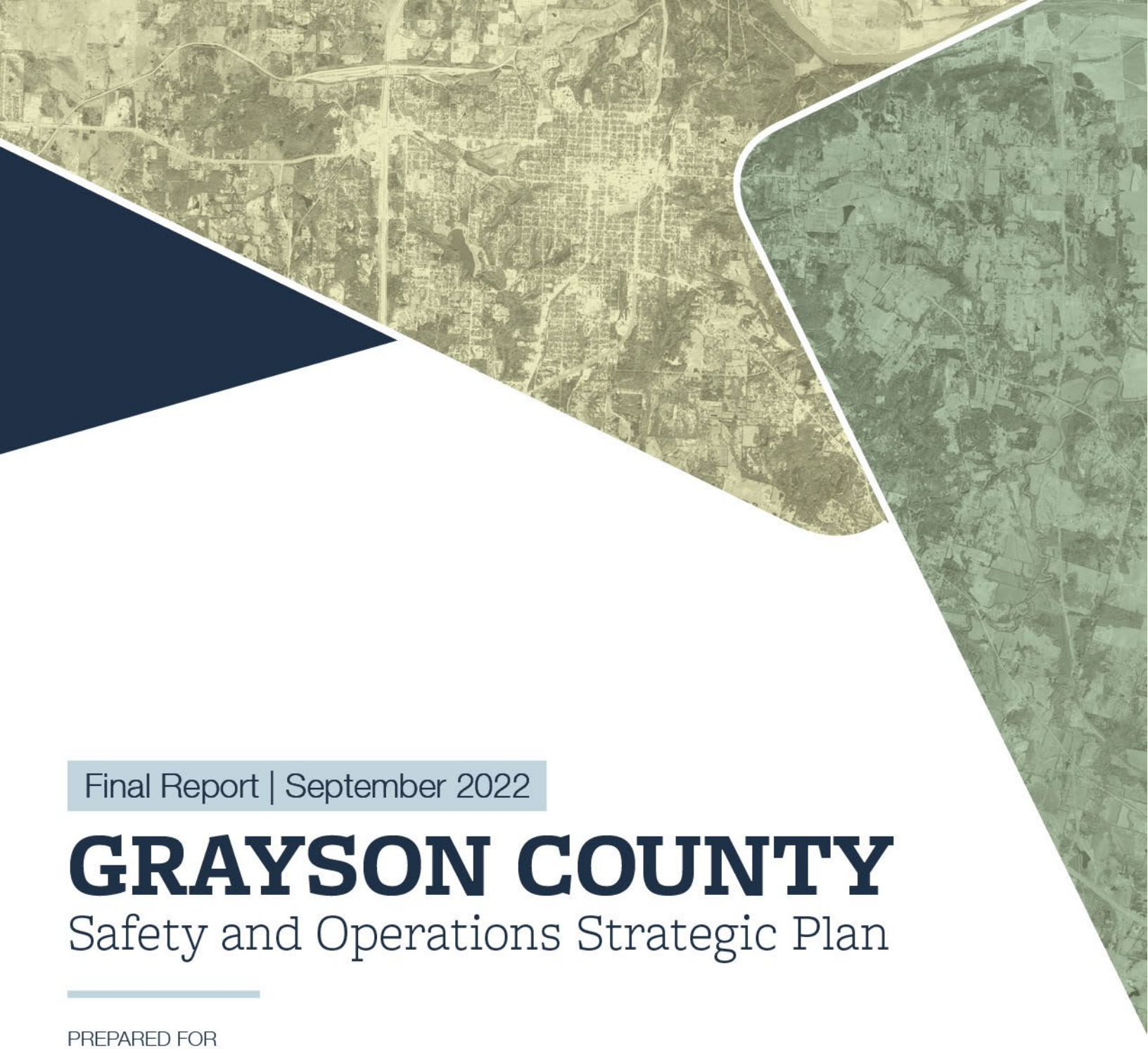

Final Report | September 2022

GRAYSON COUNTY

Safety and Operations Strategic Plan

PREPARED FOR

GRAYSON COUNTY MPO
METROPOLITAN PLANNING ORGANIZATION
INTERMODAL URBAN TRANSPORTATION PLANNING

PREPARED BY

Kimley»Horn

Grayson County Safety and Operations Strategic Plan

FINAL REPORT

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LIST OF ACRONYMS

AADT	Average Annual Daily Traffic
AC	Alternating Current
ADA	Americans with Disabilities Act
ADT	Average Daily Traffic
ATSPM	Automated Traffic Signal Performance Measure
AVL	Automated Vehicle Location
CCTV	Closed-Circuit Television
CDFI	Community Development Financial Institutions
CMV	Commercial Motor Vehicle
CRIS	Crash Records Information System
DC	Direct Current
DCFC	Direct Current Fast Charing
DMS	Dynamic Message Sign
DOT	Department of Transportation
DVMT	Daily Vehicle Miles Traveled
EV	Electric Vehicle
FHWA	Federal Highway Administration
GPS	Global Positioning Satellite
HERO	Highway Emergency Response Operator
HSIP	Highway Safety Improvement Program
IRA	Inflation Reduction Act of 2022
ITS	Intelligent Transportation Systems
LPI	Leading Pedestrian Interval
LRSP	Local Road Safety Program
MPH	Mile Per Hour
MPO	Metropolitan Planning Organization
MTP	Metropolitan Transportation Plan
NCTCOG	North Central Texas Council of Governments
NEVI	National Electric Vehicle Investment Program
NMTC	New Markets Tax Credit
PCS	Power Control System
PHB	Pedestrian Hybrid Beacon
PSC	Proven Safety Countermeasure
RHiNo	Roadway-Highway Inventory
RITIS	Regional Integrated Transportation Information System
RRFB	Rectangular Rapid Flashing Beacon
RSA	Road Safety Audit
SHSP	Strategic Highway Safety Plan
SII	Safety Improvement Index
SMART	Strengthening Mobility and Revolutionizing Transportation
SSC	Speed Safety Camera
SS4A	Safe Streets and Roads for All
TAC	Technical Advisory Committee
TERP	Texas Emissions Reduction Plan
TMC	Traffic Management Center
TPP	Transportation Planning and Programming
TSMO	Transportation Systems Management and Operations
TTI	Texas A&M Transportation Institute
TWLTL	Two-Way Left Turn Lane
TxDOT	Texas Department of Transportation
USDOT	United States Department of Transportation
VPD	Vehicles Per Day
VSL	Variable Speed Limit

EXECUTIVE SUMMARY

Overview

The Grayson County Metropolitan Planning Organization (MPO) has identified a need to study traffic safety and operations within Grayson County. As population has increased over the past ten years, the County has also experienced an increase in traffic crashes and congestion. This Grayson County Safety and Operations Strategic Plan aligns with 2045 Metropolitan Transportation Plan (MTP) goals related to safety, congestion, and environment.

The purpose of the Grayson County Safety and Operations Strategic Plan is to identify and prioritize potential improvements to the transportation system that can:

- Increase safety
- Reduce congestion
- Improve travel time reliability
- Support increased use of renewable energy for transportation in the region

This plan presents an analysis of crash trends, congestion trends, and electric vehicle (EV) charging system needs for Grayson County. Road corridors throughout the County are prioritized based on the trend analysis. Project recommendations in the areas of transportation safety, traffic operations management, and EV infrastructure development are made along these priority corridors.

Findings

Safety

Crashes in Grayson County have been trending upward from 2017 through 2021, with the numbers of both total crashes and fatal or serious injury crashes peaking in 2021 within Grayson County. While the number of crashes due to distracted or impaired driving has remained generally consistent over the past five years, the crash rates for other state emphasis areas including speeding crashes, pedestrian related crashes, crashes at intersections, and roadway departure crashes have all increased. High crash segments in Grayson County occur along US 75, US 82, SH 91, SH 56, FM 120, and FM 121.

Operations

The average recording of daily traffic from all Texas Department of Transportation (TxDOT) traffic count stations in Grayson County increased by nearly 20 percent from 2017 to 2021. In contrast to traffic volume trends elsewhere in Texas, which generally saw traffic counts fall during the COVID-19 pandemic, in Grayson County the -pandemic had very little impact on traffic volumes. This increase in vehicle travel has led to the formation of occasional traffic bottlenecks in locations throughout Grayson County. The highest-ranking bottleneck segments within the County occurred along portions of US 75, US 377, US 69, SH 56, SH 11, and SH 160.

Electric Vehicle Charging

Grayson County ranked 31st among all Texas counties with 343 registered EV as of August 2022. Six of the nine existing EV charging stations within Grayson County are located either along or near US 75. Three of the nine stations do not require payment from the user.

Recommendations

Safety

Safety recommendations were drawn from the Federal Highway Administration (FHWA) list of Proven Safety Countermeasures as well as TxDOT's list of safety countermeasures eligible for funding through the Highway Safety Improvement Program (HSIP). Systemic safety recommendations that should be considered broadly at locations throughout Grayson County as part of upcoming scheduled maintenance and construction efforts included:

- Signing and marking improvements at stop-controlled intersections
- Dedicated right and left turn lanes or continuous turn lanes
- Signal head backplates with reflective borders
- Roadway widening (along road shoulders, for example)
- Continuous safety lighting along a corridor where no lighting is present
- Enhanced delineation on curves

Targeted safety recommendations were developed in response to specific crash patterns observed at hotspots throughout the County along roads including US 75, US 82, SH 91, SH 56, SH 11, Spur 503, FM 120, and FM 691. Recommendations included low-cost items such as signing and striping improvements, rumble strips, and pedestrian infrastructure. Several higher cost items such as shoulder widening, roadway lighting, and traffic signal upgrades were also included where applicable.

Operations

Operations recommendations were developed from discussions with stakeholders from across Grayson County and from a review of both national best practices and previously completed local traffic management planning efforts. Many of the recommendations are focused on regional efforts, such as the establishment of a jointly operated traffic management center (TMC) to monitor freeway mobility and arterial corridor traffic signal operations or the development of a freeway service patrol to improve freeway incident management detection and response.

Location-specific operations recommendations largely center around the deployment of new field infrastructure, such as additional closed-circuit television (CCTV) cameras and dynamic message signs (DMS) along high-volume TxDOT facilities such as US 75, US 82, US 377, SH 91, Spur 503, and FM 1417. In urban portions of Grayson County, targeted operations deployments include improved traffic signal controllers as well as enhanced vehicle detection, surveillance, emergency vehicle preemption, and performance measurement capabilities along key arterial corridors such as SH 56 in Sherman or Main Street in Denison. Targeted flood detection equipment recommendations are also provided for roads in rural parts of the County.

Electric Vehicle Charging

EV charging station location recommendations were developed through discussions with the Grayson County MPO Technical Advisory Committee (TAC) and from a review of surrounding traffic generators and land uses near proposed charging sites. Four potential charging station sites were evaluated within Grayson County:

- Denison Travel Center near the state border along US 75
- Downtown Denison parking lot near Chestnut Street and Fannin Avenue just off Main Street
- Downton Denison parking lot near Chestnut Street and Rusk Avenue just off Main Street

- Downton Sherman parking lot near Houston Street and Crockett Street across from Courthouse Square

Next Steps

The Grayson County Safety and Operations Strategic Plan identified a series of next steps needed to move closer to reaching the goals identified in the 2045 MTP related to safety, congestion, and environment. These next steps are described below.

Incorporate Systemic Safety Countermeasures Throughout the Region. Incorporate the FHWA Proven Safety Countermeasures and HSIP Systemic Safety Measures on future transportation projects in the Grayson County MPO Region. Lead agencies are the TxDOT Paris District, Grayson County, and cities with support from the Grayson County MPO.

Apply for TxDOT HSIP Funding. Apply for TxDOT HSIP funding for the highest ranked segments identified for safety improvements in the Grayson County Safety and Operation Strategic Plan. Continue to apply for HSIP funding in subsequent years until all segments have been submitted for HSIP funding. Lead agencies are the TxDOT Paris District, Grayson County, and cities.

Apply for United States Department of Transportation (USDOT) Safe Streets and Roads for All (SS4A) Funding. Apply for a USDOT SS4A Action Plan grant during the 2023 application period. The application should build off the safety issues and countermeasures identified in the Grayson County Safety and Operations Strategic Plan. If successful, upon completing the Action Plan apply for an Implementation Grant under the same program. Lead agency is the Grayson County MPO.

Implement a Regional TMC. Implement a regional TMC that could include the TxDOT Paris District, Grayson County, and City of Sherman. The TMC could support freeway operations, provide arterial traffic signal management, and coordinate video sharing with the Grayson County Emergency Operations Center. Lead agencies are the TxDOT Paris District possibly in coordination with the City of Sherman and Grayson County.

Deploy Intelligent Transportation Systems (ITS) Infrastructure on US 75 and Other State Highways. Deploy ITS infrastructure identified by the TxDOT Paris District on US 75 and other state highways in Grayson County. ITS infrastructure includes CCTV cameras, DMS, flood detection, and communication systems. Lead agency is the TxDOT Paris District.

Implement Upgrades to the Traffic Signal System Throughout the Region. Traffic signal system upgrades should include CCTV cameras at all traffic signals, traffic signal communication and detection improvements, emergency vehicle signal preemption along key emergency response corridors, and the use of automated traffic signal performance measures (ATSPMs) to monitor signal and corridor improvements. The City of Sherman should also begin preparing for the takeover of TxDOT maintained traffic signals within City boundaries prior to the 2030 Census. Lead agencies are the TxDOT Paris District and City of Sherman.

Support the Implementation of EV Charging Stations in Grayson County. Support the implementation of EV charging stations in Grayson County as identified in the Texas Electric Vehicle Infrastructure Plan. Implementation could include deployment of charging stations at the Denison Travel Information Center on US 75 and in downtown Sherman and Denison. Lead agencies are the Grayson County MPO, TxDOT Paris District, and cities.

1 INTRODUCTION

1.1 Study Overview

The Grayson County Metropolitan Planning Organization (MPO) has identified a need to study traffic safety and operations within Grayson County. Located in north Texas between the Dallas-Fort Worth Metroplex and Oklahoma, Grayson County has experienced a rapid growth in population over the last ten years. As population has increased, the County has also experienced an increase in traffic crashes and congestion. With safety and congestion reduction identified as two of the major goals in the 2045 Metropolitan Transportation Plan (MTP) for Grayson County, the region is planning to direct additional resources to projects that address both these areas. A third goal in the 2045 MTP was focused on the effects of the transportation system on the environment. In support of this goal, the Grayson County MPO also included a task in the Grayson County Safety and Operations Strategic Plan that is focused on increasing the use of renewable energy for transportation in the region by identifying potential locations for electric vehicle (EV) charging stations.

2045 Metropolitan Transportation Plan Goals for Safety, Congestion, and Environment

Safety. The region's transportation system should strive to reduce crashes for both motorized and nonmotorized users.

Congestion Reduction. The region's transportation system should strive to improve the person-capacity of congested corridors.

Effects on the Environment. Transportation improvements should be focused on reducing environmental impacts.

Major highways in Grayson County include US 75, which links the Dallas-Fort Worth Metroplex to Oklahoma, US 82 which links Sherman and Whitesboro, and US 377 and US 289 which connect Grayson County to the Metroplex. Traffic on each of these highways has grown over the last decade, and with additional development planned along each route, that growth is expected to continue. The population of Grayson County was estimated to be over 139,000 in 2021, a growth of more than 15.1% since 2010. That growth is far above the 7.3% growth of the U.S. population and just slightly less than Texas' statewide population growth of 17% during the same period. As the population and resulting traffic continues to increase, it is likely that the number of crashes and congestion across the County will also increase unless action is taken.

To address the growing number of crashes and expected increase in congestion, the Grayson County MPO developed the Grayson County Safety and Operations Strategic Plan. The development of the plan was led by the Grayson County MPO Technical Advisory Committee (TAC), which met several times with the project team to provide input and guidance throughout the plan development process. Safety recommendations included projects that could be eligible for funding through the Highway Safety Improvement Program (HSIP) funding process. Congestion and reliability improvements were focused on the use of intelligent transportation systems (ITS) strategies, which can also provide a secondary benefit of improving safety. EV charging station recommendations focused on deployment in publicly owned parking areas along both controlled access highways and in urban downtown areas.

1.2 Study Goals and Objectives

The Grayson County Safety and Operations Strategic Plan aligns with the 2045 MTP goals related to safety, congestion, and environment. The purpose of the Safety and Operations Strategic Plan is described below.

The purpose of the Grayson County Safety and Operations Strategic Plan is to identify and prioritize potential improvements to the transportation system that can:

- Increase safety
- Reduce congestion
- Improve travel time reliability
- Support increased reliance on renewable energy for transportation in the region

The Grayson County Safety and Operations Strategic Plan analyzes the existing conditions of Grayson County's transportation system by reviewing historic crash data from the Texas Department of Transportation (TxDOT) Crash Records Information System (CRIS). The plan identifies and prioritizes crash hot spots along key corridors to determine potential countermeasures to reduce crashes. The safety related countermeasures considered for implementation include the Federal Highway Administration (FHWA) Proven Safety Countermeasures and the Texas HSIP approved safety countermeasures. These countermeasures are widely accepted as effective approaches to improving safety either on a systemic or a spot location basis. Use of the HSIP countermeasures also provides the stakeholder agencies in the Grayson County MPO region with documentation that can be used to support their HSIP funding applications.

The Grayson County Safety and Operations Strategic Plan determines the priority of key corridors in need of operational improvements by analyzing the 2021 INRIX bottlenecks and Texas A&M Transportation Institute (TTI) congestion data. The plan considers several ITS related strategies for reducing congestion and improving travel-time reliability, including a regional traffic management center (TMC), closed-circuit television (CCTV) cameras, freeway safety service patrols, dynamic message signs (DMS), traffic signal pre-emption for emergency vehicles, weather, and flood detection, and use of automated traffic signal performance measures (ATSPMs).

This document was also developed to support increased reliance on renewable energy for transportation in the region by identifying potential locations for EV charging stations, as well as sources for funding. Potential sites for EV charging station were identified along US 75 and in downtown Sherman and Denison and recommendations are provided on site layout and types of charging infrastructure that should be considered at each site.

1.3 Stakeholder Input

A critical component in the development of the Grayson County Safety and Operations Strategic Plan was the participation by stakeholder agencies throughout the County. Stakeholder participation ensured that the needs of agencies throughout the County were reflected in the document. Stakeholders were also able to provide key input regarding safety hotspots, congestion, and other

operational challenges, and input as to the most feasible locations for EV charging stations within the County.

Stakeholder meetings included presentation and discussion on the Grayson County Safety and Operations Strategic Plan at the March 2022 and August 2022 Grayson County MPO TAC meetings. Individual meetings were also held with the Grayson County MPO, TxDOT Paris District, and City of Sherman. All stakeholders were provided an opportunity to provide input on corridor selection and prioritization for safety and operations, as well as the provide input on the Draft Grayson County Safety and Operations Strategic Plan.

Stakeholders participating in the development of the Grayson County Safety and Operations Strategic Plan are included below in **Table 1**.

Table 1 – Strategic Plan Participating Stakeholders

Stakeholder and Agency	
Clay Barnett, Grayson County MPO	Gracie Johnson, Grayson County
Rob Rae, City of Sherman	Paula Shaw, Grayson County
Bobby Atteberry, City of Denison	Shellie White, TAPS Public Transit
Len McManus, City of Van Alstyne	Aaron Bloom, TxDOT Paris District
Barbara Maley, FHWA	Mansour Shiraz, TxDOT TPP Division
Bill Benton, Grayson County	

1.4 Other Existing Studies

1.4.1 TxDOT Paris District Transportation Systems Management and Operations Program Plan

Transportation Systems Management and Operations (TSMO) is an approach that aims to improve mobility, security, safety, and reliability for all modes of by making use of mobility solutions and ITS that can be implemented faster and are relatively low in cost compared to projects seeking to add roadway capacity. The TSMO approach allows for holistic management of the transportation network through field deployments, stakeholder engagement, data-driven decision making, and well-defined and collaborative institutional arrangements.

A TSMO Program Plan recently completed by the TxDOT Paris District identified a list of TSMO action items that would improve management of the transportation network throughout the region. Some action items applicable to Grayson County included the expansion of work zone technology and ITS device deployments which could then be managed through the establishment of a regional TMC, the deployment of a freeway service patrol to improve incident response, and traffic signal system investments to improve remote surveillance capabilities and traveler throughput. Although the TxDOT Paris District TSMO Plan identifies general action items for its nine-county service area, Grayson County MPO identified the need to build upon the TxDOT plan by tailoring recommendations and actions that would align better with the County's current transportation priorities.

1.4.2 US 82 Safety Study

The US 82 Safety Improvement Feasibility Study was conducted by TxDOT in 2019 as part of the initial planning efforts to increase safety and mobility along US 82. The study corridor consists of an 18-mile stretch of US 82 spanning from the Cooke County line to the FM 1417 interchange in Grayson County. This corridor was selected due to the crash data along this segment showing a percentage of severe crashes higher than the rural statewide average. The detailed study proposed phased transportation solutions and enhancements to the corridor intended to decrease the likelihood of crashes and improve localized intersection and interchange safety.

Study recommendations were grouped into initial, interim, and ultimate phases. The initial phase includes improvements that may be implemented over the next 10 years, such as restriping, additional signage, and guardrail replacements. Interim phase solutions are ones that can be made 10 to 20 years from now, such as ramp reconstructions or conversions from two-way frontage roads to one-way frontage roads. Ultimate phase solutions include ones that may be advanced in 20 or more years. An ultimate solution proposed by TxDOT involved converting the study corridor to an access-controlled freeway with grade-separated interchanges along with making necessary improvements to the already existing grade-separated interchanges.

1.4.3 Sherman-Denison MPO Freight Plan

Completed in September 2018, the Sherman-Denison MPO (now named Grayson County MPO) Freight Mobility Plan investigated freight movement on highways, railroads, and airports within Grayson County. Through this study, current safety conditions along with their subsequent needs in relation to freight mobility were identified. Using crash data from 2012 to 2016, the study highlighted that Grayson County has a lower rate of crashes involving commercial motor vehicles (CMVs) than Texas as a whole. However, the plan still identified opportunities to improve freight mobility and safety.

At the time of the study, most congestion and crashes involving CMVs within Grayson County occurred on or near US 75. Having initially been designed as a 45 mile per hour (mph) roadway, US 75 experiences a level and speed of traffic today that it was never intended to support. Two projects were referenced in the plan as solutions to the issues involving US 75. The first project involved widening the existing four lanes of US 75 to a six-lane divided roadway from FM 1417 to SH 56. The second project involves the relocation of the US 75 ramps at Spur 503 and at FM 1417.

To address other segments with freight traffic throughout Grayson County, the plan also recommended the addition of acceleration and deceleration lanes to separate turning vehicles from higher speed through traffic. The study also recommended various improvements to ramp spacing, roadway curves, bridge height clearance, and roadway grade changes to create a safer highway network overall for CMVs.

2 EXISTING CONDITIONS

Section 2 presents current traffic, crash, and congestion trends for Grayson County and identifies systemwide and corridor-based safety and operations challenges. This section utilizes historic traffic volume data to review the average annual daily traffic (AADT) volume and daily vehicle miles traveled (DVMT) trends for Grayson County to grasp the impacts the COVID-19 pandemic had on traffic patterns in the region at a high level. AADT is the estimation of the mean traffic volume in a day across all days for a year on a section of roadway, while DVMT is the total number of miles travelled by the vehicles in one day. To calculate DVMT, AADT is multiplied by the length of the roadway section. Crash data from the TxDOT Crash Records Information System (CRIS) is used to identify crash hot spots and determine trends in crashes. And data from INRIX and TTI is used to identify bottlenecks and delay due to congestion.

2.1 General Traffic Pattern Trends

2.1.1 Average Annual Daily Traffic

During the March 2022 Grayson County TAC Meeting, the members of the TAC noted that the COVID-19 pandemic had little impact on traffic volumes throughout Grayson County. Most of the jobs in the region require employees to be on site and employees did not have the option to work remotely. Since remote work was not an option for many residents, the County did not experience a reduction of traffic volumes. The TAC members also noted that traffic volumes and congestion increased in portions of the Grayson County because fewer businesses were closed in Grayson County compared to business located closer to the DFW Metroplex and many people from the DFW Region traveled to Grayson County to visit the businesses that remained open.

TxDOT's Transportation Planning and Programming (TPP) Division maintains TxDOT's traffic station count data and shares the data with the public. **Table 2** shows the average of the percent change in AADT for each TxDOT traffic station within Grayson County, from year to year between 2017 and 2021. Unlike most regions of the state, which experienced a decrease of over five percent in AADT, Grayson County only experienced a one percent decrease between 2019 and 2020 which was the height of the COVID-19 pandemic.

Table 2 – Grayson County AADT Average Percent Change

Change from 2017 to 2018	Change from 2018 to 2019	Change from 2019 to 2020	Change from 2020 to 2021
3%	6%	-1%	11%

While the overall traffic volumes in Grayson County may not have changed drastically in 2020, the traffic patterns did shift, due to the influx of visitors coming into the County to do their shopping. **Figure 1** shows a map of the TxDOT AADT traffic stations in Grayson County, colored based on if the volumes at that location increased or decreased from 2019 to 2020.

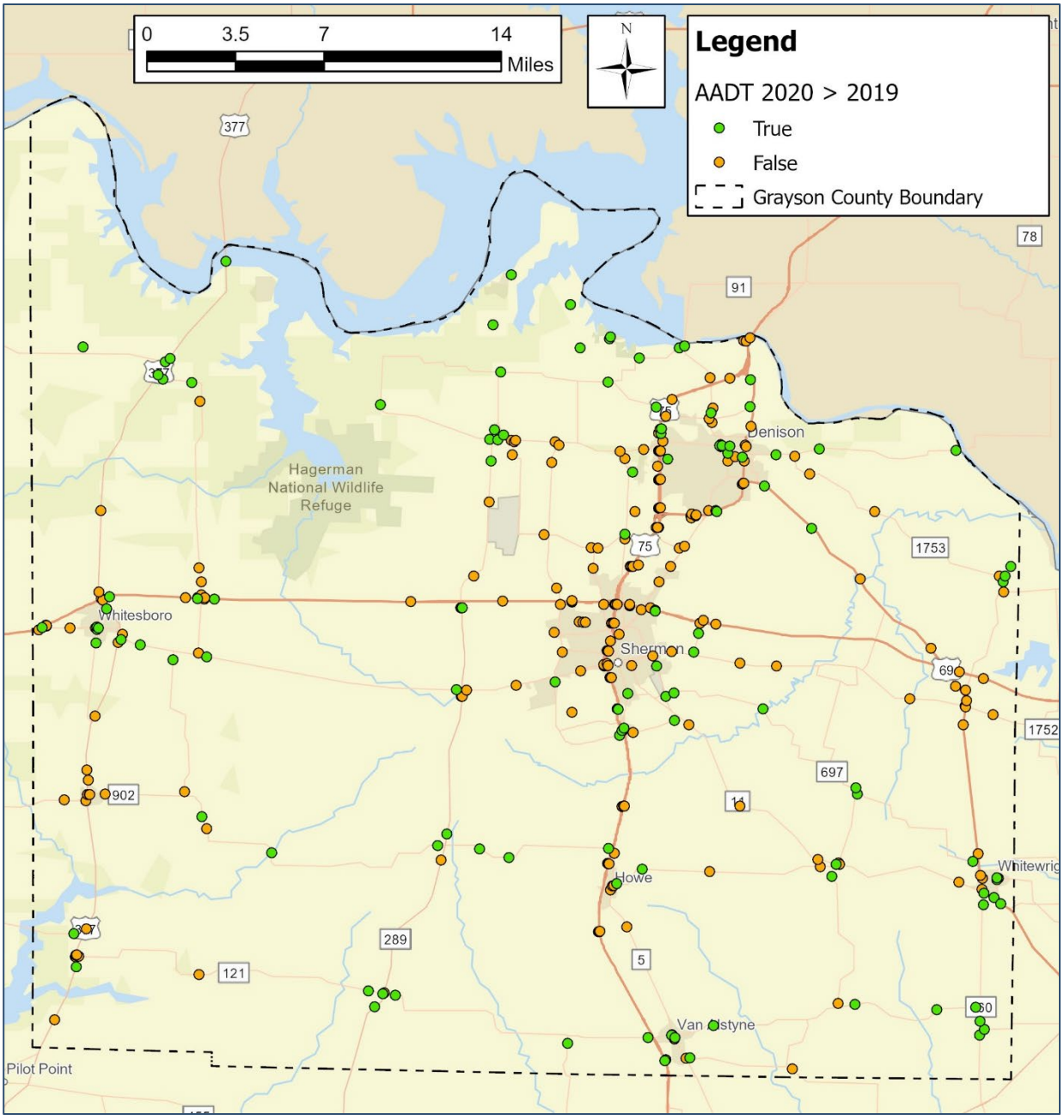


Figure 1 – Map of AADT Growth from 2019 to 2020

2.1.2 Daily Vehicle Miles Traveled

The historic DVMT data provides further insight into the impacts that the COVID-19 pandemic had on traffic patterns at a high level. TxDOT's Roadway Inventory Annual Data is published every year with statistics on the use of public roadways such as lane miles, DVMT, and truck DVMT. The statewide statistics can also be broken down to the district and county level and filtered by highway system, ownership, functional classification, etc.

Statewide and Nationwide

The statewide DVMT had steadily increased between 2014 until 2019, but then fell nearly ten percent between 2019 and 2020. The annual DVMT for the State of Texas in 2020 dropped below the level it had been four-year previously in 2016. Nationally, DVMT had also been increasing steadily but the 2020 numbers dropped below 2015 levels.

Grayson County

While Grayson County saw a decrease in DVMT from 2019 to 2020, the DVMT value 2020 did not drop below any other previous recorded year. This trend may have been due to the increase in visitors from neighboring jurisdictions for shopping and restaurants during the pandemic, as discussed previously in the AADT section. The steady growth of Grayson County's population, which has increased over 1.5 percent each year from 2016 through 2020, may also have been a contributor to the minimal decrease in DVMT in 2020.

Similar Counties

The DVMT trends in other rural Texas counties that have similar characteristics to Grayson County were reviewed to determine if the trends seen in Grayson County are consistent with trends experienced in similar regions elsewhere in the state. Wichita and Taylor Counties were selected for comparison. Similar to Grayson County, Wichita and Taylor Counties are both made up of mostly rural towns with one or two larger cities, and contain major interstate and state routes that carry high through traffic volumes.

The 2020 populations of Grayson, Wichita, and Taylor counties are 133,527, 132,154, and 137,521 respectively. Grayson County's largest cities are the City of Denison and the City of Sherman, connected by US 75 and divided by US 82. US 69 and US 377 also run all the way through Grayson County. The Cities of Wichita Falls and Burkburnett have the highest population in Wichita County. I-44, US 287, US 281, and US 277 cross Wichita County, all cutting through the City of Wichita Falls. The City of Abilene is the city with the greatest population in Taylor County. Taylor County's major corridors include I-20, US 84, US 83, and US 277.

Figure 2 compares the overall DVMT of Grayson County to Wichita County and Taylor County from 2017 through 2020. While the DVMT of Wichita County and Taylor County decreased 8.1 percent and 6.8 percent, respectively, Grayson County saw a decrease of only 3.6 percent, despite it having the highest DVMT of the three.

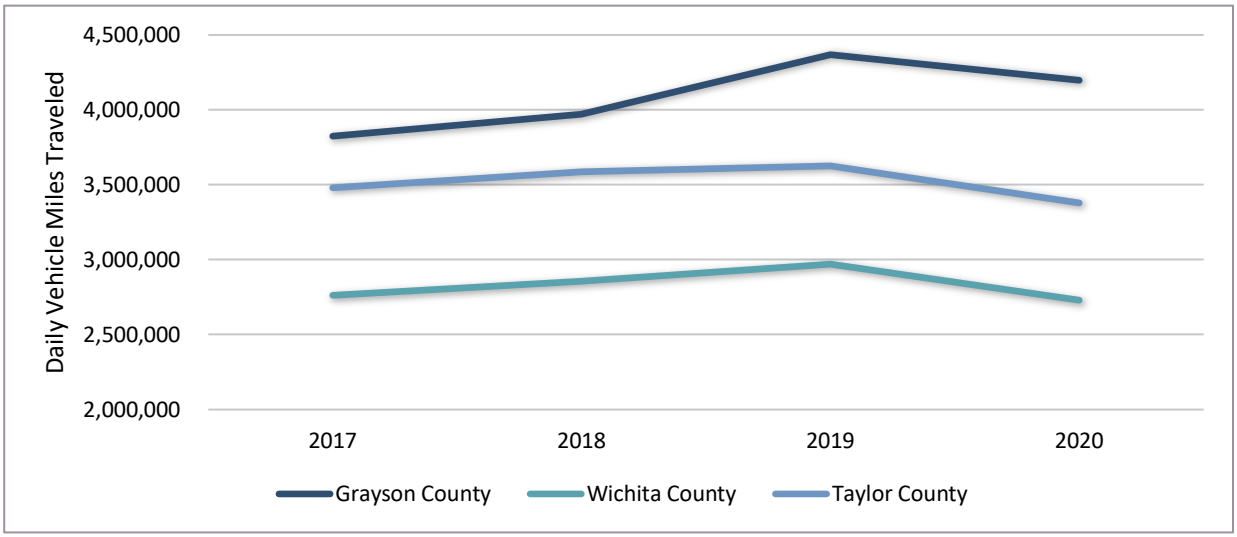


Figure 2 – Similar Counties DMVT by Year

2.2 Safety Trends

The safety focused analysis of existing conditions uses historic crash data to determine crash trends and crash hotspots within Grayson County. Crash data was collected from CRIS, which has a crash data query tool that provides details of reported crashes within Texas. Crashes are filterable based on a variety of characteristics, such as date, location, severity, and manner of collision.

2.2.1 Crash History

Historical crash data was reviewed for the past five years of CRIS data, from 2017 through 2021. Crash data is available further back in CRIS, however after so many years the validity of crash data begins to lessen as improvements in road geometry, pavement, signing and striping that may have occurred in more recent years are negated by older data. In addition to Grayson County, CRIS data was also collected on a statewide basis, as well as for two other counties with characteristics similar to Grayson County, to compare Grayson County crash trends with statewide and similar county trends.

Statewide

In 2021, 4,489 deaths occurred due to crashes on Texas roads. This is an increase of 15.2 percent from 2019's death toll of 3,896 people. **Figure 3** shows that although the total number of crashes in Texas experienced a significant drop in 2020 of 15.5 percent from 2019, the fatal crash count continued to increase, and the number of serious injury crashes only decreased by 6.2 percent and has since increased over 30 percent in 2021. This trend, like crash trends across the nation, showed an overall decrease in the total number of crashes caused by the decrease in traffic volumes due to the COVID-19 pandemic. An increase in fatal crashes was seen nation-wide which is widely attributed to higher speeds on roadways that occurred as a result of less congestion.

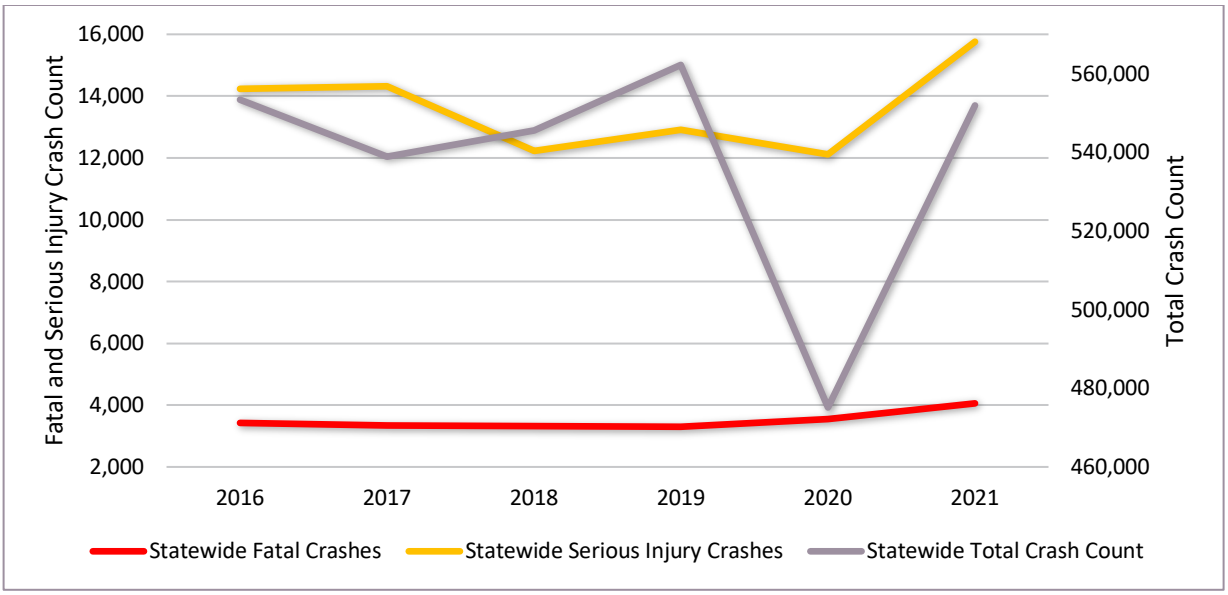


Figure 3 – Statewide Total, Fatal, and Serious Injury Crash Count by Year

Grayson County

Figure 4 shows that unlike the statewide crash trend, the number of all crashes in Grayson County experienced a decline of 1,817 crashes to 1,737 crashes in 2019 and increased a total of 14.5 percent over the following two years, to 1,997 total crashes in 2021. The number of fatal crashes also continued to increase from 2019 through 2021, from 20 to 26, despite the impacts of the COVID-19 pandemic on traffic volumes. While the serious injury crash count experienced a five-year low of 77 in 2020, a five-year peak was reached in 2021 at 109 serious injury crashes.

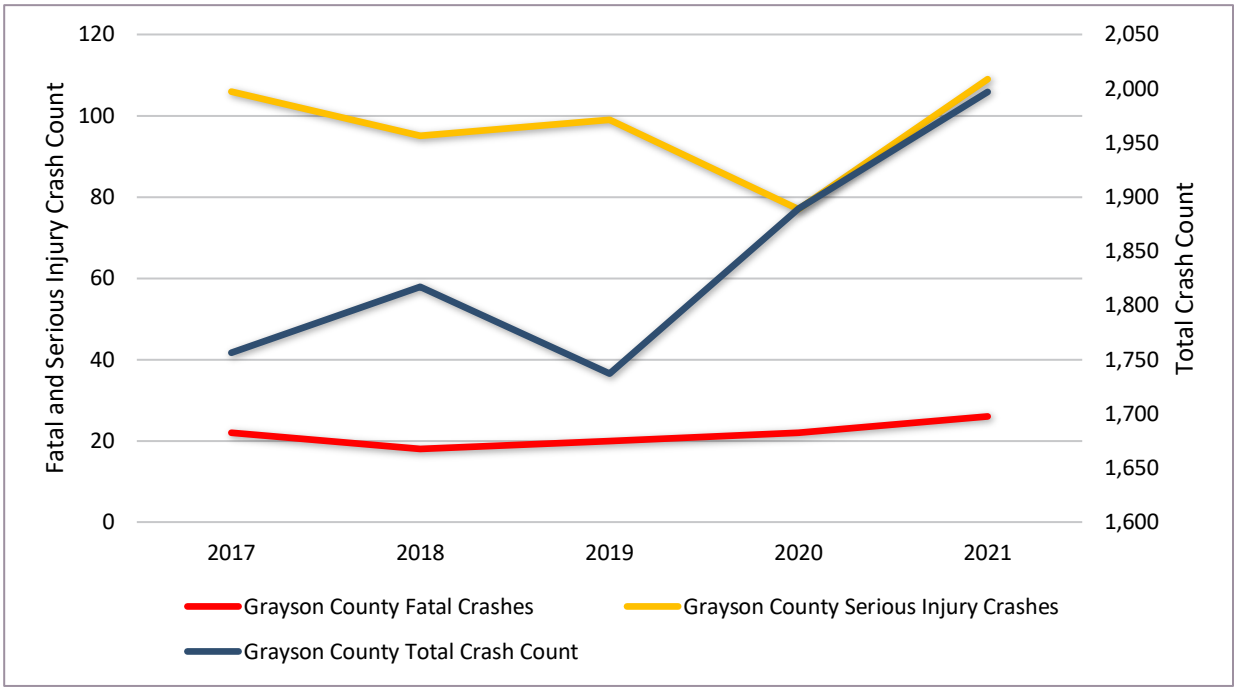


Figure 4 – Grayson County Total, Fatal, and Serious Injury Crash Count by Year

Fatal and all injury crashes recorded in CRIS from 2017 through 2021 are included in **Figure 5**. Non-injury crashes are not included in this map as the high number of these types of crashes covers most of the roadways and makes it difficult to distinguish specific locations.

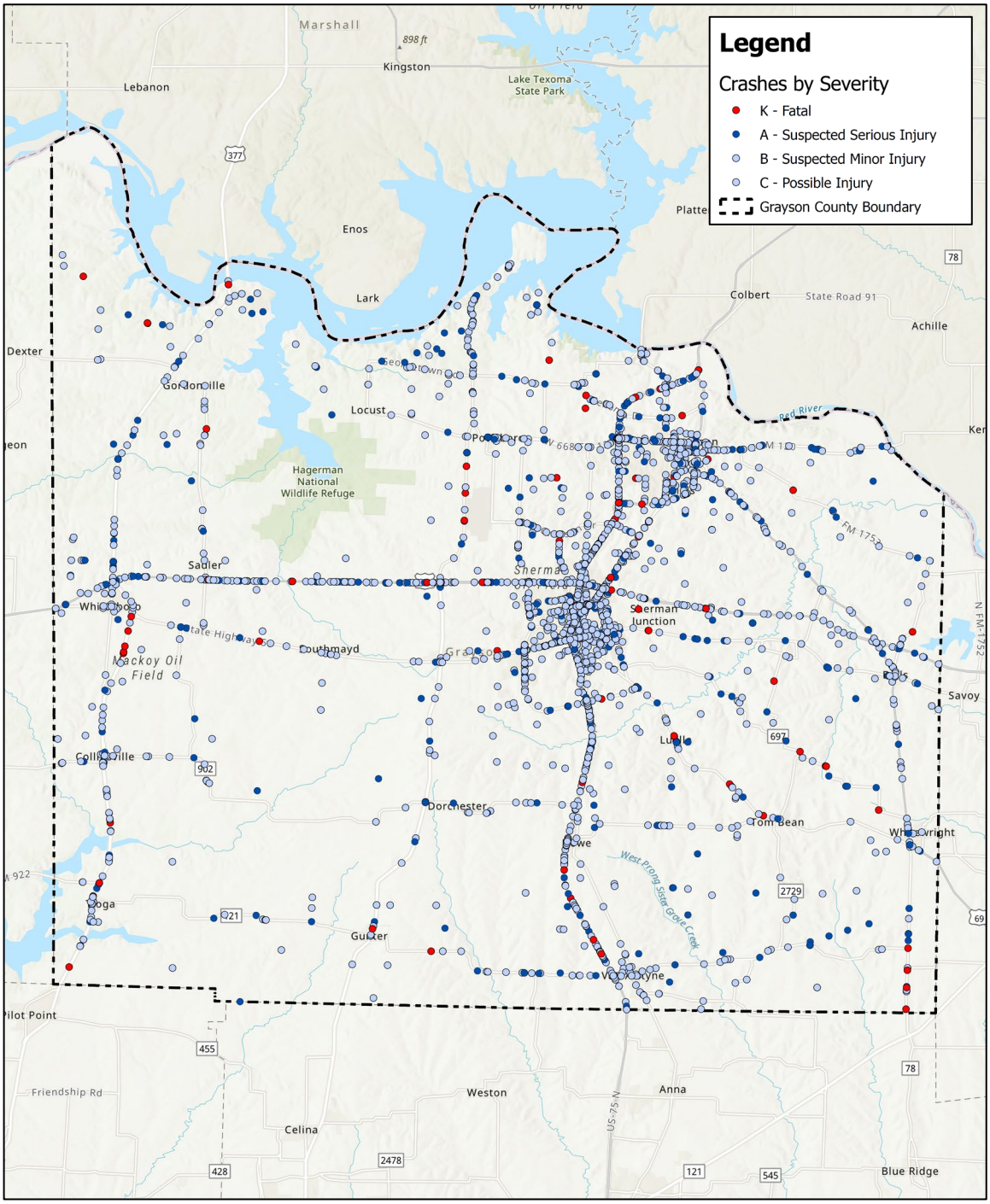


Figure 5 – Grayson County Fatal and All Injury Crash Locations

Fatal and serious crashes recorded in CRIS from 2017 through 2021 are included in **Figure 6**. Removing all injury crashes except serious injury crashes makes it easier to identify the fatal and serious injury crashes that occur in the more urban areas of Sherman and Denison.

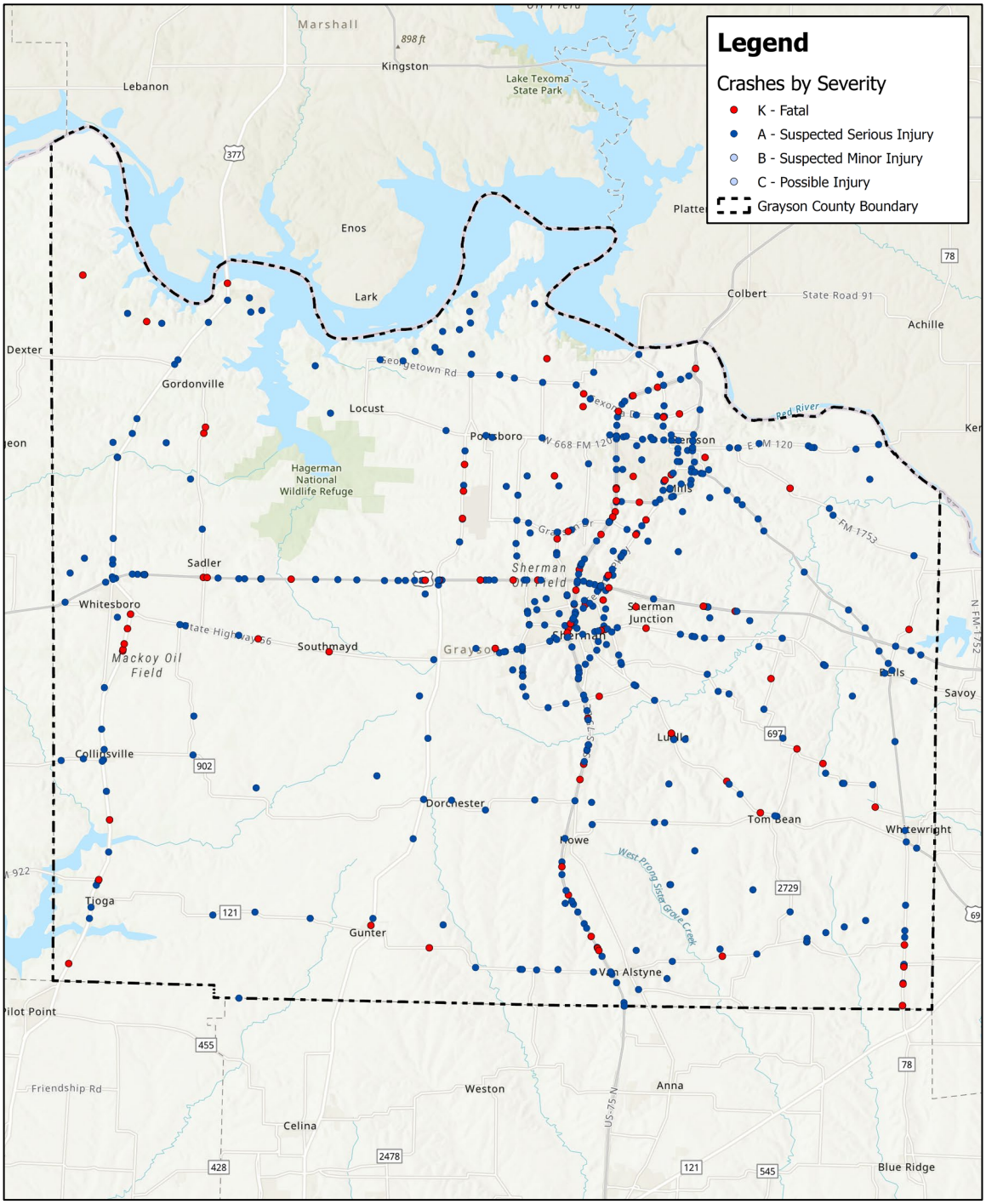


Figure 6 – Grayson County Fatal and Serious Injury Crash Locations

Similar Counties

Similar to the DVMT trend section, a comparison was made between the total number of crashes in Grayson County and the total number of crashes in Wichita and Taylor Counties. The comparison with these counties, which have similar characteristics to Grayson County, was made to determine if the crash trends seen in Grayson County are consistent with trends experienced elsewhere in the state.

While Grayson County has a population between that of the other two counties and is growing significantly faster, and has the greatest DVMT for each of the past five years, it has the lowest number of all recorded crashes each year for the past five years, as shown in **Figure 7**. However, the total number of crashes in Grayson County has steadily increased each year and is approaching a number similar to Wichita County.

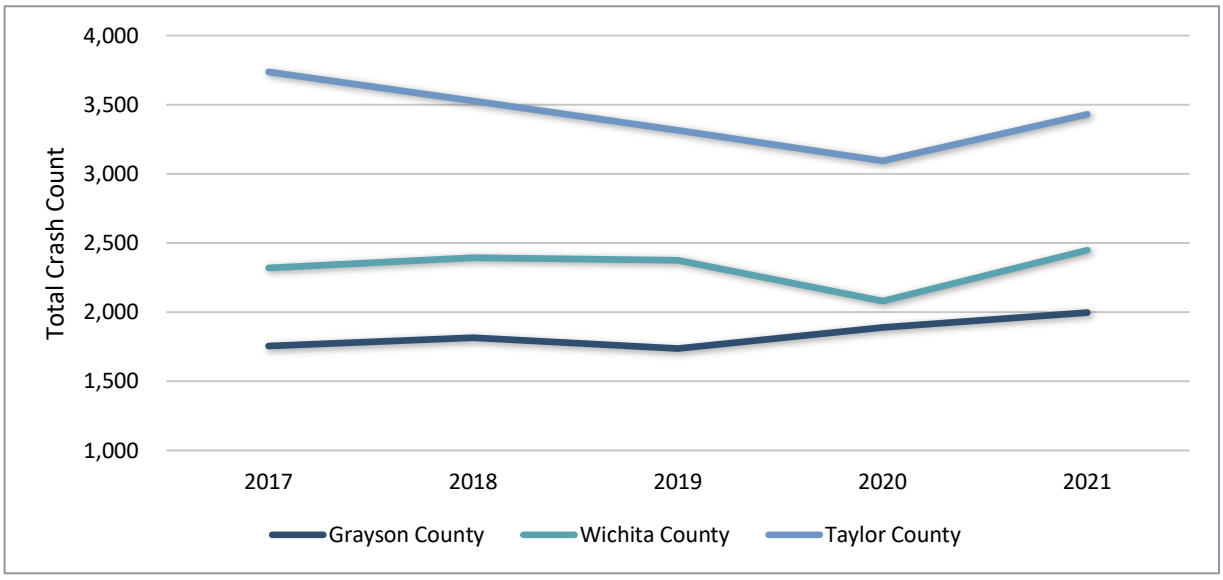


Figure 7 – Similar Counties Total Crash Count by Year

2.2.2 Grayson County Crash Hotspots

The heat map in **Figure 8**, shows crash density of crashes within Grayson County from 2017 through 2021. The largest crash hotspots are along US 75, US 82, SH 91, SH 56, FM 120, and FM 121. Most of the section of US 75 that spans Grayson County has a moderate to high crash density. However, US 75 south of SH 91 and the segment of US 75 between N Loy Lake Road and US 82 were recently reconstructed, are currently under construction, or have plans in place for construction. Due to the recent, existing or planned construction, crash data for these segements is not valid and the segments were not considered for safety improvements as part of this study.

The intersections of US 82 and US 377 in the City of Whitesboro, US 69 and SH 56 in the City of Bells, and SH 56 and FM 1417 were identified as high crash density locations. Travis Street, through the City of Sherman, was also identify as a crash hotspot.

The CRIS data for the portion of US 82 from the City of Whitesboro to the intersection with FM 289 generally shows a moderate crash density. Between Collinsville and the southwestern corner of the

Grayson County boundary, US 377 has multiple moderate crash hotspots. SH 289, from FM 120 to Elks Boulevard near Preston, also has many low to moderate crash hotspots.

While **Figure 8** only identifies some corridors containing crash hotspots, **Table 5** includes a full list of corridor segments with crash hotspots that are considered for safety improvements.

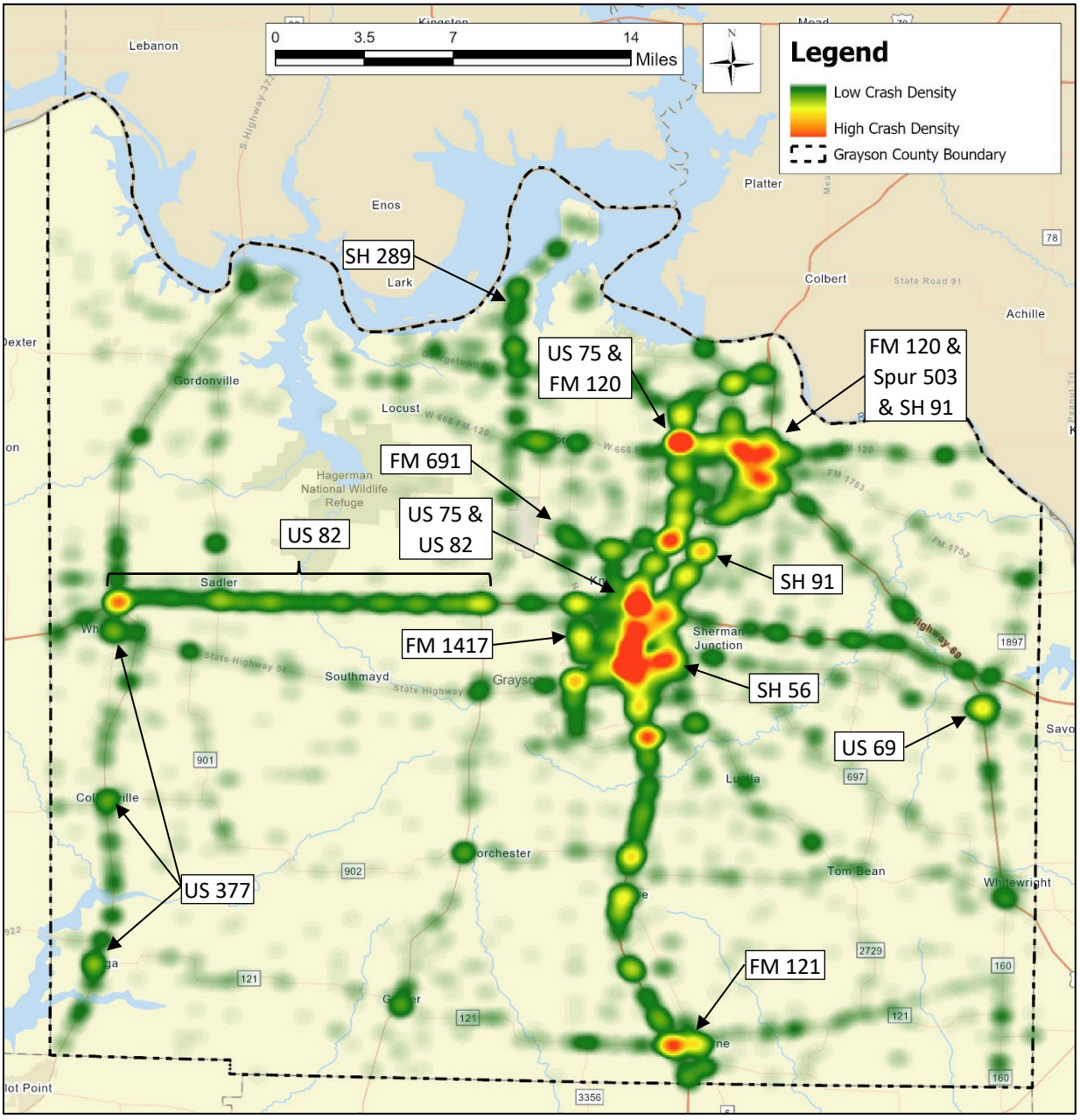


Figure 8 – Grayson County Crash Heat Map (2017 – 2021)

2.2.3 Texas Strategic Highway Safety Plan Emphasis Areas

The Strategic Highway Safety Plan (SHSP) is a statewide coordinated safety plan that provides a framework for reducing highway fatalities and injuries on all public roads. A major requirement of the federally aided Highway Safety Improvement Program (HSIP), the development of the Texas SHSP occurs on a five-year cycle using a data-driven process to identify safety problems across the State. The Texas SHSP is led in conjunction by the TxDOT Traffic Safety Division and Texas A&M Transportation Institute Center for Transportation Safety. Per the US DOT, "The SHSP allows highway safety programs and partners in the State to work together in an effort to align goals, leverage resources and collectively address the State's safety challenges."

The SHSP has identified seven areas of emphasis for eliminating crashes based crash data throughout Texas. The SHSP advocates that agencies focus on eliminating the types of crashes identified by the emphasis areas because the mitigation measures that have been developed to address them are seen as having the greatest promise of success for crash reduction in the shortest timeframe.

Strategic Highway Safety Plan Emphasis Areas:

- Distracted Driving
- Impaired Driving
- Intersection Safety
- Older Road Users
- Pedestrian Safety
- Roadway and Lane Departures
- Speeding

The Grayson County Safety and Operations Strategic Plan filtered crash data to analyze crashes related to the SHSP emphasis areas. A summary of the crash data over the last five years for crashes in the SHSP emphasis areas is provided in **Table 3**.

Table 3 – Crashes Related to Texas SHSP Emphasis Areas from 2017 Through 2021

SHSP Emphasis Area	By Year					Total Crash Counts for 2017 – 2021		
	2017	2018	2019	2020	2021	All Crashes	Fatal Injury	Serious Injury
Distracted Driving	356	291	240	296	295	1,478	8	78
Impaired Driving	106	111	95	113	102	527	27	60
Intersection Safety	663	698	673	676	797	3,507	21	151
Older Road Users	284	289	292	309	342	1,516	27	79
Pedestrian Safety	12	24	17	18	20	91	22	24
Roadway and Lane Departures	546	624	549	645	613	2,977	42	206
Speeding	146	168	129	182	187	812	13	57

Crashes related to distracted driving were trending down from 2017 to 2019, but did rise again in 2020 and remained steady from 2020 to 2021. Impaired driving crashes have remained consistent over the five-year period studied. The other five SHSP emphasis areas have each shown an upward trend, with 2021 representing the highest number of crashes over the five-year period for all categories except roadway and lane departures, which peaked in 2020.

On the following pages, each of the seven SHSP emphasis areas is discussed in further detail. Heat maps showing crash hot spots for each type of crash, as well as graphs with five-year trends, are provided. Additional information about where certain types of crashes are occurring and why that might be is also provided.

Distracted Driving

Distracted driving is often attributed to distraction in a vehicle due to the use of a smart phone and subsequent driver inattention. Distracted driving crashes are commonly coupled with speeding crashes, as distractions while speeding can significantly increase the chances of crashing. Some strategies to reduce this crash type include improved educational techniques, increased law enforcement capabilities, and use of technologies and engineering countermeasures.

Throughout Texas, the total number of distracted driving crashes has risen and fallen over the past five years, with a peak in 2017 at 51,645 and a minimum of 41,974 in 2020. The second lowest annual distracted driving crash count for the state occurred in 2018 with 49,471 distracted driving crashes.

During the March 2022 Grayson County TAC Meeting, members of the TAC expressed concern for fatalities caused by distracted driving. However, data presented in **Figure 9** shows that the number of fatal crashes related to distracted driving within Grayson County has not exceeded three per year from 2017 through 2021. Three fatal distracted driving crashes occurred in both 2017 and 2020, while none occurred in 2018. Only one fatal distracted driving crash occurred in 2019 and in 2021.

Serious injury crashes related to distracted driving increased between 2019 and 2021 from 10 to 14 crashes, after a 56.5 percent decrease from the five-year peak of 23 crashes in 2018. The total number of all crashes related to distracted driving within Grayson County has also increased since the lowest annual count of crashes of 240 in 2019. The distracted driving crash counts for 2018, 2020, and 2021 are all close to each other: 291, 296, and 295 respectively. The greatest number of crashes related to distracted driving, 356 crashes, occurred in 2017.

Figure 9 includes a heat map that shows hotspots for crashes related to distracted driving that occurred from 2017 through 2021. The four highest density crash locations fall along US 75. SH 91, US 69/Spur 503, and FM 1417 contain multiple moderate crash hotspots. Low to moderate crash hotspots are found at the intersection of US 75 and FM 121, the intersection of US 82 and US 377, along US 377 through Tioga, and along US 69 in Bells.

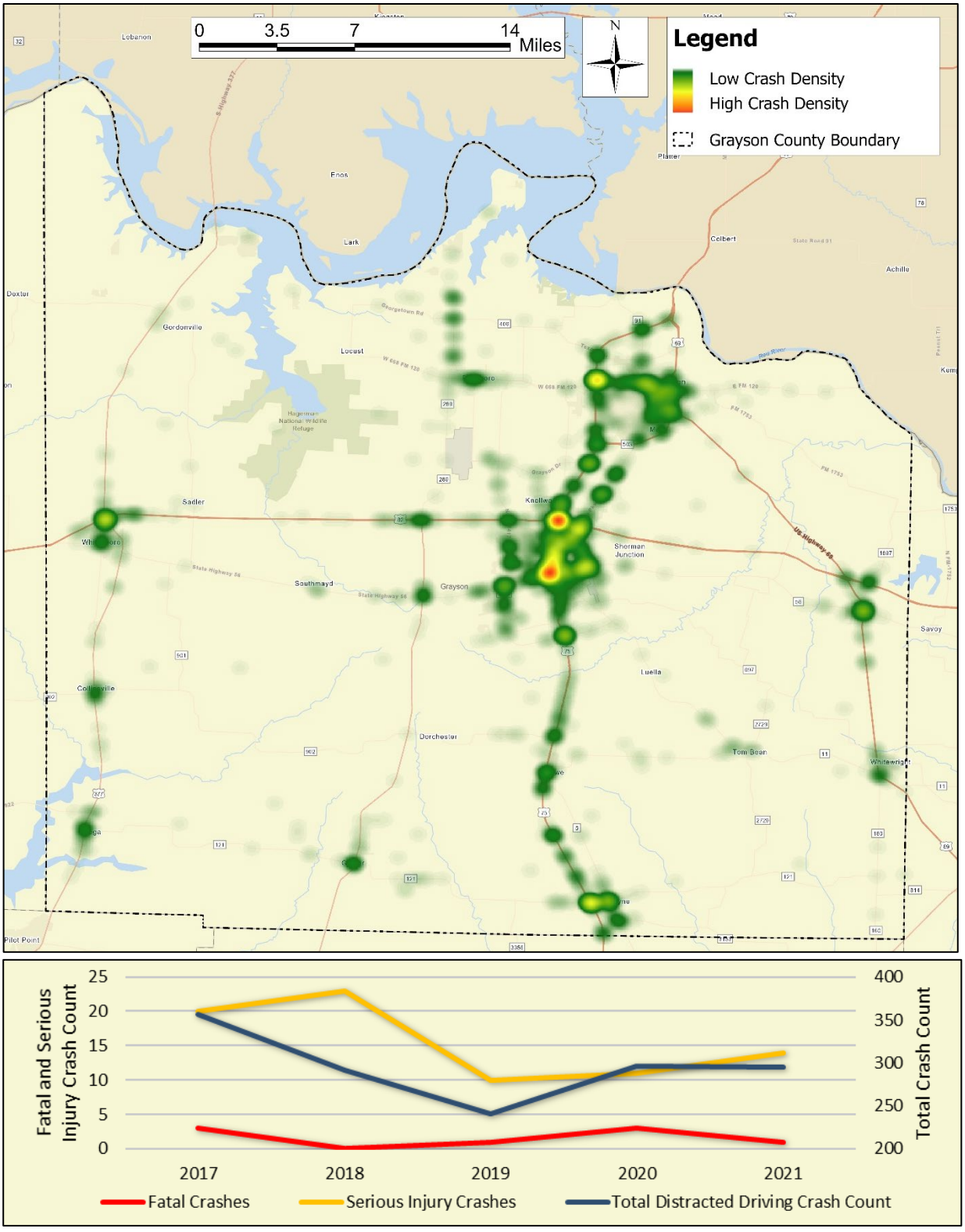


Figure 9 – All Distracted Driving Crashes (2017 – 2021)

Impaired Driving

Crashes are reported as related to impaired driving when at least one driver involved in the reported crash was identified as having been under the influence of alcohol or drugs. Approximately 60 percent of impaired driving crashes resulting in a fatality or serious injury occur between 9 PM and 4 AM. Countermeasures for impaired driving include the use of data to identify various hotspots, proper education about mobility options for those who are impaired, and the pursuit of more intensive interventions such as blow tests.

In 2021, 1,077 people died in motor vehicle traffic crashes in Texas where a driver was under the influence of alcohol, which makes up 24 percent of the total number of motor vehicle fatalities in the state. The statewide total number of crashes involving a driver under the influence of alcohol or drugs steadily rose between 2017 and 2019 to peak at 18,811 crashes, then dropped in 2020 to 17,724. The count of impaired driving related crashes rose again to 18,683 in 2021.

Figure 10 includes a graph comparing the trendlines of the entire state, Grayson County, and counties with similar characteristics as Grayson County. Wichita County and Taylor County experienced a decline in impaired driving related crashes from 2018 through 2020 and only Taylor County crashes slightly increased in 2021.

Again, unlike the statewide trend, Grayson County experienced a decrease in total number of crashes involving a driver under the influence of alcohol or drugs in 2019, with a crash count of 95 impaired driving related crashes, and a rise in these crashes in 2020 to 113 impaired driving related crashes.

The heat map in **Figure 10** shows crash density for crashes within Grayson County involving a driver under the influence or alcohol or drugs. The majority of the City of Sherman is shown to have a high crash density, including the segments of US 75, US 82, SH 56, SH 91, SH 11, FM 1417, and Travis St through the city. A large portion of the center and eastern side of the City of Denison is also shown to be a major impaired driving related crash hotspot, including segments of US 75, US 69, Spur 503, SH 91, and FM 120.

The northern segment of SH 289, between FM 120 and the Texas-Oklahoma state line, has the highest impaired driving related crash density hotspots outside of the Sherman and Denison city boundaries. Anecdotal experience from TAC staff explained that this location is likely a hotspot for impaired driving related crashes because people often go to Lake Texoma and drink, then try to drive home.

Multiple moderate to high crash hotspots are located along US 377 near Tioga and along US 82 between Whitesboro and SH 289. The segment of FM 160 between Jack England Road and the County boundary also contains a moderate impaired driving related crash hotspot. FM 121, in the vicinity of Van Alstyne, and FM 691, between Denison and Sherman, contain multiple low to moderate impaired driving related crash hotspots.

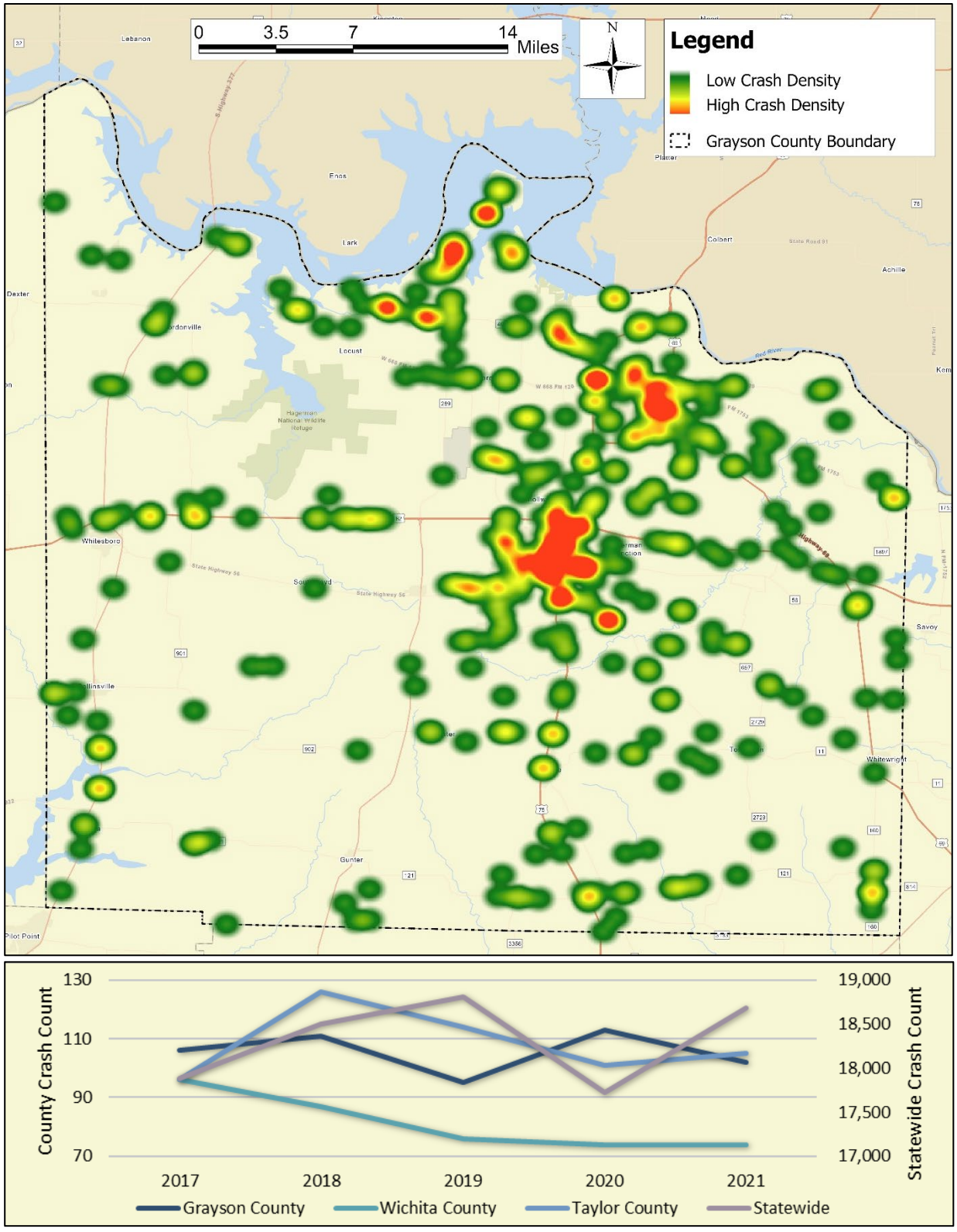


Figure 10 – All Impaired Driving Related Crashes (2017 – 2021)

Intersection Safety

Intersection crashes include any crashes that occur within or related to movement through an intersection. Commonly associated with the failure to yield right of way, this crash type is most frequent in urban areas. Countermeasures for intersection crashes vary depending upon location, but often involve increasing intersection visibility and improving traffic movement control through traffic signalization and signal timing and phasing adjustments.

Although the statewide total number of intersection crashes dropped by over 34,500 in 2020, the number of these crashes that resulted in a fatality has continued to increase since 2018. The large drop in intersection crashes in 2020 is generally attributed to a decreased in traffic volume due to the COVID-19 pandemic.

The intersection crash count for Grayson County had remained relatively stable, in the upper 600s, since 2017 until the count increased to 797 crashes in 2021, as shown in **Figure 11**. Grayson County intersection crashes did not see a steep decrease in numbers in 2020 like the statewide data, but do follow a similar pattern as other comparable counties. However, these counties have a total number of intersection crashes much higher than Grayson County.

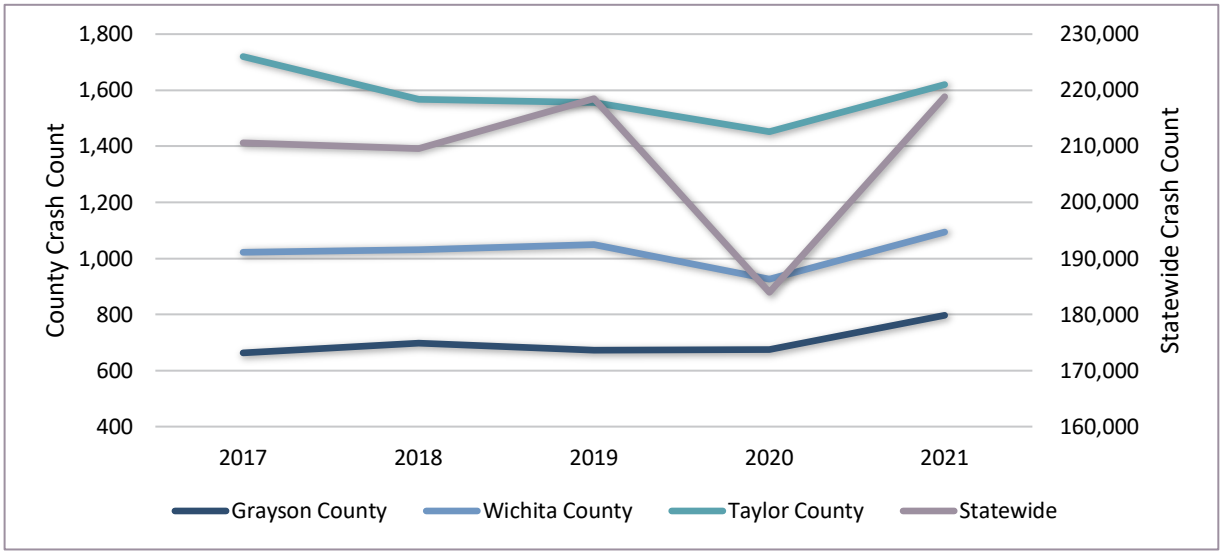


Figure 11 – Trendlines for All At Intersection and Intersection Related Crashes (2017 – 2021)

Downtown Sherman contains the two highest crash density locations of intersection crashes within Grayson County. These major hotspots are both along US 75, at the intersections with US 82 and SH 56, displayed in the downtown Sherman inset of **Figure 12**. SH 91 and SH 56 show multiple moderate to high crash hotspots. FM 1417 and Travis St have multiple low to moderate crash hotspots.

A high intersection crash density location also exists in downtown Denison where US 75 intersects FM 120. Downtown Denison also has multiple low to moderate hotspots, located along FM 120 between US 75 and Spur 503, as well as along Spur 503 itself.

Low to moderate crash hotspots outside of the Denison and Sherman downtown areas include along SH 91 between Denison and Sherman, along FM 121 in Van Alstyne, at the intersection of US 82 and US 377, and at the intersection of US 69 and SH 56 in Bells

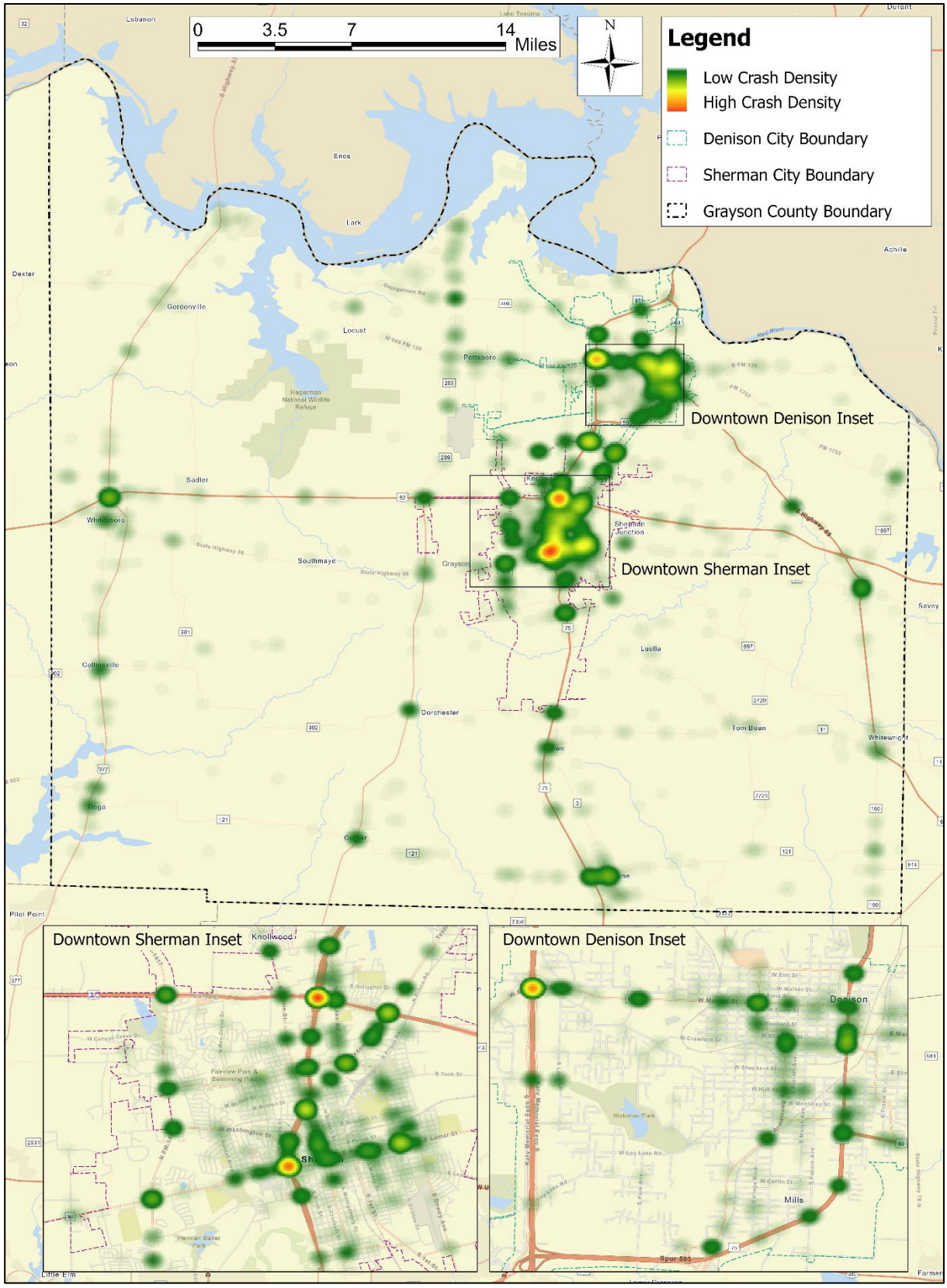


Figure 12 – All At Intersection and Intersection Related Crashes Heat Map (2017 – 2021)

Older Road Users

The older road users emphasis area focuses on drivers and pedestrians 65 years of age or older. With the average life expectancy generally increasing or remaining steady every year, the number of older road users is expected to continue to increase. Countermeasures include engineering training to incorporate Human Factors Guidelines into roadway design, the tracking and dissemination of wrong-way crash results, and encouragement of older road users to use safer modes of transportation.

The statewide total number of crashes involving an older road user dropped over 21 percent from 2019 to a five-year low in 2020 of 60,727 crashes. The total number of crashes then rose 19 percent in 2021 to 72,252 crashes, but did not exceed the previous peak of 77,119 older road user related crashes in 2019. The number of fatal crashes involving an older road did reach a five-year peak in 2021, as did the number of serious injury crashes involving an older road user.

While the State of Texas, TxDOT Paris District, and counties similar to Grayson County experienced the lowest number of older road user crashes in 2020 that those regions had seen in the past five years, the total number of older road user crashes in Grayson County has increased every year for the last five years, as displayed in the graph in **Figure 13**. The crash count increased 5.8 percent from 2019 to 2020 and 10.7 percent from 2020 to 2021, peaking at 342 crashes in 2021.

FM 120 is a crash hotspot for older road users, with the hotspot varying from low to high density between US 75 and Spur 503, through downtown Denison. The highest density crash hotspot for older road user crashes within Grayson County is shown in **Figure 13** to be in the vicinity of the intersection of US 75 and FM 120, along the west side of the City of Denison. Spur 503, from FM 120 to SH 91, is also a low to moderate crash hotspot, along the east side of the City of Denison.

Another high to moderate crash density location is the section of US 75 from just north of US 82 to FM 1417, through the City of Sherman. Downtown Sherman has a moderate density of older road user crashes along SH 91 and a low density of crashes along SH 56.

Low and moderate crash hotspot locations include the intersection of US 82 and US 377 in Whitesboro, the intersection of US 69 and SH 56 in Bells, and along FM 121 through the City of Van Alstyne. Multiple low density crash hotspots are shown along FM 1417 between US 82 and US 75.

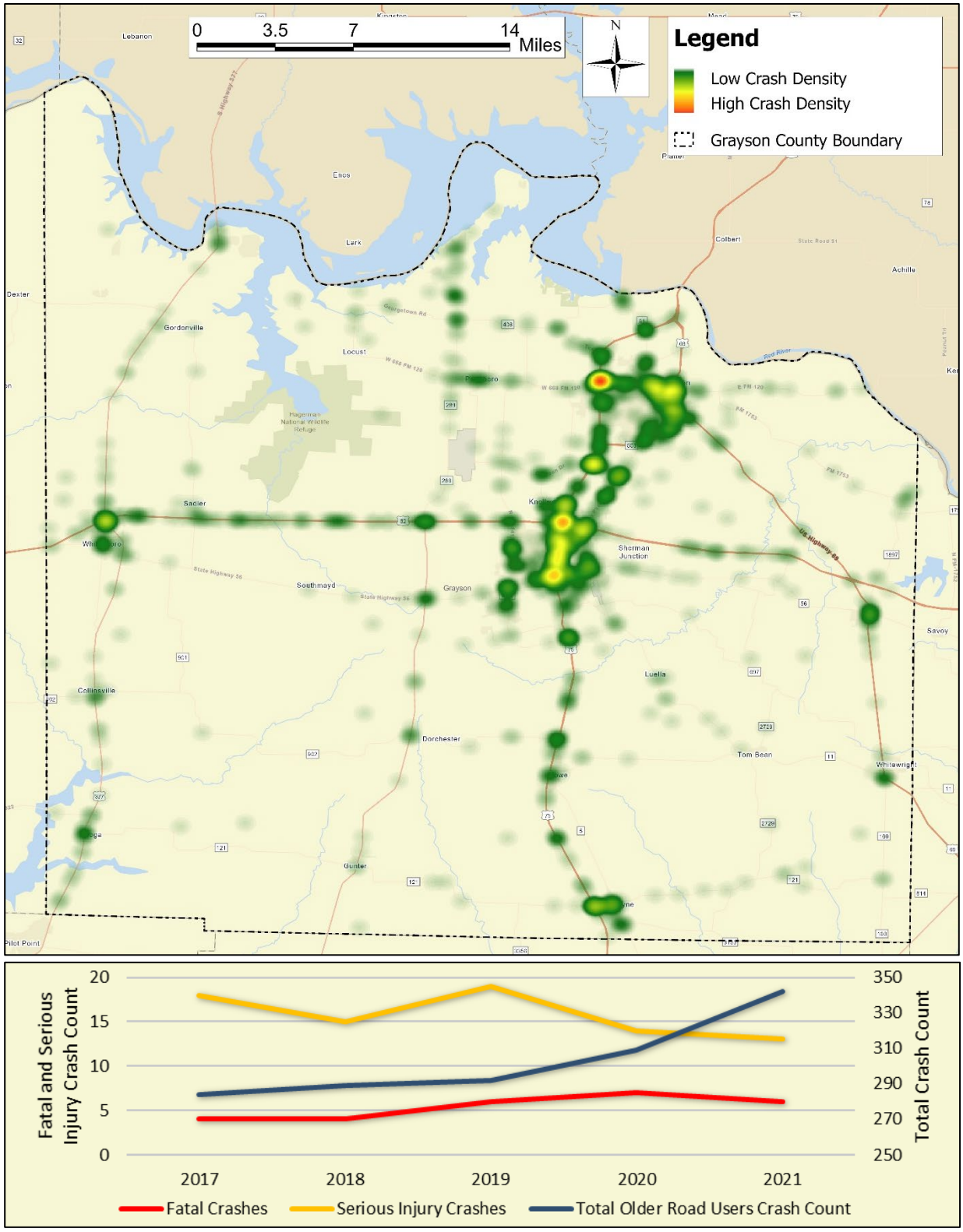


Figure 13 – All Older Road Users Related Crashes (2017 – 2021)

Pedestrian Safety

Pedestrian crashes involve at least one pedestrian and one motor vehicle. In Texas, approximately 80% of fatal pedestrian crashes occur at nighttime. Strategies that improve pedestrian visibility at crossing locations are particularly important to reduce the number of these crashes. Awareness campaigns about the dangers of walking at night, walking while impaired, or walking near high-speed roadways are other strategies to addressing pedestrian crashes.

The number of crashes involving pedestrian fatalities has been increasing since 2017 in Texas. In 2021, there were 824 pedestrian fatalities on Texas roadways, a 15.24 percent increase from 2020.Serious injury crashes involving pedestrians reached a new high of 1,347 crashes in 2021, exceeding the previous peak of 2019 by 10.4 percent. However, the total number of all crashes involving pedestrians was 10.3 percent less in 2021 than the previous five-year peak of 5,977 crashes in 2019.

During the March 2022 Grayson County TAC Meeting, the members of the TAC expressed concern for pedestrian fatalities, noting that the number of pedestrian fatalities had been increasing significantly in recent years. While the graph in **Figure 14** does show that the annual number of fatal pedestrian crashes was steady for four years from 2017 to 2020, pedestrian fatalities increased to six in 2021. Eight pedestrian serious injury crashes also occurred in 2021, doubling the previous year's total.

The total number of crashes involving a pedestrian within Grayson County has continuously increased since 2019 to reach 20 crashes in 2021. Pedestrian crashes peaked in 2018 at 24 crashes, doubling the 2017 crash count of 12.

Anecdotal experience from TAC members included discussion of people getting out of their vehicle on the highway when a car breaks down or to tend to a flat tire, then getting struck by a passing vehicle. **Figure 14** supports this by showing that the majority of the fatal pedestrian crashes within the past five years have occurred on the freeways and highways in Grayson County.

Three fatal crashes occurred within 3.25 miles along US 82, east of Whitesboro between FM 901 and Miller Rd. Two serious injury crashes and one no injury crash involving pedestrians also occurred along US 82, east of Whitesboro between US 377 and Rogers Rd. Two more fatal pedestrian crashes occurred along US 82 in the vicinity of the City of Sherman.

Three crashes involving pedestrians that resulted in fatalities occurred on SH 11 within 0.03 miles of each other near the intersection of SH 11 and Watkins Rd. Two fatal pedestrian crashes occurred south of Whitesboro, 0.68 miles apart along US 377.

Through downtown Sherman, six pedestrian crashes occurred on SH 56 and Travis St from 2017 through 2021. Along SH 91, three pedestrian crashes occurred within the City of Sherman and four pedestrian crashes occurred through downtown Denison, including one fatal and one serious injury crash along the route within each city. Along Spur 503 through downtown Denison, four pedestrian crashes occurred in the past five years, including another fatal crash and another serious injury crash.

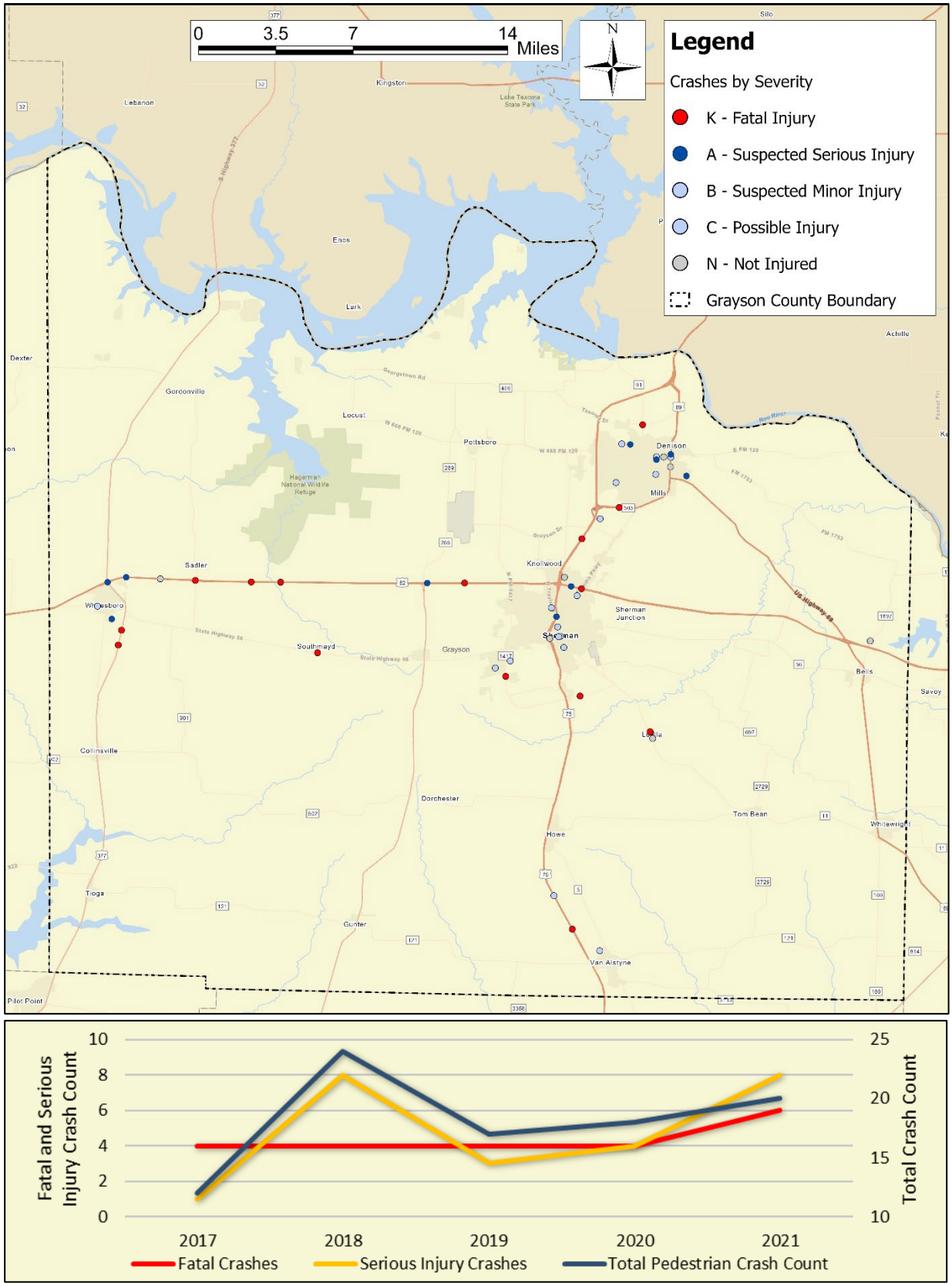


Figure 14 – All Pedestrian Crashes (2017 – 2021)

Roadway and Lane Departures

There are two crash types encompassed in the roadway and lane departures emphasis area: single motor vehicles that run off the road and head-on collisions. One strategy in reducing the number of fatalities resulting from these crashes is to improve emergency response time in rural areas, especially in reference to the single motor vehicle crashes due to the isolation of rural roadways. Another notable countermeasure is the improvement of roadway configuration to provide sufficient recovery area for when vehicles depart the roadway, coupled with the addition of guidance technologies such as rumble strips, curve delineators, raised pavement markings, and LED chevrons.

Roadway and lane departure crashes are the most common type of crash in Texas. Throughout the State of Texas, 34.35 percent of all motor vehicle deaths in 2021 were a result of single vehicle, run-off the road crashes, totaling 1,550 deaths from 1,420 crashes. The total number of run-off the road crashes increased by over 10,000 from 2019 to 2021, reaching the statewide five-year peak of 106,624 crashes in 2021.

While the TxDOT Paris District, Wichita County, and Taylor County experienced a similar increase in run-off the road crashes, Grayson County saw a decrease in these crashes between 2020 and 2021. The run-off the road crashes within Grayson County dropped 12 percent from 2018 to 2019, increased by 17.5 percent to the five-year peak of 645 in 2020, then dropped again by 5 percent in 2021.

The graph in **Figure 15** shows the variation from year to year and slight upward trend in the overall number of run-off the road crashes within Grayson County. A slight overall downward trend in fatal and serious injury run-off the road crashes can also be seen.

The heat map in **Figure 15** displays the highest density crash hotspot of run-off the road crashes located along US 75 through downtown Sherman, between US 82 and FM 1417. Multiple moderate and low-density crash hotspots cover the majority of US 75 through the rest of Grayson County. Moderate density crash hotspots are also located along US 82, between Riley Rd and FM 289, and the segment through the City of Sherman. The remaining portion of US 82 within Grayson County, east of Sherman, has a consistent stretch of low-density crash hotspots.

SH 56, SH 11, and FM 1417 have low to moderate crash hotspots in the vicinity of downtown Sherman. SH 91 contains multiple low to moderate crash hotspots through both the City of Sherman and the City of Denison. Near downtown Denison, low to moderate density crash locations are shown along Spur 503 and FM 120.

Outside of the two cities, low density hotspots include the northern segment of SH 289, between FM 120 and the Texas-Oklahoma state line, and the intersection of US 69 and SH 56 in Bells.

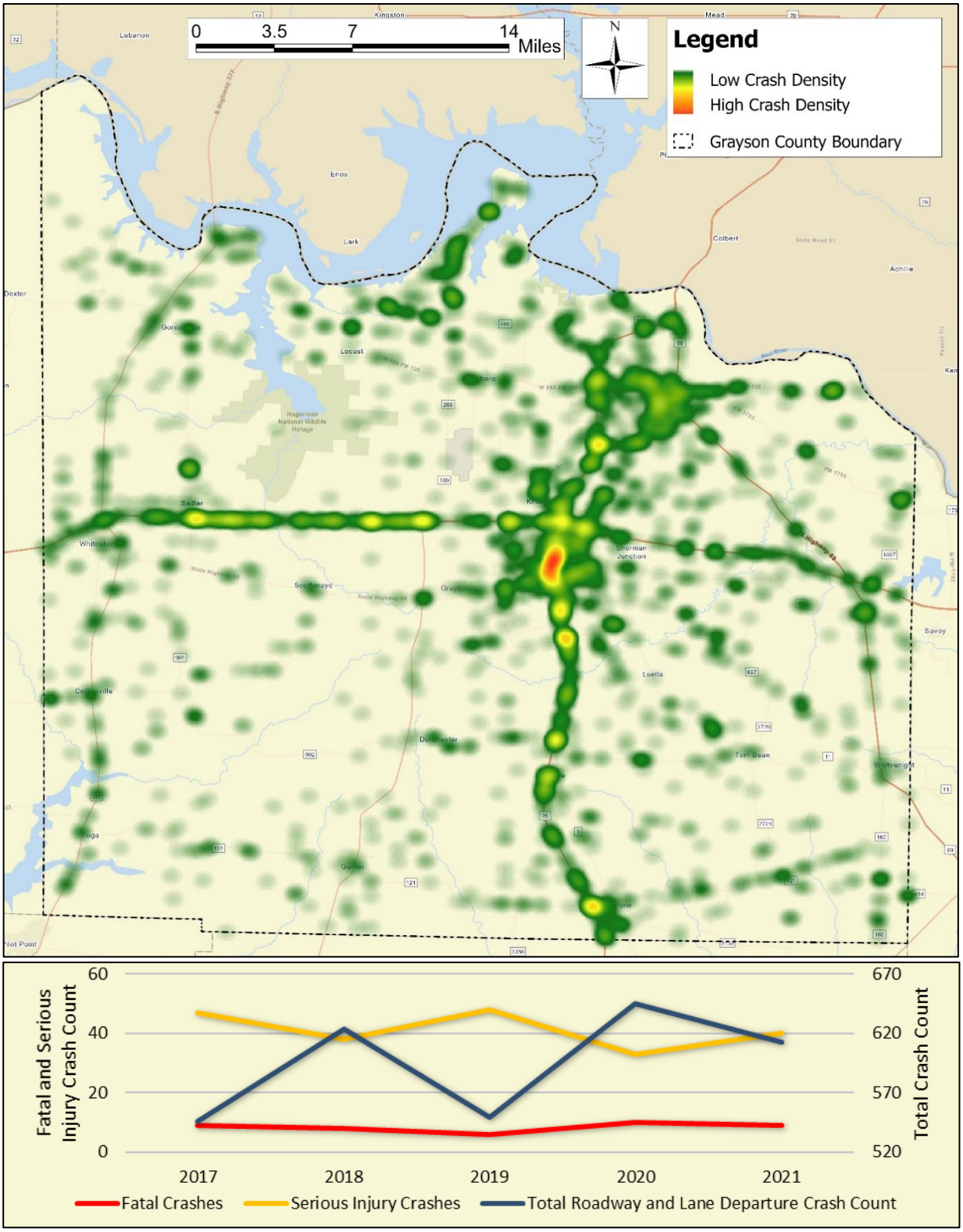


Figure 15 – All Roadway and Lane Departure Crashes (2017 – 2021)

Speeding

An important trend to take note of when considering the safety of a roadway is that the injury severity of crashes typically increases as speed increases. The speeding emphasis area includes crashes where unsafe speed under the posted speed limit or speeding over the posted speed limit was cited as a contributing factor. Speeding has been a contributing factor in some percentage of every emphasis area previously described, and speeding is an especially common contributing factor in SVROR and head-on collisions. Strategies for speeding include increased enforcement and education.

Differing from the crash trends of the previous SHSP emphasis areas, the number of speedi related crashes in Texas decreased from 2018 to 2019 and increased in 2020. The increase of speed related crashes in 2020 is likely a result of the decrease in traffic volumes due to the COVID-19 pandemic, which reduced congestion and allowed for greater speeds. The number of fatal crashes involving speeding increased by nearly 24 percent from 2019 to 2020 and by an additional 5.7 percent from 2020 to 2021. This trend was seen nationwide because vehicles were traveling at much higher speeds while there were lower traffic volumes on the road, causing the crashes to be much more severe. Since 2019, the speed related crash count has increased consistently at approximately 8.5 percent per year, reaching a five-year peak of 22,393 crashes in Texas in 2021.

The trendlines for speed related crashes within Grayson County and the TxDOT Paris District look similar to that of the state. Grayson County and the TxDOT Paris District also saw a drop in speeding crashes in 2019 followed by an increase in 2020, likely also due to lower traffic volumes during the COVID-19 pandemic. However, Grayson County experienced a steeper increase in fatal speeding crashes from 2020 to 2021 than from 2019 to 2020, 18 percent compared to 10 percent.

The crash hotspots for speed related crashes, in **Figure 16**, look very similar to those seen in **Figure 15** for run-off the road crashes. The two highest density crash hotspots of speeding crashes are located along US 75 through downtown Sherman, with multiple moderate and low-density crash hotspots covering the majority of US 75 through the rest of Grayson County.

The area around the intersection of US 377 and US 82 has a moderate to high crash density of speed related crashes. Between there and the intersection with FM 289, US 82 has either a low or moderate crash density. Within the City of Sherman, the crash density is low or moderate as well. The remaining portion of US 82 within Grayson County, east of Sherman, has multiple low density crash hotspots.

Low to moderate hotspots are located along SH 56 through downtown Sherman. Low to moderate hotspots are also located along SH 91 through the City of Sherman and downtown Denison. In the City of Denison, FM 120 contains moderate crash hotspots and Spur 503 contains low to moderate crash hotspots. FM 691, between the two cities, is a low-density crash hotspot for speed related crashes.

Outside of the cities of Denison and Sherman, low density hotspots include the southern portion of US 377 in Tioga, the northern segment of SH 289, between FM 120 and the Texas-Oklahoma state line, and the intersection of US 69 and SH 56 in Bells.

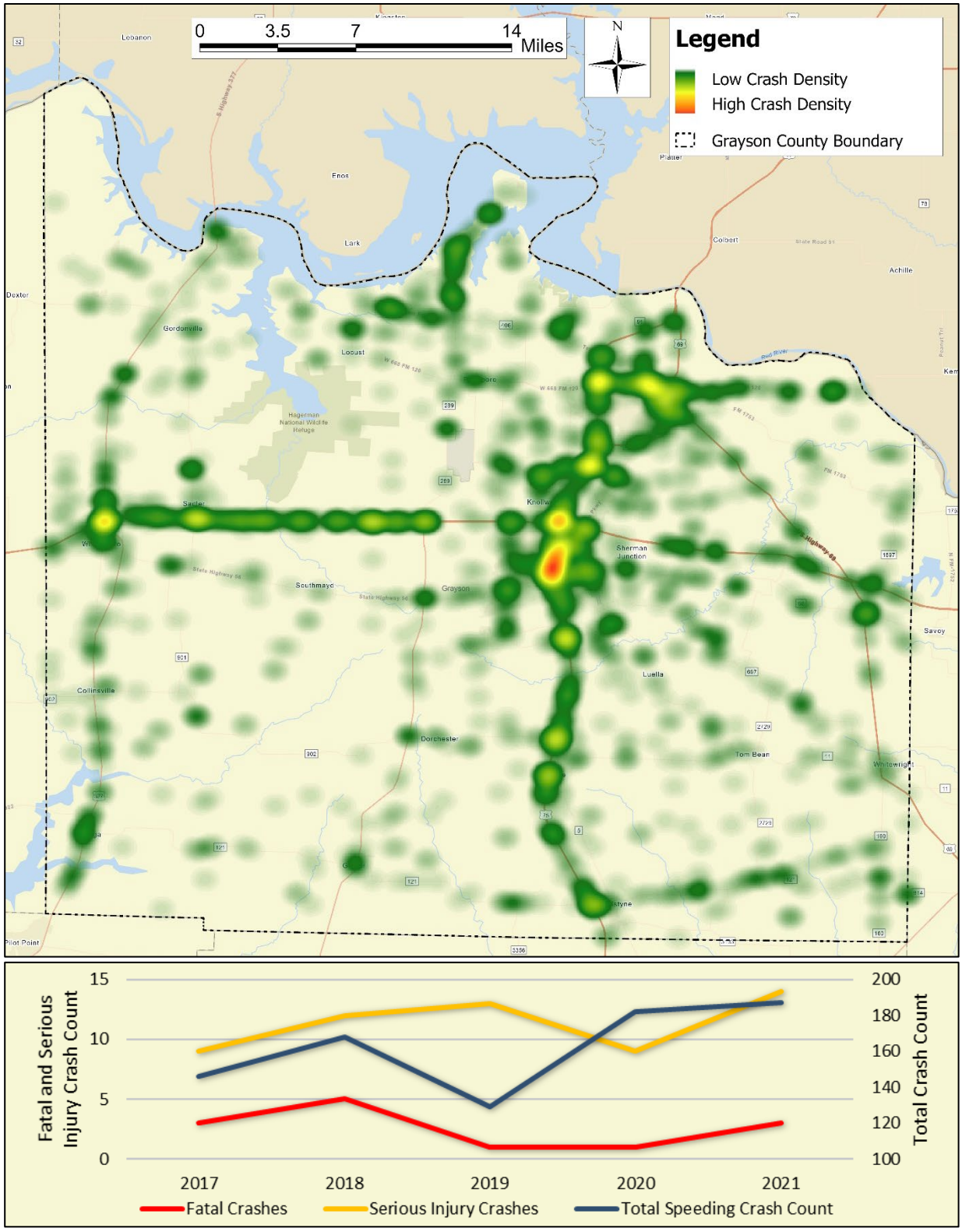


Figure 16 – Speed Related Crashes (2017 – 2021)

2.3 Operational Trends

The operations focused analysis of existing conditions examines congestion performance metrics, INRIX bottleneck rankings, and TTI's delay data to identify congestion hotspots within Grayson County.

2.3.1 INRIX Bottlenecks

The operations analysis reviews INRIX probe-based traffic data to identify segments of key corridors within Grayson County that are considered bottlenecks and experience frequent congestion. INRIX is a probe-based data database that consolidates commercial Global Positioning Satellite (GPS), DOT sensor, and GPS-enabled vehicle data. Probe-based traffic data is collected using Bluetooth-enabled devices, probe vehicle runs, toll tag and license plate readers, automatic vehicle location (AVL) systems, GPS mobile devices, and cell phone GPS-tracking services. These systems track a vehicle's position over time to determine speed and travel time between two points. This type of vehicle data can be aggregated to give insight to traffic delays and queueing information to pinpoint bottlenecks.

Regional Integrated Transportation Information System (RITIS) is a data-driven platform for transportation analysis, monitoring, and data visualization. The RITIS Probe Data Analytics Suite utilizes INRIX data to identify bottlenecks and their impacts to rank congestion locations. The top ten bottlenecks from the 2021 INRIX Bottleneck Ranking Base Impact data for the top 1,000 bottlenecks within Grayson County are listed in **Table 4** and mapped in **Figure 17**. Each circle with a number represents the location of the bottleneck and its base impact rank. The tail of small road segments represents the extents of each bottleneck's impacts according to the number of days the segment was impacted.

Table 4 – Top 10 Bottlenecks in Grayson County (2021)

Rank	Roadway with Bottleneck Impacts	Direction of Bottleneck	Intersecting Road
1	US 75	SB	US 69
2	US 377	NB	US 82
3	US 75	SB	US 69
4	US 69	SB	SH 11/SH 160
5	SH 56	WB	US 75
6	US 75	NB	SH 91
7	US 377-BR	NB	US 82
8	SH 11	NB	FM 1417
9	US 75	SB	N Loy Lake Rd
10	SH 160	NB	US 69
Other Bottlenecks Identified by the Grayson County MPO			
A	US 75	NB and SB	US 82
B	US 82	EB and WB	US 75

In addition to the top 10 bottlenecks that were identified from INRIX data, the Grayson County MPO also identified the intersection of the US 75 and US 82 frontage roads as an area of concern for

bottlenecks in Grayson County. Bottleneck data from the frontage roads at the intersection of US 75 and US 82 was not collected by INRIX as part of the 2021 bottleneck dataset, and therefore these roads did not appear in the ranking. There is construction at this interchange that is on-ongoing as of the completion of the Grayson County Safety and Operations Strategic Plan. Construction includes the addition of U-turn lanes for east and westbound US 82 and expansion to three lanes for all legs of the intersection. The full impact of these improvements will not be known until construction is complete, however the Grayson County MPO expects that this intersection will continue to see bottlenecks that are higher than normal in the County.

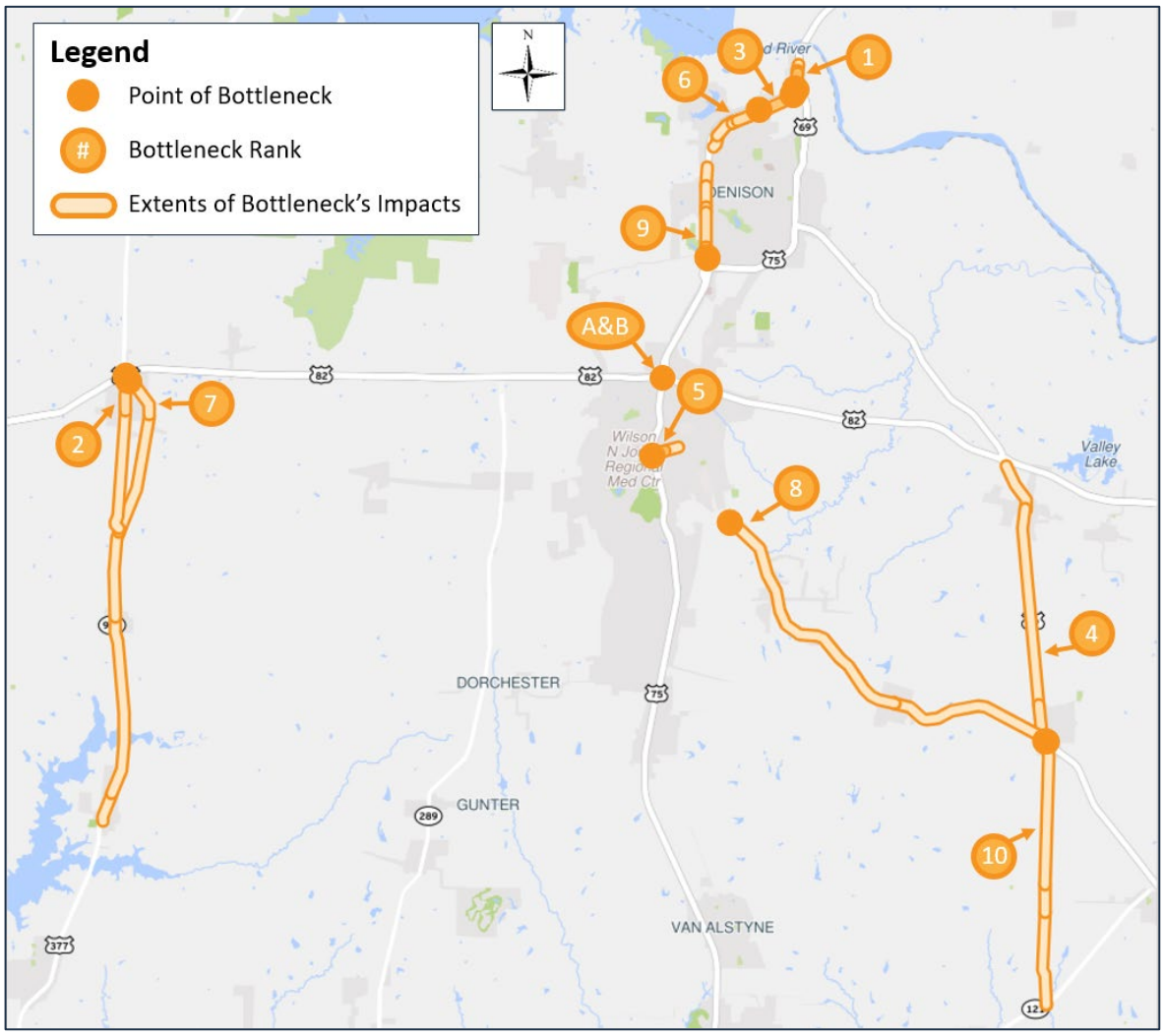


Figure 17 – Top 10 Bottlenecks in Grayson County (2021)

2.3.2 TTI Delay Per Mile

The operations analysis reviews TTI's 2021 Most Congested Roadways in Texas to determine the delay per mile, in person-hours. TTI compares TxDOT Roadway-Highway Inventory (RHiNo) traffic volume data and INRIX speed data in road sections of every roadway in Texas to estimate average travel speed and establish a free-flow travel speed for each road section. TTI utilizes the traffic volume, vehicle occupancy, difference in average and free-flow travel time, and length of the road section to calculate the delay per mile along each road section.

3 CORRIDOR PRIORITIZATION

Section 3 lays out the method and factors considered for prioritizing key segments of corridors in need of safety and operations related improvements. To determine segment priority and potential improvements, the prioritization process scores each corridor segment based on the category or range the segment falls within for various criteria. The criteria include the corridor's general characteristics such as roadway classification and ADT volume, as well as safety and operations information including crash severity and bottleneck impacts. The general, safety, and operations criteria and scores for prioritizing key corridor segments is provided in **Appendix A**.

3.1 General Prioritization Criteria

The prioritization process for ranking both the segments identified as needing safety improvements and the segments identified as needed operations improvements considers general roadway characteristics for each of the identified safety and operations key corridor segments, including the roadway classification and the 2020 average daily traffic (ADT) in vehicles per day (vpd). The roadway classification for each identified segment is based on the Grayson County Geographic Information System (GIS) interactive map. Some of the identified segments have more than one roadway classification between the identified segment's bounds. For example, part of the identified safety segment of FM 120, from FM 131 to S Center Avenue, is shown to be partially a major arterial and part of it is shown as minor arterial and part of the identified operations segment of SH 91, from Texoma Dr to Spur 503, is shown to be partially a minor arterial and part of it is shown as major collector.

For prioritizing the safety segments and the operations segments, the identified segments can receive a maximum score of 90 total points. Roadway classification is awarded the fewest number of points, with a maximum of ten. The maximum number of points a segment is given for ADT is 20 points. The remaining 60 points is made up from the safety specific or operations specific criteria, discussed in the following sections.

3.2 Safety Segment Prioritization

The prioritization of the identified segments in need of safety improvements reviews general roadway characteristics and crash data. Again, note that high density crash hotspots of crashes that occurred from 2019 through 2021 are located along US 75 throughout Grayson County. The segment of US 75 between Spur 503 and US 82 and US 75 south of SH 91 were recently reconstructed, are currently under construction, or have plans in place for construction in the near future and therefore are not considered for safety improvements as part of this study.

3.2.1 Safety Segment Selection

The key corridor segments identified in previous sections as containing crash hotspots, and therefore are safety concerns, are shown in **Figure 18**. These identified segments are prioritized and considered for safety improvements in later sections. Again, note that high density crash hotspots of crashes that occurred from 2019 through 2021 are located along US 75 throughout Grayson County. The segment of US 75 between Spur 503 and US 82 and US 75 south of SH 91 were recently reconstructed, are currently under construction, or have plans in place for construction in the near future and therefore are not considered for safety improvements as part of this study.

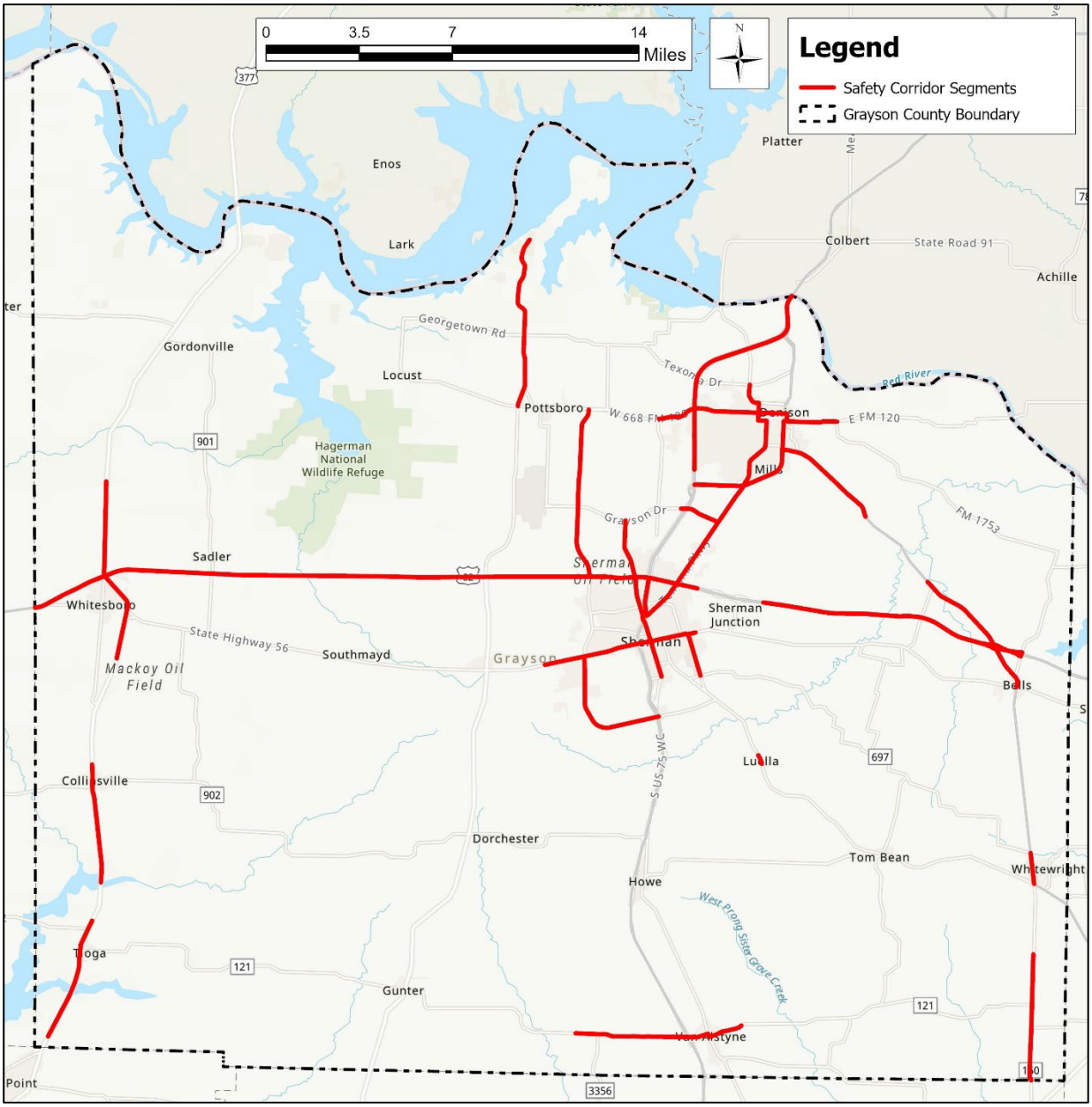


Figure 18 – Key Corridor Segments Identified as Safety Concerns

3.2.2 Safety Prioritization Criteria

The analysis considers crash density as the key safety metric. To determine the average crash density for each identified segment, the analysis divides the number of crashes that occurred within each segment by the length of the specific segment. The number of crashes comes from the CRIS crash data over the last five years, 2017 through 2021. HSIP focuses on fatal, serious injury crashes, and minor injury crashes. Therefore, the count of fatal, serious, and minor crashes per mile of identified corridor segment is the main criteria for the safety analysis. The score for this criteria is out of 40 points.

When considering the total number of crashes along each segment, the crash data is weighted by severity. The weight of each severity is based on the formula for the safety improvement index (SII) as

part of the HSIP benefit/cost analysis. The SII formula weights fatal and serious injury crashes equally, and minor injury crashes are weighted by approximately 14 percent. Crashes that did not result in an injury, such as property damage only crashes, are weighted by 1.97 percent in the total number of crashes. Segments may receive up to 20 points under this criteria.

3.2.3 Safety Corridors Prioritized

The two segments of US 75 included in this study scored first and third out of the 25 corridor segments identified as a safety concern, with scores of 90 and 73 points. The segment of FM 1417 from FM 120 to US 82 ranked 25th at 16 points. A full list of the prioritized safety segments, with each segment's data and score broken out by criteria, is included in **Table 5**. The top ten priority corridors identified as needing safety improvements are shown in **Figure 19**, color coded by priority with red being the highest priority and green being lowest priority.

Table 5 – Safety Analysis Key Segment Prioritization Table

General Segment Characteristics						Guiding Factor of Selection	Other Factors Considered							Prioritization Scoring[6]				
Roadway Name	Roadway Classification[1]	From	To	Approx. Segment Length (mi)[2]	ADT (vpd)[3]	Hotspot Crash Density[4]	Number of Fatal Crashes	Number of Serious Injury Crashes	Number of Minor Injury Crashes	Number of Possible Injury Crashes	Number of No Injury Crashes	Fatal, Serious Injury, and Minor Injury Crashes per Mile within Segment	All Crashes (Weighted) per Mile within Segment[5]	Classification Score (10 Points)	ADT Score (20 Points)	Fatal, Serious, and Minor Injury Crashes per Mile Score (40 Points)	All Crashes per Mile Score (20 Points)	Total (90 Points)
US 75	Freeway	US 82	SH 91	1.92	56,017	Medium - High	2	10	42	78	150	28.13	11.66	10	20	40	19	**89**
US 82	Freeway	Reynolds Rd	Baker Ridge Rd	6.29	28,048	Medium - High	5	15	70	76	214	14.31	5.65	10	19	31	11	**71**
FM 691/ Grayson Dr	Major Arterial	FM 1417	SH 91	1.31	5,534	Low - Medium	0	8	24	29	96	24.43	10.56	7	4	40	18	**69**
SH 91	Principal Arterial	Spur 503	US 75	5.50	8,400	Low - Medium	4	18	89	83	170	20.18	7.18	9	8	38	13	**68**
SH 56	Major Arterial	Friendship Rd	N Colbert Ave	5.55	14,099	Medium - High	2	17	80	85	214	17.84	6.51	7	12	34	12	**65**
SH 91	Minor Arterial & Major Collector	Texoma Dr	Spur 503	4.49	15,519	Medium	3	12	42	32	159	12.69	5.49	4	12	28	11	**55**
US 75	Freeway	County Boundary	N Loy Lake Rd	9.94	52,475	Medium - High	6	16	55	53	234	7.75	3.56	10	20	15	6	**51**
FM 120	Major Arterial & Minor Arterial	FM 131	FM 1753	7.01	15,229	Medium	1	14	59	61	289	10.56	4.31	6	12	24	8	**50**
Spur 503	Major Arterial	US 75	W Main St/E FM 120	4.70	14,439	Low - Medium	1	15	27	48	111	9.15	4.88	7	12	20	10	**49**
FM 1417	Major Arterial	SH 56/W Houston St	US 75	4.69	12,470	Low	1	13	29	38	66	9.17	4.29	7	11	20	8	**46**
US 82	Freeway	SH 56/W Main St	Bar Seven Dr	14.53	19,932	Low - Medium	8	29	56	69	333	6.40	3.63	10	14	15	6	**45**
SH 11	Major Arterial	Judy Dr	Cedar Rd	0.61	3,612	Low	4	1	1	0	1	9.84	8.46	7	2	20	15	**44**
Travis St	Minor Arterial	FM 691/ Grayson Dr	W Park Ave	6.00	7,014	Low - Medium	1	10	55	58	151	11.00	3.81	5	6	24	8	**43**
US 69	Principal Arterial	S Austin Ave	Mack Nelsen Ln	3.86	6,562	Low	0	9	15	14	43	6.22	3.17	9	6	15	6	**36**
US 69	Principal Arterial	FM 697	SH 11	1.25	7,936	Low	0	2	5	4	10	5.60	2.38	9	6	10	4	**29**
US 377	Principal Arterial	FM 922	Pierce Spring Branch	4.56	9,747	Low	2	4	14	10	40	4.39	1.96	9	8	10	2	**29**
SH 11	Minor Arterial	Lamar St	FM 697	1.61	6,831	Low	0	4	5	7	15	5.59	3.19	5	6	10	6	**27**
FM 121	Minor Arterial	Durning Rd	Van Alstyne City Boundary	3.65	8,441	Low - Medium	1	4	12	22	117	4.66	2.58	5	8	10	4	**27**
US 82	Freeway	Junction Rd	FM 1897	10.25	13,792	Low	3	6	15	22	80	2.34	1.28	10	11	5	0	**26**
SH 289	Principal Arterial & Minor Arterial	Peddicord Ln	FM 120	6.50	6,134	Low	0	5	27	16	61	4.92	1.59	8	6	10	2	**26**
US 377	Principal Arterial	W Ford St	Patton Rd	3.42	7,422	Low	4	5	4	31	105	3.80	3.58	9	6	5	6	**26**
US 69	Principal Arterial	Craft Rd	Bells Blvd	4.82	9,072	Low	0	5	8	17	63	2.70	1.60	9	8	5	2	**24**
FM 160	Principal Arterial	Jack England Rd	County Boundary	4.42	5,131	Low	5	5	2	5	15	2.71	2.42	9	4	5	4	**22**
US 377	Principal Arterial	Dixie Rd	Gunter Rd	5.85	8,424	Low	1	2	6	10	27	1.54	0.78	9	8	0	0	**17**
FM 1417	Major Arterial	FM 120	US 82	7.82	4,978	Low	0	6	20	15	33	3.32	1.25	7	4	5	0	**16**

[1]Some of the identified roadway segments in the table have different classifications through portions of the segment.

[2]This is the approximate length, in miles, of the identified roadway segment where the frequency of crashes creates a crash hotspot (see footnote 4 below).

[3]The average daily traffic (ADT), in vehicles per day (vpd), may be used for prioritizing roadway segments by traffic volume.

[4]CRIS data from 2017 through 2021 for all fatal and injury crashes that occurred within Grayson County was used to create a heat map. Crash density was used to identify crash hotspots within the County.

[5]CRIS data from 2017 through 2021 for fatal and injury crashes that occurred along the identified segment was used to calculate the number of crashes that occur per mile of the identified segment.The number of crashes is weighted by severity. Fatal and serious injury crashes are weighted by 100%, and minor injury crashes are weighted by 14.05%. Crashes that did not result in an injury, such as property damage only crashes, are weighted by 1.97%.

[6]Please see Appendix A for criteria and points used for prirotitizing these identified segments.

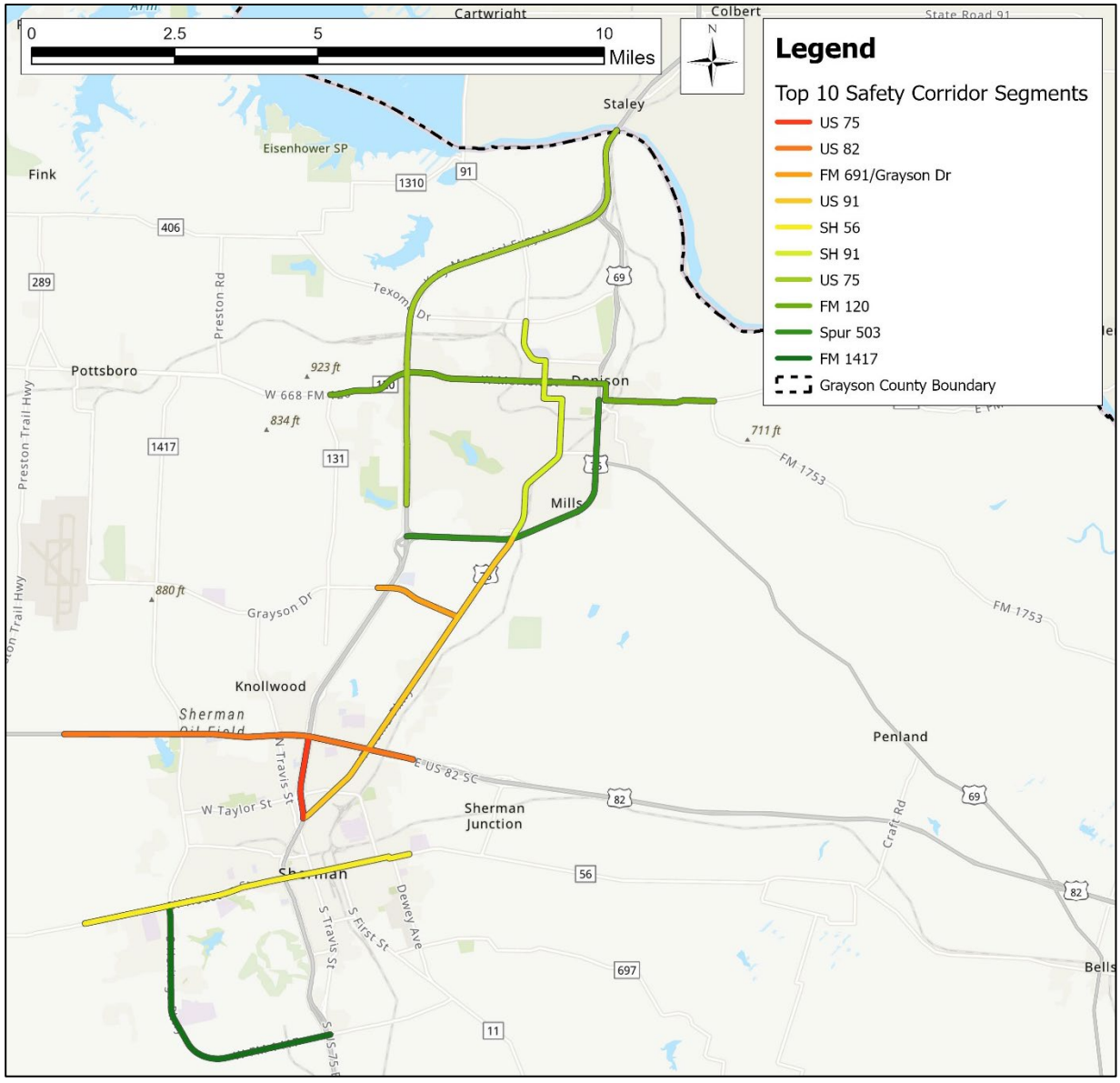


Figure 19 – Top 10 Safety Corridor Segments

3.3 Operations Segment Prioritization

The prioritization of the identified segments in need of operations improvements reviews general roadway characteristics and congestion data along key corridor segments containing numerous bottlenecks or consistently being impacted by delays.

3.3.1 Operations Segment Selection

The key corridor segments identified in previous sections as containing and being impacted by bottlenecks, and therefore are operations concerns, are shown in **Figure 20**. These identified segments are prioritized and considered for operations improvements in later sections. Similar to the safety corridor segments, note that the segment of US 75 between N Loy Lake Rd and US 82 and US 75 south

of SH 91 are not considered for operations improvements as part of this study due to recently completed construction, current construction, or existing plans for construction in the near future.

Concern was noted by the Grayson County MPO regarding FM 121 in Van Alstyne. For east and westbound travelers on FM 121, a turn onto SH 5 is required followed by a second turn back onto FM 121. FM 121 currently has about 5,000 to 6,000 vehicles per day. Volumes are expected to continue to grow on FM 121. The MPO believes that once volume reach approximately 10,000 or more per day, the series of intersections will not be able to accommodate traffic at the SH 5 intersections without significant delay.

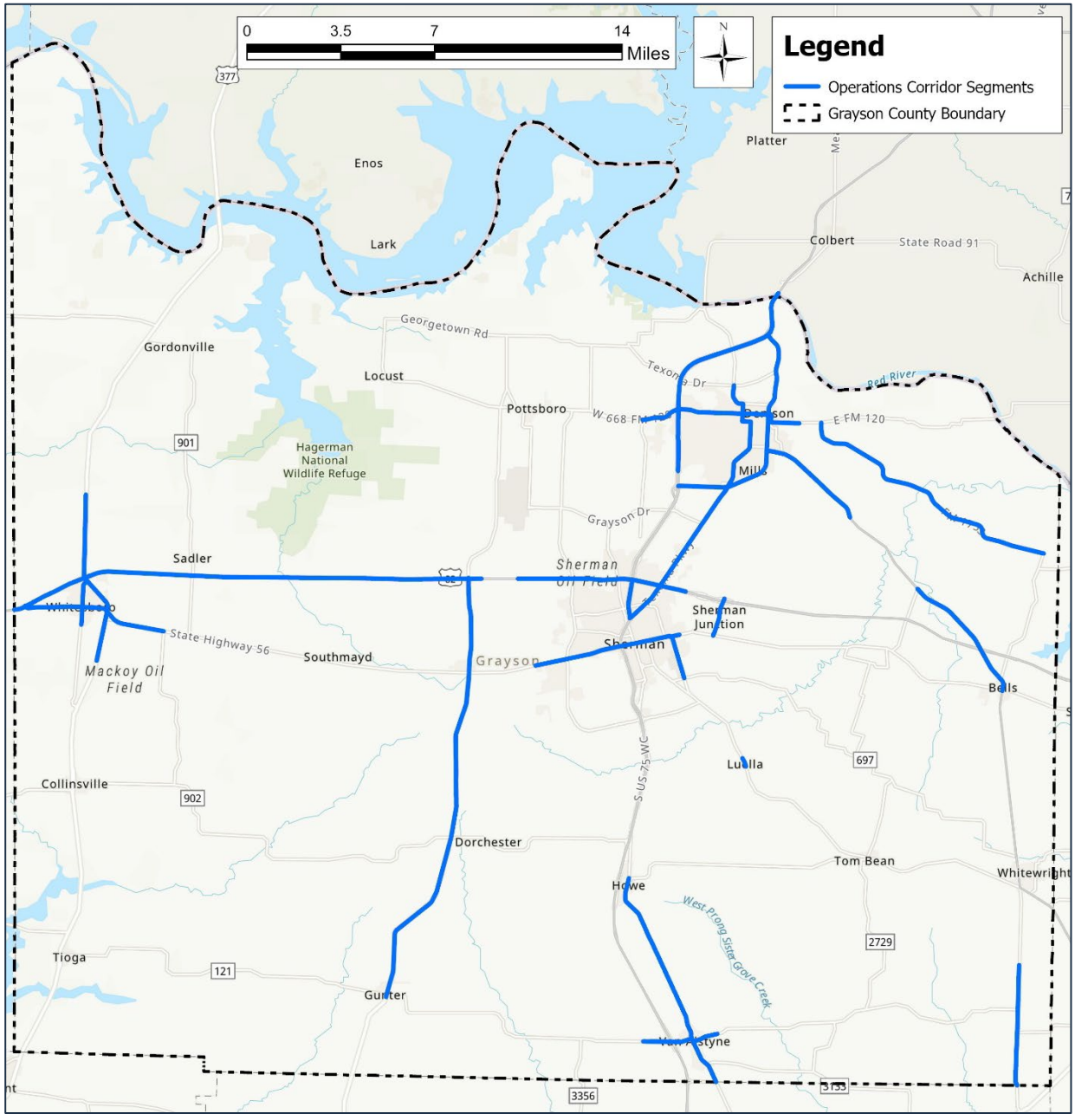


Figure 20 – Key Corridor Segments Identified as Operations Concerns

3.3.2 Operations Prioritization Criteria

The operations prioritization analysis reviews INRIX probe-based traffic data and TTI's congestion performance measures to weight the priority of each identified segment based on congestion metrics. The two congestion metrics are bottleneck base impact and delay per mile, discussed below. These two metrics are both worth a maximum of 30 points to balance the two types of congestion data for a maximum total of 60 points.

To determine the bottleneck score for each identified segment, the analysis reviews 2021 INRIX Bottleneck Ranking Base Impact data for the top 1,000 bottlenecks within Grayson County. The base impact of a bottleneck is the sum of queue lengths over the duration of the bottleneck. The base impact for each bottleneck that occurred within an identified segment is weighted by the number of days the bottleneck impacted that specific segment. The base impact is also weighted depending on whether or not the head of the bottleneck is located within the identified segment. The overall bottleneck value for each identified segment is the sum of the weighted base impacts of all the bottlenecks that have impacts within each specific segment.

The operations analysis reviews TTI's 2021 Most Congested Roadways in Texas to determine the delay per mile, in person-hours, for each identified segment. The analysis sums the delay per mile along all road sections within each identified segment.

3.3.3 Operations Corridors Prioritized

Unlike the results from the safety analysis prioritization, no operations focused segment received the maximum number of points. FM 120 through downtown Denison ranked first with 78 points, 16 points higher than the segment of US 75 that ranked second. The two segments of US 75 included in this study scored second and fourth out of the 22 corridor segments identified as operational concerns, with scores of 62 and 60 points. The segment that ranked fifth, Spur 503, has almost half as many points as the fourth place US 75 segment.

A full list of the prioritized operations segments, with each segment's data and score broken out by criteria, is included in **Table 6**. The top ten priority corridors identified as needing operations improvements are shown in **Figure 21**, color coded by priority with red being the highest priority and green being lowest priority.

Table 6 – Operations Analysis Key Segment Prioritization Table

Segment Information						Guiding Factor of Segment Selection	Other Factors Considered	Prioritization Scoring[6]				
Roadway Name	Roadway Classification[1]	From	To	Approx. Segment Length (mi)[2]	ADT (vpd)[3]	Bottleneck Ranking (2021) Base Impact[4]	TTI Delay per Mile (person-hours)[5]	Classification Score (10 Points)	ADT Score (20 Points)	Bottleneck Ranking Score (30 Points)	TTI Delay per Mile Score (30 Points)	Total (90 Points)
FM 120	Major Arterial & Minor Arterial	FM 131	East of S Center Ave	6.61	15,229	7,163.79	22,602	6	12	30	30	**78**
US 75	Freeway	County Boundary	N Loy Lake Rd	9.94	52,475	88,497.82	1,008	10	20	30	2	**62**
SH 56	Major Arterial	Friendship Rd	N Colbert Ave	5.55	14,099	16,108.18	9,366	7	12	30	12	**61**
US 75	Freeway	US 82	SH 91	1.92	56,017	110.24	26,384	10	20	0	30	**60**
US 82	Freeway	Reynolds Rd	Baker Ridge Rd	6.29	28,048	77.87	3,516	10	19	0	6	**35**
Spur 503	Major Arterial	W Main St/E FM 120	US 75	4.65	14,439	1,781.63	-	7	12	14	0	**33**
US 377-BR	Minor Arterial	US 82	Parker Ln	1.66	4,535	3,087.61	-	5	4	24	0	**33**
SH 11	Minor Arterial	Lamar St	FM 697	1.61	6,831	1,889.66	-	5	6	14	0	**25**
SH 56	Major Arterial	US 82	FM 901	4.63	3,067	2,147.42	-	7	2	16	0	**25**
US 82	Freeway	SH 56/W Main St	Bar Seven Dr	14.53	19,932	118.30	-	10	14	0	0	**24**
SH 91	Minor Arterial & Major Collector	Texoma Dr	Spur 503	4.49	15,519	-	3,976	4	12	0	6	**22**
SH 91	Principal Arterial	Spur 503	US 75	5.50	8,400	715.24	-	9	8	4	0	**21**
US 377	Principal Arterial	Dixie Rd	Gunter Rd	5.85	8,424	472.49	-	9	8	2	0	**19**
FM 1753	Minor Arterial	FM 120	FM 1897	9.84	1,521	1,529.33	-	5	0	12	0	**17**
SH 5	Minor Arterial	FM 902	County Boundary	8.32	4,147	1,209.19	-	5	4	8	0	**17**
SH 289	Principal Arterial	US 82	FM 121	6.50	5,990	531.27	-	9	4	4	0	**17**
US 69	Principal Arterial	Craft Rd	Bells Blvd	4.82	9,072	83.42	-	9	8	0	0	**17**
FM 160	Principal Arterial	Jack England Rd	County Boundary	4.42	5,131	393.41	-	9	4	2	0	**15**
US 69	Principal Arterial	S Austin Ave	Mac Nelsen Ln	3.86	6,562	21.61	-	9	6	0	0	**15**
Spur 503	Major Arterial	US 75/US 69	W Main St/E FM 120	3.44	6,058	236.85	-	7	6	0	0	**13**
FM 121*	Minor Arterial	Eagle Point Rd	Van Alstyne City Boundary	3.55	8,441	-	-	5	8	0	0	**13**
FM 1417-EXT	Major Arterial	US 82	SH 56	1.28	3,773	499.22	-	7	2	2	0	**11**
SH 11	Major Arterial	Judy Dr	Cedar Rd	0.61	3,612	70.49	-	7	2	0	0	**9**

*Additional segment requested by Grayson County MPO TAC that was not initially included due to lack of INRIX bottleneck data and TTI delay along the segment.

[1]Some of the identified roadway segments in the table have different classifications through portions of the segment.

[2]This is the approximate length, in miles, of the identified roadway segment where the frequency of bottlenecks is high.

[3]The average daily traffic (ADT), in vehicles per day (vpd), may be used for prioritizing roadway segments by traffic volume.

[4]The raw 2021 Bottleneck Ranking Base Impact data comes from the INRIX data and RITIS top 1000 bottleneck analysis. The values in this column are the sum of the base impacts of all the bottlenecks that have impacts within the identified segment, weighted by the number of days the bottleneck impacted the segment. The value is also weighted depending on whether or not the head of the bottleneck was located within the identified segment or not.

[5]This is the sum of the annual delay per mile, in person-hours, along TTI's 2021 most congested roadways in Texas that are within each identified segment. If there is no TTI Delay per Mile, TTI's list did not identify that segment in its 2021 list of most congested corridors in Texas.

[6]Please see Appendix A for criteria and points used for prirotitizing these identified segments.

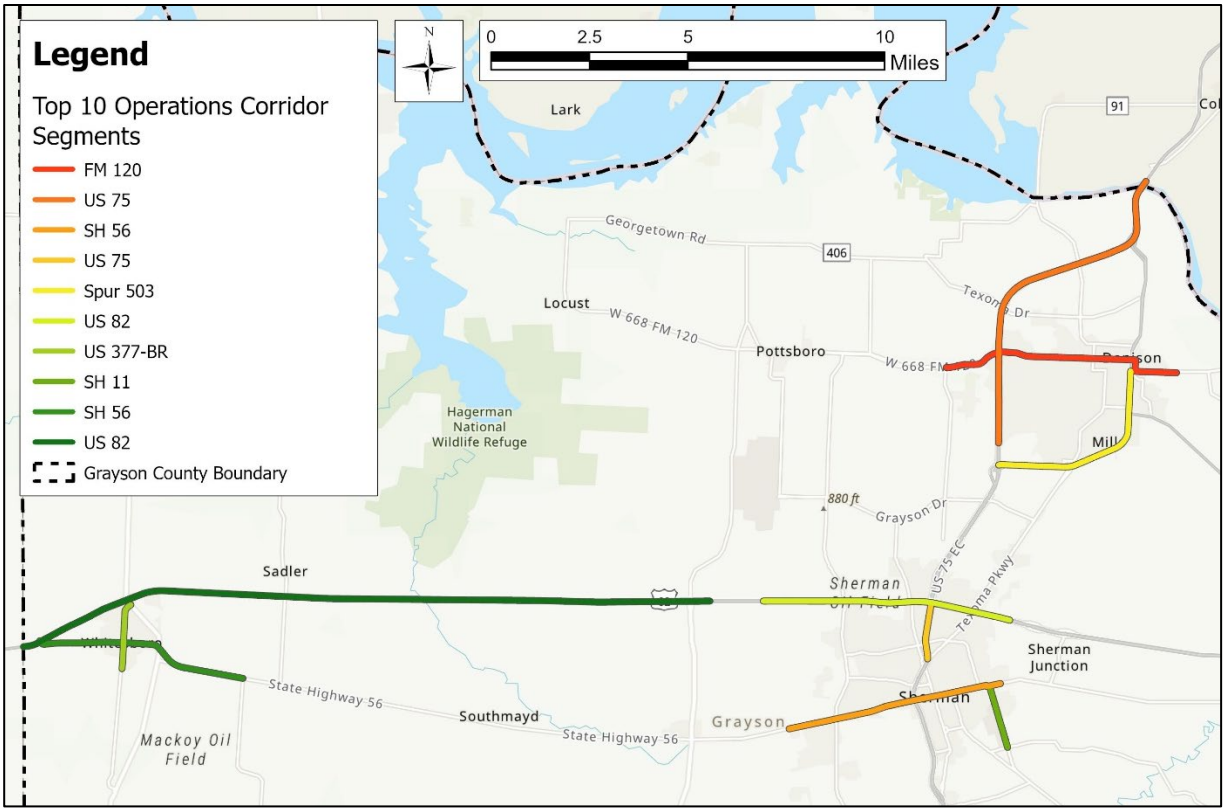


Figure 21 – Top 10 Operations Corridor Segments

4 CONSIDERED IMPROVEMENTS

This section presents information for each of the types of improvements that are considered for implementation to address the safety and operations challenges Grayson County faces, as discussed in previous sections. Improvements considered include FHWA's Proven Safety Countermeasures, HSIP approved systemic safety countermeasures and individual location improvements, and operational strategies such and signal system improvements and deployment of ITS technology.

4.1 FHWA Proven Safety Countermeasures

FHWA's Proven Safety Countermeasure are strategies and improvements effective in reducing deaths and injuries caused by crashes on the Nation's roadways. The FHWA recommends the implementation of Proven Safety Countermeasures in transportation agencies nationwide to better accelerate the achievement of safety goals. Below are FHWA's descriptions for five safety focus areas relating to different crash types that the FHWA has identified to categorize its Proven Safety Countermeasures. Those with a red "New" flag at the top left of the icon are countermeasures that were added in FHWA's Proven Safety Countermeasures November 2021 update.

4.1.1 Speed Management

With the potential for fatal injuries increasing as the speed of a crash increases, it is important to realize the need for proper speed management. The following countermeasures are proven to combat the potentially fatal effects of high-speed crashes before they even happen.

Speed Safety Cameras (SSCs): An effective and reliable technology that can aid the current methods in practice, SSCs use speed measuring devices to detect a speeding vehicle and catalog the evidence for later penalization. These devices not only provide an alternative to current policing measures, but also offer an unbiased enforcement of speeding independent of driver age, race, gender, or soci-economic status.

Variable Speed Limits (VSLs): When ideal conditions of a roadway are not met and the posted speed limit is predetermined for ideal conditions, there is a greater chance that a driver error could result in a crash. VSLs can adapt to changing circumstances to reduce the risks of nonideal driving conditions. This countermeasure is particularly effective for urban and rural freeways with posted speed limits greater than 40 mph.

Appropriate Speed Limits for All Road Users: Consider the fact that a driver traveling at 35 mph has a 45 percent chance of either killing or seriously injuring a pedestrian if hit, while that percentage drops to 5 percent if the speed is just 15 mph less, at 20 mph. This fact highlights the impact speed limits have on all road users and not just those in the vehicles.

4.1.2 Roadway Departure

As previously stated in Section 2, roadway departures account for over a third of all fatal accidents in Texas and account for more than half when looking at nationwide traffic fatalities. The following countermeasures aim to reduce the number of departure related fatalities.

Wider Edge Lines: Without identifiable travel lanes and upstream road alignment, the risk of roadway departure is heightened. By increasing the width of edge lines from the minimum of four inches to the maximum of six inches, associated crashes can be reduced by 37 percent. Wider edge lines are relatively low cost with a benefit-cost ratio of 25:1.

Enhanced Delineation for Horizontal Curves: Enhanced delineation for horizontal curves includes additional delineation along the approach to a curve and/or within the curve. A few countermeasures are the installation of chevron signs, delineators, or enhanced conspicuity such as larger, fluorescent, and/or retroreflective signs.

Longitudinal Rumble Strips and Stripes on Two-Lane Roads: Rumble strips are a series of grooves in the pavement or raised elements along the travel lane edges intended to alert drivers through vibration or sound that their vehicle has left the travel lane. White edge line or yellow center line stripes may be painted over rumble strips to increase lane visibility during non-ideal conditions. These countermeasures can be used to alert drifting drivers and reduce many head-on and roadway departure fatal and serious injury crashes.

SafetyEdge^{SM}: SafetyEdge^{SM} is a low-cost and effective pavement edge technology that eliminates the potential for vertical drop-offs by shaping the edge at approximately 30 degrees from the pavement cross slope. This shallow slope allows for a controlled return to the travel lane for drivers who have left the roadway and combats edge raveling of asphalt.

Roadside Design Improvements at Curves: These countermeasures include treatments for the high-risk roadside environment along the outside of horizontal curves that reduce roadway departure fatalities and serious injuries. They may aim to give vehicles a chance to recover safely from roadway departures, such as removing obstructions along the roadside and implementing clear zones, flattening steep side slopes, and adding or widening shoulders. Cable barriers, metal-beam guardrails, and concrete barriers may reduce the severity of a crash in the instance a safe recovery is not possible.

Median Barriers: Longitudinal barriers that separate opposing traffic on a divided highway are used to redirect vehicles that have left the travel lane and are heading towards opposing traffic. Hotspots of head-on crashes can give a good idea of where median barriers may be of the most use. Median barriers installed on rural four-lane freeways have resulted in a 97 percent reduction in cross-median crashes.

4.1.3 Intersections

Responsible for a large portion of fatal and serious injury crashes, intersections are a major focal point for safety analyses. The following countermeasures will highlight the multitude of ways to reduce intersection related crashes.

Backplates with Retroreflective Borders: With one inch to three inch wide yellow retroreflective borders, these types of backplates improve the visibility of a traffic signal. This treatment to traffic signals accounts for older and color vision deficient road users, not to mention its usefulness during blackouts in providing a visible cue for drivers to stop at the intersection ahead of them.

Corridor Access Management: Access management strategies can be used individually or in combination to enhance safety for all modes of transportation, encourage and facilitate walking and biking, and reduce trip delay and congestion. Some strategies include tandem roundabouts that reduce left-turn conflicts, turn lanes, and reduction in density through driveway closure, consolidation, or relocation.

Dedicated Left- and Right-Turn Lanes at Intersections: Left- and Right-turn only lanes can provide physical separation for turning traffic and thus reduce the potential for crash types like rear-end collisions or left-turns across opposing traffic.

Reduced Left-Turn Conflict Intersections: In the same realm as the previous countermeasure, these intersections are geometrically designed to alter how left-turn movements occur. Simplifying decision-making for drivers, the most effective of these designs rely on U-turns and can greatly reduce the potential for higher severity crash types, including head-on and angle crashes.

Roundabouts: Roundabouts are intersections that move traffic through channelized approaches along a circular configuration. They allow for safe and efficient routes by eliminating left-turn conflicts and keeping the traffic along roadways moving, thus minimizing delays and queueing.

Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections: As the name suggests, this treatment involves a series of low-cost countermeasures for stop-controlled intersections through better signage and pavement markings. Some methods for stop controlled and through approaches include posting signs on both sides of the road, oversized advance intersection warning signs, and retroreflective signage.

Yellow Change Intervals: With practices in place that regularly review and update traffic signal timing policies relating to yellow change intervals, the length of yellow light, crashes associated with red-light running can be reduced.

4.1.4 Pedestrian and Bicyclist

Often the most vulnerable users of the roadway, pedestrians and bicyclists require a large part of the focus applied to traffic safety practices. The proven safety countermeasures for these road users generally include improving the visibility of pedestrian and bicycle facilities and alerting drivers to be aware of potential pedestrian or bicycle encounters. These strategies are particularly useful near transit locations, schools, and other areas with a large amount of pedestrian or bicyclist activity.

Crosswalk Visibility Enhancements: The three main enhancements for crosswalk visibility are high-visibility crosswalks, improved lighting, and enhanced signing and pavement markings. These countermeasures do not just provide an increased potential for drivers to identify potential points of conflict, but they also assist in the decision-making of users trying to cross the road.

Bicycle Lanes: By creating a separate lane for bicyclists the number of crashes between vehicles and bicycles can be reduced while also encouraging and facilitating bicycles as a mode of transportation.

Rectangular Rapid Flashing Beacons (RRFBs): Usually accompanied by a pedestrian warning sign, RRFBs flash with an alternating high-frequency and can increase the visibility of pedestrians when trying to use a crosswalk.

Leading Pedestrian Interval (LPI): LPIs allow for pedestrians to enter the intersection a few seconds before conflicting turning movements, like right or left turning vehicles, are given a green light. Pedestrians can establish their presence with the help of these intervals and reduce their risk of going unnoticed.

Medians and Pedestrian Refuge Islands in Urban and Suburban Areas: Medians and pedestrian refuge islands can be installed to reduce the high number of pedestrian fatalities that occur at midblock locations in urban and suburban areas. These countermeasures protect pedestrians and bicyclists as they cross one direction of multi-lane traffic at a time.

Pedestrian Hybrid Beacons (PHB): As stated in the previous countermeasure, many pedestrian fatalities occur at non-intersection locations, with one notable factor being the speed of vehicles in the area. PHBs are red-yellow signalizations that can be activated by a pedestrian to prompt approaching vehicles to stop and give the pedestrian the right-of-way for safe crossing.

Road Diets (Roadway Reconfiguration): The common use of road diets involves converting an existing four-lane undivided roadway into a three-lane roadway with one through lane in each direction, a center two-way left-turn lane, and potentially the installation of bike lanes. Road diets calm traffic which not only provides safer roads for pedestrians and non-motorized road users but also benefits motorized vehicles with regards to safer left-turns and consistent speeds.

Walkways: Any space that is well-defined and intended for the use of a person traveling by foot or using a wheelchair may be considered a walkway, including sidewalks, multi-use paths, and roadway shoulders. Roadway shoulders are some of the least safe walkways, while elevated sidewalks provide significantly more protection for pedestrians.

4.1.5 Crosscutting

While the countermeasures listed up until now have each addressed their corresponding crash types (speed, departures, intersections, and pedestrians/bicycles), crosscutting is an area of focus that

involves the reduction of multiple crash types with the application of a single countermeasure. Discussed below are those countermeasures and the crash types they combat.

Pavement Friction Management: With an emphasis on areas where vehicles make frequent turns, stops, and decelerations, the implementation of proper maintenance and treatment of pavement friction can prevent roadway departure, intersection, and pedestrian-related crashes.

Lighting: While the number of fatal crashes occurring during the day and during the night are comparable, the nighttime fatality rate is higher due to less vehicles miles traveled at night. Therefore, improved lighting in area associated with turns, stoppage, or pedestrian crossings present ample safety benefits. All of the previously mentioned crash types can benefit from lighting in one form or another.

Local Road Safety Plans (LRSP): LRSPs provide framework for roadway safety improvements on local roads by identifying a list of prioritized action items that can be implemented at a low-cost and timely process. Again, all crash types can be addressed with LRSPs as these plans use localized crash data that can determine the hotspot locations for each crash type.

Road Safety Audit (RSA): An audit or assessment that is performed to analyze the existing safety conditions of a road and identify potential improvements with consideration for all road users, factors, and capabilities. RSAs can reduce crashes anywhere in the range of 10 to 60 percent and may affect one, some, or all crash types.

Like the previous crash trends section, **Table 7** reviews crash data from the last five full years, from 2017 through 2021. This table provides the overall percent change over the last five years for crashes within each of the SHSP emphasis areas, as well as the total number of crashes and number of fatal, serious injury, and minor injury crashes for each SHSP emphasis area. These statistics assist with identifying priority crash types to address by showing which crashes have increased the most over the last five years compared to which were the most common and which resulted in the most severe crashes.

Table 7 also presents which SHSP emphasis areas each of the FHWA Proven Safety Countermeasures addresses to help identify potential improvements once the most frequent and fastest increasing crash types are determined. The table shows that over the last five years pedestrian related crashes have the highest percent change of the seven SHSP emphasis areas, but it has the overall lowest crash count. Meanwhile, crashes involving distracted driving decreased significantly from 2017 to 2021, although it has the fourth greatest number of all crashes.

Crashes that occurred at an intersection or were intersection related resulted in the greatest number of crashes and increased over 20 percent. Many of the FHWA Proven Safety Countermeasures related to intersections were seen as potentially effective for crashes in Grayson County and should be considered for deployment, some of which may also address the large increase in pedestrian crashes. In addition, many of the FHWA Proven Safety Countermeasures were also identified for pedestrian crashes and roadway and lane departures crashes and should be considered for deployment.

Table 7 – FHWA Proven Safety Countermeasures and SHSP Emphasis Areas

		SHSP Emphasis Areas						
		Distracted Driving	Intersection Safety	Pedestrian Safety	Impaired Driving	Older Road Users	Roadway & Lane Departures	Speeding
Crash Data (2017 – 2021)								
Percent Change from 2017 to 2021		-17.13%	20.21%	66.67%	-3.77%	20.42%	12.27%	28.08%
All Crashes		1,478	3,507	91	527	1,516	2,977	812
Fatal, Serious Injury, and Minor Injury Crashes		656	1558	89	272	720	1283	326
FHWA Proven Safety Countermeasure								
Speed Management	Speed Safety Cameras							✓
	Variable Speed Limits							✓
	Appropriate Speed Limits for All Road Users					✓		✓
Roadway Departure	Wider Edge Lines					✓	✓	
	Enhanced Delineation for Horizontal Curves						✓	
	Longitudinal Rumble Strips and Stripes						✓	
	Safety Edge						✓	
	Roadside Design Improvements at Curves						✓	
	Median Barriers						✓	
Intersections	Backplates with Reflective Borders		✓			✓		
	Corridor Access Management		✓					✓
	Left- and Right-Turn Lanes at Two-Way Stop-Controlled Intersections		✓					
	Reduced Left-Turn Conflict Intersections		✓					
	Roundabouts		✓					✓
	Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections		✓	✓		✓	✓	✓
	Yellow Change Intervals		✓					
Pedestrian/ Bicyclist	Crosswalk Visibility Enhancements			✓		✓		
	Bicycle Lanes							
	Rectangular Rapid Flashing Beacons			✓				
	Leading Pedestrian Interval		✓	✓				
	Medians and Pedestrian Refuge Islands in Urban and Suburban Areas		✓	✓			✓	
	Pedestrian Hybrid Beacons			✓		✓		
	Road Diets (Roadway Reconfiguration)		✓	✓				✓
	Walkways			✓				
Crosscutting	Pavement Friction Management		✓	✓			✓	
	Lighting		✓	✓		✓	✓	
	Local Road Safety Plans	✓	✓	✓	✓	✓	✓	✓
	Road Safety Audits	✓	✓	✓	✓	✓	✓	✓

4.2 Highway Safety Improvement Program Approved Safety Countermeasures

The TxDOT Traffic Safety Division developed HSIP Guidelines to help local partner agencies apply for federal funding to implement roadway safety improvements with a goal of reducing crashes and fatalities on Texas roadways. HSIP applications utilize crash history from the most recent three full years to determine the need and priority for funding. Therefore, unlike the previous crash trends and FHWA Proven Safety Countermeasures sections that reviewed crash data from the last five full years (2017 through 2021), the crash data in **Table 8** ranges from 2019 through 2021. This table provides the overall percent change over the last three years for crashes within each of the SHSP emphasis areas, as well as the total number of crashes and number of fatal, serious injury, and minor injury crashes for each SHSP emphasis area. These statistics assist with identifying priority crash types to address by showing which crashes have increased the most over the last three years compared to which were the most common and which resulted in the most severe crashes.

The HSIP guidelines provide a detailed list of safety improvements, including each improvement's definition, the specific crash types the improvement targets to reduce, the reduction factor for those particular crashes, the expected service life of the improvement, and the general anticipated maintenance cost for some improvements.

Each safety improvement is assigned an identifying 'work code' and the reduction factors and service life for many combinations of work codes are provided in the list. Some work codes and combinations may be implemented systemwide in an effort to address safety issues that are consistent throughout the region or may not be identified using a traditional site analysis. The TxDOT HSIP Guidelines outline a systemic approach to address systemwide safety issues by combining a number of individual improvements.

The systemic approach to safety discusses the need to identify and address issues that may not result in separate clusters of crashes, but are spread across the network, such as rural lane departures. This approach begins with identifying the issue based on regionwide data from the most recent three years, then investigates characteristics, such as location and geometry, common in severe crashes. Low-cost countermeasures are selected to address the factors contributing to these crash types experiencing low densities but high aggregate numbers. HSIP groups these systemic countermeasures into three categories based on the targeted crash type: roadway departure, intersections, and pedestrian/bicyclist.

Table 8 also presents which SHSP emphasis areas each of the HSIP approved systemic countermeasures addresses to help identify potential improvements that may qualify for HSIP funding once the most frequent and fastest increasing crash types are determined. The table shows that over the last three years the number of crashes related to speeding have highest percent change of the seven SHSP emphasis areas, but is has only the fifth highest number of crashes.

Crashes that occurred at an intersection or were intersection related resulted in the greatest number of crashes and increased over 18 percent. HSIP approved systemic countermeasures related to intersections, as well as countermeasures related to pedestrian safety, were seen as particularly effective for addressing safety issues in Grayson County and should be considered for deployment.

Table 8 – HSIP Approved Systemic Countermeasures and SHSP Emphasis Areas

		SHSP Emphasis Areas						
		Distracted Driving	Intersection Safety	Pedestrian Safety	Impaired Driving	Older Road Users	Roadway & Lane Departures	Speeding
Crash Data (2019 – 2021)								
Percent Change from 2019 to 2021		22.92%	18.42%	17.65%	7.37%	17.12%	11.66%	44.96%
All Crashes		831	2,147	55	297	943	1,807	497
Fatal, Serious Injury, and Minor Injury Crashes		354	927	54	136	430	733	196
HSIP Approved Systemic Countermeasures								
Roadway Departure	Median barrier			✓			✓	
	Roadway widening					✓	✓	
	Continuous safety lighting along a corridor where no lighting is present			✓		✓	✓	
	Enhanced delineation on curves					✓	✓	
Intersections	Signing and marking improvements at stop-controlled intersections		✓	✓		✓		
	Low-cost urban intersection improvements (includes additional signal heads, protected left-turn signal phases, pavement markings…)		✓	✓				
	Dedicated right and left turn lanes		✓					
	Signal head backplates with reflective borders		✓			✓		
	Leading Pedestrian Intervals		✓	✓				
	Close Median Openings (Crossovers)		✓	✓			✓	
	Rural intersection improvements – signing and marking improvements at stop-controlled intersections		✓			✓		
	Rural intersection improvements – safety lighting		✓	✓				
	Rural intersection improvements – rumble strips on stop-controlled approaches		✓					✓
	Rural intersection improvements – installation of roadside flashers or embedded LEDs for Stop signs on controlled approaches and “Intersection Ahead” warning signs along uncontrolled approaches		✓			✓		
	Two-way left-turn lanes (TWLTLs/Continuous Left Turn Lanes)		✓					
Pedestrian/ Bicyclist	Safety lighting at urban intersections where pedestrian facilities are present and no lighting is present		✓	✓				
	Installation of attachments to existing concrete barrier systems to deter prohibited pedestrian crossings on divided highways			✓			✓	
	Uncontrolled crossing location improvements (including crosswalk pavement markings, lighting at the crosswalk, raised crosswalks…)			✓				
	Median and crossing islands in urban and suburban areas			✓				

4.3 Operational Improvements

ITS devices, traffic signal, and incident management strategies were considered for operational improvements. These improvements, which rely heavily on technology, are often much more cost effective and can be implemented sooner than large infrastructure projects. They often lead to operational improvements to reduce both recurring and non-recurring congestion, including non-recurring congestion from incidents, construction, weather, and special events.

4.3.1 ITS Devices

The TxDOT Paris District has a plan for deployment of ITS devices on major routes in Grayson County. While not funded, the future plans include CCTV cameras on US 75, US 82, US 377, SH 91, Spur 503, and FM 1417. DMS are also planned on US 75 and US 82.

The devices provide the TxDOT Paris District with the ability to monitor the system and provide information to travelers at the roadside. They are considered key building blocks to improving operations. However, these systems are only effective if they are actively monitored, and actions are taken in response to conditions. ITS devices and a TMC to provide a centralized operations center for use of the devices are recommended for Grayson County in the Implementation Plan section.

Road weather information systems were also considered in Grayson County. Several locations were identified where high water has been an issue. Similar to CCTV cameras and DMS, active monitoring of these devices is needed. Often maintenance of these devices is a challenge and many regions that have deployed weather information systems found them to be not as useful if they are not actively monitored and maintained. In Grayson County, it may be best to focus on the basics of adding CCTV cameras, DMS, and upgrading traffic signals first before embarking on additional deployment of technology.

4.3.2 Signal Upgrades

Signal system improvements are often the most effective way to improve operations and reduce congestion in a region. Traffic signal programs that include reliable detection, traffic responsive timing, and a robust traffic signal performance measures program yield high benefit costs and reduce congestion in a region.

TxDOT has been adding CCTV cameras at signals throughout Grayson County to be able to remotely monitor and diagnose issues with traffic signals. CCTV cameras have been proven to be a valuable tool in traffic signal operations and are recommended for Grayson County in the Implementation Plan section.

4.3.3 Other Strategies

Many regions have found that freeway service patrol programs are especially effective and reducing congestion on freeways as well as improving safety for travelers and first responders. Freeway service patrol programs have effectively been deployed across the country on all types of urban and rural highways. Several cities have also implemented similar programs on arterial streets in urban areas. This strategy was considered for Grayson County and a proposed approach is included in the Implementation Plan section.

5 IMPLEMENTATION PLAN

This section identifies the safety and operations recommended improvements for Grayson County at both a systemic corridor segment level. Systemic improvements can generally be applied throughout Grayson County and address safety and operations issues that exist at multiple locations. Corridor segment recommendations focus on the top ten corridor segments identified and prioritized in earlier sections. Operational improvements generally focus on systemwide improvements that can support improved operations but should be focused on the priority corridors first. An overview of various funding opportunities, such as HSIP and United States Department of Transportation (USDOT) Safe Streets and Roads for All (SS4A) grant program, is provided to assist the Grayson County MPO and its partners in implementing the recommended improvements.

5.1 Safety Improvements – Systemic

The HSIP program identifies HSIP work categories that can be applied systemically throughout a region to address system-wide safety programs. These work categories are eligible for HSIP funding at a systemic level.

Based on a region-wide review of safety issues in Grayson County, the HSIP approved systemic safety countermeasures discussed in this section should be considered for deployment in the region. The recommended improvements include systemic intersection and roadway lane departure improvements due to the high number of intersection related crashes, and roadway and lane departures crashes, in the region. These improvements, listed in **Table 9**, should be considered for existing condition improvements, as well as during the planning and design process for any future construction projects.

Table 9 – Recommended HSIP Systemic Improvements

HSIP Systemic Category	HSIP Improvement
Intersection Related HSIP Approved Safety Countermeasures	Signing and Marking Improvements at Stop-Controlled Intersections
	Rural Intersection Improvements
	Low-Cost Urban Intersection Improvements
	Dedicated Right and Left Turn Lanes, Two-Way Left-Turn Lanes (TWLTLs), or Continuous Turn Lanes
	Signal Head Backplates with Reflective Borders
Roadway Lane Departure Related HSIP Approved Systemic Safety Countermeasures	Roadway Widening
	Continuous Safety Lighting Along a Corridor Where No Lighting is Present
	Enhanced Delineation on Curves

5.1.1 Intersection Related HSIP Approved Systemic Safety Countermeasures

The following intersection related HSIP approved systemic safety countermeasures are recommended for deployment in Grayson County to address intersection related crashes.

Signing and Marking Improvements at Stop-Controlled Intersections: The signing and marking improvements of this countermeasure include the installation of oversize advance signs, street name plaques, pavement markings, stop ahead warning signs, retroreflective sheeting on signposts, stop bars, sight distance improvements, and two-direction large arrow sign at T intersections. Each of these items enhances the visibility of stop-controlled intersections and increases drivers' awareness of the upcoming stop condition. This reduces the risk of intersection related crashes caused by a driver disregarding the stop sign or rear-ending a vehicle stopped at the stop sign/bar.

Rural Intersection Improvements: Rural intersection improvements include many of the items identified for stop-controlled intersections above because rural intersections are generally stop-controlled. Rural intersection improvements also include safety lighting and rumble strips. Safety lighting further enhances the visibility of intersections due to the general lack of lighting in rural areas. Rural roadways typically have higher speed limits and drivers may not anticipate the need to come to a stop. Therefore, rumble strips on stop-controlled approaches physically alert drivers of the upcoming stop condition and warns them to begin to slow down in advance. These improvements should be considered for Grayson County at particularly dark intersections and stop-controlled intersections with a history of crashes related to disregard of the stop condition.

Low-Cost Urban Intersection Improvements: Low-cost urban intersection improvements include protected left-turn signal phases, pavement markings, signing improvements, and signal-ahead warning signs. Similar to the stop-controlled and rural intersection improvements above, these items enhance the visibility of an intersection's geometry and give advanced warning so drivers are aware of and may react appropriately to the upcoming roadway conditions. These improvements most likely apply to the more developed areas of Grayson County, such as downtown Denison and downtown Sherman, where there are greater traffic volumes that warrant traffic signals.

Dedicated Right and Left Turn Lanes, Two-Way Left-Turn Lanes, or Continuous Turn Lanes: Dedicated turn lanes, two-way left-turn lanes (TWLTLs), and continuous turn lanes remove vehicles slowing or stopping to wait to turn from the main lanes. Drivers continuing straight through an intersection may not expect the vehicle ahead to slow down or stop to turn, or the following driver simply may not be paying attention and does not notice or react quick enough to the vehicle in front changing speed. Therefore, separating the turning vehicles from other traffic that would not otherwise slow down or stop, reducing the risk for a rear-end crash.

Turn lanes should be considered where high turning volumes exist, high opposing direction volumes exist, and along two-lane corridors with high-speed traffic and multiple access points. TWLTLs and continuous turn lanes should also be considered at these locations, particularly at unsignalized intersections or access points, as well as along corridors with a high density and closely spaced access points. Turn lanes can address safety and operations concerns where vehicles turning may have difficulty finding a gap in the opposing traffic to turn, therefore blocking a main travel lane, acting as a potential hazard for inattentive or speeding drivers and causing delay by holding up through traffic.

Signal Head Backplates with Reflective Borders: Retroreflective backplates for signal heads enhance the visibility of signalized intersections, and as a result, reduce intersection related crashes. When a traffic signal loses power, these backplates help drivers identify that there is an intersection ahead that is usually controlled by a signal and therefore the driver should proceed with caution. This countermeasure should be implemented at all traffic signals in Grayson County, with traffic signals that

frequently lose power and go dark and signalized intersections with a history of red light running and disregard for the signal as a priority.

5.1.2 Roadway Lane Departure Related HSIP Approved Systemic Safety Countermeasures

The following roadway lane departure related HSIP approved systemic safety countermeasures are recommended for deployment in Grayson County to address intersection related crashes.

Roadway Widening: HSIP identifies rural two-lane roadways and two-way undivided highways with a paved surface width of less than 24 feet as key candidates for roadway widening, with the recommended width of at least 28 feet. The addition of rumble strips is also identified in this safety countermeasure. These improvements target crashes related to roadway and lane departures by increasing the space between vehicles in different lanes, providing additional recovery space, and physically alerting the driver of the vehicle departing its lane.

Continuous Safety Lighting Along a Corridor Where No Lighting is Present: Similar to some of the intersection related improvements, safety lighting is recommended along corridors to enhance the visibility of the roadway's geometry, other vehicles, and potential hazards in the road ahead. This countermeasure should be implemented where no lighting is present throughout Grayson County, particularly along corridors that frequently experience nighttime crashes.

Enhanced Delineation on Curves: Potential strategies for enhancing the visibility of curves include wider pavement markings, retroreflective strips on sign posts, delineators, chevron signs, dynamic curve warning signs, and sequential dynamic chevrons. These may be implemented ahead of a curve to give drivers advance warning of an upcoming curve to provide sufficient time for them to slow down, or implemented within the curve to improve drivers' ability to see the curve's geometry. These improvements should be considered along curves that have a history of crashes in Grayson County.

5.2 Safety Improvements – Corridor Segments

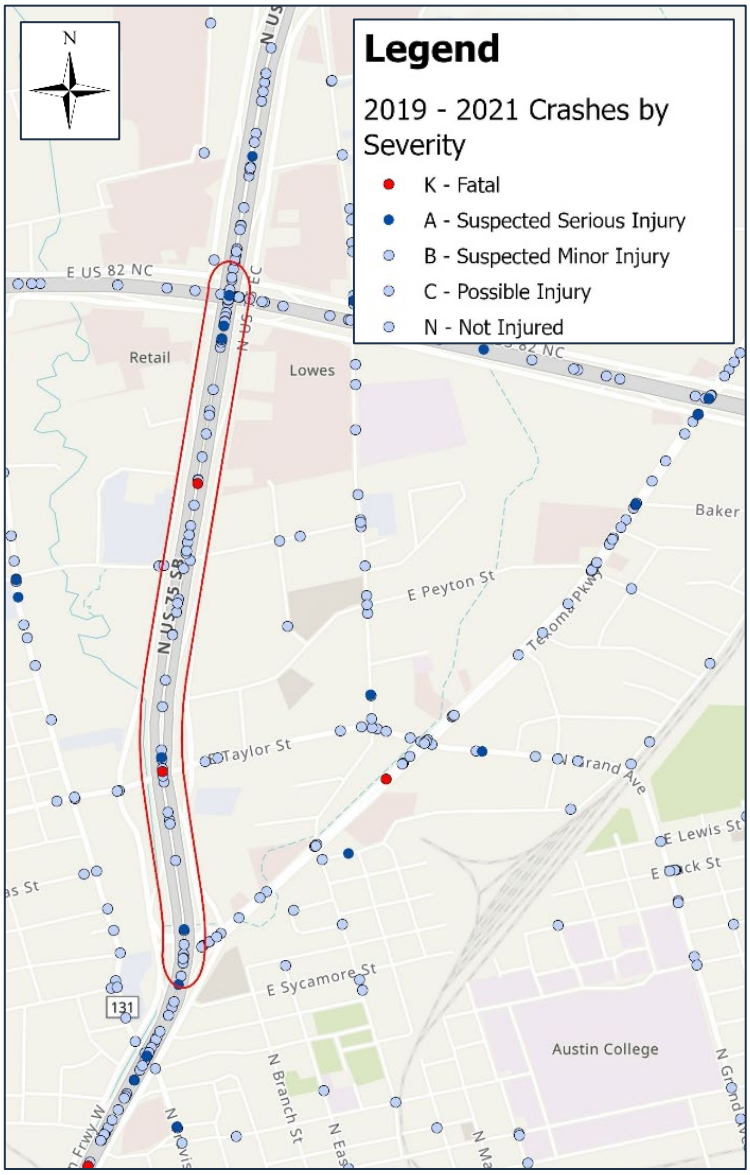
Specific safety improvements are recommended for each of the top ten corridor segments identified as having safety concerns and needs. The list of improvements for each segment includes HSIP approved systems countermeasures, FHWA Proven Safety Countermeasures, and other recommendations as appropriate HSIP recommendations can be used to develop HSIP applications for future funding. The FHWA Proven Safety Countermeasures are included to emphasize the common crash types along each segment that need to be addressed and to assist Grayson County with prioritizing and grouping safety improvements.

HSIP applications utilize crash history from the most recent three full years to determine the need and priority for funding. In the following recommendations for the top ten safety corridor segments, only three years of crash data (2019 through 2021) is presented to align with the HSIP application process.,

It is also important to note that the percent reduction attributed to each HSIP safety improvement applies to specific crash types, not the total number of crashes. The crash types that each HSIP countermeasure targets are included in the HSIP guidelines. For example, HSIP work code 209 for safety treating fixed objects has a 50 percent crash reduction factor specifically for crashes that occurred off the roadway, in the shoulder, or in the median or crashes that involved a vehicle hitting a fixed object such as a curb, guardrail, or utility pole. A full list of the HSIP work codes is provided in **Appendix B**.

ROADWAY: US 75

Segment: *From US 82 to SH 91*
Classification: *Freeway*
ADT: *56,017 vpd*



Segment Discussion

More than 65 percent of the crashes that occurred along this segment of US 75, between US 82 and SH 91, involve multiple vehicles traveling in the same direction. The most common manner of collision is an angle crash where both vehicles were traveling straight, likely caused by a vehicle departing its designated lane.

One vehicle going straight is another common manner of collision, one of which resulted in a fatal crash. This crash type typically involves a vehicle running off the road or hitting a fixed object.

Recommended Improvements

All of the following recommended improvements are identified to address roadway and lane departure crashes. Safety treating fixed objects can reduce the severity when an object is struck after a vehicle leaves the roadway. Rumble strips paired with wider edge lines enhance the visibility of the travel lanes and physically alert the driver of the lane departure. Wider shoulders would provide additional recovery space for departing vehicles and would be beneficial for traffic incident management activities and reducing the risk for secondary crashes.

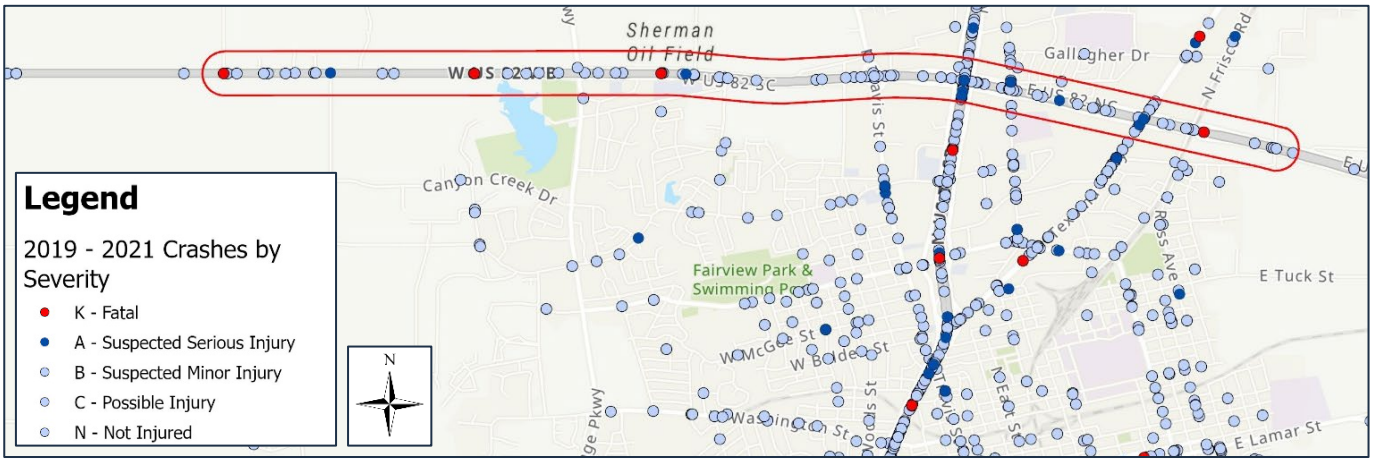
Grayson County TAC members identified the need to reconstruct US 75, because the rough existing pavement is likely a major contributor to the crashes along the freeway, as drivers attempting to dodge potholes and uneven segments of pavement often swerve and leave their lane, resulting in run off the road and sideswipe crashes.

Source	Improvement	Reduction %
HSIP – 209	Safety Treat Fixed Objects	50
HSIP – 532	Milled Edgeline Rumble Strips	15
HSIP – 536	Widen Paved Shoulders (to >5ft.)	31
HSIP – 542	Milled Centerline Rumble Strips	26
FHWA PSC	Wider Edge Lines	N/A
Other	Pavement Reconstruction	N/A

Crash Severity	Count
Fatal (K)	2
Serious/Incapacitating Injury (A)	5
Minor/Non-Incapacitating Injury (B)	28
Total for All Crash Severities	189

ROADWAY: US 82

Segment: *From Reynolds Road to Baker Ridge Road*
Classification: *Freeway*
ADT: *28,048 vpd*



Segment Discussion

Nearly one third of the crashes along this segment of US 82 involve one motor vehicle traveling straight, either running off the road or hitting a fixed object. Impaired driving and speeding are the top contributing factors of these crashes involving one motor vehicle traveling straight occurred, which resulted in five fatal injury and serious injury crashes. Over a quarter of the total number of crashes are speed related. The severity of crashes is increased due to the high posted speed limit, which ranges from 70 mph to 75 mph, as well as the frequency of speeding along this corridor.

Out of the nine overall fatal injury and serious injury crashes that occurred on this segment, two fatal injury crashes and one serious injury crash took place when the lighting condition was recorded as dark and not lighted.

Recommended Improvements

Numerous access points exist sporadically along US 82, few of which are aligned to create a four-way intersection. Advanced warning signs and safety lighting could alert drivers of upcoming conflict points where vehicles may slow down to turn or stop, while corridor access management strategies could reduce the number of conflict points.

Rumble strips paired with wider edge lines enhance the visibility of the travel lanes and physically alert the driver of the lane departure. Wider shoulders would provide additional recovery space for departing vehicles and would be beneficial for traffic incident management activities and reducing the risk for secondary crashes.

Source	Improvement	Reduction %
HSIP – 128	Install Advanced Warning Signs	5
HSIP – 209	Safety Treat Fixed Objects	50
HSIP – 304	Safety Lighting	49
HSIP – 532	Milled Edge Line Rumble Strips	15
HSIP – 536	Widen Paved Shoulders (to >5 ft.)	31
HSIP – 542	Milled Centerline Rumble Strips	26
FHWA PSC	Wider Edge Lines	N/A
FHWA PSC	Corridor Access Management	N/A
Other	Pavement Reconstruction	N/A

Crash Severity	Count
Fatal (K)	4
Serious/Incapacitating Injury (A)	6
Minor/Non-Incapacitating Injury (B)	43
Total for All Crash Severities	245

ROADWAY: FM 691/GRAYSON DR

Segment: *From FM 1417 to SH 91*
Classification: *Major Arterial*
ADT: *5,534 vpd*

Segment Discussion

Approximately 60 percent of the crashes along this segment were reported as having ocurred at an intersection or being intersection related. 33 of the crashes involved multiple vehicles traveling in the opposite direction with one continuing straight and one turning left, making this the most common manner of collision. 13 of the crashes were reported involving multiple vehicles traveling in the same direction with one continuing straight and one turning left.

The contributing factor for 71 of the crashes was reported as disregard for the traffic control or failure to yield to the vehicle turning left with the right of way. Nearly a fourth of the crashes were reported as speed related. These factors are both likely outcomes from distracted driving and driver inattention due to the presence of this issue along the previously discussed segments.

Recommended Improvements

Traffic signal improvements such as upgrading to flashing yellow arrow for left-turns provide a more intuitive signal for vehicles turning left to yield and a separate green arrow to indicate when the left-turn movement is protected. Other traffic signal improvements such as signal retiming and yellow change interval increase mobility along a corridor by facilitating the orderly movement of traffic and increasing vehicle throughput at signalized intersections. Mitigating congestion could address driver inattention brought on by stop and go traffic.

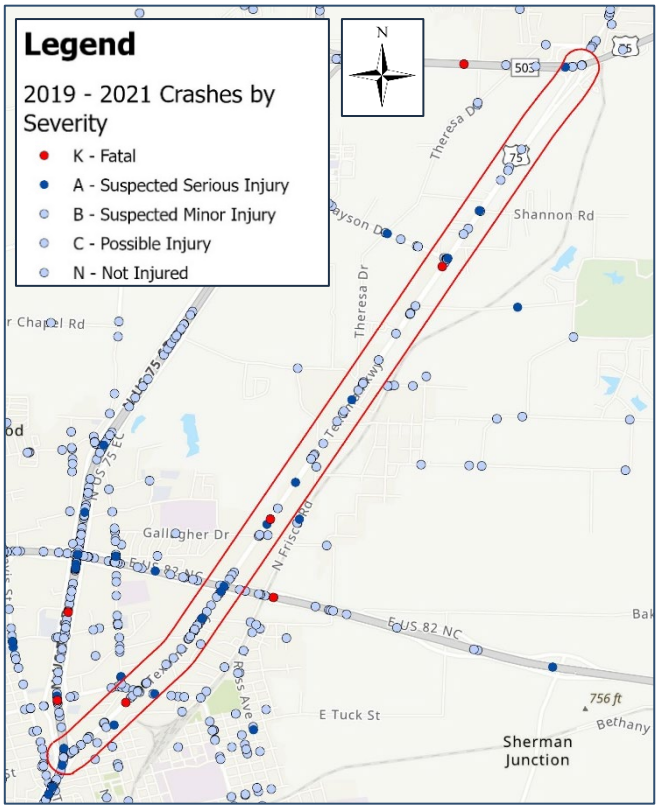
Advanced warning signs and signals, backplates with retroreflective borders, and safety lighting at intersections enhance the visibility of intersections. These improvements alert the driver to slow down for the upcoming intersections and possible stop conditions and conflicts.

Source	Improvement	Reduction %
HSIP – 108	Improve Traffic Signals	24
HSIP – 124	Install Advanced Warning Signals and Signs (Intersection)	27
HSIP – 128	Install Advanced Warning Signs (Intersection)	5
HSIP – 305	Safety Lighting at Intersection	13
FHWA PSC	Backplates with Retroreflective Borders	N/A
FHWA PSC	Yellow Change Interval	N/A

Crash Severity	Count
Fatal (K)	0
Serious/Incapacitating Injury (A)	4
Minor/Non-Incapacitating Injury (B)	16
Total for All Crash Severities	105

ROADWAY: SH 91

Segment: *From Spur 503 to US 75*
Classification: *Principal Arterial*
ADT: *8,400 vpd*



Segment Discussion

About a third of the crashes, including one fatal crash and two serious injury crashes, along this segment were caused by distracted driving and driver inattention. These factors lead to drivers unintentionally leaving their lane or not slowing down for stopped or slow traffic ahead. Of all the distracted driving and driver inattention crashes, 63 crashes involved multiple vehicles, with one traveling straight and one stopped, making this the most common manner of collision.

129 crashes occurred at signalized and stop controlled intersections, resulting in four serious injury crashes, three of which are in the vicinity of the US 82 interchange. 53 of these controlled intersection crashes involved a vehicle turning left, mostly concentrated between Peyton St and Baker Dr.

Pedestrians were involved in one fatal, three serious injury, and three minor injury crashes. There is little to no existing pedestrian factilities to protect pedestrians walking along or crossing SH 91.

Recommended Improvements

Traffic signal improvements and timing adjustments, including interconnecting adjacent signals, increase mobility along a corridor by facilitating the orderly movement of traffic and increasing vehicle throughput at signalized intersections. Mitigating congestion could address driver inattention brought on by stop and go traffic. Advanced warning signs and backplates with retroreflective borders enhance the visibility of intersections.

Numerous access points exist very close together, between four-way intersections along SH 91. Corridor access management strategies could reduce the number of conflict points and support traffic signal improvements in optimizing mobility.

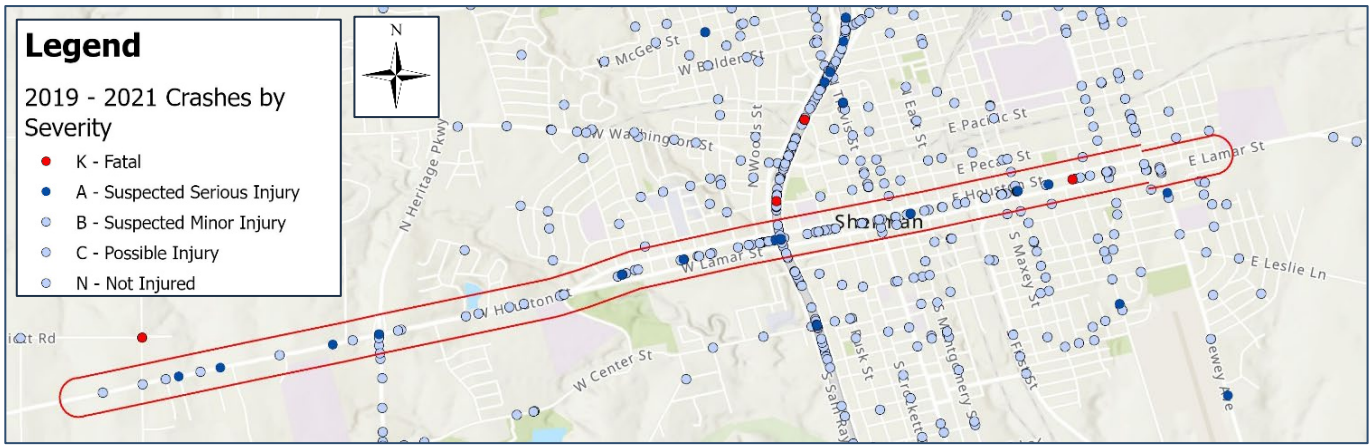
The installation of pedestrian facilities such as signals, crosswalks, and sidewalk would provide protection for pedestrians to safely travel along or cross the roadway, without walking in the shoulder or getting stranded on a median.

Source	Improvement	Reduction %
HSIP – 108	Improve Traffic Signals	24
HSIP – 110	Install Pedestrian Signal	34
HSIP – 111	Interconnect Signals	10
HSIP – 128	Install Advanced Warning Signs (Intersection)	5
HSIP – 403	Install Pedestrian Crosswalk	10
HSIP – 407	Install Sidewalks	65
HSIP – 508	Realign Intersection	TBD
FHWA PSC	Backplates with Retroreflective Borders	N/A
FHWA PSC	Corridor Access Management	N/A

Crash Severity	Count
Fatal (K)	3
Serious/Incapacitating Injury (A)	8
Minor/Non-Incapacitating Injury (B)	51
Total for All Crash Severities	222

ROADWAY: SH 56

Segment: *From Friendship Road to N Colbert Avenue*
Classification: *Major Arterial*
ADT: *14,099 vpd*



Segment Discussion

Nearly 37 percent of the crashes, including seven serious injury crashes, along this segment were caused by distracted driving and driver inattention. These factors lead to drivers unintentionally leaving their lane or not slowing down for stopped or slow traffic ahead, resulting in multiple vehicle angle crashes which were the most common manner of collision.

84 of the angle crashes involved two vehicles going straight, likely a result of a driver not paying attention and leaving their designated lane. 36 angle crashes involved two vehicles traveling in the same direction with one continuing straight while the other turned left, also likely a result of the driver traveling straight not noticing the vehicle infront of it slowing down to turn left. Similar driving behavior may have been the cause behind the 30 rear-end crashes, which resulted in one fatal crash and one serious injury crash, and the 39 crashes attributed to a driver's disregard for a stop sign or light. A total of 110 crashes occurred at a signalized or stop-controlled intersection.

Recommended Improvements

Mitigating congestion could address driver inattention brought on by stop and go traffic. Traffic signal timing adjustments and interconnecting signals increases mobility along a corridor by facilitating the orderly movement of traffic and increasing vehicle throughput at signalized intersections. Traffic signal improvements would also address conflicts between the through and turning movements to reduce rear-end crashes.

Advanced warning signs and backplates with retroreflective borders enhance the visibility of intersections. Rumble strips paired with wider edge lines enhance the visibility of the travel lanes and physically alert the driver of the lane departure.

Source	Improvement	Reduction %
HSIP – 108	Improve Traffic Signals	24
HSIP – 111	Interconnect Signals	10
HSIP – 128	Install Advanced Warning Signs (Intersection)	5
HSIP – 401	Install Pavement Markings	20
HSIP – 532	Milled Edge Line Rumble Strips	15
FHWA PSC	Wider Edge Lines	N/A
FHWA PSC	Backplates with Retroreflective Borders	N/A

Crash Severity	Count
Fatal (K)	1
Serious/Incapacitating Injury (A)	12
Minor/Non-Incapacitating Injury (B)	37
Total for All Crash Severities	238

ROADWAY: SH 91

Segment: *From Texoma Drive to Spur 503*
Classification: *Minor Arterial & Major Collector*
ADT: *15,519 vpd*

Segment Discussion

41 crashes along this segment were caused by distracted driving and driver inattention. These factors lead to drivers unintentionally leaving their lane, not slowing down for stopped or slow traffic ahead, and disregard for intersection signage or signals. On this segment 40 crashes occurred due to failure to yield to right of way and disregard for stop sign or signal, most of which were a result of distracted driving. A total of 79 crashes occurred at a signalized or stop-controlled intersection.

Similar driving behavior caused the 14 opposite direction crashes that involved one vehicle traveling straight and one vehicle turning left. 32 crashes involved multiple vehicles, with one traveling straight and one stopped, such as a rear-end crash, which can likely be attributed to distracted driving.

Recommended Improvements

Traffic signal and timing improvemnets, including interconnecting adjacent signals and adjusting the yellow change interval, increase mobility along a corridor by facilitating the orderly movement of traffic and increasing vehicle throughput at signalized intersections. Mitigating congestion could address driver inattention brought on by stop and go traffic.

The pavement markings along this segment are faded or non existant. New pavement markings, as well as safety lighting, would enhance the visibility of the roadway geometry and intersections to reduce lane and roadway departures. Longitudinal rumble strips with overlayed stripes further enhance lane visibility and physically alert the driver of lane departure.

Source	Improvement	Reduction %
HSIP – 108	Improve Traffic Signals	24
HSIP – 111	Interconnect Signals	10
HSIP – 305	Safety Lighting at Intersection	13
HSIP – 401	Install Pavement Markings	20
HSIP – 402	Install Edge Marking	25
HSIP – 544	Raised Centerline Rumble Strips	17
FHWA PSC	Longitudinal Rumble Strips and Stripes on Two-Lane Roads	N/A
FHWA PSC	Yellow Change Interval	N/A

Crash Severity	Count
Fatal (K)	1
Serious/Incapacitating Injury (A)	6
Minor/Non-Incapacitating Injury (B)	24
Total for All Crash Severities	145

ROADWAY: US 75

Segment: *From County Boundary to N Loy Lake Road*
Classification: *Freeway*
ADT: *52,475 vpd*

Segment Discussion

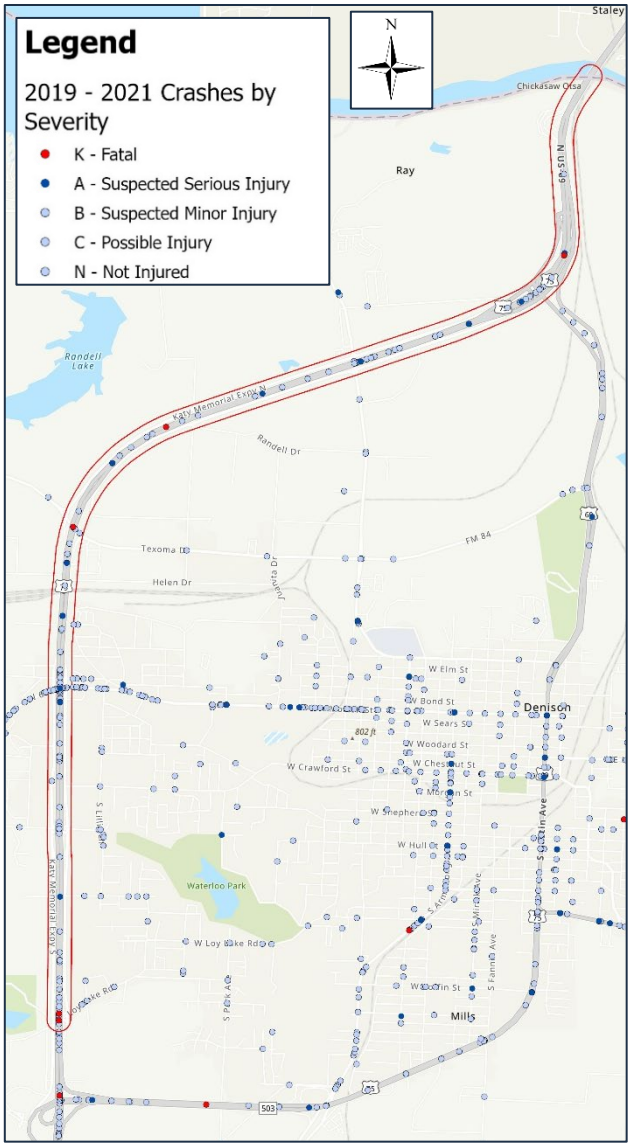
More than 57 percent of the crashes along this segment reported the manner of collision as involving multiple vehicles with at least one traveling straight, resulting in two fatal crashes and four serious injury crashes. The second most common manner of collision at 18 percent is a single vehicle traveling straight. This type of crash resulted in three fatal crashes and four serious injury crashes.

Distracted driving and driver inattention contribute to 27 percent of the crashes. A contributing factor for 17 percent of the crashes is speed related, including speeding, failure to control speed, and driving at an unsafe speed. The severity of crashes is increased due to the high posted speed limit, which ranges from 70 mph to 75 mph, as well as the frequency of speeding along this corridor.

Recommended Improvements

All of the following potential improvements are identified to address roadway and lane departure crashes. Safety treating fixed objects can reduce the severity when an object is struck after a vehicle leaves the roadway. Rumble strips paired with wider edge lines enhance the visibility of the travel lanes and physically alert the driver of the lane departure. Wider shoulders would provide additional recovery space for departing vehicles and would be beneficial for traffic incident management activities and reducing the risk for secondary crashes.

Grayson County TAC members identified the need to resurface US 75, because the rough existing pavement is likely a major contributor to the crashes along the freeway, as drivers attempting to dodge potholes often swerve and leave their lane, resulting in run off the road and sideswipe crashes.

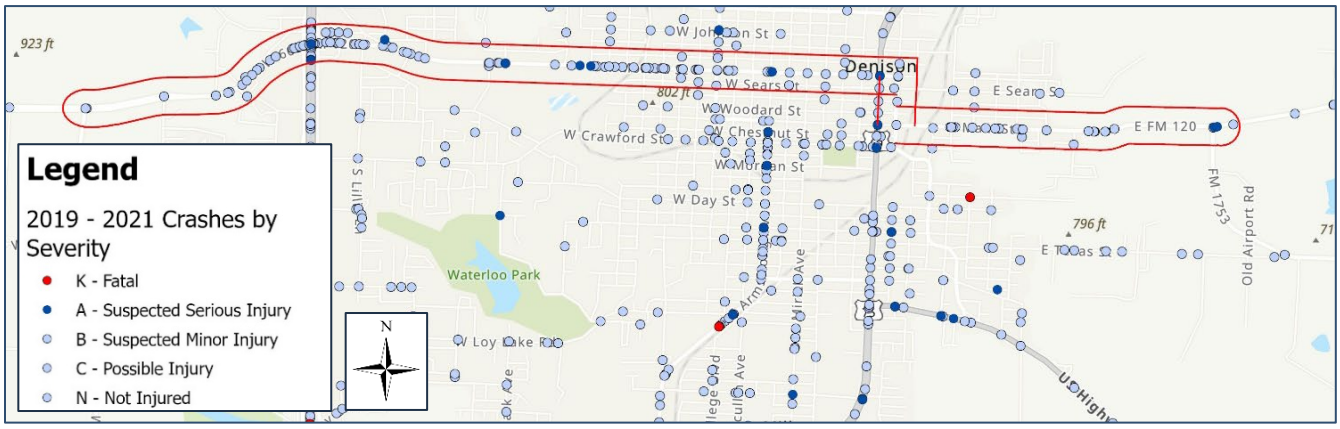


Source	Improvement	Reduction %
HSIP – 209	Safety Treat Fixed Objects	50
HSIP – 217	Install Impact Attenuation System	60
HSIP – 532	Milled Edge Line Rumble Strips	15
HSIP – 542	Milled Centerline Rumble Strips	26
FHWA PSC	Wider Edge Lines	N/A
Other	Reconstruct and Widen from 4 Lanes to 6 Lanes	N/A

Crash Severity	Count
Fatal (K)	5
Serious/Incapacitating Injury (A)	11
Minor/Non-Incapacitating Injury (B)	35
Total for All Crash Severities	243

ROADWAY: FM 120

Segment: *From FM 131 to FM 1753*
Classification: *Major Arterial & Minor Arterial*
ADT: *15,229 vpd*



Segment Discussion

Almost a third of the crashes along this segment were related to distracted driving and driver inattention, making it the most frequent contributing factor. This driving behavior leads to drivers unintentionally leaving their lane or not slowing down for stopped or slow traffic ahead. Of all the distracted driving and driver inattention crashes, 83 crashes involved multiple vehicles, with one traveling straight and one stopped, such as a rear-end crash, also making this the most common manner of collision.

135 crashes occurred at signalized and stop controlled intersections, 32 of which were a result of a driver disregarding a stop sign or light and 24 were caused by a driver failing to yield to the vehicle turning left with the right of way. Another common manner of collision along this segment is opposite direction involving one vehicle traveling straight and one turning left. 37 crashes, particularly concentrated at the FM 120/US 75 interchange, were reported.

Recommended Improvements

Closely spaced intersections along with numerous access points create an abundance of conflict points along a corridor. Traffic signal improvements and timing adjustments, including upgrading to flashing yellow arrow for left-turns and interconnecting adjacent signals, increase mobility along a corridor by facilitating the orderly movement of traffic and increasing vehicle throughput at signalized intersections. Mitigating congestion could address driver inattention brought on by stop and go traffic. Advanced warning signs and signals, and backplates with retroreflective borders enhance the visibility of intersections. Implementing corridor access management strategies could reduce the overall number of conflict points.

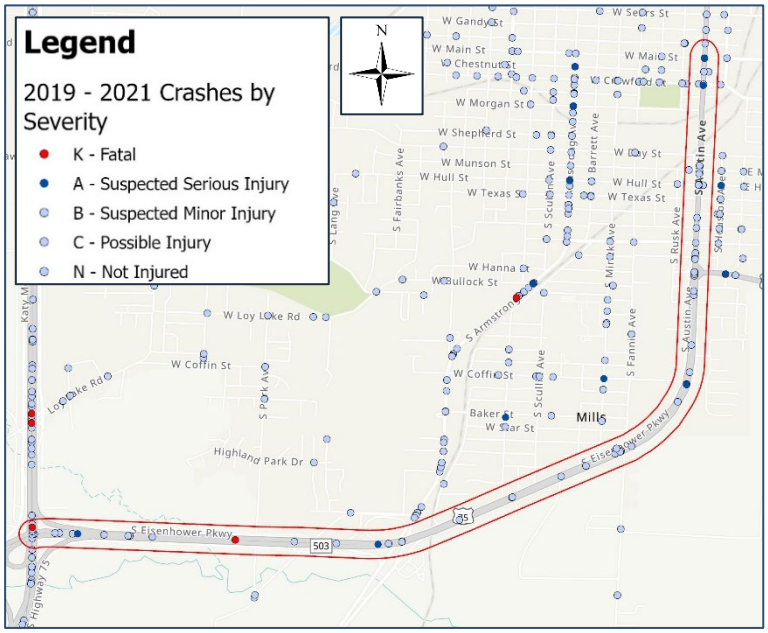
Source	Improvement	Reduction %
HSIP – 108	Improve Traffic Signals	24
HSIP – 111	Interconnect Signals	10
HSIP – 124	Install Advanced Warning Signals and Signs (Intersection)	27
HSIP – 128	Install Advanced Warning Signs (Intersection)	5
HSIP – 304	Safety Lighting	49
HSIP – 305	Safety Lighting at Intersection	13
HSIP – 401	Install Pavement Markings	20
HSIP – 402	Install Edge Marking	25
HSIP – 404	Install Centerline Striping	65
FHWA PSC	Backplates with Retroreflective Borders	N/A
FHWA PSC	Yellow Change Interval	N/A

The pavement markings along this segment are faded or non existant. Therefore new pavement markings, as well as safety lighting, would enhance the visibility of the roadway geometry and intersections to reduce lane and roadway departures. Increased lighting would also improve visibility of other potential hazards ahead such as fixed objects, pedestrians, and animals along the road.

Crash Severity	Count
Fatal (K)	0
Serious/Incapacitating Injury (A)	8
Minor/Non-Incapacitating Injury (B)	44
Total for All Crash Severities	276

ROADWAY: SPUR 503

Segment: *From US 75 to W Main St/E FM 120*
Classification: *Major Arterial*
ADT: *14,439 vpd*



Segment Discussion

Approximately 69 percent of the crashes along this segment were reported as having ocurred at an intersection or being intersection related. A third of these crashes were caused by a driver's disregard for a stop sign or traffic signal or a driver's failure to yield to right of way. Almost 43 percent of the crashes along this segment involved two vehicles both traveling straight. All of these crash types are likely a result of distracted driving and driver inattention, as a third of all crashes on this segment were reported as such.

Almost 24 percent of the crashes along this segment involved one vehicle traveling straight, over half of which hit a fixed object. One fatal and one serious injury crash ocurred when the lighting conditions was reported as dark, not lighted, and one serious injury crash ocurred when the lighting condition was dark, lighted.

Recommended Improvements

Advanced warning signs and signals alert drivers to the upcoming intersection and potential need to stop. Traverse rumble strips can be used to physically alert drivers to slow down for the upcoming intersection. Safety lighting at intersections also gains drivers' attention and improves the intersection's visibility, as well as the visibility of the overall road geometry and other potential hazards ahead such as fixed objects, pedestrians, and animals along the road.

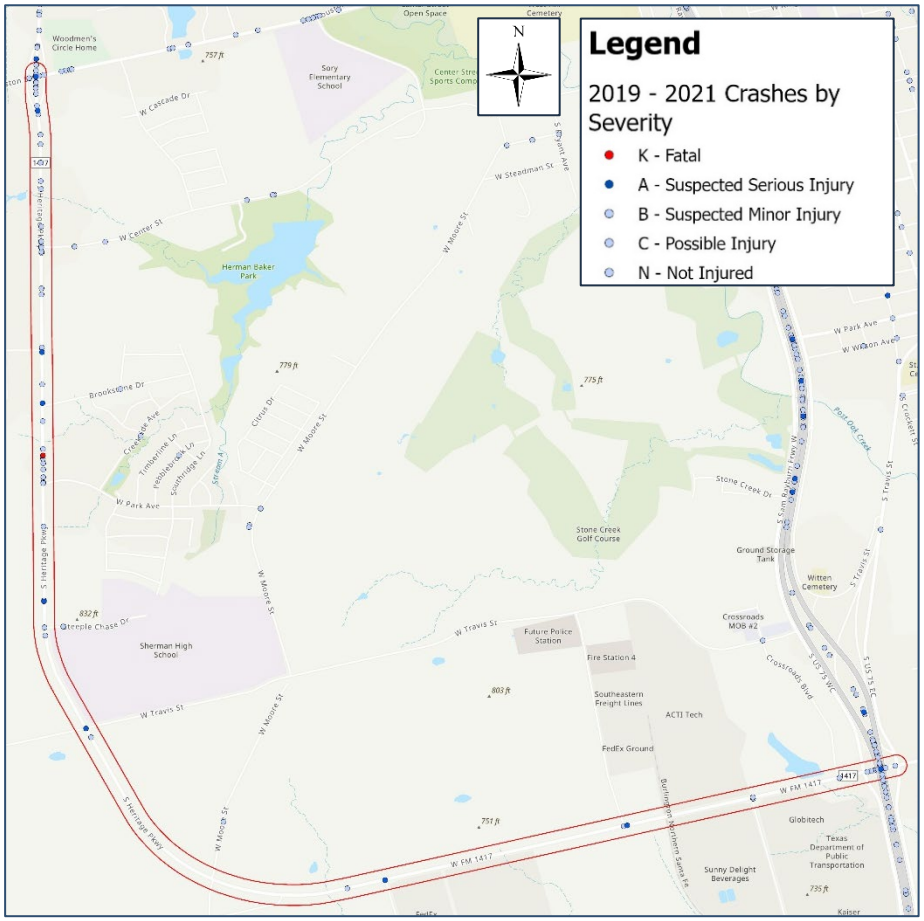
Pavement markings and rumble strips target roadway and lane departures by further enhancing the visibility of travel lanes and physically alerting the driver of the departure. Wider shoulders would provide additional recovery space for departing vehicles and would be beneficial for traffic incident management activities and reducing the risk for secondary crashes. Safety treating fixed objects and installing impact attenuation systems can reduce the severity when vehicle does leave the roadway and strikes an object.

Source	Improvement	Reduction %
HSIP – 124	Install Advanced Warning Signals and Signs (Intersection)	27
HSIP – 128	Install Advanced Warning Signs (Intersection)	5
HSIP – 201	Install Median Barrier	75
HSIP – 209	Safety Treat Fixed Objects	50
HSIP – 217	Install Impact Attenuation System	60
HSIP – 304	Safety Lighting	49
HSIP – 305	Safety Lighting at Intersection	13
HSIP – 401	Install Pavement Markings	20
HSIP – 402	Install Edge Marking	25
HSIP – 504	Construct Paved Shoulders (1-4 ft.)	25
HSIP – 525	Convert to One Way Frontage Roads	68
HSIP – 532	Milled Edge Line Rumble Strips	15
HSIP – 545	Transverse Rumble Strips	15

Crash Severity	Count
Fatal (K)	1
Serious/Incapacitating Injury (A)	7
Minor/Non-Incapacitating Injury (B)	20
Total for All Crash Severities	125

ROADWAY: FM 1417

Segment: *From SH 56 to US 75*
Classification: *Major Arterial*
ADT: *12,470 vpd*



Segment Discussion

Along the FM 1417 corridor segment, one fatal injury and two serious injury crashes occurred when the lighting conditions were recorded as dark with no lighting.

The most common manner of collision is an angle crash where both vehicles were traveling straight, likely caused by a vehicle changing lanes into the two-way left-turn lane (TWLTL) and the other driver not paying attention. This manner of collision may also occur when two vehicles in opposing directions enter the TWLTL at the same time.

36 percent of the crashes were related to distracted driving and driver inattention. 13 of these crashes involved multiple vehicles, with one traveling straight and one stopped, such as a rear-end crash, also making this the second most common manner of collision.

Recommended Improvements

This segment of FM 1417 is located along the outskirts of the City of Sherman and therefore generally has less lighting and fewer signs. Advanced warning signs and signals, and safety lighting could alert drivers of the upcoming conflict points where vehicles may slow down to turn or stop. Safety lighting would also improve the visibility of the intersections, as well as the overall road geometry and other potential hazards ahead such as fixed objects, pedestrians, and animals along the road.

Rumble strips paired with wider edge lines increase the visibility of the travel lanes and physically alert the driver of the lane departure. This may enhance the warning to drivers as they change from the main lane to the TWLTL. Intersection warning signs could improve awareness of the potential for conflict when vehicles from the opposing direction are using the continuous turn lane to turn left as well.

Source	Improvement	Reduction %
HSIP – 124	Install Advanced Warning Signals and Signs (Intersection)	27
HSIP – 128	Install Advanced Warning Signs (Intersection)	5
HSIP – 304	Safety Lighting	49
HSIP – 305	Safety Lighting at Intersection	13
HSIP – 532	Milled Edge Line Rumble Strips	15
FHWA PSC	Wider Edge Lines	N/A

Crash Severity	Count
Fatal (K)	1
Serious/Incapacitating Injury (A)	7
Minor/Non-Incapacitating Injury (B)	17
Total for All Crash Severities	97

5.2.1 Additional Locations for Safety Recommendations

During the March 2022 Grayson County MPO TAC Meeting, the members of the TAC noted the high frequency of crashes along US 377 compared to SH 289, despite the similarity of the roadway geometries and existing conditions. The members of the TAC also expressed concern for the significant upcoming development along US 377, through Tioga and Pilot Point, and the implications it may have on the future safety of the corridor.

Both corridors generally run north-south and consist mainly of one 12-foot lane in each direction and shoulders on either side with widths ranging from eight feet to 12 feet. The posted speed limit along US 377 through Grayson County is consistently 55 mph, while along SH 289 the posted speed limit ranges from 45 mph to 70 mph with a majority of the corridor being 65 mph or higher. The 2020 ADT volume is generally about 1,000 vpd to 2,000 vpd higher on US 377 than SH 289, with lower daily volumes at the norther end of the corridors and greater volumes to the south.

Although US 377 and SH 289 appear to have similar characteristics within Grayson County, from 2019 through 2021 the section of SH 289 had nearly half as many fatal crashes, over 20 percent fewer serious injury crashes, and over 20 percent lower total number of crashes than the section of US 377. South of US 82, SH 289 had only a third as many fatal crashes and half the total number of crashes as US 377 south of US 82.

The Grayson County MPO TAC members noted that portions of SH 289 have recently been reconstructed, likely a factor in the lower crash count on SH 289. Upon an initial review of the existing conditions in March 2022, SH 289 appeared to be overall in better condition than US 377, with newer signs, pavement markings with greater visibility, prevalent rumble strips, and smoother pavement. US 377 appears to have more access points, including roads and driveways, and unaligned intersecting state routes and county roads, all of which increase the number of conflict points. Unaligned intersections lead to higher safety risks and greater congestion, as vehicles must make two turns to remain on a road instead of continuing straight through a four-way intersection. However, multiple stop-controlled minor street approaches along US 377 had some new signage, such as LED-embedded stop signs.

A road safety audit (RSA) is recommended along US 377 to further investigate the historic crash data and existing conditions to determine the most common crash types, contributing factors, and manners of collision and analyze differences between US 377 and SH 289 that may be linked to the greater number of crashes on US 377. An RSA could identify potential improvements with considerations for all road users and the future growth in the region.

5.3 Operations Improvements

Regional and local operational improvements are discussed below related to ITS and other technology deployments in the region.

5.3.1 Regional Improvements

TxDOT has identified a plan for additional deployment of CCTV cameras along US 75, US 82, US 377, SH 91, Spur 503, and FM 1417. Additional DMS have also been planned for US 75 and US 82. Deployment of these devices should be a priority to increase the operational capabilities of TxDOT on major routes in the region. In addition, TxDOT has been deploying CCTV cameras at signalized intersections in

Grayson County to improve their ability to monitor and respond to issues at traffic signals. Continued deployment of these cameras should also be prioritized to support improvement traffic signal operations and allow TxDOT to respond more quickly to traffic signal issues.

Four strategies were identified to improve regional operations. These strategies should be focused first on US 75, US 82, and other segments identified in operations key segment prioritization list table presented in **Table 6**. Strategies include the following:

- **Joint TMC** to act as the hub of future operations for freeway and arterial management.
- **US 75 Freeway Service Patrol** to support incident management on US 75 including improved safety and reduced congestion due to incidents.
- **Comprehensive Traffic Signal System Upgrades** to improve traffic signal performance, provide responsive traffic signal timing, provide emergency vehicle traffic signal preemption, and improve response times to address traffic signal issues.
- **Automated Traffic Signal Performance Measures (ATSPMs)** to continually track traffic signal performance and respond quickly to any changes in performance.

STRATEGY: JOINT TRAFFIC MANAGEMENT CENTER

Objective

Plan for and establish a jointly operated regional TMC to support freeway and arterial traffic management and traveler information dissemination throughout Grayson County.

Need

Several regional partners, including the TxDOT Paris District, have identified the need for improved collaboration in traffic management activities among the agencies who operate transportation systems within Grayson County. While the TxDOT Paris District is considering the development of TMC as part of its planned reconstruction of the TxDOT Paris District Headquarters, constructing and maintaining a TMC within Grayson County that is jointly operated by TxDOT and local agency staff would allow for improved regional traffic management along key freeway facilities in the area. In addition, with the City of Sherman expected to take over TxDOT signals within city limits by 2030, there will be a new need for city staff to actively manage signal operations from a centralized location.

Implementation Recommendations

Prior to constructing the TMC, a systems engineering analysis and concept of operations study should be completed to identify the traffic management needs of all stakeholders who would be supporting the facility's development. This study should establish objectives and functional requirements that will be validated once the TMC is implemented. Conducting this study will also help each partner agency identify what agency staff and how many would sit at the TMC, potential funding sources that could support construction and sustain operations, and potential locations for the TMC that meet space and communications connectivity requirements. Once this framework has been developed, the TMC should be constructed as funding allows. The TMC will likely need to operate only during peak travel periods initially. With continued population growth in the region, extended hours may eventually be advantageous for improving regional traffic operations.

Expected Benefits

A regional TMC would allow the TxDOT Paris District, City of Sherman, and any other partners involved to detect, verify, and respond to incidents more quickly. A regional TMC would also enable the TxDOT Paris District to maintain a centralized dispatch and operations center for the operation of a freeway safety service patrol along area freeways. From this location, both the TxDOT Paris District and City of Sherman could also manage traffic signal corridors and adjust timings in response to changing arterial traffic conditions.

Strategy and Best Practice

The City of Lubbock and the TxDOT Lubbock District operate a joint TMC. The TMC was first installed through a partnership with Texas Tech University in 2007. In addition to daily traffic monitoring operations, the TMC continues to provide real-time highway video feeds to dispatchers and first responders. Through this partnership, the TMC is an integral part of coordination for incident response by providing accurate location and incident information to emergency management services.

STRATEGY: US 75 FREEWAY SERVICE PATROL

Objective

Establish a freeway service patrol that operates along US 75 within Grayson County to reduce response and clearance times for minor traffic incidents and provide support to first responders in larger traffic incidents.

Need

There is currently some surveillance along US 75 in the form of CCTV cameras maintained and operated by the TxDOT Paris District, but several gaps in coverage exist in the more rural parts of Grayson County. For stretches of those roads without deployed CCTV cameras, vehicles that become disabled or involved in a crash often go undetected until they are reported to law enforcement. Of all facilities within the County, US 75 experiences the greatest total number of crashes, and due to the persistent traffic volumes along the freeway also experiences the greatest amount of travel disruption due to those crashes. Law enforcement and towing service response times are often slow in rural portions of the County, leaving motorists in the traveled way for longer periods and increasing the risk of secondary crashes.

Implementation Recommendations

A freeway service patrol program can provide a wide variety of services. Identifying the core services that are desired for such a program can dictate the vehicles, equipment, and staff training that is required of operators. Stakeholders should consider at a minimum including motorist assistance and traffic control equipment on patrol vehicles and may also consider vehicle relocation capabilities to assist with relocation of disabled vehicles away from travel lanes. Stakeholders should also identify desired hours of operation for the service. Many service patrols often begin by operating during morning and afternoon weekday peak periods only, eventually expanding to midday service and incorporating other event operations as needed. These decisions allow for the development of a program budget and staffing approach that can be used to secure sustained program funding. TxDOT has implemented these services through use of TxDOT staff and equipment, as well as through contract service by a private provider.

Expected Benefits

Freeway service patrol benefits depend on the level of program deployment and the services provided, but an agency can generally expect a freeway service patrol program to reduce traffic incident duration, remove debris from the road more quickly, help stranded motorists and crash victims, and improve traffic control and incident scene management along the routes of operation. Secondary benefits include improved traffic flow and safety because of reduced traffic incident duration.

Strategy and Best Practice

Several regions throughout Texas operate freeway service patrol programs known as Highway Emergency Response Operator (HERO) programs. HERO patrol vehicles are deployed along freeways during peak travel hours and can also be deployed during construction events to minimize the impacts of traffic incidents when freeway capacity is already limited. Some HERO vehicles are equipped with "snatch-and-grab" towing apparatus that allow operators to relocate disabled vehicles off the freeway. Often, HERO vehicles are the first responders to detect incidents and are also first to arrive on scene. Some agencies, such as the Tennessee DOT, also provide a "lite" version of their freeway service patrol vehicles to serve rural parts of the state. These vehicles are usually smaller with less equipment than standard patrol trucks, but still provide similar benefits.

STRATEGY: COMPREHENSIVE TRAFFIC SIGNAL UPGRADES

Objective

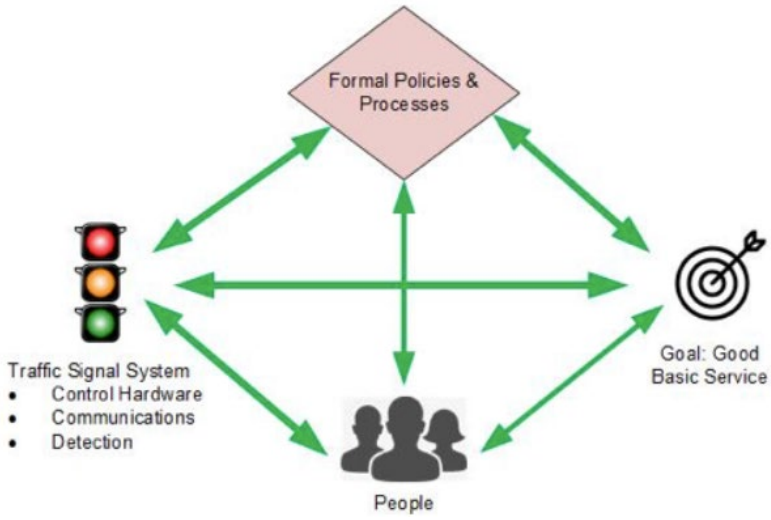
Install modern vehicle detection systems and CCTV surveillance cameras at signalized intersections across Grayson County, and invest in emergency vehicle preemption technology deployments along major response corridors.

Need

Only two freeways (US 75 and a segment of US 82) pass through Grayson County. The remainder of all vehicular traffic navigates through the region via surface street networks where major intersections are controlled by traffic signals that are currently operated and maintained by the TxDOT Paris District. The Paris District identified a need to upgrade signal technology currently in use as part of its recently completed Transportation Systems Management and Operations (TSMO) Program Plan. Furthermore, the City of Sherman will likely take over operation and maintenance of traffic signals from TxDOT that are within city limits following the 2030 Census. Stakeholders have identified improving arterial mobility through enhanced responsiveness to changing conditions as a priority.

Implementation Recommendations

Stakeholders should review traffic signal inventory records from the TxDOT Paris District to determine the existing technology deployed at traffic signals and cabinets from throughout Grayson County. If this data is unavailable or incomplete, a new traffic signal system inventory should be conducted to collect this data. Detection upgrades to modern systems, such as video or radar detection, should be budgeted for intersection approaches that have obsolete or otherwise defunct detection as well as approaches without detection systems currently in place. Stakeholders should also develop a prioritized list of corridors and hotspot intersections in partnership with local public safety agencies for deploying CCTV and emergency vehicle preemption systems.



Expected Benefits

Improving the functionality of vehicle detection systems across the traffic signal network in Grayson County will reduce overall vehicle delay and improve travel times through signalized intersections by improving the effectiveness of existing signal timing plans that operate based upon detector actuation. Furthermore, installing CCTV cameras at signalized intersections will improve stakeholder capabilities for remotely diagnosing malfunctions and reducing equipment downtime. CCTV cameras, in conjunction with emergency vehicle preemption technology, will also help reduce incident detection and response times for crashes that occur on the arterial road network.

Strategy and Best Practice

FHWA has established guidance to support agencies who want to improve traffic signal system operations. One way to do so is to establish a traffic signal management plan, which is a document that helps transportation professionals strategically connect their activities related to traffic signal design, operations, maintenance, and management with the goals and objectives of their agency. The design of infrastructure that supports active traffic management is one common component of these plans, especially when a traffic signal system undergoes an ownership transfer between agencies.

STRATEGY: AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES

Objective

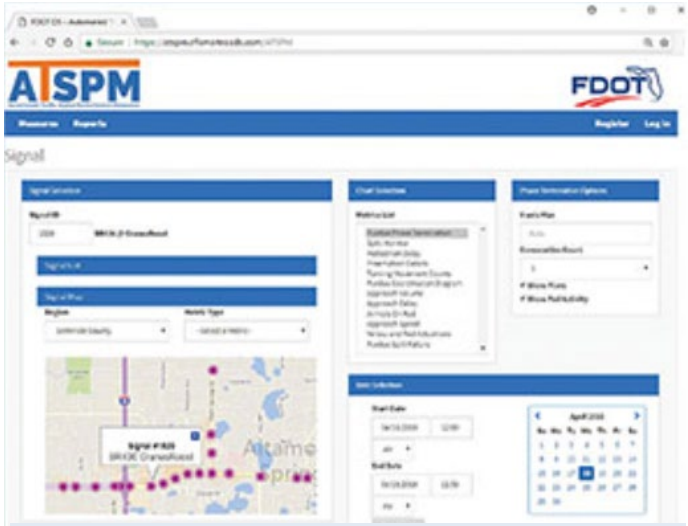
Develop and implement an approach for collecting and tracking traffic signal system performance data, including system uptime and vehicle delay, and use performance measurement information to guide signal corridor retiming efforts.

Need

The TxDOT Paris District currently retimes signals on an as-needed or requested basis within Grayson County. There is no current signal program in place to evaluate and update signal timings in a scheduled manner. Furthermore, some stakeholders identified that routine maintenance work has sometimes caused signals to become uncoordinated with those along the rest of the corridor. Without any way to automatically detect when this occurs, these uncoordinated signals can operate inefficiently for weeks or months at a time. In response to the identification of these challenges and as part of Transportation Systems Management and Operations (TSMO) Program Plan development, the TxDOT Paris District identified the need to explore the implementation of ATSPMs to set goals and track signal performance.

Implementation Recommendations

Stakeholders, led by the TxDOT Paris District, should first formalize ATSPM program objectives by selecting performance measures to focus on, determining how ATSPM data will be managed and analyzed, and establishing criteria for prioritizing which signals to deploy signal cabinet upgrades to first. A traffic signal system inventory will also be necessary to identify which signal cabinets in Grayson County already have equipment compatible with the desired ATSPM system. Newer traffic signal locations are more likely to already be compatible, but not all equipment may support ATSPM data collection. Once all this data and planning has been completed, a budget can be developed for phased implementation of signal cabinet technology upgrades needed for ATSPM compatibility. Single location upgrades can be the more cost-effective option for implementing ATSPM, but linear deployments along a major corridor provide the greatest benefit overall.



Strategy and Best Practice

Seminole County, in Florida, operates 387 traffic signals that are now all recording high-resolution traffic data using an ATSPM program. The County partnered with the Florida DOT to get the technology up and running. The County now uses ATSPM data in place of manual traffic data collection. Lane-by-lane detection capabilities also allow the County to calculate useful operations information, such as approach delay and speed, signal cabinet equipment failures, and automatically generated signal coordination diagrams.

Expected Benefits

ATSPM analysis allows for more effective signal timing plans, and the data can help stakeholders in reducing delay, reducing conflicting movements, supporting proactive maintenance activities, or pursuing other goals related to signal operations. Ultimately ATSPM deployments will provide relief to traffic signal system managers who experience staffing shortages by providing remote system diagnostics and analytics, cutting down on the frequency and duration of signal maintenance trips.

5.3.2 Additional Locations for Operations Recommendations

FM 121 through Van Alstyne was identified as a particular concern for future travel due to the required two turns to get onto and off of SH 5. FM 121 currently has about 5,000 to 6,000 vehicles per day but traffic is expected to increase and the MPO is concerned that as traffic reaches 10,000 vehicles per day the system may experience severe congestion.

Operationally, the system is constrained by the turns and limited number of lanes. Without realigning or adding additional turn lanes, improved signal operations provide the greatest opportunity to maximize throughput and keep this segment operating at an acceptable level of service. On the previous pages, the use of a ATSPMs to optimize signal operations is recommended. An ATSPM program, combined with an active TMC that is staffed to monitor the intersection using CCTV cameras and continuous feedback from the ATSPMs, will allow the region to operate these signalized intersections for as long as possible before considering more costly improvements such as realignment or additional lanes.

5.4 Funding Opportunities

5.4.1 Highway Safety Improvement Program

Each fall, TxDOT releases a call for projects as part of its Highway Safety Improvement Program (HSIP). HSIP is a data-driven and performance-focused core federal aid program that exists to achieve a reduction in traffic fatalities and serious injuries on all public roads. HSIP funding is provided by the federal government and administered by the TxDOT Traffic Safety Division through Category 8 project funding. Each year, approximately 90 percent of HSIP funding goes to projects that are on the TxDOT roadway network. The remaining 10 percent of funding is awarded on a competitive basis to projects that are on Texas roads that are not maintained by TxDOT.

The application process for off-system roads involves completing a benefit-cost analysis using expected benefits of highway safety countermeasures based upon certain TxDOT work codes. The Grayson County MPO's Safety and Operations Strategic Plan includes potential countermeasures and associated TxDOT work codes that could be used in support of HSIP applications at crash hotspots throughout the region. The call for applications each year generally opens from September through December, with project selections announced early the following year. Off-system HSIP applications are submitted through the local TxDOT District office, which for the Grayson County MPO would be the TxDOT Paris District.

Projects that are successful receive HSIP funding through TxDOT that covers 90 percent of construction costs. Local contributions are required for the remaining 10 percent of construction costs and any design costs. Certain projects, such as roundabouts or signing and striping projects, may be eligible for 100 percent HSIP funding of construction costs. The Grayson County MPO member agencies have been successful recipients of past HSIP project awards.

5.4.2 Safe Streets and Roads for All

In May 2022, the USDOT released a notice of funding opportunity for the first year of the five-year SS4A discretionary grant program. The program is funded at $5 billion across fiscal years 2022-2026. The program is open to sub-state entities of government, including MPOs, counties, cities, transit agencies, and tribal governments, and applicants are encouraged to submit applications as multijurisdictional groups of those governmental entities.

SS4A provides grant funding for two types of transportation safety efforts: the development of transportation safety action plans for entities that do not yet have one, and the implementation of recommendations from previously developed action plans. Both grant program tracks require a 20 percent local match of funding or other in-kind contribution.

The Grayson County MPO does not yet have a comprehensive transportation safety action plan developed, so the agency would be eligible to submit an SS4A application along the action plan track. The expected minimum funding level for action plan grants is $200,000, while the expected maximum funding level for action plan grants is $5,000,000 for MPOs or other joint applications from coalitions of agencies. In fiscal year 2022, it is expected that up to 40 percent of the total value of grants awarded will be for action plan development.

While the submittal period for fiscal year 2022 SS4A grant applications closed in September 2022, the Grayson County MPO can review existing identified safety program needs and recommendations in preparation for an action plan grant application for submittal in the fiscal year 2023 funding round. USDOT's desired focus for action plan development is the prevention of roadway fatalities and serious injuries, so recommendations related to these crash severity types should form a central part of the grant application. The Grayson County MPO should consider leading the application process in collaboration with member cities, counties, and other agencies, as collaborative applications are encouraged by the USDOT and are eligible for a greater amount of funding as part of an individual grant award.

The Grayson County MPO Safety and Operations Strategic Plan identifies transportation safety needs for the region but does not qualify as an action plan for SS4A. In general, action plan development should include the following components and activities:

- Official public commitment from agency leadership to an eventual goal of zero fatalities and serious injuries on roads.
- Establishment of a task force or committee for action plan development and implementation.
- Analysis of existing conditions and historical trends related to transportation safety.
- Robust and inclusive public engagement and practitioner stakeholder engagement.
- Equity impact assessments related to transportation safety.
- Assessment of existing policy and processes and identification of recommended changes to improve traffic safety.
- Identification of a comprehensive set of recommended transportation safety projects and strategies.
- An approach to ongoing measurement of plan implementation progress and maintenance of transparency in implementation efforts.

Once the Grayson County MPO has developed a safety action plan, staff can submit an implementation grant application in a subsequent fiscal year for funding through the SS4A program. Implementation grants would provide funding for the construction or implementation of recommended transportation safety projects and strategies identified in the completed transportation safety action plan. USDOT expects the minimum implementation grant award to be $3,000,000 for projects in rural areas, and the maximum award for MPO-led or joint applications to be $50,000,000.

Implementation grant applications can be for a variety of countermeasures and are assessed according to four different project criteria:

1. Safety Impact
2. Equity, Engagement, and Collaboration
3. Effective Practices and Strategies
4. Climate Change, Sustainability, and Economic Competitiveness

5.4.3 Strengthening Mobility and Revolutionizing Transportation

In late 2022, USDOT will release a notice of funding opportunity for the first year of the five-year Strengthening Mobility and Revolutionizing Transportation (SMART) discretionary grant program. The SMART program provides funding to conduct demonstration projects focused on advanced smart community technologies and systems to improve transportation efficiency and safety. The program is funded at $100 million per year across fiscal years 2022-2026. Many public entities, including states, cities, counties, transit agencies, and MPOs, are eligible to apply for a SMART grant.

SMART grants will be awarded to projects that demonstrate smart community technologies in one or more of the following focus areas:

- Coordinated automation
- Connected vehicles
- Sensors
- Systems integration
- Delivery and logistics
- Innovative aviation
- Smart grid
- Traffic signals

While detailed scoring criteria for grant applications is not yet available, it is expected that candidate projects will be assessed on merit factors that include safety and reliability, equity and access, climate and resilience, and system integration. Several recommendations from the Grayson County MPO Safety and Operations Strategic Plan could potentially be expanded into a deployment project for a SMART grant application.

For example, the establishment of a TMC allowing for incident management along TxDOT facilities and arterial management within the cities of Sherman and Denison could be incorporated with freeway service patrol and traffic signal system upgrades into a project that could align well with the safety and reliability and system integration merit factors. The deployment of EV charging technology and integration with existing TxDOT systems and regional traveler information systems might be a project that aligns well with the climate and resilience and system integration merit factors.

6 ELECTRIC VEHICLE CHARGING STATIONS

Section 6 introduces the existing facilities and increasing demand for electric vehicle (EV) charging stations within Grayson County as well as statewide. This section reviews the three types of EV chargers and identifies four proposed sites for the deployment of EV charging stations in the City of Denison and the City of Sherman.

6.1 Electric Vehicle Trends

According to the Dallas-Fort Worth Clean Cities Coalition, a program of the North Central Texas Council of Governments (NCTCOG) and the Regional Transportation Council that promotes the improvement of air quality by reducing transportation energy use, 140,014 EVs had been registered throughout the State of Texas as of August 1, 2022.

Just within a five-month span, Texas has seen a drastic increase of over 21 percent in its number of registered EVs. From March 1, 2022 to August 1, 2022 the San Antonio region saw the biggest increase in the number of EVs at 36.5 percent, as shown in **Figure 22**. However, the Dallas-Fort Worth region made up 36 percent of all EVs registered in Texas as of August 2022, leading all metropolitan areas in Texas in the total number of registered EVs with 49,783. Grayson County, just north of the Dallas-Fort Worth Metroplex, experienced significant growth in its number of EVs, increasing two percent more than the statewide average. Approximately 0.26 percent of all registered vehicles in Grayson County were electric in August 2022, when five months prior 0.22 percent were electric. This means that although the total count of registered vehicles in Grayson County has increased, more EVs are being registered than in the past.

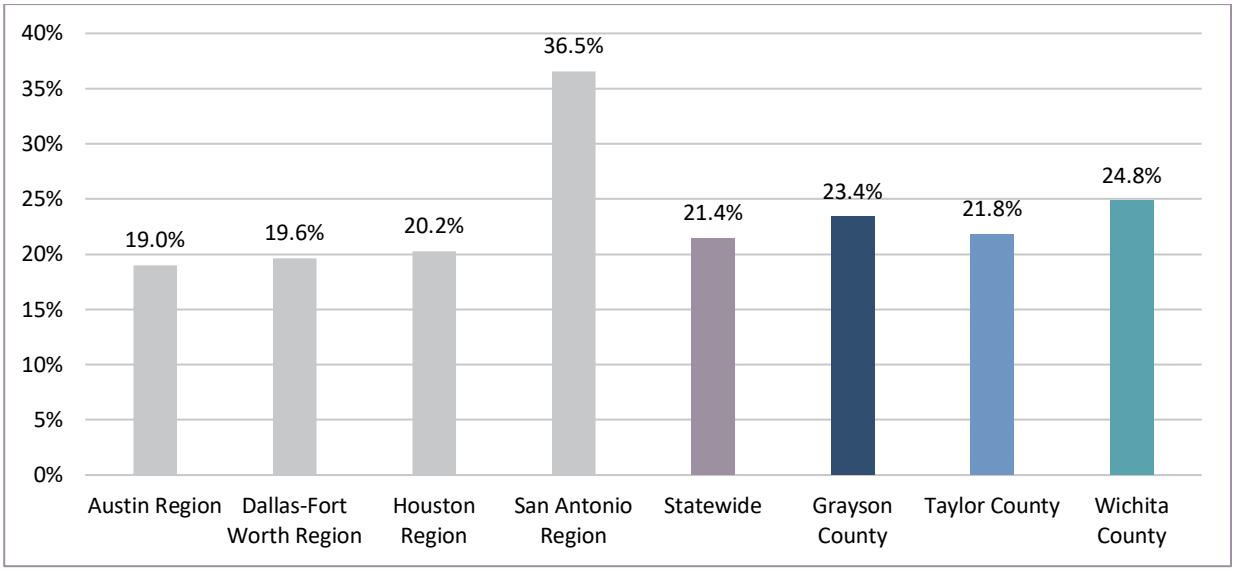


Figure 22 – Percent Growth in Number of EVs from March to August 2022

Similar counties, Taylor County and Wichita County, increased more than the statewide number of EVs as well. Although Wichita County's number of EVs increased more than Grayson County's, **Figure 23** shows that Grayson County ranked 31st in number of EVs among other Texas counties with 343 registered EVs at the beginning of August while Wichita County only had 196.

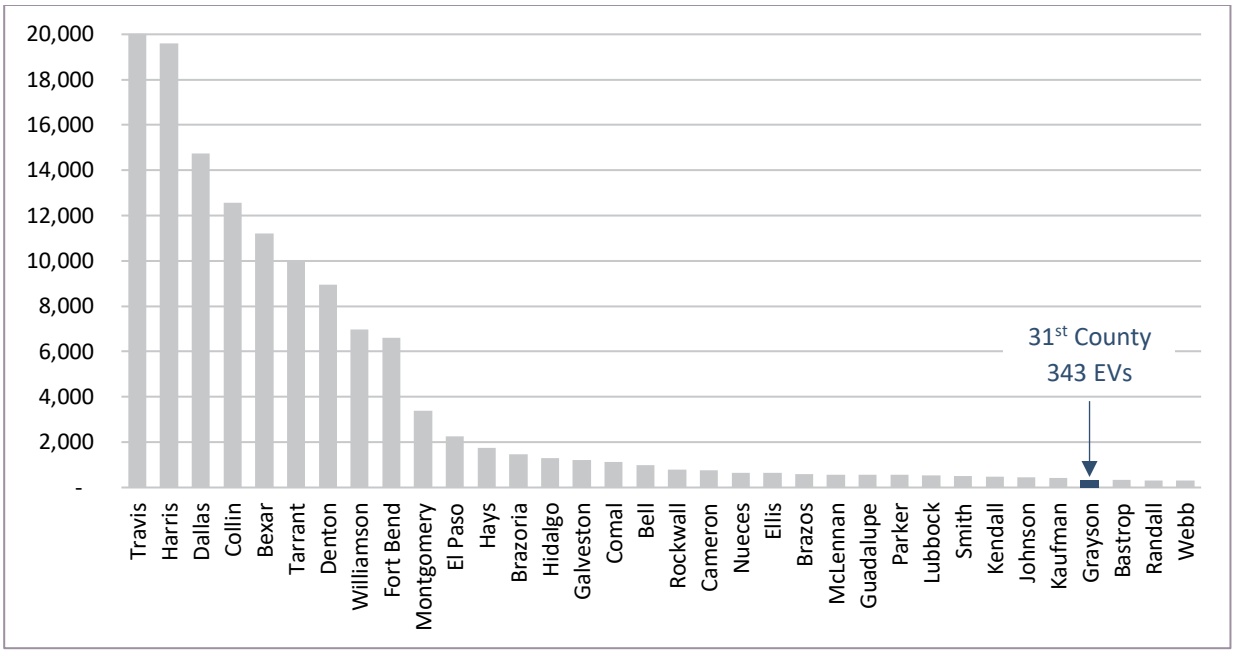


Figure 23 – Number of Registered EVs by County in August 2022

6.2 Existing Electric Vehicle Infrastructure

There are over 2,000 charging stations throughout Texas and due to the increasing demand, numerous new stations are planned or already under construction. Because the Dallas-Fort Worth region has the greatest volume of EVs, it also has a high density of EV charging stations. The US Department of Energy's map in **Figure 24** displays EV charging station locations in North Texas. Currently, there are few EV charging stations north of the City of Denton and the City of McKinney until US 75 reaches the City of Sherman.

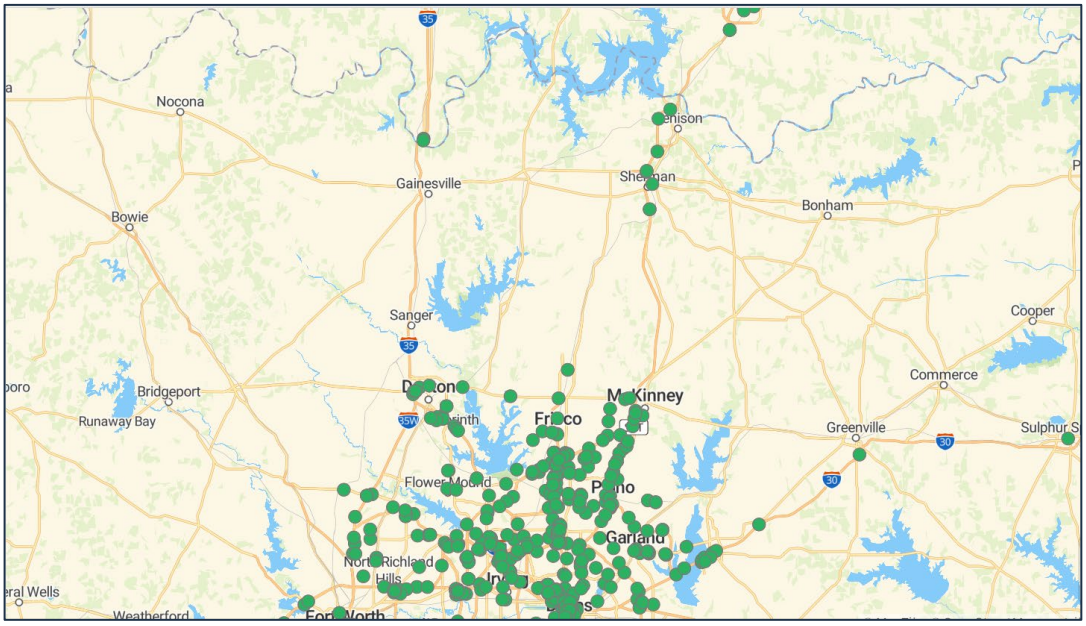


Figure 24 – Existing EV Charging Stations in North Texas

Most of the existing EV charging stations within Grayson County are located along US 75, likely because US 75 is a key north south route through the larger cities of Sherman and Denison and connects Oklahoma to the Dallas-Fort Worth region. **Figure 25** shows the EV charging locations within Grayson County as identified by PlugShare, a mapping and route planning tool that allows users to find EV charging stations recommended by TxDOT. PlugShare provides users with information including the type of EV charging station plug, power, payment requirements, and charging station reviews for each location. Three of the nine existing EV charging stations within Grayson County do not require payment and the orange station indicates that the station is a high-power supercharger EV charging station.

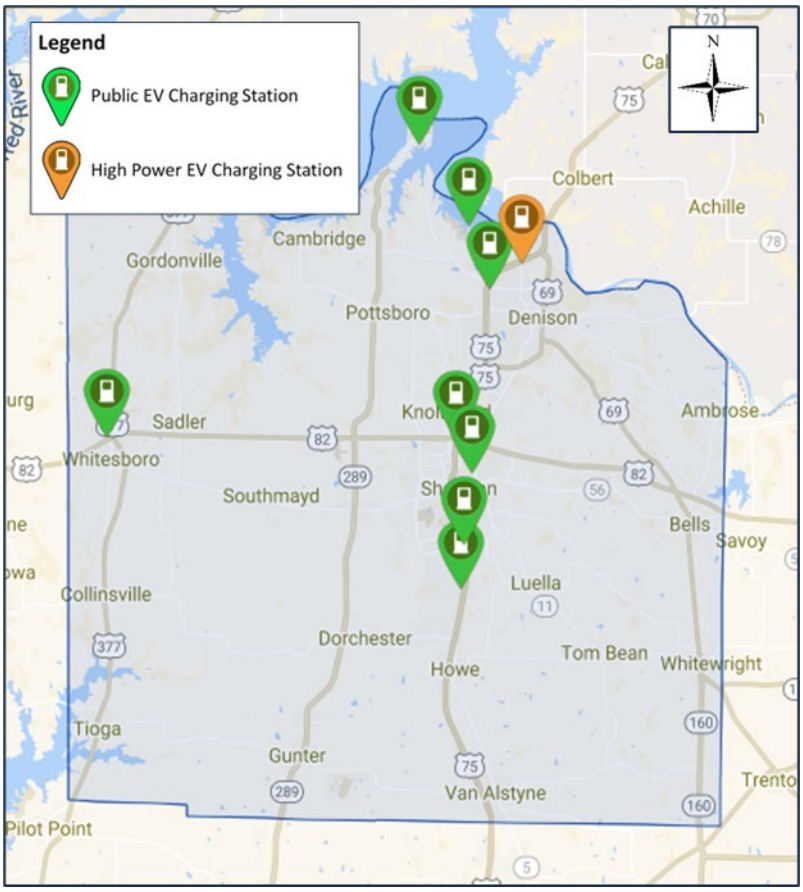


Figure 25 – Existing EV Charging Stations in Grayson County

6.3 Types of Chargers

There are three common types of EV chargers: Level 1, Level 2, and Direct Current Fast Charging (DCFC). Characteristics and feasibility for deployment of each are discussed below.

6.3.1 Level 1

A Level 1 EV charger is a standardized charging cable that EV manufacturers typically provide with the vehicle at the time of purchase but can also be purchased for under $500. The charging cable plugs directly into a standard 120 volt (V) alternating current (AC) outlet, which supplies an average of 1.9 kiloWatts (kW). This slowest type of EV charger results in a charging rate of about two to five miles of EV range per hour, making it best suited for personal use at home so the vehicle can charge for long periods of time such as overnight.

6.3.2 Level 2

Level 2 EV chargers charge faster but come at a higher price due to more equipment and power used than the Level 1 chargers. These chargers charge at a rate of 10 to 20 EV miles per hour of charge, making them best suited for commercial areas where drivers will be at one location for an extended period-of-time, including movie theaters, shopping centers, and employee parking lots. The price of a

Level 2 charger ranges from $500 to $8,000 per charger for equipment and $600 to $13,000 per charger for installation depending on the existing conditions of the site where the charging station is deployed. These chargers utilize 240 V outlets to draw 10 kW, which may require utility service and framework upgrades if the surrounding infrastructure already uses most of the available resources, therefore resulting in additional costs.

6.3.3 Direct Current Fast Charging

DCFC stations, commonly referred to as Level 3 chargers, are the most practical for long distance driving and areas drivers do not tend to stay parked for long such as grocery stores, rest stops, and individual shops because they have the fastest charging rate of 150 to up to 400 EV miles per hour of charge. To achieve this fast-charging speed, these chargers pull 50 to 180 kW and require a power control system (PCS) to convert AC to direct current (DC). The cost of DCFC stations also has a wide range due to the many variables of every site's existing condition, the necessary utility service upgrades, and additional equipment to convert the power source to a useable form. The cost of equipment ranges from $15,000 to $40,000 per charger and the cost of installation ranges from $8,000 to $50,000 per charger.

6.4 Electric Vehicle Charging Station Considerations

Aside from the type of charger, many other factors must be considered when determining the feasibility of deploying EV charging stations and where the optimal parking stalls are. These factors include existing utilities, available power supply, Americans with Disabilities Act (ADA) accessibility, and room for charging station equipment.

6.4.1 Power Supply

Coordination with the local utility provider is essential in site selection as well as identifying optimal parking stalls for installing EV charging station equipment. There must be access to a power source nearby for the charging equipment to connect to without impacting the power supply to neighboring facilities that are already utilizing that source. Oncor is the main electricity provider in North Texas, including Grayson County. Due to the large number of existing EV charging stations in the North Texas region, Oncor is likely familiar with the process for estimating the power demand a new EV charging station site will have and determining if there is sufficient available supply in the vicinity.

6.4.2 Accessibility

Federal guidelines regarding EV charging station accessibility require two aspects of accessibility: mobility and communication. Accessible mobility features consider physical access for people who use mobility devices, such as wheelchairs, walkers, and canes and the physical operability of the charger. Accessible communications features allow enables users who are deaf or hard of hearing and other people with disabilities who do not need accessible mobility features to use the charger.

Some states, counties, and cities have specific ADA requirements for EV charging stations in addition to the federal guidelines. Texas Accessibility Standards require 20 percent of proposed EV charging stations to be ADA accessible, with no fewer than one accessible EV charging station. The parking stall is required to be at least 96 inches wide and provide an accessible route with a minimum width of 36 inches on both sides, accompanied with the appropriate ADA and EV charging station signage.

6.4.3 Equipment Placement

Considerations for installing EV charging stations along the outer edge of a parking lot, typically adjacent to sidewalks or a street, include excessive light, utility access, city or county ordinances, and right of way. Some EV charging station equipment includes lights or bright screens that may conflict with existing street illumination and may be confusing or distracting to drivers. Utilities are typically located along the property line; therefore a power source is likely easier to access from a charging stall at the edge of a parking lot. However, city or county ordinances for building set back distances and right of way boundaries could limit how close charging station equipment can be placed to adjacent streets, preventing the installation of EV charging stations along the edge of a site.

Factors that may impact installing EV charging stations at inner stalls, not along the outer edge of a parking lot, include space and protection for equipment and additional width for ADA accessibility requirements. While EV charging technology continues to advance and become more efficient, the charging station equipment still requires more space per vehicle in a parking lot than a standard parking stall. If placed in the center of a parking lot, the equipment may consume space that could otherwise be used for another parking stall or vehicle movement through the parking lot. However, if there is room between the inner rows where equipment can be placed, middle parking stalls can be desirable. General vehicle movement through a parking lot and given that vehicles typically pull up to park in front of the equipment, the equipment is naturally susceptible to getting hit. Raised islands, parking blocks, and bollards serve as protection for EV charging equipment by creating a barrier between the equipment and parking vehicles. Wider ADA accessible EV charging stalls also reduce the area available for other parking stalls, and if placed in the middle of a lot, exposes patrons using the stall to moving vehicles.

6.5 Potential Electric Vehicle Charging Station Sites

During the March and August 2022 Grayson County MPO TAC meetings, four sites were identified to be considered for the deployment of EV charging stations, shown in **Figure 26**. The TAC members' interest in EV charging stations is driven by the growing number of EVs traveling through Grayson County and the desire to find a way to convert the through traffic into visitors to generate revenue.

EV charging stations could draw travelers into the downtown areas of Denison and Sherman to stop to charge their vehicles, and they could shop, eat, or attend other local attractions while waiting for the vehicle to charge. Three out of the four sites are in downtown Denison or downtown Sherman close to local attractions. The fourth site is the Denison Travel Center, which could also increase visitors by sparking travelers' interest in the area as they tour the travel center.

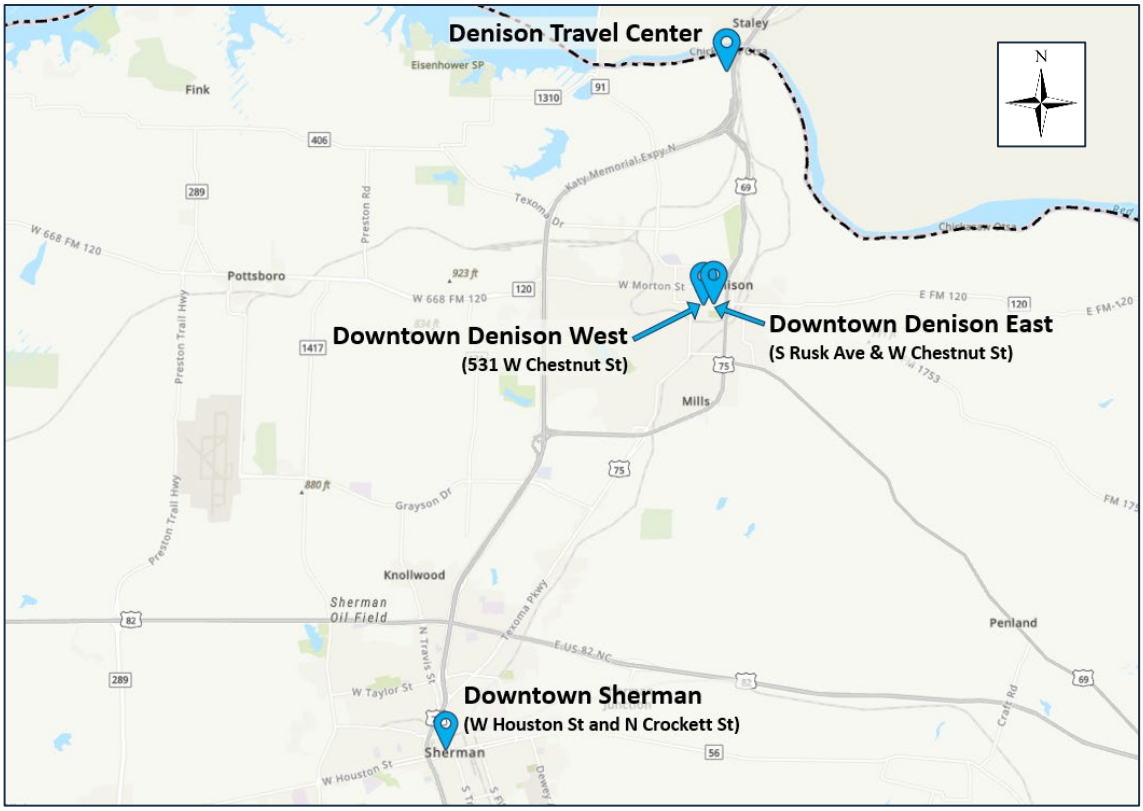


Figure 26 – Proposed EV Charging Station Sites for Grayson County

Within each site, the existing parking stalls with raised islands, parking blocks, or bollards and are near a power source are considered as optimal parking stalls for the installation of an EV charging station due to the protection provided for the equipment and convenient utilities. Stalls in the center of the parking lots are also optimal, as the light from the charging equipment may conflict with street illumination or be distracting to drivers.

Figure 27 through **Figure 30** highlight the optimal parking stalls at each of the identified potential EV charging station sites in Grayson County. The stalls highlighted green identify optimal standard EV charging station locations, while the blue highlight represents existing stalls adjacent to stripping or open pavement that could be utilized for accessible EV charging stations. To fulfil the Texas Accessibility Standards ADA accessibility requirements, at least one blue accessible EV charging stall is shown at each site and for every four green standard EV charging stalls selected, one blue accessible EV charging stall is shown. It is not mandatory for these five stalls to be connected, although it may make the utility connection and equipment installation process more efficient, as well as have minimal impacts to the existing parking lot's layout.

6.5.1 Denison Travel Center

The Denison Travel Center is located on southbound US 75/US 69, approximately a half mile south of the Texas/Oklahoma border. This site is convenient for travelers entering Grayson County from Oklahoma, as there are many vehicles traveling between Oklahoma and the Dallas-Fort Worth region. The two-way US 75 frontage road allows this site to also be accessed by both southbound and northbound vehicles. DCFCs are recommended for this site so drivers can stop at the Denison Travel Center while quickly charging their vehicle before continuing a trip. The optimal charging station parking stalls are shown in **Figure 27**.

The most optimal existing parking stall for an ADA accessible EV charging station is the northernmost stall because it is the widest of the existing stalls and would not result in the loss of other existing parking stalls. Three pairs of existing parking stalls are identified as other optimal accessible EV charging station locations due to existing striping of access aisle markings that may have designated these stalls as ADA parking in the past, which would also not result in the loss of other parking stalls. In locations where two wide ADA accessible stalls would allow for eight standard charging stalls, for a total of 10 charging stations at this site.

The current source of power for this site is a transformer located near the building. All of the highlighted stalls identified as potential charging station locations are approximately the same distance from the building and the transformer. The existing electrical infrastructure will need to be upgraded to properly serve DCFC charging stations. Further coordination with the local utility provider is needed to determine how much capacity is being utilized within the existing transformer.

The total cost of adding five DCFCs would likely be approximately $450,000, which includes equipment and installation fee. Due to the lack of EV traffic data available along this corridor and lack of visitor data for the Denison Travel Center, additional analysis is required to determine the number of potential EV charging station users (per day/week/month/year) and gauge the monthly power cost.

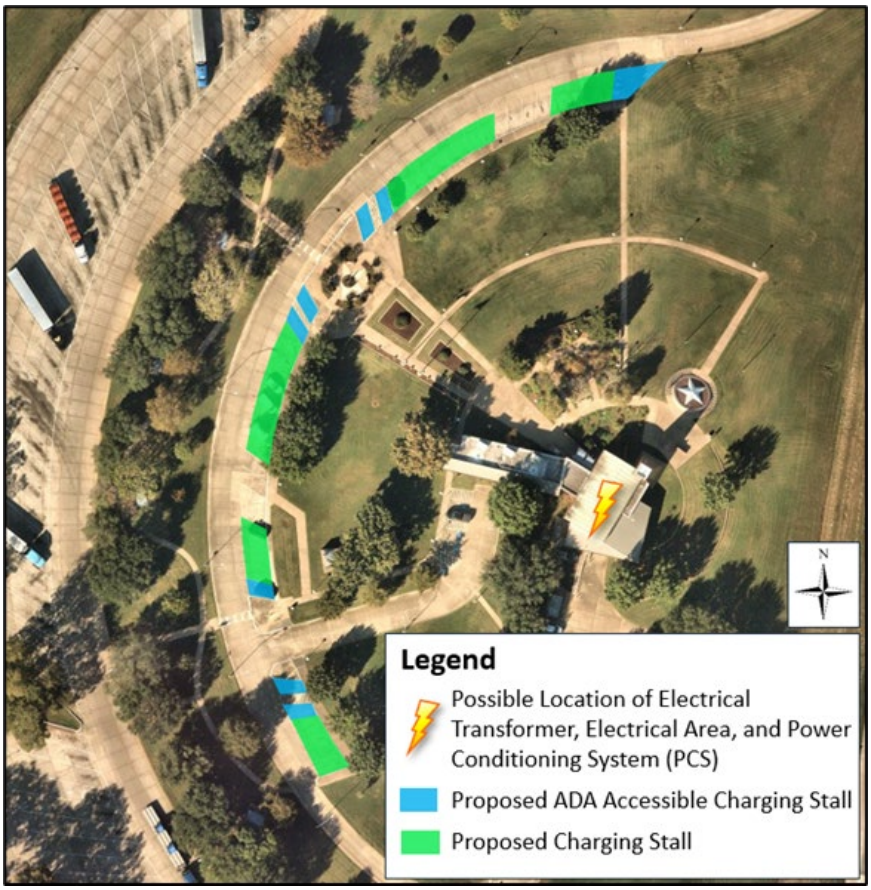


Figure 27 – Denison Travel Center Proposed EV Charging Stations

6.5.2 Downtown Denison - West

Two existing parking lots were identified in downtown Denison as potential EV charging station sites. This first lot is located at 531 W Chestnut Street, between South Mirick Avenue and South Fannin Avenue, towards the west end of the shops and restaurants concentrated along Main Street, shown in **Figure 28**.

Power is located along the north edge of the lot at multiple power poles. Level 2 charging stations are recommended for this lot so patrons can easily walk to the newly renovated Main Street to visit the numerous shops, restaurants, and other services, while charging their vehicle.

The optimal location for EV charging stations is in the center of the lot, within the two existing rows of parking stalls. Additional pavement markings stipe off wide areas at one end of each row, providing ample space for ADA accessible EV charging stalls. Stalls identified for four standard EV charging stalls are highlighted adjacent to the ADA accessible options, as they could utilize the existing striping. These two existing rows of center stalls are divided by a raised island, on which the charging station equipment could be placed and serve as protection from vehicles as they park and drive through the parking lot.

Due to the lack of EV traffic data available for downtown Denison and parking lot user data, additional analysis is required to determine the number of potential EV charging station users (per day/week/month/year) and gauge the monthly power cost. Further coordination with the local utility provider is needed to determine how much capacity is currently being used and how much is available. However, a preliminary cost estimate for the installation of Level 2 EV charging stations at this site is between $42,000 and $105,000. Cost will be dependent of access to power, number of spaces, local ordinance and set back requirements, and any accommodations needed for ADA accessibility.

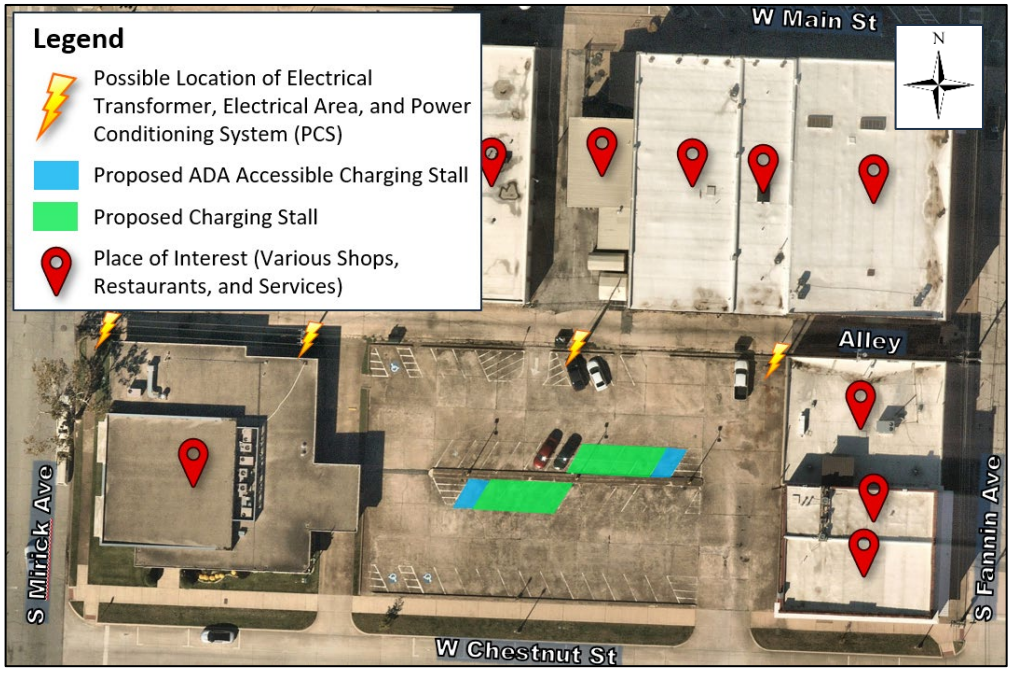


Figure 28 – Downtown Denison West Proposed EV Charging Stations

6.5.3 Downtown Denison - East

This second parking lot identified as a potential EV charging station in downtown Denison is located on the northwest corner at the intersection of South Rusk Avenue and West Chestnut Avenue, towards the east end of the newly renovated Main Street with an abundance of shops, restaurants, and services. Like the previous downtown Denison location, Level 2 EV charging stations are recommended for this site so patrons can shop or eat while they wait for their vehicle to charge.

The optimal charging stall locations are shown in **Figure 29.** Optimal locations were identified to be along the northern edge, which has an ADA accessible area, or in the center of the lot, within the two existing rows of parking stalls. The existing electrical infrastructure for this site consists of a transformer and power poles running east-west along the northern side of the parking lot and alley. These could serve as a convenient power source for the highlighted stalls at the north edge of the lot. A blue accessible charging stall is identified at this location due to the currently open space between the driveway and end parking stall, which would not reduce the total number of parking stalls in the lot.

The two existing rows of center stalls could also be converted to EV charging stalls. There is sufficient space between the two rows of parking to place the equipment for Level 2 charging stations. Although a concrete parking block exists at each stall that could provide a buffer between a vehicle and the equipment, bollards would be a more ideal preventative measure to protect the equipment. Unlike the previous downtown Denison site, extra pavement is not currently marked off at the ends of these rows. This means that if ADA accessible charging stalls were to be installed, it would result in the loss of parking stalls. Parking stalls would also be lost if DCFC stations are deployed, due to additional electrical equipment.

Further coordination with the local utility provider is needed to determine how much capacity is being utilized from the existing transformer. Again, due to the lack of EV traffic data available for downtown Denison and parking lot usage data, additional analysis is required to determine the number of potential EV charging station users (per day/week/month/year) and gauge the monthly power cost. An estimated cost range for installing Level 2 EV charging stations at this location is $42,000 to $105,000. Cost will be dependent of access to power, number of spaces, local ordinance and set back requirements, and any accommodations needed for ADA accessibility.

Figure 29 – Downtown Denison East Proposed EV Charging Stations

6.5.4 Downtown Sherman

An existing parking lot in downtown Sherman was identified as a potential EV charging station site during the Grayson County MPO TAC Meeting in August 2022. The site is located on the northwest corner of West Houston Street and North Crockett Street, at 227 West Lamar Street.

This site includes power poles on the southern and eastern edges of the property, that could be used to power the stations. Level 2 EV charging stations are recommended here so surrounding businesses can benefit from the extended stay of customers waiting for their EV to charge. In **Figure 30**, existing parking stalls are highlighted to identify optimal locations along the outer edges of the lot for EV charging stations. One blue accessible EV charging stall and four green standard EV charging stalls could be installed at any of these locations. The two locations adjacent to streets offer landscape islands for the placement and protection of the charging station equipment, as well as more convenient access to the power poles. Because the center parking stalls have no space at the front of the stalls to accommodate EV charging equipment, use of the center stalls is not recommended.

Further investigation will be needed to determine how much capacity exists within the existing transformer on site and new meters would need to be installed. EV traffic data for downtown Sherman and parking lot usage data is also not available for this site. Therefore, additional analysis is required to determine the number of potential EV charging station users (per day/week/month/year) and gauge the monthly power cost. An estimated cost range for installing Level 2 EV charging stations at this location is $42,000 to $105,000. Cost will be dependent of access to power, number of spaces, local ordinance and set back requirements, and any accommodations needed for ADA accessibility.

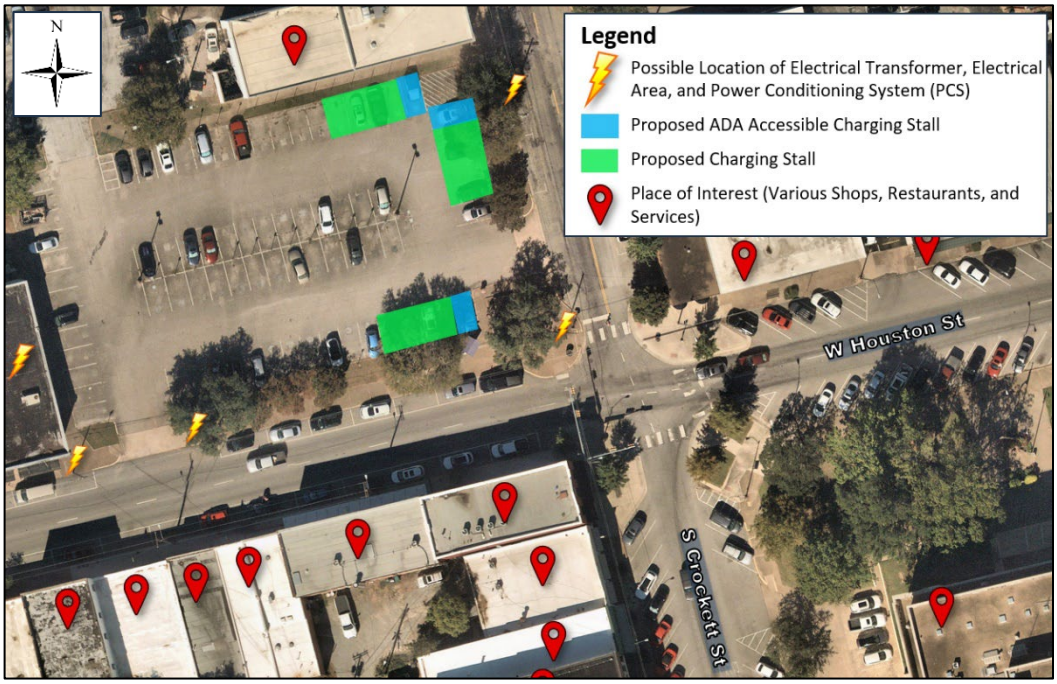


Figure 30 – Downtown Sherman Proposed EV Charging Stations

6.6 Funding Opportunities

Although the Grayson County MPO is interested in exploring increased deployment of EV charging stations throughout the region, the cost for equipment and labor is not currently budgeted. Funding sources such as grants will allow the jurisdictions to more quickly deploy EV charging stations unless additional local resources can be identified.

6.6.1 Alternative Fuel Vehicle Refueling Property Tax Credit

The Alternative Fuel Vehicle Refueling Property Tax Credit begins January 1, 2023 and continues through 2032, established by the Inflation Reduction Act of 2022 (IRA). Through this financial incentive, a commercial, industrial, government, or nonprofit corporation may receive a tax credit of 6 percent of the cost for Level 2 and DCFC EV charging equipment, up to $100,000 for each item. However, a tax credit of 30 percent for EV charging equipment, up to $100,000, may be received for projects that meet certain labor standards.

The IRA updated the requirements for the location of the refueling property to limit the tax credit to low-income communities or census tracts that were not considered urbanized areas in the 2010 Census. As defined under §45D(e) of the IRA, a low-income community is a census tract with a poverty rate of at least 20 percent or the tract's median family income does not exceed 80 percent of the statewide median family income. The property on which the charging station equipment will be installed also cannot include a building or building components, must be depreciable property whose original use begins with the tax payer, and it must be used for the storage or dispensing of clean-burning fuel, the most common alternative fuel being electricity.

New Markets Tax Credit (NMTC) Resource Center mapping tool shows the Community Development Financial Institutions (CDFI) Fund's NMTC Public Data Release, published in December 2021. This mapping tool shows the census tract eligibility for the tax credit. The four sites identified for EV charging stations in Grayson County fall within tracts shown as severe distress or non-metropolitan and eligible on the NMTC map in **Figure 31**.

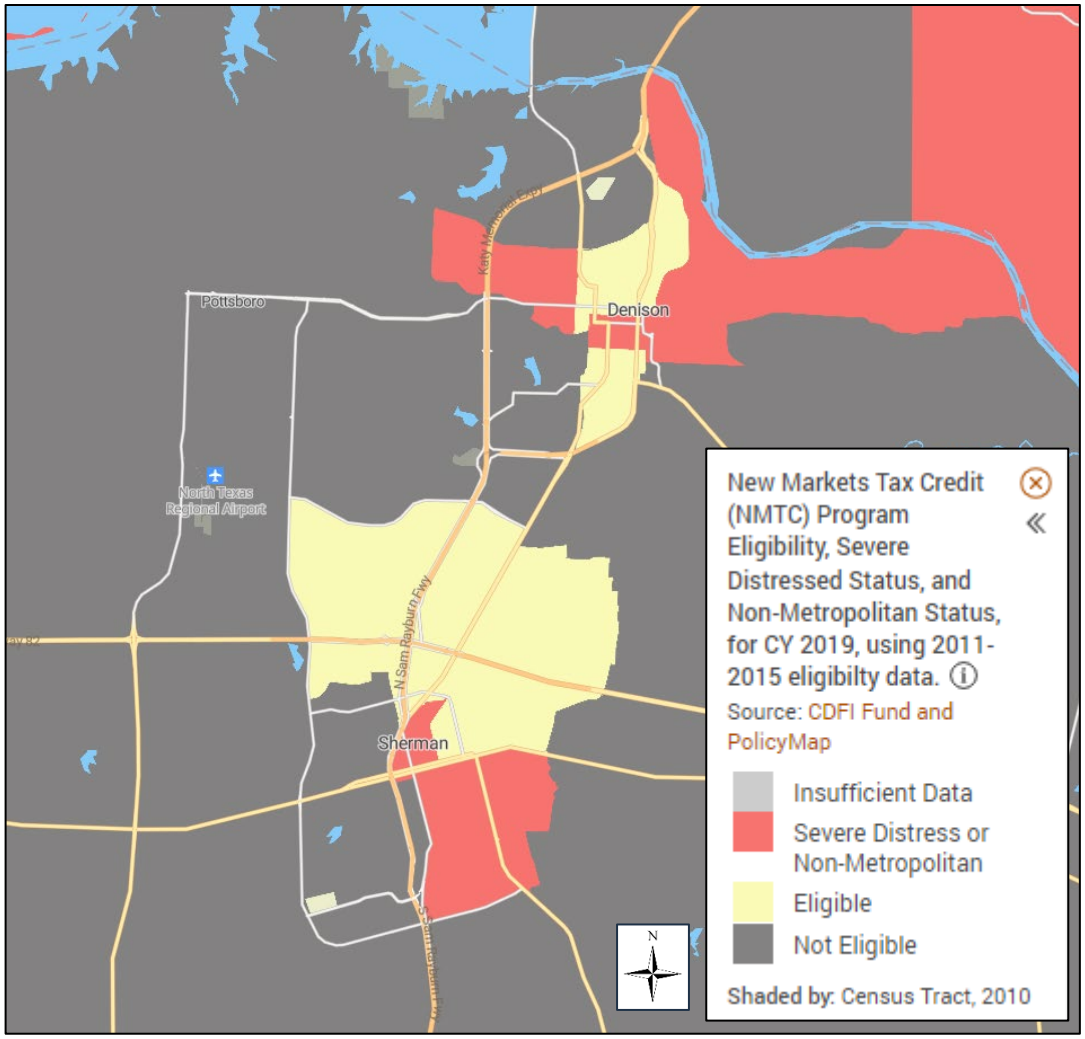


Figure 31 – New Markets Tax Credit Program Eligibility in Grayson County (2010 Census)

Additional information from the 2010 Census for the tracts each of the Grayson County EV charging station sites is located in is included in **Table 10**. All four sites are eligible for the Alternative Fuel Vehicle Refueling Property Tax Credit.

Table 10 – Grayson County Proposed EV Site New Markets Tax Credit Eligibility (2010 Census)

Site	Tax Credit Eligibility	Poverty Rate	Area Median Income (AMI)
Denison Travel Center	Not Urban Area	10	127.7
Downtown Denison - West	Severe Distress or Non-Metropolitan	17.8	69.1
Downtown Denison - East			
Downtown Sherman	Severe Distress or Non-Metropolitan	26.1	51.8

6.6.2 National Electric Vehicle Investment Program

The National Electric Vehicle Investment Program (NEVI) was established in November 2021 with the enactment of the Bipartisan Infrastructure Law. The legislation pledged to invest $7.5 billion to build out a national network of 500,000 EV chargers throughout the United States by 2030. State Departments of Transportation (DOTs) were required to review the existing alternative fuel corridors and nominate additional routes, prioritizing the Interstate Highway System by May 13, 2022. Then, the DOTs submitted their EV Infrastructure Deployment Plans to the Joint Office of Energy and Transportation. The FWHA, who released the guidance for the NEVI Formula Program, reviewed the plans and provided feedback to state departments of transportation.

TxDOT has developed the Texas EV Infrastructure Plan, which was approved by the FHWA in September 2022. The plan includes $1,224,867 for deployment of EV charging stations in the Grayson County MPO Region and $306,217 for the five-year operation and maintenance of the stations.

6.6.3 Additional Funding Opportunities

Additional funding opportunities are available for alternative fuel and renewable energy technologies. The Texas Commission on Environmental Quality provides grants to reduce emissions. Individuals, businesses, and state and local governments may be eligible for various grants under the Texas Emissions Reduction Plan (TERP), including grants for EV charging station equipment. The TERP program offers grants for new and upgraded equipment to reduce pollution and improve the air quality in Texas.

The North Carolina Clean Energy Technology Center has compiled the Database of State Incentives for Renewable and Efficiency. This data base lists about 2,500 policies and incentives throughout the United States. With 115 policies and incentives, Texas has one of the highest numbers in the nation of clean energy related initiatives, some of which are applicable to EVs and EV charging stations.

7 NEXT STEPS

The Grayson County MPO and its partner agencies are committed to meeting the goals set in the 2045 MTP related to safety, congestion, and environment. They worked in partnership to develop the Grayson County Safety and Operations Strategic Plan and identified a series of key next steps that are needed to move closer to reaching those goals. These next steps are described below.

Incorporate Systemic Safety Countermeasures Throughout the Region. Incorporate the FHWA Proven Safety Countermeasures and HSIP Systemic Safety Measures on future transportation projects in the Grayson County MPO Region. Lead agencies are the TxDOT Paris District, Grayson County, and cities with support from the Grayson County MPO.

Apply for TxDOT HSIP Funding. Apply for TxDOT HSIP funding for the highest ranked segments identified for safety improvements in the Grayson County Safety and Operation Strategic Plan. Continue to apply for HSIP funding in subsequent years until all segments have been submitted for HSIP funding. Lead agencies are the TxDOT Paris District, Grayson County, and cities.

Apply for USDOT Safe Streets and Roads for All (SS4A) Funding. Apply for a USDOT SS4A Action Plan grant during the 2023 application period. The application should build off the safety issues and countermeasures identified in the Grayson County Safety and Operations Strategic Plan. If successful, upon completing the Action Plan apply for an Implementation Grant under the same program. Lead agency is the Grayson County MPO.

Implement a Regional TMC. Implement a regional TMC that could include the TxDOT Paris District, Grayson County, and City of Sherman. The TMC could support freeway operations, provide arterial traffic signal management, and coordinate video sharing with the Grayson County Emergency Operations Center. Lead agencies are the TxDOT Paris District possibly in coordination with the City of Sherman and Grayson County.

Deploy ITS Infrastructure on US 75 and Other State Highways. Deploy ITS infrastructure identified by the TxDOT Paris District on US 75 and other state highways in Grayson County. ITS infrastructure includes CCTV cameras, DMS, flood detection, and communication systems. Lead agency is the TxDOT Paris District.

Implement Upgrades to the Traffic Signal System Throughout the Region. Traffic signal system upgrades should include CCTV cameras at all traffic signals, traffic signal communication and detection improvements, emergency vehicle signal preemption along key emergency response corridors, and the use of ATSPM to monitor signal and corridor improvements. The City of Sherman should also begin preparing for the takeover of TxDOT maintained traffic signals within City boundaries prior to the 2030 Census. Lead agencies are the TxDOT Paris District and City of Sherman.

Support the Implementation of EV Charging Stations in Grayson County. Support the implementation of EV charging stations in Grayson County as identified in the Texas Electric Vehicle Infrastructure Plan. Implementation could include deployment of charging stations at the Denison Travel Information Center on US 75 and in downtown Sherman and Denison. Lead agencies are the Grayson County MPO, TxDOT Paris District, and cities.

APPENDIX

Appendix A – Safety and Operations Prioritization Criteria

Appendix B – Highway Safety Improvement Program Work Codes

Appendix A – Safety and Operations Prioritization Criteria

General Prioritization Criteria and Scoring		
Criteria	**Range**	**Score**
Roadway Classification	Major Collector	3
	Minor Arterial & Major Collector	4
	Minor Arterial	5
	Major Arterial & Minor Arterial	6
	Major Arterial	7
	Principal Arterial & Minor Arterial	8
	Principal Arterial	9
	Freeway	10
Average Daily Traffic (ADT)	< 2,001	0
	2,001 – 4,000	2
	4,001 – 6,000	4
	6,001 – 8,000	6
	8,001 – 10,000	8
	10,001 – 12,000	10
	12,001 – 14,000	11
	14,001 – 16,000	12
	16,001 – 18,000	13
	18,001 – 20,000	14
	20,001 – 22,000	15
	22,001 – 24,000	16
	24,001 – 26,000	17
	26,001 – 28,000	18
	28,001 – 30,000	19
	30,001 <	20

Safety Prioritization Criteria and Scoring		
Criteria	**Range**	**Score**
Fatal, Serious Injury, and Minor Injury Crashes per Mile	< 2	0
	2 – 4	5
	4 – 6	10
	6 – 8	15
	8 – 10	20
	10 – 12	24
	12 – 14	28
	14 – 16	31
	16 – 18	34
	18 – 20	36
	20 – 22	38
	22 – 24	39
	24 <	40
All Severity Crashes (Weighted) per Mile	< 1.5	0
	1.50 – 2.25	2
	2.25 – 3.00	4
	3.00 – 3.75	6
	3.75 – 4.50	8
	4.50 – 5.25	10
	5.25 – 6.00	11
	6.00 – 6.75	12
	6.75 – 7.50	13
	7.50 – 8.25	14
	8.25 – 9.00	15
	9.00 – 9.75	16
	9.75 – 10.50	17
	10.50 – 11.25	18
	11.25 – 12.00	19
	12.00 <	20

Operations Prioritization Criteria and Scoring		
Criteria	**Range**	**Score**
2021 Bottleneck Ranking Base Impact	< 250	0
	251 – 500	2
	501 – 750	4
	751 – 1,000	6
	1,001 – 1,250	8
	1,251 – 1,500	10
	1,501 – 1,750	12
	1,751 – 2,000	14
	2,001 – 2,250	16
	2,251 – 2,500	18
	2,501 – 2,750	20
	2,751 – 3,000	22
	3,001 – 3,250	24
	3,251 – 3,500	26
	3,501 – 3,750	28
	3,751 <	30
Delay per Mile (Person-Hours)	< 500	0
	501 – 2,000	2
	2,001 – 3,500	4
	3,501 – 5,000	6
	5,001 – 6,500	8
	6,501 – 8,000	10
	8,001 – 9,500	12
	9,501 – 11,000	14
	11,001 – 12,500	16
	12,501 – 14,000	18
	14,001 – 15,500	20
	15,501 – 17,000	22
	17,001 – 18,500	24
	18,501 – 20,000	26
	20,001 – 21,500	28
	21,501 – 23,000	30

Appendix B – Highway Safety Improvement Program Work Codes

100 SIGNING AND SIGNALS

101 Install Warning/Guide Signs	
Definition:	Provide advance signing for unusual or unexpected roadway features where no signing existed previously.
Reduction Factor (%):	20%
Service Life (Years):	6
Maintenance Cost:	N/A
Preventable Crash:	(Vehicle Movements/Manner of Collision = 20-22 or 30) OR (Roadway Related = 2, 3 or 4)
107 Install Traffic Signal	
Definition:	Provide a traffic signal where none existed previously. This does not include the installation of flashing beacons.
Reduction Factor (%):	35%
Service Life (Years):	10
Maintenance Cost:	$3,400 (Isolated) $3,900 (Interconnected) $5,400 (Diamond Interchange)
Preventable Crash:	[(Intersection Related = 1 or 2) AND (Vehicle Movements/Manner of Collision = 10-39)] OR (First Harmful Event = 1 or 5)
108 Improve Traffic Signals	
Definition:	Improve existing intersection signals to current design standards.
Reduction Factor (%):	24%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	(Intersection Related = 1 or 2) AND [(Vehicle Movements/Manner of Collision = 10-39) OR (First Harmful Event = 1 or 5)]
110 Install Pedestrian Signal	
Definition:	Provide a pedestrian signal at an existing signalized location where no pedestrian phase exists, but pedestrian crosswalks are existing, or in conjunction with Refer to W.C. 403 for installation of pedestrian crosswalks.
Reduction Factor (%):	34%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	First Harmful Event = 1
111 Interconnect Signals	
Definition:	Provide a communication link between two or more adjacent signals in a corridor. Specify all signalized intersections to be included in the interconnection.
Reduction Factor (%):	10%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	All

113 Install Delineators	
Definition:	Install post-mounted delineators to provide guidance.
Reduction Factor (%):	12%
Service Life (Years):	7
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2 , 3 or 4) AND (Light Condition = 3, 4 or 6)
114 Install School Zones	
Definition:	Place school zones to include flashers, signing and/or pavement markings where none existed previously. Refer to W.C. 403 for pedestrian crosswalk markings.
Reduction Factor (%):	20%
Service Life (Years):	5
Maintenance Cost:	N/A
Preventable Crash:	All
118 Replace Flashing Beacon with a Traffic Signal	
Definition:	Replace an existing flashing beacon at an intersection with a traffic signal.
Reduction Factor (%):	25%
Service Life (Years):	10
Maintenance Cost:	1300
Preventable Crash:	(Intersection Related = 1 or 2) AND [(Vehicle Movements/Manner of Collision = 10-39) OR (First Harmful Event = 1 or 5)]
119 Install Overhead Signs	
Definition:	Install overhead advance regulatory, warning or guide signing for unusual or unexpected roadway features where no signing existed previously.
Reduction Factor (%):	20%
Service Life (Years):	6
Maintenance Cost:	N/A
Preventable Crash:	Vehicle Movements/Manner of Collision = 20-29
122 Install Advanced Warning Signals (Intersection - Existing Warning Signs)	
Definition:	Provide flasher units in advance of an intersection where none previously existed but where advance warning signs already exist.
Reduction Factor (%):	10%
Service Life (Years):	10
Maintenance Cost:	$1,300 per approach
Preventable Crash:	Intersection Related = 1 or 2
123 Install Advanced Warning Signals (Curve- Existing Warning Signs)	
Definition:	Provide flasher units in advance of a curve where none previously existed. Advance warning signs already exist.
Reduction Factor (%):	10%
Service Life (Years):	10
Maintenance Cost:	$1,300 per approach
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision= 20-24 or 30)

124 Install Advanced Warning Signals and Signs (Intersection)	
Definition:	Provide flasher units and signs in advance of an intersection where none previously existed.
Reduction Factor (%):	27%
Service Life (Years):	10
Maintenance Cost:	$1,300 per approach
Preventable Crash:	Intersection Related = 1 or 2
125 Install Advanced Warning Signals and Signs (Curve)	
Definition:	Provide flasher units and signs in advance of a curve where none previously existed.
Reduction Factor (%):	15%
Service Life (Years):	10
Maintenance Cost:	$1,300 per approach
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision = 20-24 or 30)
128 Install Advanced Warning Signs (Intersection)	
Definition:	Provide signs in advance of an intersection where none previously existed.
Reduction Factor (%):	5%
Service Life (Years):	6
Maintenance Cost:	N/A
Preventable Crash:	Intersection Related = 1 or 2
130 Install Advanced Warning Signs (Curve)	
Definition:	Provide signs in advance of a curve where none previously existed.
Reduction Factor (%):	5%
Service Life (Years):	6
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision = 20-24 or 30)
131 Improve Pedestrian Signals	
Definition:	Bring existing pedestrian signal units into conformance with current standards.
Reduction Factor (%):	10%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	First Harmful Event = 1
132 Install Advance Warning Signals and Signs	
Definition:	Provide flasher units and signs in advance of hazard where none previously existed.
Reduction Factor (%):	10%
Service Life (Years):	10
Maintenance Cost:	$1,300 per approach
Preventable Crash:	To be determined
133 Improve School Zone	
Definition:	Improve an existing school zone by upgrading signing, pavement markings or signals.
Reduction Factor (%):	5%
Service Life (Years):	5
Maintenance Cost:	N/A
Preventable Crash:	All

136 Install LED Flashing Chevrons (Curve)	
Definition:	Install LED flashing chevrons on curve to provide guidance.
Reduction Factor (%):	35%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3, or 4) OR (Vehicle Movements/Manner of Collision = 20 - 24, or 30)
137 Install Chevrons (Curve)	
Definition:	Install chevrons on curve to provide guidance.
Reduction Factor (%):	25%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3, or 4) OR (Vehicle Movements/Manner of Collision = 20 - 24, or 30)
138 Install Flashing Yellow Arrow	
Definition:	Improve existing intersection signals by adding a flashing yellow arrow indication and install the LEFT TURN YIELD ON FLASHING YELLOW ARROW (R10-17T) sign. Refer to W.C. 108 for improvement of traffic signal.
Reduction Factor (%):	41%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	(Intersection Related = 1 or 2) AND (Vehicle Movements/Manner of Collision = 29, 34, 36)
139 Install Surface Mounted Delineators on Centerline	
Definition:	Install surface mounted delineators on centerline.
Reduction Factor (%):	12%
Service Life (Years):	7
Maintenance Cost:	N/A
Preventable Crash:	(Vehicle Movements/Manner of Collision = 21 or 30) OR (Roadway Related = 2 or 3)
140 Wrong Way Driver Warning Signs	
Definition:	Provide warning signs to warn wrong way drivers at freeway entrances.
Reduction Factor (%):	35%
Service Life (Years):	6
Maintenance Cost:	N/A
Preventable Crash:	Contributing factor = 71
141 Wrong Way Driver Warning Markings	
Definition:	Provide markings (lane direction arrows) to warn wrong way drivers at freeway entrances.
Reduction Factor (%):	40%
Service Life (Years):	4
Maintenance Cost:	N/A
Preventable Crash:	Contributing factor = 71

142 Wrong Way Driver Advanced Technologies	
Definition:	Provide advanced technologies to detect and warn wrong way drivers at freeway entrances.
Reduction Factor (%):	TBD
Service Life (Years):	8
Maintenance Cost:	25000
Preventable Crash:	Contributing factor = 71
143 Pedestrian Hybrid Beacon	
Definition:	Provide pedestrian hybrid beacon at established crosswalk or in conjunction with installation of new crosswalk (403). Requires TRF-P&S approval.
Reduction Factor (%):	15%
Service Life (Years):	10
Maintenance Cost:	2100
Preventable Crash:	First Harmful Event = 1
144 Install RRFB	
Definition:	Install pedestrian activated rectangular rapid flashing beacon (RRFB) at existing or in conjunction with installation of new crosswalk (403). Requires TRF-P&S approval. Systemic only.
Reduction Factor (%):	N/A
Service Life (Years):	10
Maintenance Cost:	$1,300 per roadside assembly
Preventable Crash:	First Harmful Event = 1
145 Flashing or LED-embedded Stop Signs	
Definition:	Install LED stop signs or top-mounted flashers on existing stop signs at intersections where only standard stop signs are present.
Reduction Factor (%):	10%
Service Life (Years):	10
Maintenance Cost:	$1,300 per roadside assembly
Preventable Crash:	[(Intersection Related = 1 or 2) AND (Vehicle Movements/Manner of Collision = 10-19)]

200 ROADSIDE OBSTACLES AND BARRIERS

201 Install Median Barrier	
Definition:	Construct a concrete or cable safety system median barrier where none existed previously.
Reduction Factor (%):	75%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	Vehicle Movements/Manner of Collision = 30

203 Install Raised Median	
Definition:	Install a roadway divider using barrier curb
Reduction Factor (%):	25%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	(Part of Roadway No. 1 Involved = 1) AND (Vehicle Movements/Manner of Collision = 10, 14, 20-22, 24, 26, 28-30, 34, 36, or 38)
204 Flatten Side Slope	
Definition:	Provide an embankment side slope of 6:1 or flatter.
Reduction Factor (%):	5%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	Roadway Related = 3
209 Safety Treat Fixed Objects	
Definition:	Remove, relocate, or safety treat all fixed objects including the installation of guardrail for safety treatment of a fixed object or drainage structures within the project limits, to include both point and continuous objects.
Reduction Factor (%):	50%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Object Struck = 20-26, 29-36, 40-42, 56-58, 60, 62, or 63)
217 Install Impact Attenuation System	
Definition:	Provide any of a variety of impact attenuators where none existed previously.
Reduction Factor (%):	60%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	(Object Struck = 20, 30, 40, or 42)
218 Widen Bridge	
Definition:	Provide additional width across an existing structure, either by rehabilitation or replacement. Specify existing bridge width, existing approach roadway width and roadway type (2 lane, 4 lane undivided, etc.)
Reduction Factor (%):	55%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	(Bridge Detail is not blank) OR (Vehicle Movements/Manner of Collision = 20, 21, or 30) OR (Roadway Related = 2, 3 or 4)
225 Pedestrian Crossing Deterrent	
Definition:	Install attachments to existing concrete barrier systems to deter prohibited pedestrian crossings on divided highways. Systemic only.
Reduction Factor (%):	N/A
Service Life (Years):	TBD
Maintenance Cost:	TBD
Preventable Crash:	First Harmful Event = 1

300 RESURFACING AND ROADWAY LIGHTING

303 Resurfacing	
Definition:	Provide a new roadway surface to increase pavement skid numbers on all the lanes.
Reduction Factor (%):	30%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	Surface Condition = 2, 5, 6, or 9 (Skid Value must be less than 20)
304 Safety Lighting	
Definition:	Provide roadway lighting, either partial or continuous, where either none existed previously or major improvements are being made. Refer to W.C. 305 for intersection lighting.
Reduction Factor (%):	49%
Service Life (Years):	15
Maintenance Cost:	$100 per Luminaire
Preventable Crash:	Light Condition = 3, 4 or 6
305 Safety Lighting at Intersection	
Definition:	Install lighting at an intersection where either none existed previously or major improvements are proposed. Refer to W.C. 304 for general lighting.
Reduction Factor (%):	13%
Service Life (Years):	15
Maintenance Cost:	$100 per Luminaire
Preventable Crash:	Light Condition = 3, 4 or 6 AND Intersection Related = 1 or 2

400 PAVEMENT MARKINGS

401 Install Pavement Markings	
Definition:	Place complete pavement markings, excluding crosswalks, in accordance with the TMUTCD where either no markings or nonstandard markings exist. This work code includes items such as turn arrows, stop bars, lane markings, etc. Refer to W.C. 402 for edge ma
Reduction Factor (%):	20%
Service Life (Years):	4 (Product used must meet 4 year service life.)
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 1) OR (Vehicle Movements/Manner of Collision = 21 or 30)
402 Install Edge Marking	
Definition:	Place edge lines where none existed previously.
Reduction Factor (%):	25%
Service Life (Years):	4 (Product used must meet 4 year service life.)
Maintenance Cost:	N/A
Preventable Crash:	Roadway Related = 2, 3 or 4

403 Install Pedestrian Crosswalk	
Definition:	Place pedestrian crosswalk markings where none existed previously. Refer to W.C. 114 for school zones, and W.C. 110 for pedestrian signal.
Reduction Factor (%):	10%
Service Life (Years):	4 (Product used must meet 4 year service life.)
Maintenance Cost:	N/A
Preventable Crash:	First Harmful Event = 1
404 Install Centerline Striping	
Definition:	Provide centerline striping where either no markings or nonstandard markings existed previously. Refer to W.C. 401 for complete pavement markings.
Reduction Factor (%):	65%
Service Life (Years):	4 (Product used must meet 4 year service life.)
Maintenance Cost:	N/A
Preventable Crash:	Vehicle Movements/Manner of Collision = 30
407 Install Sidewalks	
Definition:	Install sidewalks where none existed previously.
Reduction Factor (%):	65%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	First Harmful Event = 1 or 5

500 ROADWAY WORK

502 Widen Lane(s)	
Definition:	Provide additional width to the lane(s). Refer to W.C. 517 if adding a through lane.
Reduction Factor (%):	30%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision = 13, 21, 23, 30 or 33)
503 Widen Paved Shoulder (to 5 ft. or less)	
Definition:	Extend the existing paved shoulder to achieve desirable shoulder width. Refer to W.C. 504 or 537 for constructing a paved shoulder.
Reduction Factor (%):	25%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (First Harmful Event = 4)
504 Construct Paved Shoulders (1-4 ft.)	
Definition:	Provide paved shoulders of 1- to 4-foot width where no shoulders existed previously. Refer to W.C. 503 or 536 for widening paved shoulders.
Reduction Factor (%):	25%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision = 20, 23-24 or 30) OR (First Harmful Event = 4)

505 Improve Vertical Alignment	
Definition:	Reconstruct the roadway to improve sight distance.
Reduction Factor (%):	50%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision = 13- 14, 20-24, 30, 32 or 34)
506 Improve Horizontal Alignment	
Definition:	Flatten existing curves. Refer to W.C. 507 for providing superelevation, and W.C. 508 for intersection realignment.
Reduction Factor (%):	55%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision = 20- 24 or 30)
507 Increase Superelevation	
Definition:	Provide increased superelevation on an existing curve.
Reduction Factor (%):	65%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision = 30)
508 Realign Intersection	
Definition:	Improve an existing intersection by partial or complete relocation of the roadway(s). Refer to W.C. 509 for channelization, and W.C. 506 for improving horizontal alignments.
Reduction Factor (%):	TBD
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	Will be determined from supplied diagram
509 Channelization	
Definition:	Install islands and/or pavement markings to control or prohibit vehicular movements. A sketch of the proposed channelization should be provided. Refer to W.C. 508 for intersection realignment.
Reduction Factor (%):	TBD
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	Will be determined from supplied diagram
510 Construct Turn Arounds	
Definition:	Provide turnarounds at an intersection where none existed previously.
Reduction Factor (%):	40%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	(Intersection Related = 1 or 2) AND (Vehicle Movements/Manner of Collision = 12, 14, 18, 20, 22, 24, 26, 28, 29, or 34)

514 Grade Separation	
Definition:	Construct vertical separation of intersecting roadways.
Reduction Factor (%):	80%
Service Life (Years):	30
Maintenance Cost:	N/A
Preventable Crash:	Intersection Related = 1 or 2
515 Construct Interchange	
Definition:	Construct vertical separation of intersecting roadways to include interconnecting ramps.
Reduction Factor (%):	65%
Service Life (Years):	30
Maintenance Cost:	N/A
Preventable Crash:	Intersection Related = 1 or 2
516 Close Crossover	
Definition:	Permanently close an existing crossover.
Reduction Factor (%):	50%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	(Part of Roadway Involved = 1) AND (Vehicle Movements/Manner of Collision = 10, 14, 20-22, 24, 26, 28-30, 34 or 38)
517 Add Through Lane	
Definition:	Provide an additional travel lane.
Reduction Factor (%):	28%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	Vehicle Movements/Manner of Collision = 20-24, 26-27, 29-30
518 Install Continuous Turn Lane	
Definition:	Provide a continuous two-way left turn lane where none existed previously.
Reduction Factor (%):	50%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	Vehicle Movements/Manner of Collision = 20-22, 24, 26, 28-30, 34 or 38
519 Add Left Turn Lane	
Definition:	Provide an exclusive left turn lane where none existed previously. The affected intersection approaches must be specified.
Reduction Factor (%):	25%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	Vehicle Movements/Manner of Collision = 20-22, 24, 26, 28-30, 34 or 38 AND Intersection Related != 4
520 Lengthen Left Turn Lane	
Definition:	Provide additional length to an existing exclusive left turn lane. Affected intersection approaches must be specified.
Reduction Factor (%):	40%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	Vehicle Movements/Manner of Collision = 20-22 AND Intersection Related != 4

521 Add Right Turn Lane	
Definition:	Provide an exclusive right turn lane where none existed previously. Affected intersection approaches must be specified.
Reduction Factor (%):	25%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	Vehicle Movements/Manner of Collision = 20-23, 25-27, 33 or 36 AND Intersection Related != 4
522 Lengthen Right Turn Lane	
Definition:	Provide additional length to an existing exclusive right turn lane. Affected intersection approaches must be specified.
Reduction Factor (%):	40%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	Vehicle Movements/Manner of Collision = 20-22 AND Intersection Related != 4
523 Construct Pedestrian Over/Under Pass	
Definition:	Construct a pedestrian crossover where none existed previously.
Reduction Factor (%):	95%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	First Harmful Event = 1
524 Increase Turning Radius	
Definition:	Provide an increased turning radius at an existing intersection.
Reduction Factor (%):	10%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	[(Vehicle Body Style = 87 or 91) AND (First Harmful Event = 7)] OR (Vehicle Movements/Manner of Collision = 13, 20-21, 30 or 33)
525 Convert to One Way Frontage Roads	
Definition:	Convert two-way frontage roads to one-way operation.
Reduction Factor (%):	68%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	Part of Roadway Involved = 2
532 Milled Edgeline Rumble Strips	
Definition:	Install continuous milled depressions (rumble stripes or rumble strips) along the edgeline. Stand-alone rumble strip project proposals will not be accepted.
Reduction Factor (%):	15%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision = 30)

533 Profile Edgeline Markings	
Definition:	Install profile edgeline markings. Stand-alone rumble strip project proposals will not be accepted.
Reduction Factor (%):	7%
Service Life (Years):	5
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision = 30) OR (Surface Condition = 2, 5, 6 or 9)
534 Raised Edgeline Rumble Strips	
Definition:	Install non-reflective raised traffic buttons (yellow or white) along the edgeline. Stand-alone rumble strip project proposals will not be accepted.
Reduction Factor (%):	17%
Service Life (Years):	2
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision = 30) OR (Surface Condition = 2, 5, 6 or 9)
536 Widen Paved Shoulders (to >5 ft.)	
Definition:	Extend the existing paved shoulder to greater than 5 ft. Refer to W.C. 504 or 537 for constructing a paved shoulder.
Reduction Factor (%):	31%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (First Harmful Event = 4)
537 Construct Paved Shoulders (>= 5ft.)	
Definition:	Provide paved shoulders 5 feet or greater where no shoulders existed previously. Refer to W.C. 503 or 536 for widening paved shoulders.
Reduction Factor (%):	40%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision = 20, 23-24 or 30) OR (First Harmful Event = 4)
538 Convert 2 Lane Facility to 4 Lane Divided	
Definition:	Convert an existing 2-lane facility to a 4-lane divided facility.
Reduction Factor (%):	45%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3 or 4) OR (Vehicle Movements/Manner of Collision = 10, 13, 14, 20, 21, 22, 24 or 30)
540 Install Passing Lanes on 2 Lane Road	
Definition:	Widen roadway to install passing lanes on a 2-lane roadway where none currently exist.
Reduction Factor (%):	25%
Service Life (Years):	15
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 1, 2, or 3) AND (Vehicle Movements/Manner of Collision = 20-24 or 30)

541 Provide Additional Paved Surface Width	
Definition:	Provide additional paved surface width with appropriate subsurface to each side of two lane, two-way roadways with existing paved surface width less than 24' to a maximum width of 28'.
Reduction Factor (%):	30%
Service Life (Years):	20
Maintenance Cost:	N/A
Preventable Crash:	(Roadway Related = 2, 3, or 4) OR (Vehicle Movements/Manner of Collision = 21 or 30) OR First Harmful Event = 10)
542 Milled Centerline Rumble Strips	
Definition:	Install milled centerline rumble strips along the centerline. Stand-alone rumble strip project proposals will not be accepted.
Reduction Factor (%):	26%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	(Vehicle Movements/Manner of Collision = 21 or 30) OR (Roadway Related = 2 or 3)
543 Profile Centerline Markings	
Definition:	Install profile centerline markings and preformed thermoplastic strips along the centerline. Stand-alone centerline rumble strip project proposals will not be accepted.
Reduction Factor (%):	7%
Service Life (Years):	5
Maintenance Cost:	N/A
Preventable Crash:	(Vehicle Movements/Manner of Collision = 21 or 30) OR (Roadway Related = 2 or 3) OR (Surface Condition = 2, 5, 6 or 9)
544 Raised Centerline Rumble Strips	
Definition:	Install non-reflective raised traffic buttons (yellow or black) and preformed thermoplastic strips along the centerline. Stand-alone centerline rumble strip project proposals will not be accepted.
Reduction Factor (%):	17%
Service Life (Years):	4
Maintenance Cost:	N/A
Preventable Crash:	(Vehicle Movements/Manner of Collision = 21 or 30) OR (Roadway Related = 2 or 3) OR (Surface Condition = 2, 5, 6 or 9)
545 Transverse Rumble Strips	
Definition:	Install transverse or in-lane rumble strips in advance of a high incident and special geometric location.
Reduction Factor (%):	15%
Service Life (Years):	5
Maintenance Cost:	N/A
Preventable Crash:	Intersection Related = 1 or 2
547 Construct a Roundabout	
Definition:	Convert an existing intersection to a single lane roundabout design
Reduction Factor (%):	62%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	Intersection Related = 1 or 2

550 Restricted Crossing U-Turn (RCUT)	
Definition:	Convert intersection to restricted crossing U-turn (RCUT) intersection.
Reduction Factor (%):	42%
Service Life (Years):	10
Maintenance Cost:	N/A
Preventable Crash:	Intersection Related = 1 or 2