridor crashes occurred. Approximately 94% of all crashes occurred under clear or cloudy skies. The pavement was dry in nearly 84% of crashes. While overall weather conditions

do not appear to be a significant contributing factor to collisions, there were several locations where clusters of crashes on wet or icy pavement were observed.

Other Notable Trends

The time of day and lighting conditions can have an impact on driving conditions and collisions. **Table 7** summarizes the collision frequency and severity by lighting conditions along the roadway. As shown, only 35% of all crashes occurred at night, but the most severe collisions occurred at dusk or at night without street lighting.

Table 7: Collisions by Lighting Condition, FM 1209 at FM 969

Lighting Condition	Number of Collisions
Daylight	21
Dark-No Street Lights	12
Dusk-Dawn	1

Field Observations

Researchers visited this intersection and observed the potential for high-speed collisions due to the geometry. It is likely that this intersection performed adequately under low-volume conditions, but as potential conflicts increased, high speeds and awkward viewing angles (due to the Y-configuration) have contributed to crashes.

Upcoming Development

A new property development, XS Ranch, is expected to be built approximately 0.5 miles southeast from the FM 969/FM 1209 intersection, along FM 969. The property is currently being developed by a joint venture from California, and it is expected to consist of approximately 10,000 units. This new property will generate additional trips in the region overall, and specifically at this intersection. It will be important that the impacts are identified and mitigated to ensure safety is maintained at this location.

Recommendations

Short Term

- Add flashing beacons at the intersection (already planned to be completed by TxDOT maintenance personnel).
- Re-apply pavement markings (already planned to be completed by TxDOT maintenance personnel).
- Add transverse rumble strips (already planned to be completed by TxDOT maintenance personnel).

- Install Advance Intersection Warning, Curve Warning, and Speed Feedback Signs at each approach
- Consider replacing existing Yield signs with Stop signs.

Medium Term

- Consider installing street lighting at each approach to the intersection to help reduce the number and severity of nighttime crashes.

Long Term

- Install southbound right-turn lane from FM 969 into FM 1209.
- Consider redesigning the Y-intersection to reduce conflict points, operating speeds, and ultimately reduce the number and severity of collisions.
- Consider realigning FM 1209 to align with the future X/S Ranch driveway connection with FM 969. Coordinate with all related stakeholders to ensure safety is considered during each step of the XS Ranch development process.

Benefits and Costs of Recommendations

The table below shows the estimated countermeasure costs and safety benefits of each recommended treatment at this location; in some cases, the treatment has an established entry in TxDOT's Work Codes Table.

Table 8. Benefits and Costs of Recommended Treatments at the FM 1209 / FM 969 intersection

Treatment	Crash Reduction Factor and type affected [23]	Estimated Implementation Cost [24]
105 – Install Intersection Flashing Beacon	35% intersection-related	$10,000 (TxDOT-installed)
Re-apply Pavement Markings	Unknown	$2,000 (TxDOT-installed)
545 – Transverse Rumble Strips	15% intersection-related	$2,000 (TxDOT-installed)
124 – Install Advance Intersection Warning Signals and Signs	15% Intersection-related	$160,000
Replace Yield Signs with Stop Signs	Unknown	$500 per sign
305 – Safety Lighting at Intersection	45% dark conditions	$150,000

[23] http://onlinemanuals.txdot.gov/txdotmanuals/hsi/preventable_crash_decoding.htm
[24] Preliminary, planning-level estimate to be reviewed for each treatment to incorporate recent TxDOT bids. Sources include FHWA, Oregon DOT.

521 – Add Right Turn Lane	25% intersection-related	$192,000
Convert Y-intersection to T-intersection	Unknown	$600,000, if intersection only. Cost to be determined based on connection location future coordination necessary with the X/S Ranch Developers and the City of Bastrop

FM 969 AT SH 21/71 FRONTAGE ROAD

The intersection of FM 969 and SH 21/71 Frontage Road operates as a T-intersection with right-in, right-out movements only.

Figure 20: FM 969 at SH 21/71 Frontage Road (Google Maps, 2017)

Collision Analysis

Figure 21 below illustrates the location of collisions in the area via the CRIS mapping tool.

Figure 21: Collisions at FM 969 and SH 21/71 Frontage Road, 1/1/11-7/30/19 (Source: CRIS)

Between January 2011 and July 2019, seven collisions have occurred in the vicinity of FM 969 and SH 21. Of those, none caused injuries. Approximately 72% of all crashes occurred under clear or cloudy skies. The pavement was dry for all crashes. Approximately 57% of crashes occurred in the dark where street lighting was not present. **Table 9** summarizes the collision types by year.

Table 9. Collisions by Year and Severity, FM 969 at SH 21/71 Frontage Road

Collisions by Severity				
Year	Fatal	Injury	PDO	Total Collisions
2011	0	0	1	1
2012	0	0	0	0
2013	0	0	0	0
2014	0	0	1	1
2015	0	0	3	3
2016	0	0	1	1
2017	0	0	0	0
2018	0	0	0	0
2019	0	0	1	1
TOTAL	0	0	7	7

Field Observations

Researchers reviewed the FM 969 approach at SH 21 during their field observations on July 22, 2019. In general, signing and pavement marking appeared consistent with the TMUTCD and TxDOT RDM. However, due to the oversizing of certain regulatory and warning signs, the existing standard sized ONE WAY appeared small in comparison as shown in **Figure 22**.

Figure 22: Left – FM 969 at SH 21 (Google Maps, 2018). Right – Artist rendition of oversized ONE-WAY sign

Recommendations

Short Term

- Consider upsizing existing ONE-WAY sign to “54x18” in accordance with Freeway/Expressway sizing in TMUTCD (see **Figure 22**).
- Near the west approach, prior to the intersection, consider an intersection warning sign with a black-on-yellow supplemental street name plaque below.
- Add “Right Turn Only” pavement markings to the southbound FM 969 approach.
- Install illumination at the intersection to address night-time crashes.
- Install transverse, in-lane rumble strips on the FM 969 approach.

Benefits and Costs of Recommendations

Table 10 below shows the estimated countermeasure costs and safety benefits of each recommended treatment at this location; in some cases, the treatment has an established entry in TxDOT’s Work Codes Table.

Table 10. Benefits and Costs of Recommended Treatments at the FM 969 at SH 21/71 Frontage Road intersection.

Treatment	Crash Reduction Factor and type affected [25]	Estimated Implementation Cost [26]
Replace existing ONE-WAY sign	Unknown	$600
101 Install Warning/Guide Signs	20% rear-end, sideswipe; off-roadway, median	$3,000
Add RIGHT TURN ONLY pavement marking	Unknown	$600
305 Safety Lighting at Intersection	45% dark conditions	$150,000
521 Add Right Turn Lane	25% intersection-related	$192,000
545 Transverse Rumble Strips	15% intersection-related	$12,000

FM 1209 AT SH 71

The intersection of FM 1209 at SH 71 is a signalized intersection with a 60 ft wide divided median (see **Figure 23)**.

Figure 23: FM 1209 at SH 71 South

[25] http://onlinemanuals.txdot.gov/txdotmanuals/hsi/preventable_crash_decoding.htm
[26] Preliminary, planning-level estimate to be reviewed for each treatment to incorporate recent TxDOT bids. Sources include FHWA, Oregon DOT.

Collision Analysis

Figure 24 below illustrates the location of collisions in the area via the CRIS mapping tool.

Figure 24: Collisions at FM 1209 and SH 71 Intersection, 1/1/11-7/30/19[27] (Source: CRIS)

Between January 2011 and July 2019, 259 collisions occurred at the intersection of FM 1209 and SH 71. The table below displays the collisions by year and severity.

[27] Several overlapping crashes are "stacked" in this figure.

Table 11. Collisions by Year and Severity, FM 1209 at SH 71

Collisions by Severity				
Year	Fatal	Injury	PDO	Total Collisions
2011	0	8	12	20
2012	0	5	16	21
2013	0	6	11	17
2014	1	11	13	25
2015	0	15	22	37
2016	2	12	24	38
2017	0	13	21	34
2018	0	13	21	34
2019	0	12	21	33
TOTAL	3	95	161	259

Fatal and Injury Collisions

Of the 259 collisions that occurred over the span of 8 years, there were three fatal crashes and 95 injury crashes. 66% of the collisions were rear-ends and 24% were angle related. One fatal collision occurred in 2014; two occurred in 2016. The fatal crashes have been detailed in the table below.

Table 12. Fatal Crash Events at FM 1209 and SH 71

Year	Day of Week	Time	Light Condition	Surface Condition	Weather Condition	Object Struck or Another Factor	Vehicle Travel Direction
2014	Tue	19:00	Daylight	Dry	Cloudy	Rear-End: Fail to control speed, Charges: Intoxication manslaughter	West
2016	Mon	17:08	Daylight	Wet	Rain	Angle: Failed to Yield	Southeast/ Southwest
2016	Sun	20:56	Dark, Lighted	Dry	Clear	One Motor Vehicle Going Straight - 2 Pedestrians failed to yield right of way to vehicle	Northeast

Weather and Pavement Conditions

In general, there were no significant trends related to the weather or pavement conditions at the time the crashes occurred. Approximately 84% of all crashes occurred under clear or cloudy skies. The pavement was dry in nearly 84% of crashes.

Other Notable Trends

The time of day and lighting conditions can have an impact on driving conditions and collisions. **Table 13** summarizes the collision frequency and severity by lighting conditions along the roadway. As shown, 74% of all crashes occurred during the daylight. The number of rear-end collisions was 172 (66%) due to motorists failing to pay attention or slowing/stopping at the traffic signal. 61 collisions (24%) were angle related where motorists were either traveling straight to avoid a rear-end or failing to yield right-of-way. The remaining 26 collisions (10%) were sideswipe or unknown.

Table 13: Collisions by Lighting Condition, FM 1209 at SH71

Lighting Condition	# of Collisions
Daylight	192
Dark-No Street Lights	27
Dark-Lighted	31
Dusk-Dawn	9

Approximately 91% of collisions occurred in clear or cloudy weather conditions. While overall weather conditions do not appear to be a significant contributing factor to collisions, there were 35 crashes on wet pavement observed.

Field Observation

The research team conducted a field observation at this location. There appeared to be no sight distance issues for motorists traveling eastbound and westbound on SH 71. Depicted in Figure 25 below, the sun may cause blinding making it hard to see the traffic signal. There are also advanced traffic signal warning signs with flashing beacons eastbound and westbound on SH 71. The speed limit of this segment is 70 mph.

Figure 25: FM 1209 and SH 71 West (Google Maps, 2018)

Recommendations

Short Term

- Consider installing transverse rumble stripes at all approaches to reduce motorist speeds prior to the traffic signal.

Medium Term

- Considering installing warning signs that indicates signal phasing (e.g., “Red Signal Ahead”).
- Install end-of-queue warning system to detect when the queue hits an identified point and warning upstream drivers with a Dynamic Message Sign.

Long Term

- Construct a grade-separated interchange as recommended in the *SH 71 (SH 130 to SH 21) Traffic Operations Analysis Summary* completed in August 2019. This report recommended the conversion of SH 71 to a freeway-frontage concept through this area with mainlanes overpassing FM 1209 and x-pattern ramps to be provided between FM 1209 and SH 21.

Benefits and Costs of Recommendations

The table below shows the estimated countermeasure costs and safety benefits of each recommended treatment at this location; in some cases, the treatment has an established entry in TxDOT's Work Codes Table.

Table 14. Benefits and Costs of Recommended Treatments at the FM 1209 / SH 71 Intersection

Treatment	Crash Reduction Factor and type affected [28]	Estimated Implementation Cost [29]
545 - Transverse Rumble Strips	15% intersection-related	$12,000
101 - Install Warning/Guide Signs	20% rear-end, sideswipe; off-roadway, median	$3,000
End of Queue Warning System	Unknown	$100,000
515 - Construct Interchange	65% intersection-related	$10,000,000

[28] http://onlinemanuals.txdot.gov/txdotmanuals/hsi/preventable_crash_decoding.htm
[29] Preliminary, planning-level estimate to be reviewed for each treatment to incorporate recent TxDOT bids. Sources include FHWA, Oregon DOT.

FM 1209 AT SH 21

The intersection of FM 1209 and SH21 is presently two-way stop-controlled with SH 21 providing free-flowing East/West movement (see **Figure 26**).

Figure 26: FM 1209 at SH 21 (Google Maps, 2017)

Collision Analysis

Figure 27 below illustrates the location of collisions in the area via the CRIS mapping tool.

Figure 27: Collisions at FM 1209 and SH21 Intersection, 1/1/11-7/30/19.[30] (Source: CRIS)

[30] Several overlapping crashes are "stacked" in this figure.

Between January 2011 and July 2019, 31 collisions occurred at the intersection of FM 1209 and SH 21. The table below displays the collisions by year and severity.

Table 15. Collisions by Year and Severity, FM 1209 at SH 21

Collisions by Severity				
Year	**Fatal**	**Injury**	**PDO**	**Total Collisions**
2011	0	0	0	0
2012	1	1	2	4
2013	0	1	0	1
2014	0	2	3	5
2015	0	2	0	2
2016	0	1	2	3
2017	0	5	3	8
2018	0	1	1	2
2019	0	6	1	6
TOTAL	1	18	12	31

Fatal and Injury Related Collisions

Most of the injury related collisions occurred during the early morning or night-time conditions where there was no street lighting present. 58% of the collisions were angle related. One fatal collision in 2012 occurred on a Saturday evening at 10:16 p.m.

Weather and Pavement Conditions

In general, there were no significant trends related to the weather or pavement conditions at the time corridor crashes occurred. Approximately 84% of all crashes occurred under clear or cloudy skies. The pavement was dry in nearly 84% of crashes. While overall weather conditions do not appear to be a significant contributing factor to collisions, there were five crashes on wet pavement.

Lighting Conditions

Table 16 summarizes the collision frequency and severity by lighting conditions along the roadway. As shown, only 35% of all crashes occurred at night, but the most severe collisions occurred at dusk or at night. There is no existing street lighting.

Lighting Condition	# of Collisions
Daylight	19
Dark-No Street Lights	9
Dusk-Dawn	3

Table 16: Collisions by Lighting Condition, FM 1209 at SH 21

Field Observation

The research team conducted a field observation at this location and identified limited sight distance for northbound N Gaines Road motorists at the STOP sign looking left (West) as depicted in **Table 17**.

Vegetation limits the sight distance for northbound drivers close to the current AASHTO standard of 570 ft of design stopping sight distance in this currently posted 60 mph speed limit zone. Maintenance operations to trim back vegetation would increase the sight distance considerably.

Table 17: Design Intersection Sight Distance (AASHTO)

Design Speed (mph)	Stopping Sight Distance (ft)	Intersection Sight Distance for Passenger Cars (ft)	
		Calculated	Design
15	80	165.4	170
20	115	220.5	225
25	155	275.6	280
30	200	330.8	335
35	250	385.9	390
40	305	441.0	445
45	360	496.1	500
50	425	551.3	555
55	495	606.4	610
60	570	661.5	665
65	645	716.6	720
70	730	771.8	775
75	820	826.9	830
80	910	882.0	885

Recommendations

The study team understands that TxDOT recently let two projects for construction at this intersection:

1. Convert 2-way stop-controlled intersection to a signalized intersection, let in January 2019.

2. Upgrade FM 1209 to a "Super-2" highway (including the section intersecting SH 21), let in October 2019.

The study team offers the following recommendations with those upcoming construction projects considered.

Short Term

- For the northbound approach along CR 81 (North Gaines Road) at the SH21/FM 1209 intersection, trim existing vegetation to open sight distance triangle.
- Ensure rutted pavement in the vicinity of the intersection is replaced as part of the construction projects.

Table 18. Benefits and Costs of Recommended Treatments at the FM 1209 / SH21 Intersection

Treatment	**Crash Reduction Factor and type affected** [31]	**Estimated Implementation Cost** [32]
Improve Intersection Sight Distance	47% injury, intersection-related	$20,000
Ensure Rutted Pavement is Replaced	Unknown	To be included in current construction

[31] http://onlinemanuals.txdot.gov/txdotmanuals/hsi/preventable_crash_decoding.htm
[32] Preliminary, planning-level estimate to be reviewed for each treatment to incorporate recent TxDOT bids. Sources include FHWA, Oregon DOT.

APPENDICES

A. Missouri DOT US 50 at Route W/Route Z Intersection Signing Layout