CITY OF POINT ARENA, CALIFORNIA

# Local Road Safety/Action Plan


September 2024
Final Report

PREPARED BY
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The preparation of this report (or plan) was programmed through the Mendocino Council of Governments' FY 2023/24 Transportation Planning Work Program and funded with State (Regional Planning Assistance) Discretionary Grant funds.

$89,707 is the dollar amount for the contract related to the preparation of this Final Report/Plan.

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# Executive Summary

The City of Point Arena's Local Road Safety/Action Plan (LRS/AP) is a comprehensive plan that creates a framework to systematically identify and analyze traffic safety related issues and recommend projects and countermeasures. The LRS/AP aims to reduce fatal and severe injury collisions through a prioritized list of improvements that can enhance safety on local roadways.

This update to the previous Local Roadway Safety Plan (LRSP) adopted in 2022 takes a proactive approach to addressing safety needs. It is viewed as a guidance document that can be a source of information and ideas. As indicated by this update, it is also be a living document, one that is routinely reviewed and updated by City staff and their safety partners to reflect evolving collision trends and community needs and priorities. With the LRS/AP as a guide, the City will be able and ready to apply for grant funds, such as the federal Highway Safety Improvement Program (HSIP) and Safe Streets and Roads for All (SS4A).

## Chapter 1 – Introduction

The Introduction presents the project, describes how this report is organized, summaries the vision and goals, and the study area for the LRS/AP.

## Chapter 2 – Safety Partners

This chapter covers Point Arena's collaborative approach to road safety, detailing the involvement of various city departments, local organizations, and agencies in developing and implementing the Local Road Safety/Action Plan. It highlights the engagement of diverse stakeholders through meetings and online platforms, as well as the city leadership's commitment to enhancing road safety through a multi-faceted approach. The chapter introduces Mendocino Council of Government (MCOG) Technical Advisory Committee (TAC) that will serve as the body to review and monitor the recommendations and Safety Project implementation and construction.

## Chapter 3 – Existing Planning Efforts

This chapter summarizes existing City and regional planning documents and projects that are relevant to the LRS/AP. It ensures that the recommendations of the LRS/AP are in line with existing goals, objectives, policies, or projects. This chapter summarized the following documents: Capital Improvement Program 2021-2025, City of Point Arena Streets and Roads; City of Point Arena FY 2022-2023 Budget (2022); Point Arena Community Action Plan (2010); City of Point Arena General Plan/Local Coastal Plan (1995); Mendocino County Regional Transportation Plan & Active Transportation Plan (2022); and Mendocino County Safe Routes to School Plan (2014).

## Chapter 4 – Collision Data Collection and Analysis

No collisions were reported in Point Arena from 2020-2022. Therefore, this chapter uses the previous collision data obtained for the five-year period from 2015 to 2019 from the California Highway Patrol's Statewide Integrated Traffic Records System (SWITRS) and the University of California at Berkeley SafeTREC's Transportation Injury Mapping Service (TIMS).

The collision analysis identified general trends of collisions in the City of Point Arena. There were a total of 10 collisions reported City-wide from 2015 to 2019. Out of these six collisions (60 percent) were property damage only (PDO) collisions, one collision (10 percent) led to complaint of pain injury and two collisions (20 percent) led to a visible injury. There was one KSI (fatal and severe injury) collision, one collision (10 percent) led to a severe injury, and there were no fatalities caused by a collision. For collisions, including those of all severity, 70 percent (seven collisions) occurred at intersections whereas 30 percent (30 collisions) occurred on roadway segments. One of the top priorities of the LRS/AP will be to address intersection safety at all intersections where collisions have historically occurred.

For all collisions, collisions were observed to occur at the edges of city limits (three of the four injury collisions), including along State Route/Highway 1 and Riverside Drive. This suggests that placing traffic calming gateways at the edges of town may be effective at reducing traffic collisions. A gateway is a geometric or physical landmark that indicates a change in environment from major road to a lower speed residential or commercial district. It sends a clear message to motorists that they have reached a specific place and must reduce speeds. Gateways may be a combination of street narrowing, medians, signs, arches over the roadway, roundabouts, or other identifiable feature. Strong visual effects are essential to gateway feature's effect on traffic collision reduction.

For all collisions, 70 percent of collisions occurred during the nighttime, including the only fatal or severe injury collision. Nighttime collisions have been observed at the intersection of Port Road and Bluff Top Road and along the r State Route/Highway 1/Main Street corridor. This may indicate that lighting at these locations should be evaluated to insure lumen levels are adequate. Many different factors can contribute to nighttime collisions, such as low lighting levels that can be targeted with countermeasure, but extraneous factors can also contribute to nighttime injury such as alcohol use, sleep and fatigue. Improvements such as installing new lighting, upgrading existing lighting to a higher lumen, installing larger signal heads, installing and upgrade signs with new fluorescent sheeting and installing pedestrian improvements with lighting elements such as RRFBs (rectangular rapid flashing beacons) and HAWKs can help make these locations safer for all road users.

For all collisions, 40 percent of collisions were hit object collisions, with most occurring at intersections. This calls for evaluating hit object collisions along the high injury network and throughout the City with similar characteristics. Hit object collisions can be mitigated by installing reflective signs, object markers, and keeping sightlines clear at intersections.

While the above analysis is based on a small amount of collisions, ten total collisions and four injury collisions, it should be noted that some of the trends identified in the City of Point Arena are similar to trends identified in Mendocino County as a whole, including hit object collisions which account for 53 percent of KSI collisions in Mendocino County, and DUI collisions, which account for 36 percent of KSI collisions in Mendocino County.

## Chapter 5 - Emphasis Areas

Emphasis areas are a focus of the LRS/AP that are identified through the various collision types and factors resulting in KSI collisions within the City of Point Arena. The five emphasis areas for Point Arena are:

- Nighttime Collisions
- Collisions close to the City Boundary
- Hit Object Collisions
- Unsafe Speed Collisions
- Young Adult (Party at Fault) Collisions

## Chapter 6 – Equity

The Equity chapter underscores Point Arena's commitment to advancing fair and equitable transportation safety improvements for all residents. The city faces disadvantages in terms of health vulnerability (83 percent) which surpasses the maximum allowable threshold of 65 percent. The analysis considers various factors including collision types, modes of transportation, violation categories and lighting conditions to provide a comprehensive overview of safety challenges in vulnerable communities.

## Chapter 7 – Countermeasure Identification

Engineering countermeasures were updated for each of the high-risk locations and for the emphasis areas identified in the 2022 LRSP. These were based off of approved countermeasures from the 2024 Caltrans Local Roadway Safety Manual (LRSM) used in HSIP grant calls for projects. The intention is to give the City potential countermeasures for each location that can be implemented either in future HSIP calls for projects, or using other funding sources, such as the City's Capital Improvement Program. Non-engineering countermeasures were also selected using the E's strategies, and are included with the emphasis areas.

## Chapter 8 – Safety Projects

A set of five safety projects were identified as part of the 2022 LRSP for high-risk intersections and roadway segments, using HSIP approved countermeasures. A benefit cost ratio analysis was conducted for each of these projects. These safety projects are:

- Project 1: Systemic Improvements at Unsignalized Intersections
- Project 2: Improvements at Unsignalized Intersections
- Project 3: Systemic Roadway Segment Improvements
- Project 4: Pedestrian and Other Roadway Segment Improvements
- Project 5: Pedestrian Set Aside

## Chapter 9 – Evaluation and Implementation

The LRS/AP is a guidance document that is recommended to be updated every two to five years in coordination with the safety partners. The LRS/AP document provides engineering, education, enforcement, and emergency medical service related countermeasures that can be implemented throughout the City to reduce KSI collisions. After implementing countermeasures, the performance measures for each emphasis area should be evaluated annually. The most important measure of success of the LRS/AP should be reducing fatal and severe injury collisions throughout the City. If the number of fatal and severe injury collisions does not decrease over time, then the emphasis areas and countermeasures should be re-evaluated.

# Safe Street and Roads for All (SS4A) Action Plan Components

SS4A defines nine action plan components that are integral to any safety action plan in order to satisfy SS4A grant requirements. Of these nine criteria, seven have to be met in order for SS4A grants to be submitted for funding. The table below describes SS4A Action Plan Components and the sections of the LRS/AP that satisfy the seven relevant components.

| Action Plan Component | Section |
|---|---|
| 1. Leadership Commitment and Goal Setting | N/A |
| 2. Planning Structure | Ch-2, Ch-9 |
| 3. Safety Analysis | Ch-4 |
| 4. Engagement and Collaboration | Ch-2 |
| 5. Equity Considerations | Ch-6 |
| 6. Policy and Process Changes | N/A |
| 7. Strategy and Project Selections | Ch-7, Ch-8 |
| 8. Progress and Transparency | Ch-9 and Mendocino Council of Governments (MCOG) website https://www.mendocinocog.org |
| 9. Action Plan Adoption Date | August 2024 |

# 1. Introduction

## What is a LRS/AP?

The LRS/AP is a localized data-driven traffic safety plan that provides opportunities to address unique highway safety needs and reduce the number of fatal and severe injury collisions. The LRS/AP creates a framework to systematically identify and analyze traffic safety-related issues, and recommend safety projects and countermeasures. The LRS/AP facilitates the development of local agency partnerships and collaboration, resulting in the development of a prioritized list of improvements that can qualify for HSIP funding.

The LRS/AP is a proactive approach to addressing safety needs and is viewed as a living document that can be constantly reviewed and revised to reflect evolving trends, and community needs and priorities.

## Vision and Goals of the LRS/AP

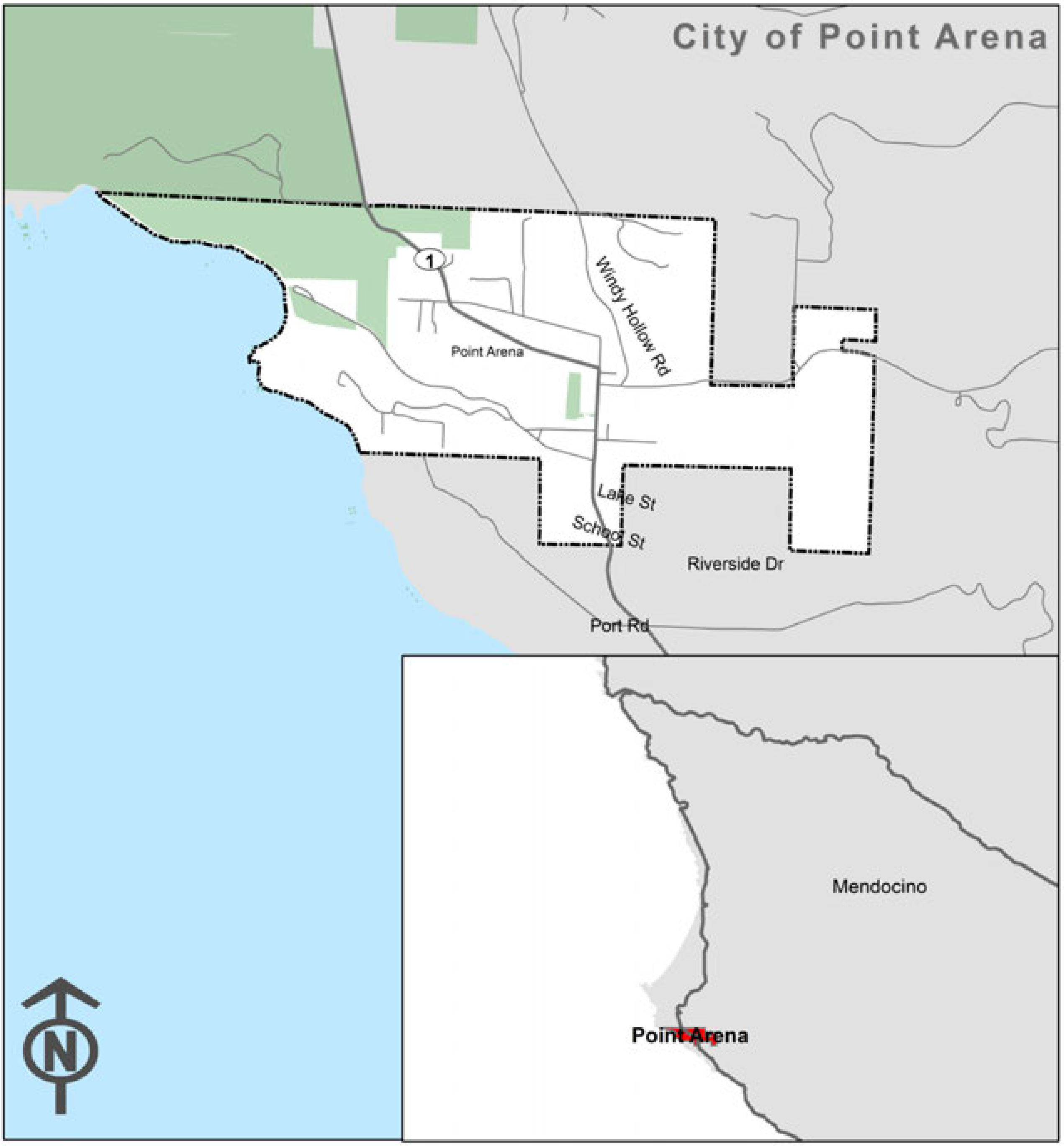
- Goal #1: Systematically identify and analyze roadway safety problems and recommend improvements
- Goal #2: Improve the safety of all road users by using proven effective countermeasures
- Goal #3: Ensure coordination and response of key stakeholders to implement roadway safety improvements within Point Arena
- Goal #4: Serve as a resource for staff who continually seek funding for safety improvements
- Goal #5: Recommend how safety improvements can be made in a manner that is fair and equitable for all Point Arena residents

## Study Area

The City of Point Arena is located in Mendocino County, California, covering a total area of about 1.36 square miles. It is located 32 miles west of Hopland, at an elevation of 118 feet.

The City's estimated population is 460 (2020 Census). State Route/Highway 1 is the major highway that connects the City of Point Arena to Fort Bragg to the North and also serves as the Main Street in the City. **Figure 1** shows the study area.

Figure 1 City of Point Arena



# 2. Safety Partners

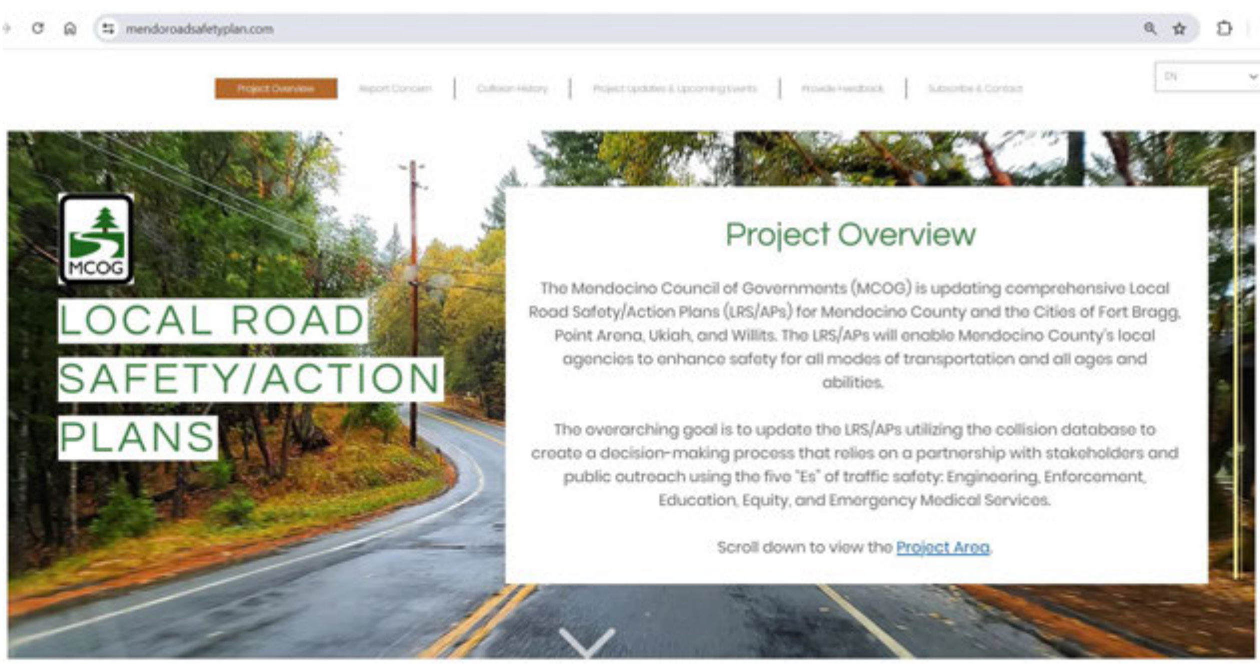
Safety partners are vital to the development and implementation of an LRS/AP. For the City of Point Arena, these include representatives from the City Manager's Office and Caltrans District 1. Three stakeholder meetings among these departments/agencies were conducted to review project goals and findings, and to solicit feedback from the group during the project timeline.

This stakeholder outreach was supplemented by a project website (mendoroadsafetyplan.com), with an interactive map input platform. As part of the project website, a public input platform called maptionnaire was published online and advertised on social media to solicit input public comments regarding traffic safety. The maptionnaire tool was open for public comments starting February 18, 2024 and closed on June 30, 2024.

No public comments were submitted for City of Point Arena during this period. **Figure 2** shows the landing page of the LRS/AP's project website.

In addition to the project website, five Public Workshops, three virtual and two in-person (in Fort Bragg and Ukiah), were held to introduce the project, present data information and recommendations, and provide a forum for comments and feedback.

**Figure 2. Project Website**



## Leadership Commitment to Road Safety

The City of Point Arena is deeply committed to enhancing road safety and significantly reducing traffic fatalities and severe injuries for all road users. Recognizing the vital importance of safe streets, the City has made it a top priority to create a safer transportation environment for residents and visitors alike.

This dedication to improving road safety is rooted in Point Arena's core values of prioritizing the well-being and quality of life for all community members, whether they drive, walk, bike, or use public transit.

To achieve these road safety goals, the City is implementing a multi-faceted, evidence-based approach that addresses the various factors contributing to traffic incidents. This strategy includes:

- Infrastructure improvements to enhance road design and safety features
- Public awareness campaigns to educate residents on safe road use practices
- Collaboration with local law enforcement to ensure traffic laws are effectively upheld

By adopting this comprehensive approach, the City is confident it can make substantial progress in reducing serious injuries and fatalities on City roadways.

The City's leadership team is fully committed to this safety initiative and have dedicated the necessary resources to drive meaningful change. Regular assessment of progress, analysis of traffic data, and engagement with community stakeholders will ensure Point Arena stays on course to meet its safety objectives.

## Technical Advisory Committee

The Technical Advisory Committee (TAC), a committee of Mendocino Council of Governments (MCOG), will serve as the body to review and monitor the recommendations and Safety Project implementation and construction. The TAC consists of nine (9) voting members or their authorized technical representatives, as follows: the County Director of Transportation, the County Director of Planning & Building Services, the Mendocino Transit Authority General Manager, the Caltrans Transportation Planning Branch Chief, one technical representative appointed by each of the four cities, and the County Air Pollution Control Officer. Additionally, one (1) non-voting member shall be a rail representative appointed by North Coast Railroad Authority. TAC meetings are typically once a month.

The nine (9) voting members or their authorized technical representatives of TAC consists as follows:

**Agency**

- City of Ukiah
- City of Willits
- City of Fort Bragg
- City of Point Arena
- Mendocino County Department of Transportation
- Mendocino County Planning & Building Services
- Mendocino Transit Authority
- Caltrans
- Air Quality Management District

The TAC will ensure a comprehensive and equitable approach to safety improvements by fostering interagency coordination and community engagement. Regular monitoring and evaluation of safety metrics will allow for adaptive management, enabling the team to adjust strategies as needed. In addition, Point Arena's staff will also be accountable for the progress made toward the plan goals.

# 3. Existing Planning Efforts

This chapter summarizes the planning documents, projects underway, and studies reviewed for the City of Point Arena's LRS/AP, being developed as a part of Mendocino Council of Governments LRS/AP's for Local Agencies. The purpose of this in-depth review is to ensure that the LRS/AP vision, goals, and the subsequent traffic safety strategies developed are aligned with prior planning efforts, planned transportation projects and non-infrastructure programs. This review includes both City and County level planning documents. The documents reviewed are listed below:

- Capital Improvement Program 2021-2025, City of Point Arena Streets and Roads
- City of Point Arena FY 2022-2023 Budget (2022)
- Point Arena Community Action Plan (2010)
- City of Point Arena General Plan/Local Coastal Plan (1995)
- Mendocino County Regional Transportation Plan & Active Transportation Plan (2022)
- Mendocino County Safe Routes to School Plan (2014)

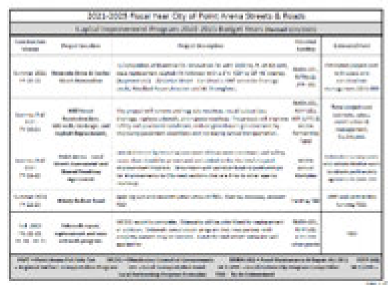
The following section includes a brief descriptions of these documents and how they inform the development of the LRS/AP. A document description summary is provided in **Table 1**. A list of relevant goals, projects, and policies from each document is summarized in **Appendix A**.

**Table 1. Document Review Summary**

| Document | Highlights |
|---|---|
| **City of Point Arena General Plan/Local Coastal Plan (1995)** | Traffic and circulation element of the General Plan details goals, policies and programs for the City's traffic, parking, street network, non-motorized transportation and public transportation infrastructure facilities. |
| **City of Point Arena FY 2022-2023 Budget (2022)** | Report on the City of Point Arena budget for FY 2022-2023. |
| **Point Arena Community Action Plan (2010)** | A community vision was developed, traffic circulation was analyzed, sustainable development scenarios were mapped, improvement strategies and funding sources were identified, and other issues were addressed. |
| **Capital Improvement Program 2021-2025, City of Point Arena Streets and Roads** | Lists the Streets and Roads improvement projects for fiscal years 2021-2025. |
| **Mendocino County Regional Transportation Plan & Active Transportation Plan (2022)** | Details all transportation mode's improvements on County significant corridors. |

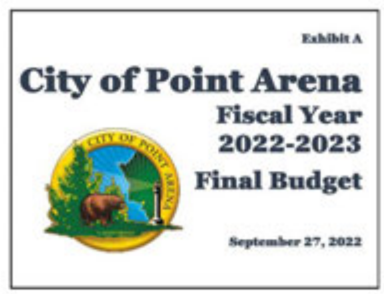
| Document | Highlights |
|---|---|
| **Mendocino County Safe Routes to School Plan (2014)** | Safe Routes to School (SRTS) is a program with a simple goal: helping more children get to school by walking and bicycling. |

### Capital Improvement Program 2021-2025, City of Point Arena Streets and Roads



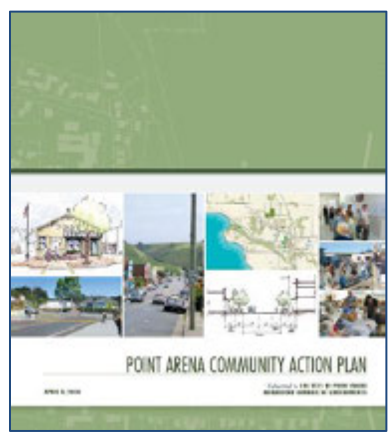
This document lists the proposed streets and roads projects under the Capital Improvement Program. One of the improvements underway entails sidewalk replacement or addition and that the sidewalk construction program that may partner with property owners might be needed. The list helps inform the LRS/AP of the planned and funded improvements helping ensure that no improvements are repeatedly recommended as a part of this plan.

### City of Point Arena FY 2022-2023 Budget (2022)



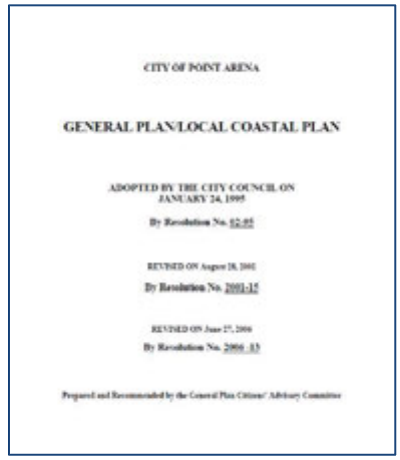

Point Arena's budget for 2022-2023 includes the street and road repair budget and also outlines funding the city has allocated to various departments and projects.

### Point Arena Community Action Plan (2010)




The Community Action Plan for the City of Point Arena identifies recommendations for a wide-range of transportation and circulation improvements, promotes the community character of the City, and helps visualize long-term and sustainable growth consistent with the City's General Plan and the community's vision. The Plan comprises of a Downtown Streetscape Plan, a Circulation and Parking Plan, recommendations for gateway, signage, and traffic calming elements.

### City of Point Arena General Plan/Local Coastal Plan (1995)


CITY OF POINT ARENA

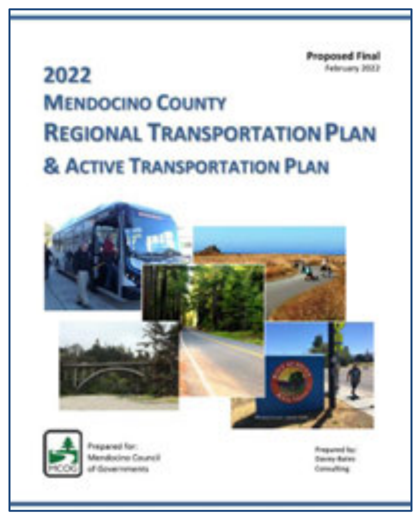
GENERAL PLAN/LOCAL COASTAL PLAN

ADOPTED BY THE CITY COUNCIL ON JANUARY 24, 1995

The Point Arena General Plan is a comprehensive, integrated, and internally consistent statement of Point Arena's environmental preservation, economic development, land use, public safety, housing, and development goals, policies, and programs. It is intended to address goals and needs for a period of approximately fifty years from the date of adoption. The plan was first adopted by the City Council in 1995 and was most recently amended in 2006. The traffic and circulation element of the General Plan entails topics associated with traffic, transportation, and Point Arena's street and pedestrian systems, and is of most relevance to the development of this roadway safety plan.

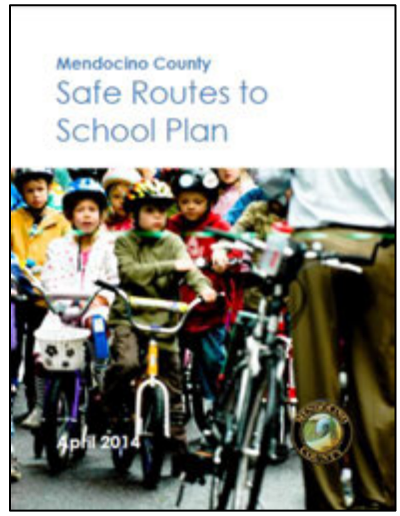
The goals of the plan are to maintain and enhance Point Arena's unique character, beautify downtown, reduce speeding along Main Street and alert drivers they are entering a city, improve the Main Street, Lake Street, school street intersection, improve downtown circulation and parking, create new open space and trails, improve access to existing open space and create new open space and trails and improve access to existing, improve the accessibility and safety of the downtown area, encourage sustainable development and provide more employment opportunities. The plan informs the LRS/AP of the existing conditions and specific circulation, streetscape and parking improvements that are recommended for future development.

### Mendocino County Regional Transportation Plan & Active Transportation Plan (2022)




This Plan identifies all transportation mode's improvements within all jurisdictions of Mendocino County, which include the Cities of Ukiah, Willits, Fort Bragg and Point Arena and the unincorporated areas Mendocino County. It lists the Riverside Drive & Center Street Renovation in the City of Point Arena, East End of Mill Street Reconstruction, Sidewalk, Drainage, and Asphalt Replacement and Citywide Sidewalk repair for Point Arena. It lists short range priority improvements for all mode of transportation. This list will help inform the LRS/AP of improvements that have been previously identified.

### Mendocino County Safe Routes to School Plan (2014)




Safe Routes to School (SRTS) is a program with a simple goal: helping more children get to school by walking and bicycling. The plan envision kids using safe streets, helped by engaged adults (from teachers to parents, engineers, planners and police officers), surrounded by responsible drivers. The plan is the first area-wide Safe Routes to School Plan in Mendocino County, designed to serve schools in the unincorporated areas of the county. The plan includes recommendations for a Safe Routes to School program that will strive to enhance children's health and well-being, ease traffic congestion near the school to improve safety, increase the number of students getting regular physical activity, improve air quality around schools and community members' overall quality of life, increase the number of students who walk and/or bike to and from school and provide clear projects and programs for implementation.

# 4. Collision Data Collection and Analysis

This chapter summarizes the results of a citywide collision analysis for collisions that occurred in the City of Point Arena between January 2020 and December 2022. A three-year city-wide collision data set was retrieved from TIMS and SWITRS.

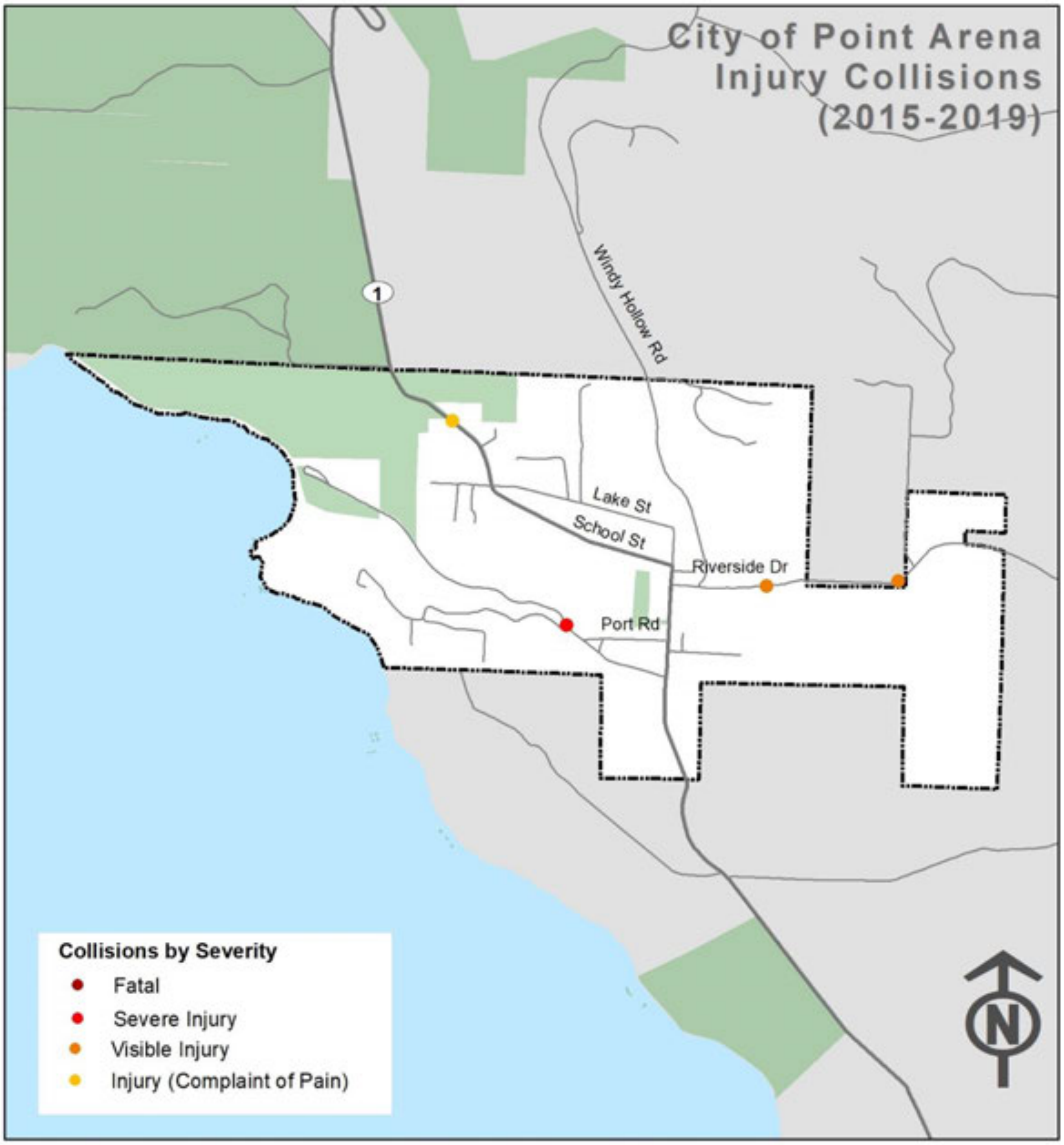
Since no collisions were reported during January 2020 to December 2022, the collision analysis in this chapter examines injury collisions that occurred between January 1, 2015 and December 31, 2019.

The LRS/AP focuses on systemically identifying and analyzing traffic safety issues to recommend appropriate safety strategies and improvements. This chapter starts with brief demographic analysis, followed by an analysis of citywide collisions of all severity, including PDO collisions, retrieved from TIMS and SWITRS. Following this, a comprehensive evaluation was conducted based on factors such as collision severity, type of collision, primary collision factor, lighting, weather and time of the day. A high-injury network of intersections and roadway segments was also identified. The following is a brief overview of the sections:

1. Demographic and Jurisdiction Characteristics
2. Data Collection
3. Collision Data Analysis
4. High Injury Network
5. Summary

**Figure 3** illustrates all the injury collisions that occurred in Point Arena from January 2015 to December 2019.

Figure 3. All Injury Collisions on City Roadways (2015 – 2019)



## Demographic and Jurisdiction Information

Demographic data has been collected from the Census in the City of Point Arena and Mendocino County, a summary of the population, centerline miles of roadway and commute to work characteristics are presented below.

### Population

According to the 2020 census data, the population of Point Arena is 460, which is 0.2 percent of the county population. The population proportion as well as the centerline miles are shown in **Table 2**.

**Table 2. Point Arena and Mendocino Population and Centerline Miles**

| Jurisdiction | Population | Percent of County Population | Centerline Miles | Percent of County Centerline Miles |
|---|---|---|---|---|
| **Point Arena** | **460** | **0.5%** | **2.3** | **0.2%** |
| Willits | 4,988 | 5.4% | 20.5 | 1.8% |
| Fort Bragg | 6,983 | 7.6% | 27.75 | 2.5% |
| Ukiah | 16,607 | 18.1% | 58.9 | 5.3% |
| Unincorporated | 62,563 | 68.3% | 1,009.9 | 90.2% |
| Total | 91,601 | | 1,119.35 | |

### Commute to Work

In the City of Point Arena, all of residents (100 percent) travel by cars or vans to work, out of which 91 percent drive alone and nine percent carpool. The different modes of transportation used to commute to work for the City are shown in **Table 3**.

**Table 3. Mendocino County Commute to Work Census Data**

| Commute to Work | Point Arena |
|---|---|
| Drive alone | 91% |
| Carpool | 9% |
| Public Transportation | 0% |

### Office of Traffic Safety (OTS) Rankings

Additional information on collisions in the City of Point Arena is provided by the California OTS. OTS is designated by the Governor to receive federal traffic safety funds for coordinating California's highway safety programs. OTS rankings from 2021, the latest available year, indicate that the City of Point Arena ranks in the top, meaning higher collisions rates in total collisions (seven out of 32 similarly sized cities), alcohol involved collisions (seven out of 32 similarly sized cities) and nighttime collisions (eight out of 32 similarly sized cities). These rankings take into account fatal and injury crashes per population and per VMT. As a result of Point Arena's small population, small amounts of collisions translates to high rankings, because these rankings are produced from a small sample size the results may not be statistically significant. **Table 4** provides a summary of the 2021 rankings[1].

**Table 4. Office of Traffic Safety Ratings 2021**

| OTS 2021 Ranking | Point Arena |
|---|---|
| Total Fatality and Injury | 7/32 |
| Alcohol Involved | 7/32 |
| Pedestrian | 7/32 |
| Bicycle | 7/32 |
| Speed Related | 11/32 |
| Nighttime | 8/32 |

[1] California Office of Traffic Safety. (2021). Office of Traffic Safety Rankings 2021. https://www.ots.ca.gov/media-and-research/crash-rankings-results/?wpv_view_count=1327&wpv-wpcf-year=2021&wpv-wpcf-city_county=Point+Arena&wpv_filter_submit=Submit

## Data Collection

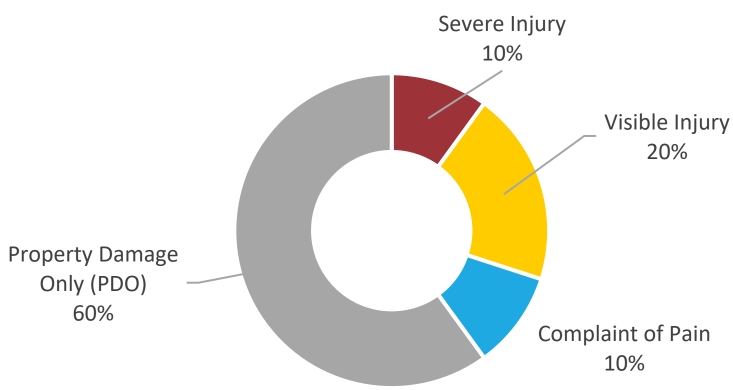
Collision data helps understand different factors that might be influencing collision patterns and various factors leading to collisions in a given area. For the purpose of this analysis, a five-year jurisdiction-wide collision data, from 2015 to 2019 was retrieved from TIMS[2] and SWITRS[3]. State route roadways were included in this analysis. The collision data was analyzed and plotted in ArcMap to identify high-risk intersections and roadways segments.

## Collision Data Analysis

### Collision Severity

There were a total of 10 collisions reported City-wide from 2015 to 2019. Out of these six collisions (60 percent) were PDO collisions, one collision (10 percent) led to complaint of pain injury and two collisions (20 percent) led to a visible injury. There was one KSI (fatal and severe injury) collision, one collision (10 percent) led to a severe injury and no fatal collisions. **Figure 4** illustrates the classification of all collisions based on severity.

**Figure 4. Collisions by Severity (2015-2019)**




[2] UC Berkeley Safe TREC. (2021). Transportation Injury Mapping System https://tims.berkeley.edu/
[3] California Highway Patrol. (2021). Statewide Integrated Traffic Records System. https://www.chp.ca.gov/programs-services/services-information/switrs-internet-statewide-integrated-traffic-records-system

The analysis first includes a comparative evaluation between all collisions and KSI collisions, based on various factors including but on limited to the collision trend, primary collision factor, collision type, facility type, motor vehicle involved with, weather, lighting, and time of the day. The collision data was segregated by facility type, i.e. based on collisions occurring on intersections and roadway segments. For the purposes of the analysis, a collision was said to have occurred at an intersection if it occurred within 250 feet of it. The reported collisions categorized by facility type and collision severity are presented in **Table 5**.

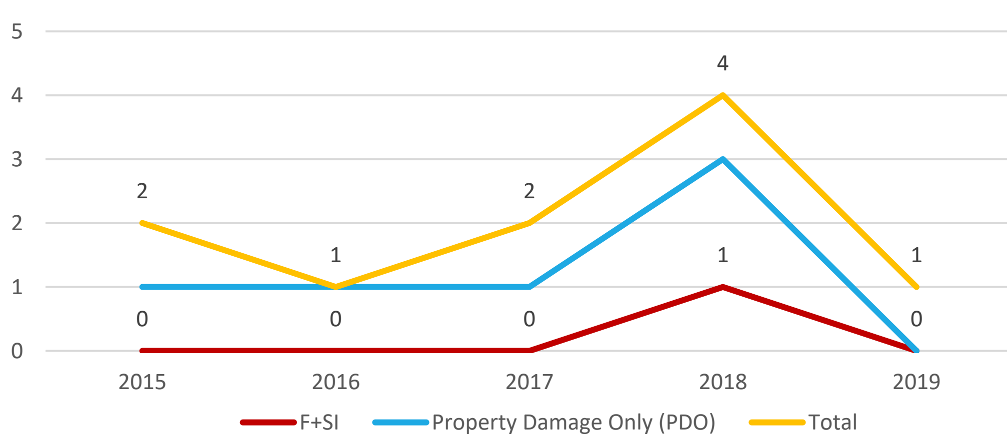
**Table 5. Collisions by Severity and Facility Type (2015-2019)**

| Collision Severity | Roadway Segment | Intersection | Total |
|---|---|---|---|
| Fatal | 0 | 0 | 0 |
| Severe Injury | 0 | 1 | 1 |
| Visible Injury | 2 | 0 | 2 |
| Complaint of Pain | 1 | 0 | 1 |
| Property Damage Only (PDO) | 0 | 6 | 6 |
| **Total** | **3** | **7** | **10** |

### Collision Severity by Year

For all collisions, the number increased from 2015 to 2018. The highest number of collisions (four collisions) were observed in 2018 and the lowest number of collisions (one) were observed in 2016 and 2019. A total of one KSI collisions occurred in the City of Point Arena during the study period in 2018. **Figure 5** illustrates the five-year collision trend for all collisions, KSI collisions and also PDO collisions.

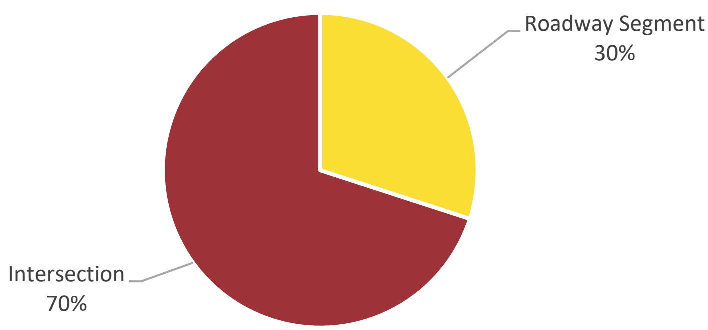
**Figure 5. Five Year Collision Trend**



### Intersection vs. Roadway Collisions

When evaluating roadways vs intersections, it was observed that the majority of collisions occurred at intersections. In the City of Point Arena, 70 percent of all collisions (seven collisions) occurred at intersections whereas 30 percent (three collisions) occurred on roadway segments. This classification by facility type can be observed in **Figure 6**.

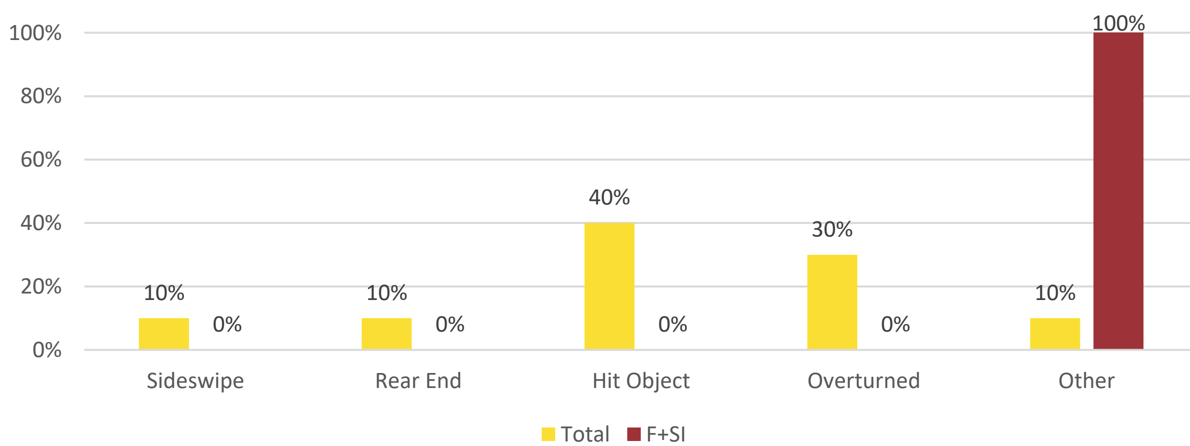
Figure 6. Intersection vs. Roadway Collisions - All Collisions




### Collision Type

Considering all collision the most commonly occurring collision type was hit object collisions (40 percent) and overturned collisions (30 percent). The only KSI collisions as type other. **Figure 7** illustrates the collision type for all collisions as well as KSI collisions.

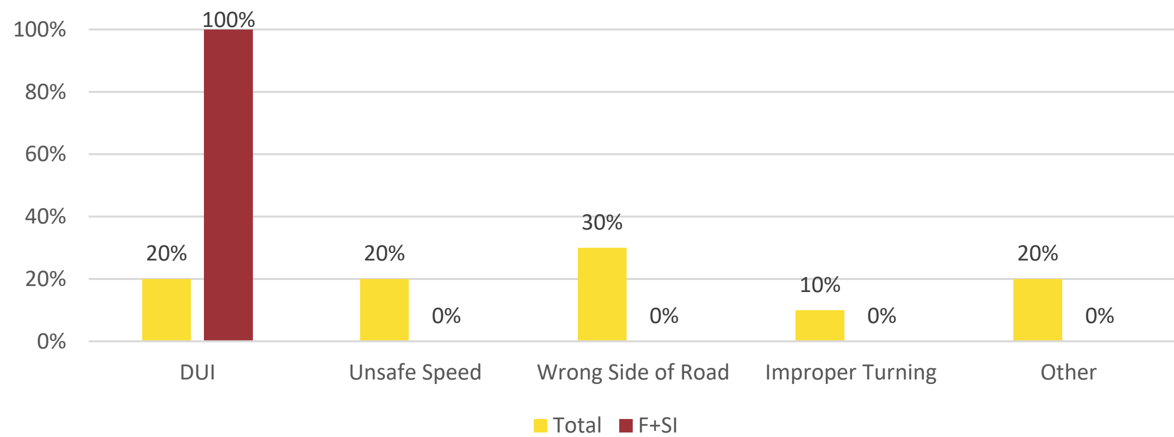
Figure 7. Collision Type – All Collisions vs. KSI Collisions



## Violation Category

Considering all collisions, the most common violation category was observed to be wrong side of road (30 percent), driving under the influence (20 percent) and unsafe speed (20 percent). The only KSI collisions was a driving under the influence collision. **Figure 8** illustrates the violation category for all collisions and KSI collisions.

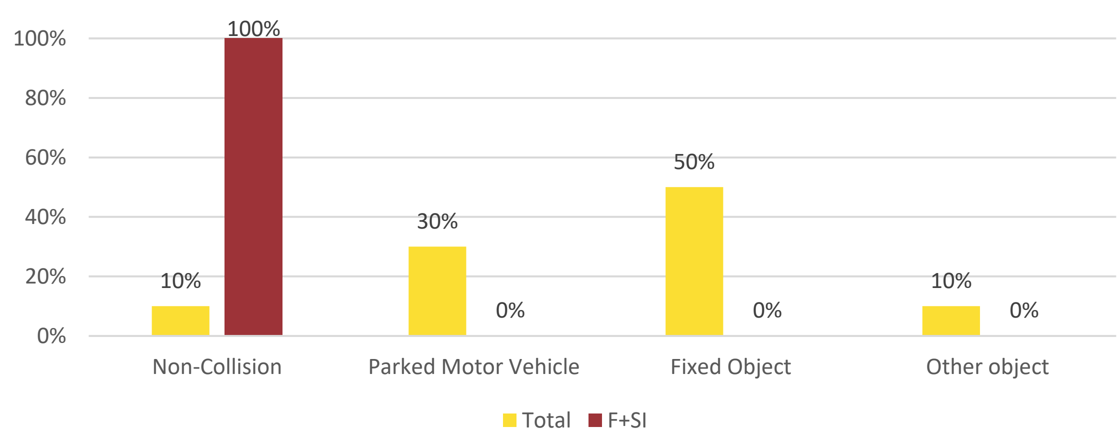
### Figure 8. Violation Category: All Collisions vs. KSI Collisions




## Motor Vehicle Involved With

Considering all collisions, 50 percent of the collisions are motor vehicle involved with fixed objects and 30 percent were motor vehicle involved with parked vehicles. The only KSI collisions was categorized as a non-collision. **Figure 9** illustrates the percentage for all collisions as well as KSI collisions.

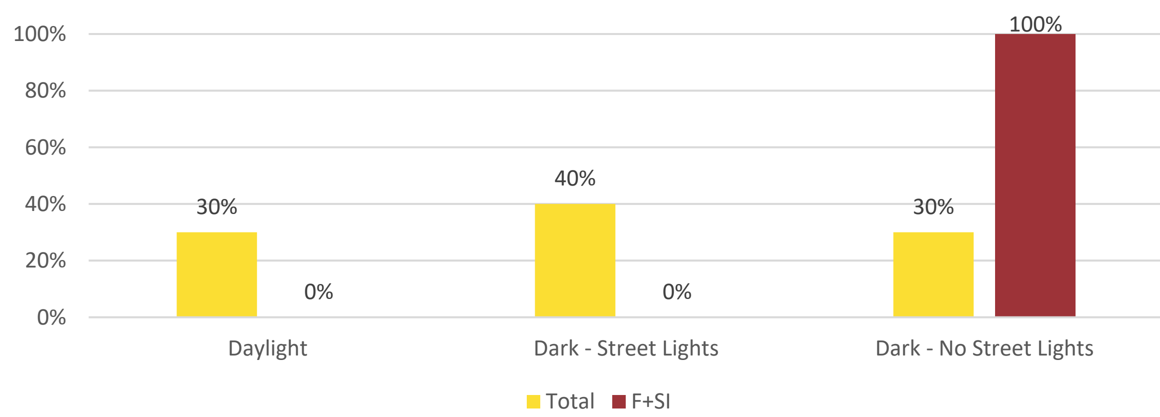
### Figure 9. Motor Vehicle Involved With: All Collisions vs. KSI Collisions



## Lighting

For collisions of all severity, 70 percent of collisions have occurred in dark, including 30 percent that occurred on streets with no streetlights. The only KSI collision occurred in the dark with no streetlights. **Figure 10** illustrates the lighting condition for all collisions and KSI collisions.

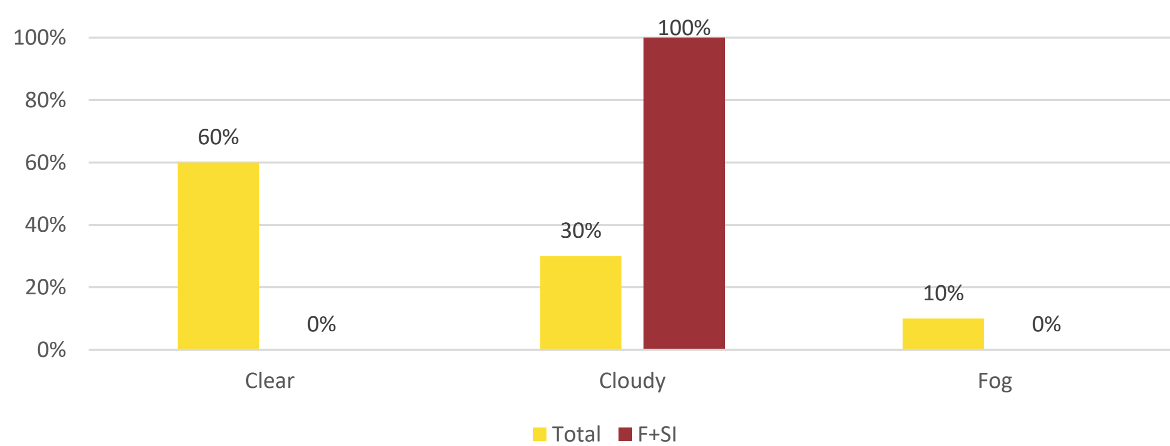
Figure 10. Lighting Conditions: All Collisions vs. KSI Collisions




## Weather

For collisions of all severity, 60 percent of the collisions have occurred during clear weather conditions, 30 percent collisions have observed to occur during cloudy weather conditions and 10 percent occurred during foggy conditions. The only KSI collision occurred during cloudy weather conditions. **Figure 11** illustrates the percentage distribution of weather conditions during occurrence of collisions of all severity as well as KSI collisions.

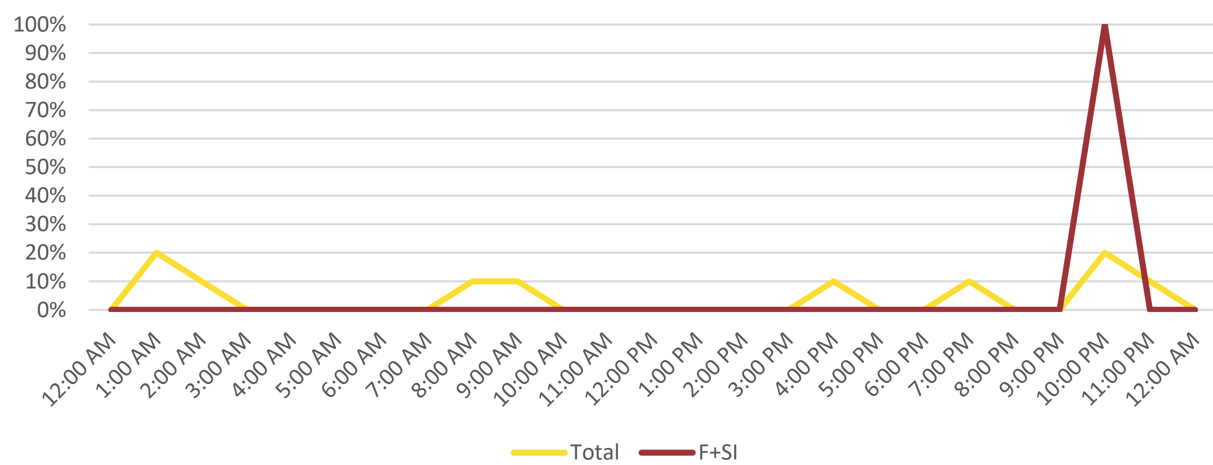
Figure 11. Weather Conditions: All Collisions vs. KSI Collisions



## Time of the Day

For collisions of all severity, the maximum number of collisions have occurred between 10:00 PM to 11:00 PM (20 percent) and 1:00 AM to 2:00 AM. The only KSI collision occurred between 10:00 PM and11:00 PM. **Figure 12** illustrates the percentage of collisions occurring during the day for all collisions as well as KSI collisions.

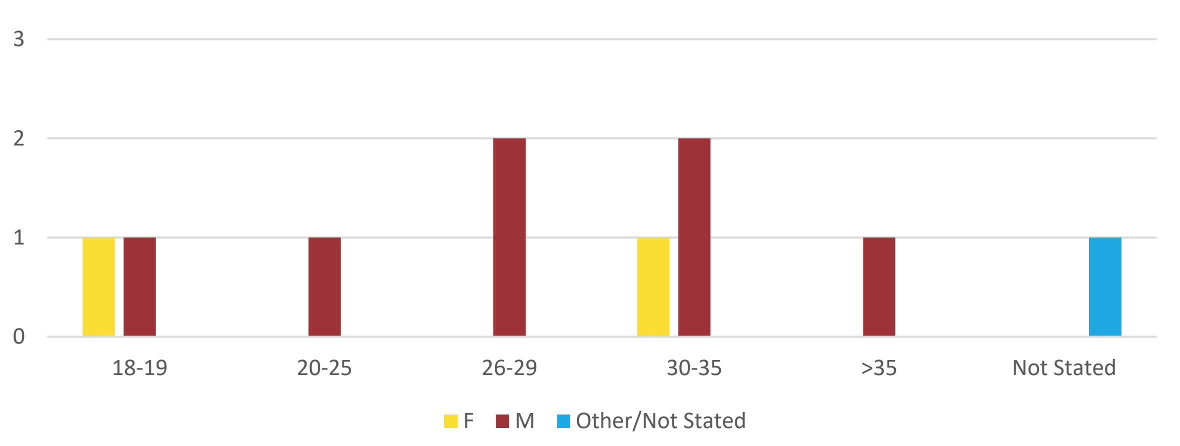
**Figure 12. Time of the Day: All Collisions vs. KSI Collisions**




## Gender vs. Age

For all collisions, the sex of the party at fault was much more likely to be male than female (70 percent of KSI collisions vs 20 percent). The party at fault for collisions are also more likely to be younger, with the majority age 35 or lower (80 percent. The only KSI collision. **Figure 13** illustrates the sex and age of the party at fault for all collisions.

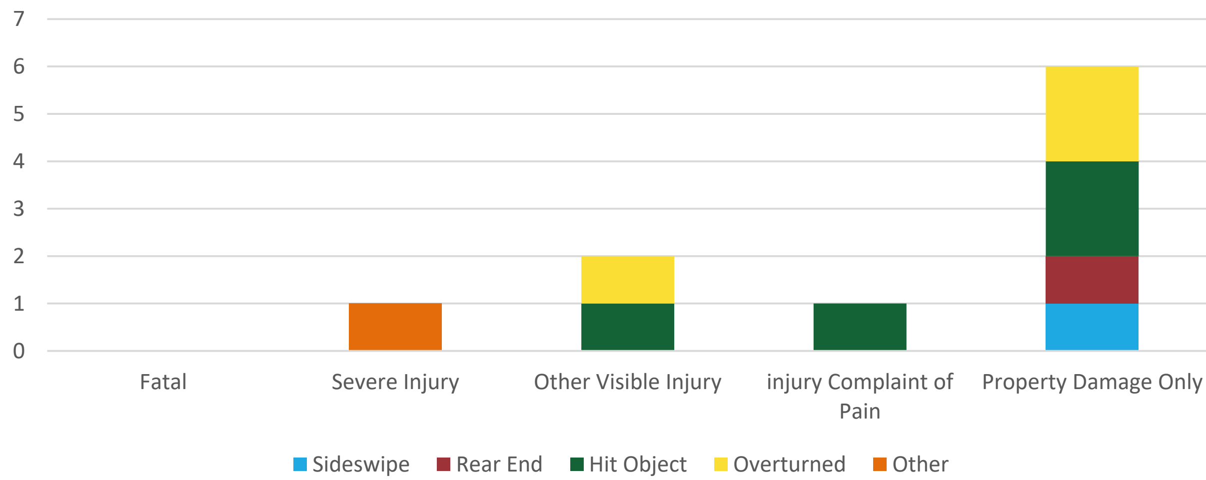
**Figure 13. All Collisions: Age vs Sex**



## Collision Type and Severity

For all collisions, the most common collision types were hit object collisions and overturned collisions. **Figure 14** below shows the severity of collisions as well as the collision types.

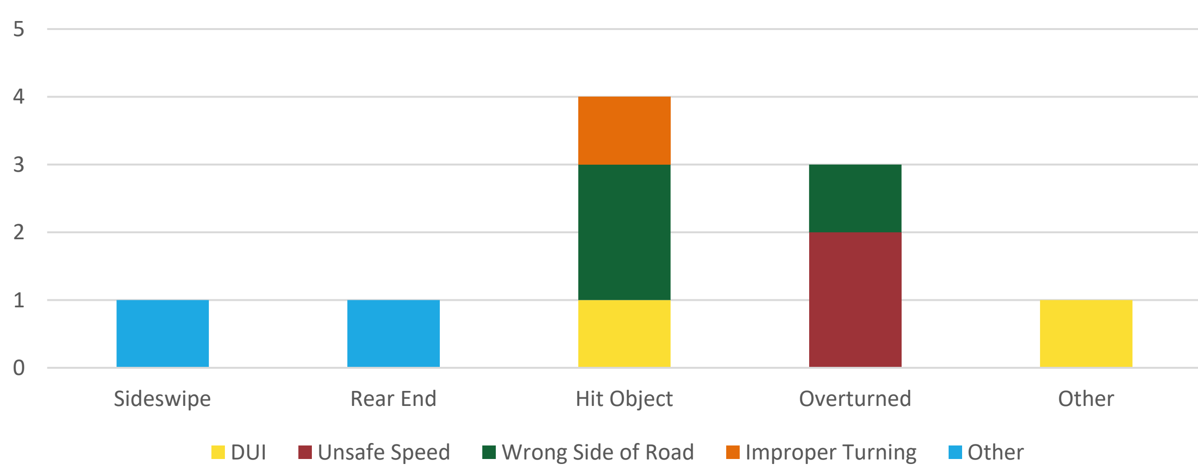
**Figure 14. All Collisions: Collision Type vs Severity (2015-2019)**




## Collision Type and Violation Category

For all collisions, the most common violation type was hit object and overturned collisions. Hit object collisions were caused by DUI, improper turning, and wrong side of road driving, while overturned collisions resulted from unsafe speed and wrong side of road driving. **Figure 15** illustrates the type of collision as well as the violation category for all collision severities.

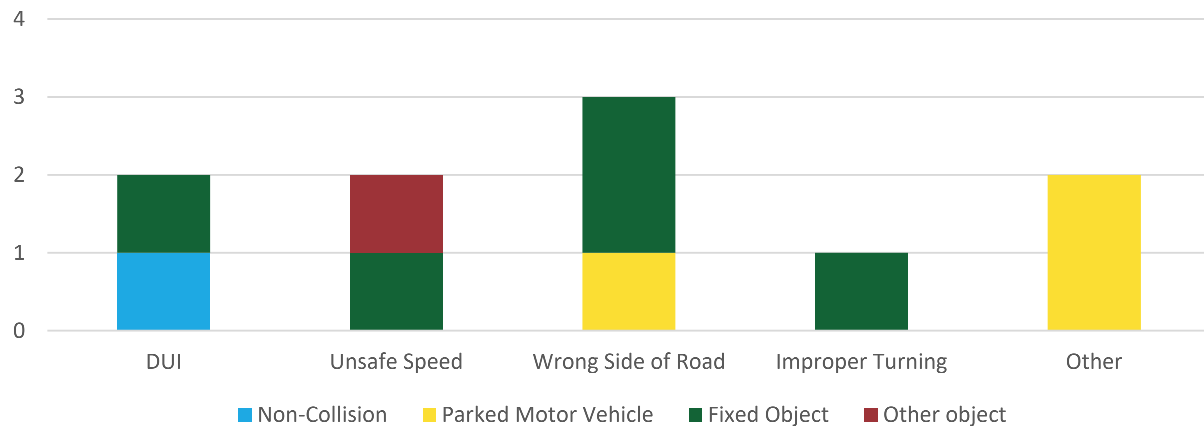
**Figure 15. All Collisions: Collision Type vs Violation Category (2015-2019)**



### Motor Vehicle Involved with and Violation Category

For all collisions, the violation category of collisions that led to the highest amount of collisions was DUI collisions and unsafe speed collisions. The results, with violation category and motor vehicle involved with, are shown in **Figure 16.**

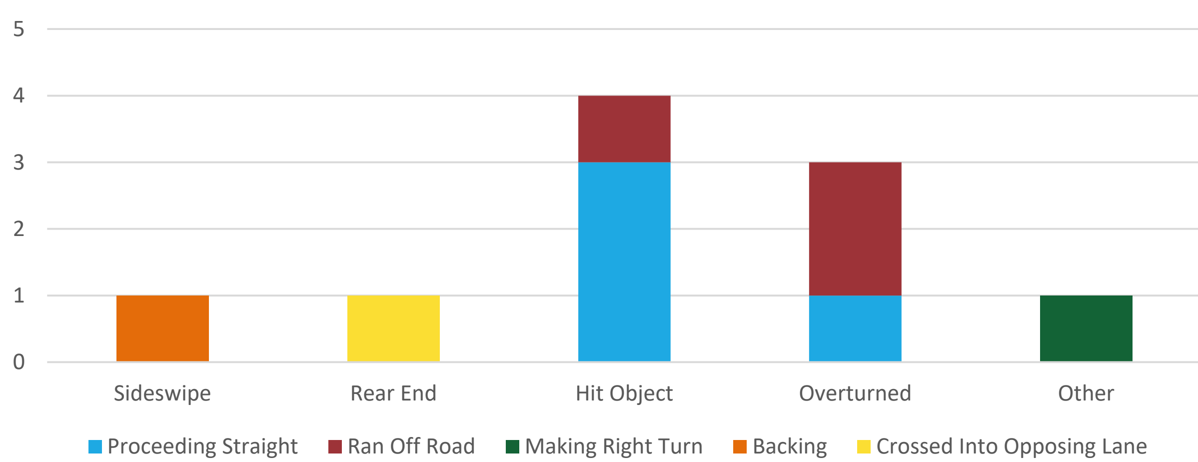
Figure 16. All Collisions: Motor Vehicle Involved with vs Violation Category




### Collision Type vs. Movement Preceding Collision of Party at Fault

For all collisions, the most common collision type was hit object collisions. The most common movement of the party at fault proceeding hit object collisions is proceeding straight or ran off road. **Figure 17** illustrates the type of collisions as well as the movement of the party at fault preceding the collision for all collision severities.

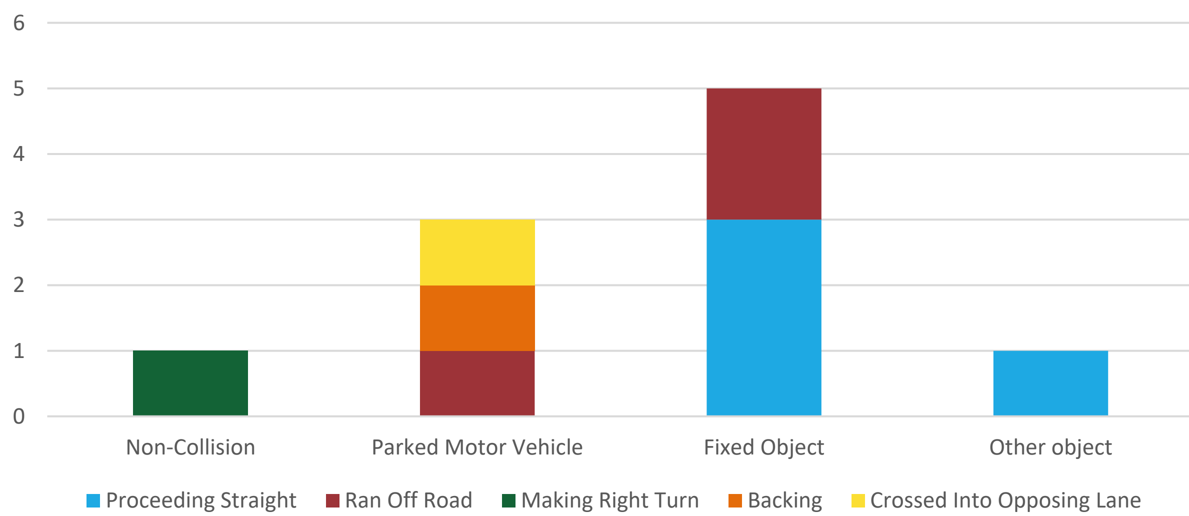
Figure 17. All Collisions: Collision Type vs. Movement Preceding Collisions of Party at Fault



### Motor Vehicle Involved with vs. Movement Preceding Collision

For all collisions, 50 percent of the collisions are with fixed object and 100 percent of these collisions the party at fault was proceeding straight or ran off road. **Figure 18** illustrates the movement of the party at fault preceding the collision along with the type of object the motor vehicle was involved with for all collisions.

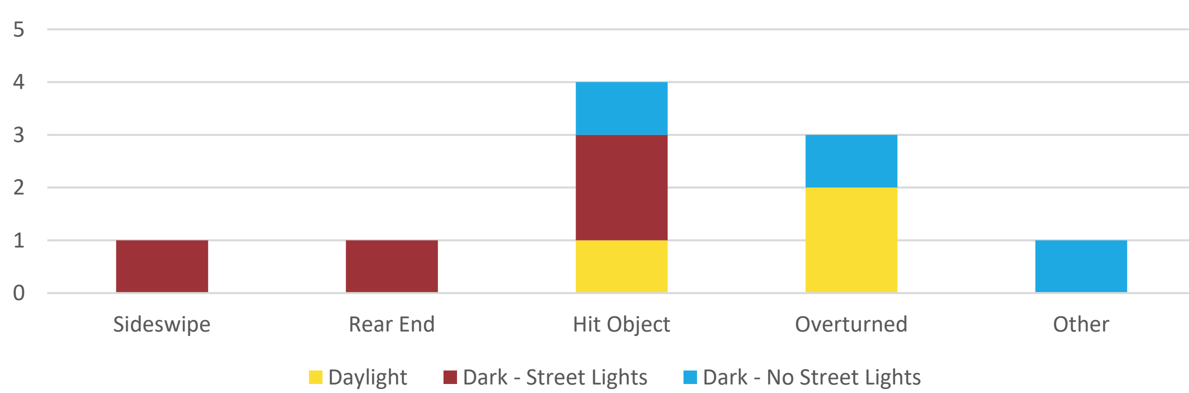
**Figure 18. All Collisions: Motor Vehicle Involved With vs. Movement Preceding Collisions**




### Collision Type and Lighting Conditions

For all KSI collisions, most collisions occurred in the daylight at an intersection. Hit-object collisions were the highest number of collisions that occurred in the dark. **Figure 19** illustrates the lighting condition and the collision type as observed for all collisions.

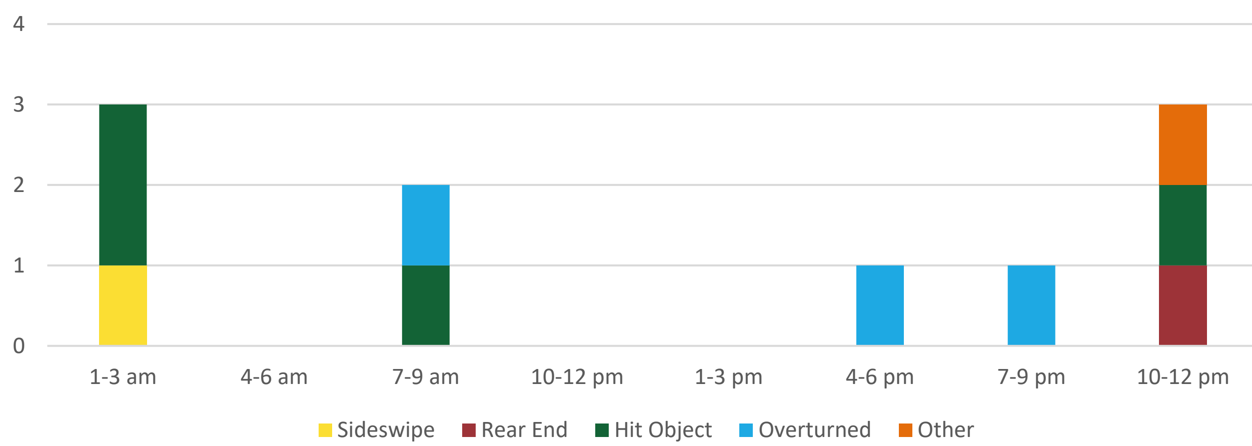
**Figure 19. KSI Collisions: Collision Type vs Lighting Conditions**



## Collision Type and Time of the Day

For all collisions types, the most common collision type was hit object and overturned. Hit object collisions have been observed to occur after 10:00 PM and before 3:00 AM. **Figure 20** illustrates the collision type by the time of the day for all collisions.

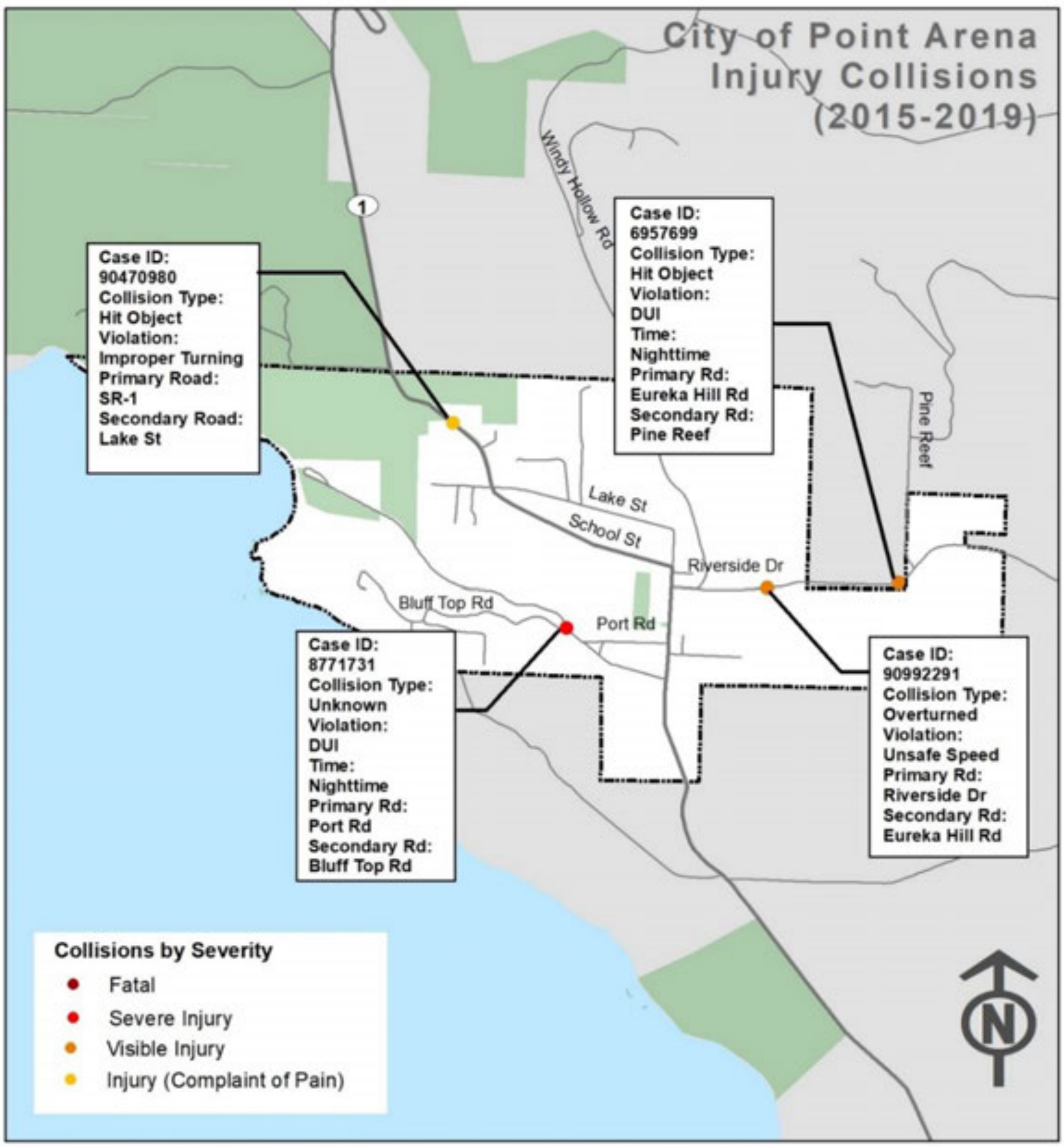
Figure 19. All Collisions: Collisions Type vs Time of the Day



## Collision Locations and Trends

The above collision analysis was used to identify three main collision factors that highlight the top trends among collisions in Point Arena. These three collision factors were identified to be hit object collisions, DUI collisions, and nighttime collisions. **Figure 21** shows the location, collision type, violation type and severity for injury collisions in Point Arena.

**Figure 20. Injury Collisions by Type and Violation Category**



## Collision Severity Weight

A collision severity weight was used to identify the high severity collision network, using the Equivalent Property Damage Only (EPDO) method. The EPDO method accounts for both the severity and frequency of collisions by converting each collision to an equivalent number of PDO collisions. The EPDO method assigns a crash cost and score to each collision according to the severity of the crash weighted by the comprehensive crash cost. These EPDO scores are calculated using a simplified version of the comprehensive crash costs per HSIP Cycle 11 application. The weights used in the analysis are shown below in **Table 6**.

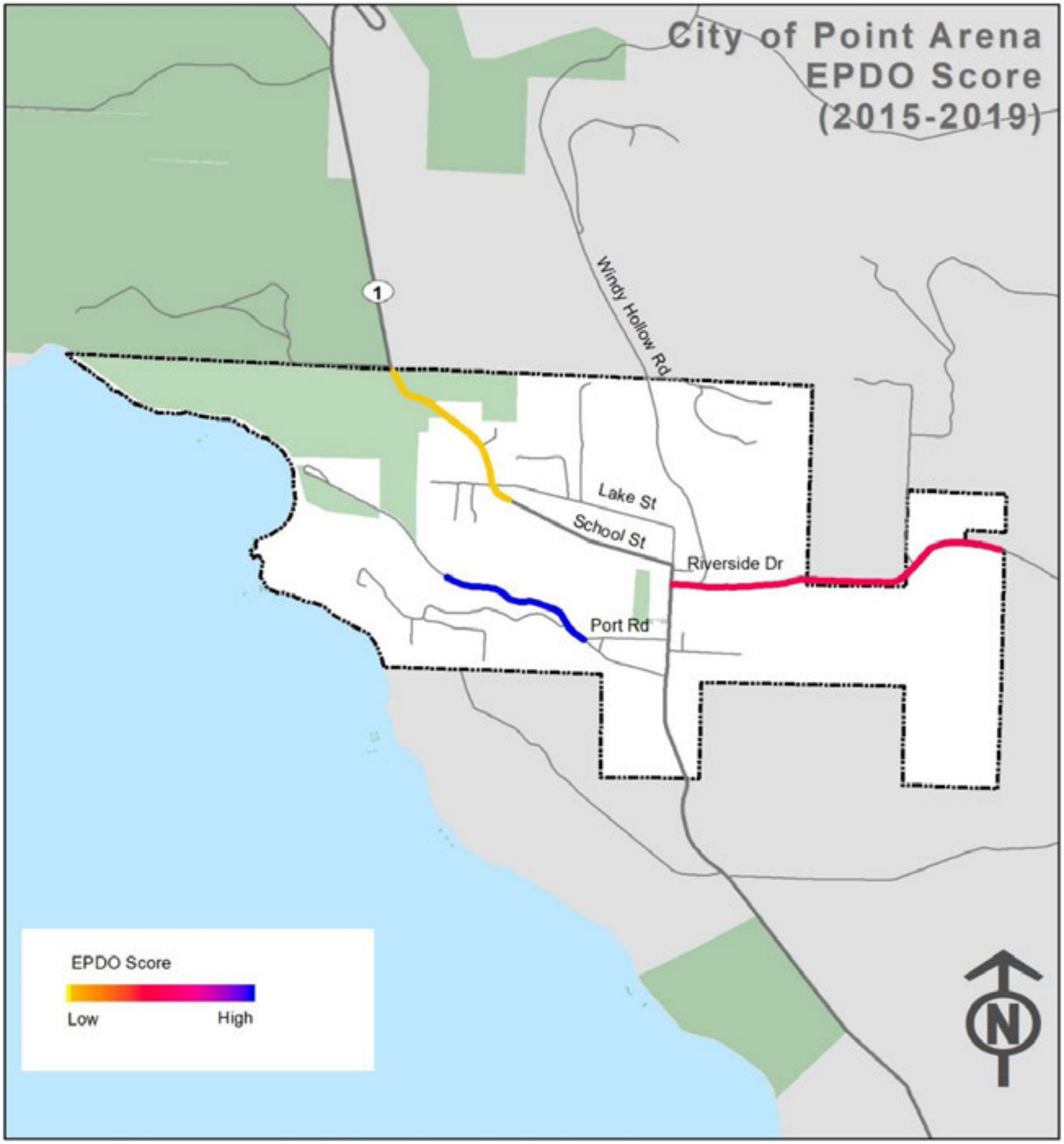
**Table 6. EPDO Score used in HSIP Cycle 11**

| Collision Severity | EPDO Score |
|---|---|
| Fatal and Severe Injury Combined | 165* |
| Visible Injury | 11 |
| Possible Injury | 6 |
| PDO | 1 |

*This is the score used in HSIP Cycle 11 for collisions on roadways segments, to simplify the analysis this study uses the same score for all KSI collisions regardless of location

The EPDO scores for all collisions can then be aggregated in a variety of ways to identify collision patterns, such as location hot-spots. The weighted collisions for the City of Point Arena were geolocated onto Point Arena's road network. **Figure 22** shows the location and geographic concentration of collisions by their EPDO score.

Figure 21. Point Arena EPDO Score



## High-Injury Locations

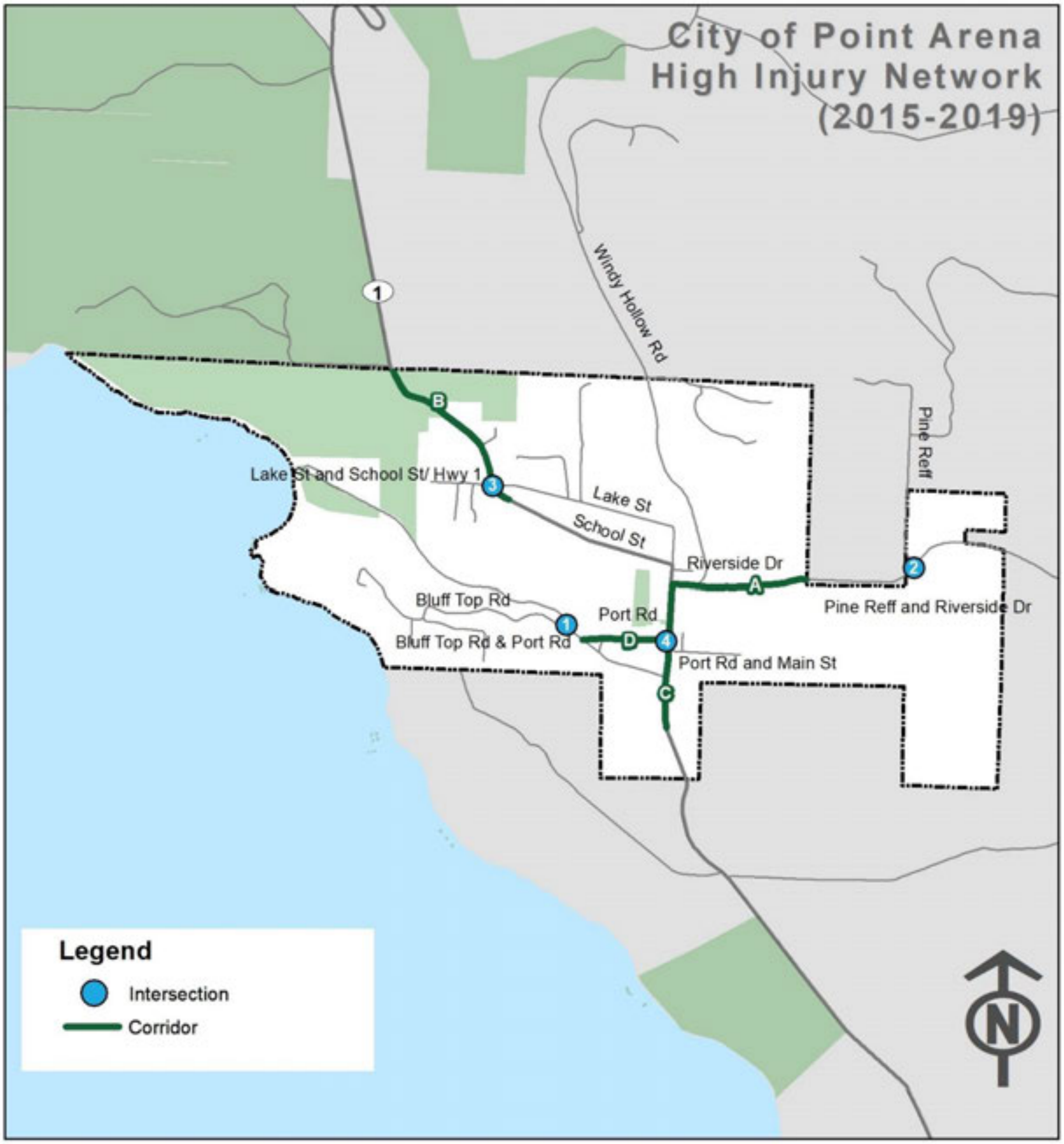
Following the detailed collision analysis, the next step was to identify the high-risk roadway segments and intersections in Point Arena. The methodology for scoring the high injury locations is the same method used in the severity weight section.

Due to the absence of collisions during 2020-2022, historical collision data spanning 2015-2019 was utilized to determine the high injury network that was part of the 2022 LRSP.

**Figure 23** shows the top four high-collision roadway segments, and top four high-collision intersections. This high collision network has a total of four injury collisions and one KSI collisions, which represents 100 percent of injury collisions and 100 percent of KSI collisions in Point Arena.

For the purposes of the high collision network analysis, intersections include collisions that occurred within 250 feet of it and roadways include all collisions that occurred along the roadway except for collisions that occurred occur directly at an intersection, or collisions that have occurred at the distance of zero feet from the intersection as per the SWITRS.

Figure 22. City of Point Arena High Injury Network



### High Injury Intersections (2015-2019)

Four intersections were identified as high injury intersections. There were a total of one KSI collisions that occurred at these intersections. The intersection of Port Road and Bluff Top Road has the highest EPDO score. Intersections without injury collisions were chosen based on PDO collisions.

**Table 7** lists the collision rate of the top four identified high-collision intersections along with their collision total and the number of KSI collisions.

**Table 7. High Injury Intersections (2015-2019)**

| ID | Intersection | Total | KSI | Hit Object | DUI | Nighttime | EPDO Score |
|---|---|---|---|---|---|---|---|
| | | Collisions | | | | | |
| 1 | Port Road and Bluff Top Road | 1 | 1 | 0 | 1 | 1 | 165 |
| 2 | Pine Reef and Riverside Drive | 1 | 0 | 0 | 1 | 1 | 11 |
| 3 | Lake Street and School Street/Highway 1 (intersections without injury collisions were chosen based on property damage only collisions) | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | Port Road and Main Street (intersections without injury collisions were chosen based on property damage only collisions) | 0 | 0 | 0 | 0 | 0 | 0 |

## High Injury Corridors (2015-2019)

Four corridors were identified as high injury corridors. There was a total zero KSI collisions on these corridors. The corridor with the highest EPDO score is Riverside Drive. Corridors without injury collisions were chosen based on PDO collisions.

**Table 8** lists the collision rate of the top four identified high-collision corridors along with the number of KSI collisions and total collisions.

Table 8. High Injury Corridors (2015-2019)

| ID | Corridors | Total | KSI | Hit Object | DUI | Night -time | Length (miles) | EPDO Score |
|---|---|---|---|---|---|---|---|---|
| | | Collisions | | | | | | |
| A | Riverside Drive: Main Street/Highway 1 to Pine Reef | 2 | 0 | 0 | 1 | 1 | 1.1 | 22 |
| B | School Street/Highway 1: Northern City Limits to Lake Street | 1 | 0 | 0 | 1 | 1 | 0.6 | 6 |
| C | Main Street/Highway 1: Riverside Drive to Southern City Limits (corridors without injury collisions were chosen based on property damage only collisions) | 0 | 0 | 0 | 0 | 0 | 0.3 | 0 |
| D | Port Road: Iverson Avenue to Main Street/Highway 1 (corridors without injury collisions were chosen based on property damage only collisions) | 0 | 0 | 0 | 0 | 0 | 0.7 | 0 |

# 5. Emphasis Areas

Emphasis areas are focus areas for the LRS/AP that are identified through the comprehensive collision analysis of the identified high injury network within the City of Point Arena. Emphasis areas help in identifying appropriate safety strategies and countermeasures with the greatest potential to reduce collisions occurring at these high-risk locations.

This chapter outlines the five primary emphasis areas for the City of Point Arena, as determined by analyzing collision data from 2015 through 2019. These emphasis areas were derived from the consolidated high injury collision database (**Appendix B**) where top injury factors were identified by combining the data manually. Along with findings from the data analysis, stakeholder input was also considered while identifying emphasis areas specific to the City of Point Arena.

- Nighttime Collisions
- Collisions close to the City Boundary
- Hit Object Collisions
- Unsafe Speed Collisions
- Young Adult Party at Fault Collisions

### The Five E's OF Traffic Safety

LRS/AP utilizes a comprehensive approach to safety incorporating "5 E's of traffic safety": **E**ngineering, **E**nforcement, **E**ducation, and **E**mergency Medical Services (EMS). While the fifth E, **E**quity, is not discussed in this chapter, it is still an area that needs to be considered and addressed as outlined in Chapter 6. This approach recognizes that not all locations can be addressed solely by infrastructure improvements. Incorporating the 5 E's of traffic safety is often required to ensure successful implementation of significant safety improvements and reduce the severity and frequency of collisions throughout a jurisdiction.

Some of the common violation types that may require a comprehensive approach are speeding, failure-to-yield to pedestrians, red light running, aggressive driving, failure to wear safety belts, distracted driving, and driving while impaired. When locations are identified as having these types of violations, coordination with the appropriate law enforcement agencies is needed to arrange visible targeted enforcement to reduce the potential for future driving violations and related crashes and injuries.

To improve safety, education efforts can also be used to supplement enforcement. Additionally, education efforts can supplement enforcement to improve the efficiency of each. Education can also be employed in the short-term to address high crash locations until the recommended infrastructure project can be implemented, addressed under

Engineering improvements and countermeasures. Similarly, Emergency Medical Services entails strategies around supporting organizations that provide rapid response and care when responding to collisions causing injury, by stabilizing victims and transporting them to facilities.

## Existing Traffic Safety Efforts in the City of Point Arena

The City of Point Arena has already implemented safety strategies corresponding to the E's of traffic safety. The strategies detailed in this section can supplement these existing programs and concentrate them on high injury collision locations and crash types. These initiatives are summarized in the table below:

**Table 9. Existing Program Summary**

| Document | Description | E's Addressed |
|---|---|---|
| **Point Arena Community Action Plan (2010)** | A community vision was developed, traffic circulation was analyzed, sustainable development scenarios were mapped, improvement strategies and funding sources were identified, and other issues were addressed. | Engineering |
| **Walk and Bike Mendocino** | Walk and Bike Mendocino promotes walking and biking as a primary transportation choice in short distance travel in Mendocino County. | Education |
| **Mendocino County Regional Transportation Plan & Active Transportation Plan (2022)** | Details all transportation mode's improvements on County significant corridors. Includes detailed priority bike and pedestrian projects. | Engineering |
| **Mendocino County Safe Routes to School Plan (2014)** | Safe Routes to School (SRTS) is a program with a simple goal: helping more children get to school by walking and bicycling. | Engineering |

### Factors considered in the determination of Emphasis Areas

This section presents collision data analysis of collision type, collision factors, facility type, roadway geometries, analyzed for the various emphasized areas. Emphasis areas were determined by factors that led to the highest amount of injury collisions, with a specific emphasis on fatal and severe (KSI) injury collisions. In addition to the collision data, emphasis areas were also determined to by the feedback received from stakeholders. This section also presents comprehensive programs, policies and countermeasures to reduce collisions in specific emphasis areas.

## Emphasis Area 1 - Nighttime Collisions

The City of Point Arena experienced a total 10 reported collisions during the 2015-2019 study period. Of these collisions, seven (70 percent) occurred at nighttime, including one severe injury collision.

| 3 | 3 | 2 |
|---|---|---|
| **Hit object collisions** | **Wrong side of road collisions** | **DUI Collisions** |

**Table 10. Emphasis Area 1 Strategies**

| | Strategy | Performance Measure | Agencies/ Organizations |
|---|---|---|---|
| **Objective: Reduce the number of collisions that occur at nighttime** | | | |
| **Education** | Conduct public information and education campaign for safety laws regarding and the larger risk of collisions during the nighttime. | Number of education campaigns | City/Police Department |
| **Enforcement** | Targeted enforcement at high-risk locations to monitor collisions that occur at nighttime. | Number of tickets issued | Police Department |
| **Engineering** | • SI02, Improve signal hardware: lenses, back-plates with retroreflective borders, mounting, size and number<br>• SI09, Install flashing beacon as warning<br>• NS08, Install/upgrade larger or additional stop signs or other intersection warning/regulatory signs<br>• R01NT, Add segment lighting<br>• R22, Install/Upgrade signs with new fluorescent sheeting (regulatory or warning)<br>• R26, Install dynamic/ variable speed warning signs<br>• R27, Install delineators, reflectors and/or object markers | Number of locations improved | City |
| **EMS** | SI04EV, Install emergency vehicle pre-emption systems | EMS vehicle response time | Mendocino County Local Emergency Services Agency |

### Emphasis Area 2 - Collisions close to the City Boundary

The City of Point Arena experienced a total 10 reported collisions with five (50 percent) of these collisions occurring close to the city limits.

**3**

**Collisions occurred near School Street and Lake Street, at the north City limit**

**3**

**Collisions were hit object collisions**

**2**

**Occurred near Riverside Drive and Pine Reef, at the east City limit**

**Table 11. Emphasis Area 2 Strategies**

| Objective | | | |
|---|---|---|---|
| **Reduce the number of collisions near City limits.** | | | |
| | **Strategy** | **Performance Measure** | **Agencies/ Organizations** |
| **Education** | Conduct public information and education campaign for safety laws regarding, unsafe speeds, distracted driving, improper turning and driving under the influence | Number of education campaigns | City/School District/ Police Department |
| **Enforcement** | Targeted enforcement at high-risk locations | Number of tickets issued | Police Department |
| **Engineering** | • R01NT, Add segment lighting<br>• R04, Install guard rail<br>• R15. Widen shoulder<br>• R21, Improve pavement friction<br>• R22, Install/Upgrade signs with new fluorescent sheeting (regulatory or warning)<br>• R26, Install dynamic / variable speed warnings<br>• NS04RA/NS05RA/S16RA, Convert intersection to roundabout<br>• Consider reducing speed limits at the northern edge of the City, and use prima facie to set speed limit instead of 80$^{th}$ percentile | Number of locations improved | City |
| **EMS** | SI04EV, Install emergency vehicle pre-emption systems | EMS vehicle response time | Mendocino County Local Emergency Services Agency |

## Emphasis Area 3 - Hit Object Collisions

The City of Point Arena experienced a total 10 reported collisions with four (40 percent) of these being hit object collisions.

| 3 | 3 | 2 |
|---|---|---|
| **Hit Object Collisions occurred on Main Street** | **Collisions occurred at night** | **Wrong side of road collisions** |

**Table 12. Emphasis Area 3 Strategies**

| Objective | | | |
|---|---|---|---|
| **Reduce the number of collisions were hit object collisions.** | | | |
| | **Strategy** | **Performance Measure** | **Agencies/ Organizations** |
| **Education** | Conduct public information and education campaign for intersection safety laws regarding, unsafe speeds, distracted driving, improper turning and driving under the influence. | Number of education campaigns | City/School District/Police Department |
| **Enforcement** | Targeted enforcement at high-risk locations | Number of tickets issued | Police Department |
| **Engineering** | • R01NT, Add segment lighting<br>• R03, Install median barrier<br>• R04, Install guard rail<br>• R15. Widen shoulder<br>• R21, Improve pavement friction<br>• R22, Install/Upgrade signs with new fluorescent sheeting (regulatory or warning)<br>• R26, Install dynamic / variable speed warnings<br>• R27, Install delineators, reflectors and/or object markers<br>• R28, Install edge lines and centerlines | Number of locations improved | City |
| **EMS** | SI04EV, Install emergency vehicle pre-emption systems | EMS vehicle response time | Mendocino County Local Emergency Services Agency |

## Emphasis Area 4 - Unsafe Speed Collisions

The City of Point Arena experienced a total 10 reported collisions with two (20 percent) of these due to unsafe speed.

| 2 | 1 | 1 |
|---|---|---|
| **Overturned Collison** | **Occurred at Route 1 and Lake Street** | **Occurred on Riverside Drive and Eureka Hill** |

**Table 13. Emphasis Area 4 Strategies**

| Objective | | | |
|---|---|---|---|
| **Reduce the number of fatal and severe injury collisions that are a result of unsafe speed.** | | | |
| | **Strategy** | **Performance Measure** | **Agencies/ Organizations** |
| **Education** | Conduct public information and education campaign for safety laws regarding unsafe speed and its dangers. | Number of education campaigns | City/ School District/ Police Department |
| **Enforcement** | Targeted enforcement at high-risk locations to monitor unsafe speed. | Number of tickets issued | Police Department |
| **Engineering** | • S16RA/NS04RA/NS05RA, Convert intersection to roundabout<br>• NS08, Install/upgrade larger or additional stop signs or other intersection warning/regulatory signs<br>• NS09, Upgrade intersection pavement markings (NS.I.)<br>• R04, Install guard rail<br>• R22, Install/Upgrade signs with new fluorescent sheeting (regulatory or warning)<br>• R26, Install dynamic/ variable speed warning signs<br>• R28, Install edge-lines and centerlines<br>• Consider reducing speed limits at the northern edge of the City, and use prima facie to set speed limit instead of $80^{th}$ percentile | Number of locations improved | City |
| **EMS** | SI04EV, Install emergency vehicle pre-emption systems | EMS vehicle response time | Mendocino County Local Emergency Services Agency |

### Emphasis Area 5 - Young Adult Party at Fault Collisions

The City of Point Arena reported a total 10 reported collisions during the study period. The following is a review of the demographic data, provided in the party data of the reported collisions.

| 80% | 70% |
|---|---|
| **Party at fault was 35 years old or younger** | **Party fault was a male** |

**Table 14. Emphasis Area 5 Strategies**

| Objective | | | |
|---|---|---|---|
| **Reduce the number of younger adult fatal and severe injury collisions** | | | |
| | **Strategy** | **Performance Measure** | **Agencies/ Organizations** |
| **Education** | Target education programs for younger adults. Distribute brochures/fliers with basic red light running, speeding, distracted driving, aggressive driving and stop sign violations information at driver training programs. Include statistics of younger adult larger risks of fatalities. | Number of education campaigns | City/ School District/ Police Department |

# 6. Equity

Through this LRS/AP update, the city of Point Arena seeks to advance equity in identifying and addressing its transportation safety needs. The City recognizes that transportation benefits and costs can accrue unequally across communities. Despite transportation's ability to connect communities to opportunities, resources, and destinations, historical patterns of decisions and investments in transportation have not addressed, and even aggravated or created, inequalities in wealth, access, and health.

Inequalities in transportation safety result in an undue concentration of collisions, unsafe roadways, or severe injury collisions in communities with social, economic, or other vulnerabilities. Data shows that roadway collisions disproportionately impact people who are Black, American Indian, and live in rural communities (USDOT's National Roadway Safety Strategy 2022).[4] Non-motorists, such as pedestrians and bicyclists, are more likely to be involved in a KSI collision than motorists. Traditional safety strategies such as enforcement face backlash for their discriminatory outcomes that burden racial minorities. These measures do not address policy or built environment limitations, resulting in safety hazards to roadway uses. Hence, a commitment to make roads safe for all users must consider equity seriously in analyzing roadway safety and recommending improvements.

It is a core goal of this LRS/AP to recommend safety improvements in a manner that is fair and equitable for all the City's residents, in line with a federal commitment to creating an equitable transportation system that is safe, efficient, and sustainable. Planning and decision-making processes followed in this LRS/AP update adequately consider inputs and feedback from communities with limited means or ability to participate effectively. Three virtual stakeholder meetings and five public workshops (three virtual and two in-person workshops) were held with residents during the LRS/AP update to gather insights into safety burdens faced by communities, share data and findings, and gather feedback on safety countermeasures and recommendations. LRS/AP is also guided by public inputs received through the online public input platform and feedback from the safety partners.

USDOT's[5] commitment to expanding "access and opportunity to all communities while focusing on underserved, overburdened, and disadvantaged communities" guides this plan in prioritizing safety projects to benefit the most vulnerable of the communities. The

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[4]https://www.transportation.gov/sites/dot.gov/files/2022-02/USDOT-National-Roadway-Safety-Strategy.pdf

[5] https://www.transportation.gov/sites/dot.gov/files/2022-04/Equity_Action_Plan.pdf

LRS/AP includes elements from the FHWA recommended Safe Systems Approach and prioritizes the needs of vulnerable road users such as bicyclists and pedestrians in identifying countermeasures and developing the countermeasure toolbox. The projects identified are also analyzed for their adherence to the Justice40 commitment to directing benefits of investments to vulnerable communities.

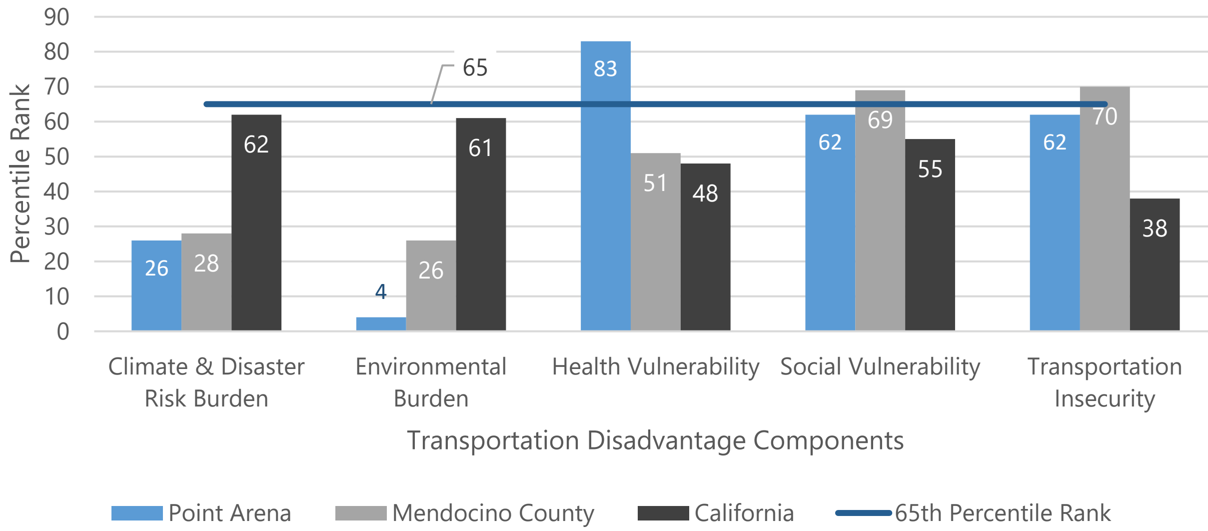
## Minimal Safety Risks in the City

The City residents are less likely to be killed in a collision as compared to the average Californian. The average annual fatality rate (AAFR) for the City of Point Arena is 0.2 persons killed per 100,000 residents for both 2017-2021 and 2018-2022 time periods, which is very modest when compared to the rate for the state of California (10.12 persons killed per 100,000 residents in 2017-2021, and 10.40 in 2018-2022). AAFR has been calculated based on the methodology provided by the Safe Streets for All grant program. The calculation worksheet and methodology are available in **Appendix C**.

## Transportation and Population Vulnerabilities in Point Arena

Transportation vulnerabilities experienced by residents of Point Arena can be ranked against communities nationwide utilizing the concept of transportation disadvantage developed by the USDOT. USDOT describes transportation disadvantage as cumulative burdens and risks in climate and disaster, environmental burden, health vulnerability, social vulnerability, and transportation insecurity due to underinvestment in the City's transportation system. USDOT’s Equitable Transportation Communities Explorer (ETCE) ranks communities (census tracts) nationwide based on their scores for each component. A 65th percentile rank or above is considered disadvantaged. There is no specific equity emphasis community as per ETCE in Point Arena, as it comprises a single census tract, which does not show any overall disadvantage. Specifically, the City faces disadvantages in terms of health vulnerability (83 percent), higher than the disadvantage level for California and the County, as shown in **Figure 24.**

**Figure 23. City of Point Arena Transportation Disadvantage**



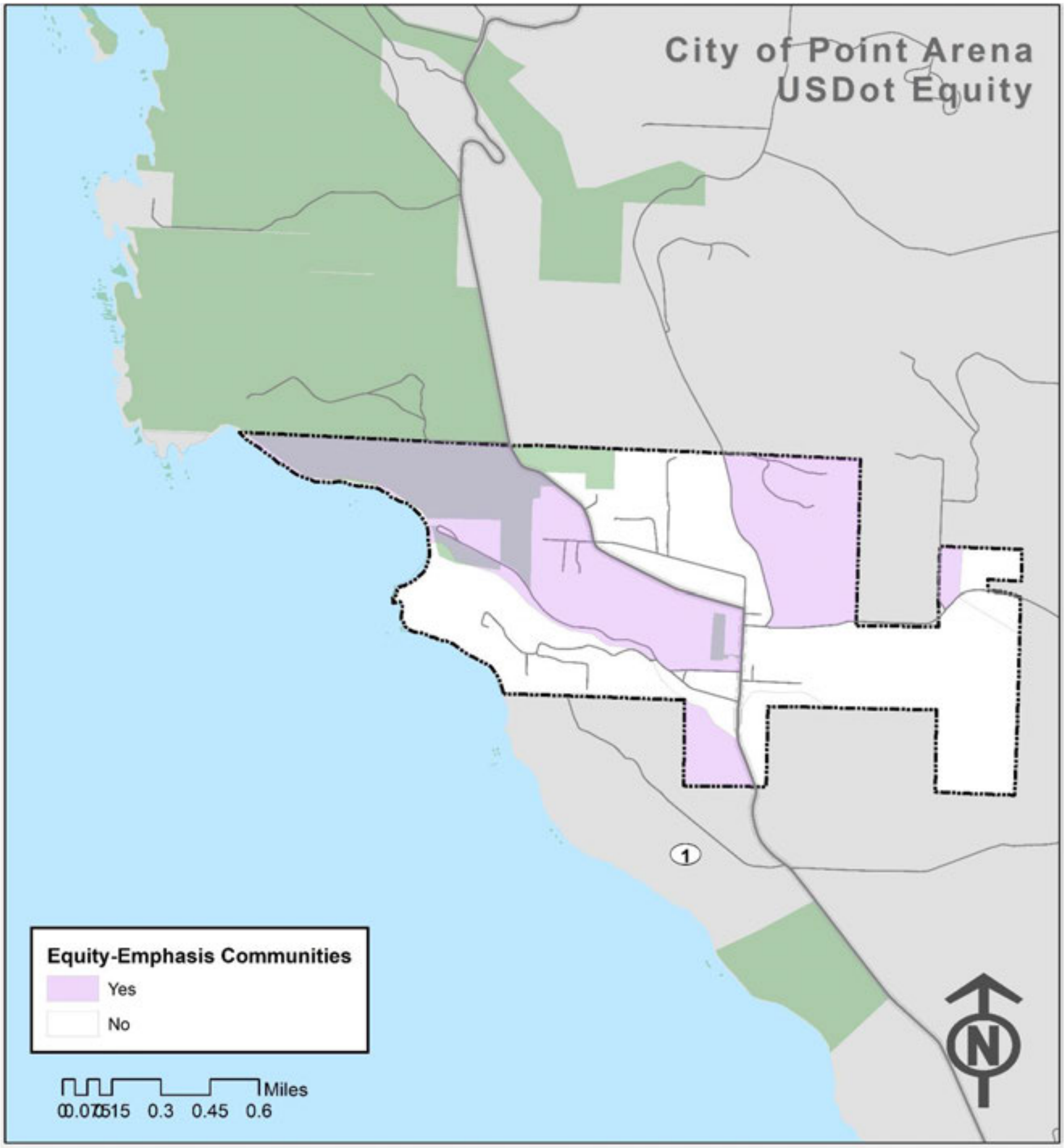

## Equity Emphasis Communities

This chapter details how the safety data is analyzed with respect to equity-emphasis communities (EEC) to identify the impact of collisions in vulnerable communities. EEC are communities within the City of Point Arena with or experiencing characteristics that lead to vulnerabilities in areas including wealth, health, social, and environmental aspects. As a small community, readily available tools, such as the ETCE, SB 535 Disadvantaged Communities, and CEJST, fail to provide spatially disaggregated data on EEC for the City. This update to the LRS/AP uses data from the 2020 Decennial Census, disaggregated to the level of blocks, to identify EEC. The Census Bureau provides data on race, age, and housing tenure for blocks used to construct indicators here. A block group with a share of indicators above the average for the City is considered vulnerable. A community that is vulnerable in two or more indicators is considered to be an EEC. The indicators and thresholds are described in **Table 15**. The map in **Figure 25** shows the equity areas identified through this analysis. Since no roadway collisions occurred between 2020 and 2022, this analysis will not analyze collision trends in equity emphasis communities in the City of Point Arena.

**Table 15. Equity Indicators**

| Indicator | Data | Threshold |
|---|---|---|
| **Minority Population** | Share of population that is non-white or of two or more races. | 85% |
| **Vulnerable Road Users** | Share of population below the age of 15 or 65 years and above. | 40% |
| **Housing Tenure** | Share of renters among total households. | 57% |

Figure 24. Equity Emphasis Communities - Point Arena



# 7. Countermeasure Identification

This section summarizes the process of selecting countermeasures on Point Arena streets as part of the analysis for the LRS/AP. Countermeasures were updated for each of the identified high-risk intersections and roadway segments based on extensive review of existing conditions at the site and characteristics of identified collisions (from year 2015 to 2019) on the High Injury Network.

Identified collision factors and existing conditions were cross referenced with the Caltrans LRSM identified countermeasures that are HSIP approved. Countermeasures that best fit the site and had the highest opportunity for systemic implementation were selected. Countermeasures were selected not only for each high-risk location, but also for each identified citywide Emphasis Area.

## Countermeasure Selection

In 2010, the Federal Highway Administration (FHWA) published a set of three manuals for local and rural road owners to present a simple, data driven safety analysis framework for rural agencies across the country. In conjunction with these documents, California Department of Transportation (Caltrans) developed the Local Roadway Safety Manual (LRSM). The goal of this manual is to "*maximize the safety benefits for local roadways by encouraging all local agencies to proactively identify and analyze their safety issues and to position themselves to compete effectively in Caltrans' statewide, data-driven call-for-projects*."[6] Although, the LRSM identifies all of California's local roadway safety issues and the countermeasures that address them, this document only highlights the issues and countermeasures relevant to the local roads of the City of Point Arena. This section identifies the different solutions for the City from HSIP-qualified and non-HSIP countermeasures. It also provides a brief description along with their corresponding crash reduction factors (CRF), expected life and baseline cost. An excerpt of the LRSM, detailing each available HSIP countermeasure referenced in the recommendations tables, is included as **Appendix D**.

The countermeasures have been divided into the following categories:

- Signalized (SI) – countermeasures only applicable for signalized intersections;
- Non-Signalized (NS) – countermeasures only applicable to stop-controlled, or uncontrolled intersections;
- Roadway Segment (R) – countermeasures only applicable to roadway segments;

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[6] https://dot.ca.gov/-/media/dot-media/programs/local-assistance/documents/hsip/2024/lrsm2024.pdf

- Other (O) – countermeasures that do not qualify for HSIP funding.

## Draft Countermeasure Toolbox

### Non-Signalized Intersections Countermeasures

**NS01NT – Add intersection lighting.** Non-signalized intersections that have a disproportionate number of night-time crashes and do not currently provide lighting at the intersection or at its approaches. Crash data should be studied to ensure that safety at the intersection could be improved by providing lighting (this strategy would be supported by a significant number of crashes that occur at night).

- Crash Reduction Factor – 40%
- Expected Life – 20 years

**NS08 – Install/upgrade larger or additional stop signs or other intersection warning/regulatory signs.** The visibility of intersections and, thus, the ability of approaching drivers to perceive them can be enhanced by installing larger regulatory and warning signs at or prior to intersections. A key to success in applying this strategy is to select a combination of regulatory and warning sign techniques appropriate for the conditions on a particular unsignalized intersection approach.

- Crash Reduction Factor – 15%
- Expected Life – 10 years

**NS09 – Upgrade intersection pavement markings (NS.I.).** Unsignalized intersections that are not clearly visible to approaching motorists, particularly approaching motorists on the major road. The strategy is particularly appropriate for intersections with patterns of rear-end, right-angle, or turning crashes related to lack of driver awareness of the presence of the intersection

- Crash Reduction Factor – 25%
- Expected Life – 10 years

**NS11 - Install flashing beacons as advance warning (NS.I.).** Non-Signalized Intersections with patterns of crashes that could be related to lack of a driver's awareness of approaching intersection or controls at a downstream intersection. Advance flashing beacons can be used to supplement and call driver attention to intersection control signs. Flashing beacons are intended to reinforce driver awareness of the stop or yield signs and to help mitigate patterns of crashes related to intersection regulatory sign violations.

- Crash Reduction Factor – 30%
- Expected Life – 10 years

**NS24PB – Install Rectangular Rapid Flashing Beacon (RRFB).** The RRFB includes pedestrian-activated

- Crash Reduction Factor – 35%

flashing lights and additional signage that enhance the visibility of marked crosswalks and alert motorists to pedestrian crossings. It uses an irregular flash pattern that is similar to emergency flashers on police vehicles. RRFBs are installed at unsignalized intersections and mid-block pedestrian crossings.

- Expected Life – 20 years

## Roadway Countermeasures

**R01NT – Add segment lighting.** Providing roadway lighting improves the safety during nighttime conditions by (1) making drivers more aware of the surroundings, which improves drivers' perception-reaction times, (2) enhancing drivers' available sight distances to perceive roadway characteristic in advance of the change, and (3) improving non-motorist's visibility and navigation.

- Crash Reduction Factor – 35%
- Expected Life – 20 years

**R22 – Install/Upgrade signs with new fluorescent sheeting (regulatory or warning).** The target for this strategy should be on roadway segments with patterns of head on, nighttime, non-intersection, run-off road, and sideswipe crashes related to lack of driver awareness of the presence of a specific roadway feature or regulatory requirement. Ideally this type of safety CM would be combined with other sign evaluations and upgrades (install chevrons, warning signs, delineators, markers, beacons, and relocation of existing signs per MUTCD standards.).

- Crash Reduction Factor – 15%
- Expected Life – 10 years
- Baseline Cost – Approximately $2,000

**R26 – Install dynamic/variable speed warning signs.** This strategy primarily addresses crashes caused by motorists traveling too fast around sharp curves. It is intended to get the drivers attention and give them a visual warning that they may be traveling over the recommended speed for the approaching curve. Care should be taken to limit the placement of these signs to help maintain their effectiveness.

- Crash Reduction Factor – 30%
- Expected Life – 10 years

**R27 – Install delineators, reflectors and/or object markers**. Roadways that have an unacceptable level of crashes on curves (relatively flat to sharp) during periods of light and darkness. Any road with a history of fixed object crashes is a candidate for this treatment, as are roadways with similar fixed objects along the roadside that have yet to experience crashes.

- Crash Reduction Factor – 15%
- Expected Life – 10 years

**R36PB – Install/upgrade pedestrian crossing (with enhanced safety features).** Adding pedestrian crossings has the opportunity to greatly enhance pedestrian safety at locations noted as being problematic. The enhanced safety elements, which may include curb extensions, medians and pedestrian crossing islands, beacons, and lighting, combined with pavement markings delineating a portion of the roadway that is designated for pedestrian crossing.

- Crash Reduction Factor – 35%
- Expected Life – 20 years

# 8. Safety Projects

This section details the methodology used to identify safety projects for the City of Point Arena's LRS/AP, based on the analysis of collisions that took place from 2015 to 2019. The next step after the identification of high-risk locations, emphasis areas and applicable countermeasures was to identify location specific safety improvements for all high-risk roadway segments and intersections.

Specific countermeasures and improvements have been updated from the 2024 Local Roadway Safety Manual (LRSM), where:

- SI refers to improvements at signalized locations,
- NS refers to improvements at non-signalized locations, and
- R refers to improvements at roadway segments.

The corresponding number refers to the countermeasure number in the LRSM (2024). The countermeasures were grouped into safety projects for high-risk intersections and roadway segments. A total of four safety projects were developed. All countermeasures were identified based on the technical teams' assessment of viability that consisted of extensive analysis, observations, and City staff input. The most applicable and appropriate countermeasures as identified have been grouped together to form projects that can help make high-risk locations safer.

**Table 16** lists the safety projects for high-risk intersections and roadway segments, along with total base planning level cost (2021 dollar amounts) estimates and the resultant preliminary Benefit-Cost (B/C) Ratio. The "Total Benefit" estimates were calculated for the proposed improvements evaluated as part of the safety analysis. This "Total Benefit" is divided by the "Total Cost per Location" estimates for the proposed improvements, giving the resultant B/C Ratio. The B/C Ratio Calculation follows the methodology as mentioned in the LRSM (2024).

These safety projects were chosen based on the previously completed collisions analysis, which was used to identify main collision attributes that were found to be leading factors of fatal and severe collisions in Point Arena. These collision factors were identified to be nighttime collisions and hit object collisions.

For all collisions, 70 percent of collisions occurred during the nighttime, including the only fatal or severe injury collision. Nighttime collisions have been observed at the intersection of Port Road and Bluff Top Road and along the corridor Highway 1/Main Street. Many different factors can contribute to nighttime collisions, such as low lighting levels that can be targeted with countermeasure, but extraneous factors can also contribute to nighttime injury such as alcohol use, sleep and fatigue. Recommended improvements at these location include installing flashing beacons as advance warning, installing and upgrade signs with new fluorescent sheeting and installing pedestrian improvements with lighting elements such as RRFBs.

For all collisions, 40 percent of collisions were hit object collisions, most of these occurred at intersections. Riverside Drive and Highway 1/School Street have more hit object collisions compared to other roads in Point Arena. Recommended improvements at these location include installing delineators, reflectors and/or object markers, and keeping sightlines clear at intersections.

**Table 16. List of Viable Safety Projects**

| Location | CM1 | CM2 | CM3 | Cost per Location | B/C Ratio |
|---|---|---|---|---|---|
| **Project 1: Systemic Improvements at Unsignalized Intersections** | | | | | |
| Port Road and Bluff Top Road | | NS08 | NS09 | $3,059 | 22.73 |
| Pine Reef and Riverside Drive | NS01NT | NS08 | NS09 | $35,434 | |
| Lake Streetand School Street/Highway 1 | | NS08 | | $1,400 | |
| Port Road and Main Street | | NS08 | | $280 | |
| Iverson Avenue and Main Street | | NS08 | | $980 | |
| **Project 2: Improvements at Unsignalized Intersections** | | | | | |
| Lake Street and School Street/Highway 1 | NS11 | | | $28,000 | 0.38 |
| Iverson Avenue and Main Street | NS11 | | | $14,000 | |
| **Project 3: Systemic Roadway Segment Improvements** | | | | | |
| Riverside Drive: Main Street/Highway 1 to Pine Reef | | R22 | | $7,980 | 43.19 |
| Main Street/Highway 1: Riverside Drive to Southern City Limits | | R22 | | $10,710 | |
| Port Road: Iverson Avenue to Main Street/ Highway 1 | | R22 | | $5,040 | |
| **Project 4: Pedestrian and Other Roadway Segment Improvements** | | | | | |
| Riverside Drive: Main Street/Highway 1 to Pine Reef | | R27 | R26 | $16,520 | 35.29 |
| School Street/Highway 1: Northern City Limits to Lake Street | | R27 | R26 | $14,840 | |
| Port Road: Iverson Avenue to Main Street/Highway 1 | R01NT | | | $69,776 | |
| **Project 5: Pedestrian Set Aside** | | | | | |
| Corner of Main Street and School Street near Methodist Church | | NS24PB | | $58,800 | N/A |
| Main Street/Highway 1: Riverside Drive to Southern City Limits | R36PB | | | $39,200 | |

Notes: CM – countermeasure. B/C ratio is the dollar amount of benefits divided by the cost of the countermeasure. NS01NT- Add intersection lighting (NS.I.), NS08- Install/upgrade larger or additional stop signs or other intersection warning/regulatory signs, NS09- Upgrade intersection pavement markings (NS.I.), NS11- Install flashing beacons as advance warning (NS.I.), NS24PB- Install Rectangular Rapid Flashing Beacon (RRFB), R01NT- Add segment lighting, R22- Install/Upgrade signs with new fluorescent sheeting (regulatory or warning), R26 - Install dynamic/variable speed warning signs, R27- Install delineators, reflectors and/or object markers, R36PB - Install/upgrade pedestrian crossing (with enhanced safety features) Costs include contingency, PS&E, environmental and construction costs.

The LRSP prioritizes the five safety projects in Point Arena identified in the previous LRSP based on collision data and stakeholder inputs. These projects address critical safety improvements for the City. These projects have been further prioritized based on the goals and vision outlined in Chapter 1. The six criteria for the prioritization are safety benefits, benefits to vulnerable road users, school safety impact, equity impact, public engagement, and ease of implementation. Each criterion is scored separately and then weighed to arrive at the final scores for each project, as described in **Table 17**. A project can receive a maximum score of 100. The project prioritization worksheets are available in **Appendix E**. **Table 18** presents the projects in the priority order.

### Table 17. Prioritization Matrix

| Criteria | Description | Weight |
|---|---|---|
| **Safety Benefits** | Safety benefits are evaluated using the Benefit-to-Cost (BCR) ratio. BCR is calculated based on five-year collision data and 2024 planning-level cost estimates, as per the HSIP norms. Projects are then grouped into three equal-range buckets based on the BCR and receive safety scores as follows:<br>• Projects in the highest bucket - 100<br>• Projects in the Middle bucket - 50<br>• Projects in the Lowest bucket – 20<br>*Note that Pedestrian Set Aside does not involve BCS allocation. Hence, this project has been assigned the highest score (100) for safety benefits.* | 40% |
| **Benefit to Vulnerable Road Users** | Considers improvements benefiting pedestrians, bicyclists, transit users, or persons with disabilities.<br>• Projects with benefits - 100<br>• Projects without benefits - 0 | 15% |
| **School Safety Impact** | Considers safety improvements on roadways and intersections within 1/4 mile of an existing school.<br>• Projects in proximity to schools - 100<br>• Projects without proximity to schools - 0 | 10% |
| **Equity Impact** | Considers the location of a project entirely or partially in an equity-emphasis community (EEC).<br>• Projects in EEC - 100<br>• Projects outside of EEC - 0 | 15% |
| **Public Engagement** | Considers projects that have garnered community and stakeholder support during the LRS/AP outreach process.<br>• Projects with community support - 100<br>• Projects without community support - 0 | 10% |
| **Ease of Implementation** | Projects are scored based on the complexity of their countermeasures. For projects with multiple countermeasures, the lowest category score is applied. | 10% |

| Criteria | Description | Weight |
|---|---|---|
| | • High-ease improvements like signs, lights, striping, flashing beacons, and crosswalks - 100<br>• Medium-ease improvements like sidewalks, medians, and new signals - 50<br>• Low-ease improvements requiring lane/geometry changes, right-of-way acquisition, or utility or drainage work – 20 | |

### Table 18. Priority Project List

| Priority | Project | Score |
|---|---|---|
| **1** | Project 5: Pedestrian Set Aside | 100 |
| **2** | Project 3: Systemic Roadway Segment Improvements | 75 |
| **3** | Project 4: Pedestrian and Other Roadway Segment Improvements | 75 |
| **4** | Project 2: Improvements at Unsignalized Intersections | 53 |
| **5** | Project 1: Systemic Improvements at Unsignalized Intersections | 35 |

# 9. Evaluation and Implementation

This chapter describes the steps the City may take to evaluate the success of this plan and steps needed to update the plan in the future. The LRS/AP is a guidance document and requires periodic updates to assess its efficacy and re-evaluate potential solutions. It is recommended to update the plan every two to five years in coordination with the identified safety partners. This document was developed based on community needs, stakeholder input, and collision analysis conducted to identify priority emphasis areas throughout the City. The implementation of strategies under each emphasis area would aim to reduce KSI collisions in the coming years.

Funding is a critical component of implementing any safety project. While the HSIP program is a common source of funding for safety projects, there are numerous other funding sources that could be pursued for such projects. Potential funding sources are listed below in **Table 19**.

**Table 19. Potential Funding Sources**

| Funding Source | Funding Agency | Amount Available | Next Estimated Call for Projects | Applicable E's | Notes |
|---|---|---|---|---|---|
| **Active Transportation Program** | Caltrans, California Transportation Commission | ~$223 million per year | 2026 | Engineering, Education | Can use used for most active transportation related safety projects as well as education programs |
| **Highway Safety Improvement Program** | Caltrans | TBD | 2024 | Engineering | Most common grant source for safety projects |
| **Surface Transportation Block Group Program** | FHWA (Administered through MCTC) | Varies by FY | TBD | Engineering | Typically used for roadway projects |
| **Office of Traffic Safety Grants** | California Office of Traffic Safety | Varies by grant | Closes January 31st annually | Education, Enforcement, Emergency Response | 10 grants available to address various components of traffic safety |
| **Affordable Housing and Sustainable Communities Program** | Strategic Growth Council and Dept. of Housing and Community Development | ~$405 million | TBD | Engineering, Education | Must be connected to affordable housing projects; typically focuses on bike/ped infrastructure/ programs |

| Funding Source | Funding Agency | Amount Available | Next Estimated Call for Projects | Applicable E's | Notes |
|---|---|---|---|---|---|
| **Urban Greening** | California Natural Resources Agency | $23.75 million | TBD | Engineering | Focused on bike/ pedestrian infrastructure and greening public spaces |
| **Local Streets and Road Maintenance and Rehabilitation** | CTC (distributed to local agencies) | $1.5 billion statewide | N/A; distributed by formula | Engineering | Typically pays for road maintenance type projects |
| **RAISE Grant** | USDOT | ~$1 billion | TBD | Engineering | Typically used for larger infrastructure projects |
| **Sustainable Transportation Equity Project** | California Air Resources Board | ~$19.5 million | TBD; most recent call in 2023 | Engineering, Education | Targets projects that will increase transportation equity in disadvantaged communities |
| **Safe Street for All (SS4A)** | USDOT | $200k - $50 million | 2026 | Engineering | Two types of SS4A grants available: Action Plan Grants and Implementation Grants |
| **Transformative Climate Communities** | Strategic Growth Council | ~$90 million | TBD; most recent call in 2022 | Engineering | Funds community-led projects that achieve major reductions in greenhouse gas emissions in disadvantaged communities |

## Implementation

The LRS/AP document provides engineering, education, enforcement, and emergency medical service related countermeasures that can be implemented throughout the City to reduce KSI collisions. It is recommended that the City of Point Arena implement the selected projects high-collision locations in coordination with other projects proposed for the City's infrastructure development in their future Capital Improvement Plans.

The success of the LRS/AP can be achieved by fostering communication among the City and the safety partners.

## Monitoring and Evaluation

For the success of the LRS/AP, it is crucial to monitor and evaluate the E-strategies continuously. Monitoring and evaluation help provide accountability, ensures the effectiveness of the countermeasures for each emphasis area, and help making decisions on the need for new strategies. The process would help the City make informed decisions regarding the implementation plan's progress and accordingly, update the goals and objectives of the plan.

After implementing countermeasures, the strategies should be evaluated annually as per their performance measures. The evaluation should be recorded in a before-after study to validate the effectiveness of each countermeasure.

### Pre-Implementation Data Collection

Before any safety project is implemented, comprehensive baseline data should be collected within the project area to enable future before/after comparison analysis. Data to be compiled includes:

Collision Data:

- Collision types (pedestrian, angle, rear-end, etc.)
- Collision severity levels
- Locations and corridors
- Contributing factors

Traffic Data:

- Vehicle traffic volumes
- Pedestrian and bicycle traffic counts

Operations Data:

- 85th percentile and pace speeds
- Vehicle/pedestrian/bicycle conflict observations
- Observable road user behavior and compliance levels

### Statistical Analysis Methodology

Appropriate statistical techniques can be applied to account for regression-to-mean effects, traffic volume changes over time, and other potential biases. Recommended approaches include Empirical Bayes method and advanced regression modeling.

Using these techniques, an estimate of the predicted long-term safety performance should be calculated assuming no safety improvements were implemented. This becomes the baseline for comparison.

### Post-Implementation Data Collection

After allowing sufficient time following project implementation (typically 1-3 years), the same scope of "after" data can be re-collected to enable before/after comparison.

### Performance Evaluation Measures

The following key safety performance measures can be evaluated by comparing predicted vs. actual post-implementation conditions:

1. Total collisions
2. Fatal and serious injury collisions (KSI)
3. Collisions by type (pedestrian, intersection, roadway departure, etc.)
4. Operating speeds
5. Conflicts between modes (vehicle/pedestrian/bicycle)

### Supplemental Measures for Behavioral Safety Projects

For safety initiatives focused on influencing driver, pedestrian, or bicyclist behavior (e.g. education campaigns, enforcement activities), leading indicators of compliance can be tracked, such as:

1. Speeding violations
2. Impaired driving arrests/citations
3. Distracted driving violations
4. Pedestrian and bicycle traffic counts
5. Observed yielding/compliance behavior

### Project Evaluation Report

All findings from the before/after analysis should be documented in a comprehensive Project Evaluation Report containing:

- Project scope and description of implemented countermeasures
- Implementation costs
- Data collection processes and sources
- Statistical analysis methodology
- Summary of before/after performance results
- Assessment of whether intended benefits were achieved
- Lessons learned and recommendations
- Supplemental policy, program or design guidance as applicable

### Continual Monitoring Process

To ensure ongoing effectiveness evaluation, city should establish:

- Routine schedules for MOE (Measure of Effectiveness) data collection and analysis
- Designated staff responsibilities for MOE activities
- Integration of MOE findings into annual performance reviews
- Mechanism for refining project approach based on evaluation results

## LRS/AP Update

The LRS/AP is a guidance document and is recommended to be updated every two to five years after adoption. After monitoring performance measures focused on the status and progress of the E's strategies in each emphasis area, the next LRS/AP update can be tailored to resolve any continuing safety problems.

Aside from the Technical Advisory Committee and City of Point Arena's review and monitoring of the projects as outlined in Chapter 2, an annual stakeholder meeting with the safety partners is also recommended to discuss the progress for each emphasis area and oversee the implementation plan. The document should then be updated as per the latest collision data, emerging trends, and the E's strategies' progress and implementation.

A copy of the final LRS/AP will be located on Mendocino Council of Governments (MCOG) website at https://www.mendocinocog.org/

# Appendices:

# APPENDIX A: MATRIX OF PLANNING GOALS, POLICIES, AND PROJECTS

Matrix of Planning Goals, Policies, and Projects

| Document | Details |
|---|---|
| **City of Point Arena General Plan/ Local Coastal Plan (1995)** | • Goal 1: Improve safety on all streets.<br>• Policy 3.1.1: New streets to be considered for acceptance into the Point Arena street system shall conform to design standards appropriate to their functional classification.<br>• 3.1.3: The City shall resolve traffic and safety impacts of development at Arena Cove, and along Iversen/Port Roads. Of immediate concern is the junction of Iversen at Main Street. Safety and operational characteristics of this intersection shall be identified and problems mitigated prior to approval of new developments.<br>• 3.1.4: The City shall investigate methods of improving sight distances at intersections. Possible solutions may include: trimming or removing weeds, shrubbery, or limbs; relocating signs or other obstructions; removing on-street parking near intersections; prohibiting large-vehicle parking near intersections; and adjusting traffic control devices to provide better views.<br>• 3.1.6: Through traffic should be diverted from local streets insofar as possible. |
| **Point Arena Community Action Plan (2010)** | **Projects:**<br><br>• **Main Street/Mill Street Intersection** By relocating the marked crosswalk, pedestrians will exit onto a sidewalk on the western side of the crosswalk, instead of a driveway as occurs today. The new marked crosswalk location also provides a more convenient crossing for the South Coast Senior Center. Bulbouts will be constructed on both the east and west sides of Main Street at the new crosswalk.<br>• **School Street/Lake Street** Install bulb outs and realign intersection.<br>• **School Street/Harper's Cut-off Trail** Install two new median refuge island and crosswalk enhancements.<br>• **Roundabout Improvements** at Windy Hollow Road/Riverside Drive and Eureka Hill Road.<br>• **Roundabout improvement** at Lake Street and Highway 1.<br>• **Class II bike lanes** along Riverside Drive/Eureka Hill Road between Main Street and Windy Hollow Road.<br>• **Class II bike lanes** along Windy Hollow Road between Riverside Drive and Manchester Point Arena Rancheria.<br>• **Class II bike lanes** along Iversen Avenue between Main Street and Port Road. |
| **Capital Improvement Program 2021-2025, City of Point Arena Streets and Roads** | • Riverside Drive and Center Street Renovation: Completion of Riverside Drive, Center Street construction of 330 feet concrete drainage swale.<br>• Mill Street Reconstruction: The project will remove and regrade roadway, install subsurface drainage, replace sidewalk, and repave roadway.<br>• Windy Hollow Road: Overlay roadway.<br>• Sidewalk Repair, replacement and new sidewalk program: Sidewalks will be prioritized for replacement or addition. Sidewalk construction program that may partner with property owners may be needed. |

| Document | Details |
|---|---|
| **Mendocino County Safe Routes to School Plan (2014)** | • Mendocino County Safe Routes to School Program Toolkit<br>• Mendocino County SRTS Plan Framework |
| **2022 Mendocino County Regional Transportation Plan & Active Transportation Plan** | Goals:<br>• To improve our public spaces so the street, road and transportation system meets the needs of all surface transportation modes, including vehicular, bicycle, pedestrian and transit.<br>• Provide a safe and useable network of bicycle and pedestrian facilities throughout the region as a means to lessen dependence on vehicular travel and improve the health of Mendocino County's residents.<br>• Maximize investment in non-motorized transportation facilities through maintenance.<br>**Priority Improvements:**<br>*Short Range:*<br>• Coastal Access Scenic Bikeway Rehabilitation<br>• Lake Street Sidewalks<br>*Long Range:*<br>• Multi-use Trail from Cove (Harper's Cut-off Trail) |

# APPENDIX B. CONSOLIDATED COLLISION DATABASE

| Case ID | Accident Year | Collision Date | Primary Road | Secondary Road | Distance | Direction | Collision Severity |
|---|---|---|---|---|---|---|---|
| 8771731 | 2018 | 43453 | PORT RD | BLUFF TOP RD | 0 | | 2 |
| 6957699 | 2015 | 42146 | EUREKA HILL RD | PINE REEF | 278 | W | 3 |
| 90470980 | 2017 | 42880 | SR-1 | LAKE ST | 1056 | N | 4 |
| 90992291 | 2019 | 43594 | RIVERSIDE DR | EUREKA HILL RI | 422 | W | 3 |
| 7086810 | 2015 | 20150917 | RT 1 | PORT RD | 18 | N | 0 |
| 8105508 | 2016 | 20160805 | PORT RD | MAIN ST | 50 | W | 0 |
| 8419133 | 2017 | 20170710 | RT 1 | LAKE ST | 40 | N | 0 |
| 8537340 | 2018 | 20180113 | LAKE ST | MAIN ST | 0 | | 0 |
| 8574682 | 2018 | 20180223 | MAIN ST | MAIN ST 365 | 0 | | 0 |
| 8613635 | 2018 | 20180305 | PORT RD | PORT RD 200 | 0 | | 0 |

# APPENDIX C: AVERAGE ANNUAL FATALITY RATES CALCULATION

## Average Annual Fatality Rate

| City | Year | Total Fatalities | Population | % of Disadvantaged census tracts | Disadvantaged Population | Average Annual Fatality Rate | Average Fatalities Per Year |
|---|---|---|---|---|---|---|---|
| **California** | 2017-2021 | 19,894 | 39,300,000 | 37% | 36% | 10.4 | 3,978.8 |
| **Mendocino County** | 2017-2021 | 136 | 87,100 | 35% | 31% | 28.2 | 27.2 |
| **Point Arena** | 2017-2021 | 0 | 460 | 0% | 0% | 0.00 | 0 |
| **California** | 2018-2022 | 20,438 | 39,300,000 | 37% | 36% | 0.0 | 4,087.6 |
| **Mendocino County** | 2018-2022 | 123 | 87,100 | 35% | 31% | 2.4 | 24.6 |
| **Point Arena** | 2018-2022 | 0 | 460 | 0% | 0% | 0.00 | 0 |

Notes on Sources and methodology:

**Total Fatalities**: NHTSA. 2017-2021 and 2018-2022 data on Persons Killed in Fatal Crashes. Accessed from: https://cdan.dot.gov/query. There are no Fatalities. In Point Arena

**Population, and Disadvantaged population share**: * Population for Point Arena is obtained from 2020 Decennial Census.

**Average Annual Fatality Rate: C**alculated per 100,000 persons. Methodology used as prescribed by the Safe Streets for All Grant 2024 instructions accessed from: https://www.transportation.gov/sites/dot.gov/files/2024-02/SS4A-FY24-Calculate-Fatality-Rate.pdf

**Average Fatalities per Year**: $\frac{\text{Total Fatalities}}{5}$

# APPENDIX D: LRSM 2024

# Local Roadway Safety Manual

## A Manual for California's Local Road Owners

Version 1.7 April 2024

Created by Caltrans in conjunction with FHWA and SafeTREC
for the express benefit of California Local Agencies.

Caltrans

U. S. Department of Transportation
Federal Highway Administration

Safe Transportation
Research & Education Center
SafeTREC

# Document History

**Version 1.0: 4/20/2012**

The California Department of Transportation - Division of Local Assistance developed the first version of the Local Roadway Safety Manual (Version 1.0) in 2012 to support the Cycle 5 HSIP call-for-projects.

**Version 1.1: 4/26/2013**

Based on feedback and lessons learned from Cycle 5, Caltrans updated Appendix B: "Table of Countermeasures and Crash Reduction Factors" to better clarify text in "Where to use", "Why it works", and "General Qualities" for several of the countermeasures included in the original manual.

No other changes were made to the Local Roadway Safety Manual as part of Version 1.1.

**Version 1.2: 03/10/2015**

Based on feedback and lessons learned from Cycle 6, Caltrans made minor updates to the text of the document as needed for achieving consistency with overall Caltrans local HSIP guidance documents. The following sections were updated: 1.2, 4.2, 5.1, 6.2, and Appendix B, E, F & G.

**Version 1.3: 04/29/2016**

Caltrans made updates to the text of the document as needed in the following sections: 4.2, 5.1 and Appendix B.

**Version 1.4: 06/08/2018**

3/30/18 - Caltrans made updates to the crash costs in Appendix D, some of the website links in Appendix G, and some other texts of the document.
6/8/18 - Countermeasure S22 ("Modify signal phasing to implement a Leading Pedestrian Interval (LPI)") is added.

**Version 1.5: April 2020**

Caltrans added a few more countermeasures (e.g. Pedestrian Scramble, Install Separated Bike Lanes, Reduced Left-Turn Conflict Intersections, and Curve Shoulder widening), renumbered the countermeasures and updated the crash costs in Appendix D.

**Version 1.6: April 2022**

For Cycle 11 Call-for-projects, Countermeasure S04 (Provide Advanced Dilemma Zone Detection for high-speed approaches) was deleted and Countermeasure NS05mr (Convert intersection to mini-roundabout) added. The HSIP Funding Eligibility was changed to 90% except for S03, of which the HSIP Funding Eligibility stays at 50%. The crash costs in Appendix D were updated.

**Version 1.7: April 2024**

For Cycle 12 Call-for-projects, Countermeasures SI14 (Install right-turn lane (S.I.) ) and R32 (Speed Safety Cameras) were added. All countermeasures were re-numbered. The crash costs in Appendix D were updated.

**Future Updates:**

In the future, Caltrans anticipates that additional changes will be needed to keep the Local Roadway Safety Manual consistent with future Calls-for-Projects' Guidelines and Application Instructions. In addition, new local HSIP programs, improvements to California data on local roadways, data analysis tools, and the latest safety research and methodologies may give rise to the need to make more significant changes to this manual.

## Table of Contents

# 1. Introduction and Purpose

The information in this document is geared towards local road managers and other practitioners with responsibility for operating and maintaining local roads, regardless of safety-specific highway training. The primary goal of this document is to provide an easy-to-use and comprehensive framework of the steps and analysis tools needed to identify locations with roadway safety issues and the appropriate countermeasures. For novice practitioners, the concepts and framework will be new, while experienced safety practitioners may find this manual to be mostly review. In both cases, the manual will provide the practitioners with a good understanding of how to complete a proactive safety analysis and ensure they have the best opportunity to secure HSIP safety funding during Caltrans calls-for-projects.

It's expected that novice and experienced practitioners will utilize this manual to help position their local agency to better compete in future Caltrans' calls-for-projects for safety programs. Inexperienced local roadway practitioners are also a target audience for this manual to gain exposure to the basic concepts that make up a proactive safety analysis of a local agency's roadway network.

The intent of this manual is to focus on key safety activities that every local agency should conduct on an annual basis (or as established by the agency) with the objective of reducing the number and severity of crashes within their jurisdiction. This manual defines this overall process as a "proactive safety analysis" approach to roadway safety. The Highway Safety Manual (HSM), documents a very similar process and refers to it as the "Roadway Safety Management Process." While the process in this document is similar and suggests the same primary elements, the HSM goes into significantly more detail, focuses more on scientific and mathematical equations behind the process, and intends to provide a comprehensive understanding of the overall processes to be applied by individual agencies across the nation. In contrast, this manual attempts to streamline the discussion; and make accommodations for the more novice safety practitioners, provide an adequate understanding of the process to complete an initial safety analysis of their roadway network, and instruct them on how to prepare applications that will compete well in Caltrans' statewide calls-for-projects. In general, this manual is intended to follow the research and methodologies presented in the HSM; however, to support Caltrans' statewide calls-for-projects process, it is important to note this manual deviates from the HSM in areas related to countermeasure selection and benefit / cost calculations. The logic behind these deviations is explained at the specific topic sections.

This manual is not intended to cover many of the day-to-day basics of traffic engineering including: maintain standard signage per the Manual on Uniform Traffic Control Devices (MUTCD); maintain sight distance (cut vegetation, remove parking); maintain a recovery zone; work with local traffic law enforcement; monitor collisions; address complaints; and manage litigation. These activities are understood to be critical elements of a local agency's traffic engineering responsibilities, but are not within the intended scope of this document.

## 1.1 California Local Roadway Safety Challenges and Opportunities

California's local roads are managed by more than 600 local agencies, including: cities, counties, and tribal governments. These local roads vary from flat multi-lane urban arterials to rural gravel roads in mountainous areas. California local agencies invest extensive resources on roadway safety every year, yet many roadways operate with outdated or insufficient safety features. A portion of these roadways even lack basic signing, pavement markings, alignment, and traffic control devices. Limited funding often prevents agencies from constructing safety projects, which can be expected. At the same time, the lack of safety data, design challenges, and lack of adequate training also hinder local agencies' accurate evaluation of their roadway network safety issues, which is more preventable.

Many small California local agencies are challenged by a lack of crash data. Without data, they have no way to identify High Crash Concentration Locations (HCCLs) or high risk roadway features, which can leave them "flying blind" with respect to the safety of their overall roadway network. Without data and analysis results, local officials may overreact when a tragic crash occurs, resulting in resources being spent in areas that will not maximize the overall application of safety funds. In conjunction with the collision mapping and analysis tools developed by UC Berkeley's SafeTREC, this document helps ensure all California local agencies have direct access to data on fatal and injury crashes within their jurisdictions and the analysis tools to effectively assess and prioritize future safety projects.

## 1.2 Safe System Approach

The Infrastructure Investment and Jobs Act (IIJA), aka Bipartisan Infrastructure Law (BIL), was signed into law on November 15, 2021. Under IIJA, the Highway Safety Improvement Program (HSIP), codified as Section 148 of Title 23, United States Code (23 U.S.C §148), is a core federal-aid program to States for the purpose of achieving a significant reduction in fatalities and serious injuries on all public roads. The IIJA emphasizes the "safe system approach":

*Safe system approach means a roadway design that emphasizes minimizing the risk of injury or fatality to road users; and that (i) takes into consideration the possibility and likelihood of human error; (ii) accommodates human injury tolerance by taking into consideration likely accident types, resulting impact forces, and the ability of the human body to withstand impact forces; and (iii) takes into consideration vulnerable road users. (23 U.S.C. 148(a)(9)).*

FHWA recognizes that the funding available through HSIP alone will not achieve the goal of zero fatalities on the Nation's roads. The Safe System approach addresses the safety of all road users, including those who walk, bike, drive, ride transit, and travel by other modes. It involves a paradigm shift to improve safety culture, increase collaboration across all safety stakeholders, and refocus transportation system design and operation on anticipating human mistakes and lessening impact forces to reduce crash severity and save lives. FHWA encourages States to prioritize safety in all Federal-aid investments and in all appropriate projects, using not only HSIP funding but also other Federal-aid funding.

The IIJA emphasizes the importance of vulnerable road user ( non-motorized road user) safety in the HSIP by adding a definition for vulnerable road users, creating a vulnerable road user special rule, and requiring States to develop and update a vulnerable road user safety assessment. All of these provisions address the increasing number of fatalities involving vulnerable road users on U.S. roads. It is imperative that States consider the needs of all road users as part of the HSIP. Investment in highway safety improvement projects that promote and improve safety for all road users, particularly vulnerable road users, aligns with the IIJA and will help Build a Better America. States and other funding recipients should prioritize projects that maximize the existing right-of-way for accommodation of non-motorized modes and transit options that increase safety, equity, accessibility, and connectivity. Projects that separate users in time and space, match vehicle speeds to the built environment, and increase visibility (e.g., lighting) advance implementation of a Safe System approach and improve safety for vulnerable road users.

## 1.3 The State's Role in Local Roadway Safety

The California Department of Transportation (Caltrans)—Division of Local Assistance is responsible for administering California's HSIP safety funding intended for local roadway safety improvements. This funding primarily comes to the state through two federal programs: Highway Safety Improvement Program (HSIP)—a federal-aid program focused on reducing fatalities and serious injuries on all public roads;  and the Active Transportation Program (ATP)—a federal aid and state funded program focused on improving safety and the overall use of non-motorized, active transportation modes of travel. Under SAFETEA-LU, High Risk Rural Roads Program (HR3) was established to focus on addressing rural road safety needs. Under the Infrastructure Investment and Jobs Act (IIJA), it is now a 'special rule' under HSIP that if triggered, directs that a certain amount of HSIP funds will need to be allocated for those rural roads that meet the definition.

Caltrans' administration of these programs encompasses many responsibilities, including: establishing program guidance; reviewing applications for improvements on local roadways; ranking applications/projects on a statewide basis; selecting projects for funding based on the greatest potential for reducing fatalities and injuries; programming the selected projects in the Federal Statewide Transportation Improvement Program (FSTIP); and assisting with programming and delivery issues throughout the delivery of the local agency projects. One goal for developing this document is to improve Caltrans' overall data-driven approach to statewide project selection of safety projects and to maximize the long-term safety improvements across California. To show the relationship between Caltrans' project selection process and this manual, a diagram showing the HSIP Call-for-Projects Process is provided in Appendix A.

Many State Departments are also actively engaged in California's Strategic Highway Safety Plan (SHSP). Caltrans developed the SHSP in a cooperative process with local, State, federal, and private sector safety stakeholders. The SHSP is a data-driven, comprehensive plan that established statewide goals, objectives, integrated the five E's of traffic safety— engineering, enforcement, education, emergency response, and emerging technologies. This manual directly supports many of the emphasis areas of the California SHSP. Local agencies are encouraged to participate in ongoing SHSP update efforts and can find more information on the SHSP at the following website: https://dot.ca.gov/programs/safety-programs/shsp.

**Local Roadway Safety Plan (LRSP) and Systemic Safety Analysis Report Program (SSARP)**

The state-funded Systemic Safety Analysis Report Program (SSARP) was established in 2016. The intent of the SSARP was to assist local agencies in performing a collision analysis, identifying safety issues on their roadway networks, and developing a list of systemic low-cost countermeasures that can be used to prepare future HSIP and other safety program applications. Late 2019, the program was evolved to Local Roadway Safety Plan (LRSP) so that the focus is not just engineering solutions but also include safety improvements in other areas such as enforcement, Education and emergency response.

The state funding for the LRSP/SSARP program is made available by exchanging the local Highway Safety Improvement Program (HSIP) federal funds for State Highway Account (SHA) funds.

For more information, please visit the LRSP/SSARP webpage at https://dot.ca.gov/programs/local-assistance/fed-and-state-programs/highway-safety-improvement-program/local-roadway-safety-plans.

## 1.4 The Local Roadway Crash Problem

Approximately 3,000 people die in California traffic crashes every year, representing nearly 10% of all traffic fatalities in the United States. Fifty-seven percent of these fatalities occur on local roadways, while only forty-three percent occur on the California State Highway System. A comparison of rural and urban roadways shows that local rural roadways have fatality rates 2 to 3 times higher than urban roadways per vehicle miles traveled. Based on these statistics, the total annual cost of local roadway fatal crashes to California is over $8 billion, while only $120 million is available annually in HSIP safety funds.

These statistics demonstrate the large and complex safety issues facing California. Through the development of this document, Caltrans is striving to help local agencies proactively identify high risk roadway features, roadway network locations/corridors with the highest safety needs, and encourage them to select effective low-cost improvements, whenever appropriate.

## 1.5 Reactive vs. Proactive Safety Issue Identification

Safety issues are identified on local roadways through a wide range of approaches. Although no single approach works best for all local agencies, some are far more effective at improving long-term roadway safety. Many agencies, often larger ones, have staff whose full-time job is dedicated to roadway safety; allowing them to focus on safety initiatives, be trained in the latest safety research, and have access to safety analysis data, tools and procedures. These agencies often utilize a 'proactive' approach to analyze their roadway network and identify safety issues.

At the same time many agencies, often the smaller ones, lack the financial ability to dedicate large portions of their staff resources to analyze safety issues and their staff has limited access to roadway safety training, safety expertise, and the latest safety analysis tools and procedures. Unfortunately, this can often result in identifying their safety issues in 'reaction' to tragic events.

The following is a basic outline of the differences in proactive vs. reactive identification approaches used by local agencies:

**Reactive Approach**

For this document, an agency is considered to be utilizing a reactive approach to roadway safety if they primarily identify safety improvements in reaction to:

- Recent crashes triggering safety investigations
- Specific crash concentrations triggering safety investigations
- Stakeholder identification of locations with safety issues and requests for improvements
- New funding becoming available

Crash concentrations and crash trends may be missed if local agencies rely exclusively on these identifiers for their roadway safety effort. They may also miss many opportunities to effectively utilize low-cost, systemic type improvements. This document encourages local agencies to adopt a more proactive approach to their roadway safety.

**Proactive Approach**

An agency is considered to be using a proactive approach to roadway safety if they go beyond the elements of a reactive approach and identify safety improvements by analyzing the safety of their entire roadway network, in one of the following ways:

- One-time, network-wide safety analysis of their roadways driven by new source of funding.
- Routine safety analyses of the roadway network (Preferred Approach!)

Agencies with a proactive approach utilize both systemic and spot location improvements (as defined in section 1.5 below). Applying improvements systemically across an entire corridor or network allows an agency to proactively address locations that have not had crash concentrations in the past, but have similar features as those currently experiencing high levels of crashes. In addition, even though a spot location improvement may be based on 'past' crashes, agencies making improvements based on countermeasures with proven crash reduction factors at their highest crash locations often have the best chance of proactively reducing future crashes.

This document encourages safety practitioners to pursue a proactive approach and routinely analyze the safety of their roadway networks to yield the best overall safety results.

## 1.6 Implementation Approaches

When an agency proactively identifies their safety issues throughout their roadway network, it is likely they will find high crash concentrations at intersections, roadway segments, and corridors. The safety practitioner should consider which implementation approach to utilize. Typical approaches include:

- Systemic Approach
- Spot Location Approach
- Comprehensive Approach incorporating human behavior issues

Each of these approaches has benefits and drawbacks. As Local agency practitioners identify their safety issues and analyze the data for crash patterns, they should be open to implementing a combination of these approaches, as documented in Sections 2 and 3 of this manual.

***Systemic Approach***

The Systemic Approach is primarily based on application of proven safety countermeasures at multiple crash locations, corridors, or geographic areas. Implementation of the Systemic Approach is generally based on 'system-wide' crash data with the estimates of the impacts being made in terms of benefits measured in traffic crash reduction and deployment cost. Identified locations experiencing high levels of crashes and locations with similar geometric features can be treated systemically with low-cost, proven safety countermeasures. *Note: The term "Systemic" used throughout in this manual is often exchanged with the term "Systematic" in many national safety documents and research studies. In general, safety practitioners will find these terms interchangeable. This manual uses "Systemic" to match the new HSM and the FHWA CMF Clearinghouse.*

Benefits of the Systemic Approach may include:

- <u>Widespread effect.</u> The Systemic Approach addresses safety issues at a large number of locations or on an entire local roadway network. It can also generate projects that combine HCCLs and locations with the potential for crashes and still have high Benefit to Cost (B/C) ratios. An example of this type of project could be upgrading pavement delineation and warning signs along a rural corridor: crashes may not have occurred on every curve or segment along the corridor, but all of the corridor's pavement delineation and warning signs can be upgraded at one time. For urban applications, an example could be protecting the left-turn phase of signalized intersections with existing left-turn pockets: severe crashes may not have occurred at each of the left-turn movements, but with minor changes to the signal hardware and signing, all or many of a city's unprotected left-turn phases can be protected with one safety project.

- Crash type prevention. By focusing on a predominant crash type, an agency can address locations that have not experienced significant numbers of these types of crashes, but have similar characteristics or conditions as existing HCCLs. The resulting B/C ratios for these types of projects will be less than if only HCCLs are included; but by using low-cost countermeasures and including as many high crash locations as possible, the resulting B/C ratios should still be high enough to allow agencies to proactively address locations that have not experienced high numbers of these types of crashes. For urban areas, projects improving pedestrian crossings can be good examples of the Systemic Approach. By applying the countermeasures systemically, the agency can often justify these projects based on relatively high B/C ratios, even though some of the improvement locations have not experienced enough crashes to yield moderate-to-high B/C ratios on their own.
- Cost-effectiveness. Implementing low-cost solutions across an entire system or corridor can be a more cost-effective approach to addressing system-wide safety issues. Even though this approach does not address all (or total) safety issues for a given location, the deployment of low-cost countermeasures often result in the highest overall safety benefit for an agency with limited safety funding. An example of this would be an agency choosing to install rumble stripes along an entire corridor for equal or less money than realigning a small portion the roadway to fix a single curve.
- Reduced data needs. The Systemic Approach can be used without a detailed crash history for specific locations, thereby reducing data needs. For example, consider a long rural corridor, which includes a section that passes through an Indian Reservation: Even if there is no documented crash data for the portion of the corridor that passes through the reservation, the entire limits can be treated with the same low-cost improvements. As long as there are sufficient past crashes documented for the entire corridor, the project will still have a reasonably high B/C ratio.

Drawbacks of the Systemic Approach may include:

- Justifying improvements can be difficult. Because this approach does not always address locations with a history of crashes and active stakeholders, it can be difficult to justify the improvements. The Systemic Approach will rarely include a recommendation for a large-scale safety improvement at a single location. Since large-scale projects usually garner attention from decision makers, the media, elected officials, and the general public, safety practitioners often need to make additional efforts to explain the Systemic Approach and its benefits to those groups. Safety practitioners can utilize the high B/C ratios of these systemic projects to convey their benefits compared to high-profile, single location projects with lower B/C ratios.

***Spot Location Approach***

The Spot Location Approach is typically based on an analysis of crash history to identify locations that have significantly higher crashes and treat them accordingly. It is important to practitioners to understand that for many locations, safety issues can be complicated and sometimes the most appropriate fixes are not quick, easy or cheap.

Benefits of the Spot Location Approach may include:

- Focus on demonstrated needs. The Spot Location Approach focuses directly on locations with a history of crashes and specifically addresses those crashes. Intersection improvements are some of the most common spot location projects. Intersections tend to have higher concentrations of crashes resulting from opposing traffic movements. These high crash concentrations often require stand-alone improvements to adequately resolve the safety issues.
- Justifying improvements can be easy. Because this approach addresses locations with a history of crashes, it is usually easy to justify improvements. For urban areas, reconfiguring/ reconstructing an entire intersection can be a good example of an effective Spot Location Approach. Large urban intersections can have extremely high crash concentrations, making major changes to the intersection the only way to significantly reduce future crashes. With these types of scenarios, even the highest cost countermeasures can be cost effective.
- If low-cost countermeasures are used, this approach can prove very cost effective. The Spot Location Approach does not always have to include moderate or high cost improvements. It is often appropriate for local agencies to make low-cost improvements at one location at a time. Ongoing maintenance and development projects offer great opportunities for these low-cost improvements to be constructed with no additional expense to local agencies.

Drawbacks of the Spot Location Approach may include:

- Assumption that the past equals the future. This approach assumes locations with a history of crashes will continue to experience the same number and type of crashes in the future. When agencies do not account for the random nature of roadway crashes (i.e., Regression to the Mean), moderate to high cost projects can be erroneously justified. Practitioners can mitigate this by using 5 years of crash data when analyzing their roadways. In addition, significant changes to land use or roadway characteristics in or around proposed projects can either increase or decrease the expected number of future crashes.
- Minimal overall benefit to the roadway network. Some local agencies use this approach with medium and high cost improvements at locations which do not represent their worst high crash concentration locations. The result can be projects with low B/C ratios and overall safety benefits that are not as high as if they utilized a Systemic Approach. This drawback can be minimized by safety practitioners who analyze their entire roadway network, propose spot location fixes only at their highest crash locations, and utilize lower cost countermeasures wherever appropriate.

The Spot Location Approach to traffic safety is ideally implemented along with the Systemic Approach to provide the best combination of safety treatments. For instance, the Spot Location Approach can be applied at locations where low-cost countermeasures are not expected to be effective in significantly reducing future crashes or at those locations that have had low-cost countermeasures previously installed systemically but, after an assessment, continue to show a higher-than-average crash rate.

***Comprehensive Approach***

The Comprehensive Approach introduces the concept of the “5 E’s of Safety”: Education, Enforcement, Engineering, Emergency Response and Emerging Technologies. This approach recognizes that not all locations can be addressed solely by infrastructure improvements. Incorporating the “5 E’s of Safety” is often required to achieve marked improvement in roadway safety. For instance, some roadway segments will be identified for which targeted enforcement is an appropriate countermeasure. Some of the most common violations are speeding, failure-to-yield, red light running, aggressive driving, failure to wear safety belts, distracted driving, and driving while impaired. When locations are identified as having these types of violations, coordination with the appropriate law enforcement agencies is needed to deploy visible targeted enforcement to reduce the potential for future driving violations and related crashes. To improve safety, education and outreach efforts can also be used to supplement enforcement efforts. Enforcement and/or education can also be effectively utilized as short-term ways to address high crash locations, until the recommended infrastructure project can be implemented.

## 1.7 Our “Safety Challenge” for Local Agencies

Caltrans, FHWA and Safe Transportation Research and Education Center (SafeTREC) “challenge” local agencies to initially commit one or more days to understanding and applying the concepts and tools outlined in this manual. Experienced safety practitioners working in agencies currently using a proactive approach can quickly review the topics in the manual and consider/test some of the new tools (e.g., TIMS) identified within it. In contrast, novice safety practitioners may need several days to better understand the underlying concepts in this manual to be able to complete the basic elements of a proactive safety analysis of their roadway network. In these situations, the room for knowledge growth, internal process improvements, and expected safety benefits will be even greater, which should more than offset the additional time invested.

By utilizing this simple framework for identifying, analyzing and implementing a proactive approach for improving safety on their roadways, practitioners will have a better understanding of their agencies’ unique safety issues, the proven low-cost countermeasures that can reduce crashes, and the existing and future funding to implement the projects. This small investment of time will help local agencies achieve significant reductions in future fatalities, injuries and overall crashes. We believe these local agencies may also gain the added unexpected benefit of improved job satisfaction of those involved, as there are few more rewarding tasks than knowing that your efforts will result in future roadway users arriving safely at their destination instead of becoming statistics.

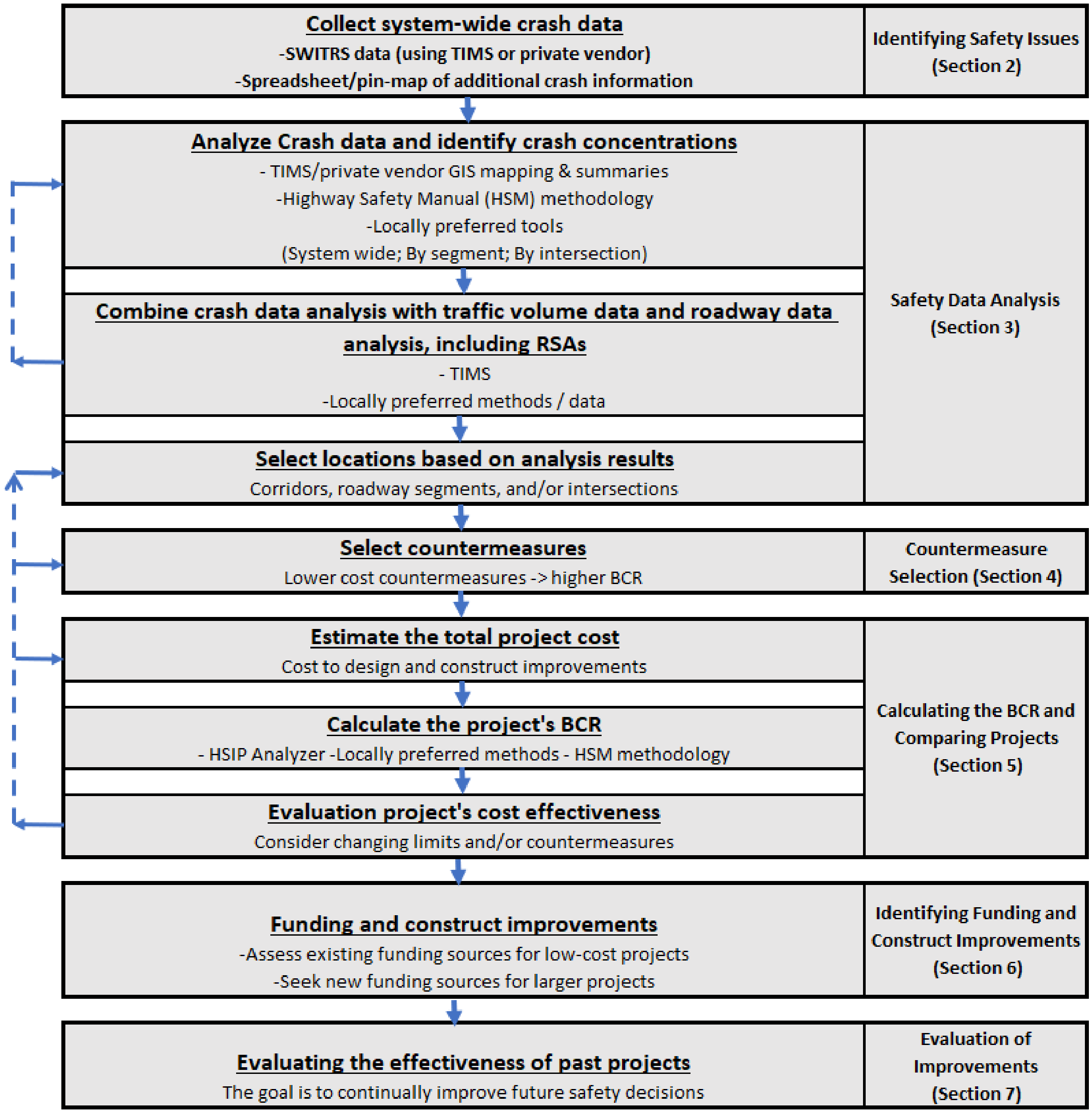
## 1.8 Summary of information in this Document

This document provides information on effectively identifying California's local roadway safety issues and the countermeasures that address them, ultimately leading to the effective implementation of safety projects that improve safety on local roadways. The document is not intended to be a comprehensive guide for roadway design and improvement or the only guide local agencies utilize for their safety analysis of their roadways.

Caltrans also expects this document will directly support its efforts in selecting local agency safety projects. The expectation is that as local agencies throughout the state utilize the proactive safety analysis approach outlined in this document, their applications for HSIP and ATP projects will include lower cost improvements at locations with the highest safety needs. This will improve Caltrans' data-driven approach to statewide project selection of safety projects and maximize the safety benefits across California.

The proactive safety analysis framework incorporated in this document is summarized in Figure 1.

**Figure 1: Local Roadway Safety: Proactive Safety Analysis Approach**



The above flowchart illustrates how each of the individual sections of this document work together to make up a proactive safety analysis approach. These sections are briefly outlined below:

**Section 2** of this manual provides an overview of the types of data to collect for the identification of roadway safety issues. It discusses sources of crash data and how they can be used.

**Section 3** summarizes the types of analyses that can be conducted to determine what roadway countermeasures should be implemented. This section is the link between the data (Section 2) and the selection of appropriate countermeasures (Section 4). It provides definitions and examples of the qualitative and quantitative factors that should be considered when evaluating roadway safety issues.

**Section 4** provides a description of selected countermeasures that have been shown to improve safety on local roads. It includes a basic set of strategies to implement at locations experiencing a history of crashes and their corresponding crash modification factors (CMF). The interrelationship between CMFs and Crash Reduction Factors (CRFs) are defined and used interchangeably throughout this document.

**Section 5** defines a methodology for calculating a B/C ratio for a potential safety project. It includes sources for estimating projected costs and benefits and the specific values/formulas Caltrans uses for its statewide evaluations of HSIP projects. This section also discusses the potential value in reevaluating projects' overall cost effectiveness at this point in the safety analysis, including: refining the project's costs and/or changing the mix of countermeasures and locations.

**Section 6** identifies existing and new funding opportunities for safety projects that local agencies should be considering. This section also briefly discusses some unique project development issues and strategies for safety projects as they proceed through design and construction.

**Section 7** presents the process to complete an evaluation of installed treatments. After the countermeasures are installed, assessing their effectiveness will provide valuable information and can help determine which countermeasures should continue to be installed on other roadways to make them safer as well as those that should be limited or discontinued.

**Appendix A** presents a flowchart of the HSIP Call-for-projects application process. This flowchart demonstrates how this document interacts with Caltrans Call-for-projects.

**Appendix B** contains Detailed Tables of countermeasures discussed in Section 4. This table includes detailed information about each countermeasure, including: where to use, why it works, general qualities (time, cost and effectiveness), crash type(s) addressed, crash reduction factor, and specific values for use in Caltrans HSIP calls-for-projects.

**Appendix C** includes a summary of "recommended actions" involved in a proactive safety analysis.

**Appendix D** contains the formulas used to calculate the B/C ratio of safety projects.

**Appendix E** presents TIMS tutorials that are available to assist local agencies in completing Caltrans call-for-projects application requirements and attachments. The tutorials include examples for Spot Location projects and systemic projects.

**Appendix F** presents a list of the abbreviations used in this document.

**Appendix G** presents a list of references.

# 2. Identifying Safety Issues

This document encourages local agency safety practitioners to proactively analyze their roadway networks with the intention of yielding the best overall safety benefits. When utilizing a proactive safety analysis approach, practitioners need to consider a wide range of data sources to get an overall picture of the safety needs.

There are a number of information sources that can be accessed to get a clearer picture of the roadway safety issues on the roadway network. These can be formal or informal sources, including:

Formal sources:

- State and local crash databases
- SafeTREC's TIMS website (or locally preferred mapping software)
- Law enforcement crash reports and citations
- Field assessments

Informal sources:

- Observational information from road maintenance crews, law enforcement, and first responders
- Citizen notification of safety concerns

Examining crash history will help practitioners identify locations with an existing roadway safety problem, and also identify locations that are susceptible to future roadway crashes. In addition to location identification, this data can provide information regarding crash causation that ultimately provides insight into identifying potentially effective countermeasures.

Emphasis on data-driven decisions is indicative of reliability and efficiency. The more reliable the data, the more likely the decisions regarding safety improvements will be effective. However, detailed, reliable crash data are not available in all areas. Under this circumstance, the practitioner should use the best available information and engineering judgment to make the best decisions. In an effort to mitigate these situations, UC Berkeley SafeTREC has developed the TIMS website, which includes GIS mapping tools to access fatal and injury crashes statewide. This site is now available to all California local agencies. See Section 2.2 for more details on TIMS.

It is generally accepted that at least 3 years, or preferably 5 years, of crash data be used for an analysis; additional years of crash data can provide better information. For low volume roadways and/or when only severe crashes are analyzed, more years of crash data may be necessary for an effective evaluation. Due to the randomness of crashes in a given year, a multi-year average of safety data will smooth outlier years of relatively high or low roadway crash rates. This concept is commonly referred to as "regression to the mean" and is critical in helping safety practitioners avoid making wrong inferences as they analyze their roadway network data. An example of this is an agency making a high-cost improvement at a location in response to one or two tragic crashes. The Highway Safety Manual (HSM) includes more details on regression to the mean and methods to reduce the random nature of crashes.

There are some circumstances where additional years of crash data may not always be advantageous. First, it's important for practitioners to recognize that as more years of crash data are used, they need to consider changes in traffic patterns, physical infrastructure, land use, and demographics that may affect their projection of future crashes. Second, if practitioners only focus on many years of past crash data, they could miss emerging safety issues and crash trends.  For these reasons, if practitioners sense one or more factors affecting crashes have changed or may be changing, they should consider looking at the crash data for the specific area on a yearly or 3-year moving average to expose any changes and crash trends that are occurring.

## 2.1 State and Local Crash Databases

California has a central repository for storing crash data called SWITRS, which stands for Statewide Integrated Traffic Records System. SWITRS is a comprehensive data source for doing roadway safety analysis that includes almost all public roads in the database except tribal roads which are currently not included. SWITRS information is available to California's local agencies, although many agencies have had difficulty identifying, extracting and utilizing their crash records from SWITRS. All California local agencies, especially those that currently have difficulty accessing and mapping crash data, are encouraged to utilize the SafeTREC TIMS website to access and map SWITRS data.

This document focuses on the SafeTREC TIMS website as a tool to access and map SWITRS data because TIMS is free to local agencies and the general public. At the same time, this document also acknowledges that TIMS currently does not offer some of the features currently available in some of the commercially available crash analysis software packages. For this reason, local agencies are encouraged to try TIMS, but they should not feel obligated to make a switch if they prefer using their vendor supplied crash analysis software. See section 2.2 for more details on TIMS.

Many agencies utilize one of several crash analysis software packages (e.g., Crossroads) to manage and access their crash records. Their use can be costly, but allows local road practitioners to identify locations with multiple roadway crashes, conduct an analysis that can produce predominant crash types, and identify associated roadway features that may have contributed. One drawback to agencies managing and updating their own individual databases is that the statewide database may become outdated and may not include the updated crash details like geo-coded locations. Agencies that manage and update their own individual databases are encouraged to share all updates, including any geo-coding information, with the SWITRS data managers at the California Highway Patrol. This will allow updated geo-coding and other crash features to be available on a statewide basis.

**Recommended Action:** Obtain at least 5 years of network-wide crash data to identify local roads that have a history of roadway crashes. This data will be used to identify predominant roadway crash locations, crash types and other common characteristics.

As practitioners gather formal and informal information relating to the safety of their roadway network, they are encouraged to develop one or more separate spreadsheets and/or pin-maps to help track and manage this data. (These spreadsheets/pin-maps should capture much of the data gathered in each of Sections 2.1 through 2.8). A spreadsheet and/or pin-map can serve as a database to help an agency identify locations and crash characteristics representing their greatest safety issues and guide them in identifying appropriate countermeasures.

The following spreadsheet is offered as an example, but each agency's spreadsheet should be reformatted to include data to meet their needs. Agencies should consider printing their spreadsheets on 'legal' or '11 x 17' paper for easy review of their data.

| | General Information | | Crash Information | | | Evaluation / Action | | |
|---|---|---|---|---|---|---|---|---|
| Location & Date | Source/Type of information | Safety Issue/Problem | Nature of Crashes | Time of Day | Weather/Traffic Conditions | Staff Evaluation | Recommend Action | Resolution |
| 1) Intersection "X" | | | | | | | | |
| 1) Feb 7, 2010 | Input from law enforcement | Clearance Intervals need adjustment | V1-WB V2-SB Side-swipe | 21:30 | Dry, Night, Free-flowing | R. Jones<br><br>2/26/10 | Increase all-red interval | Completed<br><br>2/26/10 |
| 1) Mar 9, 2010 | Citizen Complaint | Ped Crossing unsafe due to RT turns | N/A | N/A | N/A | R. Jones 3/12/10 | No RT on Red (Need study) | |
| 2) Intersection "Y" | | | | | | | | |
| 2) | | | | | | | | |
| | | | | | | | | |
| 3) Roadway Segment (PM 5.3 to PM 7.8) | | | | | | | | |
| PM 6.4 to 6.8 Sep 29, 2011 | Maintenance data | Extensive skid marks. Speed of Travel? | General WB: ROR | N/A | Dry Free-flowing | J. Smith 10/1/11 | High Friction Overlay | Preparing HSIP App. |
| PM 7.1 Jan 5, 2011 | Input from law enforcement | Stop Sign missing | N/A | N/A | N/A | J. Smith 1/5/11 | Informed Maintenance | New sign 1/5/11 |

An example of a pin-map, which could be modified to capture much of the data gathered in Section 2, is shown in the following section as part of the TIMS output.

## 2.2 Transportation Injury Mapping System (TIMS)

The Safe Transportation Research and Education Center (SafeTREC) at the University of California, Berkeley, has developed a powerful website with tools for California's local agencies to gather data for their safety analyses. Their Transportation Injury Mapping System (TIMS) website provides safety practitioners with California crash data (SWITRS, i.e. Statewide Integrated Traffic Records System) and collision mapping and analysis tools. California local agencies are encouraged to utilize TIMS at: https://tims.berkeley.edu/

Site Features:

- Applications to query map and download geo-referenced SWITRS data.
- Summary tables based on data included in SWITRS individual crash reports. These summary tables can be generated based on specified data fields or spatial limits.
- Virtual field review by connecting the crash location to Google maps and Google Street View, allowing the examination of the existing roadway infrastructure and dimensions.
- A 'Help Tab' that provides step-by-step instructions.

Please note that SafeTREC is not able to incorporate all SWITRS crashes into TIMS due to poor crash location descriptions in the crash reports. Currently, TIMS includes the majority of California fatal and injury crashes but does not include Property Damage Only collisions.

**Recommended Action:** Consider augmenting your local agency's data collection approach with information available using the suite of TIMS tools. The TIMS tools (and/or purchased software applications) can help the safety practitioner complete or assist with each of the actions in Sections 2.1 through 2.8. This website includes several tutorials specifically designed to support the individual sections of this document. Local practitioners may find the TIMS output files as a great starting point to build their tracking spreadsheet discussed in the recommendation of Section 2.1.

## 2.3 Law Enforcement Crash Reports

Both State and local law enforcement officials can be an important source of roadway crash data. The actual law enforcement crash reports can be valuable in identifying the location and contributing circumstances to roadway crashes (e.g., did the highway hardware and features operate as intended: end treatment worked, no barrier in the passenger compartment, pavement not slippery when wet, signs visible, signal timing, etc.). The following variables can and should be extracted and compiled from the crash reports:

- Location
- Date and time
- Crash type
- Crash severity
- Weather conditions
- Lighting conditions
- Sequence of events and most harmful events
- Contributing circumstances
- Driver Variables: age of driver, DUIs, use of seat belt, etc.

Similar to the crash database, the information in the crash reports can be used to assist in the identification of potential infrastructure and non-infrastructure safety treatments and the deployment approach.

**Recommended Action:** Develop a working relationship with law enforcement officials responsible for enforcement and crash investigations. This could foster a partnership where sharing crash reports and safety information on problem roadway segments becomes an everyday occurrence. Practitioners with limited access to crash data are encouraged to use TIMS to assess the local crash report data.

## 2.4 Observational Information

Law enforcement officers, local agency maintenance crews, and Emergency Medical Services personnel can serve as valuable resources to identify problem areas. Since they travel extensively on local roads, they can continuously monitor roads for actual or potential problems (e.g., poor delineation, fixed objects near the roadway, missing signs, signs of vehicles leaving the road). Law enforcement observations of driver behavior and roadway elements can provide valuable information to the local road agency. Additionally, law enforcement officers are sometimes aware of problem areas based on citations written, even if crashes related to the violations have not yet occurred. Road maintenance crews may keep logs of their work, including sign and guardrail replacements, debris removal, and edge drop-off repairs. These logs can provide supplemental information about crashes and HCCLs that may not have been reported to law enforcement. Finally, Emergency Medical Service Crash Reports can provide an entirely different perspectives and set of observations relating to crash occurrences.

Information obtained from road maintenance crews, law enforcement officers, and Emergency Medical Services personnel can help support all three methods of implementation approaches: Spot Location treatments, systemic deployments, and the Comprehensive Approach. Often, traffic violations such as speeding and impaired driving lend themselves to education and enforcement solutions to address these behaviors and supplement the intended infrastructure countermeasures.

**Recommended Action:** Add information received from law enforcement, road maintenance crew, and Emergency Medical Service observations to the agency's tracking spreadsheet and/or pin-maps. Develop a system for maintenance crews to report and record observed roadway safety issues and a mechanism to address them.

## 2.5 Public Notifications

Occasionally, when unsafe situations are observed, local citizens may notify the local government by email, letter, telephone, or at a public meeting. Information identifying safety issues on local roads may also come from community or regional newspapers, newsletters, correspondence, and from local homeowner and neighborhood associations. These sources can serve as indicators that a safety issue may exist and may warrant further review and analysis to determine the extent of the issues. Citizen reports can be tracked along with official crash data; however, safety practitioners should not regard these reports as factual, unless proven by other methods. Local safety databases should only contain objective and verifiable data.

**Recommended Action:** Review and summarize information received from these sources, identifying segments or corridors with multiple notifications and record the locations, dates, and nature of the problem that are cited. Add information received from public notifications to tracking spreadsheets and/or pin-maps once confirmed.

## 2.6 Roadway Data and Devices

It is also valuable to obtain information about the existing roadway infrastructure. Currently, many local agencies have few of their roadway characteristics in a database. For these agencies, the establishment of a roadway database could be a long-term goal. The following roadway characteristics are often used to assist practitioners in safety analyses of roadway segments:

- Roadway surface (dirt, aggregate, asphalt, concrete)
- Roadway geometry (horizontal, vertical, flat)
- Lane information (number, width)
- Shoulder information (width, type)
- Median (type, width)
- Traffic control devices present (signs, pavement marking, signals, rumble stripes etc.)

- Roadside safety hardware (e.g., guardrail, crash cushions, drainage structures)

The TIMS site, described in Section 2.2, can provide safety practitioners with much of this roadway data virtually by using Google Maps and Google Street View. By utilizing TIMS (and/or private for-profit vendors), safety practitioners can save hours and even days of driving during the initial steps in the safety analysis of their network. Once agencies start to define individual safety projects for funding and future construction, actual field reviews are needed to ensure a complete understanding of the project location and context.

As local practitioners gather information about their existing roadway infrastructure, they need to determine whether it complies with the minimum standards for signs, breakaway supports, signals, pavement markings, protective barriers, etc. Practitioners should use the most current *California - Manual on Uniform Traffic Control Devices* (CA-MUTCD), which provides the minimum standard requirements for traffic control devices on all public streets, highways, bikeways, and private roads open to public travel.[6] In addition to ensuring compliance with the MUTCD, geometric standards for sight distance, curve radius, and intersection skew angle and roadway standards for lane width, shoulder width, clear recovery zone, and super-elevation should also be evaluated.

Roadway information can be combined with crash data to help local practitioners identify appropriate locations and treatments to improve safety. For example, if a local rural segment is experiencing a high number of horizontal curve-related crashes, analysis of the inventory of roadway elements could reveal that the roadway does not have sufficient signage installed in advance of many of those curves to give motorists warning of the pending change in roadway geometry.

**Recommended Action:** Identify and track roadway characteristics for the intersections, roadway segments, and corridors, including compliance with the minimum standards. At a minimum, this should be done for locations being considered for safety improvements, but ideally agencies would establish an extensive database of roadway data to help them proactively identify high risk roadway features.

## 2.7 Exposure Data

The number of crashes can sometimes provide misleading information about the most appropriate locations for treatment. Introducing exposure data helps to create a more effective comparison of locations. Exposure data provides a common metric to the crash data so roadway segments and intersections can be compared more appropriately, helping local agencies prioritize their potential safety improvements.

The most common type of exposure data used on roadway segments is traffic volume. Ideally, volume would be broken down by pedestrians, bicycles, cars, motorcycles, and large trucks. A count of the number of vehicles and non-motorized users can provide information for comparison. For example, if two roadway segments have the same number of crashes but different traffic volumes, the segment with fewer vehicles (i.e., less exposure) will have a higher crash rate, meaning that vehicles were more likely to experience a crash along that roadway segment. In situations where traffic volume is not available, segment length or population can serve as an effective exposure element for comparison.

**Recommended Action:** Consider the availability of exposure data and track it along with the other crash data to help prioritize potential locations for safety improvements.

## 2.8 Field Assessments and Road Safety Audits

Local road practitioners should always consider conducting field assessments in conjunction with their collection of crash data to help identify problem locations. An assessment can be as informal as driving, walking or virtually viewing the road network looking for evidence of roadway crashes. Ideally, informal field assessments are to be performed by multidisciplinary teams that include a traffic safety expert, law enforcement personnel, and others. The team can visit several sites and document evidence of crashes or deficiencies on the roadway or roadside, including: damaged trees or fences, skid marks, ruts on the shoulder, car parts on the shoulder, and/or pavement drop-offs. This information, along with observations of actual driver-behavior, can be used to develop recommendations for improvement.

Field reviews can also be more formalized such as in conducting a Road Safety Audit (RSA). A RSA is a formal safety performance examination of an existing or future road by an independent, multidisciplinary team. The team examines and reports on existing or potential road safety issues and identifies opportunities for safety improvements for all road users. Agencies considering RSAs for the first time are encouraged to consider requesting support from FHWA. For more information on FHWA's free RSA support, go to their website at: http://safety.fhwa.dot.gov/rsa/.

Informal field assessments and more formal RSAs provide an opportunity for local safety practitioners to gather and summarize all of the information sources discussed in Section 2. They can also be used to identify potential project delivery obstacles. The field assessments/RSAs should identify major environmental, right-of-way, infrastructure, and operational issues that need to be considered when applying countermeasures.

**Recommended Action:** Consider completing formal or informal field assessments and RSAs at certain locations to help ensure all relevant information is collected and available for the safety practitioners to complete their safety analysis and identify the most appropriate countermeasures. It's recommended that local agencies develop simple straightforward criteria on when one of these will be undertaken. The information gathered during the assessments should be added to the agency's tracking spreadsheet, as discussed in section 2.

# 3. Safety Data Analysis

Proactive safety analysis will assist in making informed decisions on the type, deployment levels, and locations for safety countermeasures. This builds on the previous discussions on information sources that identify safety issues. 'Safety Data Analysis' is one of the most critical steps in an agency's overall proactive safety analysis approach. Ideally, agencies regularly analyze the safety data for their entire roadway networks to identify and prioritize the locations with the most severe safety issues. This step is often skipped by agencies reacting to a recent tragic crash and the corresponding public outcry, which may leave their most critical safety locations undetected.

As agencies analyze their safety data, they will need to select the implementation approach that most effectively address the safety issues identified; Systemic Approach, Spot Location Approach, Comprehensive Approach, or a combination of these approaches. For example, if a high number of crashes are occurring at a particular curve or along a short segment of roadway, a spot treatment may be appropriate. However, systemic treatment of multiple locations experiencing similar crash types may be necessary and most beneficial for reducing overall fatalities and injuries. These implementation approaches were described in Section 1.5. With all of the approaches, safety practitioners should be looking for patterns in the crash data and not just the total number of crashes. These patterns include: types of crashes, severity of crashes, mode of travel, pavement conditions, time of day, etc. Identifying and analyzing the patterns in the crash data will help ensure the most appropriate countermeasure is selected and the safety problems are effectively addressed.

## 3.1 Quantitative Analysis

Crash data analysis is used to determine the extent of the roadway safety issues, the priority for application of scarce resources, and the selection of appropriate countermeasures. The two main quantitative analysis methods for roadway crashes are crash frequency and crash rate.

**Crash Frequency**

Crash frequency is defined as the number of crashes occurring within a determined study area. A practitioner can determine crash volumes using methods discussed in Section 2, including: State crash database (SWITRS), TIMS, local agency crash databases, law enforcement crash reports, pin-maps, etc. The practitioner should analyze the data to identify locations and crash characteristics with the highest frequency. There are numerous methods to assist practitioners in this process. Each agency will have their own preferred methods for initially selecting their top priority locations. The following are a few examples of the methods used to determine Crash Frequency:

- Summarize the crashes by attributes such as type, severity and location to identify patterns in the crash data and the most significant problem locations.
    - Top 10 (or 20) lists of intersections and roadway segments. It is common to weight more severe crashes higher in this process.

- Spatially display the sites on a pin-map or a GIS software package.
  - For small or rural agencies with lower volume roadways, network-wide pin-maps may be all that is needed to identify the highest priority locations.
- Develop collision diagrams showing the direction of movement of vehicles, types of crashes, and pedestrians involved in the crashes.

As stated earlier, this manual acknowledges many local agency safety practitioners may have their preferred methods for completing these analyses. For those agencies that do not and for those willing to try something new, Caltrans recommends using the TIMS website along with the processes outlined in this document to complete these analyses.

Once the crash frequency information is collected and displayed, the practitioner can complete a methodical analysis by geographic area, route, or a cluster analysis to determine which locations have experienced a high or moderate level of crashes. The resulting crash information can be further analyzed for recurring patterns or events. As agencies consider their locations with high levels of crashes, they should understand the overall random nature of crashes and the concept of "regression to the mean", as discussed in Section 2. Otherwise, if the natural variations in crash occurrence are not accounted for, a site might be selected for study when the number of crashes is randomly high, or overlooked when the number of crashes is randomly low.

**Crash Rate**

Crash rate analysis can be a useful tool to determine how a specific roadway or segment compares with similar roadway types on the network. A simple count of the number of crashes can be inadequate when comparing multiple roadways of varying lengths and/or traffic volume. Local agencies are also encouraged to compare their crashes with those occurring in similar areas around the state; doing so will help in determining just how severe the number and types of crashes are in the local area. When working with limited budgets, Crash Rates are often used to prioritize locations for safety improvements that will achieve the greatest safety benefits with limited resources. Where traffic volume data is unavailable, other information can be used to provide exposure information. One often-used factor is the length of the roadway segment on each route studied. Comparing the number of roadway crashes per mile or per intersection can help an agency identify potential opportunities to improve safety. The FHWA Roadway Departure Safety and Intersection Safety manuals include the following formulas for calculating crash rates on roadway segments and intersections:

The crash rate for crashes on a roadway is calculated as:

**R = (C x 100,000,000) / (V x 365 x N x L)**

Where:

R = Crash rate for the road segment expressed as crashes per 100 million vehicle-miles of travel,
C = Total number of crashes in the study period
V = Traffic volumes using Average Annual Daily Traffic (AADT) volumes
N = Number of years of data
L = Length of the roadway segment in miles

The crash rate for crashes at an intersection is calculated as:

**R = (1,000,000 x C) / (365 x N x V)**

Where:

R = Crash rate for the intersection expressed as crashes per million entering vehicles (MEV)
C= Total number of intersection-related crashes in the study period
N = Number of years of data
V = Traffic volumes entering the intersection daily

Similar to Crash Frequency, there are numerous methods for local safety practitioners to utilize Crash Rate in their safety data analysis and each will have their own preferred methods for initially selecting their top priority locations. The following are a few examples:

- Top 10 (or 20) lists of roadway segments with the highest crashes in relationship to roadway length, traffic volumes, and/or population density.
- Top 10 (or 20) lists of intersections, sorted by crash rate.
- Top 10 (or 20) lists of the highest volume intersections, sorted by crash frequency or rate.

Even though crash frequency and crash rate are helpful for local agency safety practitioners to effectively rank their most critical locations for improvements, the lack of reliable statewide traffic volumes for all roadway types precludes Caltrans from using the crash rate methodology in their statewide project scoring and ranking processes for the HSIP (discussed in more detail in Section 5).

**Recommended Action:** Complete a quantitative analysis of the roadway data using both Crash Frequency and Crash Rate methodologies. Safety practitioners should look for patterns in the crash data, including: types of crashes, severity of crashes, mode of travel, pavement conditions, roadway characteristics, time of day, intersection control, etc.

## 3.2 Qualitative Analysis

Qualitative analysis considers the physical characteristics of the roadway network, through the examination of maps, photographs, and field assessments. Certain roadway infrastructure characteristics relate to design standard and compliance issues and should continually be identified and upgraded on a network-wide basis (e.g., signing and pavement delineation characteristics relating to CA-MUTCD compliance as discussed in more detail below). Other roadway characteristics are more important as they relate to locations with high crash frequencies and rates (e.g., well defined pedestrian paths crossing the roadway or a high number of utility poles/fixed objects adjacent to the edge of travel way). All of these characteristics should to be accounted for in an agency's proactive safety analysis.

**Ensuring Compliance with CA-MUTCD and Design Standards**

It is important for local agencies to continually evaluate their roadways for compliance with the minimum safety standards. The CA-MUTCD provides the minimum standard requirements for traffic control devices on all public streets, highways, bikeways, and private roads open to public travel. In addition to ensuring compliance with the CA-MUTCD, geometric standards should be evaluated as they relate to sight distance, curve radius, and intersection skew angle and roadway standards for lane width, shoulder width, clear recovery zone, and super-elevation. Many local agencies have their own specific roadway design standards, while others rely on Caltrans' Highway Design Manual[7], FHWA's "Green Book" policy manual[8] and PEDSAFE guide[9], and AASHTO's Roadside Design Guide[10]. If the traffic control devices or roadway geometry are not in compliance, appropriate devices/countermeasures should be installed. Non-compliance is an important consideration that can affect road safety and may have liability implications for a jurisdiction. Using CA-MUTCD compliant devices results in uniformity among California roadways and serves to meet road user expectations.

**Field Assessments**

While the qualitative analysis of compliance issues should continually occur on a network-wide basis, a qualitative analysis should also occur for each of the locations and corridors identified as a result of a 'Quantitative Analysis'. The consideration of roadway infrastructure characteristics in conjunction with crash frequency or crash rate gives a more complete picture of overall safety and should be used in an agency's identification and prioritization process for locations needing safety improvements. The qualitative assessment of HCCLs can be completed through the examination of maps and photographs, but the importance of in-field assessments by multi-disciplinary teams should not be underestimated. In some cases, field reviews of all potential project locations may not be practical, so safety practitioners are encouraged to utilize internet-mapping tools to view maps and photographs and virtually visit these sites from their offices.

Actual field visits or RSAs can be done at the highest priority locations before or during the countermeasure selection process. In many cases, field assessments are often the only way for practitioners to identify potential countermeasure implementation and project delivery obstacles. Without in-field assessments, right-of-way, infrastructure, and operational constraints can be overlooked, including: sensitive environmental resources (widening may not be feasible next to wetlands), roadway users (rumble strips may not be feasible on roadways with high bicycle volumes and narrow shoulders), or nearby roadway stakeholders (flashing beacons may be problematic for adjacent residents.) Assessments can provide critical information for local practitioners as they prioritize their crash locations and select countermeasures with the greatest potential for cost effective deployment.

**Recommended Action:** Incorporate qualitative analysis elements into agency's proactive analysis approach. Consider completing field assessments and RSAs to identify locations with roadway infrastructure characteristics that relate to both compliance issues and high crash frequencies/rates. As part of field assessments, common roadway and crash characteristics should be identified for the potential systemic deployment of countermeasures. Rather than reviewing all crash sites individually, agencies may find the use of Internet mapping tools offers significant time savings. For agencies without a preferred virtual field review method, the SafeTREC TIMS website automatically links the SWITRS crash locations to Google Maps and Google Street View.

Caltrans recommends all agencies complete both quantitative and qualitative analyses before starting their applications for HSIP program funding. The findings from these analyses should be documented in spreadsheets and/or pin-maps similar to the ones discussed in Section 2.

# 4. Countermeasure Selection

Once locations and crash problems are identified as illustrated in Sections 2 and 3, the safety practitioners will need to select the set of proposed safety improvements to reduce the likelihood of future crashes. Individual elements of standard safety improvements are referred to as countermeasures and most countermeasures have corresponding Crash Modification Factors (CMFs).

When applied correctly, CMFs can help agencies identify the expected safety impacts of installing various countermeasures to reduce crashes. CMFs are multiplicative factors used to estimate the expected number of crashes after implementing a given countermeasure at a specific site (the lower the CMF, the greater the expected reduction in crashes). Crash Reduction Factors (CRFs) are directly connected to the CMFs and are another indication of the effectiveness of a particular treatment, measured by the percentage of crashes the countermeasure is expected to reduce. The CRF for a countermeasure is defined mathematically as (1 – CMF) (the higher the CRF, the greater the expected reduction in crashes). *NOTE: Given that CRF values can be more intuitive when analyzing roadways for potential "reductions" in crashes; this document shows CRF values in the countermeasure tables. The terms CMFs and CRFs are used interchangeably throughout the text of this section and in other sections of this document.*

In an effort to stretch the limited highway safety funding, local transportation agencies are encouraged to identify and implement the optimal combination of countermeasures to achieve the greatest benefits. Combined with crash cost data and project cost information, CRFs can help safety practitioners compare the B/C ratio of multiple countermeasures and then choose the most appropriate application for their proposed safety improvement projects.

As agencies consider the overall scope/cost of their projects, they also need to consider the number of locations to which each countermeasure may be applied in order to maximize the B/C ratio and the overall effectiveness of their limited safety funding. For HCCLs with varying causes, the Spot Location Approach may be the most appropriate. In contrast, the Systemic Approach should be considered where a high proportion of similar crash types tend to occur at locations that share common geometric or operational elements. In these situations, installing the same low-cost safety countermeasure at multiple locations can increase the cost effectiveness of the safety improvement, allowing an increased number of treatments to be applied.

It is important to note that there are many safety issues and corresponding countermeasures that are more "maintenance" in nature (e.g., visibility issues relating to the need for brush clearing and roadway departure issues relating to the need to replace shoulder backing). As these issues are identified when investigating crash locations, it's expected that the local safety practitioners would take the necessary steps to remedy the situation in the short-term. For this reason, most of the common maintenance-type safety countermeasures are not included in this document.

## 4.1 Selecting Countermeasures and Crash Modification Factors / Crash Reduction Factors

Selecting an appropriate countermeasure and corresponding CMF is similar to choosing the right tool for a job. In some cases, a countermeasure and CMF may not be perfect, but will still work well enough to get the job done by providing a reasonable estimation of the countermeasure's effect. In other cases, using an improper countermeasure or CMF may do more harm than good. Applying a CMF that does not fit a specific situation may give a false sense of the countermeasure's safety effectiveness and may result in an increased safety problem.

The Federal Highway Administration (FHWA) is leading a concerted effort to develop information on CMFs and makes it available to State and local agencies to assist with highway safety planning. The CMF Clearinghouse, a free online database introduced in 2009 and accessible at http://www.cmfclearinghouse.org/, details the varying quality and reliability of CMFs available to transportation professionals.

FHWA has identified three main considerations to assure appropriate selection of CMFs for a given countermeasure: the **availability** of relevant CMFs, the **applicability** of available CMFs, and the **quality** of applicable CMFs. The following sections detail these considerations and describe how Caltrans recommended CRF and service life values meet these criteria.

**Availability:** The availability of a CMF that applies to a specific situation depends on whether research has been conducted to determine the safety effects of a particular countermeasure or combination of countermeasures, and whether researchers have documented it. The CMF Clearinghouse contains more than 2,900 CMFs and receives quarterly updates to include the latest research.

At this point, Caltrans has established a small subset of 82 countermeasures and a single CRF for each of these countermeasures that must be used when submitting applications for Caltrans statewide calls-for-projects. This methodology allows for a statewide data-driven process that facilitates a fair and accurate comparison of project applications. (The reason for limiting the number of countermeasures is further explained below under "applicability").

**Applicability:** In general, once a local safety practitioner determines that one or more CMFs exist for a specific countermeasure, the next step is to determine which CMF is the most applicable. Applicability depends on how closely the CMF represents the situation to which it will be applied. Safety practitioners should evaluate the potentially applicable CMFs, eliminating any that are not appropriate for the situation. Practitioners should only choose the most appropriate CMFs for their specific project based on factors including but not limited to: urban areas vs. rural areas; low vs. high traffic volumes; 2-lane vs. 6-lane roadways; individual vs. combination treatments; signalized vs. non-signalized intersections; and minor crashes vs. fatal crashes. If practitioners choose to use a CMF outside the range of applicability, the safety effect will likely be over or underestimated.

The mix of countermeasures and CRFs included in this document is intended to meet Caltrans' goal for a data-driven award process for local agencies to follow that allows for a fair and accurate comparison of project applications. Where possible and appropriate, the CRF value intended for use in statewide calls-for-projects is based on research studies that specifically established the CRF to be used for 'all' project areas, roadway types, and traffic volumes. Where not all applicability factors have already been established by prior research, Caltrans worked closely with FHWA to approximate CRFs for countermeasures often utilized by local agencies.

**Quality:** Often a search of the CMF Clearing House results in multiple CMFs for the same countermeasure. A practitioner needs to examine the quality of each CMF. The quality of a CMF can vary greatly depending on several factors associated with the process of developing the CMF. The primary factors that determine the quality of a CMF are the study design, sample size, standard error, potential bias, and data source. The CMF Clearinghouse provides a star rating for each based on a scale of 1 to 5, where 5 indicates the highest quality. The most reliable CMFs in the HSM are indicated with a bold font.

Wherever possible, the CRFs included in this document are based on research that has a CMF Clearinghouse star rating of 3 or more. For countermeasures that do not have corresponding research of a star rating of 3 or more but were deemed important to provide flexibility to local practitioners, Caltrans worked closely with FHWA to establish CRFs based on the best available research.

## 4.2 List of Countermeasures

The list of countermeasures discussed in this section is not an all-inclusive list, and only includes those available in the Caltrans' HSIP Cycle 12 Call-for-projects. Only thoroughly researched countermeasures with a readiness to be applied by local agencies on a statewide basis are utilized. In addition, the California Local HSIP program places further restrictions on the eligibility of some countermeasures to meet the most critical needs on California local roadways. Practitioners are encouraged to utilize the FHWA CMF Clearinghouse for a more comprehensive list as they establish their local agency specific set of proposed improvements and prioritize their projects.

The countermeasures listed in the following three tables have been sorted into 3 categories: Signalized Intersection, Non-Signalized Intersection, and Roadway Segment. Pedestrian and bicycle related countermeasures have been included in each of these categories, as the consideration of non-motorized travel is important for all roadway classifications and locations. The countermeasures included in these tables are also used in the HSIP Analyzer. When selecting countermeasures and CMFs to apply to their specific safety needs, local agency safety practitioners should consider the **availability, applicability**, and **quality** of CMFs, as discussed in section 4.1.

Only Crash Types, CRFs, Expected Lives, and HSIP Funding Eligibility of the countermeasures for use in Caltrans local HSIP program are provided in this section. Fields in the countermeasure tables are:

- **Crash Types -** "All", "P & B" (Pedestrian and Bicycle), "Night", "Emergency Vehicle", or "Animal".
- **CRF -** Crash Reduction Factor used for HSIP calls-for-projects.
- **Expected Life -** 10 years or 20 years.
- **Funding Eligibility –** the maximum HSIP reimbursement ratio for HSIP Cycle 12 Call-for-projects.
  - Eighty-one (85) countermeasures: 90%
  - One (1) countermeasure: 50% (CM No. SI03: Improve signal timing, as this CM will improve the signal operation rather than merely the safety.)
- **Systemic Approach Opportunity -** Opportunity to Implement Using a Systemic Approach: "Very High", "High", "Medium" or "Low".

The list of countermeasures presented in this section is intended to be a quick-reference summary. Appendix B of this manual provides more details on each of these countermeasures including Where to use, Why it works, General Qualities (Time, Cost and Effectiveness), and information from FHWA CMF Clearinghouse (Crash Types Addressed and range of Crash Reduction Factor).

**Recommended Action:** At this point, agencies should use all information and results obtained by completing the actions in Sections 2, 3 and 4 to select the appropriate countermeasures for their HCCLs and systemic improvements. As novice safety practitioners select countermeasures, they must realize that a reasonable level of traffic 'engineering judgment' is required and that this manual should not be used as a simple cheat-sheet for preparing and submitting applications for funding.

**Table 1. Countermeasures for Signalized Intersections**

| No. | Type | Countermeasure Name | Crash Type | CRF | Expected Life (Years) | HSIP Funding Eligibility | Systemic Approach Opportunity? |
|---|---|---|---|---|---|---|---|
| SI01NT | Lighting | Add intersection lighting (S.I.) | Night | 40% | 20 | 90% | Medium |
| SI02 | Signal Mod. | Improve signal hardware: lenses, back-plates with retroreflective borders, mounting, size, and number | All | 15% | 10 | 90% | Very High |
| SI03 | Signal Mod. | Improve signal timing (coordination, phases, red, yellow, or operation) | All | 15% | 10 | 50% | Very High |
| SI04EV | Signal Mod. | Install emergency vehicle pre-emption systems | Emergency Vehicle | 70% | 10 | 90% | High |
| SI05 | Signal Mod. | Install left-turn lane and add turn phase (signal has no left-turn lane or phase before) | All | 55% | 20 | 90% | Low |
| SI06 | Signal Mod. | Provide protected left turn phase (left turn lane already exists) | All | 30% | 20 | 90% | High |
| SI07 | Signal Mod. | Convert signal to mast arm (from pedestal-mounted) | All | 30% | 20 | 90% | Medium |
| SI08 | Operation/ Warning | Install raised pavement markers and striping (Through Intersection) | All | 10% | 10 | 90% | Very High |
| SI09 | Operation/ Warning | Install flashing beacons as advance warning (S.I.) | All | 30% | 10 | 90% | Medium |
| SI10 | Operation/ Warning | Improve pavement friction (High Friction Surface Treatments) | All | 55% | 10 | 90% | Medium |
| SI11 | Geometric Mod. | Install raised median on approaches (S.I.) | All | 25% | 20 | 90% | Medium |
| SI12PB | Geometric Mod. | Install pedestrian median fencing on approaches | P & B | 35% | 20 | 90% | Low |
| SI13 | Geometric Mod. | Create directional median openings to allow (and restrict) left-turns and u-turns (S.I.) | All | 50% | 20 | 90% | Medium |
| SI14 | Geometric Mod. | Install right - turn lane (S.I.) | All | 15% | 20 | 90% | Medium |
| SI15 | Geometric Mod. | Reduced Left-Turn Conflict Intersections (S.I.) | All | 50% | 20 | 90% | Medium |
| SI16RA | Geometric Mod. | Convert intersection to roundabout (from signal) | All | Varies | 20 | 90% | Low |
| SI17RA | Geometric Mod. | Convert intersection to compact roundabout (from signal) | All | Varies | 20 | 90% | Low |
| SI18PB | Ped and Bike | Install pedestrian countdown signal heads | P & B | 25% | 20 | 90% | Very High |
| SI19PB | Ped and Bike | Install pedestrian crossing (S.I.) | P & B | 25% | 20 | 90% | High |
| SI20PB | Ped and Bike | Pedestrian Scramble | P & B | 40% | 20 | 90% | High |
| SI21PB | Ped and Bike | Install advance stop bar before crosswalk (Bicycle Box) | P & B | 15% | 10 | 90% | Very High |
| SI22PB | Ped and Bike | Modify signal phasing to implement a Leading Pedestrian Interval (LPI) | P & B | 60% | 10 | 90% | Very High |

**Table 2. Countermeasures for Non-Signalized Intersections**

| No. | Type | Countermeasure Name | Crash Type | CRF | Expected Life (Years) | HSIP Funding Eligibility | Systemic Approach Opportunity? |
|---|---|---|---|---|---|---|---|
| NS01NT | Lighting | Add intersection lighting (NS.I.) | Night | 40% | 20 | 90% | Medium |
| NS02 | Control | Convert to all-way STOP control (from 2-way or Yield control) | All | 50% | 10 | 90% | High |
| NS03 | Control | Install signals | All | 30% | 20 | 90% | Low |
| NS04RA | Control | Convert intersection to roundabout (from all way stop) | All | Varies | 20 | 90% | Low |
| NS05RA | Control | Convert intersection to roundabout (from stop or yield control on minor road) | All | Varies | 20 | 90% | Low |
| NS06RA | Control | Convert intersection to compact roundabout (from all way stop) | All | Varies | 20 | 90% | Medium |
| NS07RA | Control | Convert intersection to compact roundabout (from stop or yield control on minor road) | All | Varies | 20 | 90% | Medium |
| NS08 | Operation/ Warning | Install/upgrade larger or additional stop signs or other intersection warning/regulatory signs | All | 15% | 10 | 90% | Very High |
| NS09 | Operation/ Warning | Upgrade intersection pavement markings (NS.I.) | All | 25% | 10 | 90% | Very High |
| NS10 | Operation/ Warning | Install Flashing Beacons at Stop-Controlled Intersections | All | 15% | 10 | 90% | High |
| NS11 | Operation/ Warning | Install flashing beacons as advance warning (NS.I.) | All | 30% | 10 | 90% | High |
| NS12 | Operation/ Warning | Install transverse rumble strips on approaches | All | 20% | 10 | 90% | High |
| NS13 | Operation/ Warning | Improve sight distance to intersection (Clear Sight Triangles) | All | 20% | 10 | 90% | High |
| NS14 | Operation/ Warning | Improve pavement friction (High Friction Surface Treatments) | All | 55% | 10 | 90% | Medium |
| NS15 | Geometric Mod. | Install splitter-islands on the minor road approaches | All | 40% | 20 | 90% | Medium |
| NS16 | Geometric Mod. | Install raised median on approaches (NS.I.) | All | 25% | 20 | 90% | Medium |
| NS17 | Geometric Mod. | Create directional median openings to allow (and restrict) left-turns and u-turns (NS.I.) | All | 50% | 20 | 90% | Medium |
| NS18 | Geometric Mod. | Reduced Left-Turn Conflict Intersections (NS.I.) | All | 50% | 20 | 90% | Medium |
| NS19 | Geometric Mod. | Install right-turn lane (NS.I.) | All | 20% | 20 | 90% | Low |
| NS20 | Geometric Mod. | Install left-turn lane (where no left-turn lane exists) | All | 35% | 20 | 90% | Low |
| NS21PB | Ped and Bike | Install raised medians / refuge islands (NS.I.) | P & B | 45% | 20 | 90% | Medium |
| NS22PB | Ped and Bike | Install pedestrian crossing at uncontrolled locations (new signs and markings only) | P & B | 25% | 10 | 90% | High |
| NS23PB | Ped and Bike | Install/upgrade pedestrian crossing at uncontrolled locations (with enhanced safety features) | P & B | 35% | 20 | 90% | Medium |
| NS24PB | Ped and Bike | Install Rectangular Rapid Flashing Beacon (RRFB) | P & B | 35% | 20 | 90% | Medium |
| NS25PB | Ped and Bike | Install Pedestrian Signal (including Pedestrian Hybrid Beacon (HAWK)) | P & B | 55% | 20 | 90% | Low |

**Table 3. Countermeasures for Roadways**

| No. | Type | Countermeasure Name | Crash Type | CRF | Expected Life (Years) | HSIP Funding Eligibility | Systemic Approach Opportunity? |
|---|---|---|---|---|---|---|---|
| R01NT | Lighting | Add segment lighting | Night | 35% | 20 | 90% | Medium |
| R02 | Remove/ Shield Obstacles | Remove or relocate fixed objects outside of Clear Recovery Zone | All | 35% | 20 | 90% | High |
| R03 | Remove/ Shield Obstacles | Install Median Barrier | All | 25% | 20 | 90% | Medium |
| R04 | Remove/ Shield Obstacles | Install Guardrail | All | 25% | 20 | 90% | High |
| R05 | Remove/ Shield Obstacles | Install impact attenuators | All | 25% | 10 | 90% | High |
| R06 | Remove/ Shield Obstacles | Flatten side slopes | All | 30% | 20 | 90% | Medium |
| R07 | Remove/ Shield Obstacles | Flatten side slopes and remove guardrail | All | 40% | 20 | 90% | Medium |
| R08 | Geometric Mod. | Install raised median | All | 25% | 20 | 90% | Medium |
| R09 | Geometric Mod. | Install median (flush) | All | 15% | 20 | 90% | Medium |
| R10PB | Geometric Mod. | Install pedestrian median fencing on approaches | P & B | 35% | 20 | 90% | Low |
| R11 | Geometric Mod. | Install acceleration/ deceleration lanes | All | 25% | 20 | 90% | Low |
| R12 | Geometric Mod. | Widen lane (initially less than 10 ft) | All | 25% | 20 | 90% | Medium |
| R13 | Geometric Mod. | Add two-way left-turn lane | All | 30% | 20 | 90% | Medium |
| R14 | Geometric Mod. | Road Diet (Reduce travel lanes and add a two way left-turn and bike lanes) | All | 35% | 20 | 90% | Medium |
| R15 | Geometric Mod. | Widen shoulder | All | 30% | 20 | 90% | Medium |
| R16 | Geometric Mod. | Curve Shoulder widening (Outside Only) | All | 45% | 20 | 90% | Medium |
| R17 | Geometric Mod. | Improve horizontal alignment (flatten curves) | All | 50% | 20 | 90% | Low |
| R18 | Geometric Mod. | Flatten crest vertical curve | All | 25% | 20 | 90% | Low |
| R19 | Geometric Mod. | Improve curve superelevation | All | 45% | 20 | 90% | Medium |
| R20 | Geometric Mod. | Convert from two-way to one-way traffic | All | 35% | 20 | 90% | Medium |
| R21 | Geometric Mod. | Improve pavement friction (High Friction Surface Treatments) | All | 55% | 10 | 90% | High |

**Table 3. Countermeasures for Roadways (Continued)**

| No. | Type | Countermeasure Name | Crash Type | CRF | Expected Life (Years) | HSIP Funding Eligibility | Systemic Approach Opportunity? |
|---|---|---|---|---|---|---|---|
| R22 | Operation/ Warning | Install/Upgrade signs with new fluorescent sheeting (regulatory or warning) | All | 15% | 10 | 90% | Very High |
| R23 | Operation/ Warning | Install chevron signs on horizontal curves | All | 40% | 10 | 90% | Very High |
| R24 | Operation/ Warning | Install curve advance warning signs | All | 25% | 10 | 90% | Very High |
| R25 | Operation/ Warning | Install curve advance warning signs (flashing beacon) | All | 30% | 10 | 90% | High |
| R26 | Operation/ Warning | Install dynamic/variable speed warning signs | All | 30% | 10 | 90% | High |
| R27 | Operation/ Warning | Install delineators, reflectors and/or object markers | All | 15% | 10 | 90% | Very High |
| R28 | Operation/ Warning | Install edge-lines and centerlines | All | 25% | 10 | 90% | Very High |
| R29 | Operation/ Warning | Install no-passing line | All | 45% | 10 | 90% | Very High |
| R30 | Operation/ Warning | Install centerline rumble strips/stripes | All | 20% | 10 | 90% | High |
| R31 | Operation/ Warning | Install edgeline rumble strips/stripes | All | 15% | 10 | 90% | High |
| R32 | Operation/ Warning | Speed Safety Cameras | All | 20% | 10 | 90% | High |
| R33PB | Ped and Bike | Install bike lanes | P & B | 35% | 20 | 90% | High |
| R34PB | Ped and Bike | Install Separated Bike Lanes | P & B | 45% | 20 | 90% | High |
| R35PB | Ped and Bike | Install sidewalk/pathway (to avoid walking along roadway) | P & B | 80% | 20 | 90% | Medium |
| R36PB | Ped and Bike | Install/upgrade pedestrian crossing (with enhanced safety features) | P & B | 35% | 20 | 90% | Medium |
| R37PB | Ped and Bike | Install raised pedestrian crossing | P & B | 35% | 20 | 90% | Medium |
| R38PB | Ped and Bike | Install Rectangular Rapid Flashing Beacon (RRFB) | P & B | 35% | 20 | 90% | Medium |
| R39AL | Animal | Install animal fencing | Animal | 80% | 20 | 90% | Medium |

# 5. Calculating the B/C Ratio and Comparing Projects

Practitioners need to consider the expected B/C ratio of their proposed projects. This is an important step in a proactive safety analysis process because it provides two key pieces of information: First, it defines the cost effectiveness of the proposed projects; and second, it gives the safety practitioner a means to help prioritize their safety projects both inside the agency's traffic safety section and against other proposed operational and maintenance projects competing for funding.

## 5.1 Estimate the Benefit of Implementing Proposed Improvements

Sections 2 through 4 provide the practitioner all the information needed to calculate the expected 'Benefit' of the proposed safety projects. The resulting expected benefit value is derived by applying the proposed countermeasures and corresponding CMFs to the expected crashes. It is of critical importance for the practitioner to understand that misapplication of a CMF will lead to misinformed decisions. Four main factors need to be considered when applying countermeasures and CMFs to calculate the expected benefit value: (1) how to estimate the number of expected crashes without treatment, (2) how to apply CMFs by type and severity, (3) how to apply multiple CMFs if multiple treatments are to be included in the same project, and (4) how to apply a benefit value by crash severity. The following text explains how these factors affect the expected benefit value in more detail.

**Estimating expected crashes without treatment:** Before applying CMFs, local safety practitioners first need to select countermeasures and CMFs. The CMF is applied to the expected safety performance (expected crashes) without any treatment in order to estimate the expected crashes with the treatment. The reduction in expected crashes multiplied by the expected costs per each crash gives the practitioner the expected benefit.

As mentioned earlier in this manual, the random nature of roadway crashes suggests that over time the number of crashes at any particular locations will change. This concept is known as "regression to the mean" and it gives rise to the concern that a site might be selected for study when the crashes are at a randomly high fluctuation, or overlooked from study when the site is at a randomly low fluctuation. The HSM presents several methods for estimating the expected safety performance of a roadway or intersection including the Empirical Bayes method, which combines observed information from the site of interest with information from similar sites to estimate the expected crashes without treatment. Another common way to minimize the impact of regression to the mean is to increase the number of years of crash data being analyzed.

For statewide calls-for-projects, Caltrans strives to ensure that all projects are fairly ranked based on a consistent statewide approach. Given this, Caltrans has avoided using methodology requiring agencies to mathematically adjust their crash data (e.g., Empirical Bayes) and instead has opted to use 3 to 5 years of "observed crashes" in estimating "expected crashes."

**Applying CMFs by type and severity:** Section 4.1 of this manual discusses the application of CMFs and the need for them to represent the situation to which they will be applied. It also stresses the need for practitioners to choose the most appropriate CMFs for their specific project. In many circumstances, estimating the change in crashes by type and severity is useful; however, local safety practitioners only can use this approach when CMFs exist for the specific crash types and severities in question. If practitioners choose to use a CMF outside the range of applicability, the safety effect may be over- or underestimated. (For example: past research relating to installing a channelized left turn lane, has estimated CMFs as high as 68% for Right-Angle crashes of all severities and as low as 11% for Rear-End crashes with severities of only fatal and injury).

**Applying multiple CMFs:** In real-world scenarios, transportation agencies commonly install more than one countermeasure per project as part of their safety improvement program. This leads to the question, "What is the safety effect of the combined countermeasures?" The calculation methods that Transportation agencies use include: applying the CMF for the single countermeasure expected to achieve the greatest reduction, applying CMFs separately by crash type and summing them to get a project-level effect, and applying CMFs based on a review of crash patterns, etc. Regardless of the specific method employed, “engineering judgment” is required when combining multiple CMFs and it is important for local agencies to apply their method consistently throughout their analysis to ensure a fair comparison of projects.

One common practice is to assume that CMFs are multiplicative when they are applied to the same set of crash data. In other words, each successive countermeasure will achieve an additional benefit when implemented in combination with other countermeasures. The multiplicative method is a common, generally accepted method and is presented in the HSM and in the CMF Clearinghouse. This method is also used in the HSIP calls-for-projects.

To allow agencies maximum flexibility in combining countermeasures and locations into a single project while ensuring all projects can be consistently ranked on a statewide basis, Caltrans only allows up to three (3) individual countermeasures can be utilized in the B/C ratio for a project location site. The CMFs are multiplicative if there are multiple countermeasures, i.e. each successive countermeasure will achieve an additional benefit based on the remainder of the crashes after the effect of the prior countermeasures, not the original number of the crashes.

More information on these requirements and procedures are provided in the documents (Application Form Instructions, etc.) for each call-for-projects.

**Applying benefit value by crash severity:** The last step in estimating the overall benefit of a proposed improvement project is to multiply the expected reduction in crashes by a generally accepted value for the “cost” of crashes. In other words, the expected “benefit” value for a project is actually the expected “reduction in costs” value from reducing future crashes. There are many sources for the costs of crashes (e.g., HSM, FHWA & National Safety Council) and some of the sources vary widely depending on how they account for the economic value of a life and when the numbers were last updated.

When calculating the "benefit" to be used in calculating an improvement's B/C ratio, it is important for the practitioner to consider whether a total benefit value for the "life" of the improvement is needed or if the benefit value should be annualized (i.e., benefit per year). Whichever method is used to calculate the overall cost of the improvements must also be used for calculating the benefit.

Caltrans has currently chosen to use published Cost-of-Crash values from the first edition of the HSM and increase the values by 4% annually. These values may be updated in the future, when updated cost-of-crash values are published by FHWA or another national source. The specific values for each of the crash severities and the formulas uses to calculate the total benefit are shown in Appendix D.

**Recommended Action:** Prepare Total Benefit estimates for the proposed projects being evaluated in the proactive safety analysis.

## 5.2 Estimate the Cost of Implementing Proposed Improvements

After calculating the expected benefit of the proposed safety projects, the next step for the practitioner is to develop an estimate of the Total Project Costs. These costs need to include both the construction costs and the project development and administration costs. The most common approach to estimating construction costs is through an "Engineer's Cost Estimate." A Template for Detailed Engineer's Estimate and Cost Breakdown by Countermeasures is included in the HSIP Analyzer. When calculating the administration costs for a project, the complexity of the improvements must be accounted for: Low-cost countermeasures, typically used in the Systemic Approach, often have minimal environmental and right-of-way impacts and require minimal design effort. In contrast, many medium to high cost improvements tend to have greater impacts to the environment and right-of-way and require significant design efforts. It's crucial to account for these differences to accurately determine the true B/C ratio of the projects and prioritize them correctly.

When an agency is initially evaluating several potential locations and countermeasures as part of their proactive safety analysis or in preparing for Caltrans call-for-projects, they should consider first using rough 'ballpark' cost estimates using previous projects that had similar scope, if possible. Ballpark cost estimates can allow the practitioner to quickly establish B/C ratios for all of their potential projects and identify the projects with high cost effectiveness and with a reasonable chance of receiving HSIP funding in a Caltrans call-for-projects.

**Recommended Action:** Prepare 'Total Project Cost' estimates for the proposed projects being evaluated in the proactive safety analysis.

## 5.3 Calculate the B/C Ratio

In general, the B/C ratio is calculated by taking a project's overall benefit (as calculated in Section 5.1) and dividing it by the project's overall cost (as calculated in Section 5.2). There are, however, several methods and input-factors available for calculating a project's B/C ratio and practitioners may want to consider other methods as defined in the HSM.

Based on Caltrans' need for a fair, data-driven, statewide project selection process for HSIP call-for-projects, Caltrans requires the B/C ratio for all applications to be completed using the same process. Applicants must utilize the HSIP Analyzer to calculate the B/C ratio of the project. Additional details and formulas included in the calculation are included in this document as Appendix D.

**Recommended Action:** Calculate the B/C ratio for each of the proposed projects being evaluated in the proactive safety analysis.

## 5.4 Compare B/C Ratios and Consider the Need to Reevaluate Project Elements

By implementing a comprehensive proactive safety analysis approach, agencies will likely identify more potential safety projects than they can fund and deliver. It will be important for an agency to prioritize their projects internally before funding is sought. It is not uncommon for projects to have a B/C ratio as low as 0.1 or as high as 100. Once the relative cost effectiveness of an agency's potential projects has been established, the projects with low to mid-ranged B/C ratios should be reassessed. Projects with very low initial B/C ratios may be dropped while projects with low to mid ranged B/C ratios may be redefined by changing the limits of the proposed improvements to focus on higher crash locations or incorporating lower-cost countermeasures. This reiterative process is illustrated in Figure 1 in Section 1 of this document.

At the conclusion of this step, the local agency should have several potential safety projects ready to move into the project development and construction phases. Ideally, there will be a variety of low cost safety projects and potentially a few higher cost roadway reconstruction projects. How each local agency prioritizes their list of safety improvements will vary, but projects with the highest B/C ratios should generally have a high overall priority. It should be understood that available funding will play a key role in local agency prioritization (e.g., higher-cost projects may have to wait for funding to become available while low-cost improvements with lower B/C ratios can be constructed with in-house maintenance crews), but in the goal of maximizing overall safety benefits, the role of politics and public influence should be minimized.

**Recommended Action:** Compare, reevaluate, and prioritize the potential safety projects. Consider changing the project limits to maximize the number of fatal and injury crashes addressed within the limits. Consider lower cost countermeasures in areas where high and medium cost countermeasures resulted in low B/C ratios.

# 6. Identifying Funding and Construct Improvements

Funding strategies for implementing safety projects need to vary as widely as local agency's roadway types, project costs, and proposed improvements. At this point in the proactive safety analysis process, local agencies should have several potential safety projects ready to move into the project development and construction phases. There are likely a wide range of 'approaches' to fund each of these projects. This section of the document discusses some of the most common approaches.

## 6.1 Existing Funding for Low-cost Countermeasures

For projects utilizing low-cost countermeasures, the total project cost may be low enough that the agency can construct the project using its existing roadway funding by utilizing the ongoing activities of their roadway maintenance staff and equipment. Other low-cost projects (e.g., overlays, sealcoats, drainage, signing, and striping projects) may be more important to incorporate into larger maintenance projects. It is common for agencies to have 1-, 5-, and 10-year plans for making these standard maintenance improvements. With upfront planning and coordination between agency staff, the low-cost safety projects identified through the proactive safety analysis can be incorporated with minimal costs to an agency's maintenance program. Maximizing the cost effectiveness of the program may even allow the transportation managers to justify increasing the funding for their overall roadway maintenance program.

In addition to their maintenance program, transportation managers should also strategically seek out planned capital improvement and development projects that can incorporate low and medium cost countermeasures identified in their safety analysis. Local agencies may also find opportunities to partner with private enterprises and insurance companies to fund special safety projects that further both organizations' strategic goals.

**Recommended Action:** Survey planned maintenance, developer and capital projects to determine whether they overlap any of the proposed safety projects. Where projects overlap, leverage the existing funding sources to include safety countermeasures.

## 6.2 HSIP and Other Funding Sources

In addition to the HSIP Program, the Division of Local Assistance's web site includes several other Caltrans administered funding programs:
https://dot.ca.gov/programs/local-assistance

**Recommended Action:** Consider all potential funding opportunities to incorporate the identified safety countermeasures.

## 6.3 Project Development and Construction Considerations

In general, roadway safety projects don't garner the same level of attention from decision makers, media, elected officials, and the general public, that large operational and development-driven projects do. As a result, local safety practitioners and project sponsors often find their projects have difficulty in competing for the agencies' limited project delivery resources. Establishing and implementing a comprehensive safety analysis process can assist safety practitioners in delivering their safety programs in many ways, including:

- Credibility and awareness to individual projects and delivery schedules.
- Increased stakeholders tracking and delivery of a project when low-cost improvements are incorporated into ongoing maintenance and capital projects.
- An increased focus on low-cost countermeasures typically corresponds to projects with less environmental, right-of-way and other impacts; resulting in projects that have streamlined project delivery processes and short construction schedules.

**Recommended Action:** Safety practitioners should follow their safety projects all the way through the project delivery and construction process. In addition, they should establish a safety program delivery plan that brings awareness and support to the expedited delivery of safety projects. Where possible, safety practitioners should involve the media and even consider having their own program intended to "toot their own safety-horn."

# 7. Evaluation of Improvements

Evaluation of the effectiveness of roadway treatments following installation should be used to guide future decisions regarding roadway countermeasures. Field reviews should also be conducted shortly after the project is completed to insure the project is operating as intended.

A record of crash history and countermeasure installation forms the foundation for assessing how well the implemented strategies have performed. An important database to maintain is a current list of installed countermeasures with documented “when/where/why” information. Periodic assessments will provide the necessary information to make informed decisions on whether each countermeasure contributed to an increase in safety, whether the countermeasure could or should be installed at other locations, and which factors may have contributed to each countermeasure’s success.

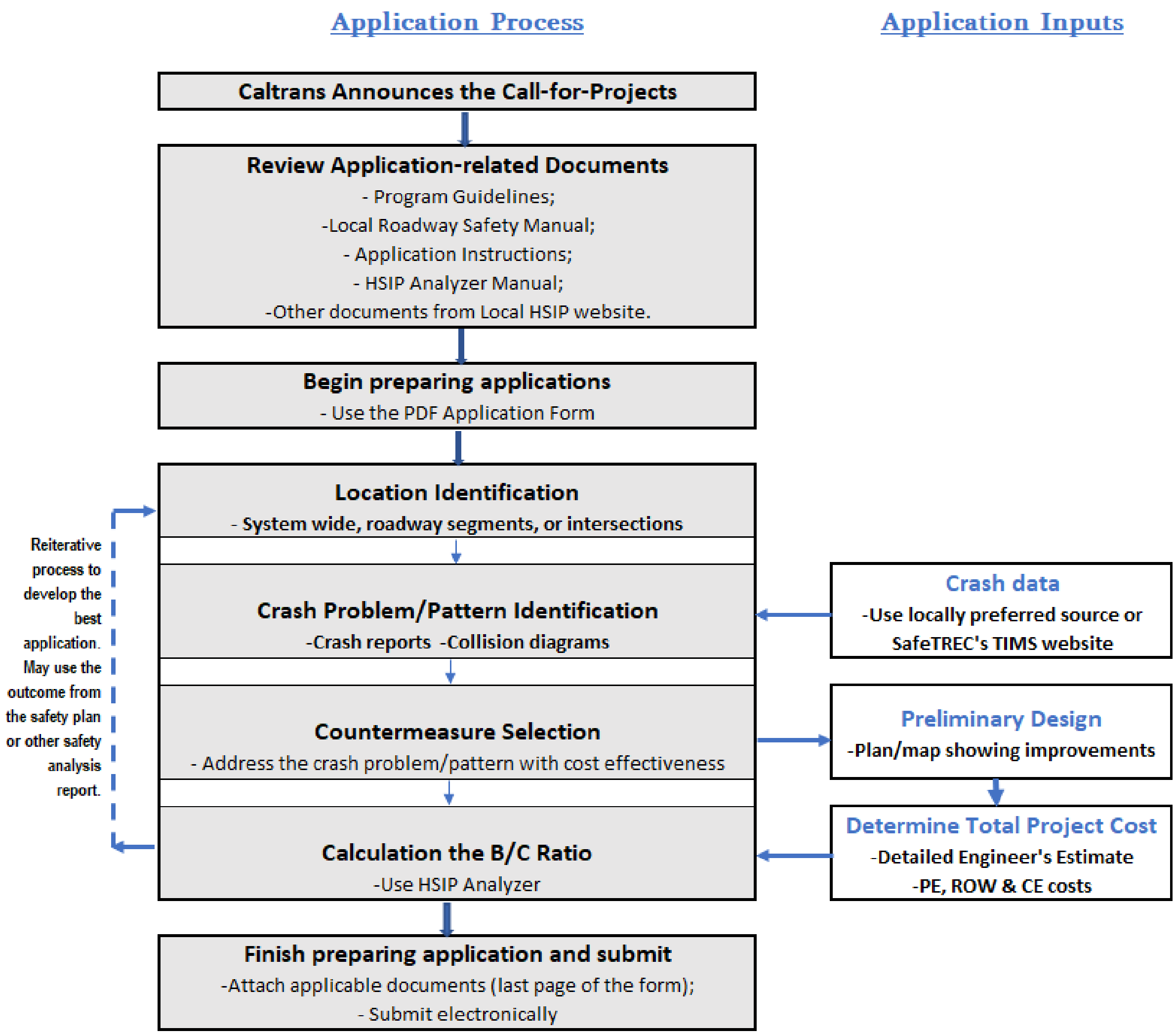
In order to perform the assessment, it is necessary to collect the required information for a certain period after strategies have been deployed at the locations. The time period varies, but whenever possible, 3 to 5 years is recommended to reduce the effects of the random nature of roadway crashes (i.e., Regression to the Mean). The information required may consist of public input and complaints, police reports, observations from maintenance crews, and local and State crash data.

It is important to keep the list of safety installations up-to-date since it will serve as a record of countermeasure deployment history (see table below for an example). By using this type of system, assessment dates can be scheduled to review the crashes and other pertinent information on segments where roadway countermeasures have been installed. Making “after” assessments will inform the practitioner on the effectiveness of past improvements and can provide data to help justify the value of continuing and expanding the local agency’s safety program in the future.

| Location | Type of Countermeasure Installed | Date Installed | Crashes Before<br><br>(Duration and Severity) | Crashes After<br><br>(Duration and Severity) | Comments |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

**Recommended Action:** Develop a spreadsheet or database to track future safety project installations and record 3 or more years of “before” and “after” crash information at those locations. Once safety countermeasures are constructed, schedule and track assessment dates to ensure they happen.

# Appendix A: HSIP Call-for-Projects Application Process



# Appendix B: Detailed Tables of Countermeasures

The intent of the information contained in this appendix is to provide local agency safety practitioners with a list of effective countermeasures that are appropriate remedies to many common safety issues. The tables in Section 4.2 present a quick summary of the specific values that the Caltrans Division of Local Assistance uses to assess and select projects for its calls- for-projects. In addition to the same information as in Section 4.2, this appendix also includes notes for Caltrans HSIP calls-for-projects and "General information" regarding where the countermeasure should be used, why it works, the general qualities that can be used to suggest the potential complexity of installation, and information from FHWA CMF Clearinghouse on the type of crashes where the countermeasure is best used and a range of their expected overall effectiveness.

The countermeasures have been sorted into 3 categories: Signalized Intersection, Non-Signalized Intersection, and Roadway Segment. Pedestrian and bicycle related countermeasures have been included in each of these categories.

Caltrans gives careful consideration to the fair application of its calls-for-projects process. Starting in 2012, the award of safety funding has been solely based on a determined benefit-to-cost ratio for each project. The fixed set of countermeasures and CRFs included in these tables are intended to allow for all projects to be evaluated consistently and fairly throughout the project selection process. However, at this time, there are no CRFs/CMFs available for several safety improvements, such as: "dynamic/variable speed regulatory signs", "non-motorized signs and markings (regulatory and warning)", "Square-up (reduce curve radius) turn lanes" and non-infrastructure elements. These safety improvement items can be included in project applications, but they will not be included into the B/C ratio calculations, unless the safety improvements meet the intent of other separate countermeasures included in the attached lists. Caltrans is interested in adding these countermeasures (and many others) to these tables once CRFs/CMFs have been established. Caltrans will continue to periodically update this list of allowable countermeasures and CRFs as new safety research data becomes available. With this in mind, Caltrans is interested in feedback and suggestions from local agency safety practitioners on the overall countermeasure list as well as specific details of individual countermeasures, including locally developed safety effectiveness information.

Caltrans used the following references to assist its team in developing the information shown in the following tables. Safety Practitioners are encouraged to utilize these references for a more expansive list of countermeasures and CRFs / CMFs.

The Crash Modification Factors Clearinghouse
https://www.cmfclearinghouse.org/

NCHRP Report 500 Series: Volumes 4, 5, 6, 7, 10, 12, 13, and others
https://www.trb.org/Main/Blurbs/152868.aspx

Highway Safety Manual (HSM)
http://www.highwaysafetymanual.org

Pedestrian and Bicycle - Tools to Diagnose and Solve the Problem
https://safety.fhwa.dot.gov/ped_bike/tools_solve/

FHWA Local and Rural Road / Training, Tools, Guidance and Countermeasures for Locals
https://safety.fhwa.dot.gov/local_rural/training/

## For each countermeasure (CM):

### (Title) CM No., CM Name

- CM No. is
  - SI01NT through SI22PB for Intersection Countermeasures – Signalized,
  - NS01NT through NS24PB for Intersection Countermeasures – Unsignalized, or
  - R01NT through R39AL for Roadway Countermeasures.

*Some CM Numbers have two letters at the end – this is used to quickly identity the specific feature of the CM. For example, "NT" - reducing night crashes, "PB" – reducing Pedestrian and Bicycle crashes, "EV" – countermeasure toward Emergency Vehicle involved crashes, "AL"- countermeasure toward Animal involved crashes, and "RA" – roundabout.*

### For HSIP Calls-for-projects:

- **Funding Eligibility -** 90% or 50%.
- **Crash Types Addressed -** "All", "Pedestrian and Bicycle", "Night", "Emergency Vehicle", or "Animal".
- **CRF -** Crash Reduction Factor used for HSIP calls-for-projects.
- **Expected Life -** 10 years or 20 years.
- **Notes -** Specific requirements are provided for utilizing the countermeasure on applications for Caltrans statewide calls-for-projects.
-

### General Information:

- **Where to use** – Roadway segments and intersections with specific common characteristics can be addressed with similar countermeasures that are most effective.
- **Why it works** – A discussion of the benefit of a countermeasure is important to determine its appropriateness in addressing certain roadway crash types at areas with specific issues as determined by the data and roadway features.
- **General Qualities (Time, Cost and Effectiveness)** – This category is more subjective and can vary substantially. 'Time' refers to the approximate relative time it can take to implement the countermeasure. Costs can vary considerably due to local conditions, so 'cost' represents the relative cost of applying a countermeasure. A relative overall 'effectiveness' is also provided for some countermeasures. All of this subjective information may not be applicable to the unique circumstances for the agency and should not be utilized without verification by the safety practitioner.

- **FHWA CMF Clearinghouse**
  - **Crash Types Addressed** – In order to effectively reduce the number and severity of roadway crashes, it is necessary to match countermeasures to the crash types they are intended to address. Depending on the type of problem, one or more of a range of countermeasures could be the most effective way to reduce the number and severity of future crashes.
  - **Crash Reduction Factor** – The crash reduction factor (CRF) is an indication of the effectiveness of a particular treatment, measured by the percentage of crashes it is expected to reduce. Note: As mentioned earlier in this section, the effectiveness of a countermeasure can also be expressed as a Crash Modification Factor (CMF), which is defined mathematically as 1 – CRF. However, this document uses CRFs as they can be more insightful when analyzing roadways for potential "reductions" in crashes. There is a range of CRF values that exist for each of the countermeasures (or similar countermeasures). The range of CRFs is provided to give local safety practitioners a clear understanding that they may need to go to the FHWA CMF Clearinghouse to find the most appropriate countermeasure and CRF for their specific projects and local prioritization.

## B.1 Intersection Countermeasures – Signalized

### SI01NT, Add intersection lighting (Signalized Intersection => S.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | "night" crashes | 40% | 20 years |
| Notes: | This CM only applies to "night" crashes (all types) occurring within limits of the proposed roadway lighting 'engineered' area. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Signalized intersections that have a disproportionate number of night-time crashes and do not currently provide lighting at the intersection or at its approaches. Crash data should be studied to ensure that safety at the intersection could be improved by providing lighting (this strategy would be supported by a significant number of crashes that occur at night). | | | | |
| **Why it works:** | | | | |
| Providing lighting at the intersection itself, or both at the intersection and on its approaches, improves the safety of an intersection during nighttime conditions by (1) making drivers more aware of the surroundings at an intersection, which improves drivers' perception-reaction times, (2) enhancing drivers' available sight distances, and (3) improving the visibility of non-motorists. Intersection lighting is of particular benefit to non-motorized users. Lighting not only helps them navigate the intersection, but also helps drivers see them better. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| A lighting project can usually be completed relatively quickly, but generally requires at least 1 year to implement because the lighting system must be designed and the provision of electrical power must be arranged. The provision of lighting involves both a fixed cost for lighting installation and an ongoing maintenance and power cost which results in a moderate to high cost. Some locations can result in high B/C ratios, but due to higher costs, these projects often result in medium to low B/C ratios. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Night, All | CRF: | 20-74% |

### SI02, Improve signal hardware: lenses, back-plates with retroreflective borders, mounting, size, and number

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 15% | 10 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the upgraded signals. This CM does not apply to improvements like "battery backup systems", which do not provide better intersection/signal visibility or help drivers negotiate the intersection (unless applying past crashes that occurred when the signal lost power). If new signal mast arms are part of the proposed project, CM "S2" should not be used and the signal improvements would be included under CM "S7". | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Signalized intersections with a high frequency of right-angle and rear-end crashes occurring because drivers are unable to see traffic signals sufficiently in advance to safely negotiate the intersection being approached. Signal intersection improvements include new LED lighting, signal back plates, retro-reflective tape outlining the back plates, or visors to increase signal visibility, larger signal heads, relocation of the signal heads, or additional signal heads. | | | | |
| **Why it works:** | | | | |
| Providing better visibility of intersection signals aids the drivers' advance perception of the upcoming intersection. Visibility and clarity of the signal should be improved without creating additional confusion for drivers. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Installation costs and time should be minimal as these type strategies are classified as low cost and implementation does not typically require the approval process normally associated with more complex projects. When considered at a single location, these low cost improvements are usually funded through local funding by local maintenance crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in low to moderate cost projects that are more appropriate to seek state or federal funding. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Rear-End, Angle | CRF: | 0-46% |

## SI03, Improve signal timing (coordination, phases, red, yellow, or operation)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 50% | All | 15% | 10 years |

| | |
|---|---|
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the new signal timing. For projects coordination signals along a corridor, the crashes related to side-street movements should not be applied. This CM does not apply to projects that only 'study' the signal network and do not make physical timing changes, including corridor operational studies and improvements to Traffic Operation Centers (TOCs).<br>In Caltrans calls for projects, this CM has a HSIP reimbursement ratio of 50%, considering that it will improve the signal operation rather than merely the safety. |

**General information**

**Where to use:**

Locations that have a crash history at multiple signalized intersections. Signalization improvements may include adding phases, lengthening clearance intervals, eliminating or restricting higher-risk movements, and coordinating signals at multiple locations. Understanding the corridor or roadway's crash history can provide insight into the most appropriate strategy for improving safety.

**Why it works:**

Certain timing, phasing, and control strategies can produce multiple safety benefits. Sometimes capacity improvements come along with the safety improvements and other times adverse effects on delay or capacity occur. Corridor improvements often have the highest benefit but may take longer to implement. Projects focused on capacity improvements (without a separate focus on signal timing safety needs) may not result in a reduction in future crashes.

**General Qualities (Time, Cost and Effectiveness):**

In general, these low-cost improvements to multiple signalized intersections can be implemented in a short time. Typically these low cost improvements are funded through local funding by local maintenance crews. However, some projects requiring new interconnect infrastructure can have moderate to high costs making them more appropriate to seek state or federal funding. The expected effectiveness of this CM must be assessed for each individual project.

| | | | | |
|---|---|---|---|---|
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 0 - 41% |

## SI04EV, Install emergency vehicle pre-emption systems

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Emergency Vehicle - only | 70% | 10 years |

| | |
|---|---|
| Notes: | This CM only applies to "E.V." crashes occurring on the approaches / influence area of the new pre-emption system. |

**General information**

**Where to use:**

Corridors that have a history of crashes involving emergency response vehicles. The target of this strategy is signalized intersections where normal traffic operations impede emergency vehicles and where traffic conditions create a potential for conflicts between emergency and nonemergency vehicles. These conflicts could lead to almost any type of crash, due to the potential for erratic maneuvers of vehicles moving out of the paths of emergency vehicles

**Why it works:**

Providing emergency vehicle preemption capability at a signal or along a corridor can be a highly effective strategy in two ways; any type of crash could occur as emergency vehicles try to navigate through intersections and as other vehicles try to maneuver out of the path of the emergency vehicles. In addition, a signal preemption system can decrease emergency vehicle response times therefore decreasing the time in receiving emergency medical attention, which is critical in the outcome of any crash. When data is not available for past crashes with emergency vehicles, an agency may consider combining the E.V. pre-emption improvements into a comprehensive project that also makes significant signal hardware and/or signal timing improvements.

**General Qualities (Time, Cost and Effectiveness):**

Costs for installation of a signal preemption system will vary from medium to high, based upon the number of signalized intersections at which preemption will be installed and the number of emergency vehicles to be outfitted with the technology. The number of detectors, a requirement for new signal controllers, and the intricacy of the preemption system could increase costs. This CM is considered systemic as it is usually implemented on a corridor-basis.

| | | | | |
|---|---|---|---|---|
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Emergency Vehicle - only | CRF: | 70% |

### SI05, Install left-turn lane and add turn phase (signal has no left-turn lane or phase before)

| **For HSIP Cycle 12 Call-for-projects** | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 55% | 20 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the new left turn lanes. This CM does NOT apply to converting a single-left into double-left turn. | | |

| **General information** | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Intersections that do not currently have a left turn lane or a related left-turn phase that are experiencing a large number of crashes. Many intersection safety problems can be traced to difficulties in accommodating left-turning vehicles, in particular where there is currently no accommodation for left turning traffic. A key strategy for minimizing collisions related to left-turning vehicles (angle, rear-end, sideswipe) is to provide exclusive left-turn lanes and the appropriate signal phasing, particularly on high-volume and high-speed major-road approaches. Agencies need to document their consideration of the MUTCD, Section 4D.19 guidelines; the section on implementing protected left-turn phases. | | | | |
| **Why it works:** | | | | |
| Left-turn lanes allow separation of left-turn and through-traffic streams, thus reducing the potential for rear-end collisions. Left-turn phasing also provides a safer opportunity for drivers to make a left-turn. The combination of left-turn storage and a left turn signal has the potential to reduce many collisions between left-turning vehicles and through vehicles and/or non-motorized road users. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Implementation time may vary from months to years. At some locations, left-turn lanes can be quickly installed simply by restriping the roadway. At other locations, widening of the roadway, acquisition of additional right-of-way, and extensive environmental processes may be needed. Such projects require a substantial time for development and construction. Costs are highly variable and range from very low to high. Installing a protected left turn lane and phase where none exists results in a high Crash Reduction Factor and is often highly effective. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 17 - 58 % |

## SI06, Provide protected left turn phase (left turn lane already exists)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 30% | 20 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the new left turn phases. This CM does NOT apply to converting a single-left into double-left turn (unless the single left is unprotected and the proposed double left will be protected). | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Signalized intersections (with existing left turns pockets) that currently have a permissive left-turn or no left-turn protection that have a high frequency of angle crashes involving left turning, opposing through vehicles, and non-motorized road users. A properly timed protected left-turn phase can also help reduce rear-end and sideswipe crashes between left-turning vehicles and the through vehicles as well as vehicles behind them. Protected left-turn phases are warranted based on such factors as turning volumes, delay, visibility, opposing vehicle speed, distance to travel through the intersection, presence of non-motorized road users, and safety experience of the intersections. Agencies need to document their consideration of the MUTCD, Section 4D.19 guidelines; the section on implementing protected left-turn phases. | | | | |
| **Why it works:** | | | | |
| Left turns are widely recognized as the highest-risk movements at signalized intersections. Providing Protected left-turn phases (i.e., the provision for a specific phase for a turning movement) for signalized intersections with existing left turn pockets significantly improve the safety for left-turn maneuvers by removing the need for the drivers to navigate through gaps in oncoming/opposing through vehicles. Where left turn pockets are not protected, the pedestrian and bicyclist crossing phase often conflicts with these left turn maneuvers. Drivers focused on navigating the gaps of oncoming cars may not anticipate and/or perceive the non-motorized road users. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| If the existing traffic signal only requires a minor modification to allow for a protected left-turn phase, then the cost would also be low. The time to implement this countermeasure is short because there is no actual construction that has to take place. In-house signal maintainers can perform this operation once the proper signal phasing is determined so the cost is low. In addition, the countermeasure is tried and proven to be effective. Has the potential of being applied on a systemic/systematic approach. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Rear-End, Sideswipe, Broadside | CRF: | 16 - 99% |

## SI07, Convert signal to mast arm (from pedestal-mounted)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 30% | 20 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the converted signal heads that are relocated from median and/or outside shoulder pedestals to signal heads on master arms over the travel-lanes. Projects using CM "S7" should not also apply "S2" in the B/C calc. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Intersections currently controlled by pedestal mounted traffic signals (in medians and/or on outside shoulder) that have a high frequency of right-angle and rear-end crashes occurring because drivers are unable to see traffic signals in advance to safely negotiate the intersection. Intersections that have pedestal-mounted signals may have poor visibility and can result in vehicles not being able to stop in time for a signal change. Care should be taken to place the new signal heads (with back plates) as close to directly over the center of the travel lanes as possible. | | | | |
| **Why it works:** | | | | |
| Providing better visibility of intersection signs and signals aids the drivers' advance perception of the upcoming intersection. Visibility and clarity of the signal should be improved without creating additional confusion or distraction for drivers. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Dependent on the scope of the project. Costs are generally moderate for this type of project. There is usually no right-of-way costs, minimal roadway reconstruction costs, and a shorter project development timeline. At the same time, new mast arms can be expensive. Some locations can result in high B/C ratios, but due to moderate costs, some locations may result in medium to low B/C ratios. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Rear-End, Angle | CRF: | 12 - 74% |

### SI08, Install raised pavement markers and striping (Through Intersection)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 10% | 10 years |
| Notes: | This CM only applies to crashes occurring in the intersection and influence areas of the new pavement markers and/or markings. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Intersections where the lane designations are not clearly visible to approaching motorists and/or intersections noted as being complex and experiencing crashes that could be attributed to a driver's unsuccessful attempt to navigate the intersection. Driver confusion can exist in regard to choosing the proper turn path or where through-lanes do not line up. This is especially relevant at intersections where the overall pavement area of the intersection is large, and multiple turning lanes are involved or other unfamiliar elements are presented to the driver. | | | | |
| **Why it works:** | | | | |
| Adding clear pavement markings can guide motorists through complex intersections. When drivers approach and traverse through complex intersections, drivers may be required to perform unusual or unexpected maneuvers. Providing more effective guidance through an intersection will minimize the likelihood of a vehicle leaving its appropriate lane and encroaching upon an adjacent lane. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Costs of implementing this strategy will vary based on the scope and number of applications. Applying raised pavement markers is relatively low cost but can be variable and determined largely by the material used for pavement markings (paint, thermoplastic, epoxy, RPMs etc.). When using this type delineators, an issue of concern is the cost-to-service-life of the material. (Note: When HSIP safety funding is used for these installations in high-wear-locations, the local agency is expected to maintain the improvement for a minimum of 10 years.) When considered at a single location, these low cost improvements are usually funded through local funding by local maintenance crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Wet, Night, All | CRF: | 10 - 33% |

### SI09, Install flashing beacons as advance warning (S.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 30% | 10 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the new flashing beacons. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| At signalized intersections with crashes that are a result of drivers being unaware of the intersection or are unable to see the traffic control device in time to comply. | | | | |
| **Why it works:** | | | | |
| Increased driver awareness of an approaching signalized intersection and an increase in the driver's time to react. Driver awareness of both downstream intersections and traffic control devices is critical to intersection safety. Crashes often occur when the driver is unable to perceive an intersection, signal head or the back of a stopped queue in time to react. Advance flashing beacons can be used to supplement and call driver attention to intersection control signs. Most advance warning flashing beacons can be powered by solar, thus reducing the issues relating to power source. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Before choosing this CM, the agency needs to confirm the ability to provide power to the site (solar may be an option). Flashing beacons can be constructed with minimal design, environmental and right-of-way issues and have relatively low costs. This combined with a relatively high CRF, can result in high B/Cs for locations with a history of crashes and lead to a high effectiveness. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Rear End, Angle | CRF: | 36 - 62% |

### SI10, Improve pavement friction (High Friction Surface Treatments)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 55% | 10 years |
| Notes: | This CM only applies to crashes occurring within the limits of the improved friction overlay. This CM is not intended to apply to standard chip-seal or open-graded maintenance projects for long segments of corridors or structure repaving projects intended to fix failed pavement. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Nationally, this countermeasure is referred to as "High Friction Surface Treatments" or HFST. Signalized Intersections noted as having crashes on wet pavements or under dry conditions when the pavement friction available is significantly less than needed for the actual roadway approach speeds. This treatment is intended to target locations where skidding and failure to stop is determined to be a problem in wet or dry conditions and the target vehicle is unable to stop due to insufficient skid resistance. | | | | |
| **Why it works:** | | | | |
| Improving the skid resistance at locations with high frequencies of wet-road crashes and/or failure to stop crashes can result in reductions of 50 percent for wet-road crashes and 20 percent for total crashes. Applying HFST can double friction numbers, e.g. low 40s to high 80s. This CM represents a special focus area for both FHWA and Caltrans, which means there are extra resources available for agencies interested in more details on High Friction Surface Treatment projects. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| This strategy can be relatively inexpensive and implemented in a short timeframe. The installation would be done by either agency personnel or contractors and can be done by hand or machine. In general, This CM can be very effective and can be considered on a systematic approach. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Wet, Night, ALL | CRF: | 10 - 62 % |

### SI11, Install raised median on approaches (S.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 25% | 20 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the new raised median. All new raised medians funded with HSIP funding should not include the removal of the existing roadway structural section and should be doweled into the existing roadway surface. This requirement is being implemented to maximize the safety-effectiveness of the limited HSIP funding and to minimize project impacts. Landscaping, if included in the project, is considered non-participating. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Intersections noted as having turning movement crashes near the intersection as a result of insufficient access control. Application of this CM should be based on current crash data and a clearly defined need to restrict or accommodate the movement. | | | | |
| **Why it works:** | | | | |
| Raised medians next to left-turn lanes at intersections offer a cost-effective means for reducing crashes and improving operations at higher volume intersections. The raised medians prohibit left turns into and out of driveways that may be located too close to the functional area of the intersection. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Raised medians at intersections may be most effective in retrofit situations where high volumes of turning vehicles have degraded operations and safety, and where more extensive CMs would be too expensive because of limited right-of-way and the constraints of the built environment. The result is This CM can be very effective and can be considered on a systematic approach. Raised medians can often be installed directly over the existing pavement. When agencies opt to install landscaping in conjunction with new raised medians, the portion of the cost for landscaping and other non-safety related items that exceeds 10% of the project total cost is not federally participated and must be funded by the applicant. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Angle | CRF: | 21 -55 % |

## SI12PB, Install pedestrian median fencing on approaches

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 35% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring on the approaches/influence area of the new pedestrian median fencing. | | |

**General information**

**Where to use:**

Signalized Intersections with high pedestrian-generators nearby (e.g. transit stops) may experience a high volumes of pedestrians J-walking across the travel lanes at mid-block locations instead of walking to the intersection and waiting to cross during the walk-phase. When this safety issue cannot be mitigated with signal timing and shoulder/sidewalk treatments, then installing a continuous pedestrian barrier in the median may be a viable solution.

**Why it works:**

Adding pedestrian median fencing has the opportunity to enhance pedestrian safety at locations noted as being problematic involving pedestrians running/darting across the roadway outside the intersection crossings. Pedestrian median fencing can significantly reduce this safety issue by creating a positive barrier, forcing pedestrians to the designated pedestrian crossing.

**General Qualities (Time, Cost and Effectiveness):**

Costs associated with this strategy will vary widely depending on the type and placement of the median fencing. Impacts to transit and other land uses may need to be considered and controversy can delay the implementation. In general, this CM can be effective as a spot-location approach.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 25- 40% |
|---|---|---|---|---|

## SI13, Create directional median openings to allow (and restrict) left-turns and U-turns (S.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 50% | 20 years |
| Notes: | This CM only applies to crashes occurring in the intersection / influence area of the new directional openings. | | |

**General information**

**Where to use:**

Crashes related to turning maneuvers include angle, rear-end, pedestrian, and sideswipe (involving opposing left turns) type crashes. If any of these crash types are an issue at an intersection, restriction or elimination of the turning maneuver may be the best way to improve the safety of the intersection.

**Why it works:**

Restricting turning movement into and out of an intersection can help reduce conflicts between through and turning traffic. The number of access points, coupled with the speed differential between vehicles traveling along the roadway, contributes to crashes. Affecting turning movements by either allowing them or restricting them, based on the application, can ensure safe movement of traffic.

**General Qualities (Time, Cost and Effectiveness):**

Turn prohibitions that are implemented by closing a median opening can be implemented quickly. The cost of this strategy will depend on the treatment. Impacts to businesses and other land uses must be considered and controversy can delay the implementation. In general, This CM can be very effective and can be considered on a systematic approach.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 51% |
|---|---|---|---|---|

### SI14, Install right-turn lane (S.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 15% | 20 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the new right-turn lanes. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| A right-turn lane may be appropriate in situations where there are an unusually high number of rear-end collisions on a single major road approach. The need for right turn lanes should be assessed on an individual approach basis. Many collisions at signalized intersections are related to right-turn maneuvers. It is also important to ensure that the right-turn lanes are of sufficient length to allow vehicles to decelerate and "queue up" before turning, ideally without affecting the flow of through traffic. When considering new right-turn lanes, potential impacts to non-motorized users should be considered and mitigated as appropriate. | | | | |
| **Why it works:** | | | | |
| The provision of right-turn lanes can minimize collisions between vehicles turning right and following vehicles, particularly on high-volume and high-speed major roads. Installation of a right turn lane at a signalized intersection is expected to reduce total crashes and improve overall intersection delay. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Implementing this strategy may take from months to years. At some locations, right-turn lanes can be quickly and simply installed by restriping the roadway. At other locations, widening of the roadway, acquisition of additional right-of-way, and extensive environmental processes may be needed. Such projects require a substantial time for development and construction. Costs are highly variable and range from very low to high. The expected effectiveness of this CM must be assessed for each individual location. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Rear-End | CRF: | 14-27% |

## SI15, Reduced Left-Turn Conflict Intersections (S.I.)

| For HSIP Cycle 12 Call-for-projects | | | | |
|---|---|---|---|---|
| Funding Eligibility | | Crash Types Addressed | CRF | Expected Life |
| 90% | | All | 50% | 20 years |
| Notes: | This CM only applies to crashes occurring in the intersection / influence area of the new Reduced Left-Turn Conflict. | | | |

**General information**

**Where to use and Why it works:**

Reduced left-turn conflict intersections are geometric designs that alter how left-turn movements occur in order to simplify decisions and minimize the potential for related crashes. Two highly effective designs that rely on U-turns to complete certain left-turn movements are known as the restricted crossing U-turn (RCUT) and the median U-turn (MUT).

**Restricted Crossing U-turn (RCUT):**

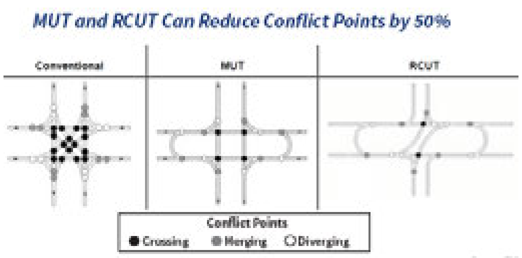
The RCUT intersection modifies the direct left-turn and through movements from cross-street approaches. Minor road traffic makes a right turn followed by a U-turn at a designated location (either signalized or unsignalized) to continue in the desired direction.

The RCUT is suitable for a variety of circumstances, including along rural, high-speed, four-lane, divided highways or signalized routes. It also can be used as an alternative to signalization or constructing an interchange. RCUTs work well when consistently used along a corridor, but also can be used effectively at individual intersections.

**Median U-turn (MUT)**

The MUT intersection modifies direct left turns from the major approaches. Vehicles proceed through the main intersection, make a U-turn a short distance downstream, followed by a right turn at the main intersection. The U-turns can also be used for modifying the cross-street left turns.

The MUT is an excellent choice for heavily traveled intersections with moderate left-turn volumes. When implemented at multiple intersections along a corridor, the efficient two-phase signal operation of the MUT can reduce delay, improve travel times, and create more crossing opportunities for pedestrians and bicyclists.




**General Qualities (Time, Cost and Effectiveness):**

Implementing this strategy may take from months to years, depending on whether additional R/W is required. Such projects require a substantial time for development and construction. Costs are highly variable and range from very low to high. The expected effectiveness of this CM must be assessed for each individual location.

| | | | | |
|---|---|---|---|---|
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Angle/Left-turn/Rear-End/All | CRF: | 34.8-100% |

## SI16RA, Convert intersection to roundabout (from signal)

| **For HSIP Cycle 12 Call-for-projects** | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | Varies | 20 years |

| | |
|---|---|
| Notes: | This CM only applies to crashes occurring in influence area of the new roundabout. This CM is not intended for compact roundabouts (SI17RA).<br>The benefit of this CM is calculated using Caltrans procedure. The CRF is dependent on the ADT, project location (Rural/Urban) and the roundabout type (1 lane or 2 lanes). The benefit comes from both the reduction in the number and the severity of the crashes. |

**General information**

**Where to use:**

Signalized intersections that have a significant crash problem and the only alternative is to change the nature of the intersection itself. Roundabouts can also be very effective at intersections with complex geometry and intersections with frequent left-turn movements.

**Why it works:**

The types of conflicts that occur at roundabouts are different from those occurring at conventional intersections; namely, conflicts from crossing and left-turn movements are not present in a roundabout. The geometry of a roundabout forces drivers to reduce speeds as they proceed through the intersection. This helps keep the range of vehicle speed narrow, which helps reduce the severity of crashes when they do occur. Pedestrians only have to cross one direction of traffic at a time at roundabouts, thus reducing their potential for conflicts.

**General Qualities (Time, Cost and Effectiveness):**

Provision of a roundabout requires substantial project development. The need to acquire right-of-way is likely and will vary from site to site and depends upon the geometric design. These activities may require up to 4 years or longer to implement. Costs are variable, but construction of a roundabout to replace an existing signalized intersection are relatively high. The result is this CM may have reduced relative-effectiveness compared to other CMs.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 35 - 67% |
|---|---|---|---|---|

## SI17RA, Convert intersection to compact roundabout (from signal)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | Varies | 20 years |
| Notes: | This CM only applies to crashes occurring in the intersection and/or influence area of the new control. The benefit of this CM is calculated using Caltrans procedure. The CRF is dependent on the ADT and the project location (Rural/Urban). The benefit comes from both the reduction in the number and the severity of the crashes. | | |

**General information**

**Where to use:**

Compact roundabouts are characterized by a small inscribed circle diameter (80-100 ft). Compact roundabouts offer most of the benefits of regular roundabouts with the added benefit of a smaller footprint. They are best suited to environments where speeds are already low and environmental constraints would preclude the use of a larger roundabout. Compact roundabouts may require minimal additional pavement, and in many cases existing curb or sidewalk can be left in place. As a result, compact roundabouts rarely require the purchase of right of way. Compact roundabouts are similar to single-lane roundabouts regarding design vehicle assumptions, ability to process traffic volumes, and signing.
Compact roundabouts are intended to be pedestrian and bicyclist-friendly because their perpendicular approach legs require very low vehicle speeds to make a distinct right turn into and out of the circulatory roadway. Capacity should not be a critical issue for this type of roundabout to be considered.

**Why it works:**

Compact roundabouts may be an optimal solution for a safety or operational issue at an existing intersection where there is insufficient right-of-way for a standard roundabout installation. The benefits of compact roundabouts are the compact size, operational efficiency, traffic safety improvement and traffic Calming.

**General Qualities (Time, Cost and Effectiveness):**

Construction costs for compact roundabouts vary widely depending upon the extent of sidewalk modifications or other geometric improvements and the types of materials used. In most cases, compact roundabouts have been installed with little or no pavement widening. Construction costs can be moderate for compact roundabouts that include raised islands and pedestrian improvements.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | NA | CRF: | NA |
|---|---|---|---|---|

## SI18PB, Install pedestrian countdown signal heads

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 25% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the intersection/crossing with the new countdown heads. | | |

**General information**

**Where to use:**

Signals that have signalized pedestrian crossing with walk/don't walk indicators and where there have been pedestrian vs. vehicle crashes.

**Why it works:**

A pedestrian countdown signal contains a timer display and counts down the number of seconds left to finish crossing the street. Countdown signals can reassure pedestrians who are in the crosswalk when the flashing "DON'T WALK" interval appears that they still have time to finish crossing. Countdown signals begin counting down either when the "WALK" or when the flashing "DON'T WALK" interval appears and stop at the beginning of the steady "DON'T WALK" interval. These signals also have been shown to encourage more pedestrians to use the pushbutton rather than jaywalk.

**General Qualities (Time, Cost and Effectiveness):**

Costs and time of installation will vary based on the number of intersections included in this strategy and if it requires new signal controllers capable of accommodating the enhancement. When considered at a single location, these low cost improvements are usually funded through local funding by local crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 25% |
|---|---|---|---|---|

## SI19PB, Install pedestrian crossing (S.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 25% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the intersection/crossing with the new crossing. This CM is not intended to be used for high-cost aesthetic enhancements to intersection crosswalks (i.e. stamped concrete or stamped asphalt). | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Signalized Intersections with no marked crossing and pedestrian signal heads, where pedestrians are known to be crossing intersections that involve significant turning movements. They are especially important at intersections with (1) multiphase traffic signals, such as left-turn arrows and split phases, (2) school crossings, and (3) double-right or double-left turns. At signalized intersections, pedestrian crossings are often safer when the left turns have protected phases that do not overlap the pedestrian walk phase. | | | | |
| **Why it works:** | | | | |
| Adding pedestrian crossings has the opportunity to enhance pedestrian safety at locations noted as being problematic. Nearly one-third of all pedestrian-related crashes occur at or within 50 feet of an intersection. Of these, 30 percent may involve a turning vehicle. Another 22 percent of pedestrian crashes involve a pedestrian either running across the intersection or darting out in front of a vehicle whose view was blocked just prior to the impact. Finally, 16 percent of these intersection-related crashes occur because of a driver violation (e.g., failure to yield right-of-way). When agencies opt to install aesthetic enhancement to intersection crosswalks like stamped concrete/asphalt, the project design and construction costs can significantly increase. For HSIP applications, these costs must be accounted for in the B/C calculation, but these costs (over standard crosswalk markings) must be tracked separately and are not federally reimbursable and will increase the agency's local-funding share for the project costs. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Costs associated with this strategy will vary widely, depending if curb ramps and sidewalk modifications are required with the crossing. When considered at a single location, these low cost improvements may be funded through local funding by local crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate to high cost projects that are appropriate to seek state or federal funding. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 25% |

## SI20PB, Pedestrian Scramble

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 40% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the intersection with the new pedestrian crossing. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Pedestrian Scramble is a form of pedestrian "WALK" phase at a signalized intersection in which all vehicular traffic is required to stop, allowing pedestrians/bicyclists to safely cross through the intersection in any direction, including diagonally. Pedestrian Scramble may be considered at signalized intersections with very high pedestrian/bicycle volumes, e.g. in an urban business district. | | | | |
| **Why it works:** | | | | |
| Pedestrian Scramble has been shown to reduce injury risk and increase bicycle ridership due to its perceived safety and comfort. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Not involving any additional R/W, Pedestrian Scramble should not require a long development process and should be implemented reasonably soon. A systemic approach may be used in implementing this CM, resulting in cost efficiency with low to moderate cost. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | -10% to 51% |

### SI21PB, Install advance stop bar before crosswalk (Bicycle Box)

| For HSIP Cycle 12 Call-for-projects | | | | |
|---|---|---|---|---|
| Funding Eligibility | | Crash Types Addressed | CRF | Expected Life |
| 90% | | Pedestrian and Bicycle | 15% | 10 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the intersection-crossing with the new advanced stop bars. | | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Signalized Intersections with a marked crossing, where significant bicycle and/or pedestrians volumes are known to occur. | | | | |
| **Why it works:** | | | | |
| Adding advance stop bar before the striped crosswalk has the opportunity to enhance both pedestrian and bicycle safety. Stopping cars well before the crosswalk provides a buffer between the vehicles and the crossing pedestrians. It also allows for a dedicated space for cyclists, making them more visible to drivers (This dedicated space is often referred to as a bike-box.) | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Costs and time of installation will vary based on the number of intersections included in this strategy and if it requires new signal controllers capable of accommodating the enhancement. When considered at a single location, these low cost improvements are usually funded through local funding by local crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 35% |

### SI22PB, Modify signal phasing to implement a Leading Pedestrian Interval (LPI)

| For HSIP Cycle 12 Call-for-projects | | | | |
|---|---|---|---|---|
| Funding Eligibility | | Crash Types Addressed | CRF | Expected Life |
| 90% | | Pedestrian and Bicycle | 60% | 10 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the intersections with signalized pedestrian crossing with the newly implemented Leading Pedestrian Interval (LPI). | | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Intersections with signalized pedestrian crossing that have high turning vehicles volumes and have had pedestrian vs. vehicle crashes. | | | | |
| **Why it works:** | | | | |
| A leading pedestrian interval (LPI) gives pedestrians the opportunity to enter an intersection 3-7 seconds before vehicles are given a green indication. With this head start, pedestrians can better establish their presence in the crosswalk before vehicles have priority to turn right or left. LPIs provide (1) increased visibility of crossing pedestrians; (2) reduced conflicts between pedestrians and vehicles; (3) Increased likelihood of motorists yielding to pedestrians; and (4) enhanced safety for pedestrians who may be slower to start into the intersection. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Costs for implementing LPIs are very low, since only minor signal timing alteration is required. This makes it an easy and inexpensive countermeasure that can be incorporated into pedestrian safety action plans or policies and can become routine agency practice. When considered at a single location, the LPI is usually local-funded. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 59% |

## B.2 Intersection Countermeasures – Non-signalized

### NS01NT, Add intersection lighting (NS.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Night | 40% | 20 years |
| Notes: | This CM only applies to "night" crashes (all types) occurring within limits of the proposed roadway lighting 'engineered' area. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Non-signalized intersections that have a disproportionate number of night-time crashes and do not currently provide lighting at the intersection or at its approaches. Crash data should be studied to ensure that safety at the intersection could be improved by providing lighting (this strategy would be supported by a significant number of crashes that occur at night). | | | | |
| **Why it works:** | | | | |
| Providing lighting at the intersection itself, or both at the intersection and on its approaches, improves the safety of an intersection during nighttime conditions by (1) making drivers more aware of the surroundings at an intersection, which improves drivers' perception-reaction times, (2) enhancing drivers' available sight distances, and (3) improving the visibility of non-motorists. Intersection lighting is of particular benefit to non-motorized users as lighting not only helps them navigate the intersection, but also helps drivers see them better. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| A lighting project can usually be completed relatively quickly, but generally requires at least 1 year to implement because the lighting system must be designed and the provision of electrical power must be arranged. The provision of lighting involves both a fixed cost for lighting installation and an ongoing maintenance and power cost. For rural intersections, studies have shown the installation of streetlights reduced nighttime crashes at unlit intersections and can be more effective in reducing nighttime crashes than either rumble strips or overhead flashing beacons. Some locations can result in high B/C ratios, but due to higher costs, these projects often result in medium to low B/C ratios. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Night, All | CRF: | 25- 50% |

### NS02, Convert to all-way STOP control (from 2-way or Yield control)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 50% | 10 years |
| Notes: | This CM only applies to crashes occurring in the intersection and/or influence area of the new control. CA-MUTCD warrant must be met. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Unsignalized intersection locations that have a crash history and have no controls on the major roadway approaches. However, all-way stop control is suitable only at intersections with moderate and relatively balanced volume levels on the intersection approaches. Under other conditions, the use of all-way stop control may create unnecessary delays and aggressive driver behavior. MUTCD warrants should always be followed. | | | | |
| **Why it works:** | | | | |
| All-way stop control can reduce right-angle and turning collisions at unsignalized intersections by providing more orderly movement at an intersection, reducing through and turning speeds, and minimizing the safety effect of any sight distance restrictions that may be present. Advance public notification of the change is critical in assuring compliance and reducing crashes. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| The costs involved in converting to all-way stop control are relatively low. All-way stop control can normally be implemented at multiple intersections with just a change in signing on intersection approaches, and typically are very quick to implement. When considered at a single location, these low cost improvements are usually funded through local funding by local maintenance crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Left-turn, Angle | CRF: | 6 - 80% |

### NS03, Install signals

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 30% | 20 years |
| Notes: | This CM only applies to crashes occurring in the intersection and/or influence area of the new signals. **All new signals must meet MUTCD "safety" warrants: 4, 5 or 7.** Given the over-arching operational changes that occur when an intersection is signalized, no other intersection CMs can be applied to the intersection crashes in conjunction with this CM. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Traffic signals can be used to prevent the most severe type crashes (right-angle, left-turn). Consideration to signalize an unsignalized intersection should only be given after (1) less restrictive forms of traffic control have been utilized as the installation of a traffic signal often leads to an increased frequency of crashes (rear-end) on major roadways and introduces congestion and (2) signal warrants have been met. Refer to the CA MUTCD, Section 4C.01, Studies and Factors for Justifying Traffic Control Signals. | | | | |
| **Why it works:** | | | | |
| Traffic signals have the potential to reduce the most severe type crashes but will likely cause an increase in rear-end collisions. A reduction in overall injury severity is likely the largest benefit of traffic signal installation. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Typical traffic signal costs fall in the medium to high category and are affected by application, type of signal and right-of-away considerations. Projects of this magnitude should only be considered after alternate and lesser means of correction have been evaluated. Some locations can result in high B/C ratios, but due to higher costs, these projects often result in medium to low B/C ratios. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 0 - 74% |

### NS04RA/NS05RA, Convert intersection to roundabout

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | Varies | 20 years |
| Notes: | This CM only applies to crashes occurring in the intersection and/or influence area of the new control.<br>The benefit of this CM is calculated using Caltrans procedure. The CRF is dependent on the ADT, project location (Rural/Urban) and the roundabout type (1 lane or 2 lanes). The benefit comes from both the reduction in the number and the severity of the crashes. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Intersections that have a high frequency of right-angle and left-turn type crashes. Whether such intersections have existing crash patterns or not, a roundabout provides an alternative to signalization. The primary target locations for roundabouts should be moderate-volume unsignalized intersections. Roundabouts may not be a viable alternative in many suburban and urban settings where right-of-way is limited. | | | | |
| **Why it works:** | | | | |
| Roundabouts provide an important alternative to signalized and stop/yield-controlled intersections. Modern roundabouts differ from traditional traffic circles in that they operate in such a manner that traffic entering the roundabout must yield the right-of-way to traffic already in it. Roundabouts can serve moderate traffic volumes with less delay than all-way stop-controlled intersections and provide fewer conflict points. Crashes at roundabouts tend to be less severe because of the speed constraints and elimination of left-turn and right-angle movements. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Construction of roundabouts are usually relatively costly and major projects, requiring the environmental process, right-of-way acquisition, and implementation under an agency's long-term capital improvement program. Even with roundabouts higher costs, they still can have a relatively high effectiveness. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Left-turn, Angle | CRF: | 12 - 78 % |

### NS06RA/NS07RA, Convert intersection to compact roundabout

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | Varies | 20 years |
| Notes: | This CM only applies to crashes occurring in the intersection and/or influence area of the new control. The benefit of this CM is calculated using Caltrans procedure. The CRF is dependent on the ADT and the project location (Rural/Urban). The benefit comes from both the reduction in the number and the severity of the crashes. | | |

**General information**

**Where to use:**

Compact roundabouts are characterized by a small inscribed circle diameter (80-100 ft). Compact roundabouts offer most of the benefits of regular roundabouts with the added benefit of a smaller footprint. They are best suited to environments where speeds are already low and environmental constraints would preclude the use of a larger roundabout. Compact roundabouts may require minimal additional pavement, and in many cases existing curb or sidewalk can be left in place. As a result, compact roundabouts rarely require the purchase of right of way. Compact roundabouts are similar to single-lane roundabouts regarding design vehicle assumptions, ability to process traffic volumes, and signing.

Compact roundabouts are intended to be pedestrian and bicyclist-friendly because their perpendicular approach legs require very low vehicle speeds to make a distinct right turn into and out of the circulatory roadway. Capacity should not be a critical issue for this type of roundabout to be considered.

**Why it works:**

Compact roundabouts may be an optimal solution for a safety or operational issue at an existing intersection where there is insufficient right-of-way for a standard roundabout installation. The benefits of compact roundabouts are the compact size, operational efficiency, traffic safety improvement and traffic Calming.

**General Qualities (Time, Cost and Effectiveness):**

Construction costs for compact roundabouts vary widely depending upon the extent of sidewalk modifications or other geometric improvements and the types of materials used. In most cases, compact roundabouts have been installed with little or no pavement widening. Construction costs can be moderate for compact roundabouts that include raised islands and pedestrian improvements.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | NA | CRF: | NA |
|---|---|---|---|---|

### NS08, Install/upgrade larger or additional stop signs or other intersection warning/regulatory signs

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 15% | 10 years |
| Notes: | This CM only applies to crashes occurring in the influence area of the new signs. The influence area must be determined on a location by location basis. | | |

**General information**

**Where to use:**

The target for this strategy should be approaches to unsignalized intersections with patterns of rear-end, right-angle, or turning collisions related to lack of driver awareness of the presence of the intersection.

**Why it works:**

The visibility of intersections and, thus, the ability of approaching drivers to perceive them can be enhanced by installing larger regulatory and warning signs at or prior to intersections. A key to success in applying this strategy is to select a combination of regulatory and warning sign techniques appropriate for the conditions on a particular unsignalized intersection approach.

**General Qualities (Time, Cost and Effectiveness):**

Signing improvements do not require a long development process and can typically be implemented quickly. Costs for implementing this strategy are nominal and depend on the number of signs. When considered at a single location, these low cost improvements are usually funded through local funding by local maintenance crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 11 - 55% |
|---|---|---|---|---|

## NS09, Upgrade intersection pavement markings (NS.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 25% | 10 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the new pavement markings. This CM is not intended to be used for general maintenance activities (i.e. the replacement of existing pavement markings in-kind) and must include upgraded safety features over the existing pavement markings and striping. | | |

**General information**

**Where to use:**

Unsignalized intersections that are not clearly visible to approaching motorists, particularly approaching motorists on the major road. The strategy is particularly appropriate for intersections with patterns of rear-end, right-angle, or turning crashes related to lack of driver awareness of the presence of the intersection. Also at minor road approaches where conditions allow the stop bar to be seen by an approaching driver at a significant distance from the intersection. Typical improvements include "Stop Ahead" markings and the addition of Centerlines and Stop Bars.

**Why it works:**

The visibility of intersections and, thus, the ability of approaching drivers to perceive them can be enhanced by installing appropriate pavement delineation in advance of and at intersections will provide approaching motorists with additional information at these locations. Providing visible stop bars on minor road approaches to unsignalized intersections can help direct the attention of drivers to the presence of the intersection. Drivers should be more aware that the intersection is coming up, and therefore make safer decisions as they approach the intersection.

**General Qualities (Time, Cost and Effectiveness):**

Pavement marking improvements do not require a long development process and can typically be implemented quickly. Costs for implementing this strategy are nominal and depend on the number of markings. When considered at a single location, these low cost improvements are usually funded through local funding by local maintenance crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding. Note: When federal safety funding is used for these installations in high-wear-locations, the local agency is expected to maintain the improvement for a minimum of 10 years.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 13 - 60% |
|---|---|---|---|---|

## NS10, Install Flashing Beacons at Stop-Controlled Intersections

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 15% | 10 years |
| Notes: | This CM only applies to crashes occurring on the stop-controlled approaches / influence area of the new beacons. | | |

**General information**

**Where to use:**

Flashing beacons can reinforce driver awareness of the Non-Signalized intersection control and can help mitigate patterns of right-angle crashes related to stop sign violations. Post-mounted advanced flashing beacons or overhead flashing beacons can be used at stop-controlled intersections to supplement and call driver attention to stop signs.

**Why it works:**

Flashing beacons provide a visible signal to the presence of an intersection and can be very effective in rural areas where there may be long stretches between intersections as well as locations where night-time visibility of intersections is an issue.

**General Qualities (Time, Cost and Effectiveness):**

Flashing beacons can be constructed with minimal design, environmental and right-of-way issues and have relatively low costs. Before choosing this CM, the agency needs to confirm the ability to provide power to the site (solar may be an option). In general, This CM can be very effective and can be considered on a systematic approach.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Angle, Rear-End | CRF: | 5-34% |
|---|---|---|---|---|

## NS11, Install flashing beacons as advance warning (NS.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 30% | 10 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the new beacons placed in advance of the intersection. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Non-Signalized Intersections with patterns of crashes that could be related to lack of a driver's awareness of approaching intersection or controls at a downstream intersection. | | | | |
| **Why it works:** | | | | |
| Advance flashing beacons can be used to supplement and call driver attention to intersection control signs. Flashing beacons are intended to reinforce driver awareness of the stop or yield signs and to help mitigate patterns of crashes related to intersection regulatory sign violations. Most advance warning flashing beacons can be powered by solar, thus reducing the issues relating to power source. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Use of flashing beacons requires minimal development process, allowing flashing beacons to be installed within a short time period. Before choosing this CM, the agency needs to confirm the ability to provide power to the site (solar may be an option). In general, This CM can be very effective and can be considered on a systematic approach. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Angle, Rear-End | CRF: | 36 - 62% |

## NS12, Install transverse rumble strips on approaches

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 20% | 10 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the new rumble strips. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Transverse rumble strips are installed in the travel lane for the purposes of providing an auditory and tactile sensation for each motorist approaching the intersection. They can be used at any stop or yield approach intersection, often in combination with advance signing to warn of the intersection ahead. Due to the noise generated by vehicles driving over the rumble strips, care must be taken to minimize disruption to nearby residences and businesses. | | | | |
| **Why it works:** | | | | |
| When motorists are traveling along the roadway, they are sometimes unaware they are approaching an intersection. This is especially true on rural roads, as there may be fewer clues indicating an intersection ahead. Transverse rumble strips warn motorists that something unexpected is ahead that they need to pay attention to. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Use of transverse rumble strips requires minimal development process, allowing transverse rumble strips to be installed within a short time period. In general, This CM can be very effective and can be considered on a systematic approach, although care should be taken to not over-use this CM. Note: When federal safety funding is used for these installations in high-wear-locations, the local agency is expected to maintain the improvement for a minimum of 10 years. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 0 - 35% |

## NS13, Improve sight distance to intersection (Clear Sight Triangles)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 20% | 10 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the significantly improved new sight distance. Minor/incidental improvements to sight distance would not likely result in the CRF shown below. | | |

**General information**

**Where to use:**

Unsignalized intersections with restricted sight distance and patterns of crashes related to lack of sight distance where sight distance can be improved by clearing roadside obstructions without major reconstruction of the roadway.

**Why it works:**

Adequate sight distance for drivers at stop or yield-controlled approaches to intersections has long been recognized as among the most important factors contributing to overall safety at unsignalized intersections. By removing sight distance restrictions (e.g., vegetation, parked vehicles, signs, buildings) from the sight triangles at stop or yield-controlled intersection approaches, drivers will be able see approaching vehicles on the main line, without obstruction and therefore make better decisions about entering the intersection safely.

**General Qualities (Time, Cost and Effectiveness):**

Projects involving clearing sight obstructions on the highway right-of-way can typically be accomplished quickly, assuming the objects are readily moveable. Clearing sight obstructions on private property requires more time for discussions with the property owner. Costs will generally be low, assuming that in most cases the objects to be removed are within the right-of-way. In general, this CMs can be very effective and can be implemented by agencies' maintenance staff and/or implemented on a systematic approach. Usually only high-cost removals would be good candidates for Caltrans Federal Safety Funding. Note: When federal safety funding is used to remove vegetation that has the potential to grow back, the local agency is expected to maintain the improvement for a minimum of 10 years.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 11 - 56% |
|---|---|---|---|---|

## NS14, Improve pavement friction (High Friction Surface Treatments)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 55% | 10 years |
| Notes: | This CM only applies to crashes occurring within the limits of the improved friction overlay. This CM is not intended to apply to standard chip-seal or open-graded maintenance projects for long segments of corridors or structure repaving projects intended to fix failed pavement. | | |

**General information**

**Where to use:**

Nationally, this countermeasure is referred to as "High Friction Surface Treatments" or HFST. Non-signalized Intersections noted as having crashes on wet pavements or under dry conditions when the pavement friction available is significantly less than needed for the actual roadway approach speeds. This treatment is intended to target locations where skidding and failure to stop is determined to be a problem in wet or dry conditions and the target vehicle is unable to stop due to insufficient skid resistance.

**Why it works:**

Improving the skid resistance at locations with high frequencies of wet-road crashes and/or failure to stop crashes can result in reductions of 50 percent for wet-road crashes and 20 percent for total crashes. Applying HFST can double friction numbers, e.g. low 40s to high 80s. This CM represents a special focus area for both FHWA and Caltrans, which means there are extra resources available for agencies interested in more details on High Friction Surface Treatment projects.

**General Qualities (Time, Cost and Effectiveness):**

This strategy can be relatively inexpensive and implemented in a short timeframe. The installation would be done by either agency personnel or contractors and can be done by hand or machine. In general, This CM can be very effective and can be considered on a systematic approach.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Wet, Night, ALL | CRF: | 10 - 62 % |
|---|---|---|---|---|

## NS15, Install splitter-islands on the minor road approaches

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 40% | 20 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of **the new splitter island on the minor road approaches.** | | |

| General information |
|---|
| **Where to use:** |
| Minor road approaches to unsignalized intersections where the presence of the intersection or the stop sign is not readily visible to approaching motorists. The strategy is particularly appropriate for intersections where the speeds on the minor road are high. In creation of a splitter island allows for an additional stop sign to be placed in the median for the minor approach. |
| **Why it works:** |
| The installation of splitter islands allows for the addition of a stop sign in the median to make the intersection more conspicuous. Additionally, the splitter island on the minor-road provides for a positive separation between turning vehicles on the through road and vehicles stopped on the minor road approach. |
| **General Qualities (Time, Cost and Effectiveness):** |
| Splitter islands at non-signalized intersections can usually be installed with minimal roadway reconstruction and relatively quickly. In general, This CM can be very effective and can be considered on a systematic approach. |

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Angle, Rear-End | CRF: | 35 - 100 % |
|---|---|---|---|---|

## NS16, Install raised median on approaches (NS.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 25% | 20 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the new raised median. All new raised medians funded with federal HSIP funding should not include the removal of the existing roadway structural section and should be doweled into the existing roadway surface. This requirement is being implemented to maximize the safety-effectiveness of the limited HSIP funding and to minimize project impacts. Landscaping, if included in the project, is considered non-participating. | | |

| General information |
|---|
| **Where to use:** |
| Where related or nearby turning movements affect the safety and operation of an intersection. Effective access management is key to improving safety at, and adjacent to, intersections. The number of intersection access points coupled with the speed differential between vehicles traveling along the roadway often contributes to crashes. Any access points within 250 feet upstream and downstream of an intersection are generally undesirable. |
| **Why it works:** |
| Raised medians with left-turn lanes at intersections offer a cost-effective means for reducing crashes and improving operations at higher volume intersections. The raised medians also prohibit left turns into and out of driveways that may be located too close to the functional area of the intersection. |
| **General Qualities (Time, Cost and Effectiveness):** |
| Raised medians at intersections may be most effective in retrofit situations where high volumes of turning vehicles have degraded operations and safety, and where more extensive approaches would be too expensive because of limited right-of-way and the constraints of the built environment. Because raised medians limit property access to right turns only, the need for providing alternative access ways should be considered. In general, This CM can be very effective and can be considered on a systematic approach. When agencies opt to install landscaping in conjunction with new raised medians, the portion of the cost for landscaping and other non-safety related items that exceeds 10% of the project total cost is not federally participated and must be funded by the applicant. |

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 20 - 39 % |
|---|---|---|---|---|

## NS17, Create directional median openings to allow (and restrict) left-turns and u-turns (NS.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 50% | 20 years |
| Notes: | This CM only applies to crashes occurring in the intersection / influence area of the new directional openings. | | |

| General information |
|---|
| **Where to use:** |
| Crashes related to turning maneuvers include angle, rear-end, pedestrian, and sideswipe (involving opposing left turns) type crashes. If any of these crash types are an issue at an intersection, restriction or elimination of the turning maneuver may be the best way to improve the safety of the intersection. Because raised medians limit property access to right turns only, they should be used in conjunction with efforts to provide alternative access ways and promote driveway spacing objectives. |
| **Why it works:** |
| Agencies are increasingly using access management techniques on urban and suburban arterials to manage the number of conflicts experienced at an intersection. A key element of access management is to restrict certain movements, create directional median openings, or close median openings that are deemed too close to an intersection. |
| **General Qualities (Time, Cost and Effectiveness):** |
| Turn prohibitions that are implemented by closing a median opening can usually be implemented quickly. Costs are highly variable but in many cases could be considered low. In some cases this strategy may involve acquiring access or constructing replacement access; those actions will significantly increase the cost of the project. Impacts to businesses and other land uses must be considered and controversy can delay the implementation. In general, This CM can be very effective and can be considered on a systematic approach. |

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 51% |
|---|---|---|---|---|

## NS18, Reduced Left-Turn Conflict Intersections (NS.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| **Funding Eligibility** | **Crash Types Addressed** | **CRF** | **Expected Life** |
| 90% | All | 50% | 20 years |
| Notes: | This CM only applies to crashes occurring in the intersection / influence area of the new Reduced Left-Turn Conflict. | | |

**General information**

**Where to use and Why it works:**

Reduced left-turn conflict intersections are geometric designs that alter how left-turn movements occur in order to simplify decisions and minimize the potential for related crashes. Two highly effective designs that rely on U-turns to complete certain left-turn movements are known as the restricted crossing U-turn (RCUT) and the median U-turn (MUT).

**Restricted Crossing U-turn (RCUT):**

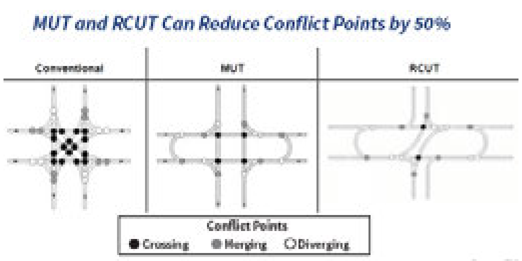
The RCUT intersection modifies the direct left-turn and through movements from cross-street approaches. Minor road traffic makes a right turn followed by a U-turn at a designated location (either signalized or unsignalized) to continue in the desired direction.

The RCUT is suitable for a variety of circumstances, including along rural, high-speed, four-lane, divided highways or signalized routes. It also can be used as an alternative to signalization or constructing an interchange. RCUTs work well when consistently used along a corridor, but also can be used effectively at individual intersections.

**Median U-turn (MUT)**

The MUT intersection modifies direct left turns from the major approaches. Vehicles proceed through the main intersection, make a U-turn a short distance downstream, followed by a right turn at the main intersection. The U-turns can also be used for modifying the cross-street left turns.

The MUT is an excellent choice for heavily traveled intersections with moderate left-turn volumes. When implemented at multiple intersections along a corridor, the efficient two-phase signal operation of the MUT can reduce delay, improve travel times, and create more crossing opportunities for pedestrians and bicyclists.




**General Qualities (Time, Cost and Effectiveness):**

Implementing this strategy may take from months to years, depending on whether additional R/W is required. Such projects require a substantial time for development and construction. Costs are highly variable and range from very low to high. The expected effectiveness of this CM must be assessed for each individual location.

| | | | | |
|---|---|---|---|---|
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Angle/Left-turn/Rear-End/All | CRF: | 34.8-100% |

## NS19, Install right-turn lane (NS.I.)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 20% | 20 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the new right-turn lanes. This CM is not eligible for use at existing all-way stop intersections. | | |

| General information |
|---|
| **Where to use:** |
| Many collisions at unsignalized intersections are related to right-turn maneuvers. A key strategy for minimizing such collisions is to provide exclusive right-turn lanes, particularly on high-volume and high-speed major-road approaches. When considering new right-turn lanes, potential impacts to non-motorized users should be considered and mitigated as appropriate. When considering new right-turn lanes, potential impacts to non-motorized users should be considered and mitigated as appropriate. |
| **Why it works:** |
| The strategy is targeted to reduce the frequency of rear-end collisions resulting from conflicts between vehicles turning right and following vehicles and vehicles turning right and through vehicles coming from the left on the cross street. Right-turn lanes also remove slow vehicles that are decelerating to turn right from the through-traffic stream, thus reducing the potential for rear-end collisions. Right-turn lanes can increase the length of the intersection crossing and create an additional potential conflict point for non-motorized users. |
| **General Qualities (Time, Cost and Effectiveness):** |
| Implementing this strategy may take from months to years. At some locations, right-turn lanes can be quickly and simply installed by restriping the roadway. At other locations, widening of the roadway, acquisition of additional right-of-way, and extensive environmental processes may be needed. Such projects require a substantial time for development and construction. Costs are highly variable and range from very low to high. The expected effectiveness of this CM must be assessed for each individual location. |

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 14 - 26 % |
|---|---|---|---|---|

## NS20, Install left-turn lane (where no left-turn lane exists)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 35% | 20 years |
| Notes: | This CM only applies to crashes occurring on the approaches / influence area of the new left-turn lanes. This CM does NOT apply to converting a single-left into double-left turn. This CM is not eligible for use at existing all-way stop intersections. | | |

| General information |
|---|
| **Where to use:** |
| Many collisions at unsignalized intersections are related to left-turn maneuvers. A key strategy for minimizing such collisions is to provide exclusive left-turn lanes, particularly on high-volume and high-speed major-road approaches. When considering new left-turn lanes, potential impacts to non-motorized users should be considered and mitigated as appropriate. |
| **Why it works:** |
| Adding left-turn lanes remove vehicles waiting to turn left from the through-traffic stream, thus reducing the potential for rear-end collisions. Because they provide a sheltered location for drivers to wait for a gap in opposing traffic, left-turn lanes may encourage drivers to be more selective in choosing a gap to complete the left-turn maneuver. This strategy may reduce the potential for collisions between left-turn and opposing through vehicles. |
| **General Qualities (Time, Cost and Effectiveness):** |
| Implementing this strategy may take from months to years. At some locations, left-turn lanes can be quickly and simply installed by restriping the roadway. At other locations, widening of the roadway, acquisition of additional right-of-way, and extensive environmental processes may be needed. Such projects require a substantial time for development and construction. Costs are highly variable and range from very low to high. The expected effectiveness of this CM must be assessed for each individual location. |

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 9 -55 % |
|---|---|---|---|---|

## NS21PB, Install raised medians (refuge islands)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 45% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the crossing with the new islands. All new raised medians funded with federal HSIP funding should not include the removal of the existing roadway structural section and should be doweled into the existing roadway surface. This requirement is being implemented to maximize the safety-effectiveness of the limited HSIP funding and to minimize project impacts. Landscaping, if included in the project, is considered non-participating. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Intersections that have a long pedestrian crossing distance, a higher number of pedestrians, or a crash history. Raised medians decrease the level of exposure for pedestrians and allow pedestrians to concentrate on (or cross) only one direction of traffic at a time. | | | | |
| **Why it works:** | | | | |
| Raised pedestrian refuge islands, or medians at crossing locations along roadways, are another strategy to reduce exposure between pedestrians and motor vehicles. Refuge islands and medians that are raised (i.e., not just painted) provide pedestrians more secure places of refuge during the street crossing. They can stop partway across the street and wait for an adequate gap in traffic before completing their crossing. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Median and pedestrian refuge areas are a low-cost countermeasure to implement. This cost can be applied to retrofit improvements or if it is a new construction project, implementing this countermeasure is even more cost-effective. In general, This CM can be very effective and can be considered on a systematic approach. When agencies opt to install landscaping in conjunction with new raised medians, the portion of the cost for landscaping and other non-safety related items that exceeds 10% of the project total cost is not federally participated and must be funded by the applicant. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian and Bicycle | CRF: | 30 - 56 % |

## NS22PB, Install pedestrian crossing at uncontrolled locations (signs and markings only)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 25% | 10 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the intersection/crossing with the new crossing. This CM is not intended to be used for high-cost aesthetic enhancements to intersection crosswalks (i.e. stamped concrete or stamped asphalt). | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Non-signalized intersections without a marked crossing, where pedestrians are known to be crossing intersections that involve significant vehicular traffic. They are especially important at school crossings and intersections with right and/or left turns pockets. See Zegeer study (Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations) for additional guidance regarding when to install a marked crosswalk. | | | | |
| **Why it works:** | | | | |
| Adding pedestrian crossings has the opportunity to enhance pedestrian safety at locations noted as being problematic. Pavement markings delineate a portion of the roadway that is designated for pedestrian crossing. These markings will often be different for controlled verses uncontrolled locations. The use of "ladder", "zebra" or other enhanced markings at uncontrolled crossings can increase both pedestrian and driver awareness to the increased exposure at the crossing. Incorporating advanced "stop" or “yield" markings provides an extra safety buffer and can be effective in reducing the 'multiple-threat' danger to pedestrians. Nearly one-third of all pedestrian-related crashes occur at or within 50 feet of an intersection. Of these, 30 percent may involve a turning vehicle. There are several types of pedestrian crosswalks, including: continental, ladder, zebra, and standard. When agencies opt to install aesthetic enhancement to intersection crosswalks like stamped concrete/asphalt, the project design and construction costs can significantly increase. For HSIP applications, these costs must be accounted for in the B/C calculation, but these costs (over standard crosswalk markings) must be tracked separately and are not federally reimbursable and will increase the agency's local-funding share for the project costs. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Costs associated with this strategy will vary widely, depending upon if curb ramps and sidewalk modifications are required with the crossing. When considered at a single location, these low cost improvements are usually funded through local funding by local crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian and Bicycle | CRF: | 25 % |

## NS23PB, Install/upgrade pedestrian crossing at uncontrolled locations (with enhanced safety features)

| For HSIP Cycle 12 Call-for-projects | | | | |
|---|---|---|---|---|
| Funding Eligibility | | Crash Types Addressed | CRF | Expected Life |
| 90% | | Pedestrian and Bicycle | 35% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the new crossing (influence area) with enhanced safety features. This CM is not intended to be used for high-cost aesthetic enhancements to intersection crosswalks (i.e. stamped concrete or stamped asphalt). | | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Non-signalized intersections where pedestrians are known to be crossing intersections that involve significant vehicular traffic. They are especially important at school crossings and intersections with turn pockets. Based on the Zegeer study (Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations) at many locations, a marked crosswalk alone may not be sufficient to adequately protect non-motorized users. In these cases, **flashing beacons, curb extensions, advanced "stop" or "yield" markings, and other safety features** should be added to complement the standard crossing elements. | | | | |
| **Why it works:** | | | | |
| Adding pedestrian crossings that include enhances safety features has the opportunity to enhance pedestrian safety at locations noted as being especially problematic. The enhanced safety elements help delineate a portion of the roadway that is designated for pedestrian crossing. Incorporating advanced "yield" markings provide an extra safety buffer and can be effective in reducing the 'multiple-threat' danger to pedestrians. Nearly one-third of all pedestrian-related crashes occur at or within 50 feet of an intersection. When agencies opt to install aesthetic enhancement to intersection crosswalks like stamped concrete/asphalt, the project design and construction costs can significantly increase. For HSIP applications, these costs must be accounted for in the B/C calculation, but these costs (over standard crosswalk markings) must be tracked separately and are not federally reimbursable and will increase the agency's local-funding share for the project costs. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Costs associated with this strategy will vary widely, depending upon the types of enhanced features that will be combined with the standard crossing improvements. The need for new curb ramps and sidewalk modifications will also be a factor. This CM may be effectively and efficiently implemented using a systematic approach with more than one location and can have relatively high B/C ratios based on past non-motorized crash history. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian and Bicycle | CRF: | 37% |

## NS24PB, Install Rectangular Rapid Flashing Beacon (RRFB)

| For HSIP Cycle 12 Call-for-projects | | | | |
|---|---|---|---|---|
| Funding Eligibility | | Crash Types Addressed | CRF | Expected Life |
| 90% | | Pedestrian and Bicycle | 35% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the influence area (expected to be a maximum of within 250') of the crossing which includes the RRFB. | | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Rectangular Rapid Flashing Beacon (RRFB) includes pedestrian-activated flashing lights and additional signage that enhance the visibility of marked crosswalks and alert motorists to pedestrian crossings. It uses an irregular flash pattern that is similar to emergency flashers on police vehicles. RRFBs are installed at unsignalized intersections and mid-block pedestrian crossings. | | | | |
| **Why it works:** | | | | |
| RRFBs can enhance safety by increasing driver awareness of potential pedestrian conflicts and reducing crashes between vehicles and pedestrians at unsignalized intersections and mid-block pedestrian crossings. The addition of RRFB may also increase the safety effectiveness of other treatments, such as crossing warning signs and markings. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| RRFBs are a lower cost alternative to traffic signals and hybrid signals. This CM can often be effectively and efficiently implemented using a systematic approach with numerous locations. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 7 – 47.4% |

## NS25PB, Install Pedestrian Signal (including Pedestrian Hybrid Beacon (HAWK))

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 55% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the intersection/crossing with the new signal. For HAWK or other pedestrian signals, the justification may be Warrant 4, 5 and/or 7, or passing the test in Figure 4F-1/4F-2 in Chapter 4F of CA MUTCD. Please refer to Chapter 4F of CA MUTCD for more details | | |

**General information**

**Where to use:**

Intersections noted as having a history of pedestrian vs. vehicle crashes and in areas where the likelihood of the pedestrian presence is high. Corridors should also be assessed to determine if there are adequate safe opportunities for non-motorists to cross and if a pedestrian signal, or a Pedestrian Hybrid Beacon (PHB) (also called High-Intensity Activated crossWalK beacon (HAWK)) are needed to provide an active warning to motorists when a pedestrian is in the crosswalk.

**Why it works:**

Adding a pedestrian signal has the opportunity to greatly enhance pedestrian safety at locations noted as being problematic. Nearly one-third of all pedestrian-related crashes occur at or within 50 feet of an intersection. In combination with this CM, better guidance signs and markings for non-motorized and motorized roadway users should be considered, including: sign and markings directing pedestrians and cyclists on appropriate/legal travel paths and signs and markings warning motorists of non-motorized uses of the roadway that should be expected.

**General Qualities (Time, Cost and Effectiveness):**

The cost of improvements are generally high, but can vary dependent on the type of signal and overall scope of the project. In most cases the project duration can be short. The expected effectiveness of this CM must be assessed for each individual location.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian and Bicycle | CRF: | 15 - 69% |
|---|---|---|---|---|

## B.3 Roadway Countermeasures

### R01NT, Add Segment Lighting

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Night | 35% | 20 years |
| Notes: | This CM only applies to "night" crashes (all types) occurring within limits of the proposed roadway lighting 'engineered' area. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Where to use: Noted substantial patterns of nighttime crashes. In particular, patterns of rear-end, right-angle, turning or roadway departure collisions on the roadways may indicate that night-time drivers can be unaware of the roadway characteristics. | | | | |
| **Why it works:** | | | | |
| Providing roadway lighting improves the safety during nighttime conditions by (1) making drivers more aware of the surroundings, which improves drivers' perception-reaction times, (2) enhancing drivers' available sight distances to perceive roadway characteristic in advance of the change, and (3) improving non-motorist's visibility and navigation. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| It expected that projects of this type may be constructed in a year or two and are relatively costly. There are several types of costs associated with providing lighting, including the cost of providing a permanent source of power to the location, the cost for the luminaire supports (i.e., poles), and the cost for routinely replacing the bulbs and maintenance of the luminaire supports. Some locations can result in high B/C ratios, but due to higher costs, these projects often result in medium to low B/C ratios. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Night, All | CRF: | 18 - 69 % |

### R02, Remove or relocate fixed objects outside of Clear Recovery Zone

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 35% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new clear recovery zone (per Caltrans' HDM). | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Known locations or roadway segments prone to collisions with fixed objects such as utility poles, drainage structures, trees, and other fixed objects, such as the outside of a curve, end of lane drops, and in traffic islands. A clear recovery zone should be developed on every roadway, as space is available. In situations where public right-of-way is limited, steps should be taken to request assistance from property owners, as appropriate. | | | | |
| **Why it works:** | | | | |
| While this strategy does not prevent the vehicle leaving the roadway, it does provide a mechanism to reduce the severity of a resulting crash. A clear zone is an unobstructed, traversable roadside area that allows a driver to stop safely or regain control of a vehicle that has left the roadway. Removing or moving fixed objects, flattening slopes, or providing recovery areas reduces the likelihood of a crash. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Projects involving removing fixed objects from highway right-of-way can typically be accomplished quickly, assuming the objects are readily moveable. Clearing objects on private property requires more time for discussions with the property owner. Costs will generally be low, assuming that in most cases the objects to be removed are within the right-of-way. This CMs can be very effective and can be implemented by agencies' maintenance staff and/or implemented on a systematic approach. High-cost removals or removals implemented using a systematic approach would be good candidates for Caltrans Federal Safety Funding. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Fixed Object | CRF: | 17 - 100 % |

## R03, Install Median Barrier

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 25% | 20 years |
| Notes: | Note: For Caltrans' statewide Calls-for-Projects, this CM only applies to crashes occurring within the limits of the new barrier. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Areas where crash history indicates drivers are unintentionally crossing the median and the cross-overs are resulting in high severity crashes. The installation of median barriers can increase the number of PDO and non-severe injuries. The net result in safety from this countermeasure is connected more to reducing the severity of crashes not the number of crashes. It is recommended to review the warrants as outlined in Chapter 7 of the Caltrans Traffic Manual when considering whether to install median barriers. | | | | |
| **Why it works:** | | | | |
| This strategy is designed to prevent head-on collisions by providing a barrier between opposing lanes of traffic. The variety of median barriers available makes it easier to choose a site-specific solution. The main advantage is the reduction of the severity of the crashes. The key to success would be in selecting an appropriate barrier based on the site, previous crash history, maintenance needs, and median width. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| This strategy would in many cases be possible to implement within a short period after site selection. Costs will vary depending on the type of median barrier selected and whether the strategy is implemented as a stand-alone project or incorporated as part of a reconstruction or resurfacing effort. Maintenance costs and worker exposure will also vary depending on the type of barrier selected. The expected effectiveness of this CM must be assessed for each individual location. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Head-on | CRF: | 0 - 94 % |

## R04, Install Guardrail

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 25% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new guardrail. This CM is not intended to be used for general maintenance activities (i.e. the replacement of existing damaged rail). For projects proposing to upgrade existing guardrail to current standards, this CM and corresponding CRF should only be applied to locations where past crash data or engineering judgment applied to the existing rail conditions suggests the upgraded guardrail may result in fewer or less severe crashes (justifying the use of the 25% CRF for this CM). | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Guardrail is installed to reduce the severity of lane departure crashes. However, guardrail can reduce crash severity only for those conditions where striking the guardrail is less severe than going down an embankment or striking a fixed object. Guardrail should only be installed where it is clear that crash severity will be reduced, or there is a history of run-off-the-road crashes at a given location that have resulted in severe crashes. New and upgraded guardrail and end-treatments must meet current safety standards; see Method for Assessing Safety Hardware (MASH) for more information. Caltrans (or other national accepted guidance) slope/height criteria need to be considered and documented. | | | | |
| **Why it works:** | | | | |
| Guardrail redirects a vehicle away from embankment slopes or fixed objects and dissipates the energy of an errant vehicle. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Strategies range from relatively inexpensive too costly. Costly projects may include those that upgrade existing guardrail applications to more semi-rigid and rigid barrier systems over extended distances. In general, this CMs can be effective and can be implemented by agencies' maintenance staff and/or implemented on a systematic approach. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Fixed Object, Run-off Road | CRF: | 11 - 78 % |

### R05, Install impact attenuators

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 25% | 10 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new attenuators. This CM is not intended to be used for general maintenance activities (i.e. the replacement of existing damaged attenuators). For projects proposing to upgrade existing attenuators to current standards, this CM and corresponding CRF should only be applied to locations where past crash data or engineering judgment applied to the existing attenuator conditions suggests the upgraded attenuators may result in fewer or less severe crashes (justifying the use of the 25% CRF for this CM). | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Impact attenuators are typically used to shield rigid roadside objects such as concrete barrier ends, steel guardrail ends and bridge pillars from oncoming automobiles. Attenuators should only be installed where it is impractical for the objects to be removed. New and upgraded barrier end-treatments must meet current safety standards; see MASH for more information. | | | | |
| **Why it works:** | | | | |
| Attenuators bring an errant vehicle to a more-controlled stop or redirect the vehicle away from a rigid object. Attenuators are effective at absorbing impact energy and increasing occupant safety. They also tend to draw attention to the fixed object, which helps drivers steer clear of the fixed objects. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Costs depending on the scope of the project, type(s) used, and associated ongoing maintenance costs. Time to install is fairly quick once site is identified. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Fixed Object, Run-off Road | CRF: | 5 - 50 % |

### R06, Flatten side slopes

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 30% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new side slopes. Minor/incidental flattening of side slopes would not likely result in the CRF shown below and may not be appropriate for use in Caltrans B/C calculations. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Roadways experiencing frequent lane departure crashes that result in roll-over type crashes as a result of the roadway slope being so severe as to not accommodate a reasonable degree of driver correction. When there is a need to reduce the severity of lane departure crashes without installing a barrier system that could result in increased numbers of crashes. | | | | |
| **Why it works:** | | | | |
| Flattened slopes provide a greater area for a driver to regain control of a vehicle. Steep slopes, ditches or unprotected hazardous drops-offs adjacent to a travel lane offer little opportunities to correct an inappropriate action by a driver and can result in sever crashes. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Roadside modifications range from relatively inexpensive to very costly. Strategies that include creating safer side slopes where none exists can be moderately expensive based on the scope of the project and the associated clearing, grading, etc. The potential for high environmental and right-of-way impacts is high which can take several years to clear. In other cases This CM can be effective and can be implemented by agencies' maintenance staff and/or implemented on a systematic approach. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Fixed Object, Run-off Road | CRF: | 5 - 62 % |

### R07, Flatten side slopes and remove guardrail

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 40% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits of both the removed guardrail and the new side slopes. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Locations where high number of crashes originate as a lane departure and result in collision with guardrail or a fixed object located on the side slope shielded by guardrail. The guardrail may or may not meet current standards. Even though guardrails are generally installed to reduce the severity of departure crashes, they still can result in severe crashes in some locations. | | | | |
| **Why it works:** | | | | |
| Flattened side slopes and an unobstructed clear zone provide a greater area for a driver to regain control of a vehicle. The existing guardrail may help protect the steep slopes, fixed objects, or unprotected hazardous drops-offs adjacent to a travel lane, but removing all of these obstacles generally improves safety. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Roadside modifications range from relatively inexpensive to very costly. Strategies that include creating safer side slopes where none exists can be moderately expensive based on the scope of the project and the associated clearing, grading, etc. The potential for high environmental and right-of-way impacts is high which can take several years to clear. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Roll Over, Fixed Object | CRF: | 42% |

### R08, Install raised median

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 25% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new raised median. All new raised medians funded with federal HSIP funding should not include the removal of the existing roadway structural section and should be doweled into the existing roadway surface. This requirement is being implemented to maximize the safety-effectiveness of the limited HSIP funding and to minimize project impacts. Landscaping, if included in the project, is considered non-participating. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Areas experiencing head-on collisions that may be affected by both the number of vehicles that cross the centerline and by the speed of oncoming vehicles. Installing a raised median is a more restrictive approach in that it represents a more rigid barrier between opposing traffic. Application of raised medians on roadways with higher speeds is not advised - instead a median barrier should be considered. Including landscaping in new raised medians can be counterproductive to the HSIP safety goals and should only be done in ways that do not increase drivers' exposure to fixed objects and that will maintain driver's sight distance needs throughout the life of the proposed landscaping. **Agencies need to consider and document impacts of additional turning movements at nearby intersections.** | | | | |
| **Why it works:** | | | | |
| Adding raised medians is a particularly effective strategy as it adds to or reallocates the existing cross section to incorporate a buffer between the opposing travel lanes and reinforces the limits of the travel lane. Raised median may also be used to limit unsafe turning movements along a roadway. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| In some cases this strategy may be a retrofit into the existing roadway by utilizing a portion of the existing paved shoulder. These raised medians can be installed directly over the existing pavement. Cost and time to implement could significantly increase if the paved area is not sufficient to include a median. The surface treatment of the raised median also significantly affects their cost-effectiveness: standard concrete or other hardscape surfaces are usually more cost effective than landscaped medians. When agencies opt to install landscaping in conjunction with new raised medians, the project design and construction costs can significantly increase due to excavation, backfill/top-soil, water-connection, irrigation, planting, maintenance needed for the landscaping. When agencies opt to install landscaping in conjunction with new raised medians, the portion of the cost for landscaping and other non-safety related items that exceeds 10% of the project total cost is not federally participated and must be funded by the applicant. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Head-on | CRF: | 20 - 75 % |

## R09, Install median (flush)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 15% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new flush median. The new median must be a minimum of 4 feet wide (or "wider" if a narrow median exists before the proposed project). | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Areas experiencing head-on collisions that may be affected by both the number of vehicles that cross the centerline and by the speed of oncoming vehicles. Roadways with oversized lanes offer an opportunity to restripe the roadway to reduce the lanes to standard widths and use the extra width for the median. | | | | |
| **Why it works:** | | | | |
| Adding medians is a particularly effective strategy as it adds to or reallocates the existing cross section to incorporate a narrow buffer median between opposing flows, thereby providing a greater opportunity to correct an errant maneuver and further reinforce the limits of the travel lane. Application widths can vary based on the available cross section and intended application. Additional safety can be provided by combining this CM with rumble strips. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| In some cases this strategy may be retrofitted into the existing roadway by utilizing a portion of the existing paved shoulder and can ultimately be as simple as restriping the roadway. Costs and time to implement could significantly increase if the paved area is not sufficient to include a median. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 15 - 78 % |

## R10PB, Install pedestrian median fencing

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 35% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring on the approaches/influence area of the new pedestrian median fencing. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Roadway segments with high pedestrian-generators and pedestrian-destinations nearby (e.g. transit stops) may experience a high volume of pedestrians J-walking across the travel lanes at mid-block locations instead of walking to the nearest intersection or designated mid-block crossing. When this safety issue cannot be mitigated with shoulder, sidewalk and/or crossing treatments, then installing a continuous pedestrian barrier in the median may be a viable solution. | | | | |
| **Why it works:** | | | | |
| Adding pedestrian median fencing has the opportunity to enhance pedestrian safety at locations noted as being problematic involving pedestrians running/darting across the roadway outside designated pedestrian crossings. Pedestrian median fencing can significantly reduce this safety issue by creating a positive barrier, forcing pedestrians to the designated pedestrian crossing. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Costs associated with this strategy will vary widely depending on the type and placement of the median fencing. Impacts to transit and other land uses may need to be considered and controversy can delay the implementation. In general, this CM can be effective as a spot-location approach. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 25 - 40% |

## R11, Install acceleration/ deceleration lanes

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 25% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new accel/decel lanes on high speed roadways. Significant improvements to the merge length for lane-drop locations is also an acceptable use of this CM. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Areas proven to have crashes that are the result of drivers not being able to turn onto a high speed roadway to accelerate until the desired roadway speed is reached and areas that do not provide the opportunity to safety decelerate to negotiate a turning movement. This CM can also be used to improve the safety of merging vehicles at a lane-drop location. | | | | |
| **Why it works:** | | | | |
| A lane that does not provide enough deceleration length and storage space for turning traffic may cause the turn queue to back up into the adjacent through lane. This can contribute to rear-end and sideswipe crashes. An acceleration lane is an auxiliary or speed-change lane that allows vehicles to accelerate to highway speeds (high speed roadways) before entering the through-traffic lanes of a highway. Additionally, if acceleration by entering traffic takes place directly on the traveled way, it may disrupt the flow of through-traffic and cause rear-end and sideswipe collisions. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Costs are highly variable. Where sufficient median or shoulder space exists it may be possible to provide acceleration/deceleration lanes at a moderate cost. Where the roadway must be widened and additional right-of-way must be acquired, higher costs and a lengthy time-to-construct are likely. The expected effectiveness of this CM must be assessed for each individual location. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Sideswipe, Rear-End | CRF: | 10 - 75 % |

## R12, Widen lane (initially less than 10 ft)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 25% | 20 years |
| Notes: | Note: For Caltrans' statewide Calls-for-Projects, this CM only applies to crashes occurring within the limits of the widened lanes. Widening must a minimum of 1 foot. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Horizontal curves or tangents and low speed or high speed roadways identified as having lane departure crashes, sideswipe or head-on crashes that can be attributed to an existing pavement width less than 10 feet. | | | | |
| **Why it works:** | | | | |
| Increasing pavement width can affect almost all crash types. A common practice is to widen the traveled way on horizontal curves to make operating conditions on curves comparable to those on tangents. Speed is a primary consideration when evaluating potential adverse impacts of lane width on safety. On high-speed, rural two-lane highways, an increased risk of cross-centerline head-on or cross-centerline sideswipe crashes is a concern because drivers may have more difficulty staying within the travel lane. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Costs will depend on the amount of reconstruction necessary and on whether additional right-of-way is required. In general, this is one of the higher-cost strategies recommended, but it can also be very beneficial. Since this is a relatively expensive treatment, one of the keys to creating a cost effective project with at least a medium B/C ratio is targeting higher-hazard roadways. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 5 - 70 % |

## R13, Add two-way left-turn lane

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 30% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new lane, where an existing median did not already exist. | | |

**General information**

**Where to use:**

Roadways having a high frequency of drivers being rear-ended while attempting to make a left turn across oncoming traffic. Also can be effective for drivers crossing the centerline of an undivided multilane roadway inadvertently.

**Why it works:**

Two-way left-turn lanes provide a buffer between opposing directions of travel and separate left turning traffic from through traffic. They can also help to allow vehicles to begin to accelerate before entering the through-traffic lanes. They reduce the disruption of flow of through-traffic and reducing rear-end and sideswipe collisions. For some roadways the option of converting a four-lane undivided arterials to two-vehicle-lane roadways with a center left-turn lane and bike lanes should be considered (see "Road Diet" CM.)

**General Qualities (Time, Cost and Effectiveness):**

In some cases this strategy may be retrofitted into the existing roadway by utilizing a portion of the existing paved shoulder and can ultimately be as simple as restriping the roadway. Costs and time to implement could significantly increase if the paved area is not sufficient to include a median, requiring new right-of-way, and having significant environmental impacts. The expected effectiveness of this CM must be assessed for each individual location as the B/C ratios will vary from low to high.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 8 - 50 % |
|---|---|---|---|---|

## R14, Road Diet (Reduce travel lanes and add a two way left-turn and bike lanes)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 35% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new lane striping. "Intersection" crashes can only be applied when they resulted from turning movements that had no designated turn lanes/phases in the existing condition and the Road Diet will provide turn lanes/phases for these movements. This CM does not apply to roadway sections that already included left turn lanes or two way left turn lanes before the lane reductions. New bike lanes are also expected to be part of these projects. if any pavement is planned to be removed for the purpose of adding landscaping, planter-boxes, or other non-roadway user features, the cost should be non-participating. | | |

**General information**

**Where to use:**

Areas noted as having a higher frequency of head-on, left-turn, and rear-end crashes with traffic volumes that can be handled by only 2 free flowing lanes. Using this strategy in locations with traffic volumes that are too high could result in diversion of traffic to routes less safe than the original four-lane design. It may also result in congestion levels that contribute to other crashes.

**Why it works:**

The application of this strategy usually reduces the roadway segment speeds and serious head-on crashes. In many cases the extra pavement width can be used for the installation of bike lanes. In addition to increasing bicycle safety, these bike lanes can improve the safety of on-street parking.

**General Qualities (Time, Cost and Effectiveness):**

Implementation would require more time than in other low-cost treatments to complete environmental analyses, traffic studies and public input. Projects that only require new lane markings and minor signalization modifications will have relatively low cost and can be very effective and can be considered on a systematic approach. These striping and signal modification costs should be considered part of this CM and not an additional CM. (If additional signal hardware improvements are being made, over what is needed for the road diet, then the Improve Signal Hardware CM may also be used.) Often road diet projects need a seal-coat placed on the roadway to fully remove the old striping. These seal coats are considered part of the proper installation of this CM. In contrast, structural-overlays should not be considered part of this CM and are not considered eligible for funding in the California Local HSIP.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 26 - 43 % |
|---|---|---|---|---|

## R15, Widen shoulder

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 30% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new paved shoulder. A minimum of 2 feet width must be added and the new/resulting shoulders must be a minimum of 4 feet wide. This CM is not eligible unless it is done as the last step of an "incremental approach", for which the agency documents that: 1) they have already pursued and installed lower cost and lower impact CMs (i.e. signing/striping upgrades to MUTCD standards/recommendations, rumble strips, etc.), 2) they have already monitored the crash occurrences after these improvements were installed, and 3) the 'after' crash rate is still unacceptably high. This 'incremental approach' (or a special exception from the HSIP program manager) must be documented in the Narrative Questions in the application and a summary of the 'before' and 'after' crash analysis must be attached to the application. | | |

**General information**

**Where to use:**

Roadways that have a frequent incidence of vehicles leaving the travel lane resulting in an unsuccessful attempt to reenter the roadway. The probability of a safe recovery is increased if an errant vehicle is provided with an increased paved area in which to initiate such a recovery.

**Why it works:**

Based on the best available research, adding shoulder or widening an existing shoulder provides a greater area to regain control of a vehicle, as well as lateral clearance to roadside objects such as guardrail, signs and poles. They may also provide space for disabled vehicles to stop or drive slowly, provide increased sight distance for through vehicles and for vehicles entering the roadway, and in some cases reduce passing conflicts between motor vehicles and bicyclists and pedestrians. The likely safety benefits for adding or widening an existing shoulder generally increase as the widening width increases - practitioners should refer to NCHRP Report 500 Series, the CMF Clearinghouse or other references for more details.

**General Qualities (Time, Cost and Effectiveness):**

Shoulder widening costs would depend on whether new right-of-way is required and whether extensive roadside modification is needed. Since shoulder widening can be a relatively expensive treatment, one of the keys to creating a cost effective project with at least a medium B/C ratio is targeting higher-hazard roadways.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Fixed Object, Run-off Road, Sideswipe | CRF: | 15 - 75 % |
|---|---|---|---|---|

## R16, Curve Shoulder widening (Outside Only)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 45% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits (or influence area) of the new shoulder widening at curves. A minimum of 2-4 feet width must be added to the outside of horizontal curves and the new traversable shoulder must be a minimum of 4 feet wide. | | |

**General information**

**Where to use:**

Roadway curves noted as having frequent lane departure crashes due to inadequate or no shoulders, resulting in an unsuccessful attempt to reenter the roadway.

**Why it works:**

Adding shoulders (outside only) creates a recovery area in which a driver can regain control of a vehicle, as well as lateral clearance to roadside objects.

**General Qualities (Time, Cost and Effectiveness):**

To minimize the R/W needs and the cost, only outside shoulder at curves is to be widened. This CM can be implemented in a relatively short timeframe.

| **FHWA CMF Clearinghouse:** | NA |
|---|---|

## R17, Improve horizontal alignment (flatten curves)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 50% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits (or influence area) of the improved alignment. **<u>This CM is not eligible unless</u>** it is done as the last step of an "incremental approach", including: the agency documents that: 1) they have already pursued and installed lower cost and lower impact CMs (i.e. signing/striping upgrades to MUTCD standards/recommendations, rumble strips, etc.), 2) they have already monitored the crash occurrences after these improvements were installed, and 3) the 'after' crash rate is still unacceptably high. This 'incremental approach' (or a special exception from the HSIP program manager) must be documented in the Narrative Questions in the application and a summary of the agency's 'before' and 'after' crash analysis must be attached to the application. | | |

| General information | | | |
|---|---|---|---|
| **Where to use:** | | | |
| Roadways with horizontal curves that have experienced lane departure crashes as a result of a roadway segment having compound curves or a severe radius. This strategy should generally be considered only when less expensive strategies involving clearing of specific sight obstructions or modifying traffic control devices have been tried and have failed to ameliorate the crash patterns. | | | |
| **Why it works:** | | | |
| Increasing the radius of a horizontal curve can be very effective in improving the safety performance of the curve. Curve modification reduces the likelihood of a vehicle leaving its lane, crossing the roadway centerline, or leaving the roadway at a horizontal curve; and minimizes the adverse consequences of leaving the roadway. Horizontal alignment improvement projects are expected to include standard/improved superelevation elements, which should be considered part of this CM and not an additional CM. | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | |
| This strategy is a long-term, higher-cost alternative for improving the safety of a horizontal curve because it usually involves total reconstruction of the roadway. It may also require acquisition of additional right-of-way and an environmental review. This strategy, albeit costly, has shown that increasing the radius of curvature can significantly reduce total curve-related crashes by up to 80 percent. The expected effectiveness of this CM must be assessed for each individual location. | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: All | CRF: | 24 - 90% |

## R18, Flatten crest vertical curve

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 25% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits (or influence area) of the improved alignment. This CM is not eligible unless it is done as the last step of an "incremental approach", including: the agency documents that: 1) they have already pursued and installed lower cost and lower impact CMs (i.e. signing/striping upgrades to MUTCD standards/recommendations, rumble strips, etc.), 2) they have already monitored the crash occurrences after these improvements were installed, and 3) the 'after' crash rate is still unacceptably high. This 'incremental approach' (or a special exception from the HSIP program manager) must be documented in the Narrative Questions in the application and a summary of the agency's 'before' and 'after' crash analysis must be attached to the application. | | |

**General information**

**Where to use:**

The target for this strategy is usually unsignalized intersections with restricted sight distance due to vertical geometry and with patterns of crashes related to that lack of sight distance that cannot be ameliorated by less expensive methods. This strategy should generally be considered only when less expensive strategies involving clearing of specific sight obstructions or modifying traffic control devices have been tried and have failed to ameliorate the crash patterns.

**Why it works:**

Adequate sight distance for drivers at stopped approaches to intersections has long been recognized as among the most important factors contributing to overall intersection safety. Vertical alignment improvement projects are expected to include standard/improved superelevation elements, which should be considered part of this CM and not an additional CM.

**General Qualities (Time, Cost and Effectiveness):**

Projects involving changing the horizontal and/or vertical alignment to provide more sight distance are quite extensive and usually take several years to accomplish. If additional right-of-way is required or environmental impacts are expected, these projects will require a substantial period of time. Since this is usually an expensive treatment, one of the keys to creating a cost effective project with at least a medium B/C ratio is targeting higher-hazard locations.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 20 - 51 % |
|---|---|---|---|---|

## R19, Improve curve superelevation

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 45% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits (or influence area) of the improved superelevation. This CM does not apply to sections of roadways where the horizontal or vertical alignments are changing via another CM. | | |

**General information**

**Where to use:**

Roadways noted as having frequent lane departure crashes and inadequate or no superelevation. Safety can be enhanced when the superelevation is improved or restored along curves where the actual superelevation is less than the optimal.

**Why it works:**

Superelevation works with friction between the tires and pavement to counteract the forces on the vehicle associated with cornering. Many curves may have inadequate superelevation because of vehicles traveling at higher speeds than were originally designed for, because of loss of effective superelevation after resurfacing, or because of changes in design policy after the curve was originally constructed.

**General Qualities (Time, Cost and Effectiveness):**

This strategy can be a higher-cost alternative for improving the safety of a curve because it involves reconstruction to some degree. Other projects may be able to be constructed by simple overlays and minimal reconstruction of roadways features. When simple overlay fixes are pursued, a systematic installation approach may be appropriate. The expected effectiveness of this CM must be assessed for each individual location.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Run-off Road, All | CRF: | 40 - 50 % |
|---|---|---|---|---|

## R20, Convert from two-way to one-way traffic

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 35% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new one-way sections. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| One-way streets can offer improved signal timing and accommodate odd-spaced signals. One-way streets can simplify crossings for pedestrians, who must look for traffic in only one direction. While studies have shown that conversion of two-way streets to one-way generally reduces pedestrian crashes and the number of conflict points, one-way streets tend to have higher speeds which creates new problems. Care must be taken not to create conditions that cause driver confusion and erratic maneuvers. | | | | |
| **Why it works:** | | | | |
| Studies have shown a 10 to 50-percent reduction in total crashes after conversion of a two-way street to one-way operation. While studies have shown that con-version of two-way streets to one-way generally reduces pedestrian crashes, one-way streets tend to have higher speeds which creates new problems. At the same time, this strategy (1) increases capacity significantly and (2) can have safety-related drawbacks including pedestrian confusion and minor sideswipe crashes. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| The costs will vary depending on length of treatment and if the conversion requires modification to signals. Conversion costs can be high to build "crossovers" where the one-way streets convert back to two-way streets and to rebuild traffic signals. It's also likely that these types of modifications will require public involvement and could significantly add to the time it takes to complete the project. The expected effectiveness of this CM must be assessed for each individual location. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 26 - 43 % |

## R21, Improve pavement friction (High Friction Surface Treatments)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 55% | 10 years |
| Notes: | This CM only applies to crashes occurring within the limits of the improved friction overlay. This CM is not intended to apply to standard chip-seal or open-graded **maintenance** projects for long segments of corridors or structure repaving projects intended to fix failed pavement. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Nationally, this countermeasure is referred to as "High Friction Surface Treatments" or HFST. Areas as noted having crashes on wet pavements or under dry conditions when the pavement friction available is significantly less than actual roadway speeds; including but not limited to curves, loop ramps, intersections, and areas with short stopping or weaving distances. This treatment is intended to target locations where skidding is determined to be a problem, in wet or dry conditions and the target vehicle is one that runs (skids) off the road or is unable to stop due to insufficient skid resistance. | | | | |
| **Why it works:** | | | | |
| Improving the skid resistance at locations with high frequencies of wet-road crashes and/or failure to stop crashes can result in a reduction of 50 percent for wet-road crashes and 20 percent for total crashes. Applying HFST can double friction numbers, e.g. low 40s to high 80s. This CM represents a special focus area for both FHWA and Caltrans, which means there are extra resources available for agencies interested in more details on High Friction Surface Treatment projects. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| This strategy can be relatively inexpensive and implemented in a short timeframe. The installation would be done by either agency personnel or contractors and can be done by hand or machine. In general, This CM can be very effective and can be considered on a systematic approach. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Wet, Rear-End, All | CRF: | 17 - 68 % |

## R22, Install/Upgrade signs with new fluorescent sheeting (regulatory or warning)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 15% | 10 years |

| | |
|---|---|
| Notes: | This CM only applies to crashes occurring within the influence area of the new/upgraded signs. This CM is not intended for maintenance upgrades of street-name, parking, guide, or any other signs without a primary focus on roadway safety. **<u>This CM is not eligible unless</u>** it is done as part of a larger sign audit project, including the study of: 1) the existing signs' locations, sizes and information per MUTCD standards, 2) missing signs per MUTCD standards, and 3) sign retroreflectivity. The overall sign audit scope (or a special exception from the HSIP program manager) must be documented in the Narrative Questions in the application. Based on the scope of the project/audit, it may be appropriate to combine other CMs in the B/C calculation. |

**General information**

**Where to use:**

The target for this strategy should be on roadway segments with patterns of head on, nighttime, non-intersection, run-off road, and sideswipe crashes related to lack of driver awareness of the presence of a specific roadway feature or regulatory requirement. Ideally this type of safety CM would be combined with other sign evaluations and upgrades (install chevrons, warning signs, delineators, markers, beacons, and relocation of existing signs per MUTCD standards.)

**Why it works:**

This strategy primarily addresses crashes caused by lack of driver awareness (or compliance) roadway signing. It is intended to get the drivers attention and give them a visual warning by using fluorescent yellow sheeting (or other retroreflective material).

**General Qualities (Time, Cost and Effectiveness):**

Signing improvements do not require a long development process and can typically be implemented quickly. Costs for implementing this strategy are nominal and depend on the number of signs. When considered at a single location, these low cost improvements are usually funded through local funding by local maintenance crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding. When considering any type of federally funded sign upgrade project, California local agencies are encouraged to consider "Roadway Safety Signing Audit (RSSA) and Upgrade Projects". Including RSSAs in the development phase of sign projects are expected to identify non-standard (per MUTCD) sign features and missing signs that may otherwise go unnoticed. More information on RSSA is available on the Local Assistance HSIP webpage.

| | | | | |
|---|---|---|---|---|
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Head on, Run-off road, Sideswipe, Night | CRF: | 18 - 35% |

## R23, Install chevron signs on horizontal curves

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 40% | 10 years |
| Notes: | This CM only applies to crashes occurring within the influence area of the new signs. (i.e. only through the curve). | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Roadways that have an unacceptable level of crashes on relatively sharp curves during periods of light and darkness. Ideally this type of safety CM would be combined with other sign evaluations and upgrades (install warning signs, delineators, markers, beacons, and relocation of existing signs per MUTCD standards.) | | | | |
| **Why it works:** | | | | |
| Post-mounted chevrons are intended to warn drivers of an approaching curve and provide tracking information and guidance to the drivers. While they are intended to act as a warning, it should also be remembered that the posts, placed along the roadside, represent a possible object with which an errant vehicle can crash into. Design of posts to minimize damage and injury is an important part of the considerations to be made when selecting these treatments. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Signing improvements do not require a long development process and can typically be implemented quickly. Costs for implementing this strategy are nominal and depend on the number of signs. When considered at a single location, these low cost improvements are usually funded through local funding by local maintenance crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding. When considering any type of federally funded sign upgrade project, California local agencies are encouraged to consider "Roadway Safety Signing Audit (RSSA) and Upgrade Projects". Including RSSAs in the development phase of sign projects are expected to identify non-standard (per MUTCD) sign features and missing signs that may otherwise go unnoticed. More information on RSSA is available on the Local Assistance HSIP webpage. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Run-off Road, All | CRF: | 6 - 64 % |

## R24, Install curve advance warning signs

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 25% | 10 years |
| Notes: | This CM only applies to crashes occurring within the influence area of the new signs. (i.e. only through the curve) | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Roadways that have an unacceptable level of crashes on relatively sharp curves during periods of light and darkness. This countermeasure may also include horizontal alignment and/or advisory speed warning signs. Ideally this type of safety CM would be combined with other sign evaluations and upgrades (install warning signs, chevrons, delineators, markers, beacons, and relocation of existing signs per MUTCD standards.) | | | | |
| **Why it works:** | | | | |
| This strategy primarily addresses problem curves, and serves as an advance warning of an unexpected or sharp curve. It provides advance information and gives drivers a visual warning that their added attention is needed. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Signing improvements do not require a long development process and can typically be implemented quickly. Costs for implementing this strategy are nominal and depend on the number of signs. When considered at a single location, these low cost improvements are usually funded through local funding by local maintenance crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding. When considering any type of federally funded sign upgrade project, California local agencies are encouraged to consider "Roadway Safety Signing Audit (RSSA) and Upgrade Projects". Including RSSAs in the development phase of sign projects are expected to identify non-standard (per MUTCD) sign features and missing signs that may otherwise go unnoticed. More information on RSSA is available on the Local Assistance HSIP webpage. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Run-off Road, All | CRF: | 20 - 30 % |

## R25, Install curve advance warning signs (flashing beacon)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 30% | 10 years |
| Notes: | This CM only applies to crashes occurring within the influence area of the new signs. (i.e. only through the curve) | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Roadways that have an unacceptable level of crashes on relatively sharp curves. Flashing beacons in conjunction with warning signs should only be used on horizontal curves that have an established severe crash history to help maintain their effectiveness. | | | | |
| **Why it works:** | | | | |
| This strategy primarily addresses problem curves, and serves as an enhanced advance warning of an unexpected or sharp curve. It provides advance information and gives drivers a visual warning that their added attention is needed. Flashing beacons are an added indication that a curve may be particularly challenging. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Use of flashing beacons requires minimal development process, allowing flashing beacons to be installed within a short time period. Before choosing this CM, the agency needs to confirm the ability to provide power to the site (solar may be an option). In general, This CM can be very effective and can be considered on a systematic approach. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 30 % |

## R26, Install dynamic/variable speed warning signs

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 30% | 10 years |
| Notes: | This CM only applies to crashes occurring within the influence area of the new signs. (i.e. through the curve) {**This CM does not apply to dynamic regulatory speed warning signs.** There are currently no nationally accepted CRFs for dynamic regulatory signs (also known as Radar Speed Feedback Signs). CRFs are being developed and Caltrans hopes to include these CMs and CRFs in future calls for projects.} | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Curvilinear roadways that have an unacceptable level of crashes due to excessive speeds on relatively sharp curves. | | | | |
| **Why it works:** | | | | |
| This strategy primarily addresses crashes caused by motorists traveling too fast around sharp curves. It is intended to get the drivers attention and give them a visual warning that they may be traveling over the recommended speed for the approaching curve. Care should be taken to limit the placement of these signs to help maintain their effectiveness. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Use of dynamic speed warning signs requires minimal development process, allowing them to be installed within a short time period. Before choosing this CM, the agency needs to confirm the ability to provide power to the site (solar may be an option). In general, This CM can be very effective and can be considered on a systematic approach. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 0 - 41 % |

## R27, Install delineators, reflectors and/or object markers

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 15% | 10 years |
| Notes: | This CM only applies to crashes occurring within the limits / influence area of the new features. {**This is not a striping-related CM**} | | |

| General information |
|---|
| **Where to use:** |
| Roadways that have an unacceptable level of crashes on curves (relatively flat to sharp) during periods of light and darkness. Any road with a history of fixed object crashes is a candidate for this treatment, as are roadways with similar fixed objects along the roadside that have yet to experience crashes. If a fixed object cannot be relocated or made break-away, placing an object marker can provide additional information to motorists. Ideally this type of safety CM would be combined with other sign evaluations and upgrades (install warning signs, chevrons, beacons, and relocation of existing signs per MUTCD standards.) |
| **Why it works:** |
| Delineators, reflectors and/or object markers are intended to warn drivers of an approaching curve or fixed object that cannot easily be removed. They are intended to provide tracking information and guidance to the drivers. They are generally less costly than Chevron Signs as they don't require posts to place along the roadside, avoiding an additional object with which an errant vehicle can crash into. |
| **General Qualities (Time, Cost and Effectiveness):** |
| These improvements do not require a long development process and can typically be implemented quickly. Costs for implementing this strategy are nominal and depend on the number of locations. When considered at a single location, these low cost improvements are usually funded through local funding by local maintenance crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in low to moderate cost projects that are more appropriate to seek state or federal funding. When considering any type of federally funded sign upgrade project, California local agencies are encouraged to consider "Roadway Safety Signing Audit (RSSA) and Upgrade Projects". Including RSSAs in the development phase of sign projects are expected to identify non-standard (per MUTCD) sign features and missing signs that may otherwise go unnoticed. More information on RSSA is available on the Local Assistance HSIP webpage. |

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | 0 - 30 % |
|---|---|---|---|---|

## R28, Install edge-lines and centerlines

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 25% | 10 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new centerlines and/or edge-lines. This CM is not intended to be used for general maintenance activities (i.e. the replacement of existing striping and RPMs in-kind) and must include upgraded safety features over the existing striping. For two lane roadways allowing passing, a striping audit must be done to ensure the passing limits meeting the MUTCD standards. Both the centerline and edge-lines are expected to be upgraded, unless prior approval is granted by Caltrans staff in writing and attached to application. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Any road with a history of run-off-road right, head-on, opposite-direction-sideswipe, or run-off-road-left crashes is a candidate for this treatment - install where the existing lane delineation is not sufficient to assist the motorist in understanding the existing limits of the roadway. Depending on the width of the roadway, various combinations of edge line and/or center line pavement markings may be the most appropriate. Incorporating raised/reflective pavement markers (RPMs) into centerlines (and edge-lines) should be considered as it has been shown to improve safety. | | | | |
| **Why it works:** | | | | |
| Installing edge-lines and centerlines where none exists or making significant upgrades to existing lines (paint to thermoplastic, adding audible disks/bumps in the thermoplastic stripes, or adding RPMs) are intended/designed to help drivers who might leave the roadway because of their inability to see the edge of the roadway along the horizontal edge of the pavement or cross-over the centerline of the roadway into oncoming traffic. New pavement marking products tend to be more durable, are all-weather, more visible, and have a higher retroreflectivity than traditional pavement markings. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| These improvements do not require a long development process and can typically be implemented quickly. Costs for implementing this strategy are nominal and depend on the number and length of locations. This CM can be effectively and efficiently implemented using a systematic approach with numerous and long locations, resulting in low to moderate cost projects that are more appropriate to seek state or federal funding. When considering any type of federally funded striping upgrade project, California local agencies are encouraged to consider "Roadway Safety Striping Audit and Upgrade Projects". Including wide-scale striping audits in the development phase of striping projects are expected to identify non-standard (per MUTCD) striping/marking features, no-passing zone limits needing adjustment, and missing striping/markings that may otherwise go unnoticed. More information on this concepts is available on the Local Assistance HSIP webpage under an RSSA example document. Note: When federal safety funding is used for these installations in high-wear-locations, the local agency is expected to maintain the improvement for a minimum of 10 years. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Head-on, Run-off Road, All | CRF: | 0 - 44 % |

## R29, Install no-passing line

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 45% | 10 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new or extended no-passing zones. | | |

**General information**

**Where to use:**

Roadways that have a high percentage of head-on crashes suggesting that many head-on crashes may relate to failed passing maneuvers. No-passing lines should be installed where drivers "passing sight distance" is not available due to horizontal or vertical obstructions. General restriping projects can be good opportunities to reevaluate and incorporate new no-passing zones limits. The incorporation 'No Passing Zone' pennants should also be considered when reevaluating the limits of no-passing zones. Installing no-passing limits in areas that are not warranted may reduce the overall safety of the corridor as drivers may become frustrated and attempt passing maneuvers at other locations without the necessary sight distance.

**Why it works:**

When the centerline markings do not differentiate between passing and no-passing areas, drivers may have difficulty determining where passing maneuvers can be completed safely. Providing clear and engineered passing and no-passing areas can encourage drivers to wait patiently for safe passing areas and avoid aggressively looking for passing opportunities.

**General Qualities (Time, Cost and Effectiveness):**

These improvements do not require a long development process and can typically be implemented quickly. Costs for implementing this strategy are nominal and depend on the number and length of locations. When considered at a single location, these low cost improvements are usually funded through local funding by local maintenance crews. However, This CM can be effectively and efficiently implemented using a systematic approach with numerous and long locations, resulting in low to moderate cost projects that are more appropriate to seek state or federal funding.

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|---|---|---|---|---|
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Head-on, Side-swipe | CRF: | 40 - 53% |

## R30, Install centerline rumble strips/stripes

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | All | 20% | 10 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new rumble strips/stripes. | | |

**General information**

**Where to use:**

Center Line rumble strips/stripes can be used on virtually any roadway – especially those with a history of head-on crashes. It is recommended that rumble strips/stripes be applied systematically along an entire route instead of only at spot locations. For all rumble strips/stripes, pavement condition should be sufficient to accept milled rumble strips. Care should be taken when considering installing rumble strips in locations with residential land uses or in areas with high bicycle volumes.

**Why it works:**

Rumble strips provide an auditory indication and tactile rumble when driven on, alerting drivers that they are drifting out of their travel lane, giving them time to recover before they depart the roadway or cross the center line. Additionally, rumble stripes (pavement marking in the rumble itself) provide an enhanced marking, especially in wet dark conditions.

**General Qualities (Time, Cost and Effectiveness):**

These improvements do not require a long development process and can typically be implemented quickly. Costs for implementing this strategy are nominal and depend on the number and length of locations. This CM can be effectively and efficiently implemented using a systematic approach with numerous and long locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding.

| | | | | |
|---|---|---|---|---|
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Head-on, Side-swipe, All | CRF: | 15 - 68% |

## R31, Install edgeline rumble strips/stripes

| For HSIP Cycle 12 Call-for-projects | | | | |
|---|---|---|---|---|
| Funding Eligibility | | Crash Types Addressed | CRF | Expected Life |
| 90% | | All | 15% | 10 years |
| Notes: | This CM only applies to crashes occurring within the limits of the new rumble strips/stripes. | | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Shoulder and edge line milled rumble strips/stripes should be used on roads with a history of roadway departure crashes. It is recommended that rumble strips/stripes be applied systematically along an entire route instead of only at spot locations. For all rumble strips/stripes, pavement condition should be sufficient to accept milled rumble strips. Special requirements may apply and care should be taken when considering installing rumble strips in locations with residential land uses or in areas with high bicycle volumes. | | | | |
| **Why it works:** | | | | |
| Rumble strips provide an auditory indication and tactile rumble when driven on, alerting drivers that they are drifting out of their travel lane, giving them time to recover before they depart the roadway or cross the center line. Additionally, rumble stripes (pavement marking in the rumble itself) provide an enhanced marking, especially in wet dark conditions. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| These improvements do not require a long development process and can typically be implemented quickly. Costs for implementing this strategy are nominal and depend on the number and length of locations. This CM can be effectively and efficiently implemented using a systematic approach with numerous and long locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Run-off Road | CRF: | 10 - 41% |

## R32, Speed Safety Cameras

| For HSIP Cycle 12 Call-for-projects | | | | |
|---|---|---|---|---|
| Funding Eligibility | | Crash Types Addressed | CRF | Expected Life |
| 90% | | All | 20% | 20 years |
| Notes: | This CM only applies to crashes occurring within the limits of the road sections that Speed Safety Cameras are newly installed.<br>Agencies should conduct a legal and policy review to determine if Speed Safety Cameras (SSCs) are authorized within a jurisdiction and how the authorization and other traffic laws will affect an SSC program. Please refer to Speed Safety Camera Program Planning and Operations Guide. FHWA, (2023). | | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Agencies should conduct a network analysis of speeding-related crashes to identify locations to implement SSCs. The analysis can include scope (e.g., widespread, localized), location types (e.g., urban/suburban/rural, work zones, residential, school zones), roadway types (e.g., expressways, arterials, local streets), times of day, and road users most affected by speed-related crashes (e.g., pedestrians, bicyclists). SSCs can be deployed as:<br>Fixed units—a single, stationary camera targeting one location.<br>Point-to-Point (P2P) units—multiple cameras to capture average speed over a certain distance.<br>Mobile units—a portable camera, generally in a vehicle or trailer. | | | | |
| **Why it works:** | | | | |
| Safe Speeds is a core principle of the Safe System Approach since humans are less likely to survive high-speed crashes. Enforcing safe speeds has been challenging; however, with more information and tools communities can make progress in reducing speeds. Agencies can use speed safety cameras (SSCs) as an effective and reliable technology to supplement more traditional methods of enforcement, engineering measures, and education to alter the social norms of speeding. SSCs use speed measurement devices to detect speeding and capture photographic or video evidence of vehicles that are violating a set speed threshold. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | All | CRF: | -46 - 61 % |

## R33PB, Install bike lanes

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 35% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring within the limits of the Class II (not Class III) bike lanes. When an off-street bike-path is proposed that is not adjacent to the roadway, the applicant must document the engineering judgment used to determine which "Ped & Bike" crashes to apply. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Roadway segments noted as having crashes between bicycles and vehicles or crashes that may be preventable with a buffer/shoulder. Most studies suggest that bicycle lanes may provide protection against bicycle/motor vehicle collisions. Striped bike lanes can be incorporated into a roadway when is desirable to delineate which available road space is for exclusive or preferential use by bicyclists. | | | | |
| **Why it works:** | | | | |
| Most studies present evidence that bicycle lanes provide protection against bicycle/motor vehicle collisions. Bicycle lanes provide marked areas for bicyclist to travel along the roadway and provide for more predictable movements for both bicyclist and motorist. Evidence also shows that riding with the flow of vehicular traffic reduces bicyclists' chances of collision with a motor vehicle. Locations with bicycle lanes have lower rates of wrong-way riding. In combination with this CM, better guidance signs and markings for non-motorized and motorized roadway users should be considered, including: sign and markings directing cyclists on appropriate/legal travel paths and signs and markings warning motorists of non-motorized uses of the roadway that should be expected. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Adding striped bicycle lanes can range from the simply restriping the roadway and minor signing to projects that require roadway widening, right-of-way, and environmental impacts. It is most cost efficient to create bike lanes during street reconstruction, street resurfacing, or at the time of original construction. The expected effectiveness of this CM must be assessed for each individual location. For simple installation scenarios, This CM can be very effective and can be considered on a systematic approach. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 0 - 53 % |

## R34PB, Install Separated Bike Lanes

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 45% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring within the limits of the separated bike lanes. When an off-street bike-path is proposed that is not adjacent to the roadway, the applicant must document the engineering judgment used to determine which "Ped & Bike" crashes to apply. | | |

**General information**

**Where to use:**

Separated bikeways are most appropriate on streets with high volumes of bike traffic and/or high bike-vehicle collisions, presumably in an urban or suburban area. Separation types range from simple, painted buffers and flexible delineators, to more substantial separation measures including raised curbs, grade separation, bollards, planters, and parking lanes. These options range in feasibility due to roadway characteristics, available space, and cost. In some cases, it may be possible to provide additional space in areas where pedestrian and bicyclists may interact, such as the parking buffer, or loading zones, or extra bike lane width for cyclists to pass one another.

**Why it works:**

Separated bike lanes provide increased safety and comfort for bicyclists beyond conventional bicycle lanes. By separating bicyclists from motor traffic, “protected” or physically separated bike lanes can offer a higher level of comfort and are attractive to a wider spectrum of the public. Intersections and approaches must be carefully designed to promote safety and facilitate left-turns for bicyclists from the primary corridor to cross street.

In combination with this CM, better guidance signs and markings for non-motorized and motorized roadway users should be considered, including: sign and markings directing cyclists on appropriate/legal travel paths and signs and markings warning motorists of non-motorized uses of the roadway that should be expected.

**General Qualities (Time, Cost and Effectiveness):**

The cost of Installing separated bike lanes can be low to medium or high, depending on whether roadway widening, right-of-way and environmental impacts are involved. It is most cost efficient to create bike lanes during street reconstruction, street resurfacing, or at the time of original construction. The expected effectiveness of this CM must be assessed for each individual location.

| | | | | |
|---|---|---|---|---|
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 3.7 - 100 % |

## R35PB, Install sidewalk/pathway (to avoid walking along roadway)

| **For HSIP Cycle 12 Call-for-projects** | | | | |
|---|---|---|---|---|
| Funding Eligibility | | Crash Types Addressed | CRF | Expected Life |
| 90% | | Pedestrian and Bicycle | 80% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring within the limits of the new walkway. This CM is not intended to be used where an existing sidewalk is being replaced with a wider one, unless prior Caltrans approval is included in the application. When an off-street multi-use path is proposed that is not adjacent to the roadway, the applicant must document the engineering judgment used to determine which "Ped & Bike" crashes to apply. | | | |

| **General information** | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Areas noted as not having adequate or no sidewalks and a history of walking along roadway pedestrian crashes. In rural areas asphalt curbs and/or separated walkways may be appropriate. | | | | |
| **Why it works:** | | | | |
| Sidewalks and walkways provide people with space to travel within the public right-of-way that is separated from roadway vehicles. The presence of sidewalks on both sides of the street has been found to be related to significant reductions in the “walking along roadway” pedestrian crash risk compared to locations where no sidewalks or walkways exist. Reductions of 50 to 90 percent of these types of pedestrian crashes. In combination with this CM, better guidance signs and markings for non-motorized and motorized roadway users should be considered, including: sign and markings directing pedestrians and cyclists on appropriate/legal travel paths and signs and markings warning motorists of non-motorized uses of the roadway that should be expected. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Costs for sidewalks will vary, depending upon factors such as width, materials, and existing of curb, gutter and drainage. Asphalt curbs and walkways are less expensive, but require more maintenance. The expected effectiveness of this CM must be assessed for each individual location. These projects can be very effective in areas of high-pedestrian volumes with a past history of crashes involving pedestrians. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 65 - 89 % |

## R36PB, Install/upgrade pedestrian crossing (with enhanced safety features)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 35% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the influence area (expected to be a maximum of within 250') of the new crossing which includes new enhanced safety features. Note: This CM is not intended to be combined with the "Install raised pedestrian crossing" when calculating the improvement's B/C ratio. This CM is not intended to be used for high-cost aesthetic enhancements (i.e. stamped concrete or stamped asphalt). | | |

**General information**

**Where to use:**

Roadway segments with no controlled crossing for a significant distance in high-use midblock crossing areas and/or multilane roads locations. Based on the Zegeer study (Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations) at many locations, a marked crosswalk alone may not be sufficient to adequately protect non-motorized users. In these cases, flashing beacons, curb extensions, medians and pedestrian crossing islands and/or other safety features should be added to complement the standard crossing elements. For multi-lane roadways, advance "yield" markings can be effective in reducing the 'multiple-threat' danger to pedestrians.

**Why it works:**

Adding pedestrian crossings has the opportunity to greatly enhance pedestrian safety at locations noted as being problematic. The enhanced safety elements, which may include curb extensions, medians and pedestrian crossing islands, beacons, and lighting, combined with pavement markings delineating a portion of the roadway that is designated for pedestrian crossing. Care must be taken to warn drivers of the potential for pedestrians crossing the roadway and enhanced improvements added to the crossing increase the likelihood of pedestrians crossing in a safe manner. In combination with this CM, better guidance signs and markings for non-motorized and motorized roadway users should be considered, including: sign and markings directing pedestrians and cyclists on appropriate/legal travel paths and signs. When agencies opt to install aesthetic enhancement to crossing like stamped concrete/asphalt, the project design and construction costs can significantly increase. For HSIP applications, these costs must be accounted for in the B/C calculation, but these costs (over standard crosswalk markings) must be tracked separately and are not federally reimbursable and will increase the agency's local-funding share for the project costs.

**General Qualities (Time, Cost and Effectiveness):**

Costs associated with this strategy will vary widely, depending on the extent of the curb extensions, raised medians, flashing beacons, and other pedestrian safety elements that are needed with the crossing. When considered at a single location, these improvements can sometimes be low cost and funded through local funding by local crews. This CM can often be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate to high cost projects that are appropriate to seek state or federal funding.

| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 8 - 56% |
|---|---|---|---|---|

## R37PB, Install raised pedestrian crossing

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 35% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the area with the new raised crossing. Note: This CM is not intended to be combined with the "Install pedestrian crossing (with enhanced safety features)" when calculating the improvement's B/C ratio. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| On lower-speed roadways, where pedestrians are known to be crossing roadways that involve significant vehicular traffic. Based on the Zegeer study (Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations) at many locations, a marked crosswalk alone, may not be sufficient to adequately protect non-motorized users. In these cases, raised crossings can be added to complement the standard crossing elements. Special requirements may apply and extra care should be taken when considering installing raised crossings to ensure unintended safety issues are not created, such as: emergency vehicle access or truck route issues. | | | | |
| **Why it works:** | | | | |
| Adding a raised pedestrian crossing has the opportunity to enhance pedestrian safety at locations noted as being especially problematic. The raised crossing encourages motorists to reduce their speed and provides improved delineation for the portion of the roadway that is designated for pedestrian crossing. In combination with this CM, better guidance signs and markings for non-motorized and motorized roadway users should be considered, including: sign and markings directing pedestrians and cyclists on appropriate/legal travel paths. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Costs associated with this strategy will vary widely, depending upon the elements of the raised crossing and the need for new curb ramps and sidewalk modifications. This CM may be effectively and efficiently implemented using a systematic approach with more than one location and can have medium to high B/C ratios based on past non-motorized crash history. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 30 - 46% |

## R38PB, Install Rectangular Rapid Flashing Beacon (RRFB)

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Pedestrian and Bicycle | 35% | 20 years |
| Notes: | This CM only applies to "Ped & Bike" crashes occurring in the influence area (expected to be a maximum of within 250') of the crossing which includes the RRFB. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| Rectangular Rapid Flashing Beacon (RRFB) includes pedestrian-activated flashing lights and additional signage that enhance the visibility of marked crosswalks and alert motorists to pedestrian crossings. It uses an irregular flash pattern that is similar to emergency flashers on police vehicles. RRFBs are installed at unsignalized intersections and mid-block pedestrian crossings. | | | | |
| **Why it works:** | | | | |
| RRFBs can enhance safety by increasing driver awareness of potential pedestrian conflicts and reducing crashes between vehicles and pedestrians at unsignalized intersections and mid-block pedestrian crossings. The addition of RRFB may also increase the safety effectiveness of other treatments, such as crossing warning signs and markings. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| RRFBs are a lower cost alternative to traffic signals and hybrid signals. This CM can often be effectively and efficiently implemented using a systematic approach with numerous locations. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Pedestrian, Bicycle | CRF: | 7 – 47.4% |

## R39AL, Install Animal Fencing

| For HSIP Cycle 12 Call-for-projects | | | |
|---|---|---|---|
| Funding Eligibility | Crash Types Addressed | CRF | Expected Life |
| 90% | Animal | 80% | 20 years |
| Notes: | This CM only applies to "animal" crashes occurring within the limits of the new fencing. | | |

| General information | | | | |
|---|---|---|---|---|
| **Where to use:** | | | | |
| At locations with high percent of vehicular/animal crashes (reactive) or where there is a known high percent of animals crossing due to migratory patterns (proactive). | | | | |
| **Why it works:** | | | | |
| Animal fencing helps to channelize the identified animals to a natural or man-made crossing, eliminating the conflict between vehicles and animals on the same place. Animal fencing is typically installed at a bridge location with its "run of need" dependent on the surrounding terrain. | | | | |
| **General Qualities (Time, Cost and Effectiveness):** | | | | |
| Time to install fencing can be moderate to lengthy depending on the environmental commitments and agreed upon solution to mitigating project impacts. Costs will be fairly low and depend on the "run of need" length. There will be minimal reoccurring maintenance costs on keeping the fence intact. The expected effectiveness of this CM must be assessed for each individual location. | | | | |
| **FHWA CMF Clearinghouse:** | Crash Types Addressed: | Animal | CRF: | 70 - 90 % |

# Appendix C: Summary of "Recommended Actions"

The information contained here represent a brief summary of each section of this manual as well as the Summary of "Recommended Actions" from Sections 2 through 7. This is intended to be a quick-reference for local agency practitioners working on a "proactive safety analysis" of their roadway network.

## Introduction and Purpose

As safety practitioners consider implementing a 'proactive safety analysis approach' they should consider the overall context of the safety issues facing California local agencies and Caltrans primary goals for preparing this manual for California's local roadway owners. Figure 1 provides a flowchart of the process and Appendices E and F provide examples and lessons learned from recent statewide calls-for-projects.

## Identifying Safety Issues

This section provides an overview of the types of data to collect for the identification of roadway safety issues. It discusses sources of crash data and how they can be used. As practitioners gather information they are encouraged to develop one or more separate spreadsheets and/or pin-maps to help track and manage this data.

**State and Local Crash Databases**

Recommended Action: Obtain at least 3 years of network-wide crash data to identify local roads that have a history of roadway crashes. This will be used to identify predominant roadway crash locations, crash types and other common characteristics.

**Transportation Injury Mapping System (TIMS)**

Recommended Action: Consider augmenting your local agency's data collection approach with information available using the suite of TIMS tools. The TIMS tools (and/or tools from private for-profit vendors) can help the safety practitioner access and manage their crash data.

**Law Enforcement Crash Reports**

Recommended Action: Develop a working relationship with law enforcement officials responsible for enforcement and crash investigations. This could foster a partnership where sharing crash reports and safety information on problem roadway segments becomes an everyday occurrence. Practitioners with limited access to crash data are encouraged to use TIMS to assess the local crash report data.

**Observational Information**

Recommended Action: Gather information received from law enforcement and road maintenance crew observations. Develop a system for maintenance crews to report and record observed roadway safety issues and a mechanism to address them.

**Public Notifications**

<u>Recommended Action:</u> Review and summarize information received from these sources, identifying segments or corridors with multiple notifications and record the locations, dates, and nature of the problem that are cited.

**Roadway Data and Devices**

<u>Recommended Action:</u> Identify and track roadway characteristics for the intersections, roadway segments, and corridors, including compliance with the minimum standards. At a minimum, this should be done for locations being considered for safety improvements, but ideally agencies would establish an extensive database of roadway data to help them proactively identify high risk roadway features.

**Exposure Data**

<u>Recommended Action:</u> Consider the availability of exposure data and track it along with the other crash data to help prioritize potential locations for safety improvements.

**Field Assessments and Road Safety Audits**

<u>Recommended Action:</u> Consider completing formal or informal field assessments and RSAs at certain locations to help ensure all relevant information is collected and available for the safety practitioners to complete their safety analysis and identification of the most appropriate countermeasures. Develop simple straightforward criteria on when one of these will be undertaken.

# Safety Data Analysis

This section summarizes the types of analyses that can be conducted to determine what roadway countermeasures should be implemented. This section is the link between the data (Section 2) and the selection of appropriate countermeasures (Section 4). It provides definitions and examples of the qualitative and quantitative factors that should be considered when evaluating roadway safety issues.

**Quantitative Analysis**

<u>Recommended Action:</u> Complete a quantitative analysis of their roadway data using both Crash Frequency and Crash Rate methodologies, including:

**Crash Frequency**

Top 10 (or 20) lists of intersections and roadway segments.

For lower volume roadways, network wide pin-maps may be more effective.

Develop collision diagrams showing the direction of movement of vehicles and pedestrians.

**Crash Rate**

Top 10 (or 20) lists of roadway segments in relationship to length, volumes, and/or density.

Top 10 (or 20) lists of intersections, sorted by crash rate.

Top 10 (or 20) lists of the highest volume intersections, sorted by crash frequency or rate.

**Qualitative Analysis**

Recommended Action: Consider completing field assessments and RSAs to identify roadway infrastructure characteristics relating to both locations with compliance issues and locations with high crash frequencies/rates. As part the field assessments, common roadway and crash characteristics should be identified for the potential systemic deployment of countermeasures.

Caltrans recommends all agencies complete both quantitative and qualitative analyses before starting their applications for HSIP program funding. The findings from these analyses should be documented in spreadsheets and/or pin-maps similar to the ones discussed in Section 2.

## Countermeasures

This Section provides a description of selected countermeasures that have been shown in this manual. It includes a basic set of strategies to implement at locations experiencing a history of crashes and their corresponding crash modification factors (CMF). NOTE: Crash Reduction Factors (CRFs) are directly connected to the CMFs and are another indication of the effectiveness of a particular treatment. The CRF for a countermeasure is defined mathematically as 1 – CMF. The terms CMFs and CRFs are used interchangeably throughout this document.

**Selecting Countermeasures and Crash Modification Factors / Crash Reduction Factors**
**Countermeasure Details and Characteristics**
Recommended Action: Agencies should use all information and results obtained through completing the actions in Sections 2, 3 and 4 to select the appropriate countermeasures for their HCCLs and systemic improvements. As novice safety practitioners select countermeasures, they must realize that a reasonable level of traffic 'engineering judgment' is required and that this manual and should not be used as a simple cheat-sheet for preparing and submitting applications for funding.

## Calculating the B/C ratio and Comparing Projects

This section defines a methodology for calculating a benefit to cost (B/C) ratio for a potential safety project. It includes sources for estimating projected costs and benefits and the specific values/formulas Caltrans uses for its statewide evaluations of HSIP projects. This section also discusses the potential value in reevaluating projects' overall cost effectiveness.

**Estimating the Benefit of Implementing Proposed Improvements**
Recommended Action: Prepare 'Total Benefit' estimates for the proposed projects being evaluated in the proactive safety analysis.

**Estimating the Cost of Implementing Proposed Improvements**
Recommended Action: Prepare 'Total Project Cost' estimates for the proposed projects being evaluated in the proactive safety analysis.

**Calculating the B/C Ratio**
Recommended Action: Calculate the B/C ratio for each of the proposed projects being evaluated in the proactive safety analysis.
**Compare B/C Ratios and Consider the Need to Reevaluate Project Elements**
Recommended Action: Compare, reevaluate, and prioritize the potential safety projects. Consider changing the project limits or utilizing lower cost countermeasures for projects with low initial B/C ratios.

# Identifying Funding and Construct Improvements

This section identifies existing and new funding opportunities for safety projects that local agencies should be considering. This section also briefly discusses some unique project development issues and strategies for safety projects as they proceed through design and construction.

**Existing Funding for Low-cost Countermeasures**
Recommended Action: Survey planned maintenance, developer and capital projects to determine whether they overlap any of the proposed safety projects. Where projects overlap, leverage the existing funding sources to include safety countermeasures.

**Other Funding Sources**
Recommended Action: Consider all potential funding opportunities to incorporate the identified safety countermeasures including the HSIP and ATP Programs.

**Project Development and Construction Considerations**
Recommended Action: Safety practitioners should follow their safety projects all the way through the project delivery and construction process. In addition, they should establish a safety program delivery plan that brings awareness and support to the expedited delivery of safety projects. Where possible, safety practitioners should involve the media and even consider having their own program intended to "toot their own safety-horn."

# Evaluation Improvements

This section presents the process to complete an evaluation of installed treatments. After the countermeasures are installed, assessing their effectiveness will provide valuable information and can help determine which countermeasures should continue to be installed on other roadways to make them safer as well.

Recommended Action: Develop a spreadsheet to track future safety project installations and record 3+ years of "before" and "after" crash information at those locations. Once safety countermeasures are constructed, schedule and track assessment dates to ensure they happen.

# Appendix D: Benefit Cost Ratio (BCR) Calculations

This appendix includes the Benefit Cost methodology used in the Caltrans Calls-for-projects in the HSIP programs. The HSM, Part B - Chapter 7, includes more details on conducting Economic Appraisal for roadway safety projects. Local agencies will be required to utilize the HSIP Analyzer to calculate the Benefit Cost Ratio (BCR) as part of their application for HSIP funding.

Starting in Cycle 7 call for projects, the fatality and severe injury costs have been combined for calculating the benefit. Because fatality figures are small and are a matter of randomness, this change is being made to reduce the possibility of selecting an improvement project on the basis of randomness.

1) Combined Crash Reduction Factor (CRF) of multiple countermeasures (CMs):
   Assume there are 3 CMs with $CRF_1$, $CRF_2$ and $CRF_3$ as their individual CRFs:

   $CRF_{combined} = 1 - (1\text{-}CRF_1)(1\text{-}CRF_2)(1\text{-}CRF_3)$.

2) $\text{Annual benefit of project} = \sum_{S=0}^{3} \frac{CRF_{combined} \times N_S \times CC_S}{Y}$
   - $CRF_{combined}$: Combined CRF of multiple CMs.
   - S: Crash severity (0/1/2/3. See the below table.
   - $N_S$: Number of crashes in each severity level.
   - $CC_S$: Crash cost of each severity level.
   - Y: Crash data time period (year).

| Severity (S) | Crash Severity * | Location Type | Crash Cost *** |
|---|---|---|---|
| 3 | **Fatality and Severe Injury Combined (KA) | Signalized Intersection | $2,162,000 |
| 3 | | Non-Signalized Intersection | $3,440,000 |
| 3 | | Roadway | $2,978,000 |
| 2 | Evident Injury – Other Visible (B) | | $193,000 |
| 1 | Possible Injury–Complaint of Pain (C) | | $110,000 |
| 0 | Property Damage Only (O) | | $18,000 |

* The letters in parenthesis (K, A, B, C and O) refer to the KABCO scale; it is commonly used by law enforcement agencies in their crash reporting efforts and is further documented in the HSM.

** Figures were calculated based on an average Fatality (K) / Severe Injury (A) ratio for each area type. These costs are used in the HSIP Analyzer.

*** Based on Table 7-1, Highway Safety Manual (HSM), First Edition, 2010. Adjusted to 2024 Dollars.

3) Life benefit of project = Annual benefit of project x Service life of project (years)

4) $\text{Project BCR} = \frac{\text{Life benefit of project}}{\text{Total project cost}}$

# Appendix E: Examples of Crash Data Collection and Analysis Techniques using TIMS

As demonstrated throughout the manual, SafeTREC's TIMS website https://tims.berkeley.edu/ can be used to assist local agencies in completing a proactive safety analysis of their roadway network.

Note: This manual focuses on TIMS as a tool to access and map SWITRS data because TIMS is free to local agencies and the general public. Local agencies are encouraged to try TIMS, but they should not feel obligated to make a switch if they prefer using their vendor-supplied crash analysis software to complete their data collection and analysis process.


**SWITRS Query & Map:**

The SWITRS Query & Map application is a tool for accessing and mapping fatal and injury crash data from the California Statewide Integrated Traffic Records System (SWITRS).

**SWITRS GIS Map:**

The SWITRS GIS Map offers an interactive map-centric approach to viewing and querying SWITRS collision data with various tools including crash diagram, rank by intersection, etc.

**Crash Diagram Tool:**

The Crash Diagram tool allows users to generate an interactive crash diagram. The crash diagram is accessible through SWITRS GIS Map after a set of crashes is selected.

**ATP Maps & Summary Data:**

The ATP Maps & Summary Data tool utilizes interactive crash maps to allow users to track and document pedestrian and bicycle crashes and generate data summaries within specified project and/or community limits. Though it is designed to support the California Active Transportation Program (ATP), this tool may be useful in developing an HSIP project targeting pedestrian and bicycle safety issues.

# Appendix F: List of Abbreviations

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ATP | Active Transportation Program |
| B/C Ratio; BCR | Benefit Cost Ratio |
| Caltrans | California Department of Transportation (Division of Local Assistance) |
| CA-MUTCD | California - Manual on Uniform Traffic Control Devices |
| CM | Countermeasure |
| CMF | Crash Modification Factor |
| CRF | Crash Reduction Factor |
| "5 E's of Safety" | Education, Enforcement, Engineering, Emergency Response and Emerging Technologies |
| EMS | Emergency Medical Services |
| FHWA | Federal Highway Administration |
| HCCL | High Crash Concentration Location |
| HR3, HRRR | High Risk Rural Roads Program |
| HSIP | Highway Safety Improvement Program |
| HSM | Highway Safety Manual |
| RSA | Roadway Safety Audit |
| SafeTREC | Safe Transportation Research and Education Center (SafeTREC) at the University of California, Berkeley |
| SHSP | Strategic Highway Safety Plan |
| SWITRS | Statewide Integrated Traffic Records System |
| TIMS | Transportation Injury Mapping System (a product of SafeTREC) |

# Appendix G: References


1. FHWA, Office of Safety website: Local and Rural Road Safety Program
    - https://safety.fhwa.dot.gov/local_rural/

2. Highway Safety Manual (HSM). Product of the American Association of State Highway and Transportation Officials.
    - http://www.highwaysafetymanual.org/Pages/default.aspx

3. National Highway Traffic Safety Administration (NHTSA): National Center for Statistics and Analysis (NCSA) Motor Vehicle Traffic Crash Data Resource
    - https://crashstats.nhtsa.dot.gov/

4. California - Manual on Uniform Traffic Control Devices (CA-MUTCD)
    - https://dot.ca.gov/programs/safety-programs/camutcd

5. Caltrans' website on the Highway Design Manual
    - https://dot.ca.gov/programs/design/manual-highway-design-manual-hdm

6. FHWA, Research and Development website for pedestrian & bicyclist safety
    - https://safety.fhwa.dot.gov/ped_bike/tools_solve/

7. AASHTO - A Policy on Geometric Design of Highways and Streets ("Green Book")

    AASHTO - the Roadside Design Guide
    - https://store.transportation.org/

8. FHWA – Public Roads Magazine:
    - https://highways.dot.gov/public-roads/home

# APPENDIX E: PROJECT PRIORITIZATION

## Project Prioritization

| Priority | Project | Safety Benefits | Benefits to Vulnerable Road Users | School Safety Impact | Equity Impact | Public Engagement | Ease of Implementation | Score |
|---|---|---|---|---|---|---|---|---|
| **1** | Project 5: Pedestrian Set Aside | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **2** | Project 3: Systemic Roadway Segment Improvements | 100 | 0 | 100 | 100 | 0 | 100 | 75 |
| **3** | Project 4: Pedestrian and Other Roadway Segment Improvements | 100 | 0 | 100 | 100 | 0 | 100 | 75 |
| **4** | Project 2: Improvements at Unsignalized Intersections | 20 | 0 | 100 | 100 | 100 | 100 | 53 |
| **5** | Project 1: Systemic Improvements at Unsignalized Intersections | 0 | 0 | 100 | 100 | 0 | 100 | 35 |

| Buckets | Value |
|---|---|
| Highest Value | 43 |
| Lowest Value | 0 |
| Group Range | 14 |
| Bucket 1 below | 15 |
| Bucket 2 below | 29 |
| Bucket 3 below | 43 |