Texas Pedestrian Safety Action Plan (PSAP)

Statewide Summary

September 2023

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Abbreviations and Acronyms

CMF	Crash Modification Factor
C.R.I.S.	Crash Records Information System
CRF	Crash Reduction Factor
DES	TxDOT's Design Division
FHWA	Federal Highway Administration
HSIP	Highway Safety Improvement Program
KABCO	Refers to all crash injury severities (K-fatal injury, A-suspected serious injury, B-suspected minor injury, C-possible injury, O- unknown injury)
PSAP	Pedestrian Safety Action Plan
PTN	TxDOT's Public Transportation Division
SHSP	Strategic Highway Safety Plan
TRF	TxDOT's Traffic Safety Division
TxDOT	Texas Department of Transportation
VPD	Vehicles per Day
VRU	Vulnerable Road User

1 Executive Summary

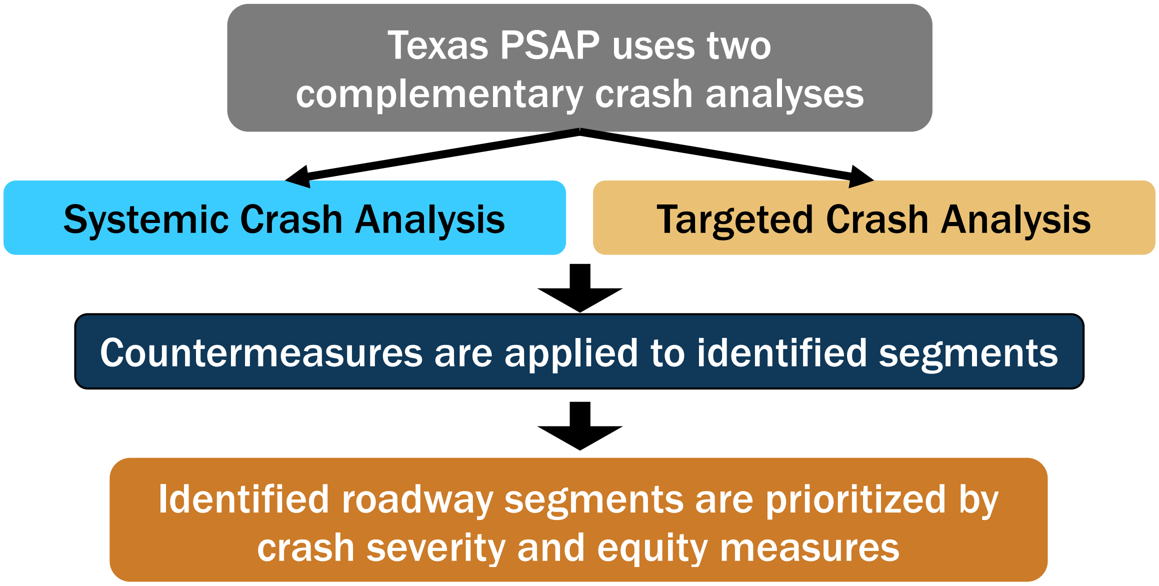
1.1 Purpose

The Texas Department of Transportation (TxDOT) initiated a Texas Pedestrian Safety Action Plan (PSAP) to address the rising number of pedestrian-related crashes occurring on Texas roadways and provide TxDOT District staff analysis identifying locations of concern for pedestrian safety as well as suggested countermeasures. The analysis results can also be used by Texas Metropolitan Planning Organizations (MPOs) as they identify and program roadway investments to create safer conditions for pedestrians within their jurisdictions.

1.2 Methodology Overview

The PSAP features two methods of statewide pedestrian crash analysis: systemic and targeted. In general, systemic safety is the practice of implementing crash reduction treatments at sites with identified risk factors for crashes rather than based on crash history. The widespread installation of treatments is intended to address infrastructure issues before a crash occurs at a given site. The proactive nature of systemic safety makes it an ideal complement to more traditional targeted crash analysis. Targeted crash analysis investigates locations and concentrations of pedestrian crashes historically to determine locations where improvements may be necessary. Pairing systemic crash analysis with targeted crash analysis results in priority locations that comprehensively address historical crash locations while also proactively working to reduce crashes.

Figure 1-1: PSAP Methodology Overview Diagram

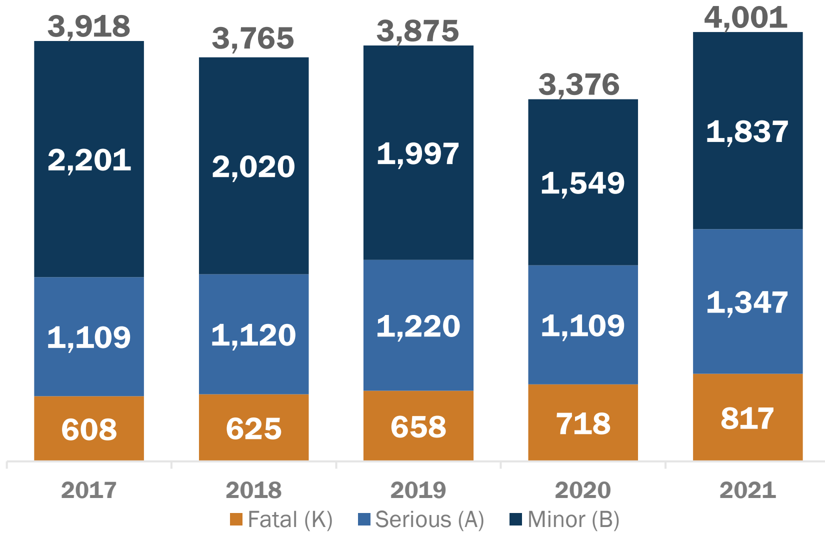


A data-driven approach was used to identify suggested pedestrian countermeasures for the resulting roadway segments from each of these parallel analyses. Twenty-five engineering-related countermeasures were selected based on a best practices review. These included all pedestrian countermeasures available in the latest Texas Highway Safety Improvement Program (HSIP). Then, utilizing available roadway design guidance and statewide data sets, engineering countermeasures along with several operational countermeasures were applied to prioritized roadway segments. See Section 4, for additional details on the countermeasure application process. Lastly, roadway segment locations were prioritized based on history of crashes, potential risk, socio-economic factors, and accumulation of suggested countermeasures (Section 4.6).

1.3 General Pedestrian Crash Analysis

The Texas PSAP used 5-years of pedestrian crash data (2017 – 2021) as the basis for analysis. As seen in Figure 1-2, aside from the societal changes brought by COVID-19, pedestrian crashes and indeed the severity of those pedestrian crashes continued to increase. This pedestrian crash trend follows those observed elsewhere.

Figure 1-2: Distribution of Texas Pedestrian KAB Crashes by Injury Severity Over Time (2017 – 2021)



Location of pedestrian crashes - From 2017 and 2021, pedestrian crashes occurred on roadways in a variety of contexts across Texas. As seen in Figure 1-3, pedestrian crashes occurred in rural and urban areas, but more crashes were observed in urban areas nearest to large population centers. Indeed, these pedestrian crashes were more prevalent in TxDOT's more metropolitan Districts (see Table 1-1). The Houston District represents the largest concentration of pedestrian crashes of anywhere in Texas, representing 27% of all pedestrian crashes during this time period. For comparison, Houston District contains about 9% of Texas' centerline road miles and about 24% of Texas' population.

When comparing TxDOT's on-system network with the many local roads (off-system network) across the state, we see that despite only comprising 25% of all centerline miles, TxDOT roadways are the location for 36% of pedestrian crashes. Furthermore, TxDOT's on-system network of 80,720 centerline miles are the site of 68% of all pedestrian fatalities. This over-representation of pedestrian fatalities on on-system roadways indicates a need for a focused approach to mitigating the pedestrian deaths on TxDOT roads.

68% of all pedestrian fatalities occur on **25%** of centerline miles

Figure 1-3: Texas Pedestrian Crash Locations (2017 - 2021)

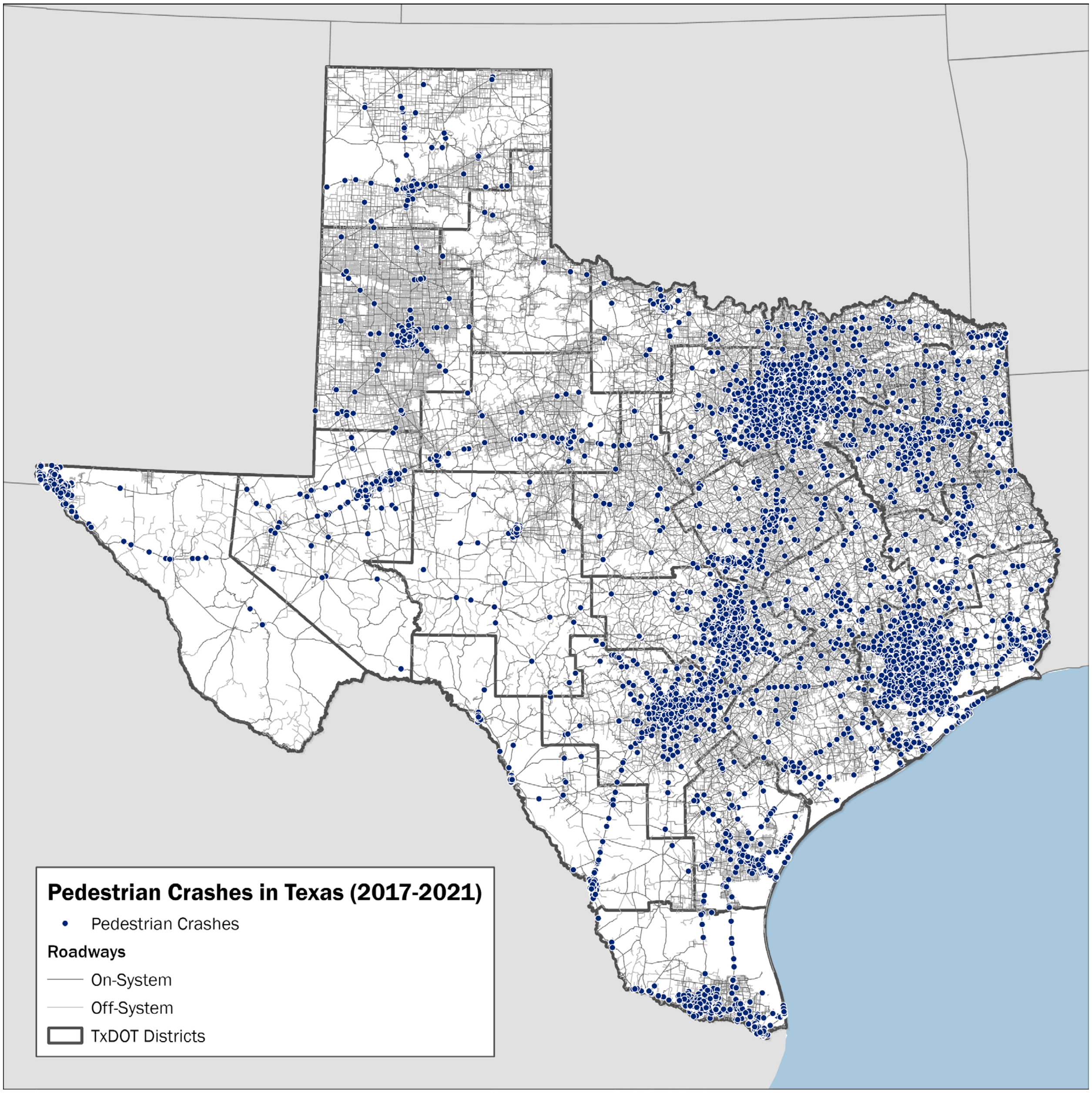


Figure 1-4: Comparison of On-system and Off-system Centerline Mileage and Pedestrian Crashes

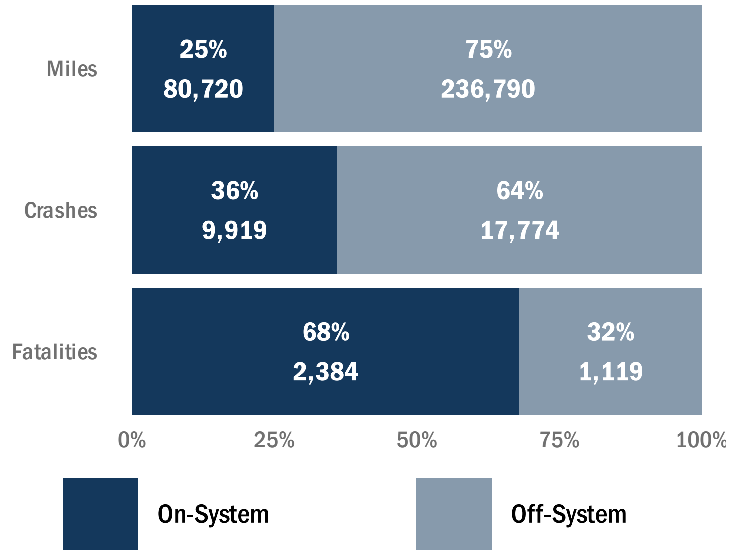


Table 1-1: Pedestrian Crashes by District and Crash Severity Level

District	*Pedestrian Crash severities*				*Comparing across Districts*					
	Fatal (K)	Serious (A)	Minor (B)	Possible (C), None (O), & Unknown (U)	Total Crashes		Total Roadway Centerline Miles within each District		District Population (2020)	
Abilene	40	50	84	27	201	1%	11,824	4%	264,371	1%
Amarillo	46	103	80	93	322	1%	13,897	4%	386,480	1%
Atlanta	42	70	75	47	234	1%	9,001	3%	318,075	1%
Austin	260	481	972	622	2,335	8%	16,637	5%	2,541,364	9%
Beaumont	117	136	157	132	542	2%	8,839	3%	609,610	2%
Brownwood	10	16	21	12	59	0%	8,684	3%	127,072	0%
Bryan	45	79	134	77	335	1%	10,327	3%	489,313	2%
Childress	4	4	0	0	8	0%	8,085	3%	11,193	0%
Corpus Christi	100	146	241	244	731	3%	9,597	3%	599,613	2%
Dallas	506	1,072	1,703	1,414	4,695	17%	23,867	8%	5,221,074	18%
El Paso	125	147	369	359	1,000	4%	6,992	2%	897,249	3%
Fort Worth	278	497	690	709	2,174	8%	18,005	6%	2,699,313	9%
Houston	792	1,544	2,254	2,771	7,361	27%	28,665	9%	6,953,835	24%
Laredo	37	73	136	162	408	1%	5,542	2%	410,959	1%
Lubbock	67	70	184	139	460	2%	23,054	7%	492,542	2%
Lufkin	45	51	53	35	184	1%	9,824	3%	318,205	1%
Odessa	65	78	135	75	353	1%	8,560	3%	429,120	1%
Paris	69	76	73	47	265	1%	11,312	4%	408,681	1%
Pharr	112	200	302	373	987	4%	9,751	3%	1,416,555	5%
San Angelo	17	28	60	19	124	0%	8,482	3%	164,028	1%
San Antonio	376	599	1,389	1,080	3,444	12%	18,598	6%	2,654,264	9%
Tyler	107	125	141	92	465	2%	13,012	4%	704,800	2%
Waco	105	171	247	155	678	2%	13,652	4%	826,305	3%
Wichita Falls	20	24	52	33	129	0%	9,018	3%	241,988	1%
Yoakum	41	65	52	41	199	1%	12,285	4%	339,980	1%
Total	3,426	5,905	9,604	8,758	27,693		317,510		29,525,989	

Statewide Pedestrian Crash Characteristics (Figure 1-5, Figure 1-6, and Table 1-2)
From 2017 to 2021:

- 36% of pedestrian crashes are intersection-related
    - Unfortunately, a statewide intersection database featuring locations and detailed attribute information is not available. Therefore, while the Targeted crash analysis captured intersection crashes, the systemic analysis was not able to include intersection characteristics nor identify intersection-related risk factors.
- 70% of pedestrian crashes involved a motor vehicle traveling straight along a roadway. 23% of pedestrian crashes involve a motor vehicle making a turning movement
- 52% of pedestrian crashes occurred in dark or unlit conditions with 82% of those resulting in fatalities
- 36% of pedestrian crashes were marked as "pedestrian failed to yield" by the responding peace officer, resulting in 2,089 fatalities
- 16% of pedestrian crashes were marked as "driver failed to yield" by the responding peace officer, resulting in 95 fatalities
- 16% of pedestrian crashes involved a distracted driver or pedestrian, resulting in 285 fatalities
- 14% of pedestrian crashes involved a person under 16 years old, while 10% of pedestrian crashes involved a person over 65 years old.

Figure 1-5: Comparison of Non-intersection and Intersection-related Pedestrian Crashes

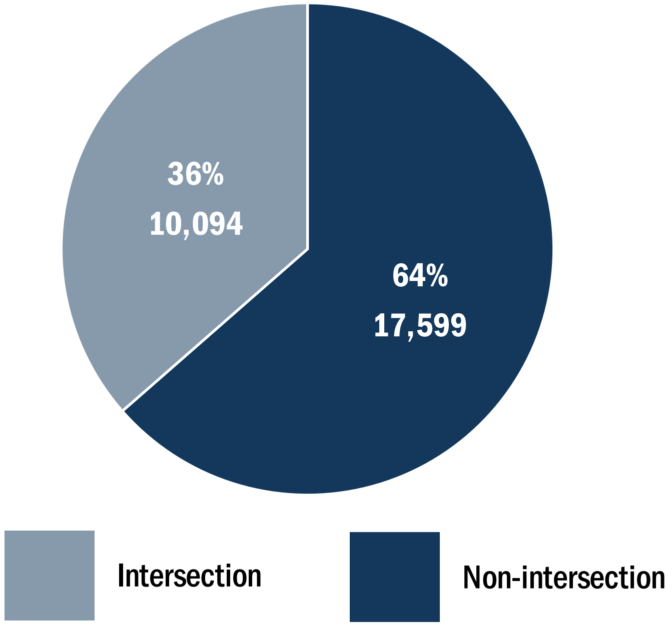


Figure 1-6: Comparison of "Manner of Collision" for Pedestrian Crashes

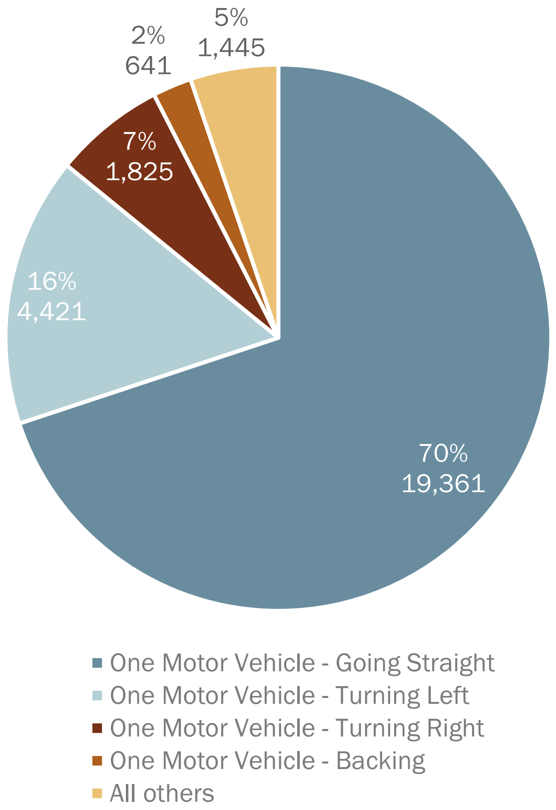


Table 1-2: Distribution of Crashes by Injury Level and Crash Characteristic

Injury level	Total Crashes	Dark/Unlit		Ped failed to yield		Driver failed to yield		Distracted driver/ped		Involved child ped		Involved senior ped	
		#	%	#	%	#	%	#	%	#	%	#	%
Fatal (K)	3,426	2,823	82%	2,089	61%	83	2%	279	8%	141	4%	522	15%
Serious (A)	5,905	3,651	62%	2,561	43%	577	10%	874	15%	708	12%	583	10%
Minor (B)	9,604	4,324	45%	3,114	32%	1,722	18%	1,792	19%	1,655	17%	896	9%
Possible (C)	7,659	3,047	40%	2,014	26%	1,540	20%	1,389	18%	1,220	16%	720	9%
None (O)	1,055	476	45%	259	25%	110	10%	166	16%	108	10%	64	6%
Unknown (U)	44	26	59%	3	7%	6	14%	8	18%	4	9%	2	5%
Total	27,693	14,347	52%	10,040	36%	4,038	15%	4,508	16%	3,836	14%	2,787	10%

Table 1-3: Selected Statewide Crash Contributing Factors (KA only)

Reportable KA Pedestrian Crashes													
Total Crashes (reportable KA pedestrian)		Intersection-related			Pedestrian failed to yield ROW to vehicle			Vehicle failed to yield ROW to pedestrian			Intoxication (Driver or Pedestrian)		
Crashes	Crashes per capita	Crashes	Share of Crashes	Crashes per capita	Crashes	Share of Crashes	Crashes per capita	Crashes	Share of Crashes	Crashes per capita	Crashes	Share of Crashes	Crashes per capita
9,331	3.16	2,127	23%	0.72	4,917	53%	1.66	733	8%	0.25	1,864	20%	0.63

<u>Notes</u>:

1) Entire table exclusively represents **reportable, KA pedestrian** crashes.
2) Crashes per capita represents crashes per 10,000 inhabitants. Population data source = Texas Demographic Center's July 2021 Estimates (https://demographics.texas.gov/Resources/TPEPP/Estimates/2021/2021_txpopest_county.csv)
3) Each crash can have multiple contributing factors
4) "Share of crashes" columns show the share of specific types of crashes with respect to all of its reportable KA pedestrian crashes.

Table 1-3 provides a statewide look at contributing factors for just pedestrian KA crashes during the 2017 - 2021 period. For county-level analysis of the contributing factors pedestrian KA crashes during the 2017 - 2021 period, please see Appendix B.

Beginning in 2021, the Texas repository for crash data, C.R.I.S. (Crash Records Information System), began to provide data extracts with a flag indicating crashes that involved unintended pedestrians. Unintended pedestrians began their trip in a motor vehicle either as a driver or passenger, but various circumstance (perhaps mechanical problems or running out of gas) led to them becoming a pedestrian. While the PSAP analysis does not distinguish between crashes that involved unintended pedestrians because crash data was not available for the full 5-year period used in this analysis, Table 1-4 provides analysis of the one year of data available during this timeframe. It indicates that statewide, only 3% of pedestrian crashes involved unintended pedestrians. Furthermore, out of the 314 total reportable **rural** pedestrian crashes in 2021, only 29 (~9%) involved an unintended pedestrian.

Appendix C provides represents these unintended crashes distributed amongst TxDOT Districts.

Table 1-2: Distribution of Unintended Pedestrian Crashes by Injury Severity (2021)

Injury Severity	Total Pedestrian Crashes	Involved an unintended pedestrian	Involved an unintended pedestrian (as a share of crashes by injury severity)
Fatal (K)	817	31	4%
Serious (A)	1,347	46	3%
Minor (B)	1,837	39	2%
Possible (C)	1,150	25	2%
None (O)	201	2	1%
Unknown (U)	13	0	0%
Total	5,365	143	**3%**

1.4 Systemic Analysis Results Summary

Systemic analysis is a data-driven process which involves screening a roadway network for risk factors based on the presence of roadway attributes corresponding to predominant crash types. The PSAP systemic analysis process involved the following three general steps:

1. **Selection and identification of focus facilities**

   The Texas systemic analysis identified a subset of on-system roadways that showed an overrepresentation of pedestrian crashes. The subset was divided into systemic peer groups based on overarching roadway characteristics. This is done to both prioritize significant roadway types and to allow for the analysis to highlight attributes critical to a variety of facility types. PSAP identified an on-system focus facility network of 19,045 miles (23.6% of the total on-system network) where 82.2% of pedestrian crashes[1] occurred. See Figure 3-2 for a map of this network.

2. **Identification of systemic risk factors for pedestrian-related crashes**

   Risk factors are roadway and/or traffic characteristics present at locations with reported crashes. Risk factors may indicate a greater potential for severe crashes to occur at the site or similar sites however they are not necessarily contributing factors and may or may not have contributed to any/all crashes at an individual site. See Table 3-10 for a summary of these risk factors and Appendix C for a summary table of risk factors by District.

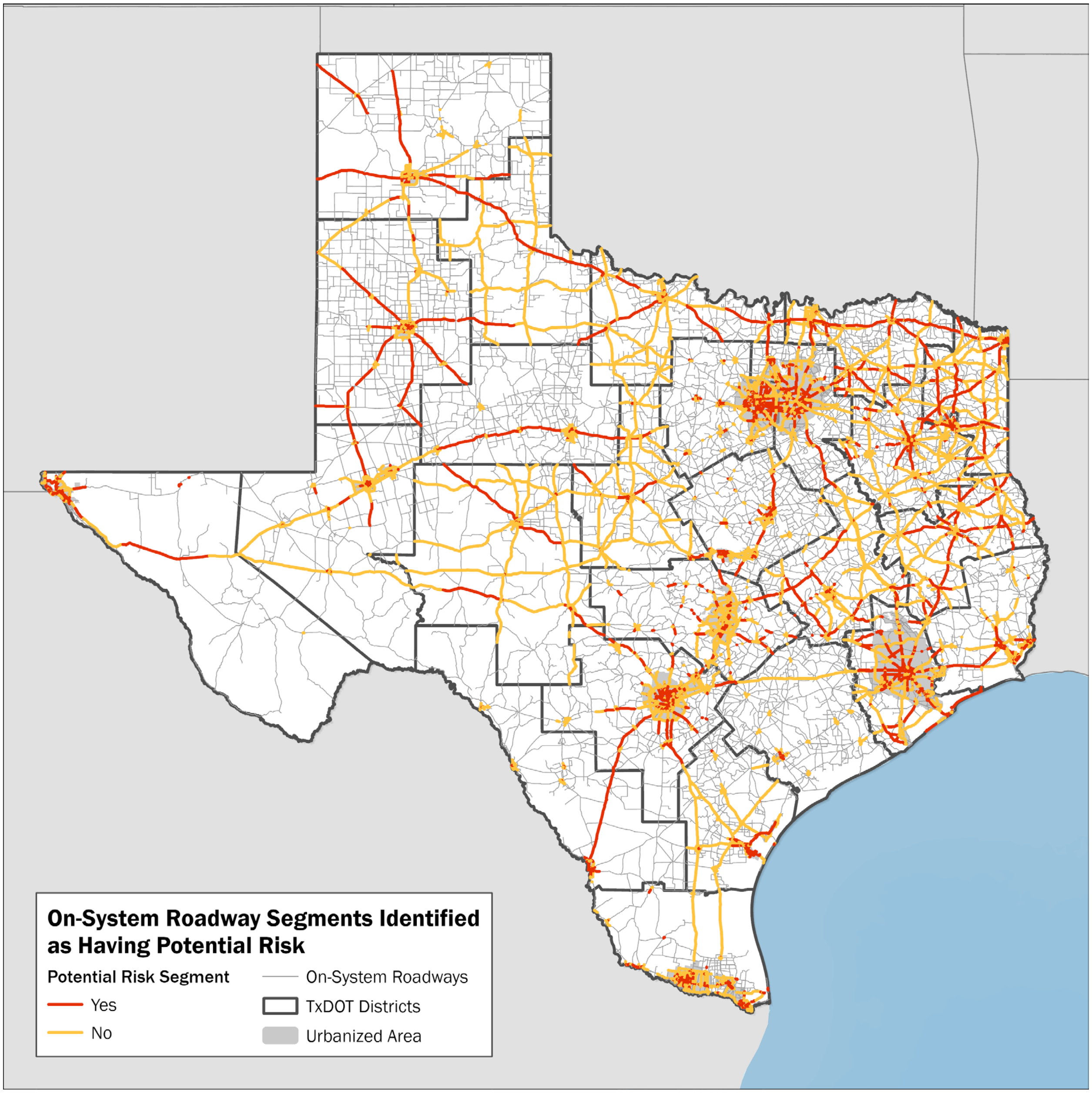
3. **Screening the study network for the presence of systemic risk factors**

   Where these risk factors are over-represented on a given on-system roadway segment, the roadway segment can be labeled as having “potential risk”. Figure 1-7 identifies the on-system roadways identified as having potential risk. As seen in Figure 1-8, 33% of all focus facility

[1] Systemic Analysis utilizes KAB pedestrian crashes that occurred on-system, were reportable, Non-Intersection Related, and had XY coordinates, (4,593 / 5,590)

centerline miles were identified as "potential risk." Meanwhile, Table 1-4 shows those potential risk segments in relation to District On-system centerline miles.

Figure 1-7: On-System Roadway Segments Identified as Having Potential Risk



NOTE: Red and yellow segments in *Figure 1-7* comprise the on-system focus facility network. This focus facility network is the 19,045 miles (23.6% of the total on-system network) where 82.2% of pedestrian crashes occurred. Over-representation analyses were completed on the on-system focus facility network only because the focus facilities are the locations where pedestrian crashes were most present. Some on-system roadways (grey) were not analyzed as part of the systemic over-representation analysis. See 3.2.1 *Systemic Analysis* for more details.

Figure 1-8: Distribution of Focus Facility Centerline Miles with Potential Risk

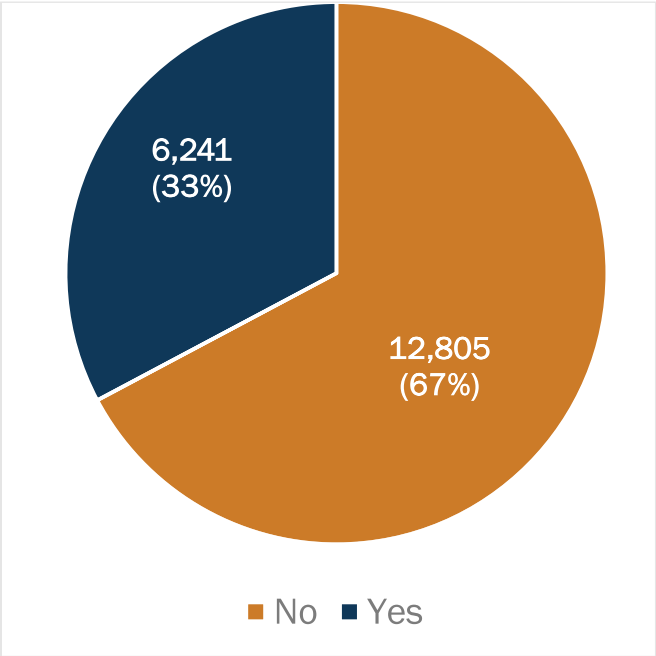


Table 1-3: Distribution of Centerline Mileage with Potential Risk by TxDOT District

District	Potential Risk			
	Focus Facility Miles (On-system Centerline Miles)		Percent of Focus Facility Centerline Miles	
	No	Yes	No	Yes
Abilene	139	148	48%	52%
Amarillo	268	303	47%	53%
Atlanta	707	377	65%	35%
Austin	618	205	75%	25%
Beaumont	363	157	70%	30%
Brownwood	849	109	89%	11%
Bryan	723	269	73%	27%
Childress	625	170	79%	21%
Corpus Christi	501	121	81%	19%
Dallas	520	365	59%	41%
El Paso	134	208	39%	61%
Fort Worth	413	334	55%	45%
Houston	572	540	51%	49%
Laredo	76	135	36%	64%
Lubbock	365	384	49%	51%
Lufkin	738	382	66%	34%

District	Potential Risk			
	Focus Facility Miles (On-system Centerline Miles)		Percent of Focus Facility Centerline Miles	
	No	Yes	No	Yes
Odessa	520	123	81%	19%
Paris	657	350	65%	35%
Pharr	474	201	70%	30%
San Angelo	927	199	82%	18%
San Antonio	639	466	58%	42%
Tyler	861	268	76%	24%
Waco	304	174	64%	36%
Wichita Falls	632	234	73%	27%
Yoakum	181	17	91%	9%
Total	12,805	6,241	67%	33%

1.5 Targeted Analysis Results Summary

Traditional (targeted) safety analysis (also known as high-injury network analysis) has been foundational for reducing the frequency of fatal and serious injury crashes across Texas. The PSAP's targeted crash analysis was completed for the entire Texas Roadway Network (on- and off-system) and utilized a sliding window technique which analyzes patterns of crashes along individual routes, aggregating these point events into generalized crash profiles. Next, the analysis resegmented the entire Texas roadway network to more uniform lengths, then calculated pedestrian crash densities (i.e., pedestrian crashes per centerline mile). With this technique all crashes across the state are compared evenly regardless of context. Figure 1-9 illustrates how crash densities for KABC crashes are distributed across the State. The highest pedestrian crash densities, shown in red and dark orange, are located in urbanized areas where populations are the highest.

The last step of the targeted analysis involved grouping the links into peer groups based on four criteria (District, simplified functional class, urban vs rural, and on- vs. off-system) and classifying the links into one of five tiers based on their crash densities: Very High, High, Medium, Low, or Minimal. Figure 1-10 illustrates how crash density tiers for KABC crashes are distributed across the State. The peer groups allow for comparisons in similar contexts. For example, a user can identify a rural location where pedestrian crashes are significant but perhaps not as numerous as a highly urban location. The analysis shows that over 95% of the roadway centerline miles in Texas were classified as minimal given little to no history of pedestrian crashes. Figure 1-11 shows the distribution centerline miles across Texas for the remainder of those classifications (Very High, High, Medium, or Low) for all crash severities analyzed. For example, when focusing only on K crashes, only 0.9% of Texas' centerline miles are classified as belonging to the Very High, High, Medium or Low crash density tiers, resulting in approximately 99.1% of the State's centerline miles being classified as belonging to the Minimal crash density tier. Conversely, when analyzing KABCO crashes, 3.8% Texas' centerline miles are classified as belonging to the Very High, High, Medium or Low crash density tiers, resulting in approximately 96.2% of the State's centerline miles being classified as belonging to the Minimal crash density tier.

Figure 1-9: Targeted Crash Analysis: Pedestrian Crash Density

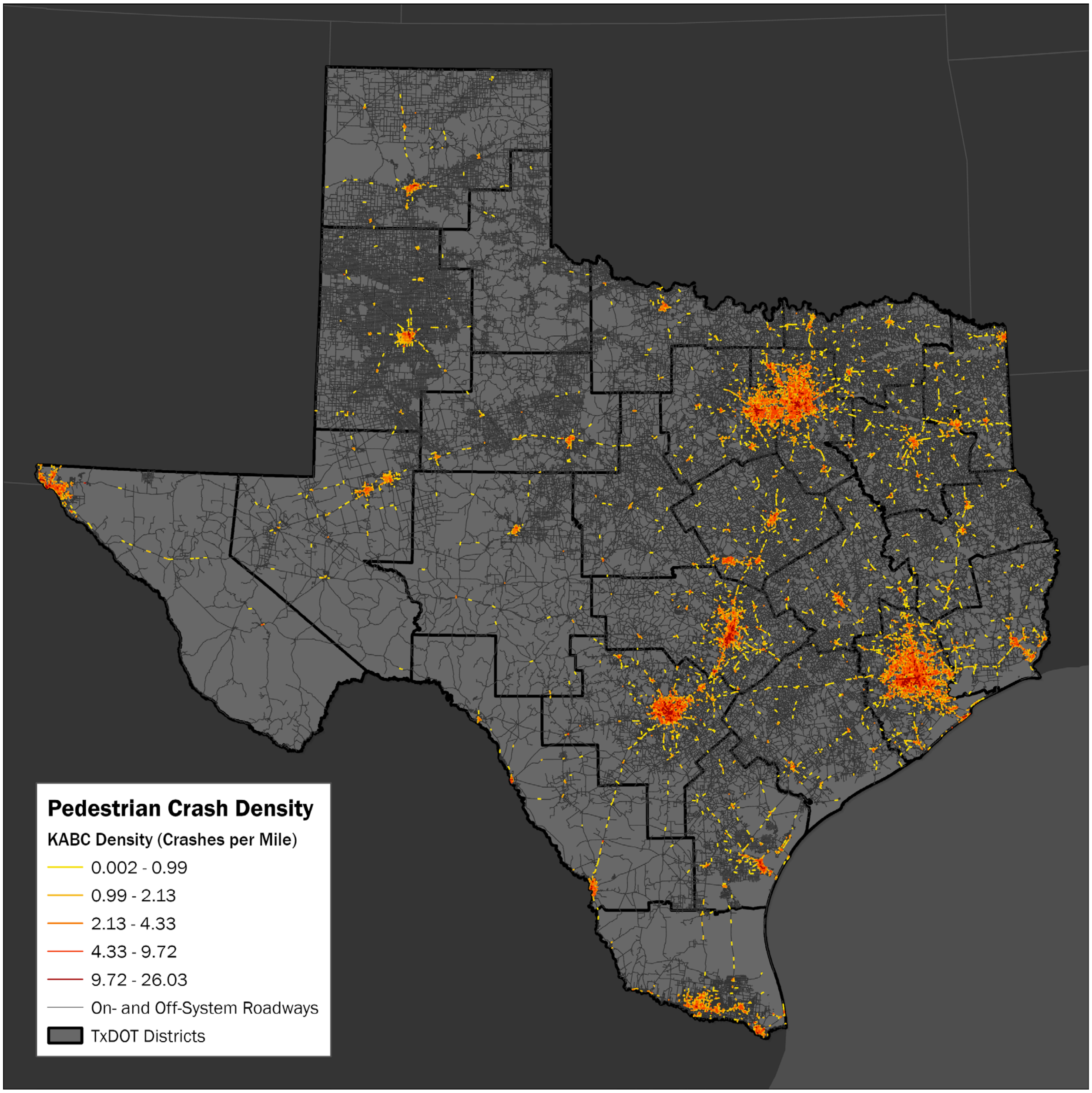


Figure 1-10: Targeted Crash Analysis: Pedestrian Crash Density Tiers

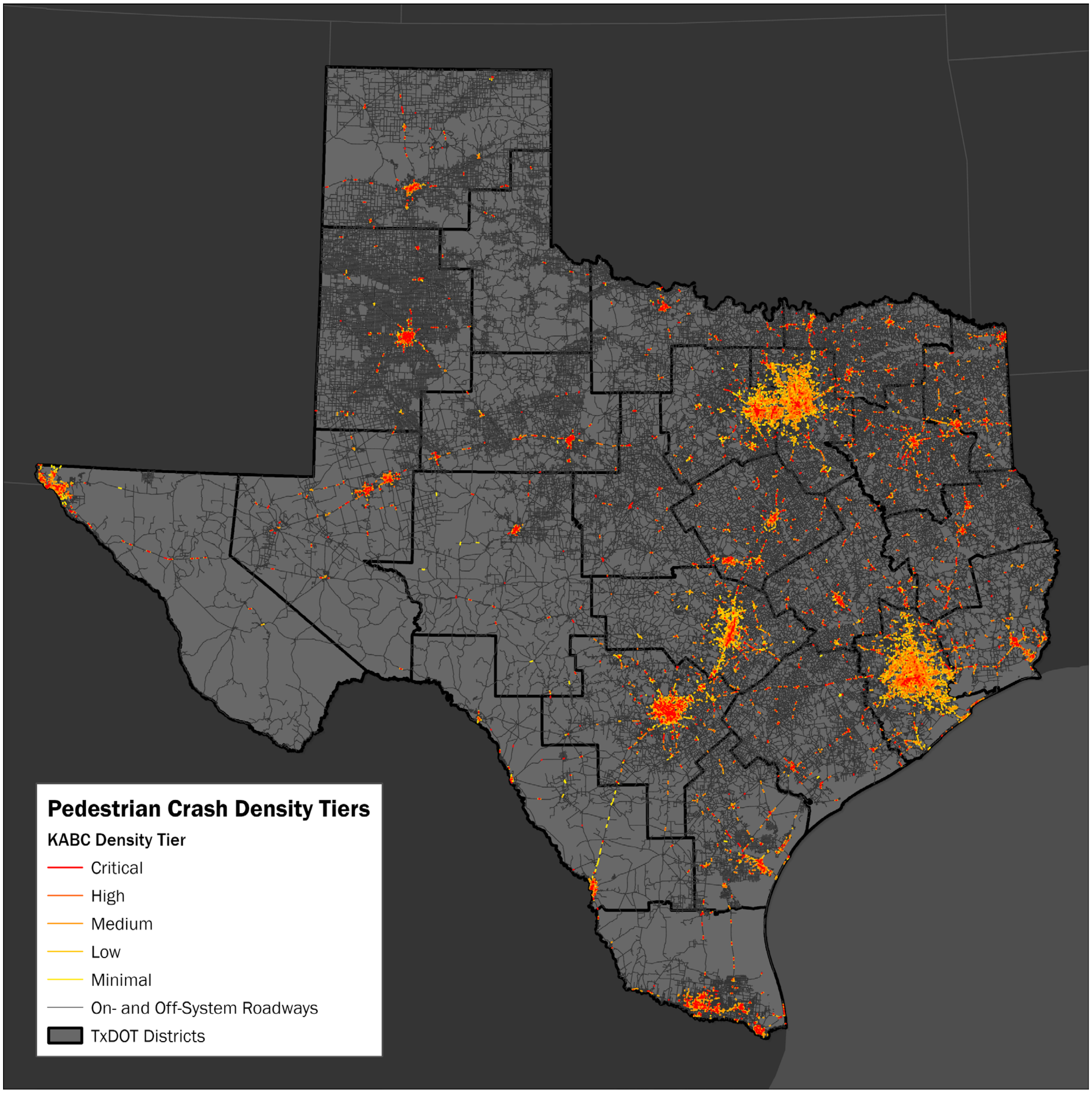
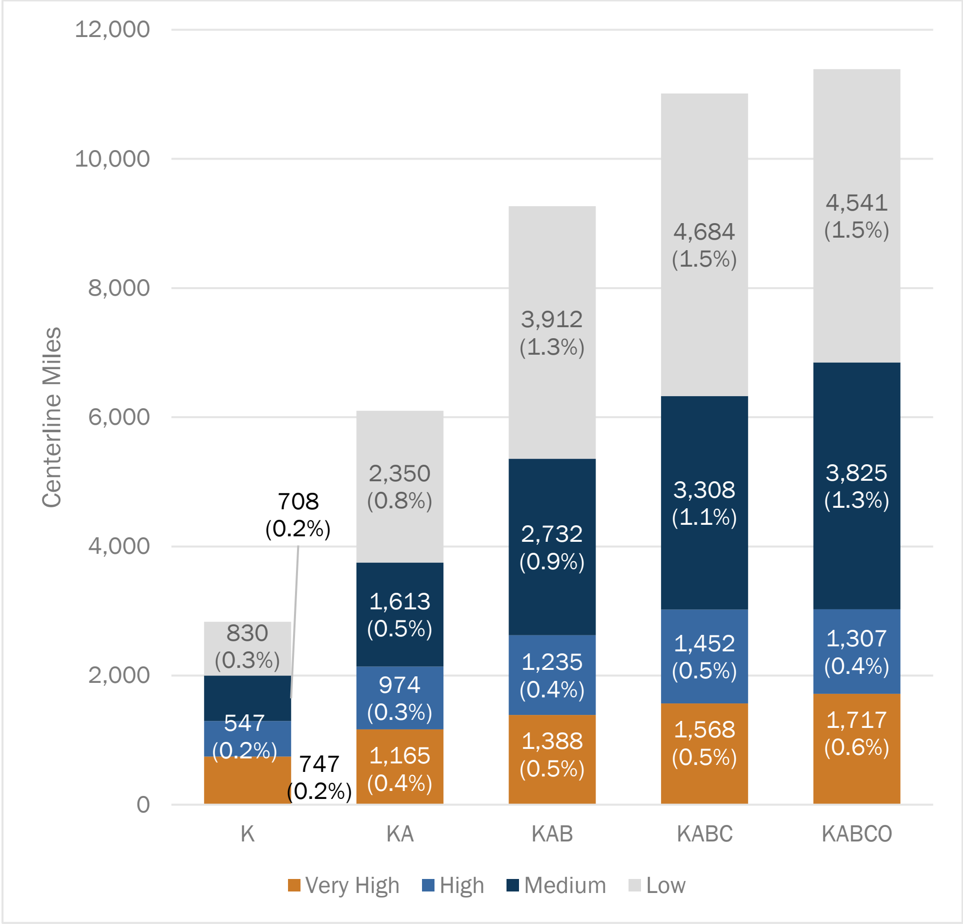


Figure 1-11: Distribution of Centerline Miles (On- and Off-System) by Pedestrian Crash Density Tier[2]



1.6 Countermeasure Summary

Investment in safety countermeasures which have been proven effective by research and analysis can mitigate future pedestrian crash risk and reduce the injury severities resulting from those crashes. The Texas PSAP selected and applied pedestrian countermeasures in the following general process:

1. **Identification of engineering and programmatic countermeasures**

   Twenty-five engineering-related countermeasures were selected based on a review of Federal Highway Administration (FHWA) best practices, TxDOT's Highway Safety Improvement Program Guidance, and a review of the Crash Modification Factor (CMF) Clearinghouse. These engineering countermeasures included improvements specific to roadway segments and spot treatments. Additionally, another 10 educational, programmatic, and operational countermeasures were identified through stakeholder engagement and best practices research. See Table 4-1 and Table 4-2 for a complete list of countermeasures.

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[2] The "Minimal" density tier is omitted from this graph because it encompasses more than 95% of the centerline miles for all five crash types, thus making it difficult to see the distribution of the rest of the system's crash density tiers.

2. **Development of logic to assess suitable locations**

   Where data and/or applicable guidance was readily available, a formulaic logic was created for countermeasures. For example, there is insufficient data indicating the locations of traffic signals on Texas roadways to adequately apply any logic for the countermeasure "Install stop lines at traffic signals." TxDOT Division staff reviewed and suggested modifications to the countermeasure application logic which resulted in 13 suggested countermeasures specific to the systemic analysis results (Section 4.3.1) and 12 suggested countermeasures for the targeted analysis results (Section 4.3.2). The logic associated with each countermeasure is similar between the two analyses and deviate slightly when presence of crash history or presence of risk factors are considered.

3. **Application of countermeasures to potential risk and hot spot segments**

   Application of this countermeasure logic resulted in 37,464 centerline miles and 63,637 locations with suggested countermeasures. Table 1-6 features a tabular summary of the extent of these suggested countermeasures applications. For details about countermeasure applications for particular segments, refer to the PSAP Screening Tool.

Table 1-4: Statewide Suggested Countermeasure Summary

Countermeasure	Analysis	Centerline Miles	Locations
Frontage Road Study	Systemic	470	--
Implement Leading Pedestrian Interval	Targeted	--	3,262
Implement Pedestrian Scramble	Targeted	--	2,083
Improve School Zones	Both	--	271
Install In-Street Pedestrian Signs	Targeted	--	20,171
Install Median Barriers	Systemic	956	--
Install Pedestrian Hybrid Beacon	Both	--	367
Install Pedestrian Refuge Island	Targeted	--	818
Install Raised Crosswalks	Targeted	--	18,497
Install Raised Median	Systemic	400	--
Install Rectangular Rapid Flashing Beacon	Both		1,477
Install School Zones	Systemic	--	2,371
Install Shared Use Path	Both	9,758	--
Install Sidewalk	Both	16,755	--
Install Traffic Calming	Systemic	966	--
Install/Upgrade Lighting	Both	6,637	--
Modify Curb Geometrics	Targeted	--	2,709
SOXSOP	Systemic	460	--
Speed Study	Systemic	1,062	--
Total		37,464	63,637

1.7 Implementation

The Texas PSAP resulted in the following products for TxDOT District staff to better identify locations where pedestrian safety concerns exist and prioritize investments to mitigate those hazards.

- District-specific Pedestrian Safety Profile – this static, 4-page Tabloid provides an overview of statewide pedestrian crash statistics and general safety performance and summarizes District-specific findings from the targeted and systemic analyses. See Appendix A for all 25 District Pedestrian Safety Profiles.
- District-specific Analysis Data – an Excel workbook featuring PSAP analysis results for each roadway segment in the District, allowing for in-depth analysis, risk assessment verification and further prioritization opportunities depending on District priorities.
- PSAP Screening Tool – an online interactive dashboard allowing users to layer the PSAP analysis results, filter attributes, and isolate geographic locations. This tool is accessible to the TxDOT District staff and MPOs. As discussed below, this tool will enable both TxDOT Districts and MPOs to develop and program investments into pedestrian safety.

PSAP analysis and products are anticipated to be used to:

- Update future Strategic Highway Safety Plans (SHSP)
  - Identification of pedestrian safety concerns and trends could be helpful in future updates to the SHSP, which normally occurs every four years.
- Create the initial Vulnerable Road User (VRU) Assessment
  - The statewide pedestrian analysis from the PSAP will be valuable inputs to TxDOT's initial VRU Assessment, which is being developed in the Spring and Summer 2023.
- Update future Highway Safety Improvement Program (HSIP) guidance
  - Coordination between TxDOT PTN and TRF during PSAP development has led to identification of additional pedestrian countermeasures than are not currently identified with the HSIP (See Table 4-1). As the next HSIP is updated, these additional pedestrian countermeasure work codes will be considered for inclusion. New work codes lead to additional opportunities for funding safe pedestrian infrastructure.
- Update programmed projects in future District Safety Plans and MPO Safety Plans
  - As pedestrian crashes are a significant concern in various areas around Texas, the PSAP Screening tool and other products can help staff at TxDOT Districts and MPOs to identify, plan, and program pedestrian safety projects for funding.
- Assist in project scoping, safety project identification, and project scoring
  - Roadway design engineers across Texas are continually developing improvements to Texas roadways and scoping various design elements within those projects. PSAP tools can be used to better identify projects that need additional scope or design elements related to the pedestrian crash history or systemic analysis results (as a potential risk segment). Alternatively, PSAP tools could also be used during a project selection process to better score pedestrian projects or design elements.
- Applying for funding grants for pedestrian safety infrastructure and plans
  - The PSAP analysis and trend data results can be used to compete for grant funding dollars. Opportunities for pedestrian planning and project funding include: TxDOT Transportation Alternatives Call for Projects; MPO-specific Transportation Alternative Calls for Projects; Safe Streets for All (USDOT) - Supplemental Planning, Demonstration Activities, and/or possibly Implementation grants; and Reconnecting Communities (USDOT).

2 Introduction

The Texas Department of Transportation (TxDOT) initiated a Texas Pedestrian Safety Action Plan (PSAP) to address the rising number of pedestrian-related crashes occurring on Texas roadways and provide District staff analysis identifying locations of concern for pedestrian safety as well as suggested countermeasures. The decision to complete a PSAP resulted from successful research projects, a recommendation from the Texas Strategic Highway Safety Plan, and interest from the Texas Transportation Commission's Safety Task Force, Pedestrian and Bicycle Safety Subcommittee and TxDOT's Bicycle and Pedestrian Advisory Committee.

Between 2019 and 2021, TxDOT funded two research projects including a study focused within the North Central Texas Council of Governments (NCTCOG) jurisdiction performed by University of Texas, El Paso (UTEP) that informed development of NCTCOG's PSAP, and a separate statewide study that identified high-level pedestrian crash trends and provided a methodology for evaluating cost-benefit of certain pedestrian safety investments performed by University of Texas – Center for Transportation Research (UT-CTR). Together, these two research projects exemplified the opportunities for crash analysis for vulnerable road users to prioritize and suggest countermeasure investments.

Additionally in 2022, the 2022 - 2027 Texas Strategic Highway Safety Plan (SHSP) was completed and featured the newly created "Vulnerable Road User: Pedestrian/Pedalcyclist" emphasis area. The SHSP utilizes FHWA's Safe Systems Approach with a focus "to reduce risk and, subsequently, death and serious injury related to traffic crashes." The SHSP authors recommend strategies and programs under the Vulnerable Road User: Pedestrian/Pedalcyclist Emphasis Area to address both infrastructure and behavior by looking to dedicate more "transportation space for users moving at different speeds". Most relevant to the PSAP, the SHSP recommends "Strategy 6.8.4: Develop strategic pedestrian safety action plans tailored to local conditions", further recommending an implementation step 6.8.4.2: "Develop a State Pedestrian Safety Action Plan including how equity is to be addressed."

With this research complete and a recommendation for completing a statewide PSAP, the TxDOT Safety Task Force, Pedestrian and Bicycle Safety Subcommittee also recommended that TxDOT begin work on PSAP in April 2022.

The following report describes the methodology the PSAP used to provide TxDOT staff and public partners statewide pedestrian crash analysis (both systemic and targeted) as well as suggested countermeasures to mitigate pedestrian safety concerns around the state. The PSAP features a robust methodology with two crash analysis processes: a systemic pedestrian crash analysis to identify road segments with a high potential pedestrian crash risk AND a targeted (hot spot) crash analysis to identify those road segments with a high number of historic pedestrian crashes. These dual analyses results are then combined to prioritize suggested countermeasure investments to improve pedestrian safety focusing on the TxDOT on-system roadway network, but also providing actionable measures for off-system locations where possible.

3 PSAP Crash Analysis Methodology

3.1 Crash Data

3.1.1 Introduction

TxDOT centralizes its crash database online on C.R.I.S. (Crash Records Information System)[3] and allows any user to query the statewide crash database. While TxDOT and certain public agencies can access actual peace officer crash reports including crash narratives and drawings, this analysis utilizes aggregated crash detail fields completed by peace officers and interpreted by TxDOT crash analysts. Crashes are continuously added to the database and crash information can also be updated months and even years after the original crash was logged. Because of the database's fluid nature, it is possible that the numbers presented in this document may vary slightly from TxDOT's official publications, such as the ones published on the Texas Motor Vehicle Crash Statistics site.[4]

The data extracted from the C.R.I.S. database that were used in this study have several components:[5]

- Crash file: contains crash-level information on each individual crash, such as the crash severity and the total number of people killed in each crash
- Unit file: contains vehicle-level information for each crash, such as the number of people inside the vehicle and factors that contributed to the crash. When pedestrians are involved in a crash, they can all be all coded into one single "unit" or into separate "units".
- Primary Person files:[6] contains person-level information regarding the primary person for each unit. Typically, this is used to indicate which of the multiple people involved in a crash was the driver.
- Person files:[6] contains person-level information regarding all other people (i.e., the non-primary people) involved in the crash.

All crashes have at least one associated unit in the data, but there might be units for which there are no associated individuals in the primary person or person files. More specifically, while the unit file might indicate that a specific vehicle has four people inside it, it is possible that none of those individuals are listed in the primary person or person files.

For the current study, crashes across Texas between January 1, 2017 and December 31, 2021 were queried on Apr 14, 2022. This yielded a total of 3,078,107 crashes.

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[3] Extracts from the C.R.I.S. database can be generated at https://cris.dot.state.tx.us/secure/Share/app/extract-request/extract-type

[4] The Texas Motor Vehicle Crash Statistics website is available at https://www.txdot.gov/inside-txdot/forms-publications/drivers-vehicles/publications/annual-summary.html

[5] The data dictionary for the C.R.I.S. database can be found online at https://ftp.txdot.gov/pub/txdot-info/trf/crash_statistics/automated/publicextractfilespecification.xlsx

[6] The person and primary person files have almost identical structures (i.e., almost the exact same columns), and therefore were "stacked" on top of each other for this study to get the largest amount of person-level data possible.

3.1.1.1 Filters and data manipulation

Regarding filtering crash data for systemic analysis, Jacobs and TxDOT decided to focus only on crashes that matched the following criteria. (NOTE: Section 3.2 discusses crash data filtering for the targeted analysis.)

Pedestrian-related crashes

- Crashes that belonged to the K, A, or B crash-severity levels according to the KABCO[7] crash severity rating system[8]
- Reportable motor-vehicle crashes[9]
- Crashes that happened on on-system roads[10]
- Non-intersection-related crashes (i.e., crashes that occurred along the roadway and not at any specific intersection)
- Located crashes (i.e., crashes that had longitude and latitude coordinate information)

Applying the filters above yielded 5,590 pedestrian-related crashes between 2017 and 2021 across Texas.

Crashes were labeled as a "pedestrian-related crash" in cases where the crash contained a unit where the field called **Unit_Desc_ID** was equal to "4 – Pedestrian".

Crash severities were determined using the field called **Crash_Sev_ID** in the crash file. The values considered in the current study included the values displayed in Table 3-1.

Table 3-1: Crash Severities Used

Value	Description	KABCO Severity	Used
4	Fatal Injury	K	Yes
1	Suspected Serious Injury	A	Yes
2	Suspected Minor Injury	B	Yes
3	Possible Injury	C	No
5	Not Injured	O	No
0	Unknown	U	No

"Reportable motor vehicle crashes" were selected as crashes where the **Txdot_Rptable_Fl** field in the crash file was equal to "Y – Yes".

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[7] Further information on the KABCO crash severity scale can be found at https://safety.fhwa.dot.gov/hsip/spm/conversion_tbl/pdfs/kabco_ctable_by_state.pdf

[8] *Note: C and O crash-severity crashes were kept in the crash dataset. These were filtered out for systemic crash analysis, but were later included in the Interactive Dashboard product to provide a more wholistic view of pedestrian crashes.*

[9] According to TxDOT, a "reportable motor vehicle crash" represents "any crash involving a motor vehicle in transport that occurs or originates on a traffic way, results in injury to or death of any person, or damage to the property of any one person to the apparent extent of $1,000". This definition can be found at https://ftp.txdot.gov/pub/txdot-info/trf/crash_statistics/2021/b.pdf

[10] According to TxDOT, "on-system roadways" are defined as "roadways designated on the State Highway System and maintained by TxDOT."

Crashes that happened on on-system roads were selected as crashes where the **Onsys_Fl** field in the crash file was equal to "Y – Yes".

The field called **Intrsct_Relat_ID** in the crash file classifies crashes into four different groups according to their configuration with respect to intersections. Crashes where the **Intrsct_Relat_ID** field was equal to "3 – Driveway Access" or "4 – Non-Intersection" were selected as crashes that were not intersection-related.

Located crashes were selected as crashes where the field called **Located_Fl** in the crash file was equal to "Y – Yes".

Crashes were classified as Rural or Urban using the field called **Rural_Urban_Type_ID**. The association between the field's original values and the simplified values can be seen in Table 3-2.

Table 3-2: Values Used for Urban and Rural Classification of the Crash Data

Value	Description	Simplified Value
1	Rural (<5,000)	Rural
2	Small urban (5,000-49,999)	Urban
3	Large urban (50,000-199,999)	Urban
4	Urbanized (200,000+)	Urban

A simplified functional classification was used to classify crashes into four separate groups using the field called used is called **Func_Sys_ID** in the crash file. The association between the original and the simplified values can be seen in Table 3-3.

Table 3-3: Values Used for Functional System Simplification of the Crash Data

Value	Description	Simplified Value
1	Interstate	Interstate, Freeway and Expressway
2	Other Freeway and Expressway	Interstate, Freeway and Expressway
3	Other Principal Arterial	Arterial
4	Minor Arterial	Arterial
5	Major Collector	Collector
6	Minor Collector	Collector
7	Local	Local

Crashes were classified as happening on divided or undivided roads using the field called **Road_Type_ID** in the crash file. The association between the original and the simplified values can be seen in Table 3-4.

Table 3-4: Values Used to Classify Crashes - Divided or Undivided

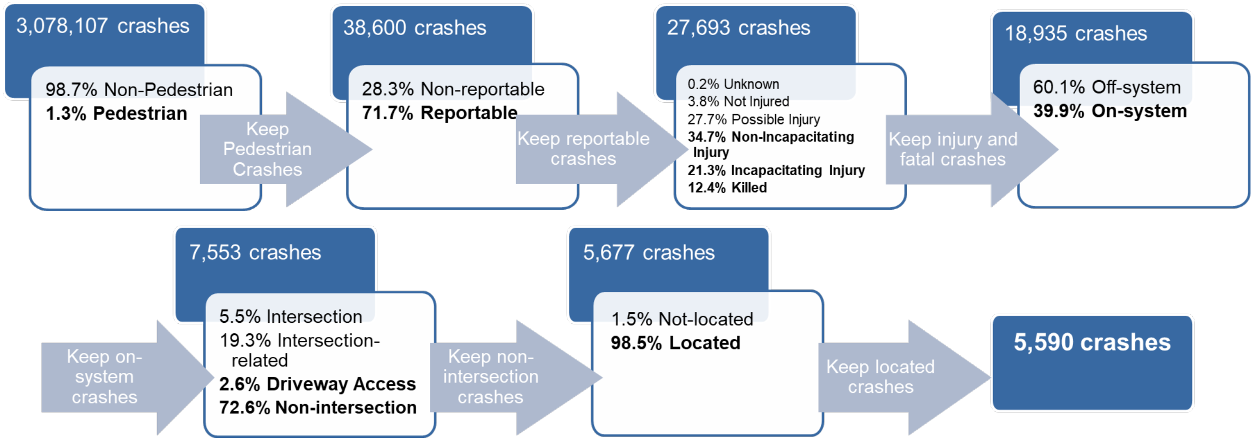
Value	Description	Simplified Value
0	Other road type	Undivided
1	2 lane, 2 way	Undivided
2	4 or more lanes, divided	Divided
3	4 or more lanes, undivided	Undivided

The field called **Crash_Speed_Limit** in the crash file was used to classify crashes in terms of their speed limits. The speed limits were rounded to the nearest 5 mph. Furthermore, speed limits were grouped into the following categories:

- Speed limit less than or equal to 40 mph
- Speed limit equal to 45 mph
- Speed limit equal to 50 mph
- Speed limit equal to 55 mph
- Speed limit equal to or greater than 60 mph

The link between the crash data and the roadway data was done using the **Hwy_Sys**, **Hwy_Nbr** and **Hwy_Sfx** fields in the crash file. When combined, these three fields result in a roadway identifier that matches the HWY field in the TxDOT Roadway Inventory. Figure 3-1 illustrates the crash filtering workflow used for the systemic pedestrian safety analysis.

Figure 3-1: Crash Filtering Workflow (Systemic Pedestrian Safety Analysis)



It should be noted that crashes that happened on main lanes as well as frontage roads were considered in this study. However, the C.R.I.S. data base does not provide enough information about each individual crash to automatically, across the whole State, identify where along the frontage road a specific crash happened, especially not in cases where there are two frontage roads. The data provided by C.R.I.S. snaps the crash location to roadways' centerlines. Therefore, when link-level graphical crash summaries are shown in this report, while only the main lanes might be shown, they are taking into consideration crashes that happened on the main lanes as well as the frontage roads.

3.1.2 Roadway Network

3.1.2.1 Introduction

Every year, TxDOT releases a database containing a digital version of its Roadway Inventory.[11] For the current study, the 2017, 2018, 2019 and 2020 Roadway Inventories were used. TxDOT's Roadway Inventory GIS file contains both on-system and off-system data attributes, but off-system attributes are not maintained by TxDOT GIS Data Management staff. The PSAP uses available roadway data and did not include any GIS data update processes. As a result, the off-system data attributes may be considered less reliable than on-system roadway segments.

As TxDOT's Roadway Inventory does not feature intersection data and TxDOT does not maintain any intersection inventory, the PSAP will not include a systemic safety analysis for intersections. A systemic pedestrian crash analysis for intersections would require data attributes about on-system intersections such as: location, number lanes entering and exiting an intersection, presence of signalization and type, etc. If these intersection inventory elements become available, a future PSAP update can include a systemic pedestrian safety analysis for intersections.

3.1.2.2 Filters and data manipulation

In discussions with TxDOT, the decision was made to focus only on on-system roadway links for the systemic pedestrian safety analysis. On-system and off-system roadway links were used for the hotspot analysis.

A filter was also applied to the **RDBD_ID** field to ensure that centerline miles were not counted multiple times. The values used in the current study can be seen in Table 3-5.

Table 3-5: Roadbed IDs that Were Used in the Study

Value	Description	Used
KG/CG	Centerline / Single Roadbed	Yes
XG	Left Frontage Road	Yes
AG	Right Frontage Road	Yes
GS	Grade Separated Connector	Yes
BG	Right Supplemental Frontage Road	No
LG	Left Roadbed	No
MG	Left Supplemental Mainlane	No
PG	Left Supplemental Supplemental Mainlane	No
RG	Right Roadbed	No
SG	Right Supplemental Mainlane	No

[11] TxDOT Roadway Inventory available at https://www.txdot.gov/inside-txdot/division/transportation-planning/roadway-inventory.html.

Value	Description	Used
TG	Right Supplemental Supplemental Mainlane	No
YG	Left Supplemental Frontage Road	No

Roadway links were classified as Rural or Urban using the field called RU. The association between the field's original values and the simplified values can be seen in Table 3-6.

Table 3-6: Values Used for Urban and Rural Classification of the Roadway Data

Value	Description	Simplified Value
1	Rural (Population <5,000)	Rural
2	Small urban (Population 5,000 - 49,999)	Urban
3	Large urban (Population 50,000 - 199,999)	Urban
4	Urbanized (Population 200,000+)	Urban

A simplified functional classification was used to classify roadway links into four separate groups. The field in the roadway data used is called **F_SYSTEM** and the association between the original and the simplified values can be seen in Table 3-7.

Table 3-7: Values Used for Functional System Simplification of the Roadway Data

Value	Description	Simplified Value
1	Interstate	Interstate, Freeway and Expressway
2	Other Freeway and Expressway	Interstate, Freeway and Expressway
3	Other Principal Arterial	Arterial
4	Minor Arterial	Arterial
5	Major Collector	Collector
6	Minor Collector	Collector
7	Local	Local

Roadway links were classified as divided or undivided using the field called **HWY_DES1**. The association between the original and the simplified values can be seen in Table 3-8.

Table 3-8: Values Used to Classify Roads - Divided or Undivided

Value	Description	Simplified Value
0	One-way-pair (couplet)	Undivided
1	One-way	Undivided
2	Two-way, Undivided	Undivided
3	Two-way, Divided - Boulevard	Divided
4	Two-way, Divided – Expressway (partial access control)	Divided
5	Two-way, Divided - Freeway (full access control)	Divided

The field called SPD_MAX was used to classify roadway links in terms of their speed limits. The speed limits were rounded to the nearest 5 mph. Furthermore, speed limits were grouped into the following categories:

- Speed limit less than or equal to 40 mph
- Speed limit equal to 45 mph
- Speed limit equal to 50 mph
- Speed limit equal to 55 mph
- Speed limit equal to or greater than 60 mph

3.2 Crash Analyses

This section describes the methodologies used to analyze pedestrian crashes across TxDOT roadways. A complementary approach of proactive and targeted analyses allows for the most comprehensive assessment of over 80,000 on-system centerline miles and the 300,000+ total centerline miles across Texas.

3.2.1 Systemic Analysis

Systemic safety is the general practice of implementing crash reduction treatments at sites with known risk factors for crashes rather than based on crash history. The widespread installation of treatments often results in addressing infrastructure issues before a crash occurs at a given site. The proactive nature of systemic safety makes it an ideal complement to more traditional hotspot network screenings. To address the rising number of pedestrian-related crashes occurring on Texas roadways, a systemic safety analysis, following the guidance of the Systemic Safety Project Selection Tool (SSPST, FHWA Report FHWA-SA-13-019) was performed to identify locations ideally suited for systemic treatments addressing pedestrian crashes. Performing these analyses in parallel with hotspot screening efforts ensures the resulting priority locations are comprehensive lists that both address historical crash locations while also proactively working to reduce crashes across on- and off-system roadways.

Systemic analysis is a data-driven process which involves screening a roadway network based on the presence of risk factors corresponding to the predominant crash types.

The systemic analysis process as outlined in the SSPST includes the following steps as utilized in the development of the PSAP systemic screening:

- Selection and identification of focus facilities
- Identification of systemic risk factors for pedestrian-related crashes
- Screening the study network for the presence of systemic risk factors

As detailed below, each of these steps was performed separately for each of the systemic peer groups identified. It’s important to reiterate that the systemic analysis detailed in Section 3.2.1 was conducted using only TxDOT-reportable, on-system, non-intersection pedestrian fatal and injury crashes.

The systemic analysis detailed in Section 3.2.1 was conducted using only TxDOT-reportable, on-system, non-intersection pedestrian fatal and injury crashes.

3.2.1.1 Focus Facilities

Systemic analysis does not typically cover all roadways within a given jurisdiction. Instead, systemic peer groups are defined based on overarching roadway characteristics. This is done to both prioritize significant roadway types and to allow for the analysis to highlight attributes critical to a variety of facility types. The selection of focus facilities is critical for identifying high-level areas of need and is a method of prioritizing analysis. The focus facilities for the systemic safety analyses were selected based on the combination of area type (urban or rural), functional classification (Interstate/freeway and arterial), travel way division (divided and undivided), and posted speed limit of the roadway (lower speed: $\leq$ 45 mph and higher speed: > 45 mph). All 25 TxDOT Districts were reviewed to identify a subset of on-system roadways that contain an overrepresentation of crashes that are unique to each District.

These District-specific focus facilities may have only relied on two or three of the four attributes that were common between the crash data attributes and the 2020 TxDOT Roadway Inventory attributes. For example, one of the three combinations of the above attributes that make up the Beaumont District focus facilities are Rural and Divided roadways. This specific combination includes all rural functional classifications and speed limits. The results from this effort for each District yield a focus facility network that is heavily skewed towards interstates, freeways, and arterials, but also may include a small portion of collectors and local roads. The analysis team created four general systemic peer groups (listed below) to mitigate this skewed effect:

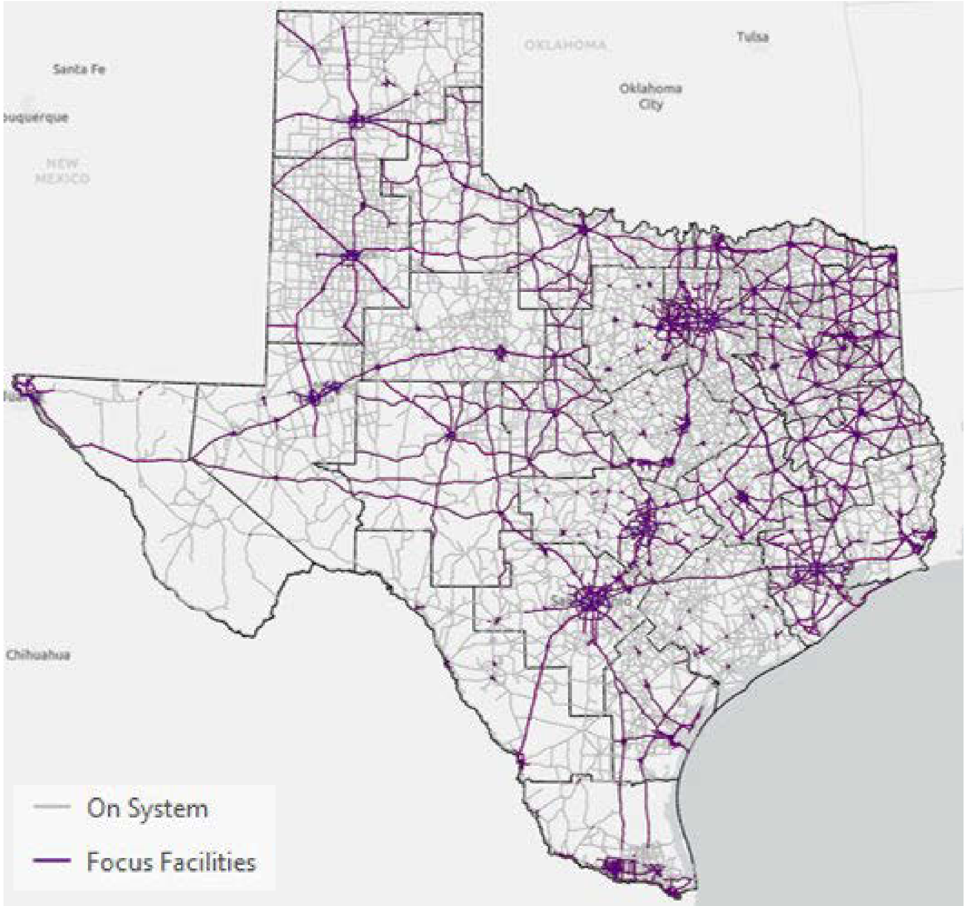
- Urban Arterials
- Rural Arterials
- Urban Interstates and Freeways
- Rural Interstates and Freeways

Districts that include collector or local functional classes were assigned in the arterial systemic peer groups since the lesser functional classes were not sufficient to support an independent risk assessment through an additional peer group. The identification of the statewide focus facility segments totaled 19,045 (Table 3-9) miles which represent approximately 23.6% of the total 80,720 on-system miles.

Table 3-9: Focus Facility Miles for Systemic Analyses

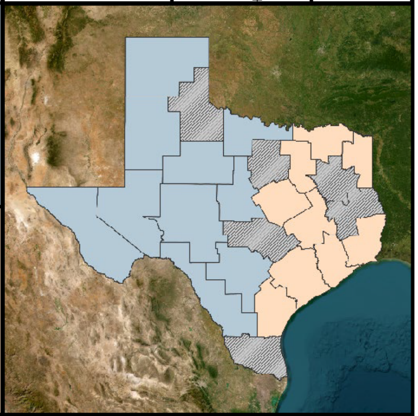
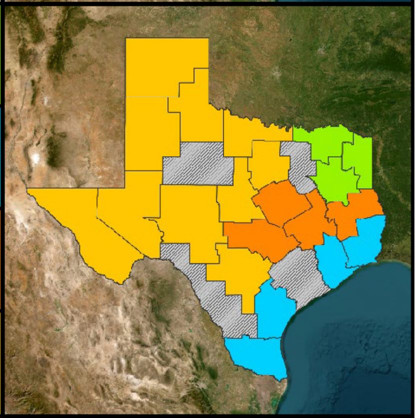
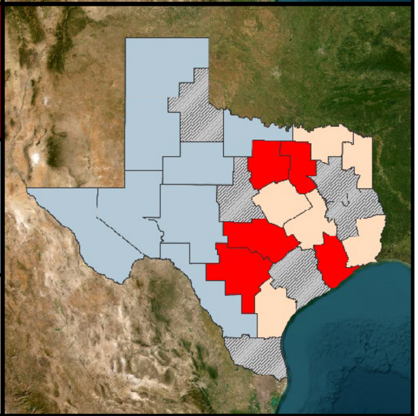
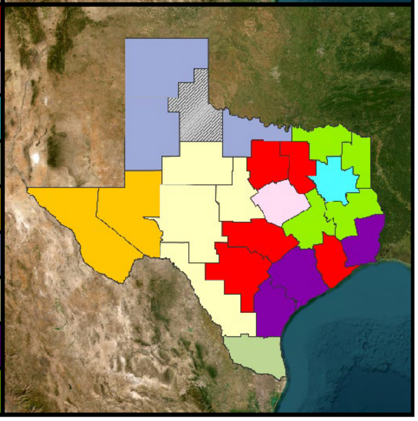
Functional Classification Groups	Rural	Urban	Total
Interstates and Freeways	1,966	2,355	**4,321**
Arterials	9,028	5,696	**14,724**
Total	**10,994**	**8,051**	**19,045**

Figure 3-2: Focus Facilities Network



Subsequently, additional District-level risk factor analyses were performed to identify District-specific risk factors following the same systemic peer groups. This process was followed to provide more individualized sets of risk factors for each of the 25 TxDOT Districts. As the total number of fatal, serious injury, and minor injury (KAB) crashes was not sufficient to develop District-specific risk factors for certain systemic peer groups, neighboring Districts were grouped together with an attempt to accumulate at least 100 KAB crashes for each systemic peer group. The five metropolitan Districts (Austin, Dallas, Fort Worth, Houston, and San Antonio) were analyzed individually for urban facility types given the higher frequency of KAB crashes and unique traffic patterns within these urban areas. These groupings were reviewed and approved by TxDOT Division stakeholders and followed regional similarities in development patterns, prevalent roadway types, and physical geography. Figure 3-3 shows the District-level groupings that were identified for the systemic analysis.

Figure 3-3: District-Level Groupings

Analysis Type	Region/District	Corresponding Map
Rural Interstate/Freeway	West	
	East	
Rural Arterial	Northeast	
	Coastal	
	East Central	
	Western	
Urban Interstate/Freeway	Top 5 Metros	
	West	
	East	
Urban Arterial	Top 5 Metros	
	Waco	
	Tyler	
	Pharr	
	West	
	North Pan	
	West Central	
	Coastal	
	Northeast	

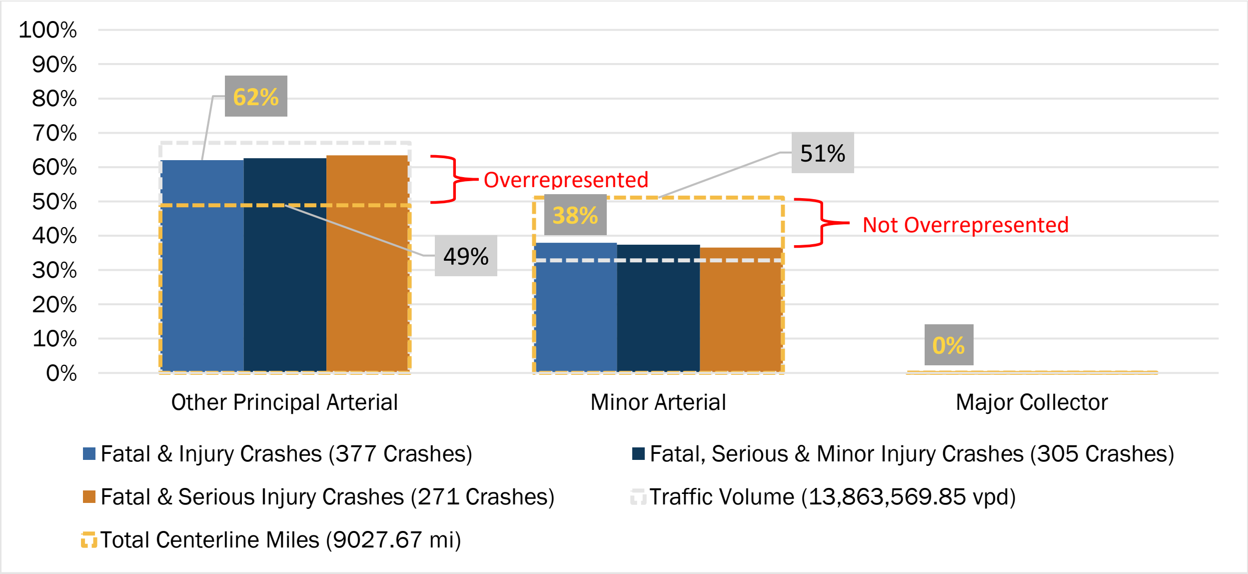
3.2.1.2 Systemic Risk Factor Analysis

> **Risk Factors**
>
> - *ARE* roadway/traffic characteristics present at locations with reported crashes
> - *ARE NOT* necessarily contributing factors and may or may not have contributed to any/all crashes at an individual site
> - *MAY* indicate a greater potential for severe pedestrian crashes to occur at the site or similar sites

Risk factors are roadway and/or traffic characteristics present at locations with reported crashes. Risk factors may indicate a greater potential for severe crashes to occur at the site or similar sites. Pedestrian crashes by severity were compiled and assigned for every segment identified in each systemic peer group. In this way, the analysis focuses on capturing trends among sites rather than the crash data itself. The combined attribute and crash data were analyzed to determine sets of systemic risk factors for each of the systemic peer groups.

Generally, systemic risk factors were identified by comparing roadway, traffic, and other contextual attributes of locations where pedestrian-related crashes have occurred. More specifically, the risk factors for each systemic peer group were identified through an evaluation of overrepresentation of KAB pedestrian crashes associated with given attributes. When a roadway attribute accounted for a higher proportion of crashes than centerline miles, an overrepresentation was determined, and the attribute was recommended as a risk factor. While safety efforts typically focus on fatal and serious injury crashes only, fatal, serious injury, and minor injury (KAB) crashes were used in the overrepresentation analysis due to the nature of pedestrian collisions and to ensure that each analysis considered enough crashes to show a range of safety performance. TxDOT staff confirmed the use of the KAB crash overrepresentation performance measure to provide additional consistency with statewide crash severity performance measures.

Figure 3-4: Systemic Risk Factor Overrepresentation Example



The example in Figure 3-4 illustrates the functional classification roadway attribute for the urban arterial systemic peer group. In the chart, the dashed yellow line represents the proportion of centerline miles along roadways within each functional class. In this case, 49% of centerline miles are classified as other principal arterials, and 51% of centerline miles are classified as minor arterials. The lighter blue vertical bars represent the percentage of fatal and injury crashes occurring on roadways with the corresponding functional classification. In the example, 62% of fatal & injury crashes occurred on roadways with a functional classification of other principal arterial, and 38% of fatal and injury crashes occurred on roadways with functional classification of minor arterial. In this example, 62% of fatal and injury crashes occurring on 49% of centerline miles indicates that other principal arterials are overrepresented for pedestrian crashes and would be recommended as a risk factor.

This process was completed individually for each available attribute in the RHINO and pedestrian databases for each systemic peer group. Note, the overrepresentation analysis considers each attribute in a vacuum, and is not powerful enough to determine crash causation. Systemic risk factors should not be interpreted as contributing factors.

Table 3-10 contains the attributes that were identified as risk factors for the statewide network.

Table 3-10: Statewide Risk Factors

Attribute Name	Rural Interstates and Freeways	Rural Arterials	Urban Interstates and Freeways	Urban Arterials
Average Daily Traffic (ADT)	X	x	X	X
Area Type			X	X
Bus Pad Offset		x		X
Bus Pad Width				X
TWLTL Presence				X
Crosswalk Presence				X
Crosswalk Width		x		
Curb Cut Offset	x	X		X
Curb Cut Presence				X
Curb Presence			X	X
Functional Class		x	X	X
Highway Division		X		X
Inside Shoulder Type		x		
Inside Shoulder Use				X
Inside Shoulder Width	X	x	X	X
Lane Width		X	X	X
Maximum Speed	X	x	X	X
Median Barrier Present	x	X	X	X
Median Type	X		X	
Median Width	x		X	X
Minimum Right-of-Way	X	x	X	X
Number of Lanes	x	X	X	X
Outside Shoulder Use				X
Outside Shoulder Width		X		X

Attribute Name	Rural Interstates and Freeways	Rural Arterials	Urban Interstates and Freeways	Urban Arterials
Roadbed Width	X		X	X
Shoulder Type		X	X	
Sidewalk Condition				X
Sidewalk Presence				X
Surface Width		x	X	X
Transit Stop Presence				X
Truck Percentage	X	x	X	X
Truck ADT	x	X	X	X

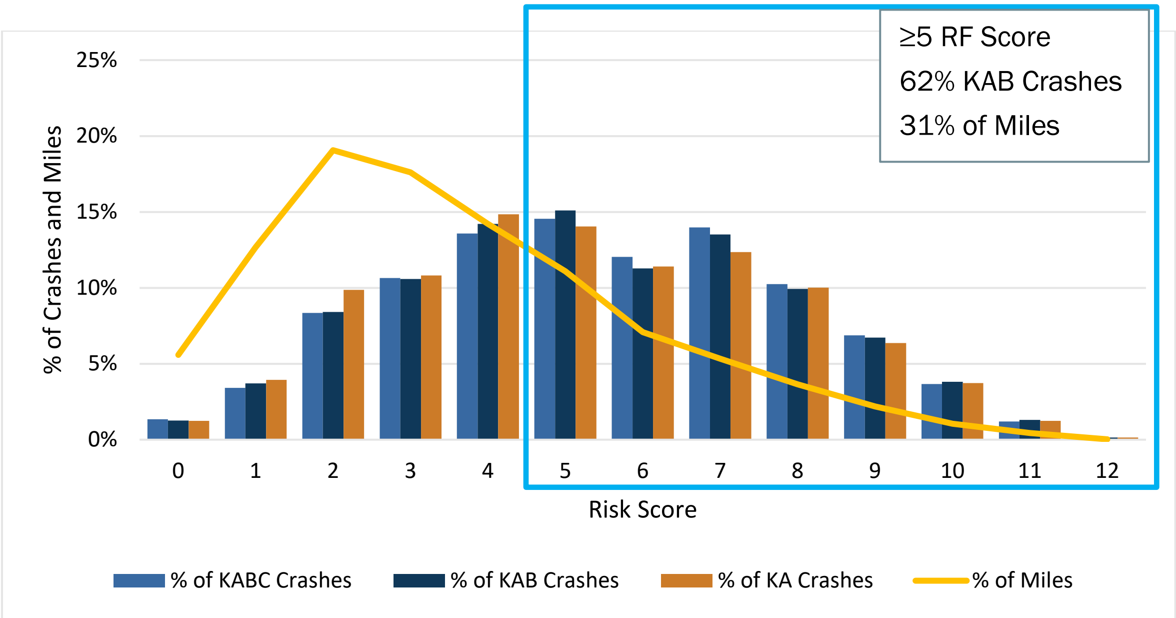
For a listing of specific Statewide risk factor attributes for each systemic peer group and for a listing of District-specific risk factors, refer to Appendix A.

3.2.1.3 Network Screening

After the systemic risk factors were identified, each of the systemic peer groups were screened for presence of the identified risk factors. Locations were each assigned a risk score equal to the total number of risk factors present. Sites with a relatively higher number of risk factors compared to peers indicate locations that may be at a higher risk for future pedestrian crashes. See Figure 3-5 for an example of a risk score determination. In this urban arterial example, locations with 5 or more risk factors are ideal locations for investment. Urban arterial on-system segments with 5 or more risk factors feature 62% of all KAB crashes on all urban arterial on-system roads, but these segments account for only 31% of the miles.

Urban arterial on-system segments with 5 or more risk factors feature 62% of all KAB crashes on all urban arterial on-system roads, but these segments account for only 31% of the miles.

Figure 3-5: Example - Urban Arterial Risk Factor Summary



After initial network screening, risk factors were checked for overlap to ensure two factors were not identifying the same underlying condition. To check for duplicate risk factors, Pearson's correlation constant was calculated between each recommended risk factor to identify whether any two given risk factors were representing largely the same segments/intersections across the roadway system when compared to one another. Between any two risk factors, a correlation coefficient of 0.6 to 1.0 is considered to have a strong statistical correlation. The correlation analysis identifies when two attributes are occurring at similar locations and does not indicate that the risk factors themselves or risk factor values are correlated in any way other than presence across the network. Risk factors with strong correlations were qualitatively evaluated to determine if the correlation warranted exclusion of an attribute.

3.2.2 Targeted (Hot Spot) Analysis

Traditional safety analysis has been foundational for reducing the frequency of fatal and serious injury crashes across Texas. The targeted analysis utilized a sliding window technique which analyzes patterns of crashes along individual routes, aggregating these point events into generalized crash profiles.

3.2.2.1 Pre-processing the Roadway Data

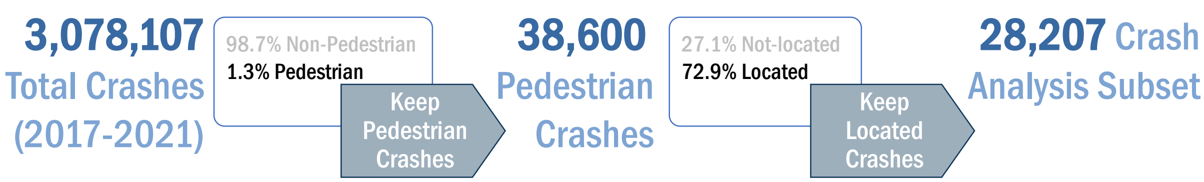
A substantial amount of data processing on both the roadway data and crash data was needed before the targeted analysis was performed. First, the 2020 Texas Roadway Inventory was loaded and filtered to only contain roadway centerline features of roads' main lanes (i.e., records where **RDBD_ID == "KG"**). This portion of the study included both on-system and off-system links. The network was then classified into peer groups, which are discussed in greater detail below. These peer groups consisted of a combination of the link's TxDOT District, its system type (on-system vs. off-system), its area type (Urban vs. Rural) and its functional classification. Since there are 25 TxDOT Districts, two system types, two area types, and four simplified functional system types, there were a total of 25*2*2*4=400 possible peer groups. Because not all these combinations of attributes are present within the dataset, the study produced a total of 316 unique peer groups.

The roadway network was dissolved according to the **RIA_RTE_ID** and **CO** fields, which represent the link's Route ID and county, respectively. Then, to ensure that links were of uniform sizes, the network was re-segmented using segment lengths of 0.4 miles for rural roads and 0.2 miles for urban roads. At this point, the roadway network was ready to be matched with individual crashes.

3.2.2.2 Pre-processing the Crash Data

As discussed in Section 2.1, the raw crash data was exported from the C.R.I.S. database on April 14, 2022. The original export contained 3,078,107 crashes from January 1, 2017 to December 31, 2021. Crashes were flagged as a "Pedestrian Crash" if any of their units had the **Unit_Desc_ID** column equal to 4, which refers to Pedestrians. This resulted in a total of 38,600 pedestrian crashes. Crashes were further filtered to keep only crashes that were labeled as "Located" (i.e., crashes that had some form of location information such as longitude and latitude coordinates and/or linear referencing information), resulting in an analysis subset of 28,207 crashes. The figure below illustrates the crash filtering workflow used for the targeted pedestrian safety analysis.

Figure 3-6: Crash Filtering Workflow (Targeted Pedestrian Safety Analysis)



3.2.2.3 Matching Crashes and Roadway Links

Matching crashes and roadway links involved two main steps:

First, crashes that already had the linear referencing information needed to be matched with the roadway links were set aside. For these crashes, the route ID was built as a concatenation of the following columns: **Hwy_Sys**, **Hwy_Nbr**, **Hwy_Sfx** and **TXDOT_CNTY_NBR**. Where applicable, the string "-KG" was also appended to the route IDs (mainly to on-system roads).

For crashes that had longitude and latitude coordinates but no linear referencing data, the crash points were projected to the nearest roadway link within 100 meters. If no roadway link was found within the 100-meter buffer, the crash was not used in the targeted analysis.

For the roadway data, the route ID was built as a concatenation of the columns **RIA_RTE_ID** and **CO**.

Second, the crashes and roadways were matched using linear referencing tools.

The crash data had information regarding what "road part" the crash took place on: on/off ramps, main lanes, frontage roads, etc. However, as described in Section 3.2.2.1, this part of the analysis only considered the centerlines of roads' main lanes. Therefore, all of a road's crashes were matched to the centerline of that road's main lanes. This was done because the Roadway Inventory does not include many of the on/off ramps present in the real world. Furthermore, when crashes occur on frontage roads of highways that have two-way frontage roads on both sides, there is no simple way to distinguish which one of the two frontage roads those crashes occurred on.

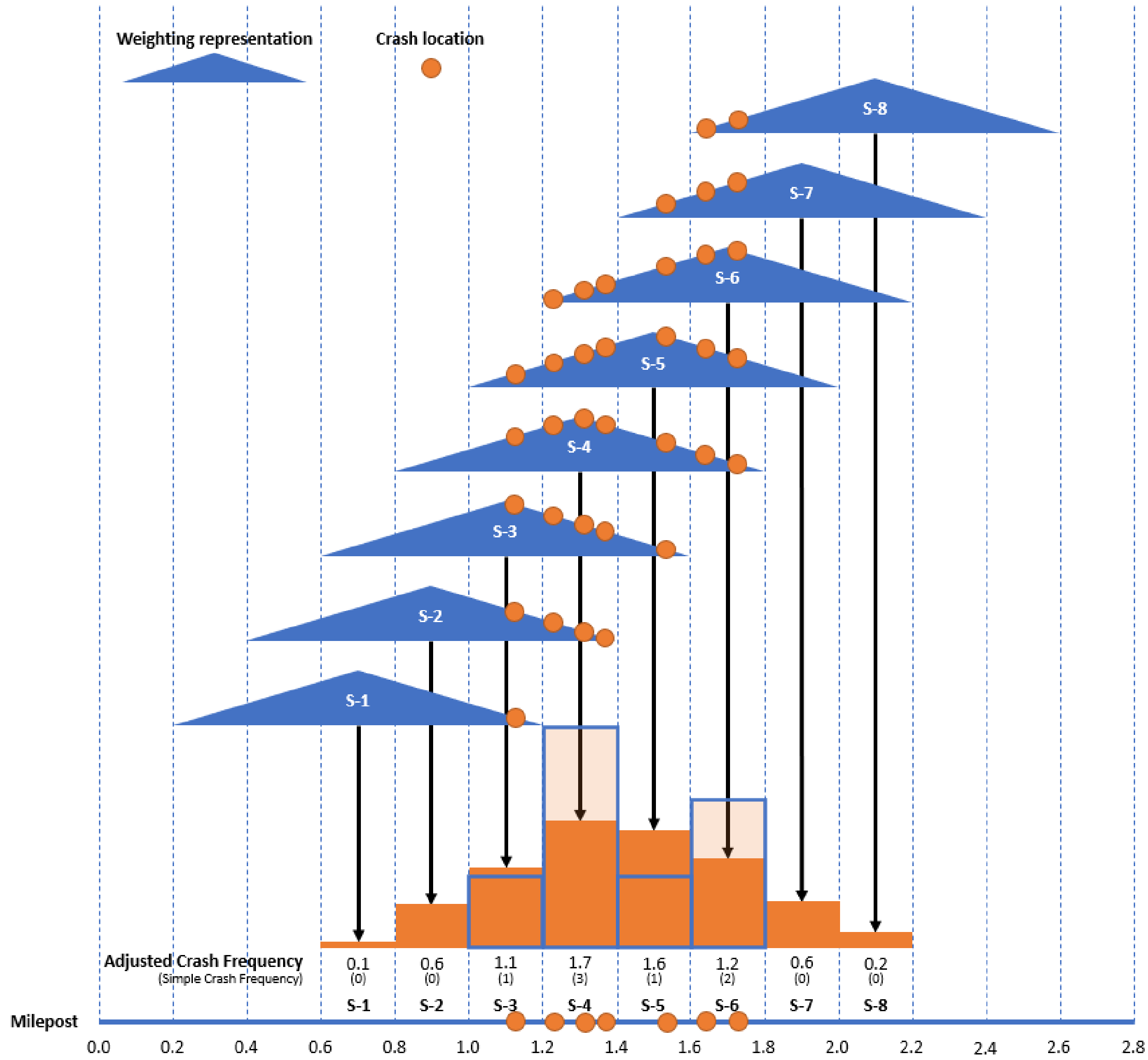
3.2.2.4 Diffusing the Effects of Crashes to Neighboring Links

Once the crashes were matched to the roadway links, the effects of each crash were diffused and spread out across four neighboring links (two in each direction). This was done using a sliding window analysis to generalize patterns of crashes, which are point events, across series of segments, which are linear events. For example, suppose a sliding window analysis is being conducted using a segment length of 0.2 miles, with segments along a given route occurring from 0.0 to 0.2, 0.2 to 0.4, 0.4 to 0.6, and so on. Suppose further that a crash occurs at mile post 0.5, right in the middle of the segment which runs from 0.4 to 0.6. To generalize the effects of this single crash, its influence area will be spread out across multiple links as follows:

- 0.111 crashes on the segment from 0.0 to 0.2
- 0.222 crashes on the segment from 0.2 to 0.4
- 0.333 crashes on the segment from 0.4 to 0.6
- 0.222 crashes on the segment from 0.6 to 0.8
- 0.111 crashes on the segment from 0.8 to 1.0

Note that even though the effect of the crash is being diffused across multiple links, the effects are more strongly concentrated on the link the crash originally occurred on and they taper off further away from the original link. Furthermore, when the diffused effects of the crash are summed, they still add up to one whole crash. A more advanced example of this methodology is visualized in Figure 3-7, which shows how 7 crashes along a route with 0.2-mile segments would get distributed based on this methodology. The filled orange bars represent the crash profile computed using the sliding window methodology, and the blue boxes represent the basic crash profile computed using simple single segment assignment. Note how the latter overly emphasizes the influence of crashes on the mile post 1.2 to 1.4 segment, which are part of a broader pattern or cluster of crashes that is more effectively captured in the sliding window analysis method.

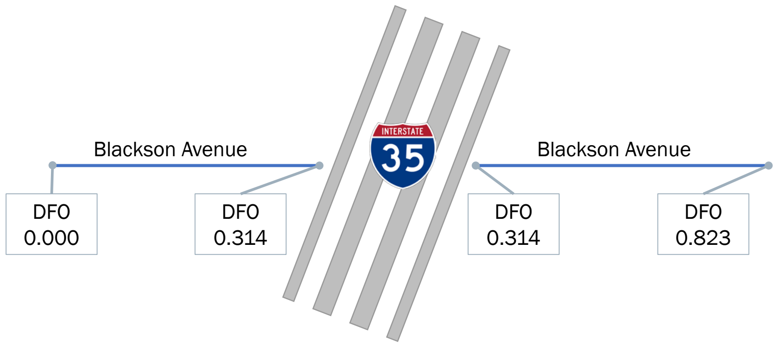
Figure 3-7: Diffusion of Crashes to Neighboring Links



Unusual Segment Breaks Issue

It is worth noting that the process described above yielded a few minor oddities, mainly for off-system roadway segments. These oddities happened in locations where roads shared **Route IDs** but had physical distance between segment endpoints. In a real-world sense, one could observe in these situations a roadway that ends, but then begins again with significant distance in between. In these situations, crashes on one side of the break contributed towards the crash totals (and crash densities) of the roadway segments on the other side of the break. For example, in the city of Austin, near the intersection of I-35 and US 183, there is a local road called "Blackson Avenue" (Route ID 1014183) which is interrupted by I-35. However, the **DFO** (distance from origin) information in the Texas Roadway Inventory can be interpreted as physically connected because the **DFO** mileage for the two adjacent segments of "Blackson Avenue" are continuous across the break from I-35 (see Figure 3-8). Therefore, diffusing the effect of a crash that happened on the west portion of road contributed to a diffusion of that crash on the east portion as well. This happened on approximately 5% of the off-system links and in less than 0.05% of the on-system links. This phenomenon was considered a small enough issue to ignore in this statewide effort.

Figure 3-8: Link with Physical Break but Continuous DFO



3.2.2.5 Calculating Crash Densities and Density Tiers

After computing the diffused effects of crashes on each link, crash densities were calculated. The benefit of considering crash density over crash frequency is that it allows for a more general comparison between segments of differing lengths and produces a performance metric that is more appropriate for analyzing linear features. This was done by simply dividing the diffused number of crashes on each link by its length. Minimum lengths of 0.4 and 0.2 miles were used for Rural and Urban links, respectively. This is because some links had very small lengths (e.g., smaller than 0.01 miles), which would have generated skewed density values. Using these floor values avoided instances of inflated crash density values along unusually short segments.

The last step of the targeted analysis involved classifying links into one of five tiers based on their crash densities:

- Very High
- High
- Medium
- Low
- Minimal

This was done by applying the Jenks Natural Breaks classification method to the crash density data for each peer group separately. This ensured fair comparisons across links, making it such that the thresholds that defined the breaks between the five categories above were specific to each peer group. It should be noted that some peer groups did not have enough observations and/or variability in them to generate five separate categories. In those cases, the categories that were generated and their names were adjusted accordingly, as can be seen in Table 3-11.

Table 3-11: Classification of Crash Density Tiers

5 Categories	
1	Very High
2	High
3	Medium
4	Low
5	Minimal

4 Categories	
1	Very High
2	High
3	Low
4	Minimal

3 Categories	
1	Very High
2	Medium
3	Minimal

2 Categories	
1	Very High
2	Minimal

1 Category	
1	Minimal

4 Countermeasure Identification and Selection Process

This section provides an overview of the countermeasure selection process and the data-driven approach to assigning engineering safety improvements to applicable locations. It also describes education, programmatic, and operational countermeasures identified to reduce pedestrian crash risk.

Investments in safety countermeasures which have been proven effective by research and analysis can mitigate future crashes involving pedestrians and reduce the injury severities resulting from those crashes. The Texas PSAP selected and applied pedestrian crash countermeasures in the following general process:

1. Identification of engineering and programmatic countermeasures
2. Development of logic to assess suitable locations
3. Application of countermeasures to potential risk and hot spot segments

Each step in the process was reviewed by a team of TxDOT Division staff from PTN, DES, and TRF with additional input from TxDOT District staff and TxDOT's Bicycle and Pedestrian Advisory Committee. Initial research and conversations with these stakeholders led to a comprehensive list of safety improvements that are eligible for Highway Safety Improvement Program (HSIP) and other state and federal highway funds and can be viewed as actionable upon the completion and adoption of the PSAP.

4.1 Engineering Countermeasures

Twenty-five engineering-related countermeasures were selected based on a review of Federal Highway Administration (FHWA) best practices,[12] TxDOT's Highway Safety Improvement Program, and a review of the Crash Modification Factor (CMF) Clearinghouse. All TxDOT HSIP work codes that relate to mitigating pedestrian crash outcomes and the associated crash reduction factors were utilized. Table 4-1 summarizes all of these identified engineering countermeasures. As of Spring 2023, TxDOT HSIP work codes are only available for less than half of this list; however, TxDOT TRF has begun investigating incorporating some of these countermeasures into future HSIP guidelines. Incorporating additional countermeasures into the HSIP adds funding flexibility and opportunities to TxDOT Districts when programming pedestrian improvements in their areas, specifically allowing Category 8 funding for additional pedestrian investments. Even though some of

[12] Proven Safety Countermeasures for Pedestrians, PEDSAFE, Toolbox of Pedestrian Countermeasures and Their Potential Effectiveness.

these improvements are not identified in the TxDOT HSIP, FHWA and the CMF Clearinghouse have supporting research and documentation that provide a range of effectiveness if a countermeasure is implemented.

Another set of tools available to TxDOT District staff is the Safety Scoring Tools which have a broader focus than just pedestrian design elements and are intended to assist roadway design engineers in making safety-driven decisions during the project development and design process. These Excel-based tools are currently available for rural highways (two lane and multi-lane) and urban intersections. An additional urban highways safety scoring tool is in development. For more information, visit the DES Division's Safety Score Tool webpage on TxDOT's website (https://www.txdot.gov/business/resources/design-tools-training.html).

There are two general categories that define where these engineering countermeasures can be implemented for both systemic and targeted analyses – along segments and at spot locations. The segment-related pedestrian countermeasures are intended to support safety improvements along a corridor, such as installing sidewalks or raised medians. In some cases, these countermeasures target pedestrian crashes that occur along a roadway between intersections, however, these segment-related countermeasures could improve safety performance at intersections as well.

The other category of countermeasures is focused on spot treatments or safety improvements at intersections or at crossing locations. There are multiple spot treatments that would modify the traffic control configuration at an intersection and there are options for providing/improving mid-block crossings by installing active crossing devices like pedestrian hybrid beacons or rectangular rapid flashing beacons. Pedestrian refuge islands, in-street pedestrian signs or raised pedestrian crossings are examples of passive crossing devices that are intended to improve pedestrian visibility while simultaneously reducing speeds of approaching vehicles.

This list of countermeasures is not exhaustive and, as research continues in the area of improving pedestrian safety, new countermeasures may be identified. Suggested countermeasures were applied statewide with the best available data followed up by a statewide quality control process. However, a robust implementation review of prioritized locations paired with local stakeholder engagement will help validate safety investments for specific locations.

Table 4-1: Engineering Countermeasures

Countermeasure Name	Countermeasure Description	Analysis Type	Target Crash Types	TxDOT HSIP Code (TxDOT CRF)[13]	CMF CLEARING-HOUSE ID(s)[14]	CMF CLEARING-HOUSE FACTORS (CRF / CMF)
Curb Geometrics	Reduce right-turn curb radii to reduce right turn vehicle speeds or bump out/extend curb ramps at intersections to reduce the crossing distance.	Targeted	Vehicle/ Pedestrian	–	STEP Countermeasure Tech Sheet	–

[13] For more information on TxDOT HSIP Codes and Crash Reduction Factors, refer to TxDOT's 2021 HSIP Guidelines

[14] CMF ID numbers are unique to the Crash Modification Factors Clearinghouse

Countermeasure Name	Countermeasure Description	Analysis Type	Target Crash Types	TxDOT HSIP Code (TxDOT CRF)[13]	CMF CLEARING-HOUSE ID(s)[14]	CMF CLEARING-HOUSE FACTORS (CRF / CMF)
Flashing Yellow Pedestrian Protection	Modify signal phasing to implement a Protected Pedestrian Interval call during a Flashing Yellow Arrow Phase.	--	Vehicle/ Pedestrian	--	--	--
Improve School Zones	Improve an existing school zone by upgrading signing, pavement markings, or signals.	Both	All Crash Types	133 (5%)	--	--
In-Street Pedestrian Sign	R1-6a sign placed in the middle of the street or W11-2, W16-7P at crossing locations. These signs serve to remind road users of laws regarding right-of-way.	Targeted	Vehicle/ Pedestrian	--	STEP Countermeasure Tech Sheet	--
Install Roundabouts	Convert an existing intersection to a single lane roundabout design.	--	Intersection Related	547 (62%)	--	--
Install School Zones	Install school zones to include flashers, signing, and/or pavement markings where none existed previously. Refer to HSIP Work Code 403 for pedestrian crosswalk markings.	Systemic	All Crash Types	114 (20%)	--	--
Install Sidewalk	Install sidewalks where none existed previously.	Both	Pedestrian, Pedalcyclist	407 (65%)	--	--
Install/Upgrade Safety Lighting	Provide roadway lighting, either partial or continuous, where either none existed previously, or major improvements are being made. Refer to HSIP Work Code 305 for intersection lighting.	Both	Lighting Conditions: Dark, Not Lighted; Dark, Lighted; Dark, Unknown Lighting	304 (49%)	--	--
Install Traffic Signal	Provide a traffic signal where none existed previously. This does not include the installation of flashing beacons.	--	Intersection Related Pedestrian/ Pedalcyclist Angle, Sideswipe, Head On	107 (35%)	--	--
Leading Pedestrian Interval	Modify signal phasing to implement a Leading Pedestrian Interval.	Targeted	Vehicle/ Pedestrian	--	1993, 9903, 9906, 9909, 9912, 9915, 9918	(9% - 58.7%) / (0.91 - 0.413)

Countermeasure Name	Countermeasure Description	Analysis Type	Target Crash Types	TxDOT HSIP Code (TxDOT CRF)[13]	CMF CLEARING-HOUSE ID(s)[14]	CMF CLEARING-HOUSE FACTORS (CRF / CMF)
Median Barriers	Construct a concrete or cable safety system median barrier where none existed previously.	Systemic	Head On	201 (75%)	--	--
Median Barrier Height Extensions	Increase height/vertical clearance on median barrier walls for high-speed facilities.	--	Vehicle/ Pedestrian	--	--	--
Pedestrian Crosswalk Markings	Place pedestrian crosswalk markings where none existed previously. Refer to HSIP Work Code 114 for school zones and HSIP Work Code 110 for pedestrian signals.	--	Pedestrian	403 (10%)	--	--
Pedestrian Hybrid Beacon (PHB)	Provide pedestrian hybrid beacons at established crosswalks or in conjunction with installation of new crosswalks (HSIP Work Code 403). Requires TRF approval.	Both	Pedestrian	143 (15%)	--	--
Pedestrian Refuge Islands	A pedestrian refuge island is a median with a refuge area that is intended to help protect pedestrians who are crossing a multi-lane road.	Targeted	Vehicle/ Pedestrian	--	STEP Countermeasure Tech Sheet	32% / 0.68
Pedestrian Scramble	Implement exclusive pedestrian phase at signalized intersections.	Targeted	Vehicle/ Pedestrian	--	4117, 5244	(35% - 51%) / (0.65 - 0.49)
Pedestrian Over/Underpass	Construct a pedestrian over/underpass where none existed previously.	--	Pedestrian	523 (95%)	--	--
Raised Median	Install a roadway divider using barrier curb.	Systemic	Angle Sideswipe Head On	203 (25%)	--	--
Raised Pedestrian Crosswalks	Install elevated pedestrian crosswalks with appropriate signs and pavement markings.	Targeted	Vehicle/ Pedestrian	--	136	46% / 0.54
Rectangular Rapid Flashing Beacon (RRFB)	Install pedestrian activated rectangular rapid flashing beacons (RRFB) at existing crosswalks or in conjunction with installation of new crosswalks (HSIP Work Code 403). Requires TRF approval.	Both	Pedestrian	144	9024, 11158, 11168, 11169	(47% - 73%) / (0.53 - 0.27)

Countermeasure Name	Countermeasure Description	Analysis Type	Target Crash Types	TxDOT HSIP Code (TxDOT CRF)[13]	CMF CLEARING-HOUSE ID(s)[14]	CMF CLEARING-HOUSE FACTORS (CRF / CMF)
Shared Use Path	Installed shared use paths where none existed previously.	Both	Vehicle/ Bicyclist	--	9250	25% / 0.75
SOXSOP	Safety and Operational Xross Section Optimization utilizes existing roadway layout and configuration to repurpose thru lanes and turn lanes to improve safety along a corridor and when accessing driveways and intersections.	Systemic	All Crash Types	--	199, 874, 875, 876, 2841, 5553, 5554, 7828, 7829, 11128, 11129, 11133, 11134, 11135, 11136, 11230, 11231	(0% - 64%) / (1 - 0.36)
Stop Lines at Traffic Signals	Provide stop bar pavement markings at signalized intersections.	--	Vehicle/ Pedestrian	--	--	--
Traffic Calming	Provide roadway improvements intended to reduce driver speed by introducing horizontal deflection devices (chicanes), reduced travel way space (lane narrowing), vertical deflection (speed humps/tables), or other means to change the perception of a high-speed roadway.	Systemic	All Crash Types	--	128, 129, 131, 132, 134, 586, 587, 588	(6% - 50%) / (0.94 - 0.5)

4.2 Educational, Programmatic, and Operational Countermeasures

Infrastructure investments have been shown to reduce the frequency and severity of pedestrian crashes. Similarly, investment in educational, programmatic, and operational countermeasures have been shown to improve pedestrian crash outcomes. Table 4-2 provides a list of strategies and programmatic and educational countermeasures that are intended to help facilitate safe social norms when drivers and pedestrians interact on public roadways.

Table 4-2: Educational, Programmatic, and Operational Countermeasures

Countermeasure Name	Type	Description/Example
Undertake Education Campaigns or Programs	Educational	● Traffic Safety Campaigns ● Pedestrian Safety Campaigns ○ Educate pedestrians to walk against, not with, the flow of traffic and to stay off the travel lane. ○ Encourage pedestrians and bicyclists to wear reflective or brightly colored clothing to improve their conspicuity. ○ Educate school-aged children on safety practices that they should follow while waiting for the bus (e.g., stay out of the road, limit horseplay, be aware of traffic, etc.) ● Stay Safe Priority ● Unintended pedestrians/stranded motorists along high-speed roadways (E.g.: Wisconsin DOT Stranded Driver tips)
Expand Disabled Vehicle Programs	Programmatic	Highway Emergency Response Operator (HERO) Program
Speed Trailer Program		Enforcement Strategy: Speed trailers discourage speeding and can be deployed at various locations and can be relocated periodically.
Undertake Frontage Road Study	Operational	Focuses on frontage roads with greater proportion of crashes (E.g.: US 287 Frontage Road Improvements Feasibility Study or I-20 Midland-Odessa Corridor Study
Undertake Speed Study		Focuses on corridors with greater proportion of speeding-related crashes, looking for speed limit reduction opportunities (Guidance: TxDOT Manual: Procedures for Establishing Speed Zones, Speed Zone Studies and NACTO Speed Safety Study guidance)
Undertake Roadway Safety Audit		Review of safety conditions and plan for improvements (FHWA guidance)
Consider Right-Turn-on-Red Restrictions		Identify signalized intersections with high right-turning volumes (FHWA Intersection Safety Campaign guidance)

The purpose of these strategies is to complement the engineering countermeasures by reminding roadway users of their responsibilities, providing assistance to potential unintended pedestrians, and identifying situational deficiencies in roadway operations. All of these efforts should involve active engagement with local stakeholders and residents to help promote a positive safety culture. This list is not exhaustive and District staff are encouraged to start thinking about implementing some of these strategies as shifting community attitudes and behavior are lengthy processes.

While some of these strategies require the organization of group leaders and safety champions, operational strategies can be incorporated into District standard practices to regularly assess locations of concern as it relates to frontage roads, excessive speed, and signalized intersections with heavy right-turning volumes. Engineering-level analysis is likely needed if specific locations are identified for actionable improvements. In subsequent sections, locations are identified based on statewide data analysis and may require additional local knowledge and review.

4.3 Countermeasure Logic Methodology and Assignment

This section describes the data-driven approaches used to identify suggested safety countermeasures for the systemic and targeted safety analysis results. There are 13 suggested countermeasures specific to the systemic analysis results (Section 3.2.1) and 12 suggested countermeasures for the targeted analysis results (Section 3.2.1). The logic associated with each countermeasure is similar between the two analyses and deviate slightly when presence of crash history or presence of risk factors are considered. The countermeasure logic was applied to all systemic segments and only to hot-spot segments where there was a history of crashes. The countermeasure logic was only applied when data and/or applicable guidance was readily available. For example, there is insufficient data indicating the locations of traffic signals on Texas roadways to adequately apply any logic for the countermeasure "Install stop lines at traffic signals."

4.3.1 Systemic Analysis Countermeasures

As a reminder, there are 19,045 centerline miles of Focus Facilities that were considered for the systemic analysis. The logic/criteria were applied to all focus facilities regardless of the "potential risk" designation. The results shown in Table 4-3 provide the number of centerline miles that met the specific logic/criteria for each countermeasure and there are many locations where multiple countermeasure criteria applied to a single segment.

Table 4-3: Systemic Analysis Countermeasure Summary

Countermeasure	Centerline Miles	Locations
Install Sidewalk	5,961	–
Install Shared Use Path	6,801	–
Install School Zones	–	2,371
Improve School Zones	–	12
Install Pedestrian Hybrid Beacon (PHB)	–	81
Install Rectangular Rapid Flashing Beacon (RRFB)	–	384
Install Median Barriers	956	–
Install Raised Median	400	–
Install/Upgrade Lighting	4,464	–
Install Traffic Calming	966	–
SOXSOP	460	–
Frontage Road Study	470	–
Speed Study	1,062	–

The following sections describe the specific set of criteria that each systemic analysis segment met for a countermeasure to be suggested.

4.3.1.1 Install Sidewalk

The Install Sidewalk countermeasure was suggested if:

CRITERION #1

- Sidewalk Coverage = “Mostly Present” to “None Present”
- Functional Classification
  - Other Principal Arterial
  - Minor Arterial
  - Major Collector
  - Minor Collector
  - Local
- Posted Speed Limit ≤ 55 mph

CRITERION #2

- Sidewalk Coverage = “Mostly Present” to “None Present”
- Functional Classification
  - Interstate
  - Other Freeway and Expressway
- Area Type = Urban

4.3.1.2 Install Shared Use Path

The Install Shared Use Path countermeasure was suggested if:

CRITERION #1

- Curb is present on both sides of roadway
- Posted speed limit ≤ 45 MPH
- (ROW width – roadbed width)/2 ≥ 14 feet

CRITERION #2

- Curb is present on both sides of roadway
- Posted speed limit ≥ 50 MPH
- (ROW width – roadbed width)/2 ≥ 16 feet

CRITERION #3

- Curb is Not Present
- (ROW width – roadbed width)/2 ≥ 20 feet
- Area Type = Urban

Shared Use Path criteria were based on TxDOT Roadway Design Manual §6.4.4, Table 6-6.

4.3.1.3 Install School Zones

The Install School Zone countermeasure was suggested if:

- Segment is within 0.5-mile buffer of school point
- Posted Speed Limit < 50 MPH

Install school zone references:

- Safe Routes Partnership: Too Far to Walk? = 0.5 to 1.5 miles
- The Threshold Distance Associated with Walking from Home to School = 0.497 miles (0.8 km)
- Evaluating the effects of active morning commutes on students' overall daily walking activity in Singapore: Do walkers walk more? = 0.42 to 0.84 miles

4.3.1.4 Improve School Zones

The Improve School Zone countermeasure was suggested if:

- Segment Crash Flag = "Active School Zone Flag"

4.3.1.5 Install Pedestrian Hybrid Beacon (PHB)

The Install Pedestrian Hybrid Beacon (PHB, commonly known as HAWK) countermeasure was suggested if:

- Sidewalk Coverage = "Mostly to Fully Present"
- Posted Speed Limit ≤ 40 MPH
- Number of Lanes = 6

Install PHB/HAWK criteria were based on TxDOT RRFB & PHB 2018 Memo. A total of 81 segments/locations were identified statewide.

4.3.1.6 Install Rectangular Rapid Flashing Beacon (RRFB)

The Install Rectangular Rapid Flashing Beacon countermeasure was suggested if:

- Sidewalk Coverage
    - Partially to Fully Present
- Posted Speed Limit ≤ 40 MPH
- Number of Lanes < 6

Install RRFB criteria were based on TxDOT RRFB & PHB 2018 Memo. A total of 384 segments/locations were identified statewide.

4.3.1.7 Install Median Barriers

Install Median Barrier specifically refers to construction of a concrete or cable safety system median barrier where none existed previously. This countermeasure was suggested if:

- Median Type = "Unprotected"
- Median Width > 10 feet
- Posted Speed Limit ≥ 50 MPH
- Crash Flag = "Pedestrian Failed to Yield ROW to Vehicle"

4.3.1.8 Install Raised Medians

The Install Raised Median countermeasure was suggested if:

- Median Type = "None" or "Unprotected"
- Median Width = 6 feet ≤ 17 feet

- Number of Lanes ≤ 6

4.3.1.9 Install/Upgrade Lighting

The Install/Upgrade Lighting countermeasure was suggested if:

- Dark Lighting Crash Ratio > 50%

The *Dark Lighting Crash Ratio* is defined by the total number of crashes with lighting condition "Dark, Not Lighted" + "Dark, Lighted" + "Dark, Unknown Lighting" divided by the total number of crashes:

$$\frac{('Dark, Not\ Lighted' + 'Dark, Lighted' + 'Dark, Unknown\ Lighting')}{Total\ number\ of\ crashes}$$

NOTE: Presence of lighting data was unavailable for this analysis.

4.3.1.10 Install Traffic Calming

The Install Traffic Calming countermeasure was suggested if:

- Lane Width ≥ 12 feet
- Number of Lanes ≤ 4
- Speed Limit Risk Factor Present
- Area Type = Urban

4.3.1.11 Safety and Operational Cross Section Optimization (SOXSOP)

Safety and Operational Xross Section Optimization (SOXSOP) evaluates the trade-offs between lane and shoulder configurations within the existing roadway width that may be needed during the design life of the highway. Please contact TxDOT's Design Division or Traffic Safety Division for more information.
The SOXSOP countermeasure was suggested if:

- Number of Lanes ≤ 4
- Traffic Volume ≤ 15,000 VPD
- Posted Speed Limit ≤ 40 MPH

4.3.1.12 Frontage Road Study

The Frontage Road Study countermeasure was suggested if:

- Frontage Road Crash Ratio ≥ 60%

The *Frontage Road Crash Ratio* is defined as the number of crashes coded as "Service / Frontage Road" based on the CRIS Road Part ID divided by the total number of crashes:

$$\frac{Crashes\ with\ CRIS\ Road\ Part\ ID\ as\ \text{“}Service\text{”}\ or\ \text{“}Frontage\ Road\ Crashes\text{”}}{Total\ number\ of\ crashes}$$

4.3.1.13 Speed Study

The Speed Study countermeasure was suggested if:

- Speeding Related Crash Ratio ≥ 20%

The *Speeding Related Crash Ratio* is defined as the number of crashes that have a “Contributing Factor” or “Potential Contributing Factor” coded as:

- Failed to Control Speed
- Unsafe Speed
- Speeding – (Over limit)

Divided by the total number of crashes on the segment:

$$\frac{(Total\ number\ of\ crashes\ with\ the\ above\ 'Contributing\ Factors'\ or\ 'Potential\ contributing\ factors'\ )}{Total\ number\ of\ segment\ crashes}$$

4.3.2 Targeted (Hot Spot) Analysis Countermeasures

The 12 suggested countermeasures for the Targeted (Hot Spot) analysis were applied to over 300,000 miles of on-system and off-system roads — a much larger set of roadway segments than was used for the systemic analysis. The logic associated with each countermeasure is similar to the systemic analysis but considers presence of crash history. The countermeasure logic was only applied when data and/or applicable guidance was readily available. Table 4-4 summarizes the number of centerline miles and locations that met the specific logic/criteria for each countermeasure by on- and off-system networks. Since the targeted analysis segmented urban and rural roadways to 0.2- and 0.4-mile lengths, respectively, these countermeasures are intended to be implemented at spot locations, whether at an intersection or mid-block.

Table 4-4: Targeted Analysis Countermeasure Summary

Countermeasure	On-System		Off-System	
	Miles	Locations	Miles	Locations
Install Sidewalk	3,718	--	7,076	--
Install Shared Use Path	2,957	--	0	--
Improve School Zones	--	33	--	226
Install Pedestrian Hybrid Beacon	--	286	--	0
Install Rectangular Rapid Flashing Beacon	--	1,069	--	24
Install In-Street Pedestrian Signs	--	164	--	20,007
Install/Upgrade Lighting	1,034	--	1,139	--
Install Raised Crosswalks	--	30	--	18,467
Modify Curb Geometrics	--	2,678	--	31
Implement Leading Pedestrian Interval	--	1,201	--	2,061
Implement Pedestrian Scramble	--	651	--	1,432
Install Pedestrian Refuge Island	--	817	--	1

4.3.2.1 Install Sidewalk

The Install Sidewalk countermeasure was suggested if:

CRITERION #1

- Sidewalk Coverage = “Mostly Present” to “None Present”

- Functional Classification
    - Other Principal Arterial
    - Minor Arterial
    - Major Collector
    - Minor Collector
    - Local
- Posted Speed Limit ≤ 55 mph
- Pedestrian crash > 0

CRITERION #2

- Sidewalk Coverage = "Mostly Present" to "None Present"
- Functional Classification
    - Interstate
    - Other Freeway and Expressway
- Area Type = Urban
- Pedestrian crash > 0

4.3.2.2 Install Shared Use Path

The Install Shared Use Path countermeasure was suggested if:

CRITERION #1

- Curb is present on both sides of roadway
- Posted speed limit ≤ 45 MPH
- (ROW width – roadbed width)/2 ≥ 14 feet
- Pedestrian crash > 0

CRITERION #2

- Curb is present on both sides of roadway
- Posted speed limit ≥ 50 MPH
- (ROW width – roadbed width)/2 ≥ 16 feet
- Pedestrian crash > 0

CRITERION #3

- Curb is "Not Present"
- (ROW width – roadbed width)/2 ≥ 20 feet
- Area Type = Urban
- Pedestrian crash > 0

Shared Use Path criteria were based on TxDOT Roadway Design Manual §6.4.4, Table 6-6.

4.3.2.3 Improve School Zones

The Improve School Zone countermeasure was suggested if:

- Segment Crash Flag = "Active School Zone Flag"

4.3.2.4 Install Pedestrian Hybrid Beacon (PHB)

The Install Pedestrian Hybrid Beacon (PHB, commonly known as HAWK) countermeasure was suggested if:

- Sidewalk Coverage = "Mostly Present" to "Fully Present"
- Posted Speed Limit ≤ 40 MPH
- Number of Lanes = 6
- Pedestrian crash > 0

Install PHB/HAWK criteria were based on TxDOT RRFB & PHB 2018 Memo.

4.3.2.5 Install Rectangular Rapid Flashing Beacon (RRFB)

The Install Rectangular Rapid Flashing Beacon countermeasure was suggested if:

- Sidewalk Coverage= "Partially Present" to "Full Present"
- Posted Speed Limit ≤ 40 MPH
- Number of Lanes < 6
- Pedestrian crash > 0

Install RRFB criteria were based on TxDOT RRFB & PHB 2018 Memo.

4.3.2.6 Install In-Street Pedestrian Signs

The Install In-Street Pedestrian Signs countermeasure was suggested if:

- Traffic Volume < 10,000 VPD
- Number of Lanes < 4
- Posted Speed Limit ≤ 30 MPH
- Signal Related Crashes = 0
- Pedestrian crash > 0

4.3.2.7 Install/Upgrade Lighting

The Install/Upgrade Lighting countermeasure was suggested if:

- Dark Lighting Crash Ratio > 50%
- Pedestrian crash > 0

The *Dark Lighting Crash Ratio* is defined by the total number of crashes with lighting condition "Dark, Not Lighted" + "Dark, Lighted" + "Dark, Unknown Lighting" divided by the total number of crashes:

$$\frac{('Dark, Not\ Lighted' + 'Dark, Lighted' + 'Dark, Unknown\ Lighting')}{Total\ number\ of\ crashes}$$

NOTE: Presence of lighting data was unavailable for this analysis.

4.3.2.8 Install Raised Crosswalks

The Install Raised Crosswalk countermeasure was suggested if:

- Functional Class =

    - Major Collector
    - Minor Collector
    - Local
- Traffic Volume < 9,000 VPD
- Posted Speed Limit ≤ 30 MPH
- Number of Lanes < 4
- Signal Related Crashes = 0
- Pedestrian crash > 0

4.3.2.9 Modify Curb Geometrics

The Modify Curb Geometrics countermeasure includes curb extensions and/or radii reductions. This countermeasure was suggested if:

CRITERION #1

- Area Type = Urban
- Presence of Transit Stop
- Pedestrian crash > 0

CRITERION #2

- Area Type = Urban
- Presence of On-Street Parking
- Pedestrian crash > 0

4.3.2.10 Implement Leading Pedestrian Interval

The Implement Leading Pedestrian Interval countermeasure was suggested if:

- Signal Related Crash Ratio ≥ 50%

NOTE: Data indicating the locations or characteristics of intersections using Leading Pedestrian Intervals was not available for this analysis.

Countdown timers and push buttons or some sort of pedestrian detection should be present or added in these locations to be effective.

4.3.2.11 Implement Pedestrian Scramble

The Implement Pedestrian Scramble countermeasure was suggested if:

- Signal Related Crash Ratio ≥ 95%
- Functional Classification =
    - Other Principal Arterial
    - Minor Arterial
    - Major Collector
    - Minor Collector
    - Local

4.3.2.12 Install Pedestrian Refuge Island

The Install Pedestrian Refuge Island countermeasure was suggested if:

- Median Type =
  - None
  - Unprotected
  - Curbed
- Non-Intersection Related Crash Presence
- Signal Related Crashes = 0
- Median Width $\geq$ 6 feet
- Traffic Volume $\geq$ 9,000 VPD

4.4 Other Engineering Countermeasures

4.4.1 Installing Smart Intersection Improvements

In 2023, the Texas A&M Transportation Institute (TTI) in partnership with TxDOT won a research grant for the Smarter Intersection Pilot Project. This award will allow transportation researchers to continue investigating technology connecting intersection infrastructure to connected transit vehicles (Vehicle-to-Everything). TTI initially began this research to help bus drivers prevent crashes with vulnerable road users with pilot tests in College Station, TX (Research Project 0-6875). As this vehicle-to-infrastructure technology improves, future countermeasure investment may include improvements to intersection's ability to communicate to vehicles.

4.4.2 Countermeasure Research Overlap & Exclusions

The University of Texas at Austin's (UT) Center for Transportation Research (CTR) completed the Developing Countermeasures to Decrease Pedestrian Deaths research project that identified 48 different improvements or investments intended to reduce pedestrian crashes and their severity. Some improvements did not have a long history of implementation or supportive academic research pointing to their efficacy; however, others were established countermeasures proven to improve pedestrian safety. From UTCTR's list of 48 improvements, 20 were not included as suggested countermeasures in TxDOT's PSAP. The following three tables provide a list of those pedestrian improvements with explanations why they that were not included and considerations for how they may contribute to a safer pedestrian environment. While these investments were not included in the PSAP, these improvements should be considered in future PSAP updates as they could greatly benefit pedestrian safety and supplement the existing countermeasures.

Table 4-5 features 8 pedestrian improvements generally related to standard TxDOT roadway design practices. For example, installing curb and gutter is a roadway design element not considered as a suggested PSAP countermeasure because there isn't an established connection between this improvement and improved pedestrian safety. While curb and gutter investments are frequently tied to alleviating drainage concerns, a curb can provide a positive barrier between vehicles and pedestrian pathways. Another example, installing curb ramp improvements should be standard practices for TxDOT to meet ADA compliance meanwhile installing signage is a standard practice to provide adequate advance warning for drivers that pedestrians may be present.

Table 4-5: Roadway Design Improvements in UT Research Absent from PSAP

Improvements Included by UTCTR, but not PSAP	Countermeasure Category
Basic Curb & Gutter	General Roadway Design Elements
Flashing Beacon	
Advanced Stop/Yield Sign	
Adding Crosswalk Signage (when crosswalks already exist)	
Install Crosswalk Sign	
Curb Ramps (to crossings)	
Access Management Improvements	
Sidewalk Railings	

Table 4-6 shows 6 countermeasures related to signalized intersection control that were not separately listed in the PSAP countermeasures list. The 4 pedestrian hardware or signal components were not included because there was not enough data readily available to support suggesting those countermeasures. An intersection GIS layer that distinguishes between signalized and unsignalized intersections does not exist and the countermeasures listed in Table 4-6 are variations of pedestrian enhancements specific to signals. The PSAP includes implementing a leading pedestrian interval with the assumption that countdown timers and push buttons or some sort of pedestrian detection are also present in those locations. If neither of those components were present at a signal, the leading pedestrian interval could not be implemented.

Table 4-6: Signalized Intersection Improvements in UT Research Absent from PSAP

Improvements Included by UTCTR, but not PSAP	Countermeasure Category
Prohibition of Left Turns	Minor Signal or Intersection Operational Changes
Pedestrian Detection - Detector (actuate)	
Pedestrian Detection - Push Button	
Audible Pedestrian Signal	
Increase Crossing Time	
Countdown Timers	

Table 4-7 shows suggested countermeasures that could be used to enhance those from the PSAP list. For example, in-pavement lighting has been used in conjunction with RRFBs. In addition, general-purpose fences can be a valuable deterrent to unsafe crossing practices when paired with safe roadway crossing access points. While hardened left turns and “daylighting” left turns both focus on channeling left turning vehicles and improving the driver’s visibility of vulnerable road users, these pedestrian improvements still need additional research and experimentation in addition to local engineering and/or planning knowledge to appropriately locate these pedestrian countermeasures. As additional evidence and roadway data becomes available, perhaps these pedestrian improvements can be included in future TxDOT PSAP updates.

Table 4-7: Other Potential Improvements in UT Research Absent from PSAP

Improvements Included by UTCTR, but not PSAP	Countermeasure Category
Hardened Left Turns	Insufficient Evidence. Further Consideration Needed
In-Pavement Lighting (flashing crosswalks)	
Daylighting Left Turns & Crossing Locations	
Fence (general purpose)	
Bollards (at crossing points)	

4.5 Summary of Countermeasure Results

The following sections provide a statewide summary of how countermeasures were applied to both the systemic and targeted analysis results. The countermeasure application process used available roadway characteristics and usage data to isolate specific locations where particular countermeasures could be applied. This statewide, high-level analysis requires additional local knowledge and insights.

4.5.1 Systemic Countermeasure Summary

The data-driven countermeasure application process was able to successfully identify countermeasures for on-system roadway segments that were identified as both Focus Facilities and as Potential-Risk segments. For Focus Facilities, 62% of segments had at least one suggested countermeasure. Meanwhile, for those portions of the Focus Facility network identified as Potential-Risk, 72% of centerline miles had at least one suggested countermeasure. See Figure 4-1 for a graphic representation of these relationships.

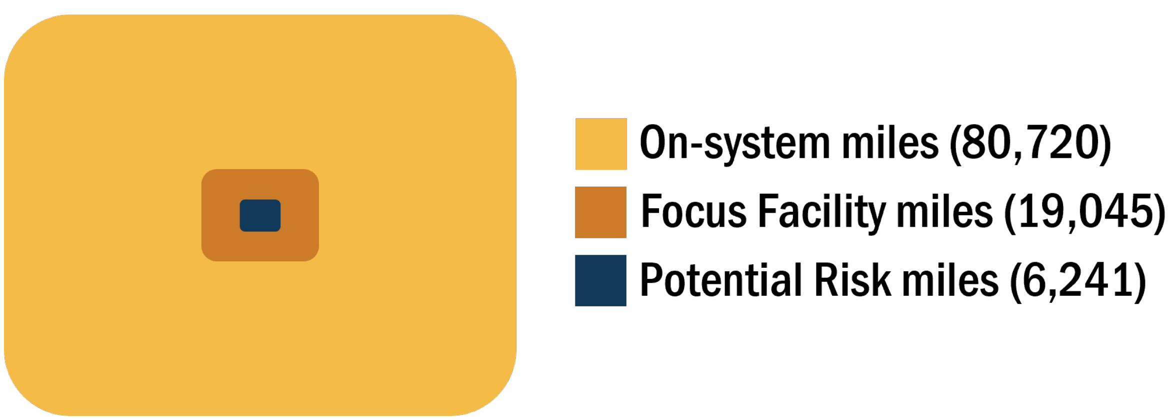
Focus Facility Road Segments:

- Total Focus Facility road segment centerline miles – 19,045 (23.6% of all on-system miles)
- Focus Facility centerline miles with at least one suggested countermeasure – 11,812 (62.0% of all Focus Facility miles)

Potential Risk Road Segments:

- Total Potential-Risk road segment centerline miles – 6,241 (7.7% of all on-system miles)
- Potential-Risk segments with at least one suggested countermeasure – 4,493 (72% of Potential-Risk miles)

Figure 4-1: Relationship Between Systemic Analysis Terminologies



4.5.2 Targeted Countermeasure Summary

For the targeted analysis, the data-driven countermeasure application process was able to successfully identify countermeasures for on-and off-system roadway segments where there was history of crashes. The on-system network is comprised of 72,978 miles and the off-system network is comprised of 241,169 miles for a grand total of 314,147 network miles.

On-System Countermeasure Summary:

- On-system segment centerline miles with crash history – 5,985 (8.2% of on-system miles)
- On-system segment centerline miles with at least one suggested countermeasure – 4,642 (78% of on-system miles with crash history)
- On-system segment centerline miles with at least one suggested countermeasure and a KA Crash Density Tier of "Very High" – 566 (12.2% of on-system miles with crash history and at least one suggested countermeasure)

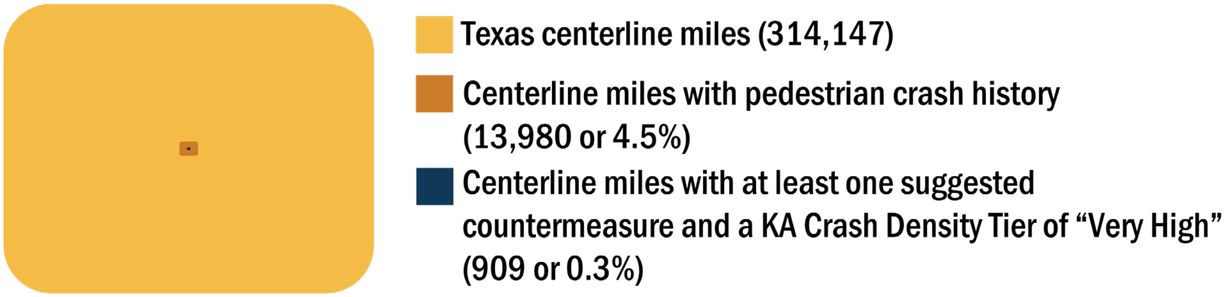
Off-System Countermeasure Summary:

- Off-system segment centerline miles with crash history – 7,995 (3.3% of off-system miles)
- Off-system segment centerline miles with at least one suggested countermeasure – 7,248 (90.7% of off-system miles with crash history)
- Off-system segment centerline miles with at least one suggested countermeasure and a KA Crash Density Tier of "Very High" – 343 (4.7% of off-system miles with crash history and at least one suggested countermeasure)

Statewide (On- and Off-System combined) Countermeasure Summary:

- Centerline miles with crash history – 13,980 (4.5% of statewide miles)
- Centerline miles with at least one suggested countermeasure – 11,890 (85.1% of statewide miles with crash history)
- Centerline miles with at least one suggested countermeasure and a KA Crash Density Tier of "Very High" – 909 (7.7% of statewide miles with crash history and at least one suggested countermeasure)

- *Figure 4-2: Relationship between Targeted Analysis Results*

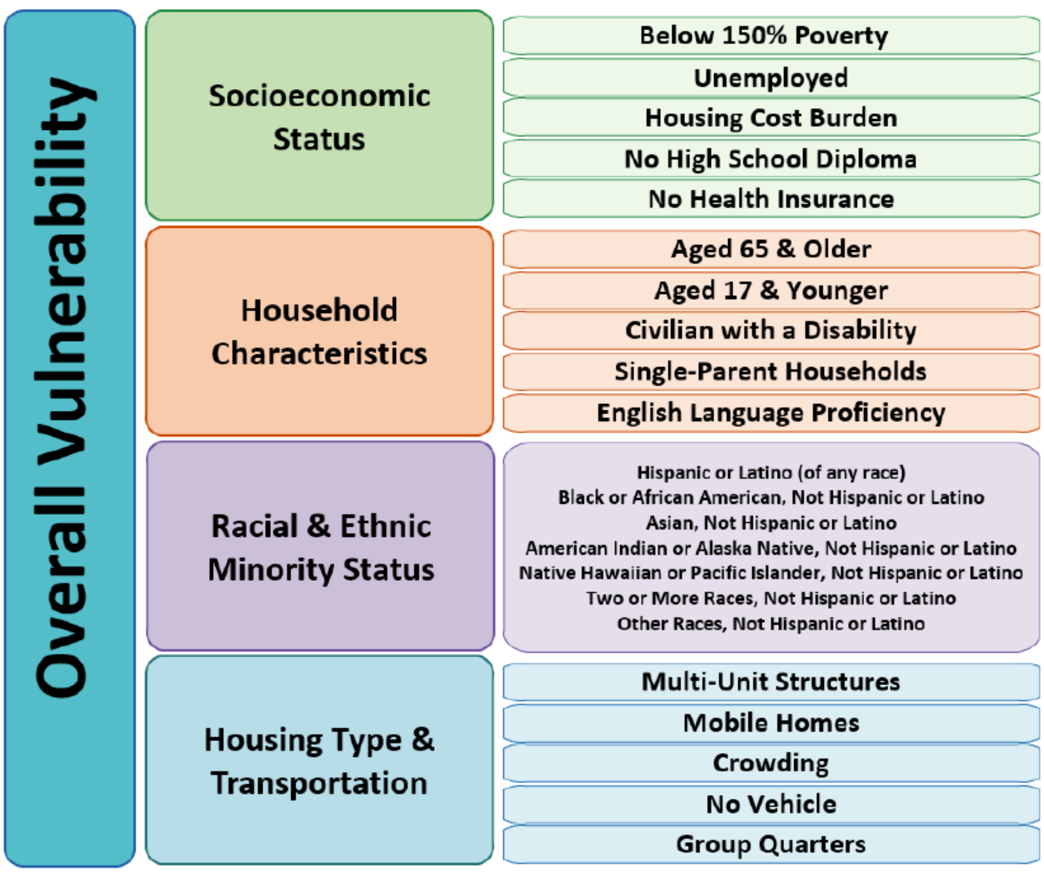


4.6 Prioritization

Texas PSAP focuses on prioritizing locations not projects. Through stakeholder engagement with both TxDOT Division staff and TxDOT’s Bicycle and Pedestrian Advisory Committee, locations of fatal and suspected serious injury pedestrian crashes were identified as the most important prioritization factor.

It is also important for prioritized locations to consider a range of socio-economic conditions across Texas. The PSAP utilizes the Social Vulnerability Index (SVI) created by the Centers for Disease Control and Prevention (CDC) as a comprehensive equity measure. The SVI assigns each U.S. Census Tract a value between 0 and 1 based on 16 U.S. Census Data social factors, as seen in Figure 4-3 below. For prioritization, this indexed value was assigned to roadway segments within each Texas Census Tract.

Figure 4-3: Social Vulnerability Index: Equity Factors



The on-system Systemic Analysis segments were prioritized according to the following measures:

1. Potential risk designation
2. Count of KA crashes on segment (highest to lowest)
3. Overall Social Vulnerability Index (SVI) Value (highest to lowest)
4. Accumulation of suggested countermeasures

Meanwhile, the on- and off-system segments resulting from the Targeted analysis were prioritized according to the following measures:

1. Very High KA Crash Density Tier
2. Count of KA crashes on segment (highest to lowest)
3. Overall Social Vulnerability Index (SVI) Value (highest to lowest)
4. Accumulation of suggested countermeasures

5 PSAP Screening Tool

The Texas Pedestrian Safety Action Plan features an interactive online dashboard called the Screening Tool that allows users to explore many of the PSAP analyses and products. The Screening Tool was primarily built to investigate locations with a history of pedestrian crashes or potential risk of pedestrian crashes and provide suggested countermeasures to mitigate future pedestrian crashes. The following section describes it's use. For access issues or more information on the PSAP Screening Tool, please contact bikeped@txdot.gov.

The PSAP Screening Tool has four main sections, all of which are highlighted and labelled in Figure 5-1:

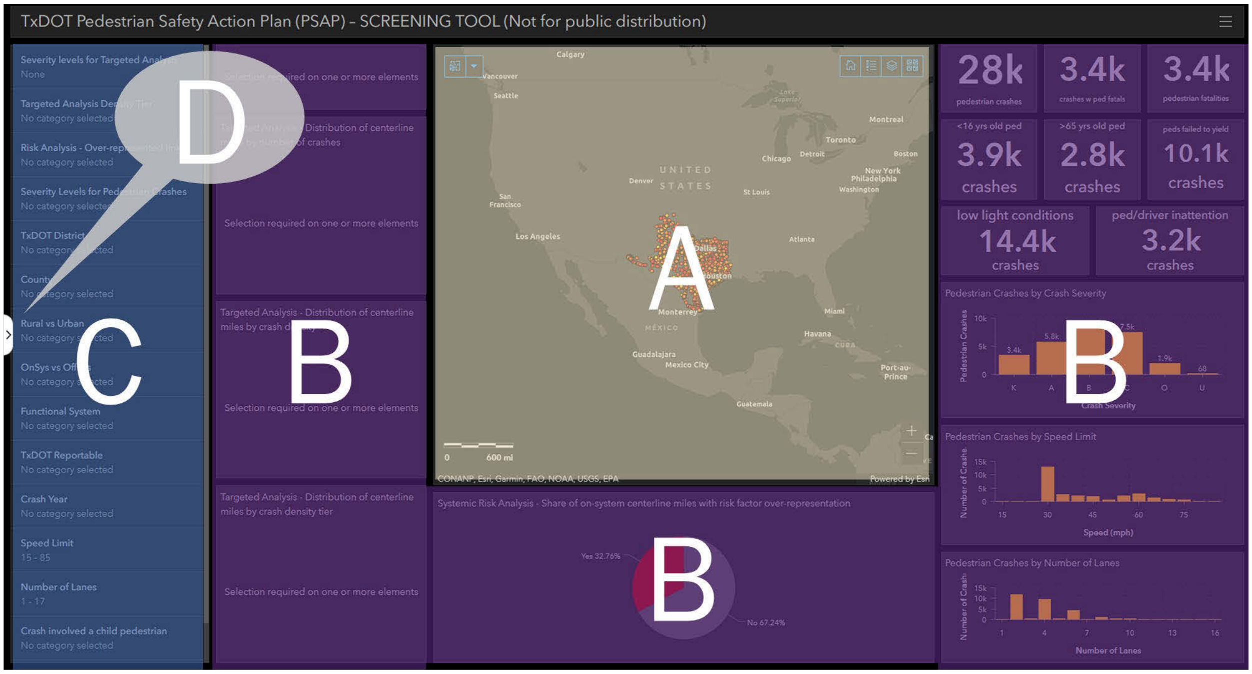
A. Map interface: this is where the user can zoom and pan throughout Texas to identify locations of interest.

B. Summary statistics: these are summary statistics that are calculated based on the map extent and the user's selection of filters from the filter/selector panel.

C. Filter/selector panel: these controls allow the user to choose which crash points and which links to show on the map and in the summary statistics.

D. Pull-out sidebar: This sidebar contains some basic instructions, a link to this document, links to the study's main page, and an email address to which users can send comments.

Figure 5-1: Screening Tool Layout and Parts



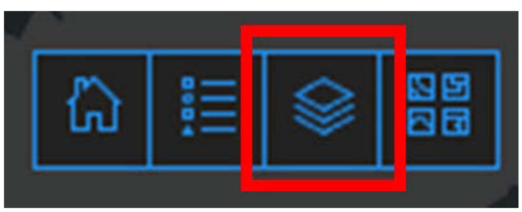
Parts A, B and C of the screening tool are interconnected and affect each other. For example, if the user wants to focus on just Travis County, she can use the County selector in Section C on the left and pick “Travis.” This will update the map in Section A to show only crashes and links in Travis County. Furthermore, it will update the summary statistics in Section B to reflect the totals for Travis County.

5.1 Interacting with the screening tool

5.1.1 The layer selector

On the top right corner of the map, there are four icons which the user can interact with. The third icon (highlighted in Figure 5-2) can be used to select which layers are visible on the map.

Figure 5-2: Icon Used to Select Visible Layers



The layers available for the user to toggle on and off include:

PSAP Analysis layers:

- Crash points
- Crash heatmap
- Systemic analysis
- Targeted analysis – Number of crashes
- Targeted analysis – Crash density
- Targeted analysis – Crash density tier

Extra layers:

- Transit stops
- TxDOT projects

Filters/Selectors:

Not all filters/selectors affect all the layers listed. Table 5-1 illustrates which layers are affected by each of the filters/selectors.

Table 5-1: How Filters/Selectors Affect the Screening Tool's Layers

Filter/Selector	Crash Points	Systemic Risk Analysis	Targeted Analysis
Severity levels for targeted analysis			✓
Targeted analysis density tier			✓
Risk analysis – potential risk		✓	
TxDOT District	✓	✓	✓
County	✓	✓	✓
Rural vs urban	✓	✓	✓
On system vs off system	✓	✓	✓
Functional system	✓	✓	✓
TxDOT reportable	✓		
Crash year	✓		
Speed limit	✓	✓	✓
Number of lanes	✓	✓	✓
Crash involved a child pedestrian	✓		
Crash involved a senior pedestrian	✓		

By toggling layers on and off and using the filters/selectors on the left-hand side of the screen, the user can explore the three main sections of the results produced throughout the PSAP's analyses:

- Crash points
- Systemic risk analysis
- Targeted analysis

5.1.2 Pop-up windows

When layers are visible, clicking on a particular point or link will make a pop-up window appear. This pop-up will contain valuable information regarding the specific point or link that was clicked on. The pop-up window for crash points, as seen in Figure 5-3, contains the Crash ID, the Route ID on which the crash occurred, and the DFO marker (distance from origin along the route) on which the crash occurred, alongside other valuable information. For the systemic risk analysis, the pop-up window, as seen in Figure 5-4, contains information about the Route ID, the link's starting and ending DFO values, and whether the link is classified as having potential risk, among other valuable link-level information. Finally, the pop-up windows for the targeted analysis, as seen in Figure 5-5, contain information about the Route IDs and DFOs as well as information regarding the number of crashes, crash density and the crash density tier for the specified link.

It is also worth noting that the pop-up windows for the systemic risk and targeted analyses also include information regarding each link's countermeasures.

Figure 5-3: Crash Point Pop-Up Window

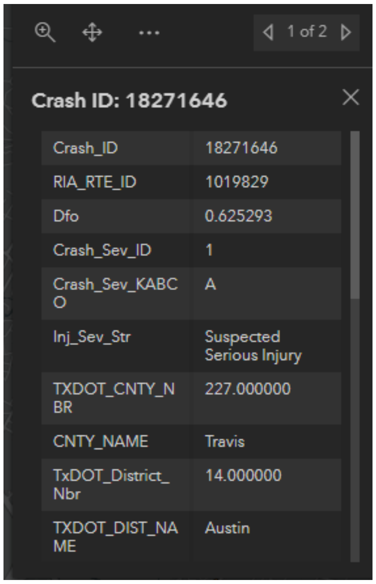


Figure 5-4: Risk Analysis Pop-Up Window

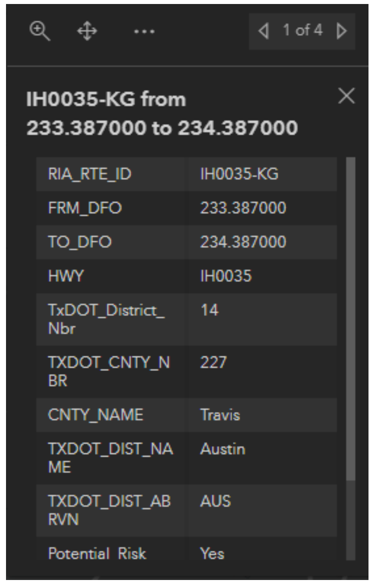
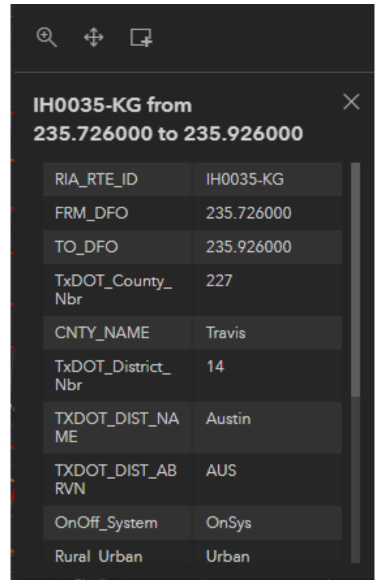


Figure 5-5: Targeted Analysis Pop-Up Window



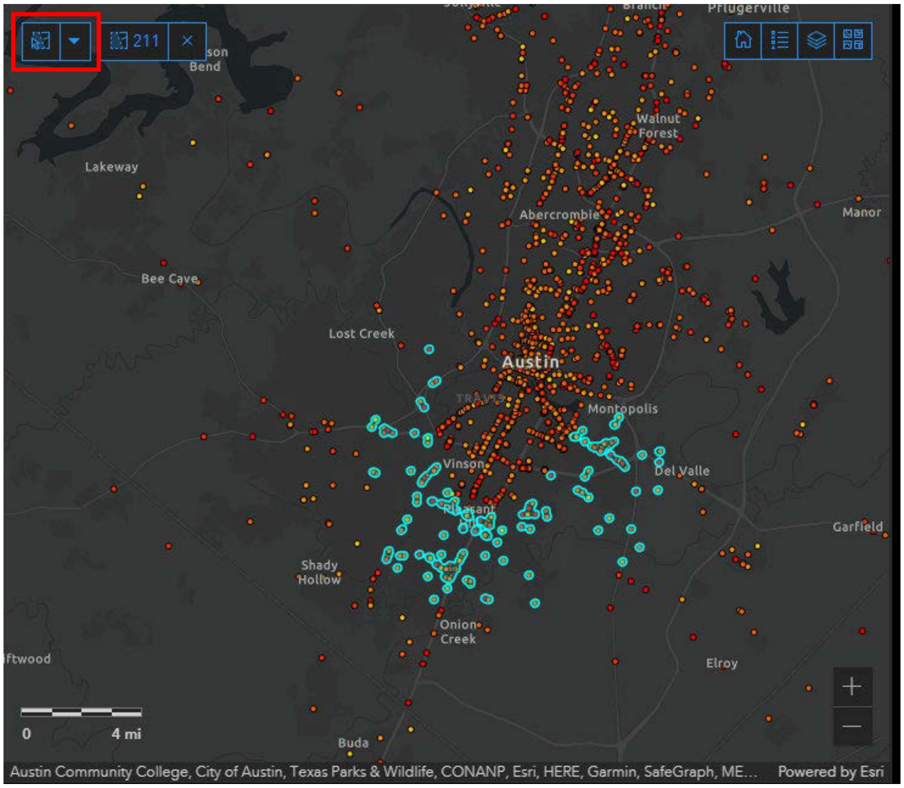
5.1.3 Manual selections

On the top-left portion of the map, the user will find the manual selection tool. By clicking on the down-pointed arrow (highlighted in Figure 5-6), the user will be allowed to choose one of multiple ways to perform manual selections:

- Point: use the mouse cursor to select points or links near one specific point
- Rectangle: use the mouse to draw a rectangle on the map and select all points or links within it
- Circle: use the mouse to draw a circle on the map and select all points or links within it
- Lasso: use the mouse to free-hand draw any shape and select all points or links within it
- Line: use the mouse to free-hand draw any line and select all points or links that intersect it

Selecting points and links this way will refresh all of the summary statistics and graphs, making them reflect values that only consider the points or links selected by the user.

Figure 5-6: Manual Selection of Crash Points Using the “Lasso” Tool



Sections 5.2, 5.3 and 5.4 discuss how results for each of the three main analyses can be viewed in the screening tool.

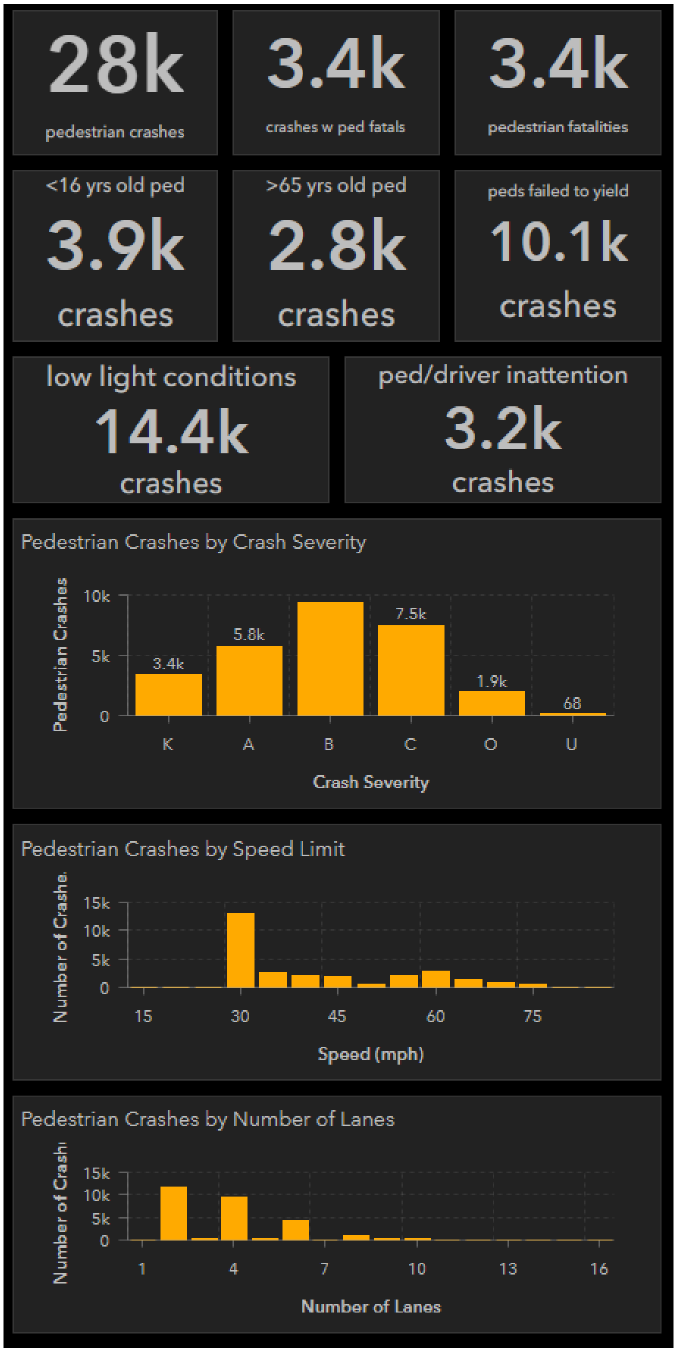
5.2 Crash locations and crash-related summaries

If the user turns on the Crash Points layer, she can explore the locations of all the crashes used in the PSAP’s analyses. The summary statistics and graphs that refer to the Crash Point data are on the right-hand side of the screen (illustrated in Figure 5-7). The summaries contain the following information:

- Number of pedestrian crashes
- Number of crashes that involved a pedestrian fatality
- Total number of pedestrian fatalities
- Number of crashes that involved younger (16 years old or younger) pedestrians
- Number of crashes that involved older (65 years old or older) pedestrians
- Number of crashes that involved “pedestrian failed to yield right-of-way to vehicle” as either a contributing factor or a potential contributing factor
- Number of crashes that occurred in low light or dim conditions
- Number of crashes that involved either pedestrian or driver inattention (according to the contributing factors and the potential contributing factors)
- Graph of the number of pedestrian crashes by crash severity
- Graph of the number of pedestrian crashes by speed limit
- Graph of the number of pedestrian crashes by number of lanes

If the user wants to focus on a specific area or type of crash, she can use the filters/selectors from the left-hand side of the screen. Doing so will automatically update all the summary statistics on the right-hand side of the screen.

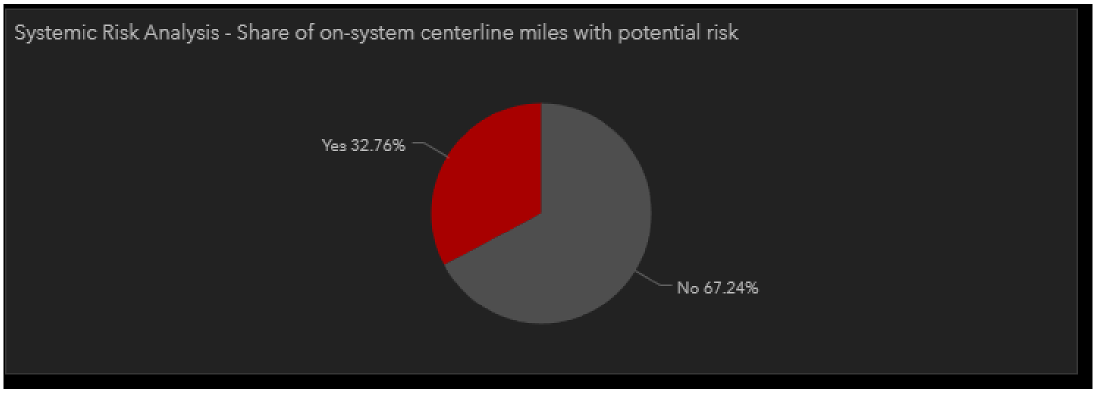
Figure 5-7: Summary Statistics for the Crash Points



5.3 Systemic crash analysis results

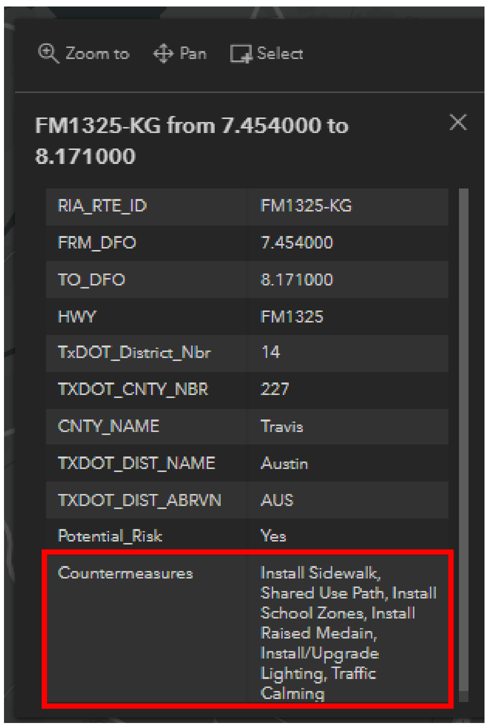
In addition to the map of the potential risk segments, the screening tool provides the user with a summary graph that illustrates the proportion of the filtered segments' centerline miles that are locations of potential pedestrian risk, see Figure 5-8.

Figure 5-8: Summary Statistics for Systemic Risk Analysis



The user can also investigate the countermeasures that were suggested for each road segment based on the results of the systemic risk analysis by clicking on a road segment viewing its pop-up window. An example of the pop-up window's appearance with the countermeasures section highlighted can be seen in Figure 5-9.

Figure 5-9: Systemic Risk Analysis Pop-Up Screen with Countermeasures



5.4 Targeted crash analysis results

The results of the targeted analysis are only visible once the user has chosen a specific severity level on the top-left corner of the screening tool, as seen in Figure 5-10. This is done so that the results from the multiple different versions of the targeted analysis (i.e., a set of crash severity levels such as all K crashes, all KA crashes, etc.) don't overlap and confuse the user.

Once a severity has been chosen, the map and the summary graphs on the left portion of the screening tool (shown in Figure 5-11) will populate. These summaries include:

- Total centerline miles visible and/or selected
- Distribution of centerline miles according to the number of crashes on each link
- Distribution of centerline miles according to the link's crash density
- Distribution of centerline miles according to the link's crash density tier

Figure 5-10: Severity Level Selection for Targeted Analysis

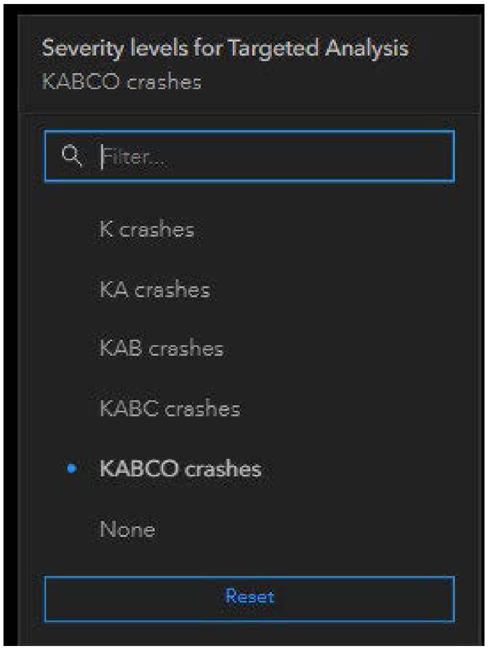
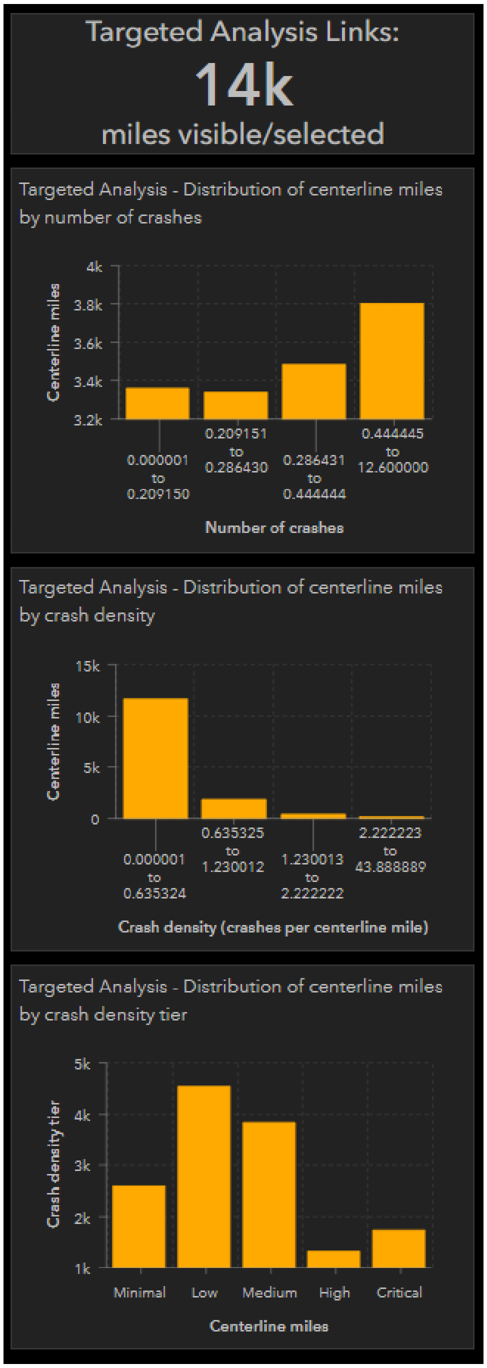
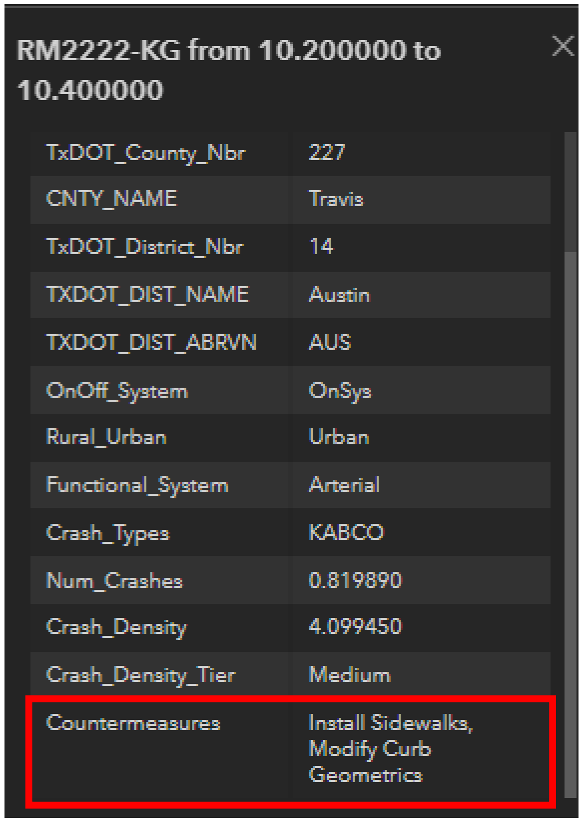


Figure 5-11: Summary Statistics for Targeted Analysis



The user can also investigate the countermeasures that were suggested for each link based on the results of the targeted risk analysis by viewing its pop-up window. An example of how the pop-up screen looks with the countermeasures section highlighted can be seen in Figure 5-12.

Figure 5-12: Targeted Analysis Pop-Up Screen with Countermeasures



RM2222-KG from 10.200000 to 10.400000

TxDOT_County_Nbr	227
CNTY_NAME	Travis
TxDOT_District_Nbr	14
TXDOT_DIST_NAME	Austin
TXDOT_DIST_ABRVN	AUS
OnOff_System	OnSys
Rural_Urban	Urban
Functional_System	Arterial
Crash_Types	KABCO
Num_Crashes	0.819890
Crash_Density	4.099450
Crash_Density_Tier	Medium
Countermeasures	Install Sidewalks, Modify Curb Geometrics

5.5 Finding pedestrian countermeasures

If the user wants to use the screening tool to specifically investigate countermeasures, she will have to do so by turning on either the systemic risk analysis layer or one of the three targeted analysis layers and click on individual links. The countermeasures will be listed at the very bottom of the pop-up windows, as shown in Figure 5-9 and Figure 5-12.

6 PSAP Implementation

The Texas PSAP resulted in the following products for TxDOT District staff to better identify locations where pedestrian safety concerns exist and prioritize investments to mitigate those hazards.

- District-specific Pedestrian Safety Profile – this static, 4-page Tabloid provides an overview of statewide pedestrian crash statistics and general safety performance and summarizes District-specific findings from the targeted and systemic analyses. The intended audience is District leadership. See Appendix A for all 25 District Pedestrian Safety Profiles.
- District-specific Analysis Data – an Excel workbook and geospatial files featuring PSAP analysis results for each roadway segment in the District, allowing for in-depth analysis, risk assessment verification and further prioritization opportunities depending on District priorities.
- PSAP Screening Tool – an online interactive dashboard allowing users to layer the PSAP analysis results, filter attributes, and isolate geographic locations. This tool is accessible to the TxDOT District

staff AND the general public. As discussed below, this tool will enable both TxDOT Districts and MPOs to develop and program investments into pedestrian safety.

PSAP implementation will include creating awareness of these products, assisting in their use, modifying the PSAP Screening Tool periodically to better meet the user's needs, and documenting requested improvements in preparation for an eventual updated PSAP.

6.1 Distribution and awareness

When the analysis and prioritization were complete on the Texas PSAP in the spring of 2023, TxDOT PTN, DES, and TRF began to distribute information internally within TxDOT. In May 2023, TxDOT and FHWA hosted a joint 2-day workshop which combined the content from two FHWA workshops: Designing for Pedestrian Safety and Safety Action Plans with an introduction to the Texas PSAP. Workshop presenters shared presentations on the basics of pedestrian safety design and focused presentations on the Texas PSAP methodology, results, and how to use the PSAP Screening Tool with staff from each of TxDOT's 25 Districts. Workshop participants provided TxDOT PTN and consultant team with initial feedback on the PSAP Screening Tool and recommendations for future improvements.

During the Summer and Fall 2023, the TxDOT PTN, TRF, and consultant team members will present to a variety of public, private, and agency stakeholders at various conferences around Texas. These conference presentations provide an opportunity to spread the word about the PSAP Methodology and the PSAP Screening Tool to help MPO and TxDOT staff better identify and prioritize pedestrian safety improvements.

Table 6-1: Conferences for PSAP Presentations and Outreach

Outreach event	Timing	Audience
FHWA & TxDOT Workshop: Designing for Pedestrian Safety 101 and Texas PSAP - Austin	May 2023	TxDOT District staff
Vulnerable Road User Assessment: Includes outreach to MPOs (New Federal requirement)	June 2023	Staff at selected Texas MPOs
2023 Texas Pedestrian Safety Forum	August 2023	General Public
TxDOT Short Course	October 2023	TxDOT Engineers and consultants
American Planning Association Texas Chapter Annual Meeting – Corpus Christi	November 2023	Texas public and private sector urban planners
Additional Planned Workshop- FHWA & TxDOT Workshop: Designing for Pedestrian Safety 101 and Texas PSAP - Austin	TBD ~ Fall 2023	TxDOT District staff

As the Texas PSAP is presented and discussed at these outreach events, TxDOT will receive feedback on the PSAP products and process. As the PSAP Screening Tool is a dynamic tool, when possible it can be modified to better suit users.

6.2 PSAP Uses: SHSP, HSIP, Safety Planning and Programming

The following are anticipated uses for PSAP results.

- Strategic Highway Safety Plan (SHSP) and the Vulnerable Road User (VRU) Assessment

  The 2022-2027 SHSP was created by Texas Department of Transportation Traffic Safety Division (TRF), working in conjunction with the Center for Transportation Safety at the Texas A&M Transportation Institute. This strategic plan focuses on identifying the most effective and efficient strategies and actions to reduce fatalities and injuries on Texas roads. The SHSP is developed collaboratively with hundreds of safety stakeholders from across Texas, representing local, regional and state agencies, law enforcement, industry and advocates, engineers, clinicians, and educators. The SHSP identified 11 safety emphasis areas including "Vulnerable Road Users: Pedestrian".

  The 2021 Infrastructure Investment and Jobs Act (IIJA) required each State DOT to complete a Vulnerable Road User Assessment which should use a data-driven process to identify areas of high-risk for vulnerable road users. Vulnerable Road Users are defined as

  > "nonmotorists with a fatality analysis reporting system (FARS) person attribute code for pedestrian, bicyclist, other cyclist, and person on personal conveyance or an injured person that is, or is equivalent to, a pedestrian or pedalcyclist as defined in the ANSI D16.1-2007. A vulnerable road user may include people walking, biking, or rolling."[15]

  The outcomes from the Vulnerable Road User Safety Assessment quantitative analysis and program of projects or strategies should be incorporated into relevant SHSP emphasis areas, strategies, and actions, as appropriate, and implemented through State and local planning procedures.

  The statewide pedestrian analysis from the PSAP will be valuable inputs to TxDOT's initial VRU Assessment, which is being developed in the Spring and Summer 2023. Additionally, identification of pedestrian safety concerns and trends could be helpful in future updates to the SHSP, which normally occurs every four years.

- Highway Safety Improvement Program (HSIP)

  The Texas HSIP, a federally mandated program managed by TxDOT, implements the priorities identified in the SHSP with the goal to achieve a significant reduction in fatalities and serious injuries on Texas roadways, including both on-system and off-system roads. The HSIP is a funding program where projects are eligible for funding if they address one of the identified HSIP safety emphasis areas. Projects are selected for funding based on specific project selection criteria and must feature countermeasures identified with specific HSIP Work Codes as found in Appendix B of the HSIP Guidance.

  Coordination during PSAP development has led to identification of additional pedestrian countermeasures than are not currently identified with the HSIP (Table 4-1). As the next HSIP is updated, these additional pedestrian countermeasure work codes will be considered for inclusion. Incorporating additional countermeasures into the HSIP adds funding flexibility and opportunities to TxDOT Districts when programming pedestrian improvements in their areas, specifically allowing Category 8 funding to be used for pedestrian investments.

[15] FHWA Vulnerable Road User Safety Assessment Guidance Memo. October 21, 2022. From Cheryl Walker (Associate Administrator, FHWA Office of Safety).

- District Safety Plans and MPO Safety Plans

  MPO and TxDOT District jurisdictions always have roadway safety projects that need funding to be built. The District Safety Plans and MPO Safety Plans prioritize and program safety funding for these projects. As pedestrian crashes are of significant concern in various areas around Texas, the PSAP Screening tool and other products can help staff at TxDOT Districts and MPOs to program pedestrian projects for funding.

- Safety Project Identification, Scoping, and Project Scoring

  In addition to safety specific funding programming, roadway design engineers across Texas are continually developing improvements to Texas roadways and scoping various design elements within those projects. PSAP tools can be used to better identify projects that need additional scope or design elements related to the pedestrian crash history or systemic analysis results (as a potential risk segment). Alternatively, PSAP tools could also be used during a project selection process to better score pedestrian projects or design elements.

- Grant Applications

  In addition to using PSAP analysis to identify projects, the analysis and trend data results can be used to compete for grant funding dollars. Opportunities for pedestrian planning and project funding include: TxDOT Transportation Alternatives Call for Projects; MPO-specific Transportation Alternative Calls for Projects; Safe Streets for All (USDOT) - Supplemental Planning, Demonstration Activities, and/or possibly Implementation grants; and Reconnecting Communities (USDOT).

Appendix A: District Pedestrian Safety Profiles

TxDOT web-version of each District’s Pedestrian Safety Profile

Appendix B: Selected Pedestrian Crash Contributing Factors (2017 – 2021) by County

Located on TxDOT.gov

Appendix C: Unintended Pedestrian Crashes by District (2021)

TxDOT District	Total pedestrian Crashes	Involved an unintended pedestrian	Involved an unintended pedestrian (as a share of district pedestrian crashes)	Involved an unintended pedestrian (as a share of total unintended pedestrian crashes)
Abilene	46	3	7%	2%
Amarillo	64	0	0%	0%
Atlanta	48	1	2%	1%
Austin	452	8	2%	6%
Beaumont	103	7	7%	5%
Brownwood	13	0	0%	0%
Bryan	82	3	4%	2%
Childress	3	0	0%	0%
Corpus Christi	141	1	1%	1%
Dallas	842	20	2%	14%
El Paso	181	3	2%	2%
Fort Worth	451	12	3%	8%
Houston	1,466	32	2%	22%
Laredo	67	1	1%	1%
Lubbock	92	5	5%	3%
Lufkin	49	0	0%	0%
Odessa	54	2	4%	1%
Paris	61	2	3%	1%
Pharr	198	8	4%	6%
San Angelo	25	0	0%	0%
San Antonio	626	21	3%	15%
Tyler	104	6	6%	4%
Waco	146	5	3%	3%
Wichita Falls	20	2	10%	1%
Yoakum	31	1	3%	1%
Total	5,365	143	3%	100%

Appendix D: District-Level Risk Factor Summaries

Abilene Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	25k to 30k		50k to 60k & 120k to 130k & 130k to 140k	10k to 20k & 25k to 30k
Area Type			Large Urbanized	Large Urbanized
Bus Pad Offset				
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width				
Curb Cut Offset	80 ft to 85 ft			30 to 35 & 40 to 45 ft
Curb Cut Presence				Present
Curb Presence			Present - One Side	Present - Both Sides
Functional Class			Interstate	
Highway Division				
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width				
Lane Width				14 ft to 15 ft
Max Speed	75		60	30 & 35
Median Presence	Median		Median	
Median Type				
Median Width				
Minimum ROW				
Number of Lanes			6 & 8	3 & 4
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width	80 ft to 85 ft			
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width			90 ft to 100 ft	
Transit Stop Presence				Present
Truck ADT	8k to 9k		13k to 14k	2k to 3k
Truck Pct	30% to 33%		9% to 12%	<3% & 9% to 12%

Amarillo Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	25k to 30k	10k to 14k	50k to 60k & 120k to 130k & 130k to 140k	15k to 25k
Area Type			Large Urbanized	Large Urbanized
Bus Pad Offset		40 ft to 45 ft		
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width		95 in to 100 in		
Curb Cut Offset	80 ft to 85 ft	25 to 35 & 40 to 45 ft		
Curb Cut Presence				
Curb Presence			Present - One Side	Present - Both Sides
Functional Class		Other Principal Arterial	Interstate	Other Principal Arterial
Highway Division		Divided		
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		3 to 4 & 13 to 14 ft		
Lane Width				
Max Speed	75	55	60	45
Median Presence	Median		Median	Median
Median Type				
Median Width				0 ft
Minimum ROW				100 ft to 125 ft
Number of Lanes		4	6 & 8	
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width	80 ft to 85 ft			
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width			90 ft to 100 ft	50 to 60 & 85 to 90 & ≥100 ft
Transit Stop Presence				Present
Truck ADT	8k to 9k		13k to 14k	
Truck Pct	30% to 33%	3% to 9% & 12% to 15%	9% to 12%	<9%

Atlanta Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	40k to 45k & 60k to 65k	10k to 12k & 18k to 20k	≥50k	15k to 25k
Area Type			Large Urbanized	
Bus Pad Offset		50 to 55 & 65 to 70 ft		
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width		70 in to 75 in		
Curb Cut Offset		25 ft to 30 ft		
Curb Cut Presence				
Curb Presence				Present - Both Sides
Functional Class		Other Principal Arterial		Other Principal Arterial
Highway Division				
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width	11 ft to 12 ft	9 ft to 10 ft	9 ft to 10 ft & 11 ft to 12 ft	
Lane Width				15 ft to 16 ft
Max Speed		55	60	40
Median Presence		Median	Median	
Median Type	Positive Barrier Rigid			
Median Width	30 ft to 36 ft			
Minimum ROW	300 ft to 325 ft		300 ft to 325 ft	100 ft to 125 ft
Number of Lanes	6	4	6	4
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width				60 ft to 70 ft
Shoulder Presence		Paved - Both Sides		
Sidewalk Condition				
Sidewalk Presence				
Surface Width				
Transit Stop Presence				Present
Truck ADT		1k to 1.5k & 3k to 3.5k	2k to 3k	500 to 1k
Truck Pct	24% to 27%	6% to 12%	3% to 9% & 24% to 27%	<3%

Austin Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT		14k to 16k & 20k to 22k & 32k to 34k		36k to 38k
Area Type				Large Urbanized
Bus Pad Offset				
Bus Pad Width				≥8.33 ft
TWLTL Presence				TWLTL
Crosswalk Presence				
Crosswalk Width				
Curb Cut Offset		≥100 ft		
Curb Cut Presence				
Curb Presence				Present - Both Sides
Functional Class		Other Principal Arterial		Other Principal Arterial
Highway Division		Divided		
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		9 ft to 10 ft		
Lane Width		12 ft to 13 ft		
Max Speed			55 & 60	45
Median Presence				
Median Type				
Median Width			0 ft to 10 ft & 25 ft to 30 ft	
Minimum ROW		175 ft to 200 ft		
Number of Lanes		4	6 & 8	4
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width				60 ft to 65 ft
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				Present
Surface Width			75 to 80 & ≥95 ft	
Transit Stop Presence				
Truck ADT		1k to 1.5k & 4k to 4.5k & 6k to 6.5k	≥18K	<1k
Truck Pct		6% to 9%	12% to 15%	<3%

Beaumont Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	40k to 45k & 60k to 65k	10k to 14k & 16k to 18k	≥50k	15k to 20k & 25k to 30k
Area Type			Large Urbanized	Large Urbanized & Urbanized
Bus Pad Offset				
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width				
Curb Cut Offset		15 ft to 20 ft		
Curb Cut Presence				
Curb Presence				Present - Both Sides
Functional Class				
Highway Division		Undivided		
Inside Shoulder Type		Unpaved		
Inside Shoulder Use				
Inside Shoulder Width	11 ft to 12 ft	5 to 6 & 10 to 11 ft	9 ft to 10 ft & 11 ft to 12 ft	
Lane Width				
Max Speed		60	60	35 to 50
Median Presence			Median	Median
Median Type	Positive Barrier Rigid			
Median Width	30 ft to 36 ft			5 ft to 10 ft
Minimum ROW	300 ft to 325 ft	125 to 150 & 325 to 350 ft	300 ft to 325 ft	100 ft to 150 ft
Number of Lanes	6		6	4 & 6
Outside Shoulder Use				
Outside Shoulder Width		7 ft to 8 ft		
Roadbed Width				
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width		30 ft to 35 ft		65 ft to 75 ft
Transit Stop Presence				Present
Truck ADT		0 to 500 & 4k to 4.5k	2k to 3k	500 to 1.5k
Truck Pct	24% to 27%	3% to 9%	3% to 9% & 24% to 27%	<6%

Brownwood Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	25k to 30k	10k to 14k		10k to 20k & 25k to 30k
Area Type				Large Urbanized
Bus Pad Offset		40 ft to 45 ft		
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width		95 in to 100 in		
Curb Cut Offset	80 ft to 85 ft	25 to 35 & 40 to 45 ft		30 to 35 & 40 to 45 ft
Curb Cut Presence				Present
Curb Presence				Present - Both Sides
Functional Class		Other Principal Arterial		
Highway Division		Divided		
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		3 to 4 & 13 to 14 ft		
Lane Width				14 ft to 15 ft
Max Speed	75	55		30 & 35
Median Presence	Median			
Median Type				
Median Width				
Minimum ROW				
Number of Lanes		4		3 & 4
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width	80 ft to 85 ft			
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width				
Transit Stop Presence				Present
Truck ADT	8k to 9k			2k to 3k
Truck Pct	30% to 33%	3% to 9% & 12% to 15%		<3% & 9% to 12%

Bryan Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	40k to 45k & 60k to 65k	14k to 16k & 20k to 22k & 32k to 34k	≥50k	15k to 25k
Area Type			Large Urbanized	
Bus Pad Offset				
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width				
Curb Cut Offset		≥100 ft		
Curb Cut Presence				
Curb Presence				Present - Both Sides
Functional Class		Other Principal Arterial		Other Principal Arterial
Highway Division		Divided		
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width	11 ft to 12 ft	9 ft to 10 ft	9 ft to 10 ft & 11 ft to 12 ft	
Lane Width		12 ft to 13 ft		15 ft to 16 ft
Max Speed			60	40
Median Presence			Median	
Median Type	Positive Barrier Rigid			
Median Width	30 ft to 36 ft			
Minimum ROW	300 ft to 325 ft	175 ft to 200 ft	300 ft to 325 ft	100 ft to 125 ft
Number of Lanes	6	4	6	4
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width				60 ft to 70 ft
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width				
Transit Stop Presence				Present
Truck ADT		1k to 1.5k & 4k to 4.5k & 6k to 6.5k	2k to 3k	500 to 1k
Truck Pct	24% to 27%	6% to 9%	3% to 9% & 24% to 27%	<3%

Childress Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT		10k to 14k		
Area Type				
Bus Pad Offset		40 ft to 45 ft		
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width		95 in to 100 in		
Curb Cut Offset		25 to 35 & 40 to 45 ft		
Curb Cut Presence				
Curb Presence				
Functional Class		Other Principal Arterial		
Highway Division		Divided		
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		3 to 4 & 13 to 14 ft		
Lane Width				
Max Speed		55		
Median Presence				
Median Type				
Median Width				
Minimum ROW				
Number of Lanes		4		
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width				
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width				
Transit Stop Presence				
Truck ADT				
Truck Pct		3% to 9% & 12% to 15%		

Corpus Christi Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	40k to 45k & 60k to 65k	10k to 14k & 16k to 18k	≥50k	15k to 20k & 25k to 30k
Area Type			Large Urbanized	Large Urbanized & Urbanized
Bus Pad Offset				
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width				
Curb Cut Offset		15 ft to 20 ft		
Curb Cut Presence				
Curb Presence				Present - Both Sides
Functional Class				
Highway Division		Undivided		
Inside Shoulder Type		Unpaved		
Inside Shoulder Use				
Inside Shoulder Width	11 ft to 12 ft	5 to 6 & 10 to 11 ft	9 ft to 10 ft & 11 ft to 12 ft	
Lane Width				
Max Speed		60	60	35 to 50
Median Presence			Median	Median
Median Type	Positive Barrier Rigid			
Median Width	30 ft to 36 ft			5 ft to 10 ft
Minimum ROW	300 ft to 325 ft	125 to 150 & 325 to 350 ft	300 ft to 325 ft	100 ft to 150 ft
Number of Lanes	6		6	4 & 6
Outside Shoulder Use				
Outside Shoulder Width		7 ft to 8 ft		
Roadbed Width				
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width		30 ft to 35 ft		65 ft to 75 ft
Transit Stop Presence				Present
Truck ADT		0 to 500 & 4k to 4.5k	2k to 3k	500 to 1.5k
Truck Pct	24% to 27%	3% to 9%	3% to 9% & 24% to 27%	<6%

Dallas Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	40k to 45k & 60k to 65k		140k to 150k	26k to 30k
Area Type			Large Urbanized	Large Urbanized
Bus Pad Offset				45 ft to 50 ft
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width				
Curb Cut Offset				
Curb Cut Presence				
Curb Presence				
Functional Class			Interstate	Other Principal Arterial
Highway Division				
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width	11 ft to 12 ft			0 ft
Lane Width			11 ft to 12 ft	
Max Speed			60	40 & 45
Median Presence			Median	Median
Median Type	Positive Barrier Rigid			
Median Width	30 ft to 36 ft			
Minimum ROW	300 ft to 325 ft			
Number of Lanes	6		8 & 10	
Outside Shoulder Use				No Designated Use
Outside Shoulder Width				
Roadbed Width				
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				Present
Surface Width				
Transit Stop Presence				Present
Truck ADT			14k to 15k	500 to 1.5k
Truck Pct	24% to 27%		6% to 9%	

El Paso Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	25k to 30k	10k to 14k	50k to 60k & 120k to 130k & 130k to 140k	15k to 25k
Area Type			Large Urbanized	
Bus Pad Offset		40 ft to 45 ft		
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width		95 in to 100 in		
Curb Cut Offset	80 ft to 85 ft	25 to 35 & 40 to 45 ft		
Curb Cut Presence				
Curb Presence			Present - One Side	Present - Both Sides
Functional Class		Other Principal Arterial	Interstate	Other Principal Arterial
Highway Division		Divided		Divided
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		3 to 4 & 13 to 14 ft		
Lane Width				11 ft to 12 ft
Max Speed	75	55	60	35 & 45
Median Presence	Median		Median	
Median Type				
Median Width				
Minimum ROW				100 to 125 & 150 to 175 ft
Number of Lanes		4	6 & 8	
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width	80 ft to 85 ft			60 ft to 75 ft
Shoulder Presence				
Sidewalk Condition				Poor
Sidewalk Presence				
Surface Width			90 ft to 100 ft	60 ft to 75 ft
Transit Stop Presence				Present
Truck ADT	8k to 9k		13k to 14k	
Truck Pct	30% to 33%	3% to 9% & 12% to 15%	9% to 12%	<9%

Fort Worth Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT		10k to 14k	150k to 170k	16k to 18k
Area Type			Large Urbanized	Large Urbanized
Bus Pad Offset		40 ft to 45 ft		
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width		95 in to 100 in		
Curb Cut Offset		25 to 35 & 40 to 45 ft		40 ft to 45 ft
Curb Cut Presence				Present
Curb Presence				Present - Both Sides
Functional Class		Other Principal Arterial	Interstate	Other Principal Arterial
Highway Division		Divided		
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		3 to 4 & 13 to 14 ft		
Lane Width				15 ft to 16 ft
Max Speed		55	60	35 & 55
Median Presence			Median	
Median Type				
Median Width				
Minimum ROW				75 to 100 & 125 to 150 ft
Number of Lanes		4	8	
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width			≥100 ft	
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width				
Transit Stop Presence				Present
Truck ADT			16k to 18K	500 to 1k
Truck Pct		3% to 9% & 12% to 15%	9% to 12%	<3%

Houston Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	40k to 45k & 60k to 65k	10k to 14k & 16k to 18k	180k to 190k & ≥200k	50k to 55k
Area Type			Large Urbanized	Large Urbanized
Bus Pad Offset				45 to 50 & 65 to 70 ft
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width				
Curb Cut Offset		15 ft to 20 ft		55 ft to 60 ft
Curb Cut Presence				Present
Curb Presence				Present - Both Sides
Functional Class			Interstate	Other Principal Arterial
Highway Division		Undivided		
Inside Shoulder Type		Unpaved		
Inside Shoulder Use				
Inside Shoulder Width	11 ft to 12 ft	5 to 6 & 10 to 11 ft		
Lane Width				
Max Speed		60	60	35 & 40
Median Presence			Median	
Median Type	Positive Barrier Rigid			
Median Width	30 ft to 36 ft			0.1 ft to 2 ft & 10 ft to 14 ft
Minimum ROW	300 ft to 325 ft	125 to 150 & 325 to 350 ft	275 ft to 300 ft	100 to 125 & 150 to 175 ft
Number of Lanes	6			6 & 8
Outside Shoulder Use				
Outside Shoulder Width		7 ft to 8 ft		
Roadbed Width			≥100 ft	
Shoulder Presence			Paved - One Side	
Sidewalk Condition				
Sidewalk Presence				
Surface Width		30 ft to 35 ft		
Transit Stop Presence				
Truck ADT		0 to 500 & 4k to 4.5k	12k to 13k	500 to 1k
Truck Pct	24% to 27%	3% to 9%	3% to 6%	<3%

Laredo Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	25k to 30k		50k to 60k & 120k to 130k & 130k to 140k	10k to 20k & 25k to 30k
Area Type			Large Urbanized	Large Urbanized
Bus Pad Offset				
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width				
Curb Cut Offset	80 ft to 85 ft			30 to 35 & 40 to 45 ft
Curb Cut Presence				Present
Curb Presence			Present - One Side	Present - Both Sides
Functional Class			Interstate	
Highway Division				
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width				
Lane Width				14 ft to 15 ft
Max Speed	75		60	30 & 35
Median Presence	Median		Median	
Median Type				
Median Width				
Minimum ROW				
Number of Lanes			6 & 8	3 & 4
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width	80 ft to 85 ft			
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width			90 ft to 100 ft	
Transit Stop Presence				Present
Truck ADT	8k to 9k		13k to 14k	2k to 3k
Truck Pct	30% to 33%		9% to 12%	<3% & 9% to 12%

Lubbock Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	25k to 30k	10k to 14k	50k to 60k & 120k to 130k & 130k to 140k	15k to 25k
Area Type			Large Urbanized	Large Urbanized
Bus Pad Offset		40 ft to 45 ft		
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width		95 in to 100 in		
Curb Cut Offset	80 ft to 85 ft	25 to 35 & 40 to 45 ft		
Curb Cut Presence				
Curb Presence			Present - One Side	Present - Both Sides
Functional Class		Other Principal Arterial	Interstate	Other Principal Arterial
Highway Division		Divided		
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		3 to 4 & 13 to 14 ft		
Lane Width				
Max Speed	75	55	60	45
Median Presence	Median		Median	Median
Median Type				
Median Width				0 ft
Minimum ROW				100 ft to 125 ft
Number of Lanes		4	6 & 8	
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width	80 ft to 85 ft			
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width			90 ft to 100 ft	50 to 60 & 85 to 90 & ≥100 ft
Transit Stop Presence				Present
Truck ADT	8k to 9k		13k to 14k	
Truck Pct	30% to 33%	3% to 9% & 12% to 15%	9% to 12%	<9%

Lufkin Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT		14k to 16k & 20k to 22k & 32k to 34k		15k to 25k
Area Type				
Bus Pad Offset				
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width				
Curb Cut Offset		≥100 ft		
Curb Cut Presence				
Curb Presence				Present - Both Sides
Functional Class		Other Principal Arterial		Other Principal Arterial
Highway Division		Divided		
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		9 ft to 10 ft		
Lane Width		12 ft to 13 ft		15 ft to 16 ft
Max Speed				40
Median Presence				
Median Type				
Median Width				
Minimum ROW		175 ft to 200 ft		100 ft to 125 ft
Number of Lanes		4		4
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width				60 ft to 70 ft
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width				
Transit Stop Presence				Present
Truck ADT		1k to 1.5k & 4k to 4.5k & 6k to 6.5k		500 to 1k
Truck Pct		6% to 9%		<3%

Odessa Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	25k to 30k	10k to 14k	50k to 60k & 120k to 130k & 130k to 140k	15k to 25k
Area Type			Large Urbanized	
Bus Pad Offset		40 ft to 45 ft		
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width		95 in to 100 in		
Curb Cut Offset	80 ft to 85 ft	25 to 35 & 40 to 45 ft		
Curb Cut Presence				
Curb Presence			Present - One Side	Present - Both Sides
Functional Class		Other Principal Arterial	Interstate	Other Principal Arterial
Highway Division		Divided		Divided
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		3 to 4 & 13 to 14 ft		
Lane Width				11 ft to 12 ft
Max Speed	75	55	60	35 & 45
Median Presence	Median		Median	
Median Type				
Median Width				
Minimum ROW				100 to 125 & 150 to 175 ft
Number of Lanes		4	6 & 8	
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width	80 ft to 85 ft			60 ft to 75 ft
Shoulder Presence				
Sidewalk Condition				Poor
Sidewalk Presence				
Surface Width			90 ft to 100 ft	60 ft to 75 ft
Transit Stop Presence				Present
Truck ADT	8k to 9k		13k to 14k	
Truck Pct	30% to 33%	3% to 9% & 12% to 15%	9% to 12%	<9%

Paris Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	40k to 45k & 60k to 65k	10k to 12k & 18k to 20k	≥50k	15k to 25k
Area Type			Large Urbanized	
Bus Pad Offset		50 to 55 & 65 to 70 ft		
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width		70 in to 75 in		
Curb Cut Offset		25 ft to 30 ft		
Curb Cut Presence				
Curb Presence				Present - Both Sides
Functional Class		Other Principal Arterial		Other Principal Arterial
Highway Division				
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width	11 ft to 12 ft	9 ft to 10 ft	9 ft to 10 ft & 11 ft to 12 ft	
Lane Width				15 ft to 16 ft
Max Speed		55	60	40
Median Presence		Median	Median	
Median Type	Positive Barrier Rigid			
Median Width	30 ft to 36 ft			
Minimum ROW	300 ft to 325 ft		300 ft to 325 ft	100 ft to 125 ft
Number of Lanes	6	4	6	4
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width				60 ft to 70 ft
Shoulder Presence		Paved - Both Sides		
Sidewalk Condition				
Sidewalk Presence				
Surface Width				
Transit Stop Presence				Present
Truck ADT		1k to 1.5k & 3k to 3.5k	2k to 3k	500 to 1k
Truck Pct	24% to 27%	6% to 12%	3% to 9% & 24% to 27%	<3%

Pharr Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT		10k to 14k & 16k to 18k		15k to 25k
Area Type				
Bus Pad Offset				40 ft to 45 ft
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width				
Curb Cut Offset		15 ft to 20 ft		25 ft to 30 ft
Curb Cut Presence				
Curb Presence				
Functional Class				Other Principal Arterial
Highway Division		Undivided		
Inside Shoulder Type		Unpaved		
Inside Shoulder Use				No Designated Use & Parking
Inside Shoulder Width		5 to 6 & 10 to 11 ft		
Lane Width				15 ft to 16 ft
Max Speed		60		30 & 35 & 45
Median Presence				
Median Type				
Median Width				
Minimum ROW		125 to 150 & 325 to 350 ft		
Number of Lanes				4 & 6
Outside Shoulder Use				No Designated Use & Parking
Outside Shoulder Width		7 ft to 8 ft		
Roadbed Width				60 to 65 & 85 to 90 ft
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				Present
Surface Width		30 ft to 35 ft		55 ft to 65 ft
Transit Stop Presence				Present
Truck ADT		0 to 500 & 4k to 4.5k		
Truck Pct		3% to 9%		<3%

San Angelo Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	25k to 30k	10k to 14k	50k to 60k & 120k to 130k & 130k to 140k	10k to 20k & 25k to 30k
Area Type			Large Urbanized	Large Urbanized
Bus Pad Offset		40 ft to 45 ft		
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width		95 in to 100 in		
Curb Cut Offset	80 ft to 85 ft	25 to 35 & 40 to 45 ft		30 to 35 & 40 to 45 ft
Curb Cut Presence				Present
Curb Presence			Present - One Side	Present - Both Sides
Functional Class		Other Principal Arterial	Interstate	
Highway Division		Divided		
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		3 to 4 & 13 to 14 ft		
Lane Width				14 ft to 15 ft
Max Speed	75	55	60	30 & 35
Median Presence	Median		Median	
Median Type				
Median Width				
Minimum ROW				
Number of Lanes		4	6 & 8	3 & 4
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width	80 ft to 85 ft			
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width			90 ft to 100 ft	
Transit Stop Presence				Present
Truck ADT	8k to 9k		13k to 14k	2k to 3k
Truck Pct	30% to 33%	3% to 9% & 12% to 15%	9% to 12%	<3% & 9% to 12%

San Antonio Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	25k to 30k	10k to 14k	125k to 175k	15k to 35k
Area Type				Large Urbanized
Bus Pad Offset		40 ft to 45 ft		
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width		95 in to 100 in		
Curb Cut Offset	80 ft to 85 ft	25 to 35 & 40 to 45 ft		
Curb Cut Presence				Present
Curb Presence				Present - Both Sides
Functional Class		Other Principal Arterial		Other Principal Arterial
Highway Division		Divided		
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		3 to 4 & 13 to 14 ft		
Lane Width				11 ft to 12 ft
Max Speed	75	55	60 & 65	40 & 45
Median Presence	Median			
Median Type			Positive Barrier Rigid	
Median Width				
Minimum ROW			300 ft to 325 ft	100 ft to 125 ft
Number of Lanes		4	6 & 8	6
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width	80 ft to 85 ft			70 to 75 & 80 to 85 ft
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width			75 to 80 & ≥100 ft	
Transit Stop Presence				
Truck ADT	8k to 9k		≥15k	1k to 2k
Truck Pct	30% to 33%	3% to 9% & 12% to 15%	3% to 6%	<3% & 6% to 9%

Tyler Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT		10k to 12k & 18k to 20k		15k to 25k
Area Type				Urbanized
Bus Pad Offset		50 to 55 & 65 to 70 ft		35 to 40 & 50 to 60 ft
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				Present
Crosswalk Width		70 in to 75 in		
Curb Cut Offset		25 ft to 30 ft		60 ft to 65 ft
Curb Cut Presence				
Curb Presence				Present - Both Sides
Functional Class		Other Principal Arterial		
Highway Division				
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		9 ft to 10 ft		
Lane Width				
Max Speed		55		40 & 45
Median Presence		Median		Median
Median Type				
Median Width				
Minimum ROW				
Number of Lanes		4		4 & 6
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width				60 ft to 65 ft
Shoulder Presence		Paved - Both Sides		
Sidewalk Condition				
Sidewalk Presence				
Surface Width				
Transit Stop Presence				
Truck ADT		1k to 1.5k & 3k to 3.5k		1k to 1.5k
Truck Pct		6% to 12%		6% to 9%

Waco Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	40k to 45k & 60k to 65k	14k to 16k & 20k to 22k & 32k to 34k	≥50k	20k to 35k
Area Type			Large Urbanized	Large Urbanized
Bus Pad Offset				50 to 55 & 60 to 65 & ≥100 ft
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width				
Curb Cut Offset		≥100 ft		40 ft to 50 ft
Curb Cut Presence				
Curb Presence				
Functional Class		Other Principal Arterial		Other Principal Arterial
Highway Division		Divided		
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width	11 ft to 12 ft	9 ft to 10 ft	9 ft to 10 ft & 11 ft to 12 ft	
Lane Width		12 ft to 13 ft		14 ft to 16 ft
Max Speed			60	40 & 45
Median Presence			Median	
Median Type	Positive Barrier Rigid			
Median Width	30 ft to 36 ft			
Minimum ROW	300 ft to 325 ft	175 ft to 200 ft	300 ft to 325 ft	
Number of Lanes	6	4	6	
Outside Shoulder Use				
Outside Shoulder Width				0 ft & 5 ft to 6 ft
Roadbed Width				60 to 65 & 75 to 80 ft
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width				50 to 55 & 75 to 80 ft
Transit Stop Presence				
Truck ADT		1k to 1.5k & 4k to 4.5k & 6k to 6.5k	2k to 3k	500 to 1k
Truck Pct	24% to 27%	6% to 9%	3% to 9% & 24% to 27%	<3%

Wichita Falls Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	25k to 30k	10k to 14k	50k to 60k & 120k to 130k & 130k to 140k	15k to 25k
Area Type			Large Urbanized	Large Urbanized
Bus Pad Offset		40 ft to 45 ft		
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width		95 in to 100 in		
Curb Cut Offset	80 ft to 85 ft	25 to 35 & 40 to 45 ft		
Curb Cut Presence				
Curb Presence			Present - One Side	Present - Both Sides
Functional Class		Other Principal Arterial	Interstate	Other Principal Arterial
Highway Division		Divided		
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width		3 to 4 & 13 to 14 ft		
Lane Width				
Max Speed	75	55	60	45
Median Presence	Median		Median	Median
Median Type				
Median Width				0 ft
Minimum ROW				100 ft to 125 ft
Number of Lanes		4	6 & 8	
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width	80 ft to 85 ft			
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width			90 ft to 100 ft	50 to 60 & 85 to 90 & ≥100 ft
Transit Stop Presence				Present
Truck ADT	8k to 9k		13k to 14k	
Truck Pct	30% to 33%	3% to 9% & 12% to 15%	9% to 12%	<9%

Yoakum Risk Factors	Rural		Urban	
	Interstate/Freeway	Arterial	Interstate/Freeway	Arterial
ADT	40k to 45k & 60k to 65k			15k to 20k & 25k to 30k
Area Type				Large Urbanized & Urbanized
Bus Pad Offset				
Bus Pad Width				
TWLTL Presence				
Crosswalk Presence				
Crosswalk Width				
Curb Cut Offset				
Curb Cut Presence				
Curb Presence				Present - Both Sides
Functional Class				
Highway Division				
Inside Shoulder Type				
Inside Shoulder Use				
Inside Shoulder Width	11 ft to 12 ft			
Lane Width				
Max Speed				35 to 50
Median Presence				Median
Median Type	Positive Barrier Rigid			
Median Width	30 ft to 36 ft			5 ft to 10 ft
Minimum ROW	300 ft to 325 ft			100 ft to 150 ft
Number of Lanes	6			4 & 6
Outside Shoulder Use				
Outside Shoulder Width				
Roadbed Width				
Shoulder Presence				
Sidewalk Condition				
Sidewalk Presence				
Surface Width				65 ft to 75 ft
Transit Stop Presence				Present
Truck ADT				500 to 1.5k
Truck Pct	24% to 27%			<6%