Safety Analysis Guide

September 2017

Multimodal Development and Delivery
Safety and Quality Division
Traffic Operations Division
Development Division
# Table of Contents

1. **Purpose** .......................................................................................................................... 1

2. **Policy** ............................................................................................................................. 1

   2.1 Executive Policies ........................................................................................................... 2

   2.2 Highway Safety Improvement Program (Federal) ............................................................ 2

   2.3 Target Zero .................................................................................................................... 2

   2.4 Design Manual ............................................................................................................... 3

   2.5 Priority Programming for Highway Development ........................................................ 3

3. **Purpose of Safety Analysis at WSDOT** ........................................................................ 3

   3.1 Limitations .................................................................................................................... 4

4. **Concepts** ....................................................................................................................... 6

   4.1 Units of safety performance ........................................................................................... 6

   4.2 Crash severity ............................................................................................................... 6

   4.3 Crash frequency ............................................................................................................ 7

5. **Technical Support** ......................................................................................................... 8

6. **Common Practice** .......................................................................................................... 8

   6.1 Data needed for Safety Analyses .................................................................................. 8

   6.2 Handling of Safety Data – 23 USC §148 and 23 USC §409 ........................................... 8

      6.2.1 Disclaimer language ............................................................................................... 9

      6.2.2 Release of crash data or summaries to entities outside WSDOT ............................. 9

      6.2.3 Handling police reports ........................................................................................ 10

      6.2.4 Crash data ............................................................................................................. 10

      6.2.5 Traffic volume data ......................................................................................... 12

      6.2.6 Roadway data ....................................................................................................... 12

   6.3 Study Period .................................................................................................................. 12

   6.4 Study Area .................................................................................................................... 13

   6.5 Crash Analysis Tools and Methods ............................................................................. 13

      6.5.1 HSM predictive method ....................................................................................... 13

      6.5.2 Tools for the HSM predictive method ................................................................. 16
6.6 Societal Cost ..........................................................................................................................17
6.7 Alternative Analysis Using Benefit and Costs .......................................................................17
6.8 Human Factors .......................................................................................................................18
6.9 Planning, Scoping, and Programming ....................................................................................18
   6.9.1 Relationship between Planning and the I2 Safety Program ...........................................18
   6.9.2 I2 Safety Project Identification and Community Engagement .....................................20
   6.9.3 Expectations for Corridor Sketch Activities and Safety .............................................20
   6.9.4 WSDOT’s I2 Safety Improvement Program Overview ................................................20
   6.9.5 Design Analysis .............................................................................................................22

7. Safety Analysis by Program Type .........................................................................................23
  7.1 Preservation (P) ....................................................................................................................23
  7.1.1 Pavement Preservation (P1) ..........................................................................................23
  7.1.2 Bridge Preservation Program (P2) ..............................................................................24
  7.1.3 Other Highway Facilities Preservation Program (P3) ................................................25
  7.2 Highway Improvement (I) ..................................................................................................26
  7.2.1 Mobility Improvement (I1) ..........................................................................................26
  7.2.2 Safety Improvement (I2) ..............................................................................................28
  7.2.3 Economic Initiatives (I3) .............................................................................................31
  7.2.4 Environmental Retrofit (I4) .........................................................................................31
  7.3 Traffic Operations (Q) ........................................................................................................32

8. Miscellaneous Activities .......................................................................................................33
  8.1 Interchange Justification Reports .......................................................................................33
  8.2 Environmental Impact Statement/Environmental Assessment .........................................34
  8.3 Developer Reviews – Traffic Impact Analysis ...................................................................35
  8.4 Crash Analysis Report ........................................................................................................36
  8.5 Intersection Control Analysis ............................................................................................36
  8.6 Work Zones ........................................................................................................................37

9. Example language for the HSM Predictive Method ............................................................37
  9.1 Scenario 1: Location with similar crash performance ..........................................................37
  9.2 Scenario 2: Location with more crashes than similar locations ........................................38
  9.3 Scenario 3: Location with fewer crashes than similar locations .........................................38
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5Es</td>
<td>engineering, education, enforcement, emergency medical services, and evaluation</td>
</tr>
<tr>
<td>AADT</td>
<td>Annual Average Daily Traffic</td>
</tr>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
</tr>
<tr>
<td>ADT</td>
<td>Average Daily Traffic</td>
</tr>
<tr>
<td>ARM</td>
<td>Accumulated Route Mileage – part of WSDOT linear referencing system</td>
</tr>
<tr>
<td>B/C or BCR</td>
<td>Benefit Cost ratio</td>
</tr>
<tr>
<td>CAC</td>
<td>Collision Analysis Corridor</td>
</tr>
<tr>
<td>CAL</td>
<td>Collision Analysis Location</td>
</tr>
<tr>
<td>CMF</td>
<td>crash modification factor</td>
</tr>
<tr>
<td>CPDM</td>
<td>Capital Program Development and Management</td>
</tr>
<tr>
<td>DM</td>
<td>Design Manual</td>
</tr>
<tr>
<td>FARS</td>
<td>Fatality Analysis Reporting System</td>
</tr>
<tr>
<td>FHWA</td>
<td>Federal Highway Administration</td>
</tr>
<tr>
<td>TDGMO</td>
<td>Transportation Data, GIS, and Modeling Office (WSDOT)</td>
</tr>
<tr>
<td>HSEC</td>
<td>WSDOT Highway Safety Executive Committee (WSDOT)</td>
</tr>
<tr>
<td>HSIG</td>
<td>WSDOT Highway Safety Issues Group (WSDOT)</td>
</tr>
<tr>
<td>HSM/HSM1</td>
<td>AASHTO Highway Safety Manual (AASHTO, 2010)</td>
</tr>
<tr>
<td>HSM2</td>
<td>2nd Edition of the HSM – currently under development</td>
</tr>
<tr>
<td>I2</td>
<td>The sub-program used to manage and track investments in capital transportation projects with a primary need related to improving safety</td>
</tr>
<tr>
<td>IAL</td>
<td>Intersection Analysis Location</td>
</tr>
<tr>
<td>IHSDM</td>
<td>Interactive Highway Safety Design Model</td>
</tr>
<tr>
<td>ISAte</td>
<td>Interchange Safety Analysis Tool enhanced</td>
</tr>
<tr>
<td>KABCO</td>
<td>Crash injury severity scale used to describe the most severe injury level sustained in a crash.</td>
</tr>
<tr>
<td></td>
<td>• K – Fatal injury crash</td>
</tr>
<tr>
<td></td>
<td>• A – Serious injury crash/suspected serious injury crash</td>
</tr>
<tr>
<td></td>
<td>• B – Evident injury crash</td>
</tr>
<tr>
<td></td>
<td>• C – Possible Injury crash</td>
</tr>
<tr>
<td></td>
<td>• PDO – Property-damage only</td>
</tr>
<tr>
<td>LRS</td>
<td>Linear Referencing System</td>
</tr>
<tr>
<td>MMUCC</td>
<td>Model Minimum Uniform Crash Criteria</td>
</tr>
<tr>
<td>NCHRP</td>
<td>National Cooperative Highway Research Program</td>
</tr>
<tr>
<td>NHTSA</td>
<td>National Highway Traffic Safety Administration</td>
</tr>
<tr>
<td>PDO</td>
<td>Property Damage Only</td>
</tr>
<tr>
<td>PTCR</td>
<td>Police Traffic Collision Report</td>
</tr>
<tr>
<td>SHS</td>
<td>WSDOT Sustainable Highway Safety (Executive Order E-1085.00)</td>
</tr>
<tr>
<td>SHSP</td>
<td>Strategic Highway Safety Plan</td>
</tr>
<tr>
<td>SPF</td>
<td>Safety Performance Function</td>
</tr>
<tr>
<td>SRMP</td>
<td>State Route Mile Post – part of WSDOT LRS and is accompanied by an ahead or back indicator (these values can change over time)</td>
</tr>
<tr>
<td>TRB</td>
<td>Transportation Research Board</td>
</tr>
<tr>
<td>WSDOT</td>
<td>Washington State Department of Transportation</td>
</tr>
<tr>
<td>WSP</td>
<td>Washington State Patrol</td>
</tr>
<tr>
<td>WTSC</td>
<td>Washington State Traffic Safety Commission</td>
</tr>
</tbody>
</table>
1. Purpose
The purpose of this guide is to provide guidance to WSDOT staff regarding expectations for safety analysis. This guide defines the focus, scale, and scope of safety analyses across the different WSDOT program areas as well as safety analysis outside the typical program areas. The target audience for the document is staff that have the responsibility for safety analysis as part of program and project development and associated activities. This document is also for those who make a determination on the appropriate scale and scope of the safety analysis for a project. This guide will include current documentation policies related to safety analysis and assumptions considered reasonable to make within the current WSDOT context. The goal of this guide is to support integration of safety performance considerations throughout planning, project development, operations, maintenance, and other WSDOT activities, projects, and programs without creating undue burden, staying practical and focusing on high value for effort. The guide provides guidance in a manner that balances the simplicity of a safety analysis with the thoroughness of a safety analysis that aids in making sound decisions that are data driven and science-based. The guide is intended to supplement sound engineering judgement and experience based on specific project conditions, context, and modal priorities. Engineering judgement should also be used to address items not covered in this guide. The guide does not replace the WSDOT Design Manual (DM), rather it supports the DM by clarifying safety analysis components that are not easily described within the DM.

The guide is not inclusive of every condition, nor does it constitute specific requirements for projects. The document is used as guidance and recognizes that individual project analysis aspects will vary as those doing the analysis consider how best to achieve their stated project goals. The guide expects teams to consider how best to achieve the safety analysis goals and objectives, early in the project development process to minimize rework and extraneous analysis efforts.

2. Policy
WSDOT has undergone a number of changes related to how it develops and operates the highway system. The Department has developed strategies to incorporate the practical solutions approach into WSDOT practices. To do so, WSDOT modified its project and program decision-making process through executive orders and Design Manual changes. An important aspect of these policy changes was the incorporation of the AASHTO Highway Safety Manual (HSM) methods into WSDOT practices related to design and operational decision-making. These policies highlight data driven safety analysis in considering how best to approach safety performance related issues on WSDOT highways. The policies also recognize that safety data analysis is a tool, and safety performance considerations are not the only issue that WSDOT deals with in the development of a project or program. The HSM methods do not fit every case (see Appendix A), nor every facility type encountered. The HSM and safety analysis in general continues to evolve and the Department envisions that this guide will evolve as additional information on new methods, procedure and information becomes available. The practitioner is encouraged to make use of multidisciplinary experts in planning, operations, maintenance, design and safety.
2.1 Executive Policies
A number of policies exist related to the use of data driven safety analysis. The policies address the implementation and use of these tools, particularly as it relates to WSDOT’s approach to practical solutions. The executive policies include:

- E 1096.00 WSDOT 2015-17: Agency Emphasis and Expectations
- E 1090.00 Moving Washington Forward: Practical Solutions
- E 1085.00 Sustainable Highway Safety Program

The executive policies provide the framework for the development of sustainable safety, practical solutions and the use of the HSM. The policies also provided direction on redevelopment of the WSDOT Design Manual.

2.2 Highway Safety Improvement Program (Federal)
The Highway Safety Improvement Program (HSIP) is a Federal-aid program administered through the Federal Highway Administration (FHWA). The purpose of the program is to reduce fatal and serious crashes on all public roads regardless of ownership. The HSIP requires a data-driven strategic approach with a focus towards performance. HSIP funds are divided between WSDOT and local agencies. WSDOT uses HSIP funds to address I2I2 safety needs.

23 U.S. Code § 148 provides the legislation to carry out the HSIP, the implementation regulations are found in Part 924 of Title 23, Code of Federal Regulations (23 CFR Part 924). The HSIP consists of three main components, the Strategic Highway Safety Plan (SHSP), State HSIP or program of highway safety improvement projects, and the Railway-Highway Crossing Program (RHCP). In addition, Washington also has a High Risk Rural Roads (HRRR) program because of an increasing fatality rate on rural roads.

2.3 Target Zero
Target Zero, the Washington State Strategic Highway Safety Plan (SHSP), forms the basis for how Washington State measures safety performance and sets the priorities for safety performance investments. This statewide plan is developed and updated in consultation with agencies and safety partners in the state. It is a formal statewide planning document approved by the FHWA Division Administrator. MAP-21 and the FAST Act require that WSDOT integrate the SHSP into WSDOT safety business practices and processes and requires states to set performance targets related to fatal and serious injuries. Target Zero’s intent is to reduce fatal and serious injury crashes and includes emphasis areas with priorities based on the number of fatalities or number of serious injuries. The plan highlights

1 Target Zero, the Washington State Strategic Highway Safety Plan
   - Emphasis areas and priorities: http://www.targetzero.com/priorities.htm

the need for multimodal approaches to safety by including emphasis areas for pedestrians, bicyclists, motorcyclists, heavy trucks, older drivers, and younger drivers.

To address Target Zero goals and other WSDOT operational objectives, WSDOT considers the full range of crash types and severity depending on the objectives of the investment.

2.4 Design Manual
The Design Manual chapters provide specific policies and guidance, criteria, procedures, and the process of documentation on safety analysis. The Safety Analysis Guidance presented as part of this guideline (in Chapter 321) supplements the Design Manual in an effort to provide additional information on intent, scale and scope of safety analysis aspects for different project types. The primary chapters in the WSDOT Design Manual the safety analyst should be aware of are:

- Chapter 321 Sustainable Safety
- Chapter 1100 Practical Design
- Chapter 1101 Need Identification
- Chapter 1102 Context Identification
- Chapter 1103 Design Control Selection
- Chapter 1104 Alternatives Analysis
- Chapter 1105 Design Element Selection
- Chapter 1106 Design Element Dimensions

These safety analysis guidelines do not supersede the Design Manual. The Design Manual uses the Strategic Highway Safety Plan and FHWA rules to identify fatal and serious injuries as the focus area for safety performance and use in the priority array methods. It is also important to consider how other crashes, crash injury levels, or crash types might influence design and operational choices.

Safety analysis does not necessarily mean HSM analysis.

2.5 Priority Programming for Highway Development
In RCW 47.05, the Washington State Legislature recognized that the complexity and diversity of transportation deficiencies was becoming increasingly challenging. The legislature also recognized that the needs of the transportation system outweighed the ability to fund every location. The RCW requires that projects be selected based on a policy of priority programming where objectives are defined within available resources, and that the selection of projects be based on factual need and evaluation of the life cycle costs and benefits.

3. Purpose of Safety Analysis at WSDOT
To address Target Zero goals and other WSDOT operational objectives, WSDOT considers the full range of crash types and severity depending on the objectives of the investment.

Through the process of conducting safety analysis, the engineer must frequently weigh the tradeoffs of implementing each change to the roadway. For example, installing a traffic signal may reduce entering
at angle collisions but increase rear end collisions, widening travel lane widths may decrease vehicle sideswipe type crashes but increase crossing distance exposure for pedestrians, or narrowing the lanes to provide a wider shoulder for bicycles may increase the collisions of vehicles but reduce the collisions for bicyclist. Each time a tradeoff is encountered, consider the whole roadway system including all users/modes. Carefully weigh the crash potential of each alternative and discuss the tradeoffs with your design team and project stakeholders.

3.1 Limitations

Each model in the Highways Safety Manual (HSM) predictive method is created for certain geometric configurations and traffic volumes. Utilizing a model outside of the boundaries for which it is developed jeopardizes the applicability of the results. As such, it is important to understand the limitations of the models that are used. The HSM discusses the geometrics and traffic volumes that are applicable to each model. Some of the geometric constraints have been summarized in Appendix A. In addition to limitations listed in Appendix A, the HSM predictive method models do not account for some unique roadway configurations such as peak period shoulder driving, toll plazas or reversible lanes. If the highway configuration or traffic volumes are outside the applicable ranges discussed in the HSM, consult the HQ Safety Technical Group (see Section 5) to determine if the model can still be utilized. If the HSM predictive method models cannot be used, the observed crash history can be used along with crash modification functions and factors (CMFs).

WSDOT recognizes that meeting the goal of zero fatal and serious crashes is aspirational and difficult. Achieving this challenge requires the effective and efficient use of scarce resources. Optimization of the analysis means that not all projects will receive the same level of safety analysis. It is important to recognize that WSDOT methods for programming and project development affect the type of analysis that occurs. As an example, preservation projects will receive less analysis than a targeted safety project, because the focus is not on reducing fatal and serious crashes, but on preservation of the system. Mobility and economic initiative projects will use safety analysis in project decision making where design and operational solutions may require an assessment between alternatives.

The I2 program on the other hand, is focused on reducing fatal and serious crashes: requiring the analysis of the contributing factors that might be leading to a given location being identified for project consideration. The I2 program often targets specific intersections and segments of the highway that would benefit from engineering countermeasure implementation.

Within the I2 Safety improvement program, safety projects are identified as part of the priority programming process. The priorities for the safety program are developed in accordance with RCW 47.05. This law requires WSDOT to follow a defined process that identifies improvement opportunities, has specific minimum performance requirements, and ultimately leads to a prioritized list of projects that includes the benefit/cost of the project.

Network screening begins with the use of specific criteria that is developed to address the historic crashes, the potential for crashes at a given location, or both. The criteria typically consider crash
severity, crash type, contributing factors, historic trends or identified factors that are considered to affect fatal and serious injury crash or injury potential.

To achieve the goals of practical solutions and Target Zero, the department is targeted in its approach to reducing crashes and our methods seek optimization in the use of scarce resources. From the safety analysis perspective, this means that if the Department makes a safety investment, to maximize the reduction in fatal and serious crashes while providing the best value. Safety analysis helps inform these decisions through careful and reliable science-based evaluation given the project type, need and focus. Not all projects need the same level of analysis because the safety focus or targets may be limited.

It is important to recognize that projects may target mobility, preservation, or safety. While the focus of each vary, the safety analysis component will vary significantly. In mobility projects, safety analysis is often focusing on comparative evaluation of different design decisions for the potential difference in terms of safety performance outcomes or the safety performance of alternatives. In preservation, a review may not occur or be limited because of the scope of those projects and the fact that WSDOT has a priority array process driving safety investments across the state.

WSDOT approaches safety in several ways:

- During Corridor Sketch development, the Target Zero Emphasis Area Summary for each corridor forms the basis for describing the safety performance of the corridor to stakeholders and the public. Safety needs are not identified or analyzed as part of the corridor sketch process. The reason is two-fold. First, this is because of the quick turnaround nature of the I2 program: projects are programmed and implemented much quicker than a normal planning process allows. Second, this approach allows WSDOT to maintain the integrity of the legislatively required priority array process for safety.
- Within the I2 program, the state highway system is screened every two years to identify segments and intersections that, when compared to similar locations, experience more fatal and serious injury crashes. These locations, called analysis locations, are evaluated by the regions. When further investigation reveals that engineering countermeasures could likely change the safety performance of the location, a report describing contributing factors and a benefit-cost analysis is presented to a panel for consideration. Note that these projects are implemented within a short time period.
- As part of the I2 program, systemic treatments and roadside features are also funded and implemented. Each of these investment types requires specific priority array processes for identifying suitable locations and that prioritizes implementation.
- During planning studies, safety analysis may be included if it is a safety focused study identified during the I2 priority array process or to assess the safety performance of alternatives if it is a mobility study. The required approach for safety analysis as part of corridor planning studies is outlined in the WSDOT Safety Guidance for Corridor Planning Studies.
- Over a period of 7 years, the state highway system is reviewed through the field operational assessment program. Locations scheduled for pavement preservation drives the program. These teams identify low cost investments (usually operational in nature) that are implemented at an
even quicker period than the I2 program. The low cost enhancement program usually funds these low cost investments.

As we move from planning to programming in the project development process, the methods outlined in this guide are intend to increase the likelihood that higher level injury crashes will diminish over time where investments have occurred. This desire to make data-driven and science based decisions that have a higher probability of returning on target investment means that additional information on travel, roadway and roadside characteristics are added, and that the methods presented leverages the predictive method in the AASHTO Highway Safety Manual (2010) along with its associated tools to inform decisions.

It is important to determine and agree to the nature, extent, and method for safety analysis upfront, given the purpose and need of the project. Take the time to determine where is most appropriate to focus analysis and evaluation consistent with the goals of Target Zero and practical solutions to determine the “right projects at the right location at the right time.”

4. Concepts
This section discusses concepts like performance-based approaches, the units for safety performance analysis, crash severity, and different measures of crash frequency.

4.1 Units of safety performance
WSDOT uses the units of “crashes per year.” Safety analysis also distinguishes between the different levels of crash severity and crash type in an effort to target investments in safety performance to align with Target Zero and MAP-21 safety performance metrics for the state.

4.2 Crash severity
Table 1 shows the injury severity levels used by WSDOT along with the KABCO scale and the Model Minimum Uniform Crash Criteria (MMUCC 4.0) severity levels.

<table>
<thead>
<tr>
<th>WSDOT</th>
<th>KABCO</th>
<th>MMUCC 4.0</th>
<th>Description of the injury (from MMUCC 4.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatality (death)</td>
<td>K</td>
<td>Fatal</td>
<td>Any injury that results in death within 30 days after the motor vehicle crash in which the injury occurred.</td>
</tr>
</tbody>
</table>
| Suspected serious injury* | A | Suspected serious injury | Any injury other than fatal which results in one or more of the following:  
  - Severe laceration resulting in exposure of underlying tissues/muscle/organs or resulting in significant loss of blood  
  - Broken or distorted extremity (arm or leg)  
  - Crush injuries  
  - Suspected skull, chest or abdominal injury other than bruises or minor lacerations  
  - Significant burns (second and third degree burns over 10% or more of the body)  
  - Unconsciousness when taken from the crash scene  
  - Paralysis |
The Police Traffic Collision Report (PTCR) and supplemental reports (updates submitted after the original PTCR was submitted) record the injury severity levels of all persons involved in a reportable crash based on the assessment by the reporting officer. These per-person injury severities are used to determine the crash severity. The severity of a crash is based on the most severe injury to any person involved in the crash. For example, if a motor vehicle crash involves four occupants and two have no injury, one has an evident injury, and one has a serious injury, then the crash is a suspected serious injury crash.

The KABCO scale is used in the HSM. Table 2 summarizes references to crash severity in the HSM with respect to WSDOT terminology.

### Table 2. HSM Terminology Related to Crash Severity

<table>
<thead>
<tr>
<th>HSM Terminology (Crash Level)</th>
<th>WSDOT Crash Severity Level(s)</th>
<th>KABCO Crash Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal and injury crashes (FI)</td>
<td>Fatal, suspected serious injury, evident and possible injury crashes</td>
<td>KABC</td>
</tr>
<tr>
<td>Property damage only crashes (PDO)</td>
<td>Property damage only crashes</td>
<td>O</td>
</tr>
</tbody>
</table>

Note: HSM calculations treat all injury categories as equal.

### 4.3 Crash frequency

The term crash frequency refers to the number of crashes per year. Crash frequency is used to describe:

- **Observed average** crash frequency: the historic average of the number of crashes per year (usually across five years).
- **Predicted** average crash frequency is an output from the HSM predictive analysis. It is the average safety performance of similar locations (see Section 6.5.1 for a discussion of the predictive method, and Chapter 9 for examples of how results can be described as part of documentation).
- **Expected** average crash frequency is an output from the HSM empirical Bayes method. The empirical Bayes method determines a more reliable average crash history by weighing the observed crash history against the predicted number of crashes per year (see Section 6.5.1 for a discussion of the predictive method, and Chapter 9 for examples of how results can be
described as part of documentation). The expected average crash frequency is a more reliable metric of existing average crash performance. Note that analysis results values are averages and should not be interpreted as point values rounded to one decimal place\(^3\) in the discussion of findings and presentation of final analysis results.

These terms are used in the HSM Predictive Method (see Section 6.5.1). Note that:

- The expected average crash frequency is a more reliable metric of existing average crash performance.
- Safety analysis results are averages crashes per year and should not be interpreted as point (absolute) values. It is important to recognize this aspect in decision-making.
- Predictive method analysis results should be rounded to one decimal place\(^4\) in the discussion of findings and presentation of final analysis results.

5. Technical Support
The HQ Safety Technical Group (see DM Chapter 321.02) is comprised of experts in safety analysis. The team has several duties including maintaining the Safety Analysis Guide, safety analysis training, review of complex safety analysis, review of Collision Analysis Reports, and recommends approval of crash modification factors. The team can also provide assistance to a project office as they conduct safety analysis. Since the makeup of this group will change over time, contact your region’s Traffic Engineer and ASDE and ask for assistance in contacting this group.

6. Common Practice
This section covers specific items of safety analysis that are applicable across all program and subprogram types.

6.1 Data needed for Safety Analyses
Safety analysis uses multiple data sources and the data sources will vary across project types, program types, and the analysis purpose. Based on 23 U.S. Code § 148 and 23 U.S. Code § 409, WSDOT regards any data used as part of safety analysis as safety data and not subject to discovery or admission into in a court of law. The WSDOT uses a disclaimer (see Section 6.2.1) to highlight this fact and it is the intent of the Department to use this disclaimer on any safety related data, spreadsheets, summaries, reports or other documents.

6.2 Handling of Safety Data – 23 USC §148 and 23 USC §409

\(^3\) All decimal places are kept throughout analysis calculations and the only the final report results are rounded to one decimal place.

\(^4\) All decimal places are kept throughout analysis calculations and the only the final report results are rounded to one decimal place.
The United States Congress requires state DOTs to collect safety data for use in the development of the Highway Safety Improvement Program (HSIP). Congress requires states, when considering use of federal funds, to identify locations that experience a higher than expected number of fatal and serious injury crashes (23 USC §148). Congress recognizes that the collection and use of safety data for the purposes of identifying locations had the potential to create significant legal liability for DOTs and exempted safety data from discovery and use as evidence against agencies. Safety data is widely defined as data used in analysis of locations and includes, crash, traffic, geometric and roadside data. WSDOT recognizes the value of this privilege and has taken steps to inform its staff in aspects related to 23 U.S. Code § 148 and 23 U.S. Code § 409 and how it relates to safety data or the develop of reports, lists, surveys, analyses, evaluations, or assessment. With respect to these deliverables, care is taken to include the disclaimer described in Section 6.2.1.

6.2.1  **Disclaimer language**

The WSDOT has developed standard disclaimer language that should be included on any page, table, or graph representing safety data or analysis results and included in emails or discussions of safety data. For safety analysis, this disclaimer must be in the footer and the font size can be adjusted to fit:

*Under 23 U.S. Code § 148 and 23 U.S. Code § 409, safety data, reports, surveys, schedules, lists compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential crash sites, hazardous roadway conditions, or railway-highway crossings are not subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.*

The disclaimer reflects the evidentiary exclusion provided for safety data as part of 23 USC §148 and 23 USC §409, as interpreted by the WSDOT Attorney General’s Office.

6.2.2  **Release of crash data or summaries to entities outside WSDOT**

Because of 23 USC §148 and 23 USC §409 and subsequent federal and state court decisions, WSDOT attempts to strike a balance between providing information to the public, while not unduly increasing the liabilities against the state in terms of potential lawsuits. To this end, WSDOT has developed a policy for the release of crash data in Policy Statement Number: P 2021.00.

*It is the policy of the Washington State Department of Transportation (WSDOT) to make crash data available to anyone who requests the data through the appropriate and applicable methods outlined below with the requestor’s acceptance and acknowledgement of the data constraints per the state and federal laws governing access to the data.*

The official policy requires the release of any crash data or summaries to any individuals outside of WSDOT (e.g., public, consultant, external agencies) occur through an official request process with the Crash Data and Reporting Branch of the WSDOT Transportation Data, GIS and Modeling Office (TDGMO). The TDGMO is the only office at WSDOT who can release crash data to the public. Other HQ or Regional Offices do not have the authority to do so. Denial of these requests is the responsibility of the Director of Risk Management and Legal Services.
In addition, the policy also includes references to federal and state laws governing access to the data, information about the different request methods, a link to the request form, and language for cover letters. These are to be used by all WSDOT TDGMO staff who provide crash data to requestors outside WSDOT so this policy is carried out in a consistent manner.

6.2.3 **Handling police reports**

During the review of crashes, and crashes involving pedestrians or bicyclists for safety performance analysis, WSDOT staff is encouraged to review the Police Traffic Collision Report (PTCR) narratives and sketches to help develop their understanding of the contributing factors and events leading to and the during the crash. PTCRs are for information only. PTCRs are not to be printed, stored, copied, scanned or emailed\(^5\), or kept as part of project documentation. WSDOT staff may request access to PTCRs by contacting the Crash Data and Reporting Branch at TDGMO.

6.2.4 **Crash data**

Locating crashes is not always straightforward and requires an understanding of the WSDOT state route linear referencing system. Staff is strongly encouraged to contact the Crash Data and Reporting Branch of the WSDOT Transportation Data, GIS and Modeling Office for any questions about the linear referencing system. The GIS and Modeling Office can also answer questions or comments about crash data. It is through these questions and discussions that staff develop a working understanding of the data, how to use it, and its limitations. It is important to note that **collision data** refers to the Washington State Patrol (WSP) data, and that **crash data** refers to the engineering crash data warehouse used at WSDOT for analysis. The engineering crash data warehouse differs from the WSP collision database in that it includes many fields that WSDOT crash coding staff create after review of the PTCR, the narrative of the PTCR, and the sketch on the PTCR. The WSDOT engineering crash data warehouse is the source for crash data in safety performance analysis at WSDOT and for WSDOT projects.

**Querying crash data**

WSDOT staff can access the crash data through Cognos™. The steps are as follows:

   
   NOTE. Review the status flag: if it is orange or red, review the notes provided by IT. Do not use Cognos™ for crash data queries if there are any issues noted with the Collision Data Warehouse.

2. Click on *Cognos™ Reports*.

3. Select from the left vertical navigation bar.

4. Select *Reports*, then *Transportation Planning*, then *Collision*. If you do not see *Collision*, you must contact the Crash Data and Reporting Branch to gain access.

5. Three report options are available.
   
   a. **Standard Crash History**:
      
      i. Click *View Reports*

\(^5\) Note that this discussion is not applicable to the financial recovery process.
ii. Select State Route Number & Enter Begin SRMP & Enter End SRMP along with the ahead/back indicator
iii. Enter or select from calendar Begin Date & End Date (Optional Collision Type)
iv. Select Standard Diagram Detail Report or Summary Report & Sort Type.

b. Standard Crash Row Flat File: Crash history with all information items in columns.
c. STATE ROUTE ONLY Condensed SRFF: Crash history with a limited number of information items in columns.

Important notes (please contact the Crash Data and Reporting Branch if there are questions):

- Location information in Cognos™ is provided by SRMP and ahead/back indicator (this is different from the ARM values in other systems). The SRMP and ARM are shown for each crash in the data.
- When extracting crash data for freeway mainline segments, review the “Primary Trafficway” column to determine if the crashes were on the freeway, on the ramps, or on the crossroad.
- The Cognos™ reports can be customized by right clicking on ‘Standard Crash History’ (or any of the other two query options), selecting ‘Edit report’, selecting ‘Save as’ (saving it under ‘My Content’. Then select the navigation item and select the Report page that you would like to customize, and save it for future use.

Reportable crashes

ANSI D16.1-2007⁶ and MMUCC 4.0⁷ set the requirements for the reporting of motor vehicle crashes in the U.S. and in Washington State WAC 446-85-010 (accident reporting threshold), RCW 46.52.030 (accident reports), and RCW 46.52.070 adds additional requirements. To meet these reporting criteria, a motor vehicle crash must:

1. Have property damage of at least $1000 or injury of any individual;
2. Be on a public roadway;
3. Involve at least one motorized vehicle; and
4. Not involve an intentional act, a legal intervention, or be medically caused.

Note that a crash is not recorded if a citizen is able to drive away without the assistance of an officer. Therefore, some locations may experience more crashes than is reported in the WSDOT Engineering Crash Data Warehouse. For uniformity with reporting standards across the state and realizing that WSDOT’s focus is on fatal and serious crashes, non-reported crashes should not be included in project specific crash analysis.

---

The Fatality Analysis Reporting System (FARS) is a national data system for fatal crashes. This data system is used for fatal metrics in the federal required state safety performance reporting and updates to Target Zero. The Washington State Traffic Safety Commission (WTSC) manages the FARS database in Washington. WSDOT is continuing efforts to more closely align the data in the WSDOT Engineering Crash Data Warehouse with FARS. Staff should continue to use the crash data in the WSDOT Engineering Crash Data Warehouse as the basis for safety analysis.

6.2.5 Traffic volume data
Safety analyses using the HSM predictive method requires the Average Annual Daily Traffic (AADT) volumes as an input. This data can be found online in the Annual Traffic Report and the GeoPortal web-based app or by contacting the Transportation Data, GIS & Modeling Office. This information is accessible through Cognos™ as part of the Transportation Planning category where crash data can be found (see Section 6.2.4), and through the Washington State Pavement Management System (WSPMS) (see Section 6.2.6). Except in areas where high traffic growth occurred or where traffic volumes greatly reduced, staff is encouraged to rely on available data without investing in additional traffic counts. Region Traffic Offices may have additional traffic count data on state and non-state route approaches.

6.2.6 Roadway data
A variety of tools at WSDOT provides access to roadway data:

- Roadway data for the state highway network can be accessed through any one of the following tools: SRView contains photos, maps, and tabular roadway data. The tool can be accessed at http://wwwi.wsdot.wa.gov/planning/data/travel/roadway/tools/srviewhome.htm.
- The roadway log summarizes roadway data on an annual basis and can be found at http://www.wsdot.wa.gov/mapsdata/roadway/statehighwaylog.htm.
- The Washington State Pavement Management System (WebWSPMS) contains roadway, traffic, and other data. The tool can be accessed at https://webapps.wsdot.loc/Materials/WSPMS. Data can be downloaded, viewed on a map, or printed as strip maps.

6.3 Study Period
Use five full calendar years (January 1st to December 31st) of historic crash data for safety analyses. There may be times where shorter study periods are appropriate. For instance, before and after periods where limited data is available. However, the shorter the period, the more likely it becomes that the crash data might indicate an unusually high or low number of crashes. If more data were included, the more likely the true average for the locations would be apparent (i.e., regression to the mean). A minimum of 2 years is required where major modifications at the site have occurred. In rare cases, when only one year of data will be available, then the use of the predicted average crash frequency from the HSM predictive method is recommended rather than the one-year crash history. The focus of this type of analysis is often the analysis of alternatives.

Document the study period, reasoning behind the selection and any assumptions as noted in Chapters 7 and 8 of this guide. For complex cases, consult with the HQ Safety Technical Group.
6.4 Study Area
A study area is the area impacted by the potential project or alternative solutions/strategies. Setting an appropriate study area is important and should occur as early as possible in the safety analysis process. Traffic analyses also use study areas and if there is a traffic analysis associated with the project then the study area would be a good starting point: this area can be modified if the safety impact area is different. Document the study area, reasoning for selection, and any assumptions as noted in Chapters 7 and 8 of this guide.

When selecting the study area consider how the potential safety performance and operational changes might affect the surrounding road and highway networks, the need to evaluate alternatives, and concerns of key stakeholders and approval authorities.

6.5 Crash Analysis Tools and Methods
This section discusses various crash analysis tools and methods used at WSDOT. The content is not meant to be all-inclusive but provides an overview of the tools, best use applications, and special considerations for use. In all cases, the tools and methods selected for the analysis are best selected early on in the project with the management team. If the HSM predictive method cannot be used, the observed crash history can be used along with CMFs. Perform a human factors review of the feasible alternative and document a review of the fatal and serious injury crashes, and any crashes involving pedestrians or bicyclists.

6.5.1 HSM predictive method
The HSM predictive method is based on the fact that similar roadways and intersections have similar crash frequencies, severities, and crash types.

The predictive method provides procedures to analyze safety performance in terms of crash severity levels and collision types (such as runoff-the-road or rear-end crashes). In most instances, this is accomplished with default distributions of crash severity level or collision types, or both.

The HSM predictive method models use safety performance functions (SPFs, see later in this section) and chapter specific crash modification factors (CMFs, see later in this section). The predictive method calculates the safety performance of similar facilities or sites (called the predicted average crash frequency), and, where applicable, the more reliable metric of existing crash performance (called the expected average crash frequency). Note that analysis results values are averages and should not be interpreted as point values and it is important to recognize that minor changes may have limited impacts on analysis outcomes. The predictive method results are rounded to one decimal place in the discussion of findings and presentation of final analysis results.

Site types
The WSDOT uses tools (see Section 6.5.2) to implement the predictive method for the following facility types (showing relevant HSM chapters):

- Rural two-lane, two-way highways (Chapter 10 in HSM)
- Rural multilane highways (Chapter 11 in HSM)
• Urban and suburban arterials (Chapter 12 in HSM)
• Freeways (Chapter 18 in HSM)
• Ramps and ramp terminals (Chapter 19 in HSM).

Each of these chapters cover segments (segment configurations) and intersections (number of legs and
control type). A project can consist of a single element (segment or intersection) or several elements
(segments and/or intersections) depending on the needs of the analysis.

Safety Performance Functions (SPFs)
Safety Performance Functions (SPFs) are regression equations that estimate the predicted average crash
frequency for a specific roadway segment or intersection type with a specific set of base conditions.
Each HSM chapter and site type has its own SPFs with a set of base conditions that are specific to that
site type.

Calibration Factor
Calibration is the process of adjusting the SPF curves up or down in an attempt to account for the
differing crash frequencies between different jurisdictions. Calibration can be undertaken for a single
state, or where appropriate, for a specific geographic region within a state. Because much of the data
used to determine the original SPFs were from Washington State the WSDOT uses the calibration factor
of 1.00, which is the default calibration factor in the HSM models.

Crash Modification Factors (CMFs)
There are two types of CMFs (Part C CMF and Countermeasure CMF), both are used to determine the
expected number of crashes for implementation of a countermeasure at a given site. As an example,
what the change in total crashes might be for a change in lane width.

Part C - CMFs
In the HSM Part C, CMFs are used in conjunction with the predictive methods. The CMFs are used as
adjustment factors to the base condition SPF. For instance, if the base condition for the model was 12’
lanes and 8’ shoulders, and the location being evaluated is 11’ lanes and 4’ shoulders, the CMFs
(adjustment factors) would be used to adjust the SPF value to the narrower conditions. In the second
edition of the HSM, the CMFs in the predictive models will be referred to as “SPF adjustment factors” to
reduce confusion.

The CMFs in the HSM Predictive Method are only used with the specific SPF for which they were
developed. For example, in the two-way two-lane rural highway segment analysis, several CMFs (i.e.,
SPF adjustment factors) can be multiplied and used with the SPF for the base conditions of the SPF: lane
width, shoulder width, horizontal curve, grade, driveway density, etc.

Countermeasure CMFs
Countermeasure CMFs are CMFs that are used to estimate the anticipated impact of a countermeasure
or mitigation on safety performance. Before selecting a countermeasure CMF, it is important to first
identify the target crashes for the countermeasure or mitigation, i.e. the particular crash types and
severities addressed by the countermeasure or mitigation. Target crashes are the most common crash
types or grouping of crashes that occur at the site. Note that for safety purposes, the focus is on groupings of crash types associated with higher severity crashes.

Countermeasure CMFs are generally developed using multiple sites and statistical methods. The quality of CMFs varies significantly, making it necessary for WSDOT to have requirements in place for the review and approval of CMFs for use in analysis. WSDOT maintains a CMF short list that contains CMFs for various measures and this list is available on the WSDOT intranet. A detailed report for each of these CMFs describes the context and background for the CMFs, allowing the analyst to determine whether the CMF is suitable for the particular application (i.e. it matches the context and specific considerations for use). Note that the selection of an appropriate CMF is complex. Selection of the CMF’s outside of the WSDOT short list should be discussed the HQ Safety Technical Group.

The selection of CMFs requires that:

1) The analysis site or corridor context matches the context of the identified CMF.
2) The quality of the study that developed the CMF is the best available for the identified CMF.
3) The CMF accounts for changes to particular crash types (the more specific the better).
4) The CMF accounts for changes to particular crash severities (the more specific the better).

When multiplying several countermeasure CMFs, the result is often a combined CMF value indicating a large reduction in crashes. Exercise care when multiplying more than one countermeasure or mitigation CMF. Ideally, use only one or two CMFs. The CMFs should be applicable to different target crash types or severity levels.

There are many types of CMFs, including those that consider all crashes, specific crash types and specific injury severity. Where CMFs on crash types or severity levels exists, they are preferred due to the ability to address the specific crash characteristics and the potential impact of the countermeasure being analyzed.

The quality of CMFs are influenced by a multitude of factors. Assumptions made in the study can greatly impact the outcome of a CMF analysis. The following items represent general considerations for the quality of the CMF study:

- The quality of SPF used in the before-after study can impact the reliability of a CMF.
- Some studies do not isolate the impact of the particular countermeasure or ignore other changes made to the road environment, biasing the results.
- The quality of the SPF used in Empirical Bayes before-after studies impacts the reliability of results in that it biases the estimation of the typical performance of similar sites.
- Some studies suffer from omitted variable bias: changes that can affect the results are not accounted for.
- A countermeasure may have different impacts on safety performance across regions and states, sometimes because of how the measure is implemented, other times because of differences in user behavior.
• The context is sometimes not well defined, mixing distinctly different road environments together and biasing results.
• Some CMFs may be applicable to certain crash severity groupings rather than all the reported crashes.
• Small sample sizes reduce the reliability of results.
• Ignoring whether results of statistical significance during CMF analysis may lead to erroneous conclusions (lack of statistical significance indicates that the analysis does not offer findings that can be used for decision making).
• CMF development with meta-analysis is often challenging because it combines different studies and these studies often represent many different analysis methods, different assumptions, and contexts.
• CMFs showing no effect or an increase in crash types or severities are often not published (publication bias).

6.5.2 Tools for the HSM predictive method

Spreadsheet Tools
There is a set of spreadsheet tools developed to automate the HSM Predictive analysis. The tools that WSDOT currently uses include:

• Extended spreadsheets:  http://safetyperformance.org/tools/
  o Chapter 10: Rural two-way two-lane highways
  o Chapter 11: Rural multilane highways
  o Chapter 12: Urban and suburban arterials
• ISATe spreadsheet:  http://wwwi.wsdot.wa.gov/HighwaySafety/SafetyTools.htm
  o Chapter 18: Freeway mainline segments and speed change lanes (Ramp Tapers)
  o Chapter 19: Ramps, ramp terminal intersections, & Collector Distributer (CD) lines).

These tools provide detailed outputs of safety performance by:

• Crash type: head-on, sideswipe, rear-end, etc.
• Severity: fatal and all injury, property damage only (PDO) and total crashes.

The results can also distinguish between the typical safety performance of similar sites (predicted average crash frequency) and the site-specific safety performance (expected average crash frequency).

Use these tools in accordance with the applicable chapter in the HSM predictive method outlined in Part C of the HSM. Data element definitions for HSM tools may differ between what is customary at WSDOT and what is required as input to the predictive method. Therefore, all the assumptions need to be applied in the analysis to reflect the existing and/or future condition(s) in terms of the input required by these tools. All analysis assumptions need to be documented in the safety analysis. The safety analysis will be included in the appropriate project or planning documents. Consult with the HQ Safety Technical Group as needed.
Chapter 9 of this guide provides examples of how the results from the predictive method can be discussed in reports and project documentation.

**IHSDM**

The Interactive Highway Safety Design Model (IHSDM) is software developed and maintained by FHWA. IHSDM is a suite of analysis tools and includes tools to implement the HSM predictive analysis. While the IHSDM is not currently used at WSDOT it is being evaluated for future use. IHSDM allows the analyst to work across all the predictive chapters of the HSM in one project file. The latest version of the tool can be downloaded at [http://www.ihsdm.org](http://www.ihsdm.org).

### 6.6 Societal Cost

The societal cost of a crash is an estimated monetary value that a state agency adopts to quantify the societal impact of a change in safety performance as part of a benefit-cost analysis. These values are updated to account for inflation, where new research results indicate the need for an update, or when updated federal cost estimates become available.

This document focuses on safety performance and therefore, does not cover any other benefits or costs of a project such as an increase in delay or reduction in carbon emissions.

Table 3 summarizes the most recent societal cost for a crash as approved by the WSDOT Highway Safety Executive Committee (HSEC) in October 2016. A memo on the WSDOT intranet describes the method used to develop the costs.

**Table 3. Societal Costs for Benefit-Cost Analysis by WSDOT**

<table>
<thead>
<tr>
<th>Crash severity (WSDOT Terminology)</th>
<th>KABCO (Most Severe Injury in Crash)</th>
<th>HSM Terminology</th>
<th>WSDOT Societal Cost/Crash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal crash</td>
<td>(K)</td>
<td>Fatal crash</td>
<td>$2,900,000</td>
</tr>
<tr>
<td>Serious injury crash</td>
<td>(A)</td>
<td>Serious injury crash or disabling crash</td>
<td>$2,900,000</td>
</tr>
<tr>
<td>Evident injury crash</td>
<td>(B)</td>
<td>Evident injury or Non-disabling crash</td>
<td>$155,000</td>
</tr>
<tr>
<td>Possible injury crash</td>
<td>(C)</td>
<td>Possible injury crash</td>
<td>$60,000</td>
</tr>
<tr>
<td>Property damage only (PDO) crash</td>
<td>(O)</td>
<td>No Injury</td>
<td>$10,000</td>
</tr>
</tbody>
</table>

The societal cost is used to calculate the benefit of a project. The values listed in Table 3 should be used in benefit cost analysis (refer to Section 6.7) for safety performance.

### 6.7 Alternative Analysis Using Benefit and Costs

Commonly, comparison of alternatives use benefit to cost ratios to evaluate the potential return on investment of a selected countermeasure (or set of countermeasures). The benefit-cost (B/C) is determined by taking the benefits of a project and dividing it by the cost. The benefits of a project, with respect to safety, are determined by calculating the reduction in crash frequency or severity for a specific investment and multiplying it by societal cost of the crash. The benefit component is based on the difference in safety benefit after the planned investment. For example, if a study area has had two fatal and 10 evident injury crashes per year over the five-year study period before the improvement,
and then one fatal and six evident injury crashes per year in the after period, the societal benefit would as shown in Table 4.

Table 4. Calculating Societal Benefits Before and After Example

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2 Fatal Injury Crash x $2,900,000)</td>
<td>(1 Fatal Injury Crash x $2,900,000)</td>
</tr>
<tr>
<td></td>
<td>+ (10 Evident Injury Crashes x $155,000)</td>
<td>+ (6 Evident Injury Crashes x $155,000)</td>
</tr>
<tr>
<td></td>
<td>$7,350,000</td>
<td>-$3,830,000</td>
</tr>
</tbody>
</table>

Societal Benefit from Reduction in Crashes $3,520,000

Taking the total benefit and dividing it by the cost will result in the B/C ratio. If the resulting B/C ratio is greater than one, then society would benefit from the construction of the improvement.

Note: For I2 projects, benefits other than those from a reduction in crash frequency and severity are not included in the B/C analysis (refer to the scoping instructions for I2 projects for more information).

For the purpose of a B/C analysis, the cost of a project is the total cost of the project including preliminary engineering, right of way, construction, and operational costs. If a third party contributes right of way or construction items/funds, the total cost can be reduced by this amount and therefore positively impact the B/C ratio.

For I2 projects, the use of a benefit-cost spreadsheet (part of the scoping instructions) is required. For all other projects, document assumptions and calculations clearly and use the societal costs listed in Section 6.6.

6.8 Human Factors
The purpose of the human factors review is to evaluate the operation of the proposed configuration. For example, evaluate how information is provided to the user, driver expectation, perception-reaction conditions, potential conflict points, the context and speed of users at the site, and how the users will interact with one another.

Chapter 2 of the HSM (2010) and NCHRP Report 600, Human Factors Guidelines for Road Systems (2nd Edition, 2015) are valuable resources that can be used to perform human factors task analysis and specific human factors considerations during design.

6.9 Planning, Scoping, and Programming

6.9.1 Relationship between Planning and the I2 Safety Program
The State Highway Strategic Plan (SHSP) is the primary focal point that guides planning, public input and the safety priority programming processes. MAP-21 and the FAST Act, along with federal safety performance rulemaking (April 2016) require states to develop a SHSP, safety performance metrics, and to align their safety programs, policies and processes with the SHSP.

In Washington State, Target Zero is the SHSP (http://www.targetzero.com). This plan is developed and updated every three to five years using a statewide stakeholder and public engagement process,
representing agreement among state agencies and safety partners in WA about the emphasis areas, priorities, and safety performance metrics. *Target Zero* uses data analysis to identify and prioritize leading crash contributing factors and types. Each priority has associated strategies in education, enforcement, engineering, emergency services, and evaluation (e.g., the 5Es). WSDOT uses *Target Zero* to provide direction in the development and approach to highway safety by organizing its safety improvement program consistent with the priorities and emphasis areas of *Target Zero*. In this manner, WSDOT is coordinated with other agencies in carrying out its responsibilities. WSDOT has developed a Public Crash Data Portal and is incorporating SHSP emphasis areas into the AASHTOWare Safety Analyst tool to provide the *Target Zero* emphasis area crash summary information for a given location.

Figure 1 shows how Target Zero is developed with statewide stakeholder input and public engagement, and how it serves as the foundation for the development of projects that make up WSDOT’s Target Zero Implementation Plan. This implementation plan relies upon the priority programming processes in the development and programming of capital safety projects. The figure shows how this process; along with planning, community engagement, and field operational assessments, may lead to non-capital actions to reduce crash potential including Low Cost Enhancements, maintenance activities, policy or operational activities.
6.9.2 I2 Safety Project Identification and Community Engagement

WSDOT uses three approaches to identify potential projects. The most restrictive approach is through the WSDOT safety priority array. For a project to be identified as a location funded by the I2 Safety Program, it must be identified, analyzed and programmed through the priority programming based on observed and expected future crashes; and only after it is ranked in comparison to other like locations throughout the state.

When a location is not identified in the priority array, the WSDOT’s Traffic Operations Low Cost Enhancement Program may be used to identify quick turnaround and lower cost solutions. With this approach, public comments are sometimes provided to region traffic staff for consideration. The demand for low cost enhancement funding exceeds the amount available and therefore it undergoes a prioritization process lead by the Region Traffic Engineer.

Based on the particular public input or comments, and the ability to identify a lower cost investment, a small project may be considered. Engineers may deem it necessary to continue to monitor the location, or identify the need to gather more data before determining next steps. In some cases, no action will be taken because a lower cost solution is not available or the analysis indicates that the potential solution(s) are unlikely to provide a return on the investment. As mentioned, both the Safety Improvement program and the Low Cost Enhancement Program are limited in the type, scale and costs of the projects they were developed to address. Some comments from the public may request actions that are outside of WSDOT’s ability to respond. For instance, a project outside of WSDOT safety priority array, or outside of the scope of Low Cost Enhancement projects. Although less common, the comments may result in future planning efforts, local investments, or other legislative actions.

6.9.3 Expectations for Corridor Sketch Activities and Safety

The Target Zero Emphasis Area summaries for each corridor are available for use in the documentation of the safety performance of a corridor. This information is presented as observed crash history based on a five-year period and is presented as factual information for use in communication with the public. A key part of this message is that the I2 safety program is driven by a statewide plan, Target Zero, and that multiple partners across the state are working together towards the Target Zero Goal.

The expectation for safety in corridor sketches is to identify opportunities that address system performance within the corridor. This activity is conducted prior to any decisions that are made regarding sources of funds to implement solutions.

It is important to inform the public that the I2 Safety Improvement Program has specific required actions outlined as part of its priority programming process.

6.9.4 WSDOT’s I2 Safety Improvement Program Overview

WSDOT’s highway safety program has been developed to reduce fatal and serious crashes across the state in the most economical and efficient manner. WSDOT works with its partners in developing and implementing a strategic approach to highway safety. This strategic approach is highlighted in Target Zero.
Zero. Using Target Zero as its guide, WSDOT uses a priority programming system to identify and determine what locations have the highest potential for the reduction of fatal and serious injury crashes, and return the greatest benefit for the cost of the project.

In this manner, projects are identified through data driven safety analysis, which is a key point to emphasize. This approach is required by Federal regulations and makes good business sense. This is because projects are more likely to return on investment because the deliberate and science-based approach is based on crash data, science, and risk. The opinion or perceptions of drivers and other road users is very important to WSDOT as it provides information not available to WSDOT, but it is supplemental to the priority programming.

The Safety Improvement Program has been developed to address both the occurrence and potential for crashes. These two categories are referred to as Crash Reduction and Crash Prevention categories.

**Crash Reduction**
The Crash Reduction category focuses on locations that experience fatal and injury crashes that meet the Collision Analysis Location/Collision Analysis Corridor (CAL/CAC) or Intersection Analysis Location (IAL) criteria. CAL/CAC and IAL locations are screened and ranked on a statewide basis. These ranked lists are provided for further analysis to the Region Offices responsible for safety scoping.

The Region identifies countermeasures and conducts cost/benefit analysis. Based on this process, proposed countermeasures are documented in a Crash Analysis Report (CAR – see Section 8.4). This information is presented to an I2 safety panel to evaluate and recommends the project for programming or additional analysis and evaluation. Of primary importance is that the potential project is consistent with Target Zero and WSDOT policies and processes.

This process is formalized under the Safety Scoping Process for State Routes.

**Crash Prevention**
The Crash Prevention program identifies engineering countermeasures that can be applied on statewide, corridor or localized basis to address particular contributing factors, crash types or countermeasures. The selection of project approaches within the Crash Prevention program considers the characteristics and context of a given facility. Systemic treatments and roadside features are commonly considered and implemented. Each of these investment types requires specific priority programming processes for identifying suitable locations and prioritizes implementation.

**Program Approval**
Together these two categories (Crash Reduction and Crash Prevention) form the WSDOT Safety Improvement (I2) Program. However, not all projects that are analyzed by the regions are programmed within the safety program because the contributing factors to the crashes may not be effectively reduced through engineering countermeasures. For instance, behavioral issues, such as impaired driving related crashes. In addition, some projects may be driven by multiple performance requirements,
including mobility, economic vitality, or preservation. These types of projects are typically higher costs and are addressed within other program areas. In some cases, WSDOT will implement lower cost projects through its Low Cost Enhancement Program. These projects typically have multiple factors driving their selection. These types of projects are limited in scale, scope and cost.

The I2 Safety program is divided into investment categories, with the highest level being Crash Reduction and Crash Prevention. Each of these may be sub-divided by safety activities. For example, Crash Prevention is currently divided into new rumble strip installation, mitigation of redirectional landforms, cable median barriers and other prevention strategies. The Division of Safety and Quality leads a joint effort with the Divisions of Traffic Operations, Development, and CPDM to develop a 10-Year Capital Investment Plan. This 10-Year plan is then presented to HSEC for agreement. Finally, the list of projects in the 10-year Plan of the WSDOT I2 Safety Program is certified annually by the Director of Safety and Quality that it conforms to Target Zero and the Safety Implementation Plan.

6.9.5 Design Analysis
The purpose of safety analysis in a design analysis is to quantify the safety performance impacts of the alternatives to help choose the preferred alternative and/or determine the best mitigation measures. In some cases, safety performance may be impacted while in other cases it will have no or a negligible impact. An analysis is only necessary if the design analyses change safety performance.

Safety analysis is contained in the options analysis section of the design analysis template. The safety analysis should focus on the number of fatal and serious injury crashes per year and crashes involving pedestrians or bicyclists. Lower severity crashes may be taken into consideration on projects where safety is a contextual need. Compare the alternatives being considered and discuss the tradeoffs with respect to safety.

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Design selection or alternative selection outside DM ranges and may impact safety performance.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area</td>
<td>The location of the elements being analyzed in the design analysis.</td>
</tr>
<tr>
<td>Study Period</td>
<td>Five calendar years unless there has been a significant change to reduce the number of years (2 years minimum).</td>
</tr>
<tr>
<td>Scope</td>
<td>The elements for which the design analysis is being written.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Determine upfront the scale and scope of the analysis. If appropriate, analyze the segments and intersections with the HSM predictive method described in the applicable chapter (Chapter 10, 11, 12, 18, or 19). If the HSM predictive method cannot be used, the observed crash history can be used along with CMFs. Perform a human factors review of the feasible alternatives and document a review of the fatal and serious injury crashes, and any crashes involving pedestrians or bicyclists. Define mitigation strategies to address changes in safety performance.</td>
</tr>
<tr>
<td>Tools</td>
<td>See Section 6.5</td>
</tr>
</tbody>
</table>
| Goals                    | 1. Evaluate existing safety performance to identify safety improvement opportunities and inform design decisions.  
2. Analyze the safety performance of all identified alternatives to provide safety performance measures to help inform the tradeoff decisions during the preferred alternative selection |
3. To reduce crashes for users, with an emphasis on fatal and serious crash reduction

| Documentation | Discuss the safety performance results and tradeoffs in the “Options Analysis” section of the design analysis template. |

7. Safety Analysis by Program Type

This section of the guide steps through the primary funding mechanisms and discusses safety analysis for each sub-program for the Preservation (P), Investment (I), and Traffic Operations (Q), programs. The Project Definition contains the primary need, solution, and purpose for a project and is used to determine the program and sub-program for a project. Final determination of the appropriate program and sub-program for a project is the responsibility of CPDM.

In each sub-section, there is a table with the following rows: Trigger, Study Area, Study Period, Scope, Scale, Methodology, Tools, Goals, and Documentation. Each table is intended to summarize the safety analysis that is needed for a project in the particular program type. The guide does not take away the responsibility of the user to apply sound engineering judgement based on specific project conditions or to address items not covered in this guide.

7.1 Preservation (P)

7.1.1 Pavement Preservation (P1)

Projects funded from P1 are to preserve pavements at the lowest life cycle cost and safety is not a baseline need, but can be a contextual need. Designers should contact their region’s Field Assessment program to determine whether there are low/no cost contextual safety elements that have been identified for the corridor and can be incorporated into the project. Documentation for these improvements has to follow the requirements of the Field Assessment program, will include a traffic basis of design (QBOD), and need to be incorporated into the Project Development Approval.

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Field Assessment or Traffic Operations programs identify items to incorporate into the project through a QBOD. See Section 7.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area</td>
<td>N/A</td>
</tr>
<tr>
<td>Study Period</td>
<td>N/A</td>
</tr>
<tr>
<td>Scope</td>
<td>N/A</td>
</tr>
<tr>
<td>Scale</td>
<td>N/A</td>
</tr>
<tr>
<td>Methodology</td>
<td>N/A</td>
</tr>
<tr>
<td>Tools</td>
<td>N/A</td>
</tr>
<tr>
<td>Goals</td>
<td>N/A</td>
</tr>
<tr>
<td>Documentation</td>
<td>The Field Assessment program will provide a QBOD that is appropriate for their program. QBODs are approved by the Region Traffic Engineer. Include the QBOD in the project DDP.</td>
</tr>
</tbody>
</table>

---

8 WSDOT 2017-2019 Capital Improvement and Preservation Program, September 2016, page II2
### 7.1.2 Bridge Preservation Program (P2)

The bridge preservation program addresses the overall preservation of bridges and structures on the state highway system. This program includes vehicular bridges, culverts longer than 20 feet, pedestrian bridges, tunnels, lids, and deck overlays.

Bridge preservation projects preserve the state’s bridge network through cost effective actions. There are numerous types of bridge preservation actions including: deck rehabilitation, seismic retrofit, painting steel bridges, and scour repair. The type of bridge preservation work that effects safety is where the lane or shoulder widths change. If the bridge is widened so that the lane and/or shoulder widths will end up larger and neither are narrowed, then no safety analysis is needed.

<table>
<thead>
<tr>
<th>Trigger</th>
<th>If the lane or shoulder width is changed or a field assessment or traffic operations programs has identify items to incorporate into the project. See Section 7.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area</td>
<td>Field Assessment limits or where the lane width or shoulder width is changed.</td>
</tr>
<tr>
<td>Study Period</td>
<td>A study period is not applicable. Compare the predicted average crash frequencies across alternatives.</td>
</tr>
<tr>
<td>Scope</td>
<td>Analyze the lane and shoulder widths being considered. Analyze the crash data for crashes that can be attributed to lane and shoulder width and their contributing factors.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Use the applicable CMF tables/equations for the roadway type with respect to lane and shoulder width. Compare the CMFs of the lane/shoulder widths being considered.</td>
</tr>
<tr>
<td>Tools</td>
<td>For the appropriate roadway type, use the following items from the HSM:</td>
</tr>
</tbody>
</table>
|   • Rural Two-Lane, Two-Way Roads: |   o Lanes: Table 10-8  
|     o Shoulders: Table 10-9 |
|   • Undivided Roadway Segment |   o Lanes: Table 11-11  
|     o Shoulders: Table 11-12 |
|   • Divided Roadway Segment |   o Lanes: Table 11-16  
|     o Shoulders: Table 11-17 |
|   • Freeway Segments: See HSM Chapter 18.7.1 |   o Lane Width: Equation 18-25  
|     o Inside Shoulder Width: Equation 18-27  
|     o Outside Shoulder Width: Equation 18-35 |
| Goals | Assess the safety performance of the alternatives being considered. |
| Documentation | Include safety performance as a contextual need in the BOD. Include CMF discussion in the alternatives comparison section of the BOD. Summarize the findings of the contributing factors analysis in the BOD. If Field Assessment or Traffic Operations request the change, then complete a QBOD and include it in the project’s DDP. |

---

### 7.1.3 Other Highway Facilities Preservation Program (P3)

Preservation of other facilities includes basic safety guardrail and signing, major drainage, major electrical, unstable slopes and other project types. P3 signal rehabilitation projects require a safety analysis as part of the Intersection Control Analysis (ICA). If the signal is being replaced with a single lane roundabout, no safety analysis is needed. If another P3 project type impacts lane and shoulder width, follow the safety analysis requirements for the Bridge Preservation Program described in Section 7.1.2.

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Refurbishing an existing signal or modifying lane/shoulder width. For projects that only modify lane/shoulder width, follow the directions provided for the bridge preservation program (Section 7.1.2). If the existing signal is being replaced by a single lane roundabout, a safety analysis is not required.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area</td>
<td>The intersection with the signal and any roadway segments that are changed.</td>
</tr>
<tr>
<td>Study Period</td>
<td>Five calendar years unless there has been a significant change to reduce the number of years (2 years minimum).</td>
</tr>
<tr>
<td>Scope</td>
<td>The scope of the safety analysis is limited, focusing on the characteristics of the intersection and intersection-related target crashes (rear-end, right-angle and sideswipe crashes) that can be addressed within the scope of the P3 signal replacement activities. For example, signal related installation, signal timing, lane markings, and signage. Recommendations should be general in nature and presented as suggestions for consideration during the installation and implementation of the signal replacement system. Determine why target crashes are happening including contributing factors.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Compare the portions of fatal and all injury crashes for intersection and intersection related crashes of the following types: rear-end, right-angled and sideswipe crashes to the typical proportions of these crashes in the applicable HSM Part C chapter and section. If the HSM predictive method cannot be used, the observed crash history can be used along with CMFs. Perform a human factors review of the feasible alternatives and document a review of the fatal and serious injury crashes, and any crashes involving pedestrians or bicyclists. Define mitigation strategies to address changes in safety performance.</td>
</tr>
</tbody>
</table>
| Tools                                        | Use the following HSM tables:  
  - Rural Two-Lane Two-Way Intersections (all crashes): Table 10-6  
  - Rural Multilane Intersections (all crashes): Table 11-9  
  - Urban/Suburban Intersections  
    - Multiple-Vehicle Crashes (3 leg & 4 leg signals) - Table 12-11  
    - Single-Vehicle Crashes (3 leg & 4 leg signals) - Table 12-12  
    - Ramp Terminal Intersections (all crashes) - Table 19-16  
| Goals                                         | Compare the crashes to determine if there is benefit to switching the signal to another method of intersection control.                                                                                                                                                                                   |
A modified collision analysis report for P3 signal preservation program is available from the WSDOT Highway Safety Intranet. Documentation of the results of the safety analysis will be contained in the ICA. Briefly summarize the findings from the investigation done in the scope and methodology sections of this table. If there is an over-representation of rear-end, right-angled and/or sideswipe crashes, discuss and review factors that contributed to this. Also, discuss and review the factors that contributed to any crashes involving pedestrians or bicyclists. Where appropriate, recommend additional analysis related to modification of signal operations and/or lane markings.

### 7.2 Highway Improvement (I)

#### 7.2.1 Mobility Improvement (I1)

The purpose of the I1 Mobility Improvement Program is to make “investments to move people, goods, and reduce congestion, by managing demand effectively, operating transportation systems efficiently, improving local network, changing policies when necessary before considering adding infrastructure capacity.”

Safety is integral to these projects and “WSDOT’s practical design approach is committed to multimodal safety as identified in Washington State’s Strategic Safety Plan (see www.targetzero.com/plan.htm). To meet this commitment, projects are required to include a baseline performance metric for evaluating the number of fatal and serious injury crashes in safety, mobility, and economic vitality category projects.” Note: Analysis of the safety performance of mobility alternatives is required regardless of whether any fatal or serious injury crashes occurred within the project limits in the past five calendar years.

The size and scope of many I-1 project requires flexibility in the safety analysis approach. Getting agreement on the specific scope and scale of the given project by the respective Region and Headquarters teams should occur early in the project development.

Note: It should be recognized that crashes may increase with an I-1 project because of the increase of exposure created by increased VMT.

Crashes may reduce the mobility performance of a given network. Consider potential strategies to address these crash impacts.

1. Compare future year safety performance for the alternatives considered.
2. Analyze observed fatal and serious crashes compared against the preferred alternative to identify needed mitigation.

---

11 Design Manual, July 2017, Chapter 1101.02(1)
<table>
<thead>
<tr>
<th>Trigger</th>
<th>Safety with respect to fatal and serious injury crashes is a baseline need and is considered and analyzed on all I1 projects (per DM Chapter 1101.02(1)).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area</td>
<td>Begin by matching the study area of the traffic analysis. Adjust the study area as necessary and as agreed to by your stakeholders. If no traffic analysis is completed for the project consult Section 6.4.</td>
</tr>
<tr>
<td>Study Period</td>
<td>Five calendar years of observed crash history unless there has been a significant change to reduce the number of years (2 years minimum).</td>
</tr>
</tbody>
</table>
| Scope | 1. Determine the existing safety performances of any mainline freeway(s), interchange(s), and roadways affected by the proposed change (in the study area). If there are segments or intersections that have been experiencing more crashes than is typical for similar segments or intersections, identify contributing factors to identify how the changes may impact these crash types or crash characteristics. This information is used to develop design alternatives.  
2. Determine the target crashes (with a particular focus on fatal and serious injury crashes, and crashes involving pedestrians or bicyclists), characteristics of the target crashes, and contributing factors to these crashes.  
3. Analyze the no-build and feasible alternatives to identify differences in safety performance for use in selecting the preferred alternative.  
4. If the proposed alternative significantly increases crash potential, determine the contributing factors to this increased crash potential and identify countermeasures to reduce this potential. Analyze the opening year, design year, and if needed the horizon year. |
| Methodology | Analyze the segments and intersections with the HSM predictive method described in the applicable chapter (Chapter 10, 11, 12, 18, or 19). If the HSM predictive method cannot be used, the observed crash history can be used along with CMFs. Perform a human factors review of the feasible alternatives and document a review of the fatal and serious injury crashes, and any crashes involving pedestrians or bicyclists. Define mitigation strategies to address changes in safety performance. |
| Tools | All analysis tools have limitations that should be considered. Select the tool that best meets project circumstances. For freeway segments, ramps, and ramp terminals, use the Interchange Safety Analysis Tool enhanced (ISATe). For other facility types, use the extended HSM spreadsheets. The analysis tools can be found online at: [http://www.wsdot.wa.gov/Design/Support.htm](http://www.wsdot.wa.gov/Design/Support.htm) |
| Goals | 1. Evaluate the safety performance of the existing safety performance to understand the nature and contributing factors to crashes. In particular, crashes involving fatal and serious injury crashes, and crashes involving pedestrians and bicyclists.  
2. Identify safety improvement opportunities and inform design decisions.  
3. Analyze the safety performance of the no-build and all identified alternatives to provide safety performance measures to help inform the tradeoff decisions during the preferred alternative selection.  
4. For alternatives where the safety performance analysis indicates a significant increase in crashes: identify any mitigation opportunities. |
5. Document the findings from the analysis and present the safety performance of the no-build and all identified alternatives. Note that safety performance is not the sole decision factor for the selection of the preferred alternative.

<table>
<thead>
<tr>
<th>Documentation</th>
<th>A separate safety analysis document showing:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Current safety performance and locations where the expected crash frequency is greater than the predicted crash frequency.</td>
</tr>
<tr>
<td></td>
<td>• A contributing factors analysis of the target crashes.</td>
</tr>
<tr>
<td></td>
<td>• How the preferred design affects existing safety performance. The safety performance of the No-Build and the each alternative(s) as used to select the preferred alternative. Use the Alternatives Comparison or an equivalent table as a tool to compare alternatives side-by-side.</td>
</tr>
<tr>
<td></td>
<td>o Note: If the preferred alternative has more crashes than the No-Build and those crashes cannot be mitigated, the project documentation will need to explain why the benefits of the preferred alternative outweigh the addition of crashes in terms of tradeoffs considered in the decision-making process.</td>
</tr>
</tbody>
</table>

### 7.2.2 Safety Improvement (I2)

The safety improvement program is a targeted program developed to reduce fatal and serious crashes on the state highway system. The program is derived through Target Zero, and further developed through WSDOT’s Target Zero Implementation Plan, where WSDOT highlights the sub-categories of the safety program and the intended performance objectives of each. The safety program is structured into Crash Reduction and Crash Prevention Categories, and sub-categories are defined with a focus on specific crash types, contributing circumstances, historical data or systemic treatments. These categories may change based on performance over time (See Figure 2). Priority array analysis is used to determine a ranked list of projects where countermeasures are evaluated and priorities are determined using a benefit cost analysis.

Section 6.9 discusses the priority array process, legislative requirements, and approach for the I2 program.

<table>
<thead>
<tr>
<th>Trigger</th>
<th>See Figure 2. If a CAR is required, see Section 8.4. For I-2 crash prevention projects that require a safety analysis per Figure 2 follow the guidance in this section.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area</td>
<td>Begin with the project limits as defined in the project documentation. The study area can be adjusted as needed to reflect the area of impact.</td>
</tr>
<tr>
<td>Study Period</td>
<td>Five calendar years unless there has been a significant change that justifies reducing the number of years (2 years minimum).</td>
</tr>
<tr>
<td>Scope</td>
<td>1. Determine the existing safety performances of any mainline freeway(s), interchange(s), and roadways affected by the proposed change in the study area.</td>
</tr>
<tr>
<td></td>
<td>2. Determine the target crashes and why they are happening including contributing factors.</td>
</tr>
<tr>
<td></td>
<td>3. Determine countermeasures that will reduce the target crashes.</td>
</tr>
<tr>
<td></td>
<td>4. Analyze the benefit-cost of the proposed investment.</td>
</tr>
<tr>
<td><strong>Methodology</strong></td>
<td>Analyze the segments and intersections with the HSM predictive method described in the applicable chapter (Chapter 10, 11, 12, 18, or 19). If the HSM predictive method cannot be used, the observed crash history can be used along with CMFs. Perform a human factors review of the feasible alternatives and document a review of the fatal and serious injury crashes, and any crashes involving pedestrians or bicyclists.</td>
</tr>
</tbody>
</table>
| **Tools** | • For freeway segments, ramps, and ramp terminals, use the Interchange Safety Analysis Tool enhanced (ISATe). For other facility types, use the applicable extended HSM predictive method spreadsheet. These tools can be found online at: [http://www.wsdot.wa.gov/Design/Support.htm](http://www.wsdot.wa.gov/Design/Support.htm).  
• Benefit/cost spreadsheet provided with the I-2 scoping instructions. |
| **Goals** | 1. Analyze the safety performance of the existing conditions to understand the safety performance issues in the study area.  
2. Identify the target crash type(s) and severity(ies), and contributing factors to these crashes.  
3. Determine countermeasures that will reduce number or severity of the target crashes. |
| **Documentation** | Write a safety analysis as part of the Design Documentation Package. Begin by discussing the study area, study period, scope, methodology, and tools (refer to the above sections of this table for more detail). Then summarize the safety analysis details making sure to discuss how the countermeasures address the target crashes. The safety analysis write-up should quantitatively contrast and compare all feasible alternatives. If the preferred alternative is not the one with the highest benefit to cost ratio or has lower safety performance outcomes than the others, document your reasoning and mitigation strategy for the chosen approach. Include the outputs of the tools as an appendix to the safety analysis. |
Figure 2. I-2 Safety Analysis for Collision Reduction and Prevention Programs
7.2.3 Economic Initiatives (I3)

I3 Economic Initiatives projects includes promoting and developing “transportation systems that stimulate, support, and enhance the movement of people and goods to ensure a prosperous economy. Economic Initiatives support freight movement and tourism development through the construction of new rest areas and bicycle touring facilities along scenic and recreational highways. To achieve the program goals, the Economic Initiatives program is subdivided into the following subcategories: 1. Freight (upgrading all-weather pavements and bridges with restricted vertical clearance). 2. Community Livability and Economic Vitality. 3. Scenic and Recreational Highways.12

The Chapter 1101.02(1) of the Design Manual requires a baseline metric for evaluating the number of fatal and serious injury crashes for all I3 projects.

Safety analysis for all I3 project is the same as for I1-Mobility projects. As a result, follow the process outlined for I1-Mobility projects as found in Section 7.2.1.

7.2.4 Environmental Retrofit (I4)

I4 environmental retrofit projects enhances “Washington’s quality of life through transportation investments that promote energy conservation, enhance healthy communities, and protect the environment. Environmental retrofit projects reduce or eliminate environmental impacts of existing highway systems to meet environmental requirements that have emerged since the highways were built.13” Environmental retrofit projects includes fish passage barriers, chronic environmental deficiency, plant management, stormwater runoff, noise reduction, and wildlife connectivity. Generally, these projects do not change the characteristics of the roadway, but do have the ability to impact clear zones and side slopes. Clear zones should be evaluated or treated per DM Chapter 1600.

<table>
<thead>
<tr>
<th>Trigger</th>
<th>If the lane width or shoulder width is reduced.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area</td>
<td>Where the lane width or shoulder width is reduced.</td>
</tr>
<tr>
<td>Study Period</td>
<td>A study period is not applicable. Compare the predicted average crash frequencies across alternatives.</td>
</tr>
<tr>
<td>Scope</td>
<td>Analyze the lane and shoulder widths being considered.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Use the applicable CMF tables/equations for the roadway type with respect to lane and shoulder width. Compare the CMFs of the lane/shoulder widths being considered.</td>
</tr>
<tr>
<td>Tools</td>
<td>For the appropriate roadway type, use the following items from the HSM:</td>
</tr>
<tr>
<td></td>
<td>• Rural Two-Lane, Two-Way Roads:</td>
</tr>
<tr>
<td></td>
<td>o Lanes: Table 10-8</td>
</tr>
<tr>
<td></td>
<td>o Shoulders: Table 10-9</td>
</tr>
<tr>
<td></td>
<td>• Undivided Roadway Segment</td>
</tr>
<tr>
<td></td>
<td>o Lanes: Table 11-11</td>
</tr>
<tr>
<td></td>
<td>o Shoulders: Table 11-12</td>
</tr>
<tr>
<td></td>
<td>• Divided Roadway Segment</td>
</tr>
<tr>
<td></td>
<td>o Lanes: Table 11-16</td>
</tr>
</tbody>
</table>

12 WSDOT 2017-2019 Capital Improvement and Preservation Program, September 2016, page II-17
13 WSDOT 2017-2019 Capital Improvement and Preservation Program, September 2016, page II-17
Goals
Assess the safety performance of the alternatives being considered.

Documentation
Include safety performance as a contextual need on the BOD. Include CMF discussion in the alternatives comparison section of the BOD.

### 7.3 Traffic Operations (Q)

“Low Cost Enhancements (LCE) are projects that can be quickly implemented to improve operational performance on state highways. The Washington State Department of Transportation’s (WSDOT) six regions use LCEs strategically to improve the operational safety and efficiency of the highway system, and to respond quickly to emergent roadway safety issues. LCE projects are implemented through WSDOT’s Traffic Operations Program.”

LCE projects can be standalone projects or incorporated into capital projects. All LCE projects must be documented per HQ Traffic Office direction and approved by the Region Traffic Engineer. If an LCE project is incorporated into another capital project, the documentation (QBOD) is completed by the Region Traffic Office and provided to the project office. The project office will incorporate the LCE documentation into the Design Approval or Project Development Approval as appropriate. LCE projects that are incorporated into other capital projects have a safety analysis included in the documentation provided by the Region Traffic Office per the following table.

<table>
<thead>
<tr>
<th>Trigger</th>
<th>If the lane width or shoulder width is reduced. Addition of turn lanes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area</td>
<td>Where the lane width or shoulder width is reduced.</td>
</tr>
<tr>
<td>Study Period</td>
<td>A study period is not applicable. Compare the predicted average crash frequencies across alternatives.</td>
</tr>
<tr>
<td>Scope</td>
<td>Analyze the lane and shoulder widths being considered.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Use the applicable CMF tables/equations for the roadway type with respect to lane and shoulder width. Compare the CMFs of the lane/shoulder widths being considered include a discussion on countermeasures as need to mitigate for increased crash potential.</td>
</tr>
<tr>
<td>Tools</td>
<td>For the appropriate roadway type, use the following items from the HSM:</td>
</tr>
<tr>
<td>Rural Two-Lane, Two-Way Roads:</td>
<td></td>
</tr>
<tr>
<td>o Lanes: Table 10-8</td>
<td></td>
</tr>
<tr>
<td>o Shoulders: Table 10-9</td>
<td></td>
</tr>
<tr>
<td>Undivided Roadway Segment</td>
<td></td>
</tr>
<tr>
<td>o Lanes: Table 11-11</td>
<td></td>
</tr>
<tr>
<td>o Shoulders: Table 11-12</td>
<td></td>
</tr>
<tr>
<td>Divided Roadway Segment</td>
<td></td>
</tr>
<tr>
<td>o Lanes: Table 11-16</td>
<td></td>
</tr>
<tr>
<td>o Shoulders: Table 11-17</td>
<td></td>
</tr>
</tbody>
</table>

---

• Freeway Segments: See HSM Chapter 18.7.1
  o Lane Width: Equation 18-25
  o Inside Shoulder Width: Equation 18-27
  o Outside Shoulder Width: Equation 18-35

Goals
Assess the safety performance of the alternatives being considered.

Documentation
Include safety performance as a baseline or contextual need on the QBOD. Include CMF discussion in the alternatives comparison section of the QBOD. If the preferred alternative is not the best performing from a safety perspective, document your reasoning. Include documentation on treatment of targeted crashes.

8. Miscellaneous Activities
This section introduces different activities that provide opportunities for different scales of analysis. Note that the goal is to optimize the value of safety analysis for the particular activity.

8.1 Interchange Justification Reports
An Interchange Justification Report (IJR) (see also DM Chapter 550) uses crash analysis to help select preferred alternatives. The safety analysis methodology and scope are discussed and agreed upon in the Methods and Assumptions document. The Operational and Crash Analyses of the IJR contains the Crash Analysis and goes hand-in-hand with the Operational Analysis. The following table details the scale and scope of a safety analysis in an IJR:

<table>
<thead>
<tr>
<th>Trigger</th>
<th>An IJR that contains an Operational and Crash Analyses and the IJR support team agrees a safety analysis is needed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area</td>
<td>Begin by matching the Study Area of the Traffic Analysis. Adjust the study area as necessary and as agreed to by the IJR support team.</td>
</tr>
<tr>
<td>Study Period</td>
<td>The study period must align with other documents related to the IJR. See DM Chapter 550.</td>
</tr>
</tbody>
</table>
| Scope | 1. Get IJR support team concurrence on the scope including the study area, study period, etc. in the Method and Assumptions document.  
2. Determine the existing safety performances of mainline freeway(s), the interchange(s), and other roadway types affected by the proposed change (in the study area). If there are segments or intersections that have been experiencing more crashes than is typical for similar segments or intersections, so identify the contributing factors to these crashes. This information will be used to determine how the proposed change will affect them.  
3. Analyze the no-build and all feasible alternatives (per DM Chapter 550) to provide insight into the safety performance of each. This information is used in the tradeoff decision making process during the selection of the preferred alternative.  
4. Determine if the proposed alternative will significantly increase crashes.  
5. If the proposed alternative significantly increases crashes, determine and document possible mitigation countermeasures that will reduce the number or severity of anticipated fatal and serious injury crashes. Document the number of crashes the mitigation may achieve for the support team to consider as a possible addition to the project. |
### Methodology

Analyze the segments and intersections with the HSM predictive method described in the applicable chapter (Chapter 10, 11, 12, 18, or 19). If the HSM predictive method cannot be used, the observed crash history can be used along with CMFs. Perform a human factors review of the feasible alternatives and document a review of the fatal and serious injury crashes, and any crashes involving pedestrians or bicyclists.

### Tools

For freeway segments, ramps, and ramp terminals, use the Interchange Safety Analysis Tool enhanced (ISATe). For other facility types, use the applicable extended HSM predictive method spreadsheet. The tools can be found online at: [http://www.wsdot.wa.gov/Design/Support.htm](http://www.wsdot.wa.gov/Design/Support.htm)

### Goals

1. Determine the safety performance of the existing conditions to understand any safety performance issues with the study area.
2. Compare the safety performance of the no-build and all feasible alternatives to help determine the preferred alternative.
3. Determine if the preferred alternative will significantly increase crashes. If so, determine and document what countermeasure(s) will mitigate crashes.

### Documentation

A separate safety analysis document is not required. The safety analysis can be incorporated into the IJR documentation as follows:

- Method and Assumptions: In the “Collision Analysis” section, discuss the study area, study period, scope, methodology, and tools. Refer to the above sections of this table for more detail.
- IJR: the Operational and Crash Analyses should contain an executive summary of the safety analysis and the details should be contained in an appendix. The IJR write-up should explain how the goals listed above were addressed as well as contrast and compare all feasible alternatives and the no-build.

### 8.2 Environmental Impact Statement/Environmental Assessment

Environmental Impact Statements (EIS) or Environmental Assessment (EA) use crash analysis to help inform the tradeoff decisions during the preferred alternatives selection process. If the EIS has a corresponding IJR, the safety analysis requirements below are applicable to both processes and documents. The Transportation Discipline Report will contain the safety analysis and the following table details the scale and scope:

<table>
<thead>
<tr>
<th>Trigger</th>
<th>An EIS/EA with a Transportation Discipline Report and the technical advisory committee agrees a safety analysis is needed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area</td>
<td>Begin by matching the Study Area of the Traffic Analysis. Adjust the Study area as necessary and as agreed to by your Stakeholders.</td>
</tr>
<tr>
<td>Study Period</td>
<td>The study period must align with other documents related to the EIS. If the other documents do not set a study period, reference Chapter 6.3.</td>
</tr>
<tr>
<td>Scope</td>
<td>Analyze no-build and all feasible alternatives that are analyzed in the EIS. Analyze all locations where there has been a physical change to the infrastructure and/or a greater than 10% change in volumes.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Analyze the segments and intersections with the HSM predictive method described in the applicable chapter (Chapter 10, 11, 12, 18, or 19). If the HSM predictive method cannot be used, the observed crash history can be used along with CMFs. Perform a human factors review of the feasible alternatives and document a review</td>
</tr>
</tbody>
</table>
of the fatal and serious injury crashes, and any crashes involving pedestrians or bicyclists.

**Tools**
For freeway segments, ramps, and ramp terminals, use the Interchange Safety Analysis Tool enhanced (ISATe). For other facility types, use the applicable extended HSM predictive method spreadsheet. The tools can be found online at: http://www.wsdot.wa.gov/Design/Support.htm

**Goal**
1. Determine the safety performance of the existing conditions to understand any safety performance issues with the study area.
2. Compare the safety performance of the no-build and all feasible alternatives to help determine the preferred alternative.
3. Determine if the preferred alternative will significantly increase crashes. If so, determine what countermeasure(s) will mitigate crashes.

**Documentation**
Transportation Discipline Report: Begin by discussing the study area, study period, scope, methodology, and tools (refer to the above sections of this table for more detail). Then summarize the crash analysis details in the Transportation Discipline Report. The crash analysis write-up should quantitatively contrast and compare all feasible alternatives. If the preferred alternative is not the best performing from a crash analysis perspective, document your reasoning. Include the outputs of the tools as an appendix.

---

**8.3 Developer Reviews - Traffic Impact Analysis**

Developer reviews are where a developer is proposing a modification to the state highway system and has been requested to analyze the impacts of that development. Depending on the scope of the development, a Traffic Impact Analysis (TIA) may be requested (See DM Chapter 320.05). Safety analysis is a component of a TIA. The safety analysis for a TIA should follow the scope and scale as detailed in the following table:

<table>
<thead>
<tr>
<th><strong>Trigger</strong></th>
<th>A TIA that has a safety analysis component.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Study Area</strong></td>
<td>The study area should match that of the TIA as detailed in DM Chapter 320.06(1).</td>
</tr>
<tr>
<td><strong>Study Period</strong></td>
<td>The study period must align with other documents related to the EIS. If the other documents do not set a study period, reference Chapter 6.3.</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Analyze no-build and all feasible alternatives to match the TIA traffic analysis scenarios as detailed in DM Chapter 320.06(2).</td>
</tr>
<tr>
<td><strong>Methodology</strong></td>
<td>Analyze the segments and intersections with the HSM predictive method described in the applicable chapter (Chapter 10, 11, 12, 18, or 19). If the HSM predictive method cannot be used, the observed crash history can be used along with CMFs. Perform a human factors review of the feasible alternatives and document a review of the fatal and serious injury crashes, and any crashes involving pedestrians or bicyclists. Define mitigation strategies to address changes in safety performance.</td>
</tr>
<tr>
<td><strong>Tools</strong></td>
<td>For freeway segments, ramps, and ramp terminals, use the Interchange Safety Analysis Tool enhanced (ISATe). For other facility types, use the applicable extended HSM predictive method spreadsheet. The tools can be found online at: <a href="http://www.wsdot.wa.gov/Design/Support.htm">http://www.wsdot.wa.gov/Design/Support.htm</a></td>
</tr>
<tr>
<td><strong>Goal</strong></td>
<td>To have a quantitative analysis supplemented with a qualitative discussion that can help select a preferred alternative.</td>
</tr>
</tbody>
</table>
**8.4 Crash Analysis Report**

A Crash Analysis Report (CAR) is a specific report utilized only for the I2 Collision Reduction program. The CAR is written during the scoping phase of the project and is required before funding for design is released. As a result, the CAR will provide sufficient safety analysis for a project and no further safety analysis is required during the design phase. When a CAR is needed, the following template must be followed: [http://www.wsdot.wa.gov/publications/fulltext/design/ASDE/CARTemplate.docx](http://www.wsdot.wa.gov/publications/fulltext/design/ASDE/CARTemplate.docx)

**8.5 Intersection Control Analysis**

An Intersection Control Analysis (ICA) conducts both an operation and safety analysis of a potential change to an intersection. For the safety analysis portion, follow the scope and scale as detailed in the following table:

<table>
<thead>
<tr>
<th>Trigger</th>
<th>An ICA has safety as a project need as noted in DM Chapter 1300.05(1).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area</td>
<td>If the ICA is a standalone document, the study area should be the intersection of interest corresponding to the study area of the ICA. If the ICA is part of a larger project, follow the guidance associated with that funding source found in Chapter 7 of this document.</td>
</tr>
<tr>
<td>Study Period</td>
<td>Select the study period in accordance with Chapter 6.3 of this document.</td>
</tr>
<tr>
<td>Scope</td>
<td>Analyze the no-build and all feasible alternatives to match the alternatives analyzed in the operational analysis section of the ICA.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Analyze the segments and intersections with the HSM predictive method described in the applicable chapter (Chapter 10, 11, 12 or 19). If the HSM predictive method cannot be used, the observed crash history can be used along with CMFs. Perform a human factors review of the feasible alternatives and document a review of the fatal and serious injury crashes, and any crashes involving pedestrians or bicyclists. Define mitigation strategies to address changes in safety performance.</td>
</tr>
<tr>
<td>Tools</td>
<td>For freeway ramp terminals, use the Interchange Safety Analysis Tool enhanced (ISATe). For other facility types, use the applicable extended HSM predictive method spreadsheet. The tools can be found online at: <a href="http://www.wsdot.wa.gov/Design/Support.htm">http://www.wsdot.wa.gov/Design/Support.htm</a></td>
</tr>
<tr>
<td>Goal</td>
<td>To have a quantitative analysis supplemented with a qualitative discussion that can help select a preferred alternative.</td>
</tr>
<tr>
<td>Documentation</td>
<td>Incorporate the safety analysis into the ICA. The safety analysis write-up should quantitatively contrast and compare all feasible alternatives. If the preferred alternative is not the best performing from a crash analysis perspective, document your reasoning in the ICA. Include the details of the safety analysis in an appendix.</td>
</tr>
</tbody>
</table>
8.6 Work Zones

Properly designed work zones are important to worker safety as well as to the safety of the traveling public. While the HSM methodologies cannot analyze how a work zone will effect worker safety, it can help in the selection of lane and shoulder widths and how this will affect the safety of the traveling public.

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Safety analysis in not required as part of the design of a work zone. However, HSM methodologies can be beneficial when selecting lane and shoulder width that will be implemented on long duration work zones.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area</td>
<td>Length of work zone.</td>
</tr>
<tr>
<td>Study Period</td>
<td>Use only the typical performance of the proposed work zone alternatives (predicted average crash frequencies) to compare work zone alternatives. Assessment of contributing factors to fatal and serious injury crashes, and crashes involving bicyclists and pedestrians can be helpful to support work zone alternative identification and assessment.</td>
</tr>
<tr>
<td>Scope</td>
<td>Analyze all feasible alternatives.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Analyze roadway segments, intersections, ramps, and ramp terminals using the Predictive Method in the HSM (use applicable HSM Chapters 10-12, 18, or 19). If the HSM predictive method cannot be used, the observed crash history can be used along with CMFs. Perform a human factors review of the feasible alternatives and document a review of the fatal and serious injury crashes, and any crashes involving pedestrians or bicyclists. Define mitigation strategies to address changes in safety performance.</td>
</tr>
<tr>
<td>Tools</td>
<td>For freeway ramp terminals, use the Interchange Safety Analysis Tool enhanced (ISATe). For other facility types, use the applicable extended HSM predictive method spreadsheet. The tools can be found online at: <a href="http://www.wsdot.wa.gov/Design/Support.htm">http://www.wsdot.wa.gov/Design/Support.htm</a></td>
</tr>
<tr>
<td>Goal</td>
<td>Quantify and understand the safety performance of different alternatives to assist in the selection of a preferred alternative.</td>
</tr>
<tr>
<td>Documentation</td>
<td>No documentation is necessary. You may include a summary of the analysis in the Transportation Management Plan if it helped select the preferred alternative.</td>
</tr>
</tbody>
</table>

9. Example language for the HSM Predictive Method

This section contains example language for a report that discusses the existing safety performance of different intersections or segments in comparison to similar facilities. There are three scenarios: location with similar crash performance, location with more crashes than similar locations, and location with fewer crashes than similar locations. Use the text below in reports that discuss the comparison of the facility being analyzed with the HSM predictive method results.

9.1 Scenario 1: Location with similar crash performance

Use the following text and table for locations where the safety performance of the location being analyzed is similar to the HSM predictive method results. The reference to “Appendix XX” is an appendix to the safety analysis report that contains the outputs of the HSM models used in the analysis:
Table 5 summarizes the results of the predictive analysis for Intersection A. The worksheets for the analysis are included as part of Appendix XX. Based on the analysis, it is anticipated that the intersection will have a safety performance similar to other intersections that have the same roadway characteristics and traffic volumes. On average, the analysis indicates the potential for two fatal and all injury crashes per year at the intersection compared to 2.1 fatal and all injury crashes per year; for similar intersections with the same traffic volume. In other words, Intersection A is performing as expected.

Table 5. Predictive Analysis Results for Intersection A

<table>
<thead>
<tr>
<th>Safety performance metric</th>
<th>Typical performance of similar intersections: Predicted average crash frequency (crashes/year)</th>
<th>Average performance of the intersection: Expected average crash frequency (crashes/year)</th>
<th>Potential for improvement: Excess average crash frequency (crashes/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal and injury crashes</td>
<td>2.1</td>
<td>2.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total crashes</td>
<td>5.6</td>
<td>5.5</td>
<td>0.0</td>
</tr>
</tbody>
</table>

9.2 Scenario 2: Location with more crashes than similar locations

Use the following text and table for locations where the safety performance of the location being analyzed is experiencing more crashes than the HSM predictive method results. The reference to “Appendix XX” is an appendix to the safety analysis report that contains the outputs of the HSM models used in the analysis:

Table 6 summarizes the results of the predictive analysis for Intersection B. The worksheets for the analysis are included as part of Appendix XX. Based on the analysis, it is anticipated that the intersection will experience more crashes than intersections with similar roadway characteristics and traffic volumes. On average, the analysis indicates the potential for 2.8 fatal and all injury crashes per year at Intersection B compared to 2.3 fatal and all injury crashes per year for similar intersections with the same traffic volume.

Table 6. Predictive Analysis Results for Intersection B

<table>
<thead>
<tr>
<th>Safety performance metric</th>
<th>Typical performance of similar intersections: Predicted average crash frequency (crashes/year)</th>
<th>Average performance of the intersection: Expected average crash frequency (crashes/year)</th>
<th>Potential for improvement: Excess average crash frequency (crashes/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal and injury crashes</td>
<td>2.3</td>
<td>2.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Total crashes</td>
<td>7.2</td>
<td>8.8</td>
<td>1.5</td>
</tr>
</tbody>
</table>

9.3 Scenario 3: Location with fewer crashes than similar locations

Use the following text and table for locations where the safety performance of the location being analyzed is experiencing more crashes than the HSM predictive method results. The reference to “Appendix XX” is an appendix to the safety analysis report that contains the outputs of the HSM models used in the analysis:

Table 7 summarizes the results of the predictive analysis for Intersection C. The worksheets for the analysis are included as part of Appendix XX. Based on the analysis, it is anticipated that the intersection will experience fewer crashes than intersections with similar roadway characteristics and traffic volumes. On average, the analysis indicates the potential for 1.3 fatal and all injury
crashes per year compared to two fatal and all injury crashes per year for similar intersections with the same traffic volume.

**Table 7. Predictive Analysis Results for Intersection C**

<table>
<thead>
<tr>
<th>Safety performance metric</th>
<th>Typical performance of similar segments: Predicted average crash frequency (crashes/year)</th>
<th>Average performance of the segment: Expected average crash frequency (crashes/year)</th>
<th>Potential for improvement: Excess average crash frequency (crashes/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal and injury crashes</td>
<td>2.0</td>
<td>1.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Total crashes</td>
<td>6.8</td>
<td>4.3</td>
<td>0.0</td>
</tr>
</tbody>
</table>
APPENDIX A

Roadway Elements Covered by the

HSM Predictive Method
### Design Elements Covered in the HSM1 Predictive methods

#### Design Elements Directly Covered by the HSM Chapters 10-12, 19

<table>
<thead>
<tr>
<th>Roadway Segments</th>
<th>Bridges</th>
<th>Intersections</th>
<th>Barriers</th>
<th>Other Elements Covered</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Two-Lane Highways (Chapter 10 of HSM1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intersections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural Multiline Highways (Chapter 11 of HSM1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roadway Segments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban &amp; Sub-urban Arterials (Chapter 12 of HSM1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freeways Interchanges (Chapter 18 and 19 of HSM1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freeway Segments &amp; Speed Change Lanes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ramps &amp; Collector Distributor Lanes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ramps Terminal Intersections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Design Elements Indirectly Covered by the HSM Chapters 10-12, 19

- Consider speeds to be the same on both sides but cannot cover the light/dark phase.
- **Not Signalized:**
  - 2 Lane Undivided
  - 3 Lane Undivided
  - 4 Lane Undivided
  - 4 Leg/6 Leg Signalized
  - 8 Lane Undivided

#### Design Elements Not Covered by the HSM Predictive Method

- High Occupancy Toll (HOT) Lanes
- High Occupancy Vehicle (HOV) Lanes
- Diverging Diamond Intersections
- Diverging Diamond Exit Ramp
- Diverging Diamond Exit Ramp
- Intersections
- Bus Stoppers Within 1,000 ft. of I/S

**Notes:**
- **Design Elements:** Not covered for your specific need and context.
- **CMF:** Covers this Design Element.
- **Not Signalized:**
  - 2 Lane Undivided
  - 3 Lane Undivided
  - 4 Lane Undivided
  - 4 Leg/6 Leg Signalized
  - 8 Lane Undivided

**Updated:** 08/01/16