VISION ZERO
WEBB LAREDO

APPENDIX D
SYSTEMIC RECOMMENDATIONS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

This appendix documents the analysis approach and recommendations for the systemic application of proven safety countermeasures as part of the Laredo Safety Action Plan development process. The focus of the Laredo Safety Action Plan is developing a holistic, well-defined strategy to prevent road fatalities and serious injuries within Webb County, Texas. Systemic treatment implementation is a common Vision Zero approach that identifies many locations for the strategic and programmed application of proven safety countermeasures designed to reduce the number of "Killed or Seriously Injured" (KSI) crashes. Systemic treatments can be proactively implemented throughout the region and in member agency jurisdictions and are generally considered well-suited for widespread implementation because of their efficacy, cost-effectiveness, and feasibility for implementation at multiple locations.

A recommendation list of safety countermeasures based on crash trends and crash profiles was developed. The countermeasures were selected from the FHWA Proven Safety Countermeasures initiative (PSCi), a collection of specific design or operational changes that have been proven nationally to improve safety. For several countermeasures (e.g., road diets, leading pedestrian intervals), candidate locations have been identified and mapped. For other countermeasures, considerations for where to implement these counter measures have been provided.

Countermeasure Identification and Candidate Location Selection Approach

A comprehensive, multi-phase approach was followed to identify countermeasures, identify conditions and candidate locations for select countermeasures, and provide considerations for implementation of additional countermeasures using a Safe System Approach.

Safe System Framework

Systemic recommendations are a core element of the Safe System Approach, which aims to proactively address road safety by focusing on the entire transportation system rather than responding to crashes after they occur. Unlike traditional reactive approaches, which typically address safety concerns only after crashes happen, the Safe System Approach works to eliminate or reduce risks before they lead to severe outcomes. By identifying systemic patterns in transportation infrastructure, road user behaviors, and environmental factors, systemic recommendations focus on broad, preventative measures that can be applied across multiple locations, ensuring safety improvements are made before crashes result in serious injuries or fatalities. This shift from reacting to individual incidents to proactively improving the overall safety framework is key to achieving Vision Zero goals of eliminating traffic fatalities and serious injuries.

Multi-Phase Approach

Crash Analysis Review & Transportation Network Safety Review

The review of the descriptive crash analysis, as detailed in Appendix B, focused on identifying overall trends and patterns, including crash types, frequency, and contributing factors, to understand the systemic issues related to KSI crashes in Webb County, Texas. KSI crashes where overrepresented for all modes on streets with more lanes, and higher speeds, suggesting that countermeasures should focused on making streets right-sized for the accommodation of all modes and reducing vehicular speeds. This analysis also included a detailed assessment of facility profile tiers (critical, high, and medium) across various transportation modes—motor vehicles, motorcycles, pedestrians, and bicycles. Specific locations were assessed using a desktop review to identify probable safety issues. This provided refined insights, establishing a comprehensive foundation for addressing safety challenges. Based on all the analysis, key characteristics and contributing factors were identified (e.g., high speeds, unsafe crossings, missing bike lanes, and undesirable bus stop locations) which were used to develop crash profiles in the next step.

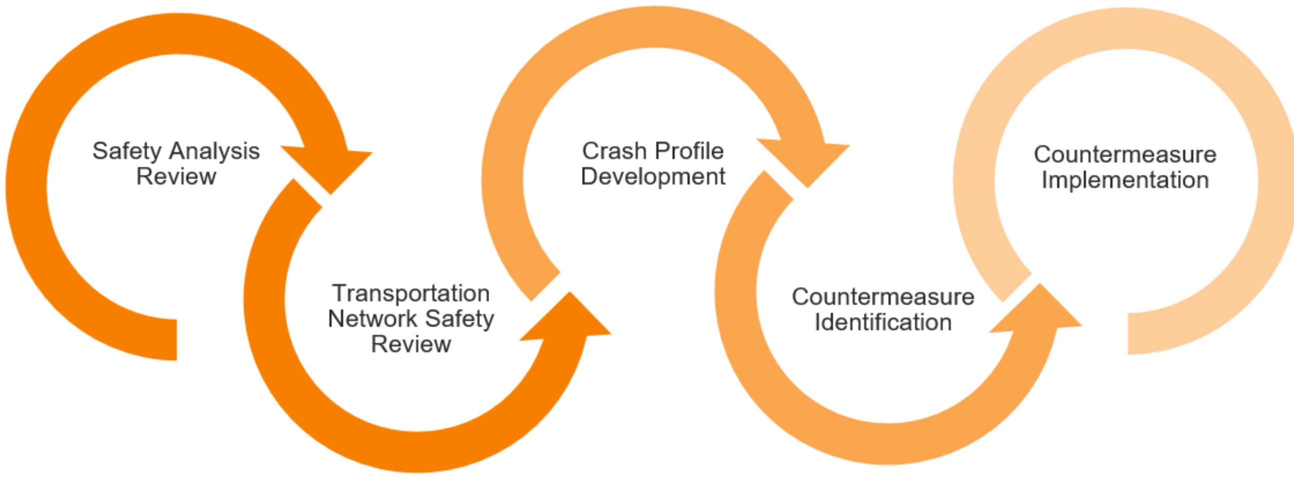

Figure 1. Approach Graphic

Crash Profile Development & Countermeasures Identification

Detailed crash profiles were created by analyzing risk factors based on modes, roadway characteristics, demographics, and land use contexts. GIS data was then used to determine the number of KSI crashes per profile, which allowed for the streamlining of crash profiles to focus on the most prevalent profiles contributing to KSI crashes. Some of the high-level findings including the following conclusions, which were the bases for some of these prevalent profiles:

- The vast majority (71% total) of motor vehicle crashes resulting in a serious injury or fatality are on non-freeway and non-interstate road segments with speed limits greater than 40 mph and freeways and interstates.
- Pedestrian KSI crashes at intersections were much more prevalent at unsignalized intersections or midblock locations (23% of pedestrian KSI) compared to signalized intersections (7% of pedestrian KSI).
- KSI crashes for the motorcycle and bicycle modes were overrepresented on streets with speed limits 40 mph or greater – both modes combined comprised approximately 25% of KSI crashes on these streets even though only 16% of streets fit into this category.

These insights helped confirm the roadway and operational characteristics to target when identifying candidate locations to address specific crash profiles. Numerous profiles were hypothesized to engage in a thorough process of identifying any cross-sectional relationships between a variety of crash characteristics that represented a notable pattern of crashes. These relationships helped pinpoint specific countermeasures that align with the appropriate mode, facility type, and operational attributes within the overall transportation network.

For example, road diets have been shown to reduce travel speeds on roadways and have been identified as a countermeasure to support improved safety for all modes. However, the implementation of road diets is only suitable within the appropriate roadway context and should consider functional class, roadway capacity, modal balance, parking demands, and other potential factors. Thus, profiles were hypothesized and evaluated based on the need to maintain the viability and efficacy of countermeasures by ensuring their application within an appropriate contexture.

Countermeasure Implementation

The final step was to provide suggestions for the proactive implementation of the recommended countermeasures. Systemic countermeasures are well-suited for widespread implementation; and this report provides maps on candidate locations for select countermeasures to support quicker implementation for City of Laredo and Webb County transportation agencies. We also provide considerations, typical applications, and suggestions for prioritizing other countermeasures.

Countermeasure implementation is most notably impacted by time and fiscal constraints, so consideration was given to a broad range of effective countermeasures that could be programmed and installed within short, medium, and long timeframes to support the congruous integration of safety countermeasure of various scale to reflect a seamless Safe System strategy.

Safety Analysis & Transportation Network Review

Crash Trends and Countermeasure Themes

The initial step involved reviewing the descriptive crash analysis documented in Appendix B. The summary below describes findings for several categories and how these findings can be addressed by selecting and prioritizing specific countermeasures that respond to the prevailing crash trends. As an initial step preceding the formulation of more detailed crash profiles, these crash trends represent the opportunity to identify an initial group of systemic countermeasure recommendations. These prevailing crash trends are summarized below.

Crashes by Mode

Vulnerable road users are much more likely to be seriously injured or killed when involved in a crash. This suggests that countermeasures that focus on vulnerable road users should be prioritized. Crashes involving motor vehicles represent the vast majority (nearly 98%) of all crashes, but account for approximately 68% of all KSI crashes. In contract, pedestrian and motorcyclists are involved in 1.2% and 0.7% of crashes, respectively, but have approximately a one in six chance (15.8% and 15.5%, respectively) of being severely injured or killed in the crash. Similarly, bicyclist representing 0.3% of crashes and 2.2% of KSI crashes; and bicycle-related crashes have a one in 14 chance of resulting in a KSI.

Commercial Vehicles

Crashes involving both commercial vehicles and vulnerable road users are much more likely to result in a serious injury or fatality than crashes involving both motor vehicles and vulnerable road users. Therefore, recommendations need to focus on countermeasures that create separation between these two users and help achieve safe commercial vehicle operations (i.e., reduced speeds). Compared to the statewide average, a higher percentage of crashes in Webb County and the City of Laredo from 2018 to 2022 are CMV-involved. CMV-involved crashes are more likely to have a severe outcome than crashes not involving CMVs and this is particularly pronounced for those crashes involving VRUs. For example, 6.3% of bicycle crashes with non-CMV result in KSI crash while 50% of bicycle crashes with a CMV result in a KSI crash. The trends are similar for pedestrians (14.9% for crashes with non-CMV vs. 32% with CMV) and motorcyclists (14.9% for crashes with non-CMV vs. 50% with CMV).

On-System vs. Off-System

Off-System roadways tend to have a higher concentration of vulnerable road users and thus accounted for 61% KSI crashes involving a vulnerable road user, almost twice the number of total crashes for all modes, and a nearly even share of total KSI crashes for all modes despite carrying only ¼ of the daily vehicle miles traveled (VMT). While focus should be given to managing speed and severity along high functional class on-system roadways, allocating commensurate resources to off-system roadways allows for a greater residual impact on the total number of crashes while addressing a nearly equal proportion of KSI crashes. With approximately 35% of total crashes being along on-system roadways, which carry over three times the vehicle miles traveled, the occurrence of crashes along on-system roadways does not reflect an over-representation. This is despite the rate of KSI crashes being double when comparing on-system versus off-system roadways (i.e., 1.6% versus 0.7%, respectively). Off-system roadways, which tend to be of a moderate to lower functional classification and consist of a significantly greater extent of access points, conflicts, diverse multimodal concentrations, and varied operational complexities, will require a broader array of recommended countermeasures to suit various geometric and operational conditions and the many cross-sectional relationships simply based on the notably greater number of crashes.

Crashes Near Destinations

KSI crashes are concentrated near specific destinations such as transit stops. Therefore, safety countermeasures should be prioritized near these destinations. It is possible that various roadway users are more concentrated at these locations, leading to distinct travel patterns, such as platoons of pedestrians crossing roadways, vulnerable road users entering the roadway at unexpected locations, legal and illegal parking maneuvers, ride-share operations, and mass ingress/egress of multimodal traffic. Traveler expectations may be more variable at specific destinations, or geometric and operational characteristics at the locations may lead to unexpected congestion or delay, which can prompt sudden errant maneuvers. Based on the data for all modes, the greatest number of KSI crashes occurred near transit stops and nearly three-quarters of KSI crashes for vulnerable road users occurred near a transit stop.

Functional Classification

Streets and intersections with higher functional classifications (excluding freeways and interstates) have an overrepresentation of overall and VRU KSI crashes. Roadways with higher functional classification (excluding freeways and interstates) are typically wider roadways with higher volumes and speeds, which confirms the need to focus on reducing street widths and speeds in countermeasure implementation. For all modes, 50% of KSI crashes occur on Other Principal Arterials, which comprise only 12.3% of the street network mileage. This trend is similar for VRUs and pedestrian and bicyclists. For intersections, a higher percentage of KSI crashes (58.5% for all modes and 62.5% for vulnerable road users) occur at intersections along local roads, which represents 89.9% of total intersections. However, crashes at intersections along higher classification roadways (major collector, minor arterial, minor collector, and other principal arterial) had an over representation of KSI crashes.

Number of Lanes on Segments and at Intersections

KSI crashes are overrepresented on roadway segments and at intersections with higher number of lanes. These findings suggest that reducing exposure through the potential reduction in the number of travel lanes or lane widths, providing intersection geometric improvements, and implementing traffic control configurations that minimize conflicts for roadway segments and intersections should be a focus of countermeasure identification. Approximately two-thirds of KSI crashes occurred on two-lane roadway segments, which is likely related to their prevalence within the Webb County road network (91.3% of total road network coverage). Three-lane roads, while being far less prevalent in Webb County (3.0% of total road network coverage), accounted for 19.8% and 17.1% of total and KSI crashes, respectively. Roadway segments with more than four lanes represent 4.4% of total road network coverage, but 19.2% and 15.5% of total and KSI crashes, respectively. For pedestrians and bicyclists, this overrepresentation is more pronounced on four lanes roadway segments where 28.0% of KSI crashes for pedestrians and bicyclists occur.

KSI crashes are also overrepresented at intersections with more total through lanes. Similar to roadway segments, approximately two-thirds of KSI crashes occurred intersections with a total of five to eight approach lanes, however, these are also the most common in Webb County, making up 90.2% of all intersections combined. Larger intersections (i.e., intersections with 9 to 12 lanes) represent only 8% of intersections, but 27% of all KSI crashes and 28% of KSI crashes with vulnerable road users.

Speed Limit on Segments and at Intersections

Comparing the percentage of roadway mileage and number of intersections with KSI crashes for various speed limits reveals that a disproportionate percentage of KSI crashes occur on roadway segments and at intersections with a posted speed limit of 40 mph or greater. This suggests that reductions in speed limit, speed management, and speed limit enforcement measures would benefit all modes. Approximately one-third of KSI crashes occurred on street segments with speed limits between 30 and 35 mph, which can be attributed to the fact that 84.0% of streets are posted with 30 mph and 35 mph regulatory speed limits. For vulnerable road users, KSI crashes are more common (half of VRU KSI crashes) on streets with speed limits of 30 mph and 35 mph, likely because the land use context, density, and access along roadways posted with this range of speed limits tend to promote a greater concentration of pedestrians and cyclists. Additionally, KSI crashes for VRUs are significantly overrepresented on streets with posted speed limits of 40 mph and above. For example, streets with speed limits of 40 mph and 45 mph represent 3.3% of street mileage but 12.0% of KSI crashes for pedestrians and bicyclists.

Approximately two-thirds of all KSI crashes occur at intersections with the highest approach speed limit being 30 mph or 35 mph, which can be attributed to the fact that 90.8% of the intersections have either of these posted speed limits. For all other speed categories, the percentage of KSI crashes are overrepresented based on the number of intersections in each speed limit category. This is more pronounced for vulnerable road users at intersections where the highest approach speed limit is 40 mph or-45 mph, which represents 22.7% of VRU KSI crashes, but only 3.7% of intersections.

Finally, the most common contributing factor to KSI crashes was “Speeding or Driving at an Unsafe Speed” as a contributing factor.

Behaviors Contributing to Crashes

Both seatbelt usage (or lack of seatbelt usage) and drug and alcohol impairment increase the likelihood of a KSI crash by more than ten times. The behaviors that contributed most to the KSI rate were seat belt usage, drug, and alcohol impairment, and driving over the speed limit. In crashes encompassing all modes, 14.9% resulted in KSI outcomes when seat belts were not used which is much higher than the 1% KSI rate for all crashes. Alcohol and drug impairment are more likely to result to KSI crashes. For all modes, 9.4% of crashes resulted in KSI outcomes when drug or alcohol were involved compared to 1.0% KSI rate for all crashes. For vulnerable road users, 63.2% of crashes resulted in KSI outcomes when drug or alcohol were involved compared to a 14.4% KSI rate for all crashes. Speeding as a factor is discussed previously.

Lane Departure

In rural settings, lane departure crashes represent a higher proportion of KSI crashes compared to urban contexts. This suggests that roadway departure should be a focus or concern and treatments to help prevent roadway departure should be applied in rural contexts. Lane departure related crashes that occurred on rural roads made up a larger share of KSI crashes (9.2%) while lane departure accounted for 5.6% of KSI crashes in urban settings.

Table 1. Key Findings and Countermeasure Focus Areas

Key Finding	Countermeasure Focus Area
Crashes by Mode – Vulnerable road users are much more likely than motorists to be seriously injured or killed when involved in a crash.	Countermeasures that focus on vulnerable road users should be prioritized.
Commercial Vehicles – CMV-involved crashes are more likely to have a severe outcome than crashes not involving CMVs and this is more notable for those crashes involving VRUs.	Countermeasures should focus on separating CMV traffic from other users through strategies such as designating truck routes, providing physical separation (e.g., separated bike lanes on segments and maintaining protection at intersections), agency engagement with truck traffic generators, and enforcement methods.
On-System vs. Off-System – Off-System roadways experience a greater proportion of KSI crashes, despite carrying one-fourth the daily traffic volume that travels along freeways and interstates. The total number of crashes occurring along off-system roadways is nearly double the total number of crashes occurring along on-system roadways.	Commensurate resources and a broader array of countermeasures should be considered for off-system roadways given the variety of geometric and operational characteristics and the more typical confluence of VRUs and motor vehicles in more constrained, dynamic environments.
Crashes Near Destinations – KSI crashes were more concentrated near destinations (schools, parks, transit stops).	Safety countermeasures should be more highly prioritized near schools, parks, and transit stations.
Functional Classification – Roadways and intersections with higher functional classifications (excluding interstates and freeways) have an overrepresentation of overall and VRU KSI crashes.	Roadways with higher functional classification (excluding interstates and freeways) are typically wider roadways with higher volumes and speeds, which confirms the need to focus on potentially reducing roadway cross-sections, lane widths, and regulatory speed limits and deploying other methods to help provide safer access for VRUs and manage vehicular speeds.
Number of Lanes along Roadway Segments and at Intersections – KSI crashes are overrepresented along roadway segments and at intersections with a higher number of through and approach lanes.	Geometric improvements that reduce the number of vehicular travel lanes and reallocate available roadway width to other modes should be considered along roadway segments (i.e., road diets, lane diets). Intersection geometric improvements that provide separate spaces and reduce exposure for VRUs (i.e., when crossing) should be pursued along with traffic control configurations that minimize conflicts.
Speet Limit on Segments and at Intersections – Comparing the percentage of roadway mileage and intersections with KSI crashes for various speed limits reveals that a disproportionate number of KSI crashes occur on streets and intersections with a posted speed limit of 40 mph or greater.	Perform evaluations to determine if a reduction in regulatory speed limit is feasible based on factors such as crash characteristics, land use context, roadway cross-section, and target speed (instead of 85^{th} percentile speed). Incorporate speed enforcement and management strategies to encourage safer speeds along roadways with posted speed limits of 40 mph or greater.

Key Finding	Countermeasure Focus Area
Behaviors Contributing to Crashes – Crashes involving lack of seat belt use or alcohol and drug impairment are more likely to be a KSI crash.	Continue the expansion of education and engagement programs and enforcement strategies associated with safe driver behaviors, particularly around major/special events. Explore systemic roadway and roadside improvements that address geometric constraints along corridors where DWI crashes are more common.
Lane Departure – In rural settings, lane departure crashes represent 9.2% of KSI compared to and 5.6% in urban contexts.	Assess clear zones and roadside obstructions and pursue roadway departure treatments in rural contexts.

Transportation Network Safety Review

Based on the Systemic Safety Analysis Results detailed as part of Appendix B, the characteristics and definitions of the critical, high, and medium tiers for each transportation mode were reviewed. A desktop review of segments within these tiers were completed to identify and document potential safety issues. Some of the more significant safety concerns are listed below:

- **Roadway geometry that may contribute to higher speeds** on roadways, contributing to safety concerns for all users.
- **Need for elements that promote safer crossing conditions** including non-high-visibility crosswalks; missing pedestrian signals or push buttons; uncontrolled or unmarked crossings, particularly at multi-lane intersections.
- **Absence of dedicated bike facilities**, increasing the potential exposure of cyclists to motor vehicle traffic.
- **Limited bus stop locations,** such as: near-side vs. far-side placements; bus stops located midblock rather than at intersections.
- **Many driveways or access points**, increasing potential conflict zones.
- **Missing sidewalk connections**, leading to gaps in the network of pedestrian facilities.
- **Sidewalk obstructions**, including vegetation, utility poles, and other barriers, reducing accessibility.

Crash Profile Development & Countermeasure Identification

As part of the crash summary review described above, recommendation themes were identified that were applicable to the overall transportation network based on the prevalence of certain crash types, modal relationships, and their contributing factors. Additionally, more detailed profiles are identified below, and specific countermeasures are selected to respond to the crash profiles. The selection of countermeasures was based on FHWA's Proven Safety Countermeasures initiative (PSCi). This system of countermeasures is categorized into five major areas, including speed management, pedestrian/bicyclist, roadway departure, intersections, and crosscutting measures. Additional details on each countermeasure can be found in the last section of this appendix. Additional measures that are not based on the PSCi are also recommended in cases where these measures constitute a "good fit" with specific crash profiles and have the potential to provide a reasonable safety benefit.

All Modes

Table 2 presents notable crash profiles for all modes, resulting KSI crashes, and recommended countermeasure(s) to address the crash profiles as well as countermeasure effectiveness as indicated by their typical crash reduction factors.

Table 2. All Modes: Crash Profiles, % KSI (Total KSI), Recommended Countermeasures, Countermeasure Effectiveness

Crash Profile	% KSI (Total KSI)	Recommended Countermeasure	Countermeasure Effectiveness
All Modes • Dark, not lighted conditions	15% of all KSI crashes (Total = 67 KSI)	*Improved Street Lighting*	**42%** reduction in nighttime injury pedestrian crashes at intersections with lighting. *(Source: FHWA-SA-21-050)*
		Backplates with Retroreflective Borders	**15%** reduction in total crashes. *(Source: FHWA-SA-21-039)*
		Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections	**10%** reduction of nighttime crashes at all locations/types/areas for stop-controlled intersections. *(Source: FHWA-SA-21-031)*

Motor Vehicles along Roadways and Freeways

Table 3 presents crash profiles for motor vehicles along roadways and freeways, resulting KSI crashes, and recommended countermeasure(s) to address the crash profiles as well as their typical crash reduction factors. KSI crashes for motor vehicles occur disproportionately on roadways, excluding freeways and interstates, with higher posted speed limits (i.e., 33% of KSI crashes and 16% of network mileage) and freeways and interstates (i.e., 39% of KSI crashes and less than 1% of network mileage). Countermeasures focus on reducing regulatory speed limits and enforcing and managing speed limits.

Table 3. Motor Vehicles along Roadways and Freeways: Crash Profiles, % KSI (Total KSI), Recommended Countermeasures, Countermeasure Effectiveness

<table>
<tr><th>Crash Profile</th><th>% KSI (Total KSI)</th><th>Recommended Countermeasure</th><th>Countermeasure Effectiveness</th></tr>
<tr><td rowspan="2">Motor Vehicles
• Roadway Segments
• > 40 mph
• (Excluding freeways and interstates)</td><td rowspan="2">32% of motor vehicle KSI crashes (Total = 100 KSI)</td><td>Appropriate Speed Limits for All Road Users</td><td>26% reduction in fatalities in Seattle after the city implemented comprehensive, city-wide speed management strategies and countermeasures inspired by Vision Zero. (Source: FHWA-SA-21-034)</td></tr>
<tr><td>Automated Speed Enforcement</td><td>54% reduction in all crashes, 47% reduction in injury crashes for fixed units on urban principal arterials. (Source: FHWA-SA-21-070)
37% reduction in fatal and injury crashes for point-to-point units on urban expressways, freeways, and principal arterials. (Source: FHWA-SA-21-070)
20% reduction in fatal and injury crashes for mobile units on urban principal arterials. (Source: FHWA-SA-21-070)</td></tr>
<tr><td rowspan="3">Motor Vehicles
• Freeways and interstates</td><td rowspan="3">39% of motor vehicle KSI crashes (Total = 121 KSI)</td><td>Dynamic Speed Feedback Sign</td><td>7% reduction in all crashes. (Source: CMF ID: 6885. Note: CMF only applicable to two-lane rural roads.)</td></tr>
<tr><td>Automated Speed Enforcement</td><td>54% reduction in all crashes, 47% reduction in injury crashes for fixed units on urban principal arterials. (Source: FHWA-SA-21-070)
37% reduction in fatal and injury crashes for point-to-point units on urban expressways, freeways, and principal arterials. (Source: FHWA-SA-21-070)
20% reduction in fatal and injury crashes for mobile units on urban principal arterials. (Source: FHWA-SA-21-070)</td></tr>
<tr><td>Variable Speed Limits</td><td>51% reduction in fatal and injury crashes. (Source: FHWA-SA-21-054)</td></tr>
</table>

Motor Vehicles at Signalized Intersections

Table 4 presents crash profiles for motor vehicles at signalized intersections, resulting KSI crashes, and recommended countermeasure(s) to address the crash profiles as well as countermeasure efficacy based on typical crash reduction factors. Signalized intersections account for approximately one quarter of the traffic control in the City of Laredo and Webb County. At signalized intersections, head-on crashes do not account for a substantial proportion of crashes (7%) but do represent a relatively high proportion of KSI crashes (7.6%).

Table 4. Motor Vehicles at Signalized Intersections: Crash Profiles, % KSI (Total KSI), Recommended Countermeasures, Countermeasure Effectiveness

Crash Profile	% KSI (Total KSI)	Recommended Countermeasure	Countermeasure Effectiveness
Motor Vehicles • Head on crashes • Signalized Intersection	3% of motor vehicles KSI crashes (Total = 8 KSI)	*Dedicated Left- and Turn Lanes at Intersections*	**28-48%** reduction in total crashes. *(Source: FHWA-SA-21-041)* **36%** reduction in fatal and injury crashes for positive offset left-turn lanes. *(Source: FHWA-SA-21-041)*
		Improve Yellow Change Intervals	**36-50%** reduction in red-light running. *(Source: FHWA-SA-21-043)* **8-14%** reduction in total crashes. *(Source: FHWA-SA-21-043)* **12%** reduction in injury crashes. *(Source: FHWA-SA-21-043)*
		Adjust All Red Clearance Interval	**20-40%** reduction in angle, head-on, and sideswipe crashes. *(Source: CMF ID: 4029 and CMF ID: 4030)*
		Install Red-Light Enforcement	**8-18%** reduction in head-on and left turn crashes. *(Source: CMF ID: 5489 and CMF ID: 5491)*
Motor Vehicles • Left-turn crashes • Signalized intersection	3% of motor vehicles KSI crashes (Total = 9 KSI)	*Improve Yellow Change Intervals*	**36-50%** reduction in red-light running. *(Source: FHWA-SA-21-043)* **8-14%** reduction in total crashes. *(Source: FHWA-SA-21-043)* **12%** reduction in injury crashes. *(Source: FHWA-SA-21-043)*
		Protected or Permissive/Protected Left Turn Signal Phasing	**99%** reduction in left turn crashes. *(Source: FHWA-SA-014 – May 2008)*

Motor Vehicles at Unsignalized Intersections

Table 5 shows crash profiles for motor vehicles at unsignalized intersections, the resulting KSI crashes, and recommended countermeasure(s) to address the crash profiles, as well as countermeasure effectiveness through typical crash reduction factors. The most notable crash types at unsignalized intersections were head on and left turn crashes which represent 6% of motor vehicle KSI crashes.

Table 5. Motor Vehicles at Unsignalized Intersections: Crash Profiles, % KSI (Total KSI), Recommended Countermeasures, Countermeasure Effectiveness

Crash Profile	% KSI (Total KSI)	Recommended Countermeasure	Countermeasure Effectiveness
Motor Vehicles • Head on crashes • Left-turn crashes • Unsignalized Intersection	6% of motor vehicles KSI crashes (Total = 18 (KSI)	*Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections*	**10%** reduction of nighttime crashes at all locations/types/areas. *(Source: FHWA-SA-21-031)* **15%** reduction of fatal and injury crashes at all locations/types/areas. *(Source: FHWA-SA-21-031)* **27%** reduction of fatal and injury crashes at rural intersections. *(Source: FHWA-SA-21-031)* **19%**reduction of fatal and injury crashes at 2-lane by 2-lane intersections. *(Source: FHWA-SA-21-031)*
		High Friction Surface Treatment (HFST)	**63%** reduction in injury crashes at ramps. *(Source: FHWA-SA-21-038)* **48%** reduction in injury crashes at horizontal curves. *(Source: FHWA-SA-21-038)* **20%** reduction in total intersection crashes. *(Source: FHWA-SA-21-038)*
		Traffic Signal Installation	**63%** reduction in angle and left turn crashes at unsignalized intersections. *(Source: CMF ID: 8086)*

Motorcycles

Table 6 presents crash profiles for motorcycles, resulting KSI crashes, and recommended countermeasure(s) to address the crash profiles. Research related to crash modification factors for motorcycle traffic is not extensive, so the relative effectiveness of these countermeasures for motorcycle traffic is based on the National Highway Traffic Safety Administration's "Countermeasures That Work" publication, which is a general reference for providing guidance to State Highway Safety Offices engaged in identifying "effective, science-based traffic safety countermeasures" to address safety concerns along major highways. Based on this guidance the following two measures, which do not currently have associated crash modification factors, should also be considered:

- **Universal Motorcycle Helmet Use Laws (for motorcyclists and passengers over the age of 21)** - "5 Stars" - Demonstrated to be effective by several high-quality evaluations with consistent results.

- **Alcohol-Impaired Motorcyclists: Detection, Enforcement, and Sanctions** - "3 Stars" - Likely to be effective based on balance of evidence from high-quality evaluations.

Volume 22 of NCHRP Report 500: Guidance for Implementation of the AASHTO Strategic Highway Safety Plan, entitled "A Guide for Addressing Collisions Involving Motorcycles", provides guidance related to various roadway design and traffic control policies and practices. This guidance includes countermeasures that are recommended for motor vehicle traffic within this summary and thus are not included in the following table, including:

- Dynamic speed feedback signs
- Dedicated left- and turn lanes at intersections
- Systemic application of multiple low-cost countermeasures at stop-controlled intersections

NCHRP Report 500 includes additional recommended countermeasures specifically for motorcycle safety. These include providing a full paved shoulder to facilitate roadside recovery, pavement surfaces that improve traction, and adequate advance warnings for motorcyclists.

KSI crashes for motorcycles occurred disproportionately on streets with posted speed limits greater than 40 mph (i.e., 28% of KSI crashes but only 16% of network mileage) and on freeways and interstates by a factor of ten (i.e., 10% of KSI crashes and less than 1% of network mileage). Countermeasures focus on policy, programs, and potential legislation that could improve motorcycle safety on all classifications of roadway.

Table 6. Motorcycles: Crash Profiles, % KSI (Total KSI), Recommended Countermeasures, Countermeasure Effectiveness

Crash Profile	% KSI (Total KSI)	Recommended Countermeasure	Countermeasure Effectiveness
A) Motorcycle • Roadways • ≥30 and ≤ 40mph B) Motorcycle • Roadways • > 40mph C) Motorcycle • Freeways/Interstates	A) 72% of motorcycle KSI crashes (Total = 36 KSI) B) 28% of motorcycle KSI crashes (Total = 14 KSI) C) 10% of motorcycle KSI crashes (Total = 5 KSI)	***High Friction Surface Treatment (HFST)***	**63%** reduction in injury crashes at ramps. *(Source: FHWA-SA-21-052)* **48%** reduction in injury crashes at horizontal curves. *(Source: FHWA-SA-21-052)* **20%** reduction in total intersection crashes. *(Source: FHWA-SA-21-052)*
		Install Wider Markings and Shoulder Rumble Strips with Resurfacing	**20%** reduction in injury crashes in urban areas and **26%** reduction in KSI crashes in rural areas. *(Source: CMF ID: 4783 and CMF ID: 4785)*
		Upgrade Narrow Unpaved Shoulders to Wide Paved Shoulders	**72%** reduction in injury crashes in rural areas at urban freeway interchanges. *(Source: CMF ID: 11203 and CMF ID: 11206)*

Pedestrians

Table 7 presents crash profiles for pedestrians, resulting KSI crashes, and recommended countermeasure(s) and their associated crash reduction factors. This section focuses on pedestrians in general and the following sections focus on pedestrians in specific conditions (i.e., along roadways, at unsignalized locations, at signalized intersections). In general, approximately one quarter (23%) of pedestrian KSI crashes occur in dark, non-lighted conditions, which emphasizes the need for improved lighting.

Table 7. Pedestrians: Crash Profiles, % KSI (Total KSI), Recommended Countermeasures, Countermeasure Effectiveness

Crash Profile	% KSI (Total KSI)	Recommended Countermeasure	Countermeasure Effectiveness
Pedestrians • Dark, not lighted conditions	23% of pedestrian KSI crashes (Total = 19 KSI)	*Improved Street Lighting*	**42%** reduction in injury pedestrians crashes nighttime injury pedestrian crashes at intersections. *(Source: FHWA-SA-21-050)*

Pedestrians along Roadways

Table 8 summarizes the crash profiles for pedestrians along roadway segments, resulting in KSI crashes, and the recommended countermeasures for addressing these crash profiles along with their associated crash reduction factors. These profiles reflect conditions along corridors where pedestrian facilities are provided and not provided. The countermeasures where pedestrian facilities are provided focus on improvements that create separation between motorized and non-motorized traffic, while the countermeasure for corridors without pedestrian facilities focuses on closing sidewalk gaps by providing accessible facilities. Roadway safety audits are also recommended to assess geometric and operational conditions around schools and parks that may contribute to the occurrence of pedestrian crashes.

Table 8. Pedestrians along Roadways: Crash Profiles, % KSI (Total KSI), Recommended Countermeasures, Countermeasure Effectiveness

Crash Profile	% KSI (Total KSI)	Recommended Countermeasure	Countermeasure Effectiveness
A) Pedestrians • Along roadways • ≥30 and ≤ 40mph B) Pedestrians • Along roadways • > 40 mph	A) 58% of pedestrian KSI crashes (Total = 49 KSI) B) 29% of pedestrian KSI crashes (Total = 24 KSI)	*Corridor Access Management*	**25-31%** reduction in fatal and injury crashes along urban/suburban arterials.
		Road Diet	**19-47%** reduction in total crashes. *(Source: FHWA-SA-21-046)*
		Median Treatment for Ped/Bike Safety	**9%** reduction in injury crashes and an **86%** reduction in fatal crashes involving pedestrians or cyclists in urban areas *(Source: CMF ID: 9121 and CMF ID: 9123)*
		Install Pedestrian Fencing	**14%** reduction in injury crashes and an **12%** reduction in all crashes involving pedestrians or cyclists in urban areas *(Source: CMF ID: 5261 and CMF ID: 5258)*
Pedestrians • Along roadways	55% of pedestrian KSI	*Sidewalk Installation*	**65-89%** reduction in crashes involving pedestrians walking

• Not on sidewalk • Not in shoulder • ≥ 30mph	crashes (Total = 46 KSI)		along roadways for adding sidewalks. *(Source: FHWA-SA-21-047)*
Pedestrians • Along roadways • Within 0.5 miles of a school or park	42% of pedestrian KSI crashes (Total = 35 (KSI)	***Road Safety Audit Surrounding Schools, (and SRTS audits)***	**10-60%** reduction in total crashes. *(Source: FHWA-SA-21-048)*

Pedestrians at Unsignalized Intersections and Midblock Locations

Table 9 lists crash profiles for pedestrians at unsignalized intersections and midblock locations, resulting in KSI crashes. This includes recommended countermeasures to address these crash profiles as well as countermeasures that are anticipated to effectively address these safety concerns. The typical crash reduction factors are also provided. Since several recommendations spanned multiple profiles, profiles have been combined to share common countermeasure recommendations.

The recommended countermeasure of providing far side bus stop placement has a crash reduction factor that can't be substantiated based on a lack of suitable background data. However, based on TCRP Report 125: Guidebook for Mitigating Fixed-Route Bus-and-Pedestrian Collisions, far-side bus stops are "highly recommended by various agencies and groups" based on stakeholders subjective ratings and comments on effectiveness.

Based on a review of crash profiles, it was determined that approximately 1/3 of pedestrian crashes occur on streets that would benefit from the installation of a refuge island.

Table 9. Pedestrians at Unsignalized Intersections and Midblock Locations: Crash Profiles, % KSI (Total KSI), Recommended Countermeasures, Countermeasure Effectiveness

Crash Profile	% KSI (Total KSI)	Recommended Countermeasure	Countermeasure Effectiveness
A) Pedestrians • Across roadway • Unsignalized intersection • Midblock crossing • > 40 mph • < 40 mph and ADT >15,000 B) Pedestrians • Across roadways • Unsignalized crossings (intersections and non-intersections) • 2 lanes and ADT ≥ 15,000	A) 23% of pedestrian KSI crashes (Total = 19 KSI) B) 25% of pedestrian KSI crashes (Total = 21 KSI)	***Pedestrian Hybrid Beacons (PHB)***	**55%** reduction in pedestrian crashes. *(Source: FHWA-SA-21-045)* **29%** reduction in total crashes. *(Source: FHWA-SA-21-045)* **15%** reduction in serious injury and fatal crashes. *(Source: FHWA-SA-21-045)*
		Crossing Improvements (Hi-Visibility Crossings, ADA Ramps, Lighting, Daylighting/Curb Extensions)	**40%** reduction in pedestrian injury crashes for high-visibility crosswalks. *(Source: FHWA-SA-21-049)* **42%** reduction in pedestrian crashes for intersection lighting. *(Source: FHWA-SA-21-049)* **25%** reduction in pedestrian crashes for advance yield or stop markings and signs. *(Source: FHWA-SA-21-049)*
		Pedestrian Refuge Island	**56%** reduction in pedestrian crashes. *(Source: FHWA-SA-21-044)*

• 3 lanes and ADT ≥ 9,000 • ≥ 4 lanes and ADT ≥ 15,000			
Pedestrians • Across roadway • Unsignalized intersection • Midblock location • Within 0.25 miles of transit/bus stop	58% of pedestrian KSI crashes (Total = 49 KSI)	*Rectangular Rapid Flashing Beacon (RRFB)*	**47%** reduction in pedestrian crashes. *(Source: FHWA-SA-21-053)*
		Pedestrian Hybrid Beacons (PHB)	**55%** reduction in pedestrian crashes. *(Source: FHWA-SA-21-045)* **29%** reduction in total crashes. *(Source: FHWA-SA-21-045)* **15%** reduction in serious injury and fatal crashes. *(Source: FHWA-SA-21-045)*
		Relocate Bus Stop to Far Side of Signalized Intersection	**1%** reduction in pedestrian crashes is expected with the installation of far side bus stops *(Source: ITE, 2004. Note: Applies to signalized intersections only. Quality of this data cannot be substantiated.)*

Pedestrians at Signalized Intersections

Table 10 presents crash profiles for pedestrians at signalized intersections and the resulting KSI crashes. The recommended countermeasure to address this crash profiles as well as the associated crash reduction factor is provided. These countermeasures focus on reducing conflicts for pedestrians at intersections by adjusting traffic signal parameters.

Table 10. Pedestrians at Signalized Intersections: Crash Profiles, % KSI (Total KSI), Recommended Countermeasures, Countermeasure Effectiveness

Crash Profile	% KSI (Total KSI)	Recommended Countermeasure	Countermeasure Effectiveness
Pedestrians • Signalized intersections	7% of pedestrian KSI crashes (Total = 6 KSI)	*Adding LPIs*	**13%** reduction in pedestrian-vehicle crashes at intersections. *(Source: FHWA-SA-21-032)*
		Increase Signal Phases Length to Allow for Longer Pedestrian Crossing Time	**51%** reduction in pedestrian-vehicle crashes at intersections. *(Source: CMF ID: 5252)*
		Crossing Improvements (Hi-Visibility Crossings, ADA Ramps, Lighting, Daylighting/Curb Extensions)	**40%** reduction in pedestrian injury crashes for high-visibility crosswalks. *(Source: FHWA-SA-21-049)* **42%** reduction in pedestrian crashes for intersection lighting. *(Source: FHWA-SA-21-049)*

Bicyclists along Roadways

Table 11 presents crash profiles for KSI crashes involving cyclists along roadway segments and the recommended countermeasures along with their associated crash reduction factors. In the State of Texas and within the City of Laredo, cyclists are permitted to use the sidewalk, thus the countermeasure recommendation for sidewalks may appropriately apply to bicyclists along roadways. Other countermeasures prescribed for pedestrian safety along roadways are listed in the table below.

Table 11. Bicycles: Profiles, % KSI (Total KSI), Recommended Countermeasures, Countermeasure Effectiveness

Crash Profile	% KSI (Total KSI)	Recommended Countermeasure	Countermeasure Effectiveness
A) Bicycle • Roadways • ≥30 and ≤ 40mph B) Bicycle • Roadways • > 40 mph	A) 80% of bicycle KSI crashes (Total = 8 KSI) B) 10% of bicycle KSI crashes (Total = 1 KSI)	*Provide Bike Lanes*	**53%** reduction in bicycle/vehicle crashes when converting traditional or flush buffered bicycle lanes to a separated bicycle lane with flexible delineator posts. *(Source: FHWA-SA-21-051)* **49%** reduction in total crashes on urban 4-lane undivided collectors and local roads for bicycle lane additions. *(Source: FHWA-SA-21-051)* **30%** reduction in total crashes on urban 2-lane undivided collectors and local roads for bicycle lane additions. *(Source: FHWA-SA-21-051)*
		Median Treatment for Ped/Bike Safety	**9%** reduction in injury crashes and an **86%** reduction in fatal crashes involving pedestrians or cyclists in urban areas *(Source: CMF ID: 9121 and CMF ID: 9123)*
		Install Pedestrian Fencing	**14%** reduction in injury crashes and an **12%** reduction in all crashes involving pedestrians or cyclists in urban areas *(Source: CMF ID: 5261 and CMF ID: 5258)*

Countermeasure Implementation

This section on countermeasure implementation describes the process, and resulting maps, for identifying candidate locations for several countermeasures followed by a section covering considerations of implementing countermeasures where candidate locations were not presented.

Candidate Locations for Select Countermeasures

Candidate locations for select countermeasures have been mapped based on characteristics of streets and intersections where risk factors are present (e.g., signalized intersections near destinations) and there is the potential for implementation (e.g., wider roads with more general-purpose travel lanes than necessary to carry vehicle volumes.)

Road Diet Candidate Locations

Road Diets were identified as a countermeasure that could benefit all modes. FHWA's Road Diet Information Guide (November 2014) was used to identify streets that could potentially be reduced to three lanes (i.e., one through lane in each direction and space for a left-turn lane or median island). The FHWA's Road Diet Informational guide presented three ADT thresholds (i.e., 15,000, 18,000, and 25,000 vehicles per day) used by different agencies to determine when to install a road diet. Candidate locations that meet these thresholds are illustrated in Figure 2 and Figure 3 for the City of Laredo and the wider Webb County, respectively.

Lane Diet/Bike Lane Candidate Locations

Lane diets reduce the lane widths for motorists and may provide space for bike lanes or separated bike lanes. Streets where lane widths could be reduced were identified using the number of lanes, the total curb to curb street width, a 10-foot minimum lane width and a 5-foot minimum bike lane width. For example, a 3-lane road is a candidate for a lane diet and adding bike lanes if there is an existing curb-to-curb width of 40 or more feet. Candidate locations that meet this criterion are illustrated in Figure 4 and Figure 5 for the City of Laredo and the wider Webb County, respectively.

Leading Pedestrian Interval Candidate Locations

Candidate locations for leading pedestrian intervals are signalized intersections within 750 feet (approximately two blocks) of a park, school, and transit stop. Given the density of parks, schools, and transit stops, many of the signalized intersections in the project area are candidates. Candidate locations that meet this criteria are illustrated in Figure 6 and Figure 7 for the City of Laredo and the wider Webb County, respectively. Additional prioritization for a first and subsequent phases of LPI implementation will likely be necessary.

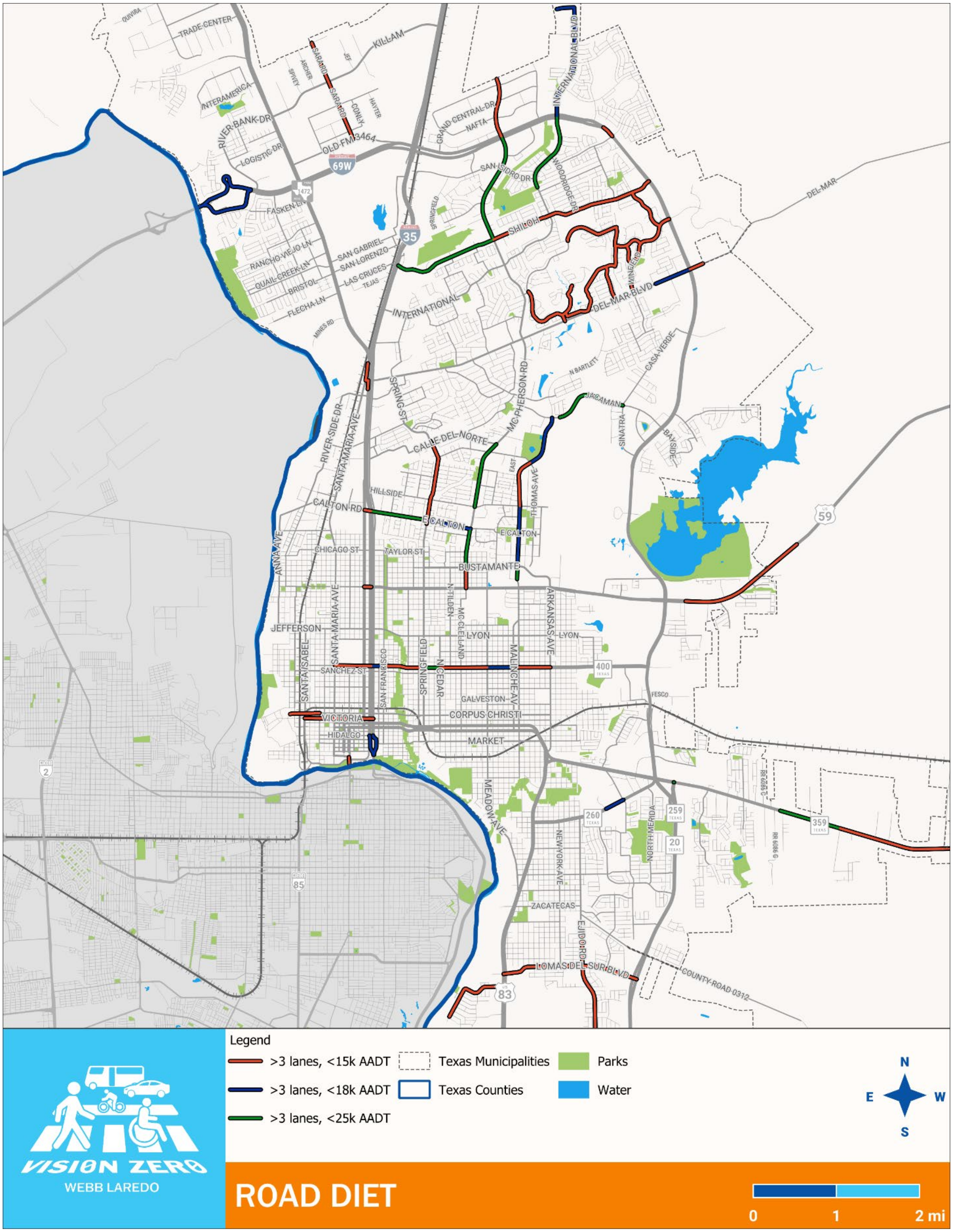

Figure 2. Map of Candidate Locations for Road Diet (City of Laredo)

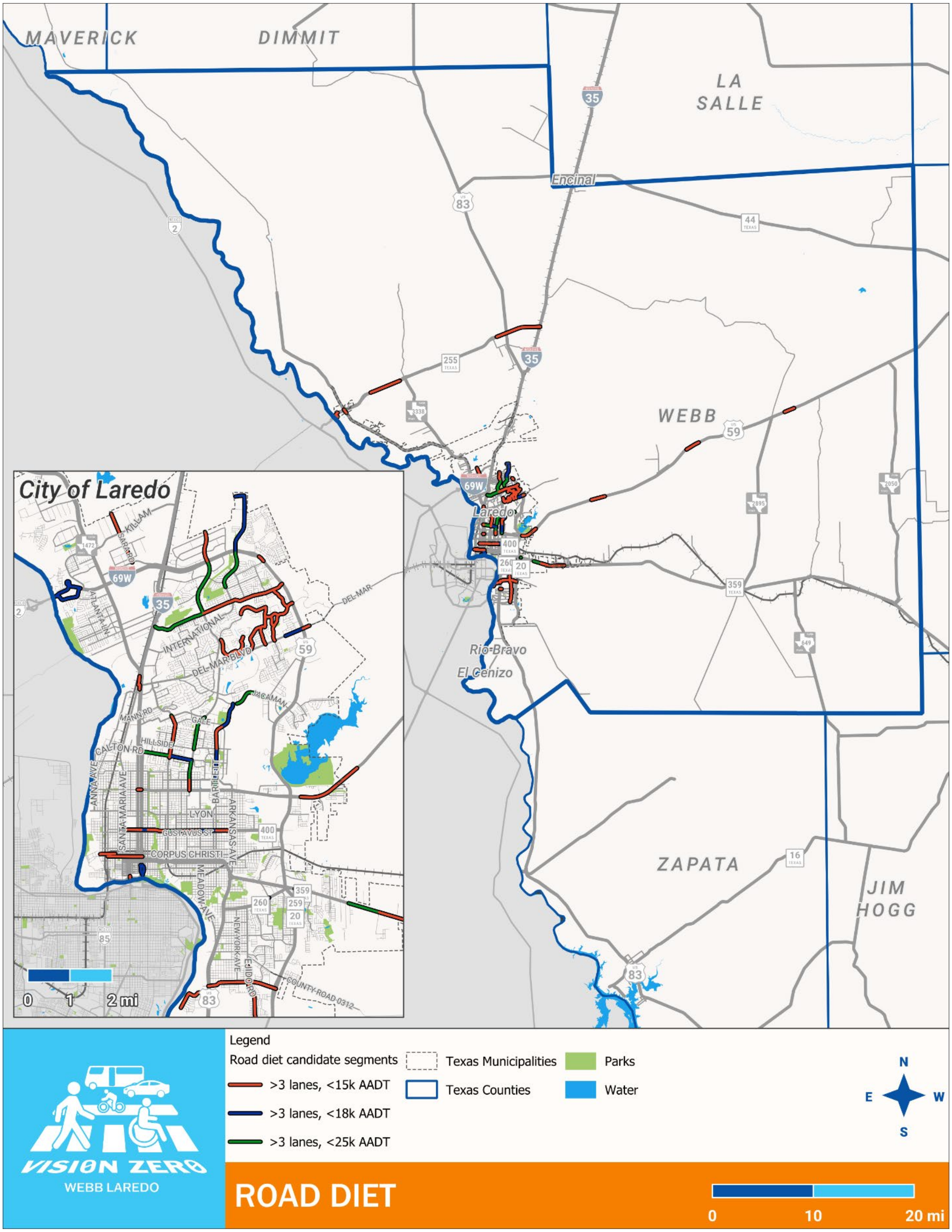

Figure 3. Map of Candidate Locations for Road Diet (Webb County)

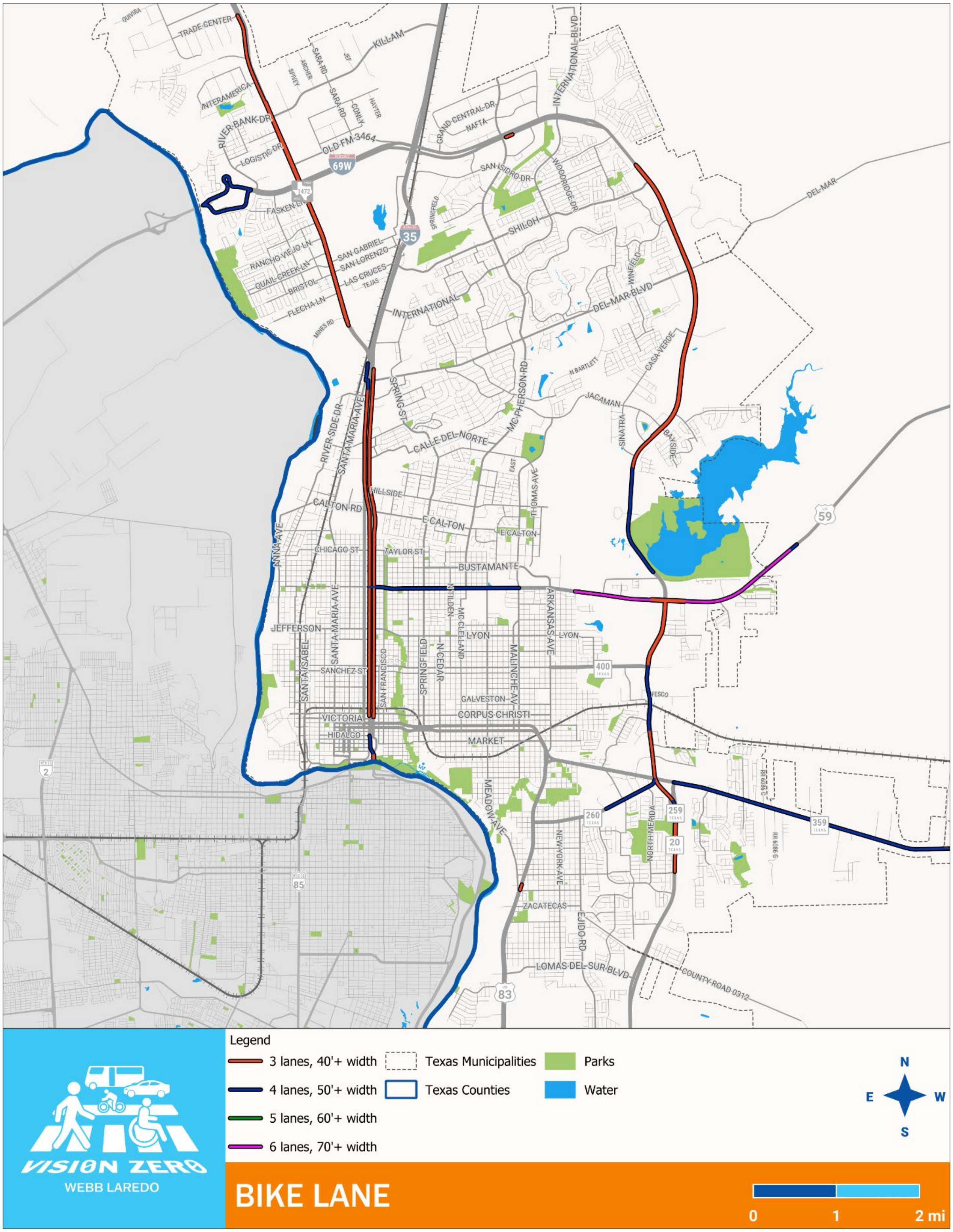

Figure 4. Map of Candidate Locations for Lane Diet/Bike Lanes (City of Laredo)

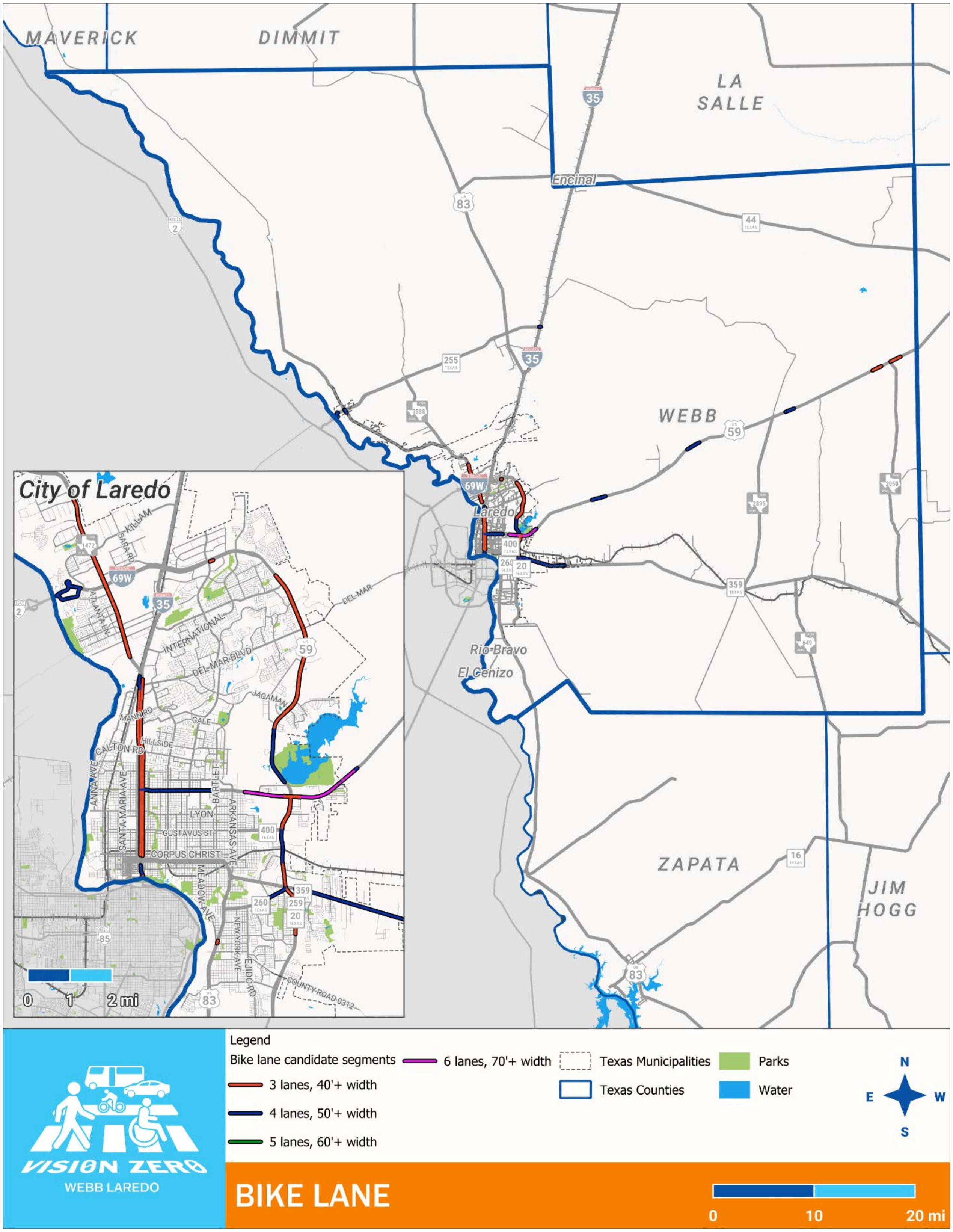

Figure 5. Map of Candidate Locations for Lane Diet/Bike Lanes (Webb County)

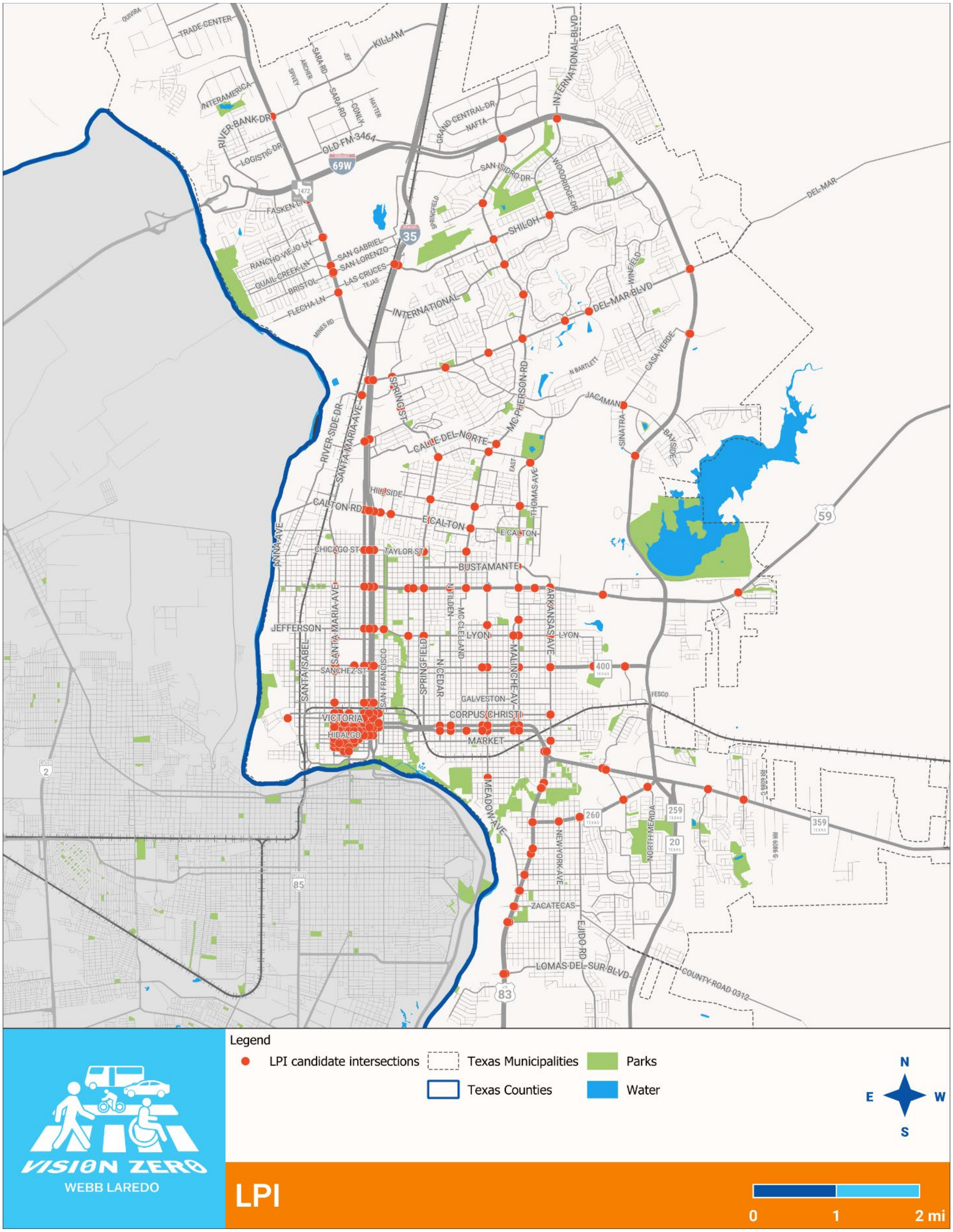

Figure 6. Map of Candidate Locations for Leading Pedestrian Intervals (City of Laredo)

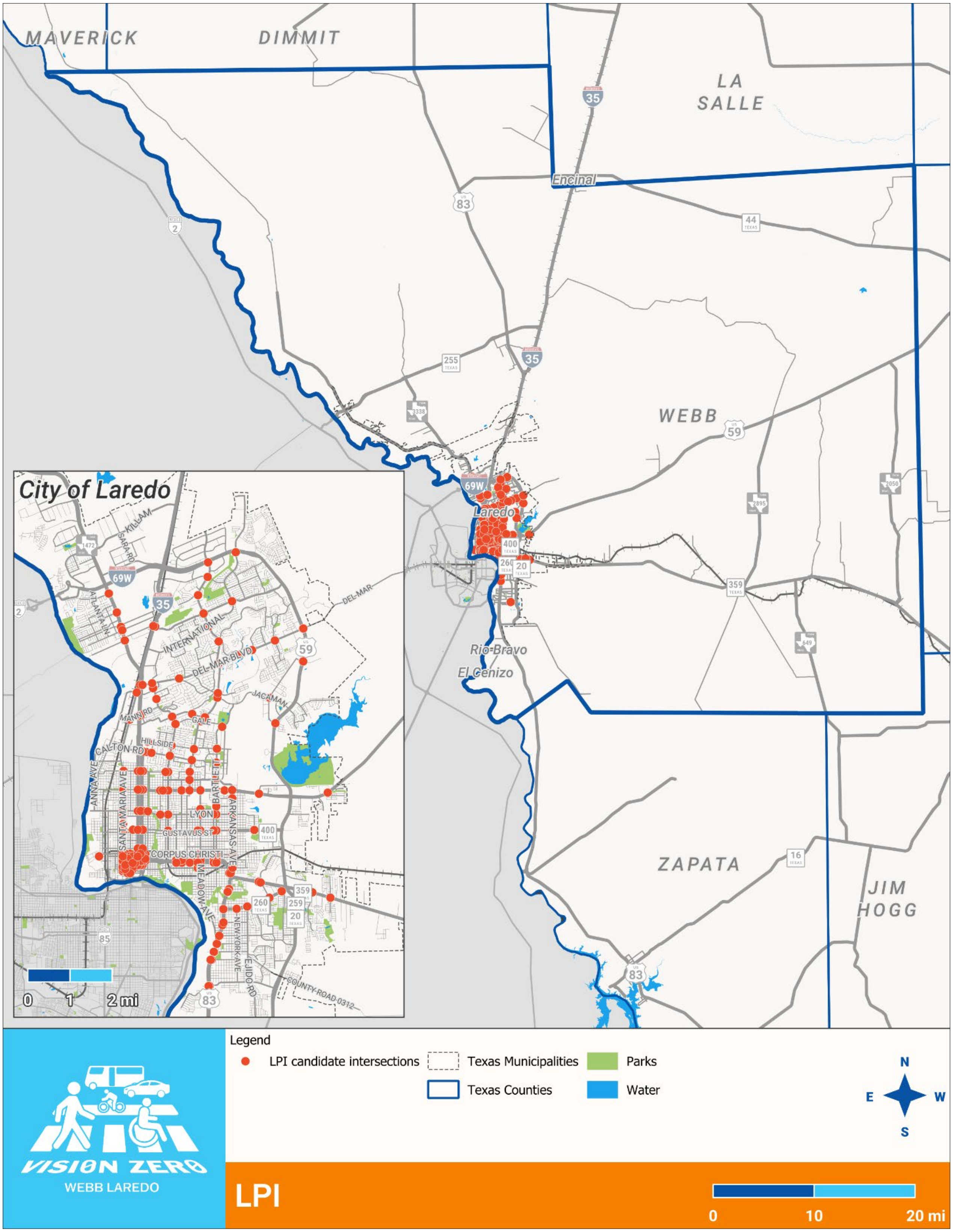

Figure 7. Map of Candidate Locations for Leading Pedestrian Intervals (Webb County)

Considerations for Implementation of Additional Countermeasures

This section provides considerations for implementation of countermeasures that do not have mapped candidate locations due to a lack of sufficient data to identify specific locations. Additional data needs include turning movement counts (TMCs), signal timing plans, curb ramp and crosswalk conditions, and access points per mile, which are critical for more precise analysis and location selection. To address these challenges, we created a list of factors to consider when selecting potential locations for these countermeasures.

Speed Management

Appropriate Speed Limits for All Road Users should be applied on all streets. Establishing safe speeds is a core strategy of the Safe System approach. Adjustments to speed limits need to be accompanied by changes to street geometry and operations to encourage the target speed as well as enforcement to reinforce the speed limit.

Automated Speed Enforcement/Dynamic Speed Feedback Sign can be used in locations most affected by speed-related crashes.

Variable Speed Limits should be used at locations where speed limits need to change by time of day, due to weather conditions, congestion, or an incident. Variable speed limit signs are most appropriate on freeways or interstates.

Pedestrians/Bicyclist

Pedestrian Walkways are necessary to provide a complete network for people walking and should be provided on at least one side of the street where pedestrians are legally allowed to travel. Walkways are most often sidewalks but can also be shoulders and shared use paths.

Crossing Improvements including pedestrian signals with countdown timers and push buttons at signalized intersections. All crossings must also meet PROWAG. High-visibility (hi-vis) crosswalks should be installed in urban settings, especially near schools, parks, and transit stops, as well as advanced warning signage and other pedestrian-related signage at crossings, particularly uncontrolled crossings. Prioritize crossing enhancements near schools, parks, and transit stops.

Pedestrian Hybrid Beacons (PHB)/ Rectangular Rapid Flashing Beacon (RRFB) should be installed where volumes, speeds, and geometry suggest the need for these traffic control devices. Generally, PHBs should be provided at crossings where speed limits are 40 mph or greater or ADT is greater than 15,000. RRFBs should generally be provided at crossings where speed limits are 35 mph or less with three or more lanes and ADT more than 9,000.

Adding Leading Pedestrian Intervals (LPIs) is a low-cost countermeasure that should be widely implemented to improve pedestrian safety. LPIs can first be prioritized at locations in urban areas with higher pedestrian traffic and where vulnerable populations (children, elderly) may be present. *See Countermeasure Details section of this appendix for additional details on this countermeasure.*

Relocating Bus Stop to Far Side is another low-cost countermeasure that should be considered at all locations. *See Countermeasure Details section of this appendix for additional details on this countermeasure.*

Relocate Bus Stop to Be at Intersection should be implemented so that pedestrian crossings are provided where bus stops are located. *See Countermeasure Details section of this appendix for additional details on this countermeasure.*

Intersections – General

Dedicated Left-Turn Lanes should be considered at intersections where left-turn movements account for at least 20% of entry volumes and on roadway segments with two-way left-turn lanes (medians can be installed in locations where left-turn movements do not exist or need to be restricted).

Roundabouts should be considered as an alternative to a traffic signal, especially in locations with safety concerns related to left-turning motorists. As a screening tool, intersections with combined average daily traffic (ADT) volume below 25,000 vehicles per day may be able to support a single-lane roundabout.

Access Management – Restricting Left Turns should be considered on roadway segments with two-way left-turn lanes and can be prioritize for segments with 20 or more access points per mile.

Intersections – Signals

All-Red Time Upgrades or Lengthening Clearance Intervals should be implemented based on an evaluation of traffic signal timing parameters for each intersection. This can be performed on an "intersection by intersection" basis, though performing this as part of a larger network-wide or area-wide optimization effort is highly preferred. This process requires the capability to access signal timing parameters from a central location for the efficient download and upload of data and the remote monitoring of operations. The adjustment of clearance intervals may result in wholesale changes to signal phase and coordination times, including cycle lengths.

Red Light Enforcement typically requires legislative and policy alignment to support implementation and can include a robust public and media engagement component. The implementation of red-light enforcement also potentially involves coordination with public safety agencies (i.e., police departments) and the fiscal management function within State, County, and local governments. Evaluate the feasibility of red-light enforcement at signalized intersections where safety improvements are needed. This countermeasure aligns closely with improvements to all-red and yellow times, given that these need to be in compliance with prescribed guidelines and best practices prior to red light compliance being enforced.

Protected Left Turn Signal Phasing should be supported by an intersection capacity analysis to determine the impact of eliminating a permissive left turn phase. Adequate turn bay storage and green time for the left turn must be provided to minimize the queuing of left turning vehicles into through lanes. While intersection capacity is a major consideration, the elimination of left turn crashes with oncoming vehicles and crossing pedestrians should also be weighted heavily.

Backplates with Retroreflective Borders should be retrofitted to existing signals and incorporated into designs for new signals wherever possible. For retrofits, backplates should typically be installed for mast arm configurations, as opposed to span configuration where the wind loading against backplates could lead to swinging signal heads. Weight impacts on existing mast arms should also be considered and evaluated. This countermeasure should be considered where there is or may be a frequent occurrence of nighttime crashes at signalized intersections.

Countermeasures Details

The descriptions below for countermeasures provided by the PSCi (and other resources) include considerations such as the identification of focal modes, implementation timeframe, relative cost, and implementation considerations are provided for each countermeasure. The focal modes are provided to help promote a balanced multimodal perspective in the planning and programming of improvements, helping ensure that a commensurate share of resources is allocated to safety improvements for all modes, particularly vulnerable users. The list below does not include all recommended countermeasures but provides information on some of the key countermeasures that were recommended based on the review of crash patterns and profiles.

Estimates of the implementation timeframe are also provided to support the concurrent pursuit and implementation of short, intermediate, and long-term improvements, particularly those that address similar safety concerns. Estimated timeframes of 0-6 months, 6-12 months, 1-3 years, and 3-5 years were provided based on engineering judgement and research related to the implementation process for each measure. These timeframes may be influenced by factors such as available funding, legislative support, and contracting and procurement processes. The estimated timeframe typically has a close relationship to the estimated cost, which is also provided to aid in planning and programming and can vary depending on the implementation scale. This approach includes planning level cost estimate ranges of 0$ to $20K, $20K to $100K, $100K-$500K, $500K to $1M, and $1M+. When available, a specific source was referenced when used to determine the planning level cost.

Lastly, a shortlist of implementation considerations is provided to also support the thought process and highlight factors that may influence the timeframe.

Speed Management

Automated Speed Enforcement

- ***Description:*** Targets speeding-related crashes by promoting compliance in high-risk areas, such as school zones or pedestrian-heavy corridors, significantly reducing the likelihood of severe crashes.
- ***Targeted Modes:*** Passenger vehicles, motorcycles, commercial vehicles.
- ***Implementation Timeframe:*** 🕐🕐🕐
- ***Relative Cost:*** $$ → $$$
- ***Implementation Considerations:*** Balance of fixed (overt) and mobile (covert) units, equitable enforcement, limits of efficacy, infrastructure needs, maintenance requirements, legal/policy support, and vendor procurement.

Dynamic Speed Feedback Sign

- ***Description:*** Reduces speed-related crashes by encouraging drivers to comply with speed limits, particularly on corridors with perceived high speeds.
- ***Targeted Modes:*** Motor vehicles, motorcycles, commercial vehicles.
- ***Implementation Timeframe:*** 🕐 *(Source: NHSTA)*
- ***Relative Cost:*** $ *(Source: NHSTA)*
- ***Implementation Considerations:*** Location selection, line of sight (radar, video detection, coordination with existing signage, power source, maintenance.

Reduce Posted Speed Limit

- ***Description:*** Mitigates severe crash risks by reducing vehicle speeds, allowing drivers more time to react, and decreasing impact forces during collisions.
- ***Targeted Modes:*** Passenger vehicles, motorcycles, commercial vehicles.
- ***Implementation Timeframe:*** Varies *(Source: NHSTA)*
- ***Relative Cost:*** $ *(Source: NHSTA)*
- ***Implementation Considerations:*** Supporting study, legal/policy support, context alignment.

Pedestrian/Bicyclist

Road Diet

- ***Description:*** Addresses crash profiles involving high-speed, multi-lane roadways by calming traffic and reducing conflict points. This measure significantly decreases rear-end and left-turn crashes, enhancing overall roadway safety.
- ***Targeted Modes:*** Motor vehicles, motorcycles, commercial vehicles pedestrians, cyclists.
- ***Implementation Timeframe:*** 🕐🕐 → 🕐🕐🕐
- ***Relative Cost:*** $$ → $$$ [assumes1 mile with no resurfacing] *(Source: FHWA)*
- ***Implementation Considerations:*** ADT ≤25,000, capacity, public engagement, design vehicle, transit impacts, bicycle accommodations, access management.

Bike Lanes

- ***Description:*** Significantly reduces conflicts between cyclists and motor vehicles, particularly in high-speed or high-volume corridors, promoting safer bicycle travel.
- ***Targeted Modes:*** Cyclists, micromobility.
- ***Implementation Timeframe:*** 🕐🕐 → 🕐🕐🕐
- ***Relative Cost:*** $$ [assumes1 mile] *(Source: Victoria Transport Policy Institute)*
- ***Implementation Considerations:*** ADA compliance, right-of-way, illumination, utilities.

Pedestrian Refuge Island

- ***Description:*** Reduces pedestrian fatalities by providing a safe midpoint at multi-lane crossings, particularly on wide roads with heavy traffic.
- ***Targeted Modes:*** Pedestrians, cyclists.
- ***Implementation Timeframe:*** 🕐 → 🕐🕐
- ***Relative Cost:*** $ → $$ *(Source: FHWA)*
- ***Implementation Considerations:*** ADA compliance, right-of-way, illumination, drainage.

Adding LPIs

- ***Description:*** Reduces conflicts between turning vehicles and pedestrians, significantly improving pedestrian safety at signalized intersections.
- ***Targeted Modes:*** Pedestrians, cyclists.

- ***Implementation Timeframe:*** 🕐
- ***Relative Cost:*** $ *(Source: FHWA)*
- ***Implementation Considerations:*** Aging populations, dense urban areas, high right turn volumes.

Sidewalk Improvements

- ***Description:*** Reduces pedestrian crashes caused by incomplete or missing sidewalks by providing safe connections in urban and suburban areas. Essential for ensuring safe pedestrian mobility.
- ***Targeted Modes:*** Pedestrians, cyclists.
- ***Implementation Timeframe:*** 🕐🕐 → 🕐🕐🕐
- ***Relative Cost:*** $$$ [assumes1 mile] *(Source: Victoria Transport Policy Institute)*
- ***Implementation Considerations:*** ADA compliance, right-of-way, illumination, utilities.

Pedestrian Hybrid Beacons

- ***Description:*** Effectively reduces mid-block pedestrian crashes by creating controlled crossing opportunities, particularly in high-traffic areas, improving safety for vulnerable road users.
- ***Targeted Modes:*** Pedestrians, cyclists.
- ***Implementation Timeframe:*** 🕐🕐
- ***Relative Cost:*** $$ *(Source: FHWA)*
- ***Implementation Considerations:*** Warrant study, signal design, ADA compliance, high-speed corridors, multilane approaches.

RRFB Exclude Interstates, Freeways or Expressways

- ***Description:*** Enhances pedestrian visibility and driver yielding behavior, addressing crashes at uncontrolled crossings and improving overall safety for pedestrians.
- ***Targeted Modes:*** Pedestrians, cyclists.
- ***Implementation Timeframe:*** 🕐 → 🕐🕐
- ***Relative Cost:*** $$ *(Source: FHWA)*
- ***Implementation Considerations:*** Warrant study, signal design, ADA compliance, high-speed corridors, multilane approaches.

Crossing Improvements (Hi-Visibility Crossings, ADA Ramps, Lighting, Daylighting/Curb Extensions)

- ***Description:*** Mitigates pedestrian crashes by improving visibility, accessibility, and reducing crossing distances, particularly at uncontrolled or multi-lane intersections. Critical for ensuring safer pedestrian movements in high-traffic areas.
- ***Targeted Modes:*** Pedestrians, cyclists.
- ***Implementation Timeframe:*** 🕐 → 🕐🕐
- ***Relative Cost:*** $ [for all measures] *(Source: PEDSAFE, FHWA)*
- ***Implementation Considerations:*** ADA compliance, presence of pedestrian signals, illumination, and maintenance.

Relocate Bus Stop to Far Side

- *Description:* Addresses turning-related crashes and improves traffic flow by minimizing bus-vehicle conflicts, enhancing safety at intersections.
- *Targeted Modes:* Pedestrians, transit.
- *Implementation Timeframe:* 🕐 → 🕐🕐
- *Relative Cost:* $ *(Source: TransitCenter)*
- *Implementation Considerations:* ADA compliance, transit agency coordination, public outreach, shelter vs. signage.

Intersections

Add All Red Time or Lengthening Clearance Intervals (Evaluate)

- *Description:* Addresses angle and rear-end crashes at signalized intersections caused by red-light running or inadequate clearance time, improving safety at intersections.
- *Targeted Modes:* Passenger vehicles, motorcycles, commercial vehicles.
- *Implementation Timeframe:* 🕐
- *Relative Cost:* $
- *Implementation Considerations:* Traffic signal timing impacts.

Increase Signal Phases Length to Allow for Longer Pedestrian Crossing Time (Evaluate)

- *Description:* Addresses pedestrian-vehicle conflicts by ensuring adequate time is available to meet fluctuations in pedestrian demand.
- *Targeted Modes:* Pedestrians, cyclists.
- *Implementation Timeframe:* 🕐
- *Relative Cost:* $
- *Implementation Considerations:* Traffic signal timing impacts.

Install Red-Light Enforcement

- *Description:* Targets speeding-related crashes by promoting compliance in high-risk areas, such as central business districts, school zones or pedestrian-heavy corridors, significantly reducing the likelihood of severe crashes.
- *Targeted Modes:* Passenger vehicles, motorcycles, commercial vehicles.
- *Implementation Timeframe:* 🕐🕐🕐
- *Relative Cost:* $$ → $$$
- *Implementation Considerations:* Installation constraints, equitable enforcement, limits of efficacy, infrastructure needs, maintenance requirements, legal/policy support, vendor procurement.

Protected or Permissive/Protected Left Turn Signal Phasing (Evaluate)

- *Description:* Providing a protected left turn phased to minimize conflicts with oncoming vehicular traffic and crossing pedestrians.
- *Targeted Modes:* Passenger vehicles, motorcycles, commercial vehicles.

- ***Implementation Timeframe:*** 🕐 → 🕐🕐
- ***Relative Cost:*** $ → $$ *(Source: FHWA)*
- ***Implementation Considerations:*** Traffic signal timing impacts, required replacement of existing signal heads.

Backplates with Retroreflective Borders

- ***Description:*** Addresses nighttime signalized intersection crashes by improving the visibility of the illuminated face of the signal using a controlled-contrast background.
- ***Targeted Modes:*** Passenger vehicles, motorcycles, commercial vehicles.
- ***Implementation Timeframe:*** 🕐 → 🕐🕐
- ***Relative Cost:*** $ *(Source: FHWA)*
- ***Implementation Considerations:*** Mast arm loads.

Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections

- ***Description:*** Involves implementing a package of multiple low-cost countermeasures, including enhanced signing and pavement markings throughout a network of stop-controlled intersections.
- ***Targeted Modes:*** Passenger vehicles, motorcycles, commercial vehicles.
- ***Implementation Timeframe:*** 🕐 → 🕐🕐
- ***Relative Cost:*** $ *(Source: FHWA)*
- ***Implementation Considerations:*** Availability of materials to perform network-wide implementation.

Crosscutting

Improved Street Lighting

- ***Description:*** Decreases nighttime crashes by addressing low-visibility conditions, especially for pedestrians and cyclists, ensuring safer travel during dark hours.
- ***Targeted Modes:*** Motor vehicles, motorcycles, commercial vehicles pedestrians, cyclists.
- ***Implementation Timeframe:*** 🕐🕐 → 🕐🕐🕐
- ***Relative Cost:*** $$ [furnish & install per streetlight] *(Source: FHWA)*
- ***Implementation Considerations:*** Right-of-way

High Friction Surface Treatment

- ***Description:*** Increases pavement friction during wet conditions and helps offset the confluence of high speeds and challenging roadway geometry.
- ***Targeted Modes:*** Passenger vehicles, motorcycles, commercial vehicles.
- ***Implementation Timeframe:*** 🕐
- ***Relative Cost:*** $$ *(Source: PennDOT)*
- ***Implementation Considerations:*** Horizontal curves, high volume intersection approaches, interchange ramps, bridges, specific interstate segments.