

## Appendix 1 Framework Memorandum

## MEMORANDUM

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Project: Deschutes County TSAP

Subject: Safety Analysis Framework

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This memorandum presents a safety analysis framework for the Deschutes County Transportation Safety Action Plan (TSAP). The framework plan outlines the purpose and desired outcomes supporting a prioritized list of projects, programs, and policies to reduce crash frequency and severity on County roadways. The Deschutes County TSAP will be conducted in parallel with the Bend Area TSAP; this framework also summarizes how the County and MPO will coordinate their Plans.

## BACKGROUND

This section provides an overview of the background and purpose of the Deschutes County TSAP.

### Deschutes County

Deschutes County is a large, primarily rural County that includes the cities of Bend, Redmond, Sisters, and La Pine. With relatively high mileage of rural two-lane highways, the crash trends in the unincorporated County differ from those in urban areas. The County is highly affected by the Bend and Redmond area growth and development, including commute patterns between communities. The County TSAP will focus on unincorporated areas of the County but also provide insight into safety issues in Redmond, Sisters, and La Pine.

As further discussed in this memo, the City of Bend is completing a Bend area TSAP in parallel with the County TSAP. The County TSAP will include the area within the Bend Metropolitan Planning Organization (MPO) that falls outside the Bend Urban Growth Boundary (UGB) area to capture trends on County roads within the urban transition areas.

### Transportation Safety Analysis Framework

This transportation safety analysis framework was informed by the County's goals and vision for a transportation safety program. The TSAP will be used as a starting point to develop strategies to eliminate the number of fatalities and serious crashes by identifying projects for implementation, as

well as providing guidance on changes to prioritization methods, roadway standards, or other programs and policies that may help reduce crashes on the system.

The framework presented below was developed based on understanding that Deschutes County would like to:

- Apply a repeatable, objective method for identifying and selecting projects to reduce the frequency and severity of crashes within County;
- Use this project as an opportunity to leverage the crash database by applying tools and methods in the *Highway Safety Manual 1<sup>st</sup> Edition* (HSM);
- Establish and document a transportation safety program that creates the opportunity for coordination within and across agency stakeholders – particularly the Bend Metropolitan Planning Organization (MPO) – in efforts to reduce crashes within the County;

Based on the County's desire for a comprehensive, systematic, and objective safety program, Kittelson and Associates, Inc. (Kittelson) has developed a safety analysis framework that builds upon statewide policies and applies crash analysis tools and methods provided in the HSM and other published resources from the Federal Highway Administration or National Cooperative Highway Research Program.

## Oregon TSAP

Oregon developed a statewide TSAP in 2016. The vision of the statewide TSAP is zero deaths or life-changing injuries on the Oregon transportation system by 2035. The TSAP includes all roads in the state and provides the long-term goals and near-term actions to work towards this vision.

The Oregon TSAP identifies the following long-term goals:

- Safety Culture – Transform public attitudes to recognize all transportation system users have responsibility for other people's safety in addition to their own safety while using the transportation system. Transform organizational transportation safety culture among employees and agency partners (e.g., state agencies, MPOs, Tribes, counties, cities, Oregon Health Authority, stakeholders, and public and private employers) to integrate safety considerations into all responsibilities.
- Infrastructure – Develop and improve infrastructure to eliminate fatalities and serious injuries for users of all modes.
- Healthy, Livable Communities – Plan, design, and implement safety systems. Support enforcement and emergency medical services to improve the safety and livability of communities, including improved health outcomes.
- Technology – Plan, prepare for, and implement technologies (existing and new) that can affect transportation safety for all users, including pilot testing innovative technologies as appropriate.

- Collaborate and Communicate – Create and support a collaborative environment for transportation system providers and public and private stakeholders to work together to eliminate fatalities and serious injury crashes.
- Strategic Investments – Target safety funding for effective engineering, emergency response, law enforcement, and education priorities.

The Oregon TSAP identifies the following near-term emphasis areas:

- Risky behaviors (including impaired driving, unbelted, speeding, and distracted driving crashes);
- Infrastructure (intersection and roadway departure crashes);
- Vulnerable users (pedestrians, bicyclists, motorcyclists, and older road users);
- Improved systems (continually improve data, train and educate transportation and safety staff, support law enforcement and emergency responders, and minimize commercial vehicle crashes).

The Deschutes County TSAP will summarize how the County is performing in these emphasis areas and provide recommendations to support the statewide TSAP long-term goals.

## STUDY AREA

The City of Bend is concurrently developing its own TSAP for the Bend Urban Growth Boundary (UGB) area. The simultaneous development of the County and City/MPO TSAPs allows opportunities for coordination between the two jurisdictions and an understanding of County-specific safety performance. This section describes the County TSAP's study area and how coordination will occur with the Bend UGB TSAP.

The Deschutes County TSAP will include the unincorporated area outside of the Bend UGB, as well as the cities of La Pine, Redmond, and Sisters. The analysis will be conducted concurrently, but the TSAP will identify separate findings and recommendations for each location due to the unique context of each area. The unincorporated area is likely to experience safety issues typically seen in rural areas, while the cities will experience more urban issues.

The Bend MPO TSAP will focus on the area within the Bend UGB. Recommendations relevant to the area outside the Bend UGB but within the MPO area will be included in both the County and MPO TSAP documents. The Bend MPO TSAP will include benchmarking against three similar cities: Medford, Springfield, and Corvallis to understand how the City of Bend's safety performance compares.

## Coordination with the Bend Area TSAP and Deschutes County TSAP

The concurrent Bend Area TSAP will focus on the area within the Bend UGB, with the County TSAP focusing on areas outside the UGB. The two projects will be coordinated, with the analysis being conducted in parallel throughout the project. Many residents commute between communities within

the County; therefore coordination between agencies is likely to result in consistency and continuity between each of the TSAP's recommendations.

Upon completion of the County TSAP, projects identified in the County TSAP that fall within the MPO area, but outside of the UGB, will be copied into the Bend Area TSAP. These projects will be located in both plans. Figure 1 illustrates the areas located within the Bend MPO but outside the UGB.

Figure 2 illustrates the process for developing the County and Bend Area TSAPs in parallel. This figure illustrates where coordination between the two projects will occur and how findings and recommendations will be separately identified for each Plan. This process will be further discussed throughout this memo in the Framework sections.

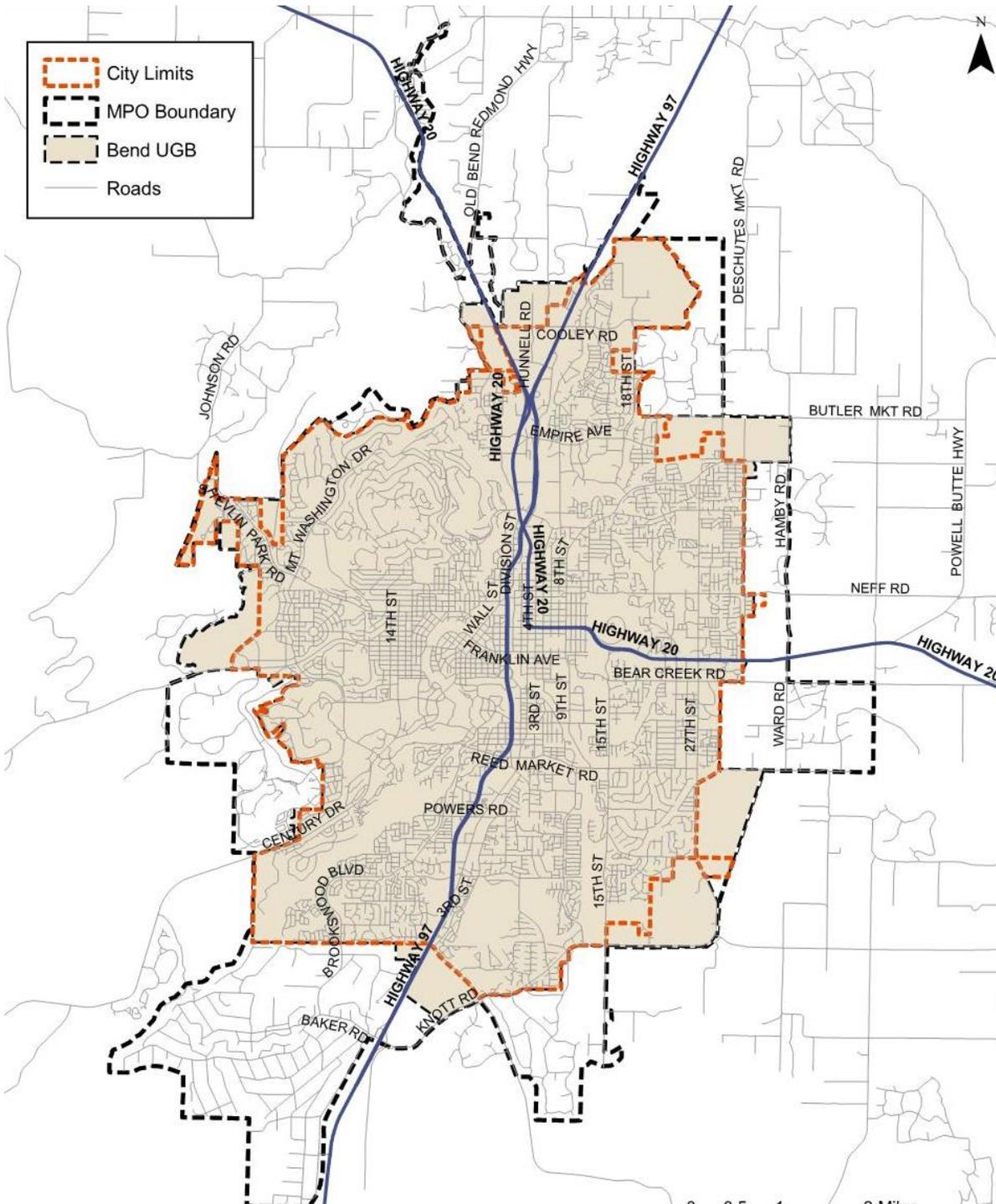
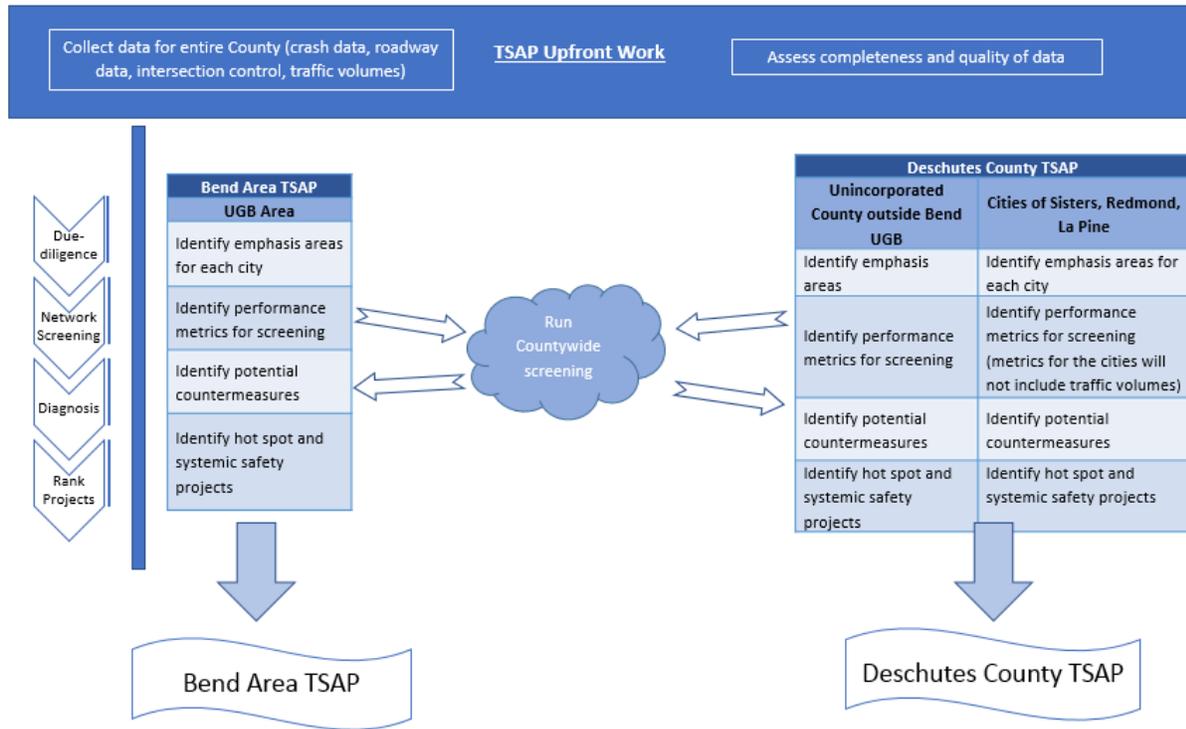


Figure 1. Bend MPO and UGB Boundaries



**Figure 2. Deschutes County and Bend Area TSAP Coordination Process**

### Data Collection and Performance Metrics

The initial data collection and inventory will be completed for the County as a whole. After the data is compiled, analysis will be run for each individual study area to identify emphasis areas specific to each location. Based on the emphasis areas identified, performance metrics for each jurisdiction will be selected.

County performance metrics are likely to relate to rural issues such as roadway departure and speed related crashes. City performance metrics will likely relate to more urban conditions at intersections and with vulnerable users. The 2012 City of Bend Multimodal Safety Program identified issues related to alcohol-crashes, roadway departure crashes, speed-related crashes, and pedestrian and bicycle crashes.

The network screening analysis will be completed for the entire County using the selected performance measures. After the network screening process, results will be filtered into priority lists based on location and reference population; the county and city will have unique lists of sites for further diagnosis. These sites will be further evaluated, and the recommended set of projects will inform the individual plans.

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## PROJECT GOALS

The County's primary intent is to develop a comprehensive safety program that systematically identifies and prioritizes safety projects and establishes a proactive approach to reducing crashes on County roadways. The vision of the safety program is to create a comprehensive safety management program to achieve zero fatal and serious injury crashes by 2035. Long-term goals to support this vision are consistent with the statewide TSAP goals.

Specific short-term goals to help the County achieve this vision include:

- Apply engineering, education, enforcement, emergency response, and evaluation (a broad base of strategies) to achieve measurable safety goals.
- Establish a proactive approach to reducing crashes on County roadways.
- Incorporate safety performance standards into the Capital Improvement Program (CIP) prioritization process and the development review process.
- Establish an objective project identification process that can be repeated to update the list of priority projects on a regular basis.

This initial TSAP will create a baseline from which to measure progress in reducing crash frequency and severity. The County has stated a commitment to conduct future TSAP updates, and the framework established for this first TSAP will serve as the base. Future TSAP updates will evaluate progress towards County goals and may result in more short-term goals to address additional emphasis areas, if needed.

## COMPREHENSIVE APPROACH TO SAFETY

A comprehensive approach to transportation safety acknowledges that policy, planning, programming, and projects are multidisciplinary and involve "the 4Es" of safety:

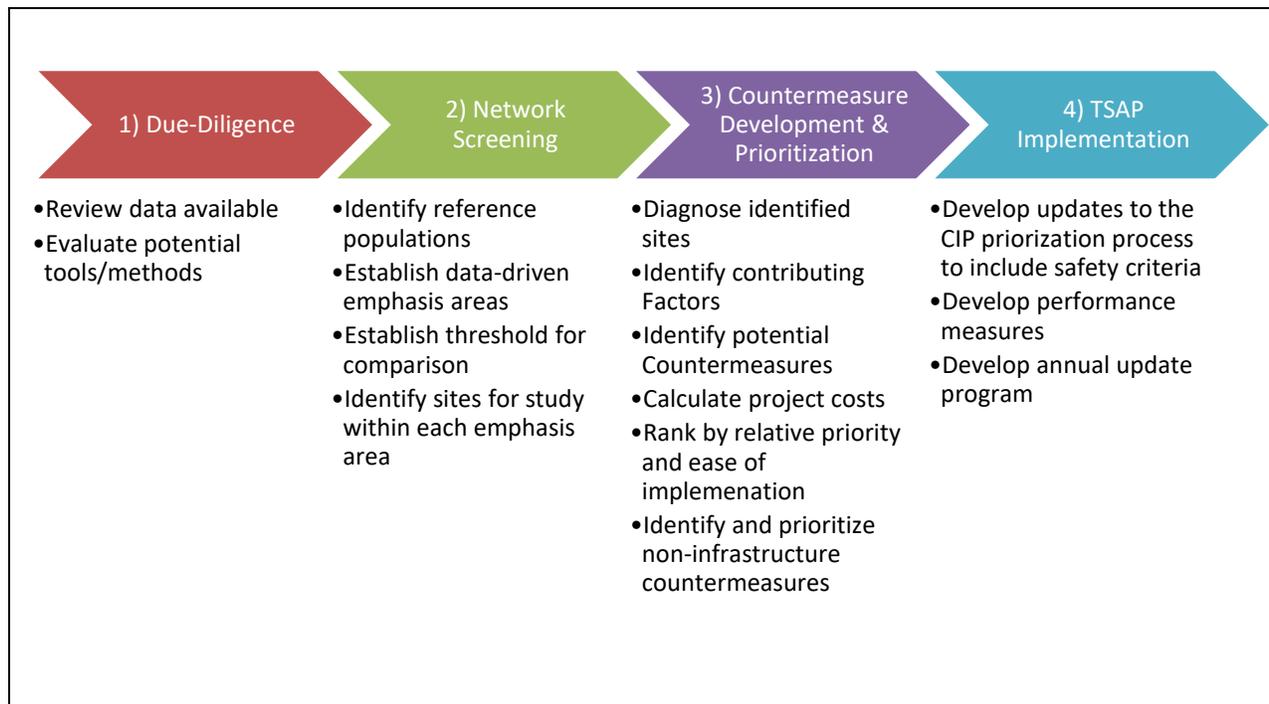
- Engineering;
- Emergency Medical Services (EMS);
- Enforcement; and
- Education.

By including elements from the 4Es that complement each other, the TSAP will provide a multidisciplinary approach that could support policy, programs, and project recommendations to achieve a vision of zero transportation fatalities or serious injuries on the Deschutes County system. This would be consistent with Oregon statewide safety objectives. To achieve this multidisciplinary plan, input from a variety of stakeholders will be used throughout the project.

- Project Management Team (PMT) – The PMT will include key staff from Deschutes County and the Oregon Department of Transportation (ODOT) who will meet regularly throughout the project to provide technical input at key steps throughout the project.
- Project Advisory Committee (PAC) – The PAC will include stakeholders representing a wide range of interests (including the County road department, health department, sheriff’s office, planning department, Bicycle and Pedestrian Advisory Committee, Emergency Medical Services, and cities located within the County). The PAC will meet three times throughout the project to provide input on the project framework and goals; the existing conditions analysis and emphasis areas; and the TSAP’s policy, program, and project recommendations.
- Multidisciplinary Stakeholder Group – This group will include the PAC members and may be expanded to capture additional non-infrastructure stakeholders. This group will meet once in a workshop format with the focus on discussing and identifying non-engineering solutions to further support crash reductions.

## FRAMEWORK PLAN

This section documents the process that will be used to develop the Deschutes County TSAP and how crash analysis tools and methods provided in the Highway Safety Manual (HSM) will be used to develop the TSAP. The overall framework includes four key phases, summarized in the flow chart in Figure 3.



**Figure 3 – Deschutes County Safety Program Framework**

The purpose and desired outcomes of each phase shown in Figure 3 are described below.

## Due-Diligence

**Purpose: Assess and identify tools and methods to apply now and in future.**



The Due Diligence will focus on the following three elements:

- 1) Assessing data availability and quality;
- 2) Evaluating methods and recommending the best methods that can be applied in Network Screening with the data available;
- 3) Identifying data collection needs that could improve the safety program in future years.

Crash, volume, and roadway inventory data is needed to apply an objective analysis in support of a safety management program. By collecting as much data is available, we will gain an understanding of where data is limited or where formats are not conducive for use with analysis tools. In some cases, this may identify the need to convert data formats to be consistent for application of Network Screening methods. Over time, the County could enhance their data collection and information management (i.e., crash data, motorized and non-motorized volume, and roadway characteristics) to increase the effectiveness of future TSAP updates.

Table 1 identifies the data requested and received from the County and MPO. Primary data reflects the critical data needed to complete the safety analysis using crash rates and distinguishing between different reference populations. The secondary data will be used, when possible, for additional analysis and site diagnosis. As shown in Table 1, the countywide data is complete for all primary data. The traffic volumes are currently in two different datasets. One dataset represents the unincorporated county area, and one dataset represents the area within the Bend-Redmond model. Kittelson will evaluate the best way to merge these datasets while retaining as much information as possible. Because the data is in point format, the team will review the dataset and estimate which volumes best apply to the various roadway segments.

**Table 1. Data Inventory**

Data	Source
<b>Primary Data</b>	
Roadway Functional Classification	County
Traffic Volumes	County and MPO (Countywide and MPO datasets will be merged)
Reported Crash Data	ODOT - Countywide dataset will be used
Jurisdiction	County and MPO
Traffic Control	County and MPO
<b>Secondary Data</b>	
Posted Speed Limit	County and MPO (Limited coverage available.)
Lane Widths	MPO
Sidewalk Presence	MPO
Bicycle Facilities	MPO
Trails	MPO
Bicycle and Pedestrian Volumes	Not Yet Provided, may be available for select areas within MPO
Transit Routes and Stops	MPO

Available data will limit the number of tools and performance measures that can be used immediately within the safety program. The data needed to allow the County to apply more robust tools and methods (reducing statistical bias) will be identified to allow the County to continually improve their safety program during future updates.

### Network Screening



***Purpose: Apply objective methods to evaluate the County’s road network to identify sites with potential for reducing crash frequency or severity.***

Network screening methods are described in detail in Chapter 4 of the HSM. The methods from the HSM will be adapted to fit the context of Deschutes County and the scope of this project. In general network screening includes the following steps:

- 1) Establish emphasis areas;
- 2) Identify reference populations;
- 3) Select performance measures; and

4) Screen and evaluate results.

Considerations for each of the steps above are discussed in the following subsections.

***Establish Emphasis Areas***

Analysis results of crash details reflected in the crash database may identify proportions of crash types, severity, location, and other transportation safety trends that the County will want to address to develop priority locations. The emphasis areas will inform goals and the performance measures selected for use in network screening.

Crash analysis to identify emphasis areas will include a review of the following crash trends at a minimum:

- Time of day
- Seasonal variability
- Age
- Crash causes
- Speeding
- Intoxication
- Severity
- Crash type
- Pedestrian and bicycle crashes
- Crash cause

***Identify Reference Populations***

To identify projects that will be most cost-effective at reducing crashes, the network will be organized into reference populations and lists of priority projects will be developed for each population.

The HSM identifies the characteristics listed below as potential characteristics for establishing reference populations. Kittelson will use these same characteristics as a starting place for identifying the appropriate reference population.

- Area type (e.g., urban, rural, suburban);
- Traffic Control (e.g., signalized, unsignalized, roundabout, etc.);
- Number of approaches (e.g., three-leg or four-leg intersection);
- Cross-section (e.g., number of through lanes and turning lanes);
- Functional Classification (e.g., principal arterial, collector, local, etc.); and,
- Traffic Volume.

Kittelson has obtained data and initial reviews indicate data is available to apply a combination of some of these characteristics to establish reference populations. The characteristics with the most

comprehensive database will be prioritized. The maximum number of reference populations will be determined based on the number of crashes within each population; a minimum frequency of crashes per population is necessary to be able to establish trends.

### **Select Performance Measures**

Performance measures are used to evaluate the crash data and result in a quantitative “score” at each site. The HSM identifies 13 performance measures that can be used in network screening. Performance measure selection is based on data available, desired statistical rigor, and program priorities. Performance measures with the greatest statistical rigor apply crash prediction models to account for “regression to the mean” bias, which is commonly evident in safety evaluations. Those methods provide the greatest reliability of the screening results and require the greatest amount of data.

Based on the available data, up to two performance measures from the following list are expected to be used in the County TSAP:

- Crash frequency;
- Equivalent property damage only crash frequency (EPDO crash frequency);
- Relative severity index;
- Crash type performance threshold; or
- Excess proportion of specific crash types.

### **Screen and Evaluate Results**

Kittelson will use Geographic Information System (GIS) tools to implement network screening methods using data from Deschutes County and the Bend MPO. The results will provide a ranked list of 20 sites within the unincorporated County and three intersections within the cities of La Pine, Redmond, and Sisters that have the greatest potential for reducing crash frequency and severity based on the two selected performance measures.



### **Countermeasure Development**

***Purpose: Identify factors contributing to crashes and specific countermeasures to reduce the frequency and severity of those crashes.***

Developing countermeasures leads to recommendations for infrastructure and non-infrastructure countermeasures. The following sections provide a general overview of the process Kittelson will use to develop these countermeasures.

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### ***Identify Contributing Factors at Sites***

Diagnosis includes desktop and field reviews for the top ranked sites from network screening. For each site, diagnosis includes reviewing the following three elements:

- 1) Crash and volume data trends;
- 2) Site history (e.g., construction, traffic control modifications, etc.); and
- 3) Field conditions.

Kittelson will work with the County to identify up to 10 sites to be diagnosed to determine factors contributing to crashes and countermeasures will be identified to address those contributing factors. In addition, Kittelson will identify the top three intersections, based on screening, for Sisters, Redmond, and La Pine, and the top three crash patterns or characteristics eligible for systemic treatments.

### ***Identify Infrastructure Countermeasures***

The contributing factors identified through the desktop and field reviews can be tied to countermeasures having the potential to reduce the number and/or severity of the crashes associated with contributing factors. In general, this step requires considering a range of countermeasures and narrowing the options to consider and select preferred countermeasures that have a documented ability (through empirical study) to reduce a specific crash type. This step uses Crash Modification Factors (CMFs) in the HSM and those identified in the Federal Highway Administration's (FHWA) website ([www.cmfclearinghouse.org](http://www.cmfclearinghouse.org)).

In addition to identifying site specific countermeasures, we will recommend low-cost systemic treatments that can be applied at a broad scale to address the emphasis areas.

### ***Identify Non-Infrastructure Countermeasures***

As documented earlier in this memorandum, engineering (infrastructure) countermeasures are only one component of a comprehensive safety program. The Multidisciplinary Stakeholder group will meet in a worksession to provide input on potential non-infrastructure countermeasures that should be considered to address identified emphasis areas for the TSAP.

### ***Prioritize Infrastructure Countermeasures***

The goal of prioritizing countermeasures is to prioritize the projects that are expected to result in the greatest reduction in crash frequency and/or severity for the least cost. Chapter 7 and 8 of the HSM outline a variety of methods for ranking projects. The ranking is based on the relative benefit-cost ratio of the projects. Therefore, ranking requires monetary costs and benefits be identified for each project. Project cost estimates will be prepared for projects at 10 sites and up to 8 systemic solutions for the unincorporated County based on established unit costs. The CMFs identified for countermeasures will be used to estimate benefits in terms of crash reductions, when available. Crash reductions are

converted to monetary benefits based on estimates of design life and societal crash costs by crash severity.

When quantitative estimates are not available documenting the effectiveness of a countermeasure or project, the project may not be ranked. Therefore, the ranked project list will only represent those projects with proven countermeasures having the greatest potential to reduce crash frequency or severity. Those projects that do not have proven countermeasures could still be implemented and their effectiveness in Deschutes County could be studied through a before-and-after study.

### ***Coordination with Other Agencies***

After an initial list of countermeasures is available, the projects will be referenced against the ODOT All Roads Transportation Safety (ARTS) and Safety Priority Index System (SPIS) sites. Where there is overlap, the site will be reviewed to determine whether the recommendations, if available, are consistent. If the recommendations differ, the TSAP will indicate that recommendations differ and identify the need for coordination with ODOT. ARTS and SPIS sites that are not identified in the TSAP projects will be carried forward into the TSAP document to provide a complete safety project list.

### **Implementation**



***Purpose: Implement the recommendations from the TSAP by fully integrating the infrastructure and non-infrastructure recommendations. Complete future updates to maintain a current safety program that addresses relevant issues as conditions change over time.***

Successful implementation of the TSAP will extend beyond identifying a prioritized list of infrastructure and non-infrastructure countermeasures. The TSAP may identify recommendations in the following areas that will help the County continue to enhance safety performance in the long-term:

- Updating the Capital Improvement Program (CIP) criteria and methods to incorporate safety performance;
- Updating the development review processes to incorporate safety performance;
- Updating roadway standards and standard details based on findings from the TSAP analysis;
- Identifying performance measures to track progress towards achieving the safety goals over time;
- Identifying new programs to improve education and/or enforcement;
- Identifying policy development needs to support the County’s long-term vision;
- Identifying data collection needs to reduce statistical bias in future updates of the TSAP;
- Considering public health connections and opportunities to support State and possible future County goals; and

- Recommending approaches for updating the TSAP (methods, frequency) to maintain a current, proactive Plan while continually enhancing the County’s roadway safety management program.

### ***Future Data Collection Needs to Reduce Statistical Bias***

As discussed in the Performance Measures section of this memo, the HSM identifies 13 performance measures that can be used in network screening. Performance measure selection is based on data available, desired statistical rigor, and program priorities. Performance measures with the greatest statistical rigor apply crash prediction models to account for “regression to the mean” bias, which is commonly evident in safety evaluations. Those methods provide the greatest reliability of the screening results and require the greatest amount of data. Table 2 summarizes the available performance measures.

The Deschutes County TSAP will provide recommendations about future data needs that could reduce the statistical bias of the program by allowing the use of some of the long-term performance measures. The County could consider future data collection and management approaches over time to incrementally increase the effectiveness of future safety evaluations. The incremental enhancements to the County’s transportation safety management plan could reduce statistical bias and create more confidence in safety programs and countermeasure effectiveness.

**Table 2. Summary of Network Screening Performance Measures**

Statistical Bias/Data Requirement Continuum*	Deschutes County Implementation Category	Network Screening Performance Measure
	Short-Term	Crash Frequency
		Equivalent Property Damage Only Crash Frequency
		Relative Severity Index
		Crash Type Performance Threshold
		Excess Proportion of Specific Crash Types
		Critical Rate
		Method of Moments
	Long-Term – Requires calibrated safety performance functions and detailed geometric information	Excess Predicted Crashes Using SPFs
		Level of Service of Safety
		Expected Crash Frequency with EB Adjustment
		EPDO Crash Frequency with EB Adjustment
		Excess Expected Crash Frequency with EB Adjustment

\* Performance measures are sorted by implementation category, which generally reflects a reduction in statistical bias as additional data is included in analysis

## NEXT STEPS

Kittelson has begun the Existing Conditions analysis, which includes summarizing crash data to identify emphasis areas and reference populations. Upon completion of draft memorandum summarizing this task in mid-December, Kittelson will identify two recommended performance measures to use for the network screening process.