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# Highway Safety Investigation Manual for the Oregon Department of Transportation

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# Highway Safety Investigation Manual for the

# Oregon Department of Transportation


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# Table of Contents

## List of Tables

# List of Figures

# 1 MANUAL OVERVIEW AND PURPOSE

Across the state, region, and nation highway safety investigators have developed a wide variety of tools and techniques for highway safety investigation procedures. Analysis techniques can range from systematic evaluation approaches such as the Oregon Department of Transportation's (ODOT's) Safety Priority Index System (SPIS) down to specific localized safety assessment strategies. It is important to develop consistent methods for safety evaluations across Oregon to ensure that safety investigations are conducted in a similar manner. It is also important to develop a screening process for proper highway safety investigations and document the procedures used for this assessment.

The objective of this manual is to provide a resource to assist ODOT traffic investigators with highway safety project screening and evaluations. Though the content of this manual is targeted for use within ODOT, the procedures outlined could be easily adapted by local jurisdictions for similar highway safety assessments. This manual, therefore, includes checklists and analysis procedures suitable for a variety of field and office safety investigations and assessments. This manual also includes information about the ODOT highway safety programs and tools, linkage to current standards and resources where design and operations methods are stipulated, a comprehensive procedure for safety investigation at both intersection and highway segments, and countermeasure definition and guidance.

This manual assumes that a particular location (a segment of roadway or an intersection) has already been identified for investigation by any of the following:

1) An investigation of a particular location (a segment of roadway or an intersection) identified by the SPIS program or as part of a proposed project;

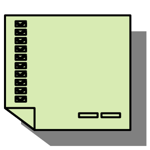
2) An investigation motivated by a citizen complaint or inquiry; or

3) An investigation initiated due to a fatal crash or crashes.

This manual is primarily directed at the first type of investigations (item 1).

When using this manual, the investigator should consider safety investigations in the following steps:

| ***Task*** | ***Objective of Task*** | ***Location in Manual*** |
|---|---|---|
| In office analysis of data sources | To develop a preliminary understanding of the most common crash types and location of these crashes, the problem area, and items to look for in a field review | Chapter 2<br>Chapter 3<br>Chapter 4 |
| Field review of location | To confirm problems identified during in-office analysis, to uncover potentially new understandings of crash mechanisms, to inspect physical features of the site for documentation. | Chapter 5 |
| In-office selection of solutions | To recommend cost-effective solutions that will improve the safety performance of the studied facility | Chapter 6 |
| Producing the necessary documentation | To provide a documentation of the investigation | Chapter 7 |



Where worksheets are provided (online and in the appendix) the icon shown to the left is used.

The basic analysis procedures identified in this manual include the seven steps demonstrated in Figure 1. Throughout the manual, this flowchart can be used to guide the user through the analysis process, with enhanced flow charts representing the individual steps.

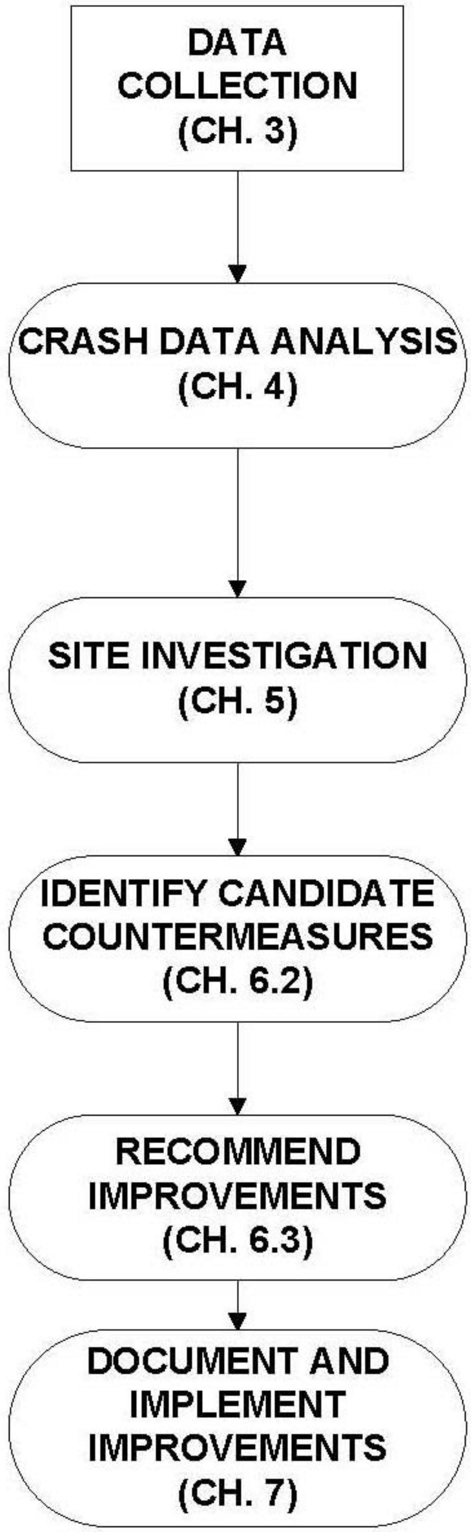



**FIGURE 1. OVERVIEW OF ANALYSIS APPROACH**

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# 2 SAFETY INVESTIGATION BASICS

The safety investigations process is a combination of scientific evaluation, the investigator's knowledge and experience, and good judgment. The investigator is essentially piecing together many clues as to why crashes occurred without having the benefit of any actual first-hand knowledge. The investigator must glean clues from a detailed analysis of crash data and a thorough investigation of field data. These clues can then be evaluated by the investigator to identify preventable crashes. For these "target" crashes, the investigator can identify feasible and effective countermeasures, make recommendations, and document the entire process. This chapter provides a brief overview about basic philosophy and information needed for crash assessments.

## 2.1 PRINCIPLES OF SAFETY INVESTIGATIONS

There are two principles that are useful to keep in mind when attempting to diagnose a crash problem. First, crashes should be considered rare events. Even though there are about 41,000 reported crashes in Oregon per year, the vast majority of interactions between vehicles, users, and the infrastructure do not result in crashes. For a crash to occur, a number of events have to occur simultaneously. For example, if a rear-end crash occurs at a signalized intersection, one or more of the following events must have transpired: two vehicles approach traffic signal as the indication turns red; driver in following vehicle following too closely or is inattentive; braking (if any) is not sufficient to stop the trailing vehicle in time due to inattention or a slow reaction, the driver in the lead vehicle then stops suddenly. If any one of these sequential events leading up to a crash was altered in some way, the crash may have been avoided. Clearly, a crash can happen even with a "perfectly" engineered, signed, and enforced facility.

If we take a longer view (years), some number of crashes can be expected. This long view can be thought of the "expected crashes" or the "average over the long run." These expected crashes vary for different environments (a rural interstate or urban minor arterial) because driver expectations, potential conflicts, traffic volumes, design standards, etc. are different. It should be pointed out that the "expected crashes" concept does not mean that this number of crashes is acceptable. This concept only reflects the recent safety performance (which can be improved).

Second, we assume that most drivers, cyclists, and pedestrians would prefer to avoid a crash and will do so in most situations; however, we know that errors will occur. While we might expect some crashes to happen, if crashes exceed what we expect then something is most likely correctable at our investigated location. Therefore, our investigative efforts are searching for a pattern of crashes that is out the ordinary. As a bonus, if these patterns can be detected, they are the most reliable guide to the remedial action. How to do this is described in Chapter 4.

Once the pattern is found, the next step in the diagnostic effort is to try to determine what might be "causing" these crashes to occur. Interpreting the crash pattern data, field investigation, and other inputs to identify likely contributing causes and countermeasure selection is discussed in Chapters 5 and 6.

## 2.2 WHAT FACTORS CONTRIBUTE TO CRASHES?

In a landmark study, Treat et al. (1979) performed an in-depth study of crashes that happened in Indiana. A team of experts defined the one event leading up to the crash that, had it not happened, the crash would have been avoided. They assigned that one event to three categories: driver, roadway, and vehicle. As one might expect, the study found that in almost all crashes, there is likely a driver-related component. There is also a strong overlap with the other elements, particularly the roadway. Roadway defects or vehicle defects are only a small percentage of the total. The results of their study have been closely replicated by a few other authors.

This does not imply that driver errors are not preventable. On the contrary, the strong overlap with the roadway causes means that our investigative efforts should focus on these driver elements, also called "human factors." If we recognize that driver abilities, behaviors, attitude, speed, risk taking (i.e. alcohol use), fatigue, physical abilities (vision, ability to turn head), and cognitive decisions or reactions are important contributing factors to collisions, we can better identify engineering solutions that might improve the situation.

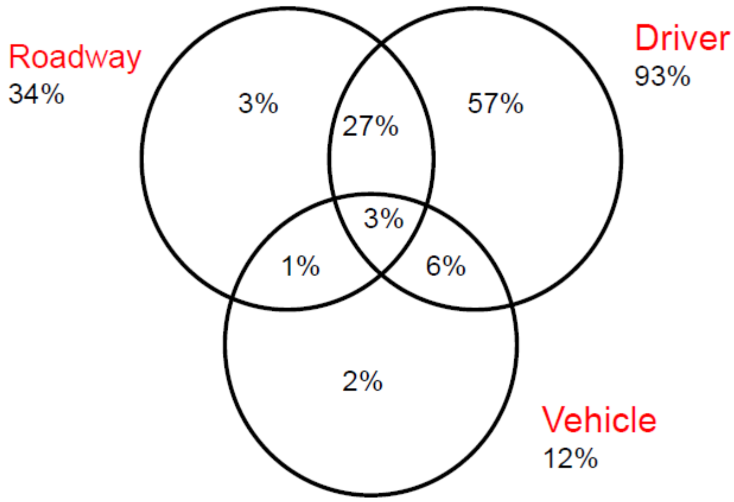



**FIGURE 2. CRASH CAUSES**

While some driver elements can only be changed through education or enforcement, there are driver related errors that can be linked to the roadway (including operations) environment. Probably the most important concept to consider when investigating crash locations is called “driver expectancy.” This concept means that drivers are conditioned to expect certain events to happen. For example, drivers know that the yellow signal indication means that a red signal indication is to follow and they should be prepared to stop. This “expectancy” decreases reaction time and improves operations. If there is an unusual situation, driver confusion or overload is more likely to occur and this can result in crashes.

Other “human factors” often need to be considered such as visual clutter or competing stimuli, experience and age of the drivers, and driver comfort or satisfaction. For example, drivers are more likely to take risks if they have become impatient due to a long delay. In this situation, a solution to turning crashes may be an operational one.

A good introductory chapter on human factors can be found in the Highway Safety Manual (HSM).

## 2.3 Relationship of Crashes to Volume

It is clear that as traffic volumes increase, if nothing else changes, the number of crashes is also likely to increase. This is the reason crash rates are calculated - to normalize for different exposures over time or between different locations.

The crash rate calculation for segments is calculated per million vehicle-miles-traveled (MVMT) (100 million VMT for Fatal and Injury A) as

$Rate = \frac{C * 1,000,000}{V(D)(L)}$, where

C = number of crashes in study period

V = volume, in Average Daily Traffic (vehicles per day or vpd) [this value is usually for both directions of travel]

D = number of days in study period

L = length of segment (miles).

For intersections, the rate is calculated per million entering vehicles (MEV)

$Rate = \frac{C * 1,000,000}{V(D)}$, where

C = number of crashes in study period

V = the sum of volumes entering from all approaches, in Average Daily Traffic (vpd)

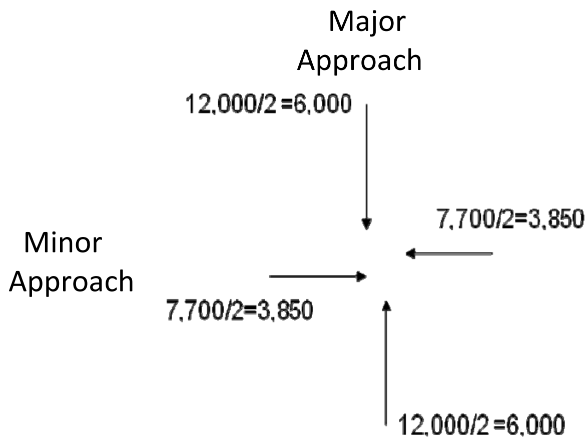
D = number of days in study period

Example 1:

- Observed 40 crashes on a 17.5 mile segment in one year. The ADT was 5,000 vpd.
- $Rate = \frac{40 * 1,000,000}{5,000(1 * 365)(17.5)}$ = 1.25 crashes per MVMT

Example 2:

- Observed 25 crashes in 6 years at a 4-Leg intersection. The ADT for the minor approach was 7,700 vpd and the major approach was 12,000 vpd. Recall that a typical year should have 365 days.
- ADT volumes are always expressed for both directions of travel. To get **entering** volumes the ADTs can just be summed since the volume of traffic that enters from each direction is assumed to be approximately one-half the ADT. If the intersection were a 3-Leg intersection, only one-half of the ADT from the T-leg would be used. It may be helpful to do a quick sketch such as:




– $$Rate = \frac{25*1{,}000{,}000}{(12{,}000 + 7{,}700)(6*365)}$$ = 0.579 crashes per MEV

Example 3:

- Observed 20 crashes in 6 years at a 3-Leg intersection. The ADT for the minor approach was 5,100 vpd and the major approach was 10,500 vpd. Recall that a typical year should have 365 days.
- ADT volumes are always expressed for both directions of travel. To get **entering** volumes the ADTs can just be summed since the volume of traffic that enters from each directions is approximately one-half the ADT. Since the intersection is a 3-Leg intersection, **only one-half of the ADT from the T-leg is used in the exposure**.

– $$Rate = \frac{20*1{,}000{,}000}{(10{,}500 + [5{,}100/2])(6*365)}$$ = 0.6998 crashes per MEV

(say 0.70 crashes per MEV)

### *2.3.1 Cautions With Rates*

Rates can be a useful calculation. One benefit is that they simply control for differences in volume. They are most appropriate when comparing similar conditions or “apples to apples.” However, rates are best used when comparing the same functional class, volume range, intersection type, or other distinguishing features. The use of rates can lead to incorrect conclusions if comparisons are made across widely different facilities. For example, one would not compare a rural interstate crash rate to a rural principal arterial rate since they are different facility types. To obtain average rates for a particular facility type, see the ODOT Crash Analysis and Reporting publication, "Crash Rate Book." The 2008 Table IV and Table V are included in Appendix B of this manual.

- http://www.oregon.gov/ODOT/TD/TDATA/car/CAR_Publications.shtml

When comparing rates over time, it is important to remember that rates can change by modifying the number of crashes (numerator) or the volume, duration, or segment length (denominator). For example, a facility could be made "safer" if volumes increase but crash counts do not (the rate would be lower). If no actual improvements have been made to the facility, the road is not any safer in the physical sense, only the risk has changed.

There is some evidence that bicyclists and pedestrians have lower risk with increased bicycle and pedestrian volumes. This is generally attributed to the "safety in numbers" concept. This means that motor vehicle operators are more likely to expect these users (and drive accordingly) if they routinely see more cyclists and pedestrians.

## 2.4 Duration of Crash Data to Study

A common question in the investigation process is: How many years of crash data to use? If too long a period is chosen, there is more likelihood that there will have been changes to site conditions (volumes, drivers, reporting thresholds, periodic maintenance, etc.). If too short a period is selected, there is likely not enough data to analyze and the crash patterns may not be representative of the long term performance of the facility.

A general recommendation is to use 3 years of crash data for analysis. In some situations, 5 years may be appropriate if there is limited crash data to evaluate. The 5 year period may also be appropriate if there was construction activity present during part of the study period or other unique site conditions.

## 2.5 Concept of Severity

The investigator should consider more than just total crashes in an investigation. There are a number of good reasons to do this. First, collision patterns may differ across severity levels. By considering severity separately a significant problem may be uncovered. Second, severe crashes represent a greater cost to society and more effort and funding should be directed at mitigating these crashes.

It is suggested to consider crashes in three severity groupings:

- *Fatal and Injury A* crashes are a better representation of high-energy collisions than just fatal crashes. The difference in outcomes (between fatal and injury A) can be a result of minor differences in the crash circumstances (e.g. difference of inches in the point of collision impact, difference in driver age or experience). Considering fatal and injury A crashes together increases the likelihood that unusual severe crashes are detected. In addition, these crashes will almost certainly have a police presence resulting in a better quality of crash data.

- *Injury B and Injury C* crashes are representative of lower-level crashes and have moderate societal cost.

- *Property Damage Only (PDO)* crashes are the least reliable in terms of data quality. They are affected by changes in reporting threshold and are less likely to have a police report. However, they are useful as an indicator of the total crash problem. (It is estimated that only 50% of the property damage crashes in Oregon are reported each year.)

The investigator should also consider that it is possible to decrease the severity of some crashes while increasing the frequency of less severe crashes. For example installing a median barrier will increase property damage crashes (vehicles will hit an object that was not there before) but head-on crashes will be virtually eliminated. This trade-off in severity can be analyzed using the benefit-cost methodology presented in this manual.

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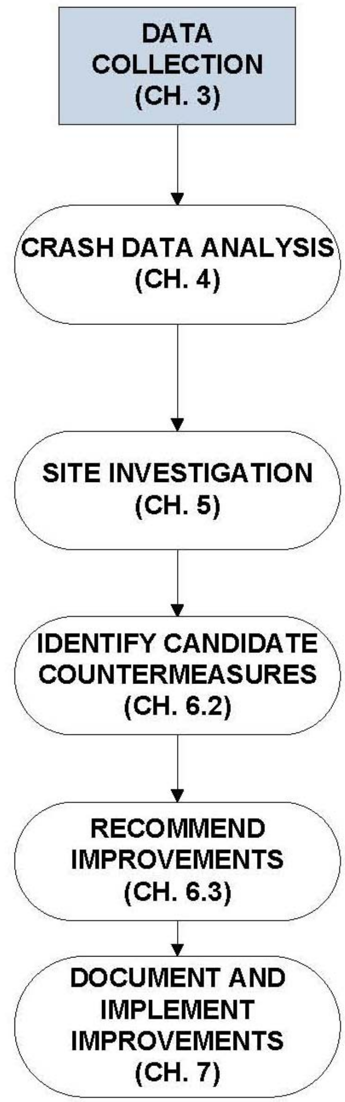
# 3 Overview of Data Types and Sources

For a safety investigation the basic information that will need to be collected includes:

- Route numbers, ODOT internal highway number(s), highway name, and milepoints;
- Functional class of highway;
- Rural, urban, or [suburban] character;
- Current traffic volumes characteristics;
- Crash data; and
- Current configuration and design of the roadway (number of lanes, type of pavement, shoulder types and width, roadside features, pavement marking, presence of traffic signal, etc.).

There will be different data elements needed for segments and intersections. The basic data collection procedure is identified in Figure 3.




## 3.1 In-Office Data

### *3.1.1 Crash Data*

The crash data collected and complied by Oregon DOT Crash Analysis and Reporting Unit (CAR) will be a key input in the safety investigations process. The crash data are maintained for analysis and are easily accessible to the investigator via the Department's internet. This resource is available by selecting the Crash Data System (CDS) icon at the following web site:

https://keiko36.odot.state.or.us/

A full description of this data source is outside the scope of this manual, but there are some key concepts that are highlighted in the following sections. The Crash Data System Code Manual descriptions are located at the following web sites:

http://www.oregon.gov/ODOT/TD/TData/car/docs/2007code.manualversion2.0.pdf
http://www.oregon.gov/ODOT/TD/TData/car/docs/2007DecodeManual.pdf

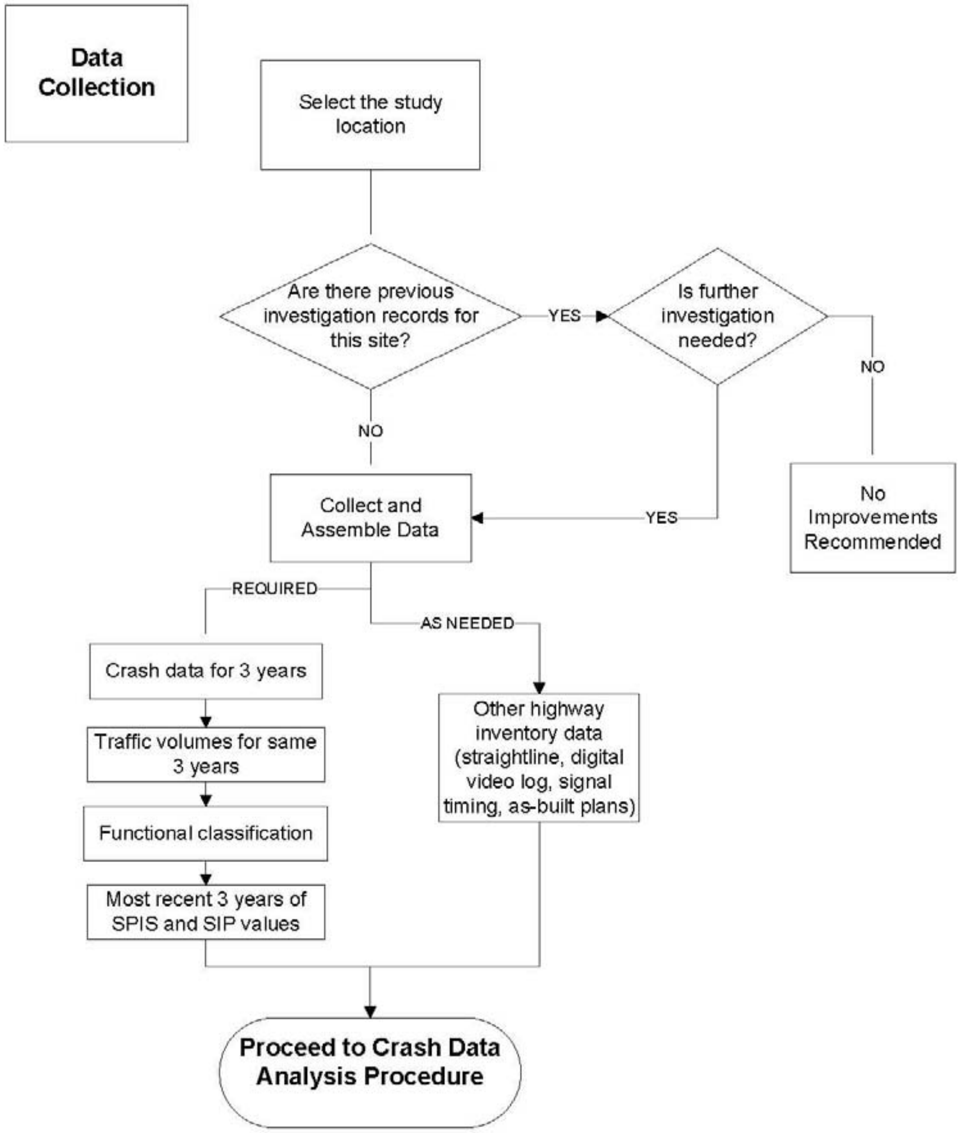



**FIGURE 3. FLOWCHART OF PROCEDURE TO COLLECT DATA**

#### 3.1.1.1 CRASH REPORTING PROCESS

A reportable crash must occur on a public roadway and meet the minimum reporting thresholds. Current Oregon law requires a citizen to report the crash to the Department of Motor Vehicles (DMV) on an Oregon Traffic Accident and Insurance Report form within 72 hours if:

- Damage to the vehicle a person was driving was over $1,500; or

- Damage to any vehicle was over $1,500 and any vehicle was towed from the scene as a result of damages from the crash; or
- Injury or death resulted from the crash; or
- Damage to any one person's property other than a vehicle involved in the crash exceeded $1,500.

These reporting “thresholds” change over time by legislative action and can affect the number of property damage crashes that are reported. The most recent change occurred in 2004. The previous reporting threshold was $1000 (since 9/1/1997).

If a police officer responds to the scene, he or she completes the Oregon Police Traffic Crash Report. Police officers are not required to file a report unless they have completed an investigation; however, they are more likely to prepare a report for the more severe crashes (this varies by police department).

A citizen must file a report even if a police officer attended and completed his or her own report. Both police and citizens submit their form to the DMV. After the crash reports are assembled and processed for insurance verification and other driving records information, they are sent to the Crash Analysis and Reporting (CAR) Unit for coding. Next, the crash coders in CAR must weave together the citizen and any police reports (if submitted) into a composite picture of the crash. There are often discrepancies in the information given by the police as well as between the drivers that the CAR coders must sort out.

Because Oregon relies so heavily on citizen reports, there will be data issues despite the best efforts of the CAR unit. First, it is important to note that not all crashes that occur will be reported in the Oregon Statewide Crash Data System (CDS). There will be instances where an investigator has evidence of a crash but it is not in the CDS. Sometimes, particularly in rural areas where it is hard to accurately report locations, the location information will not be correct. It is also worth noting that the precision of the milepost of the crash (to the hundred of a mile) is not necessarily the precision of the actual crash location. This milepost is based on interpretation of the CAR coders while referencing the highway inventory data. For example, if a crash was reported to occur 200 feet north of Y Road which is at milepost 5.11, the crash would be coded to milepost 5.15 (i.e. the precision implied by 2-decimal milepost is only related to the precision of the intersection location).

If an investigator finds an error, he or she should contact the CAR unit who can correct the database. The phone number for the CAR unit is (503) 986-4240.

#### 3.1.1.2 Data Structure

The CDS contains information for each vehicle, driver, and (most) passengers involved in motor vehicle crashes. This information is stored in a relational database with three primary tables (crash, vehicle, and participant). The crash record is a summary of the event and includes all identifying information such as location, date, time, weather, etc. If the investigator has questions about the meaning of a particular code or short abbreviation, the Crash Data System Code Manual is a helpful reference. The vehicle table will include 1 entry for each vehicle in the crash. The participant table also includes one entry for each person involved in the crash. In the example shown in Figure 4 a two-vehicle crash is represented. The crash table will have 1 record summarizing the event, there will be 2 records in the vehicle table (1 for each car involved), and 5 participant records in the participant table (though occupants other than drivers are not always captured). These are all cross-referenced by a unique crash id that is different than the serial number (a DMV code by county that repeats from year-to-year).

#### 3.1.1.3 Crash Severity

Injury severity is first coded to each person involved in the crash. All injuries are scored on a five point scale often referred to as KABCO which is defined as:

- K, fatal injury;
- A, incapacitating injury - Prevents person from walking includes severe lacerations, broken limbs, abdominal injuries;
- B, non-incapacitating evident injury - Evident to observers, lump on head, bruises, cuts;
- C, possible injury - Limping, momentary unconsciousness; and
- O, no injury (property damage only).

For example if 2 persons are involved in a crash, they will each be coded with an injury severity. The most severe of these injuries is used to determine the overall severity of the crash. When presenting severities it is important to keep the distinction between <u>persons</u> injured and the count of crash-level severity.

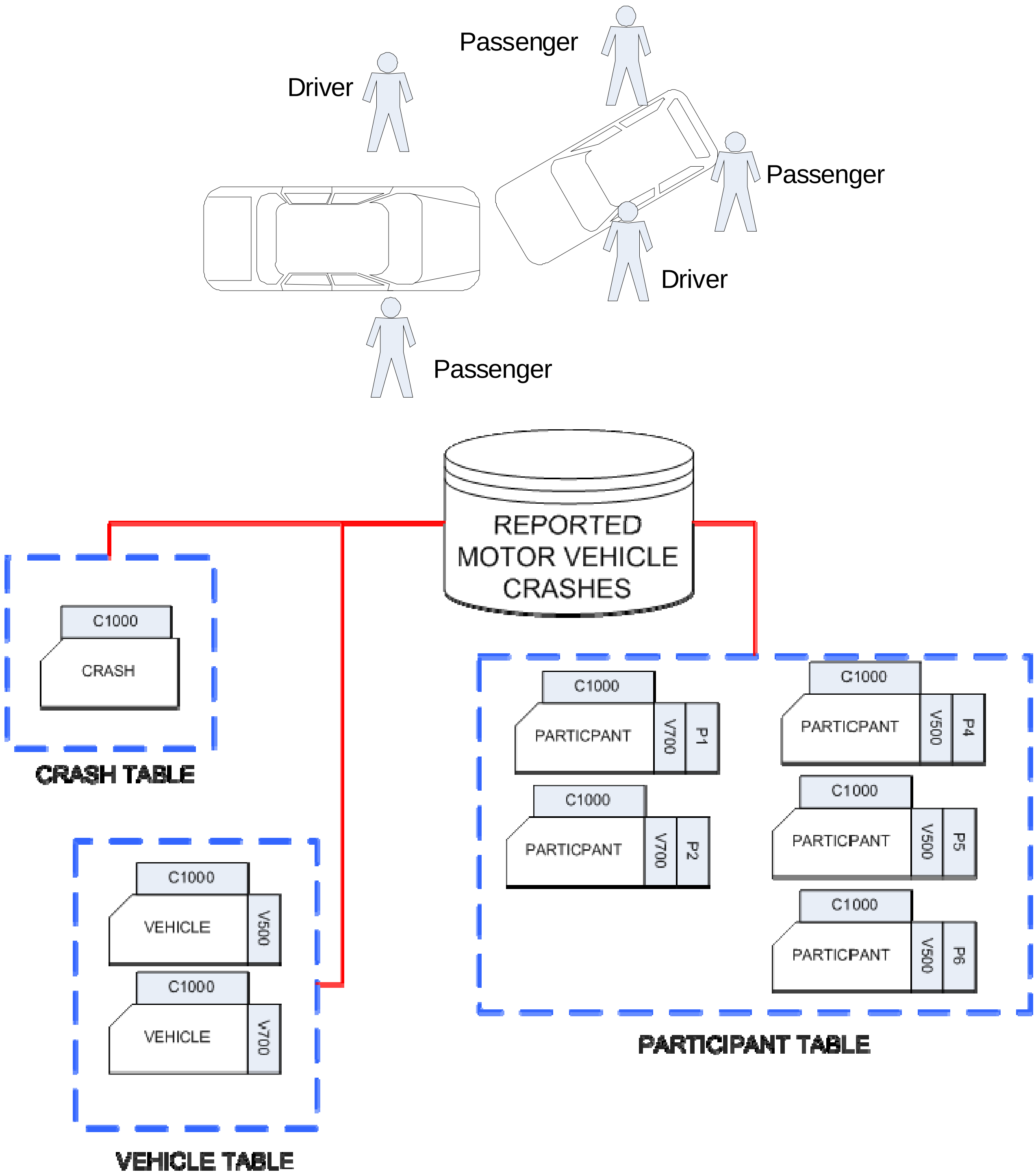



**FIGURE 4. CRASH DATABASE SCHEMATIC**

Example:

- Vehicle 1: Driver with injury A; Passenger with injury A, Passenger with injury B
- Vehicle 2: Driver with fatal injury; passenger with injury C

This crash was a fatal crash (the highest severity) but five people were injured (2 injury A, 1 injury B, 1 injury C, and 1 fatal).

It is important to be consistent in descriptions to limit confusion. Normally, the following syntax should be used in text descriptions:

- Fatal crashes (counting crashes)
- Fatalities (counting persons fatally injured)
- Severe injury crash (counting crashes)
- Severe injur*ies* (counting persons injured)

Using the example above, a fatal crash occurred but there were actually five injuries. Most often, the investigator will be dealing with information at the crash-level, not at the person-injury level.

One justification for the crash-level approach in highway safety investigations is to not give more weight to locations because of the number of vehicle occupants in particular crash.

#### 3.1.1.4 Accessing the Crash Data

These data can be accessed via the internal TransViewer website. The data are available in a number of different formats that are helpful to the investigator. They are available in text and Excel format.

- Direction Report – Useful since it lists vehicle collisions by direction
- PRC Report – A fairly detailed summary of the crash (including all vehicles)
- Crash Graphing Tool (see reference below)

These are available in print out text form or downloaded in Excel format for further analysis

- Select the CDS icon at https://keiko36.odot.state.or.us/

A helpful Excel macro – the "Crash Graphing Tool" - has been written that creates summaries of the crash data for state highways from the "Direction (Vehicle) Report." The use of this tool can supplement the worksheets described in more detail in Chapter 4.

http://intranet.odot.state.or.us/tstrafmgt/crash_graphing_tool.htm

#### 3.1.1.5 Locating Crashes

Determining the location of a crash requires knowledge of ODOT's highway inventory system and nomenclature. State highway crashes are located using this nomenclature. To identify a unique location, a combination of six elements is needed. These are:

- HWY_NO - Three digit code representing state highway index number;
- RDWY_NO - One digit code to identify roadway direction (add, non-add);
- HWY_COMPNT_CD – One digit code characterizing the highway structure where crash occurred (State Highway, Frontage Road, Couplet, Connection);
- RD_CON_NO – Connection number (if crash occurred on connection); The connection number will need to be determined from the interchange diagrams (see 3.1.4);
- MLGE_TYP_CD – Code for mileage portion of highway where crash occurred (Regular, Temp., Spur, Overlapping); and
- MP_NO – Milepost of crash.

#### 3.1.1.6 Crash Coding Manual

An invaluable resource for the investigator will be the crash coding manual. This document helps the investigator interpret the various codes about a particular crash. This document is available on the CAR webpage:

http://egov.oregon.gov/ODOT/TD/TDATA/car/CAR_Main.shtml

#### 3.1.1.7 Filed Police and Citizen Reports

In some cases it may be helpful to obtain a copy of a police report which could include a narrative and sketch. Unfortunately there is no automated manner in which this can be done at this time, this requires a special request to CAR who must then request and obtain the report from the DMV. If the crash is a fatal, a police/ODOT maintenance/ risk management report may be available (TRS). These reports may trigger the need for an investigation.

Citizen reports, due to confidentiality rules in Oregon Revised Statues 802.220(5), are not generally available as part of any request.

### *3.1.2 Safety Priority Index System (SPIS)*

The SPIS is a method "to perform network screening on the state highway network and to identify and prioritize those sites that have promise as sites for potential safety improvements and merit further investigation."

The SPIS score is based on three years of crash data and considers crash frequency (25%), crash rate (25%), and crash severity (50%). A roadway segment becomes a SPIS site if a location has three or more crashes **or** one or more fatal crashes over the three year period. Each location is defined as a 0.10 mile section of state highway. The maximum score is 100.

The SPIS is processed every year after the crash data have been finalized. The reports are named for the year they are produced but will be calculated using the three most currently available years of crash data. For example, the 2009 SPIS Reports (produced on 7/14/2009) use crash data from 2006, 2007 and 2008 in their calculation.

For each year, a "Top 10%" cutoff score is determined. This cutoff score is the score for which 90% of all 0.10 mile sections (with a calculated SPIS score) are below. As an example, if there were 100 SPIS sites and these were sorted from highest to lowest, the "Top 10%" cutoff score would be the score that was the 10 highest (100*0.10 = 10).

In an effort to adequately screen the highway network, the SPIS uses a "sliding window" approach to calculations. This is accomplished by recalculating a SPIS score in 0.01 mile steps. For example if the first SPIS site is milepost 5.00-5.10 another calculation will be performed for milepost 5.01-5.11. This means that one problem location will have more than one SPIS "site" but the investigator should consider the range of highway identified.

**Oregon Department of Transportation** Region **2**

**2003, All SPIS Sites - By Highway, Prefix, Milepoint**

| Route | Pfx | Mlg | BMP | EMP | ADT | Crsh | #Kill | City | County | Connection @ BM | Percentile | SPIS | SIP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| US-101 | 0 | 0 | 20.76 | 20.85 | 16,100 | 7 | 0 | Seaside | Clatsop | | | 20.1 | 3 |
| US-101 | 0 | 0 | 20.77 | 20.86 | 16,100 | 6 | 0 | Seaside | Clatsop | SECTION LINE AVE. | | 17.2 | 3 |
| US-101 | 0 | 0 | 20.78 | 20.87 | | 5 | 0 | Seaside | Clatsop | | | 14.3 | 3 |
| US-101 | 0 | 0 | 20.79 | 20.88 | | 5 | 0 | Seaside | Clatsop | | | 14.3 | 3 |
| US-101 | 0 | 0 | 20.8 | 20.89 | 16,100 | 5 | 0 | Seaside | Clatsop | 4TH AVE. | | 14.3 | 3 |
| US-101 | 0 | 0 | 20.81 | 20.9 | 16,100 | 6 | 0 | Seaside | Clatsop | | | 17.2 | 3 |
| US-101 | 0 | 0 | 20.82 | 20.91 | 16,100 | 5 | 0 | Seaside | Clatsop | | | 15.8 | 3 |
| US-101 | 0 | 0 | 20.83 | 20.92 | | 5 | 0 | Seaside | Clatsop | | | 15.8 | 3 |
| US-101 | 0 | 0 | 20.84 | 20.93 | 16,100 | 5 | 0 | Seaside | Clatsop | | | 15.8 | 3 |
| US-101 | 0 | 0 | 20.85 | 20.94 | | 3 | 0 | Seaside | Clatsop | 3RD AVE. | | 10.8 | 3 |
| US-101 | 0 | 0 | 20.86 | 20.95 | | 6 | 0 | Seaside | Clatsop | | | 15.7 | 3 |
| US-101 | 0 | 0 | 20.87 | 20.96 | | 6 | 0 | Seaside | Clatsop | | | 15.7 | 3 |
| US-101 | 0 | 0 | 20.88 | 20.97 | | 6 | 0 | Seaside | Clatsop | | | 15.7 | 3 |
| US-101 | 0 | 0 | 20.89 | 20.98 | | 6 | 0 | Seaside | Clatsop | | | 15.7 | 3 |
| US-101 | 0 | 0 | 20.9 | 20.99 | 16,100 | 6 | 0 | Seaside | Clatsop | 2ND AVE. | | 15.7 | 3 |
| US-101 | 0 | 0 | 20.91 | 21 | | 6 | 0 | Seaside | Clatsop | | | 17.2 | 3 |
| US-101 | 0 | 0 | 20.92 | 21.01 | 16,100 | 7 | 0 | Seaside | Clatsop | | | 18.6 | 3 |
| US-101 | 0 | 0 | 20.93 | 21.02 | | 6 | 0 | Seaside | Clatsop | | | 17.2 | 3 |
| US-101 | 0 | 0 | 20.94 | 21.03 | | 6 | 0 | Seaside | Clatsop | | | 17.2 | 3 |
| US-101 | 0 | 0 | 20.95 | 21.04 | 16,100 | 8 | 0 | Seaside | Clatsop | 1ST AVE. | | 21.3 | 3 |
| US-101 | 0 | 0 | 20.96 | 21.05 | | 10 | 0 | Seaside | Clatsop | | 85-89.99% | 43.0 | 3 |
| **US-101** | **0** | 0 | **20.97** | **21.06** | | **11** | **0** | **Seaside** | **Clatsop** | | **90-94.99%** | **45.5** | **3** |
| **US-101** | **0** | 0 | **20.98** | **21.07** | | **11** | **0** | **Seaside** | **Clatsop** | | **90-94.99%** | **45.5** | **3** |
| **US-101** | **0** | 0 | **20.99** | **21.08** | | **11** | **0** | **Seaside** | **Clatsop** | | **90-94.99%** | **45.5** | **3** |
| **US-101** | **0** | 0 | **21** | **21.09** | **16,100** | **11** | **0** | **Seaside** | **Clatsop** | **OCEAN WAY** | **90-94.99%** | **45.5** | **3** |
| **US-101** | **0** | 0 | **21.01** | **21.1** | **16,100** | **12** | **0** | **Seaside** | **Clatsop** | | **90-94.99%** | **46.5** | **3** |
| **US-101** | **0** | 0 | **21.02** | **21.11** | | **12** | **0** | **Seaside** | **Clatsop** | | **90-94.99%** | **48.0** | **3** |
| **US-101** | **0** | 0 | **21.03** | **21.12** | | **13** | **0** | **Seaside** | **Clatsop** | | **90-94.99%** | **49** | **3** |
| **US-101** | **0** | 0 | **21.04** | **21.13** | **16,100** | **14** | **0** | **Seaside** | **Clatsop** | | **90-94.99%** | **49.9** | **3** |
| **US-101** | **0** | 0 | **21.05** | **21.14** | **15,100** | **13** | **0** | **Seaside** | **Clatsop** | **BROADWAY** | **90-94.99%** | **47.8** | **3** |
| US-101 | 0 | 0 | 21.06 | 21.15 | 15,100 | 10 | 0 | Seaside | Clatsop | | | 26.8 | 3 |
| US-101 | 0 | 0 | 21.07 | 21.16 | | 9 | 0 | Seaside | Clatsop | | | 24.2 | 3 |
| US-101 | 0 | 0 | 21.08 | 21.17 | | 10 | 0 | Seaside | Clatsop | STREET | | 25.3 | 3 |
| US-101 | 0 | 0 | 21.09 | 21.18 | | 10 | 0 | Seaside | Clatsop | | | 25.3 | 3 |
| US-101 | 0 | 0 | 21.1 | 21.19 | 15,100 | 10 | 0 | Seaside | Clatsop | AVE. "A" | | 25.3 | 3 |
| US-101 | 0 | 0 | 21.11 | 21.2 | 15,100 | 8 | 0 | Seaside | Clatsop | | | 20.0 | 3 |
| US-101 | 0 | 0 | 21.12 | 21.21 | 15,100 | 7 | 0 | Seaside | Clatsop | | | 17.3 | 3 |
| US-101 | 0 | 0 | 21.13 | 21.22 | 15,100 | 6 | 0 | Seaside | Clatsop | | | 15.9 | 3 |
| US-101 | 0 | 0 | 21.14 | 21.23 | 15,100 | 5 | 0 | Seaside | Clatsop | AVE. "B" | | 14.4 | 3 |
| US-101 | 0 | 0 | 21.15 | 21.24 | 15,100 | 4 | 0 | Seaside | Clatsop | | | 12.8 | 3 |

**FIGURE 5. SAMPLE SPIS REPORT**

More information about current and past years SPIS reports is available on the TRS website

[http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/spis.shtml](http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/spis.shtml)

### 3.1.3 SAFETY INVESTMENT PROGRAM (SIP) FIVE-MILE SEGMENTS

The SIP five-mile segments are another screening tool. Fixed five-mile sections of the state highway system are categorized by the number of fatal and severe injury crashes (injury A) during a three year period. There is no sliding window used to develop the SIP segments. The following is the stratification for SIP categories:

- Category 1: 0 (no) fatal or injury A (serious) crashes;
- Category 2: 1 to 2 fatal or injury A crashes;
- Category 3: 3 to 5 fatal or injury A crashes;
- Category 4: 6 to 9 fatal or injury A crashes; and

- Category 5: 10 or more fatal or injury A crashes.

The SIP category is used mainly when considering safety improvements on preservation projects. A spreadsheet listing 5-mile categories by highway number is available on the TRS Safety Program website.

http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/safety_investment_program.shtml

Maps are also available from the GIS Unit at:

http://www.oregon.gov/ODOT/TD/TDATA/gis/odotmaps.shtml#SPIS_SIP_Maps

### 3.1.4 HIGHWAY INVENTORY REPORTS

The ODOT Integrated Transportation Information System (ITIS) – soon to be ORTRANS -- is a valuable resource for the location of intersections, other features, basic site geometry and other information. Most of these data are routinely accessed by the “State Highway Inventory Reports” interface. These reports are:

- Highway Inventory Summary Report
- Highway Inventory Detail Report
- Lane Report
- Vertical Grade Report
- Horizontal Curve Report
- Pavement Report
- Capacity Report
- Traffic Volumes and Vehicle Classification Report
- Bikeway, Sidewalk & Crosswalk Report

These reports can be accessed in either web-report or Excel versions. In some cases, the investigator is primarily concerned about the location of intersections, ramps, or other facilities.

http://www.oregon.gov/ODOT/TD/TDATA/otms/OTMS_Highway_Reports.shtml

One helpful way to access this information is to use a “straightline chart” which is a linear, graphical representation of much of the ITIS data. For complicated connections and interchanges, the investigator will need to obtain an interchange diagram. These diagrams provide an easy way to identify the complicated numbering of connections and ramps that occur at interchanges. These are needed to extract the appropriate crashes.

http://www.oregon.gov/ODOT/TD/TDATA/rics/PublicRoadsInventory.shtml#Straightline_Charts

An example interchange diagram is shown in Figure 6. To find a crash that happened on connection 1 at the UPRR crossing the following location information would be need:

| | |
|---|---|
| HWY_NO | 005 |
| RDWY_NO | 1 |
| HWY_COMPNT_CD | 6 -- Connection |
| RD_CON_NO | 1 |
| MLGE_TYP_CD | 0 -- Regular |
| MP_NO | 0.74 |

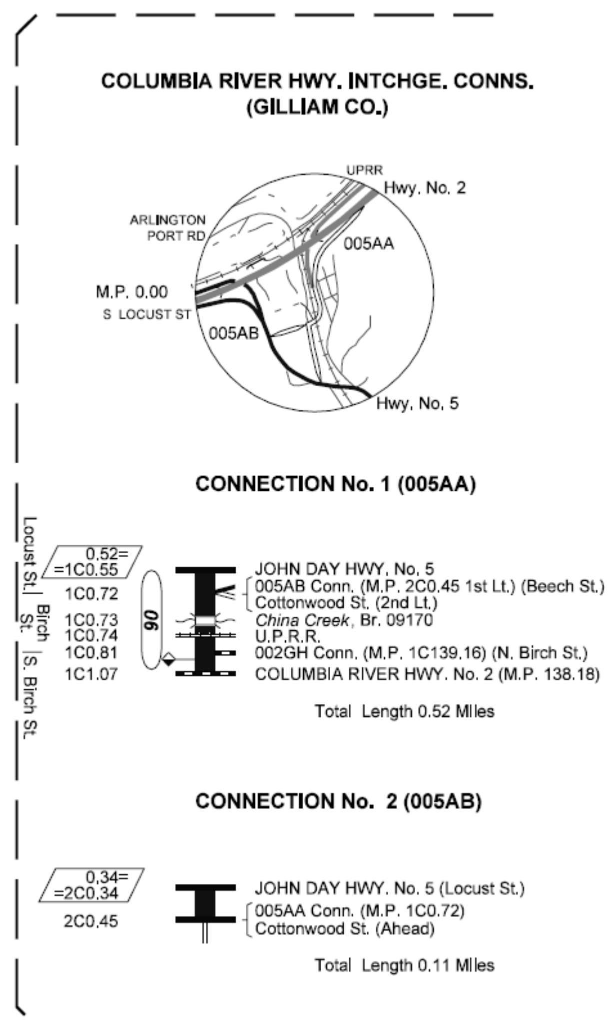



**FIGURE 6. SAMPLE INTERCHANGE DIAGRAM**

### *3.1.5 GOOGLE MAPS*

Good quality aerial photography is available using Google's Map interface. This resource also includes a useful measuring tool. You can add the distance measurement tool at this url:

http://maps.google.com/maps?showlabs=1&ftr=misc.distance.

A small ruler icon should appear in the lower left next to the scale bar. Click that ruler to use the tool. If you have a Google account, you can save this option so that it appears on all maps once you have signed in. In some cases, Microsoft's Bing Maps has better resolution.

### 3.1.6 FACILITY FUNCTIONAL CLASS

The functional class of a highway segment is defined by the amount of traffic and type of access (or service) that a facility provides. All facilities have both urban and rural classifications. The highest class of facility is "Interstate" while the lowest class is "Local". These classifications are defined and maintained by the Road Inventory and Classification Services (RICS) unit of ODOT and are periodically updated. Currently, the state highway system is classified as one the following:

- Rural interstate
- Rural other principal arterial
- Rural minor arterial
- Rural major collector
- Rural minor collector
- Rural local
- Urban interstate
- Urban other freeways and expressway
- Urban other principal arterial
- Urban minor arterial
- Urban collector
- Urban local

By defining the functional class of a highway segment, the investigator will be able to draw comparisons between the highway under investigation and all other similar highways. A current list of all highways and their classification can be found at:

http://www.oregon.gov/ODOT/TD/TDATA/rics/FunctionalClassification.shtml

### 3.1.7 TRAFFIC VOLUMES

Traffic volumes are a key input in the safety investigations process. Fortunately, the Transportation Systems Monitoring (TSM) Unit collects and reports traffic volumes in an accessible format. Volumes are available by highway and milepost on the TSM website:

http://www.oregon.gov/ODOT/TD/TDATA/tsm/tvt.shtml

#### 3.1.8 DIGITAL VIDEO LOG

The Digital Video Log (DVL) is the online record of digital images from the driver's perspective for every 0.01 of mile. The recent video logs also include images that allow roadside features to be viewed. The highway can be viewed in both increasing and decreasing mileposts. Past year logs are also available. These past year logs can be helpful to review the location for consistency. The DVL can be accessed internally at

http://rssa.odot.state.or.us/cf/dvl/

#### 3.1.9 WEB TRANSGIS

Web TransGIS is an online mapping tool that provides access to many of the ODOT management systems (bridge, congestion, pavement, safety) as well as customized interfaces for other data (traffic, environmental, freight, railroad crossing, and others). The tool is designed for all skill levels and has an easy to learn interface. Tutorials are also available. Figure 7 shows a screenshot of the TransGIS Safety interface. The main advantage of the tool is the ability to display and interact with data and to see its spatial relationship to other features. In addition, local city street networks, aerial photography, digital relief backgrounds and other useful layers are available.

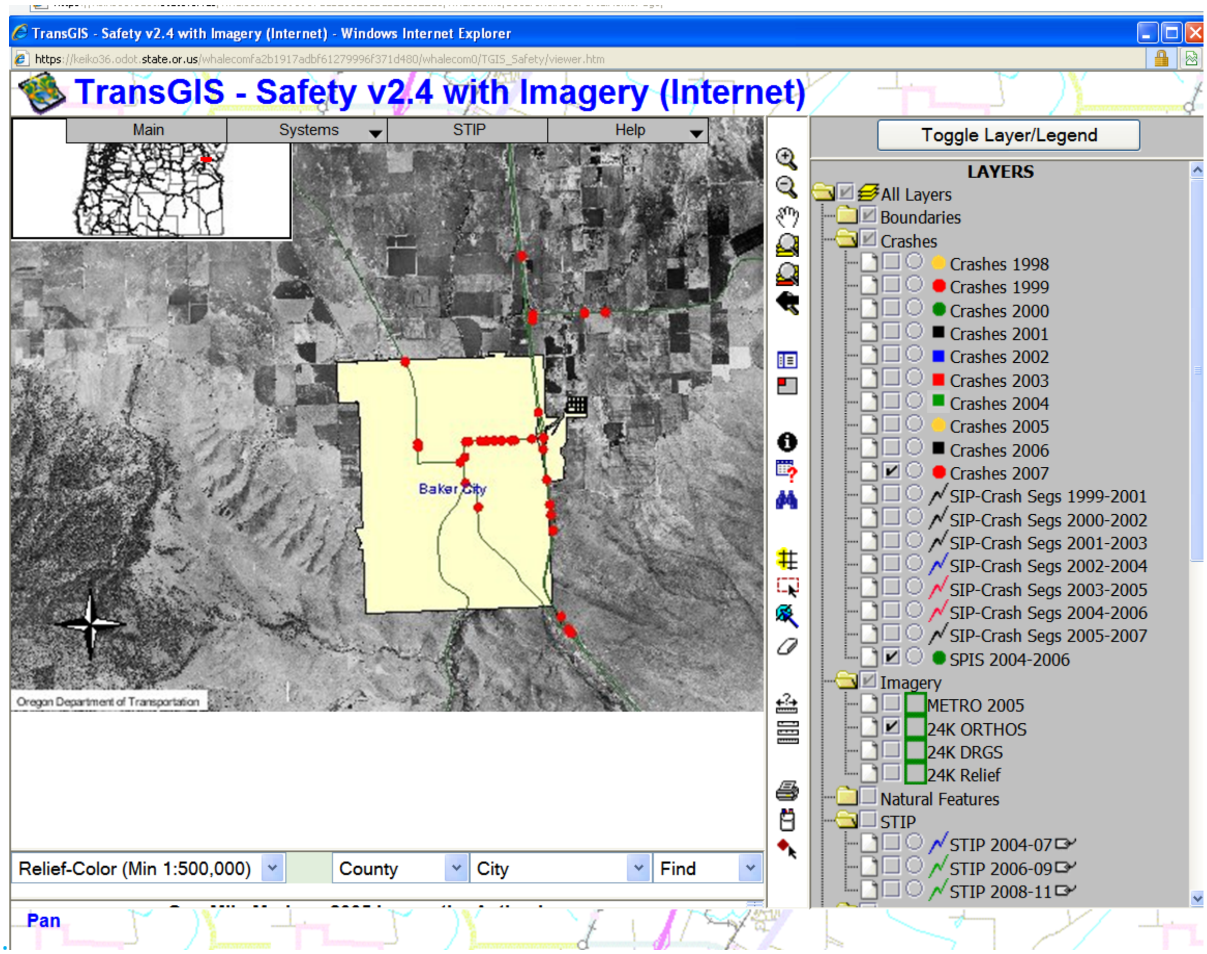



**FIGURE 7. TRANSGIS**

The TransGIS portal can be accessed via the following link

[https://keiko36.odot.state.or.us/](https://keiko36.odot.state.or.us/)

### *3.1.10 Traffic Signal Timing Information*

There is no central resource for this information. In order to obtain current timing information the investigator will need to contact the Region traffic offices.

### *3.1.11 As Built Plans*

If plan-level detail is needed, it may be possible to obtain a set of as-built roadway plans. This is especially true if there has been a recent project that has been constructed. The investigator should check with the appropriate Technical Services center in each region and possibly with the Map and Plans Center in Salem at (503) 986-3792 to see if a plan set exists.

#### *3.1.12 OTHER SOURCES*

There are a variety of "other" data sources that may be useful for the investigator to obtain:

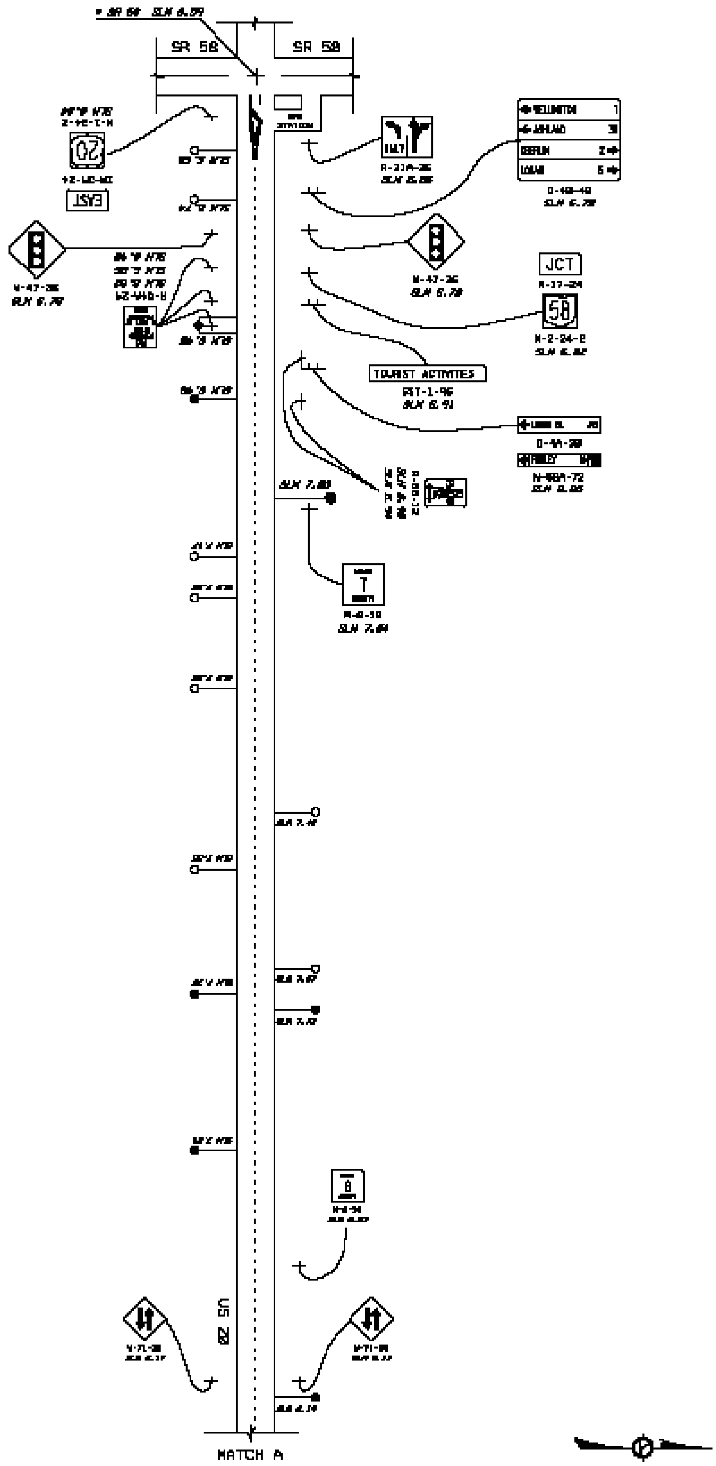
- Recent and past newspaper or other media related to the location
- Local police agency input and or reports
- Maintenance records or input
- Anecdotal information for "locals"

## 3.2 FIELD DATA

Though in-office data is invaluable for determining historic trends and conditions at a site, a safety assessment must include a site investigation (see Chapter 5 for more detail about site investigations and companion data to collect). There is a wide variety of field data that may be acquired during a site visit, but consistent documentation of site characteristics is critical. Chapter 5 addresses the various data elements that can and should be collected in the field; however, a standard source for documenting the location, orientation, and placement of field data is through the creation of a condition diagram (see Figure 8 for one example).

The condition diagram does not have to be drawn to scale, but should always include the following basic information:

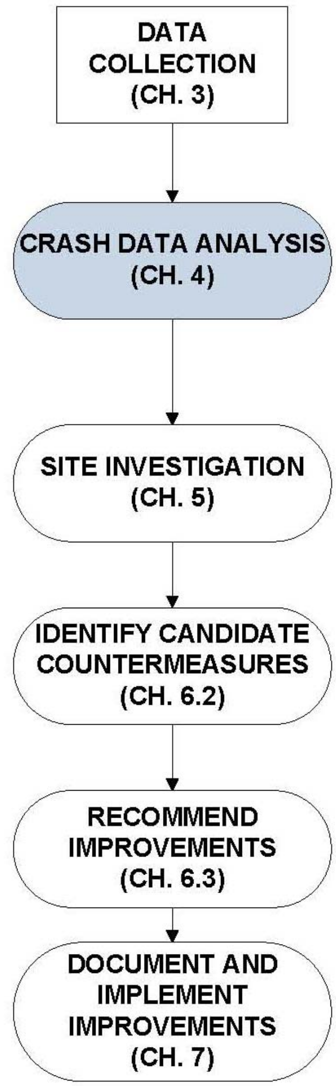
- North Arrow;
- Road Name;
- Drawing of location complete with dimensions. This includes road, curb or shoulder, sidewalks, ditches, walls, etc.;
- Traffic control devices (marking, signage, signals) and their relative placement;
- Adjacent land use;
- Type of pavement;
- Date of site visit; and
- Site investigator name.




*Source: Ohio DOT, 2002*

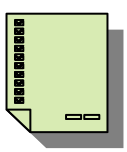
**FIGURE 8. EXAMPLE CONDITION DIAGRAM**

# 4 DIAGNOSING CRASH PATTERNS




The primary goal of a safety investigation is to diagnose the safety problem at the selected location and recommend improvements. These recommendations are based on a detailed review of in-office data, field reviews, and other input. This investigation process has an element of detective work and requires putting together information that is, at times, incomplete. While crash data is not the only input to this process, it is generally the starting point for investigations. As stated in the safety investigations basics, our investigative efforts are searching for a pattern of crashes that is "out of the ordinary." The purpose of this chapter is to document a methodology that can be used to help uncover unusual crash patterns. The general process for this crash data analysis is demonstrated in the flowchart shown in Figure 9.

## 4.1 CRASH PATTERN WORKSHEET



To assist the investigator in diagnostic efforts, a pattern diagnostic worksheet has been created. This worksheet is based on the direct diagnostics work by Kononov and Janson (2002). They argue that an overrepresentation of one type of crash relative to other crash types is a better indicator of possible improvements than a high frequency relative to other locations. For example, a high proportion of fixed-object crashes relative to all crashes on a highway segment might mean the location is a good candidate for shoulder rumble strips or enhanced delineation.

The strength of this approach is that the investigator compares the location under investigation to an average of similar locations. In doing this, the investigator can contrast the observed crash patterns at the location to what is "typical." Any unusual patterns are easily highlighted and can be the basis for more investigation. Each parameter is tested separately. These unusual crash types can also be explored in the field visits. The ability to contrast crash frequency, crash severity, crash rates, and similar metrics creates a basis for justification resulting from engineering judgment when a conventional crash rate analysis does not provide the same focus as these alternative crash statistics.

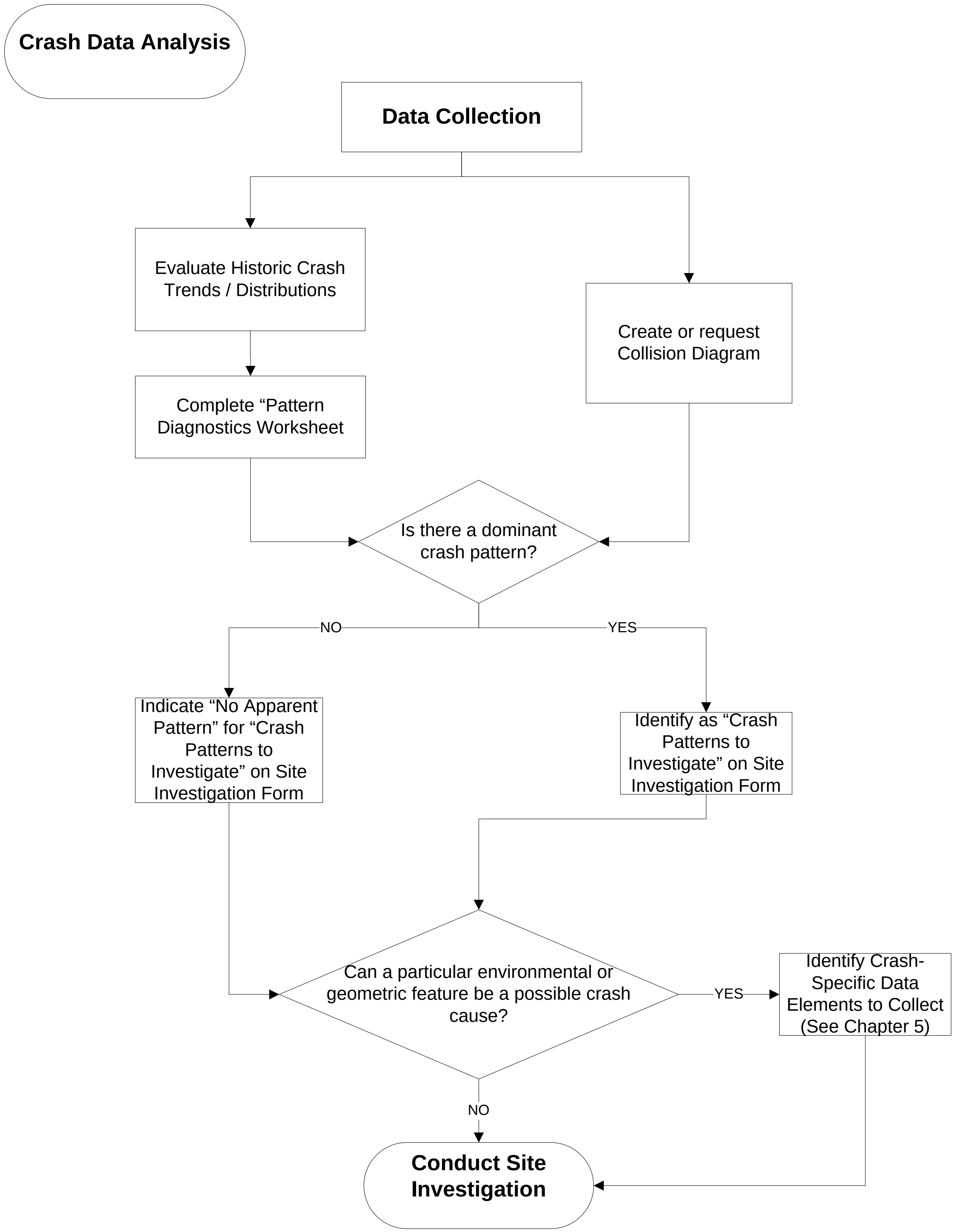



**FIGURE 9. FLOWCHART OF PROCEDURE TO ANALYZE CRASH DATA**

To do this, a tabulation of typical distributions for various crash classifications has been developed. These tabulations are developed separately for segments (by functional class) and intersections (by urban/rural, configuration, and traffic control) for all highway crashes. The worksheet already contains these distributions. These expected proportions were generated for segments: by considering all state highway crashes for a five-year period (2003-2007) and for intersections by randomly selecting intersections in each of the four categories (this work is summarized in ODOT Research Report SPR 667).

The method calculates the probability that an observed percentage of a crash classification will exceed the average percentage distribution for a similar facility. For example, say there have been 20 rear-end crashes out of 61 total crashes observed at a location that is a rural principal arterial. The question for the investigator should be is it "normal" to have 32.8% (20/61) of the total crashes be rear-end?

The probability that this proportion is "typical" can be calculated assuming crashes are Bernoulli trials with the following formula (for use in spreadsheet calculations presented later):

$$P(X \geq x) = 1 - \sum_{i=0}^{x-1} \frac{n!}{(n-i)!\,i!} p^i (1-p_i)^{n-i}$$ , where

x = the observed count of the crash type to test

n= total number of crash types at the location

p = the expected proportion of the crash types

In the above example, the observed percentage is 32.8% (20/61). All rural principal arterials had 18.9% rear-end crashes. Thus the calculation determines how likely is 32.8% rear-end crashes if the average of all rural principal arterials is 18.9%. Using the formula, the probability of observing these 20/61 rear-ends crashes at a "normal" rural principal arterial section is:

$$P(X \geq x) = 1 - \sum_{i=0}^{20-1} \frac{61!}{(61-i)!\,i!} 0.189^i (1-0.189)^{61-i} = 0.007$$ , or 0.7%

In other words, there is a very small chance that this proportion, 20/61, would be observed at a "typical" location and so can this value (32.8%) is considered unusual.

### *4.1.1 Using the Patterns Worksheet*

Despite the perceived complexity, the crash pattern worksheet essentially compares the proportions of various crash variables for the study location versus long-run averages for similar sites. For example, if the study site has 10% head-on crashes while all other sites have an average of 3.8% head-on crashes it will likely be flagged as "unusual." The primary advantage of the worksheet is the tabulation of these averages in a useable format and the fact that the tabulations of the crash data has been completely automated for the investigator.

Investigators need only complete information on the sheet labeled "COVER" and "DATA ENTRY" fields shaded yellow, then copy in the PRC crash data to use the patterns worksheets.

#### 4.1.1.1 COVER SHEET

There will be 2 worksheets: one for segments and one for intersections. This form involves many calculations and is intended as an electronic form. The general directions are below:

The header portion of the worksheet is the summary information that the investigator should have readily on hand prior to completing the remainder of the worksheet.

The investigator should complete the information that defines the location for investigation on the "COVER SHEET" tab. A critical selection to using the worksheets requires the investigator to select the appropriate "Location Type" from the drop down selection. When "Segment" is selected, a warning message will appear on the "PATTERNS_INTER" worksheet reminding the investigator to use the "PATTERNS_SEG" worksheet. Next, the investigator should complete the yellow-shaded cells information in either the "SEGMENT and CRASH DATA MPs" or the "INTERSECTION." The selection here controls which of the expected proportions will populate the worksheet.

#### 4.1.1.2 DATA ENTRY

1. Crash data and other information is entered in the "DATA ENTRY" tab. Tabulation of the crash data is automated. To enter the data complete these steps:
    a. Download the PRC Report in Excel Format (must use Internet Explorer).
    b. Copy the entire PRC report by selecting the entire sheet and using either CTRL-C or the COPY option in Excel.
    c. Select the "PRC_RAWDATA" tab in the SIM Worksheet.
    d. Move the Excel selection box to cell A1 in the "PRC RAWDATA" sheet.
    e. Paste the PRC data in cell A1.
    f. Return to the "DATA ENTRY" tab in the SIM Worksheet.

g. Click the "Extract Raw Data" button to the right.

h. Answer the prompts and the PRC report will be summarized in pink cells below. Note that the light Blue cells are sums.

2. Complete the cells in YELLOW (must be completed by investigator). Enter the date range of the crash data (MM/DD/YYY). Enter the TRAFFIC VOL. - MAJ ADT and TRAFFIC VOL. - MIN ADT for as many years as you have data. The counts will be averaged for use in the rate calculations. If you do not know the volume, leave the cell blank. The three most recent years of traffic volumes are needed for the crash rate calculation. This data can be obtained where described as follows:

   - Segments: If the segment spans multiple AADT ranges, compute a weighted average of the ADT. A weighted average of AADT can be calculated using the length and ADT values. For example, if a 2 mile section has an ADT of 5,000 and a 1 mile section has an ADT of 6,000 the weighted average is (2 x 5000 + 1 x6000)/ (2+1) = 5,333 ADT.

   - Intersections: Be sure to calculate the entering volume. Minor street volume may be difficult to obtain and may require contacting the local jurisdictions.

3. If you are entering data manually, enter the counts of the observed crash data in the PINK cells. There are checks listed in column I to make sure that you have entered the proper counts.

4. Next, select the worksheet tab for the appropriate facility (either “PATTERNS_SEGS” for segments or “PATTERNS_INTER” for intersections). NOTE – both tabs will be completed automatically though only one will actually be relevant for your facility type.

A sample of the PATTERNS_SEGS worksheet (from the Appendix Case Studies) is shown in Figure 10.

**OREGON DEPARTMENT OF TRANSPORTATION**
**SAFETY INVESTIGATIONS MANUAL**
**CRASH PATTERN WORKSHEET - SEGMENTS**

| | | | |
|---|---|---|---|
| Prepared By: | KM | Title: | OFFICE INVESTIGATOR |
| Investigation Name: | SANTIAM HWY MP 78.41 SPIS | Region: 2 | District: 3 |
| Route Number: | US-20 | Hwy Name: SANTIAM | MP From: 78.41 to 78.59 |
| Road Character: | RURAL | Facility Type: RURAL PRINCIPAL ARTERIAL | Date Compiled: 8/30/2005 |
| County: | LINN | City: | Crash Date From: 1/1/2003 to 12/31/2007 |

**CRASH TOTALS**

| Severity | *Crash* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| Fatal+ Inj A | 3 | 30.0% | 8.2% | **4.3%** |
| Injury B+C | 3 | 30.0% | 41.4% | 85.4% |
| PDO | 4 | 40.0% | 50.4% | 83.5% |
| | 10 | 100.0% | 100.0% | |

**CRASH PATTERNS**

| Collision Type (All) | *Crash* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| Angle | 0 | 0.0% | 3.3% | |
| Head-on | 1 | 10.0% | 3.8% | 32.2% |
| Rear | 0 | 0.0% | 18.9% | |
| Sideswipe-Meet | 2 | 20.0% | 3.5% | **4.5%** |
| Sideswipe-Over | 1 | 10.0% | 2.8% | 24.6% |
| Turn | 0 | 0.0% | 13.2% | |
| Parked | 0 | 0.0% | 0.3% | |
| NonCollision | 2 | 20.0% | 7.0% | 15.3% |
| Backing | 0 | 0.0% | 0.3% | |
| Pedestrian | 0 | 0.0% | 0.5% | |
| Fixed Object | 4 | 40.0% | 38.3% | 57.4% |
| Other | 0 | 0.0% | 8.0% | |
| | 10 | 100% | 100% | |

| Collision Type (F+A) | *Crash* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| Angle | 0 | 0.0% | 2.2% | |
| Head-on | 1 | 33.3% | 16.5% | 41.7% |
| Rear | 0 | 0.0% | 7.0% | |
| Sideswipe-Meet | 2 | 66.7% | 5.5% | **0.9%** |
| Sideswipe-Over | 0 | 0.0% | 0.7% | |
| Turn | 0 | 0.0% | 14.3% | |
| Parked | 0 | 0.0% | 0.0% | |
| NonCollision | 0 | 0.0% | 8.1% | |
| Backing | 0 | 0.0% | 0.0% | |
| Pedestrian | 0 | 0.0% | 3.3% | |
| Fixed Object | 0 | 0.0% | 39.2% | |
| Other | 0 | 0.0% | 3.3% | |
| | 3 | 100% | 100% | |

| Number of Veh. | *Crash* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| Multiple Vehicle | 5 | 50.0% | 47.9% | 57.0% |
| Single | 5 | 50.0% | 52.1% | 67.4% |
| | 10 | 100% | 100% | |

| Residence of Driver | *Drivers* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| Non-resident | 0 | 0.0% | 12.7% | |
| Local | 2 | 13.3% | 55.6% | 100.0% |
| In-state resident | 13 | 86.7% | 29.2% | **0.0%** |
| Not Stated | 0 | 0.0% | 2.6% | |
| | 15 | 100% | 100% | |

| Sex of Driver | *Drivers* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| Male | 4 | 26.7% | 64.7% | 99.9% |
| Female | 11 | 73.3% | 34.1% | **0.2%** |
| Not Stated | 0 | 0.0% | 1.2% | |
| | 15 | 100% | 100% | |

| Time | *Crash* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| 12 -3 AM | 0 | 0.0% | 3.6% | |
| 3 -6 AM | 0 | 0.0% | 4.6% | |
| 6 -9 AM | 0 | 0.0% | 14.8% | |
| 9-Noon | 4 | 40.0% | 15.4% | 5.5% |
| 12-3 PM | 3 | 30.0% | 18.2% | 26.9% |
| 3 -6 PM | 2 | 20.0% | 21.5% | 66.9% |
| 6-9 PM | 1 | 10.0% | 12.6% | 73.9% |
| 9-Mid | 0 | 0.0% | 8.1% | |
| UNKNOWN | 0 | 0.0% | 1.1% | |
| | 10 | 100% | 100% | |

| Light Conditioi | *Crash* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| DAWN | 0 | 0.0% | 4.1% | |
| DAY | 8 | 80.0% | 64.1% | 24.3% |
| DLIT | 0 | 0.0% | 2.6% | |
| DARK | 1 | 10.0% | 26.1% | 95.1% |
| DUSK | 1 | 10.0% | 2.8% | 24.9% |
| UNK | 0 | 0.0% | 0.3% | |
| | 10 | 100% | 100% | |

| Surface Cond. | *Crash* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| DRY | 1 | 10.0% | 53.4% | 100.0% |
| ICE | 5 | 50.0% | 22.2% | **5.0%** |
| WET | 4 | 40.0% | 18.7% | 10.0% |
| SNOW | 0 | 0.0% | 4.3% | |
| UNK | 0 | 0.0% | 1.4% | |
| Total | 10 | 100% | 100% | |

| Weekday | *Crash* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| Sunday | 3 | 30.0% | 13.6% | 14.5% |
| Monday | 2 | 20.0% | 14.8% | 44.8% |
| Tuesday | 0 | 0.0% | 12.6% | |
| Wednesday | 1 | 10.0% | 13.9% | 77.6% |
| Thursday | 1 | 10.0% | 14.0% | 77.9% |
| Friday | 1 | 10.0% | 17.9% | 86.1% |
| Saturday | 2 | 20.0% | 13.2% | 38.8% |
| | 10 | 100% | 100% | |

| Driver Age | *Drivers* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| <14 | 0 | 0.0% | 0.0% | |
| 15-18 | 1 | 6.7% | 5.9% | 59.5% |
| 19-21 | 3 | 20.0% | 8.1% | 11.6% |
| 22-24 | 2 | 13.3% | 6.4% | 24.8% |
| 25-34 | 3 | 20.0% | 15.5% | 41.6% |
| 35-44 | 2 | 13.3% | 15.4% | 69.6% |
| 45-54 | 2 | 13.3% | 17.5% | 76.7% |
| 55-64 | 2 | 13.3% | 14.5% | 66.3% |
| 65-74 | 0 | 0.0% | 7.3% | |
| >75 | 0 | 0.0% | 4.6% | |
| Not Stated | 0 | 0.0% | 4.8% | |
| | 15 | 100% | 100% | |

**TRAFFIC VOLUM** 5,600 *ADT (average )*

| RATES Severity | Invs. Rate | Peer Rate | Critical Rate | Flag? |
|---|---|---|---|---|
| All Crashes | 5.44 | 0.72 | 1.21 | **YES** |

| On Roadway | *Crashes* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| Intersection | 0 | 0.0% | 16.4% | |
| Alley | 0 | 0.0% | 4.7% | |
| Straight | 0 | 0.0% | 26.0% | |
| Transition | 0 | 0.0% | 0.2% | |
| Curve | 2 | 20.0% | 4.9% | 8.3% |
| Open Access | 0 | 0.0% | 0.3% | |
| Grade | 3 | 30.0% | 3.2% | **0.3%** |
| Bridge | 0 | 0.0% | 0.3% | |
| Tunnel | 0 | 0.0% | 0.0% | |
| Unknown | 0 | 0.0% | 0.0% | |
| | 5 | 50% | 56% | |

| Off Roadway | *Crashes* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| Intersection | 0 | 0.0% | 1.6% | |
| Alley | 0 | 0.0% | 0.3% | |
| Straight | 0 | 0.0% | 22.4% | |
| Transition | 0 | 0.0% | 0.1% | |
| Curve | 5 | 50.0% | 13.7% | **0.7%** |
| Open Access | 0 | 0.0% | 0.1% | |
| Grade | 0 | 0.0% | 5.1% | |
| Bridge | 0 | 0.0% | 0.6% | |
| Tunnel | 0 | 0.0% | 0.1% | |
| Unknown | 0 | 0.0% | 0.0% | |
| | 5 | 50% | 44% | |

| Cause Codes | *Drivers* | *Obs %* | *Ex %* | *P(Norm)* |
|---|---|---|---|---|
| TOO-CLOS | 0 | 0.0% | 10.5% | |
| TOO-FAST | 8 | 50.0% | 30.4% | 8.0% |
| NO-YIELD | 0 | 0.0% | 9.8% | |
| OTHR-IMP | 4 | 25.0% | 15.9% | 24.2% |
| IMP LN C | 0 | 0.0% | 1.0% | |
| INATTENT | 1 | 6.3% | 3.9% | 47.0% |
| DIS--RAG | 0 | 0.0% | 0.5% | |
| IMP-TURN | 0 | 0.0% | 2.1% | |
| OTHER | 0 | 0.0% | 6.3% | |
| CARELESS | 1 | 6.3% | 3.7% | 45.2% |
| FATIGUE | 0 | 0.0% | 4.1% | |
| LEFT-CTR | 2 | 12.5% | 3.0% | 8.4% |
| SPEED | 0 | 0.0% | 1.8% | |
| PHANTOM | 0 | 0.0% | 1.6% | |
| IMP-OVER | 0 | 0.0% | 2.1% | |
| RECKLESS | 0 | 0.0% | 0.8% | |
| PAS-STOP | 0 | 0.0% | 0.7% | |
| IN RDWY | 0 | 0.0% | 0.3% | |
| MECH-DEF | 0 | 0.0% | 0.9% | |
| LOADSHFT | 0 | 0.0% | 0.3% | |
| NT VISBL | 0 | 0.0% | 0.2% | |
| DIS TCD | 0 | 0.0% | 0.0% | |
| WRNG WAY | 0 | 0.0% | 0.0% | |
| IMP PKNG | 0 | 0.0% | 0.1% | |
| | 16 | 100% | 100% | |

**FIGURE 10. CRASH PATTERN WORKSHEET**

### 4.1.2 INTERPRETING THE CRASH PATTERNS

The worksheets calculate the probability that the observed proportion is “normal” in the *P(Norm)* column. A screen shot of the worksheet is shown in Figure 10 for segments. Probabilities less than 5% (chosen as the threshold) are conditionally formatted bold and grey. This threshold has been set based on experience but should not be considered an absolute value. These crash parameters should be considered for further investigation.

In Figure 10, a number of different crash trends are highlighted in grey (PNorm is less than 5%) as being potentially unusual:

- Fatal+ Inj A crashes
- Collision types (all): Sideswipe-Meet)
- Collision types (Fatal and Inj A): Sideswipe-Meet
- In-state resident drivers
- Female drivers
- Lighting: DUSK
- Surface conditions: ICE
- Curve –Off Roadway
- Grade – On Roadway

The worksheet can also be used to examine patterns that are close, but are not less than the 5% threshold. These patterns could also be potentially useful to an investigator. In Figure 10, these patterns are:

- Time period – 9-AM Noon
- Day of the Week: Sunday
- Driver age groups: 19-21;
- Surface conditions: ICE and WET
- Cause code: TOO FAST and LEFT of CENTER

A short description of the “clues” offered by overrepresentation of each category or pattern is provided below. These are not meant to be exhaustive but rather illustrative of use of the worksheet to interpret potential causes.

#### 4.1.2.1 CRASH TOTALS BY SEVERITY

If one or more severity groupings are overrepresented, the investigator should look in-depth at these crash types.

#### 4.1.2.2 COLLISION TYPES (ALL AND FATAL AND INJURY A)

If one or more severity groupings are overrepresented, the investigator should look in-depth at these crash types. The collision type is often a good indication of crash contributing factors. In many locations, there are not enough fatal and injury A crashes to test for overrepresentation by type. Note that for Rural 3-Leg Signalized and Urban 4-Leg Unsignalized intersections, there were insufficient Fatal and Injury A crashes to develop patterns by collision types.

#### 4.1.2.3 NUMBER OF VEHICLES INVOLVED

Single vehicle crashes will be related to fixed-object or non-collision crash types, while multiple vehicle crashes are head-on or intersection-related.

#### 4.1.2.4 TIME OF DAY

These patterns normally follow traffic volumes (with a majority in the afternoon peak period (3-6 p.m.). If a particular time period is identified, the investigator could consider possible relationships to congestion), significant traffic generators (e.g. a school), or perhaps sun-glare conditions.

#### 4.1.2.5 LIGHT CONDITIONS

Typically, the investigator is interested in determining whether the crashes at the investigation location are overrepresented in dark conditions. This may guide the investigator to conduct further investigations or field studies related to lighting.

#### 4.1.2.6 SURFACE CONDITIONS

The investigator may be primarily interested in identifying locations with an unusual amount of wet or snow/ice crashes. An overrepresentation of wet crashes may indicate pavement friction or drainage issues. An overrepresentation of snow/ice crashes may indicate a possible driver awareness issue. The investigator should keep in mind that the proportions are for a statewide average – locations with more winter weather may be different. Further field studies may be needed.

#### 4.1.2.7 DAY OF WEEK

Like the time-of-day summary, the investigator should consider possible relationships to key traffic generators (e.g. recreational route, school). Patterns usually follow traffic volumes, so Saturday or Sunday flagged time periods may indicate recreational or shopping generator influences.

#### 4.1.2.8 AGE OF DRIVER

An overrepresented age group is likely related to a nearby traffic generator (e.g. school). The investigator should consider the possible relationship to other causal factors if one age group is overrepresented.

#### 4.1.2.9 RESIDENCE OF DRIVER

The investigator may be primarily looking to determine if non-local drivers were overrepresented, indicating that driver expectancy or other unfamiliar situations might be contributing factors to the crash patterns.

#### 4.1.2.10 GENDER OF DRIVER

It is not likely that an overrepresentation by gender is useful for crash diagnostic purposes. However, an overrepresentation may be related to a nearby traffic generator and could be useful for non-engineering countermeasures.

#### 4.1.2.11 ROAD CHARACTERISTICS

This information is summarized separately for on-road and off-road crashes. The total between on and off road adds to the total number of crashes. On or off roadway is defined by the location of the harmful event. For example, if the crash involved a fixed-object as the first harmful event, the road characteristics will be considered off-road. The characteristic refers to the general location of the crash (e.g. curve, bridge, intersection, etc.). Overrepresented crash types here would be a clue for the investigator about what crashes on the collision diagram may need further review.

#### 4.1.2.12 CAUSE

For each crash record, several possible crash contributing factors may be listed. A detailed list of these potential causes is provided in the crash coding manual. These cause codes are another indication of potential crash causations. These codes often are correlated with other data already summarized (rear-end crashes often get coded as “Too Closely” or “Too Fast”). The proportions for these cause codes were generated considering all three possible codes for each crash. For that reason, the total cause errors will not match the total crash counts.

### *4.1.3 LIMITATIONS OF THE PATTERNS WORKSHEET*

Because this worksheet tests whether a particular distribution of crashes is different, crash locations with a small number of crashes will not be easily tested with this worksheet. It is recommended that a minimum of 10 crashes should be observed before using this worksheet. Caution should also be used for pattern categories that have few crashes (for example if there less than five fatal and injury A crashes, analysis of the patterns is not that useful).

Another issue is that for long analysis segments, an unusual crash pattern might be disguised in an overrepresented crash type in an isolated area. The investigator should always use the collision diagram to help evaluate these isolated locations.

### *4.1.4 Crash Rates*

The pattern worksheet also calculates the crash rate for total crashes. For comparison purposes, the peer rate for similar facilities is used to calculate the critical crash rate. The critical rate is calculated as:

$R_C = R_A + K\sqrt{\frac{R_A}{M}} + \frac{1}{2M}$, where

$R_C$ = critical rate

$R_A$ = the average rate for similar facility

K = probability constant based on desired level of significance (1.645 for 95%)

M = millions of VMT or entering vehicles

If the crash rate at the study location exceeds the critical rate, it is flagged. The investigator can use this as an indication to whether the location is exceeding average crash patterns as compared to other facilities. Peer rates can be found in the Crash Rate Summary book published annually by CAR and they are included in the worksheet as a look-up function.

Example:

If we observed 40 crashes on a 17.5 mile segment in one year with an ADT of 5,000, does the observed rate exceed the critical rate at 95% confidence if the average rate for similar segments is 1.02 crashes per MVMT?

$$Observed\_Rate = \frac{40 * 1{,}000{,}000}{5{,}000(1 * 365)(17.5)} = 1.25C / MVMT$$

$$M = \frac{5{,}000(1 * 365)(17.5)}{1{,}000{,}000} = 31.94$$

$$R_C = 1.02 + 1.645\sqrt{\frac{1.02}{31.94}} + \frac{1}{2 * (31.94)} = 1.33C / MVMT$$

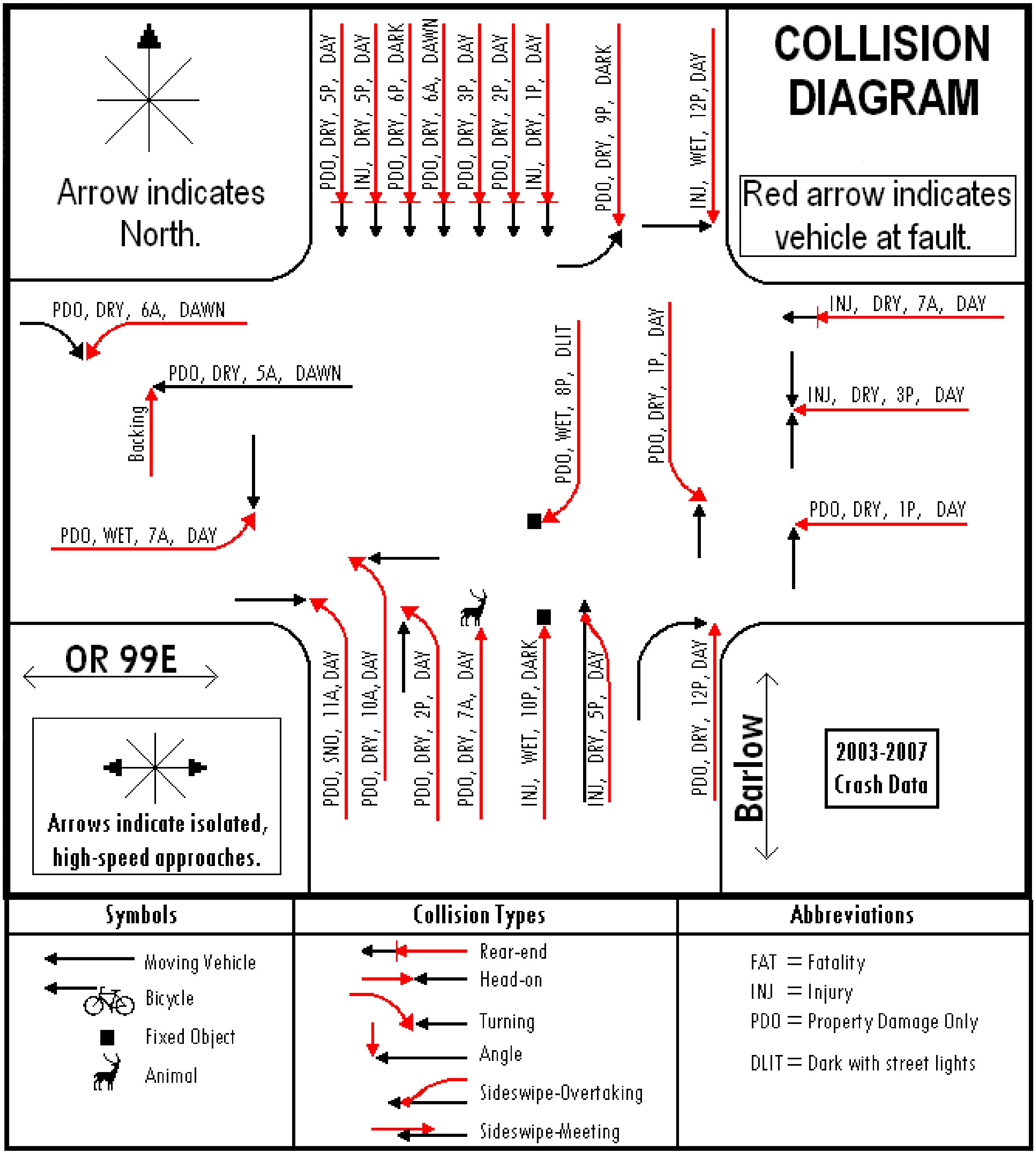
No, it does not exceed the critical rate. The observed rate, 1.25 crashes per MVMT is less than the critical rate 1.33 crashes per MVMT.

## 4.2 Collision Diagrams

In addition to patterns of crash by type, it is also important to consider the spatial patterns of the crashes. One common and easy way to do this is to construct a collision diagram. A collision diagram is a schematic representation of all crashes occurring on a simple plan view at a given location. A sample collision diagram for an intersection is shown in Figure 11.

Collision diagrams are generally not drawn to scale. Crashes are placed in the general location of a crash and arranged in groups of various crash types. Arrows are used to show the paths of vehicles and symbols are used to convey other information such as crash type, injury severity, and other parameters. Each collision at the site is represented by a set of arrows -- one for each vehicle or pedestrian involved. Text notations are used to indicate other information such as the date and time, environmental conditions, and other parameters. In general, at least 3 years of crash data should be used. It is also helpful to include a summary table on the diagram.

A collision diagram is useful because it is a graphical representation of crash patterns and this format allows for easy interpretation. In the sample Figure 11, it is clear that the southbound crashes are primarily rear-end crashes and this trend does not occur on the other intersection approaches.




Collision Diagram showing five years of crash data. Include severity, pavement conditions, time of day, and light conditions. Indicate vehicle at fault with red arrow. Include description of symbols/abbreviations.

**FIGURE 11. SAMPLE COLLISION DIAGRAM**

Currently, there are three methods for which the investigator can obtain a collision diagram:

- If there are relatively few crashes, a diagram may be drawn by hand. Some simple templates are provided in the Appendix
- Request from CAR (until automated collision diagramming is available); or
- Use the Crash Magic software (purchased by TRS).

## 4.3 GIS Pin Maps or Spot Maps

For long corridors or larger areas, a collision diagram is not that useful because it is hard to examine detailed crash information for a larger area (particularly on one drawing). A GIS map is another possible tool to see a spatial relationship between crash variables and other information. A sample map is shown in Figure 12 which shows crashes with parked vehicles on the freeway. Color coding indicates crash severity and shoulder width. A map such as the one shown in the figure could be created by contacting the GIS unit with a specific request. For simple maps, the TransGIS tool may be sufficient. This is located at the following web address:

https://keiko36.odot.state.or.us/

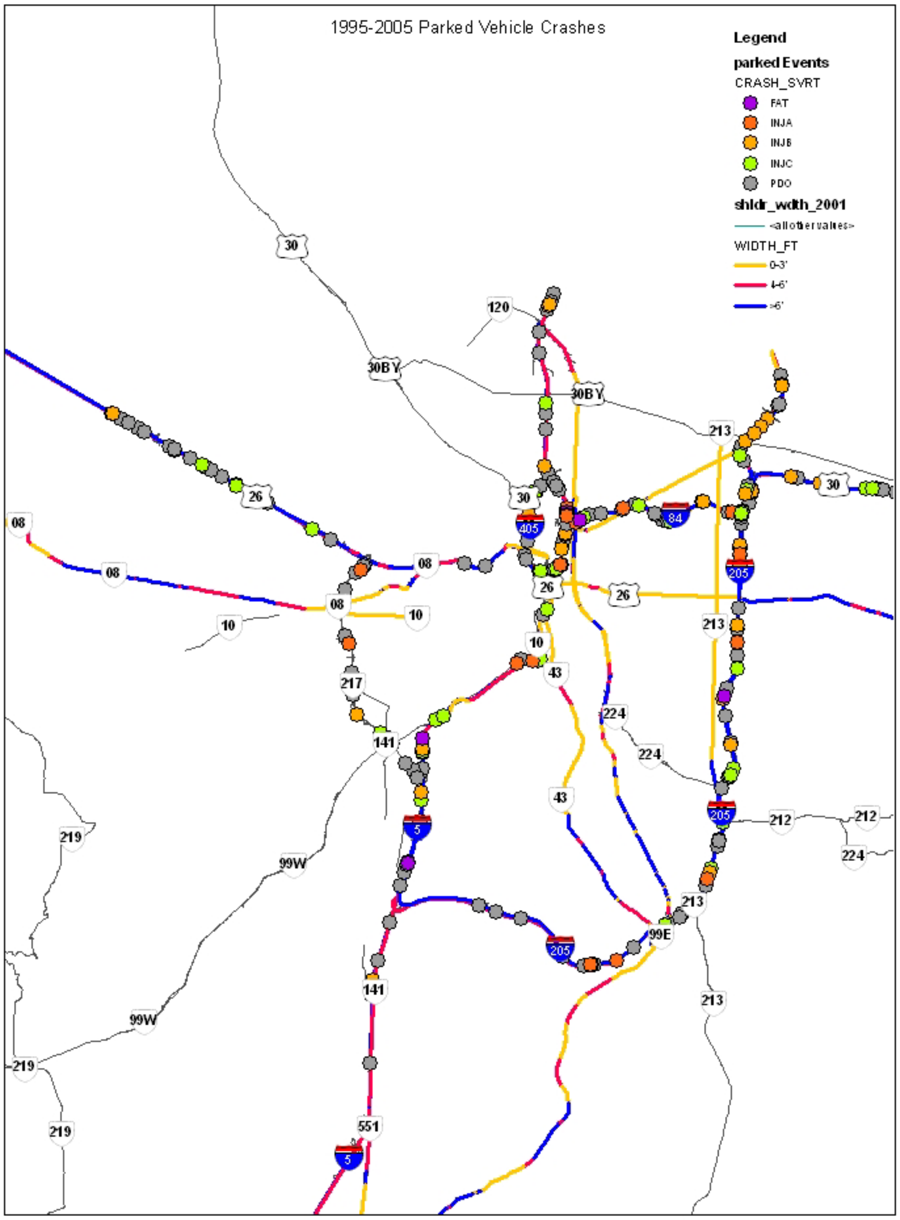
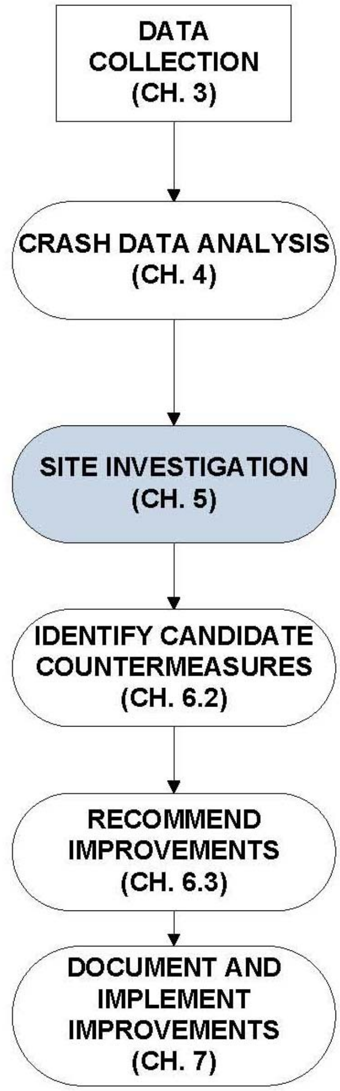



**FIGURE 12. SAMPLE GIS MAP**

# 5 SITE INVESTIGATIONS

A site investigation is an essential component of a safety assessment. The site investigation includes an evaluation of physical road and roadside conditions, prevailing traffic conditions, and road user characteristics. To perform a successful site investigation, it is important that the data collection team members are safe and do not inadvertently alter the normal traffic operations or patterns. At some locations, a set of general data elements is required; however, it is also important for the investigator to identify unique site characteristics and acquire sufficient data that will enable the diagnosis of problems at a road segment or intersection. Extra data that does not directly address the observed historic crash patterns, however, is not cost effective or necessary. In some cases the historic crash data may be typical for the site conditions (such as rear-end crashes at signalized intersection locations) and a site investigation would potentially not be required unless crash statistics show an unexpected trend. This chapter provides guidance to the site investigator as to how to perform a site investigation, document these findings, and ultimately use this data for countermeasure evaluation. Figure 13 depicts the basic procedure for performing site investigations.




## 5.1 SAFE DATA COLLECTION PROCEDURES WITHOUT INFLUENCING OPERATIONS

A high crash location can be a challenging site for field data collection. Much of the required data can be collected from a roadside location such as a corner parking lot or an elevated location overlooking the site. Site investigators should minimize their exposure to active traffic. This will help ensure their personal safety as well as limit any influence their presence may have on active traffic.

For basic data collection, the investigator should ensure personal safety by limiting how often he or she enters the active travel lanes. For operational studies, the influence of an investigator in close proximity to the road may cause the driver to alter typical driving behavior. This influence could result in incorrect measurement of typical operational characteristics.

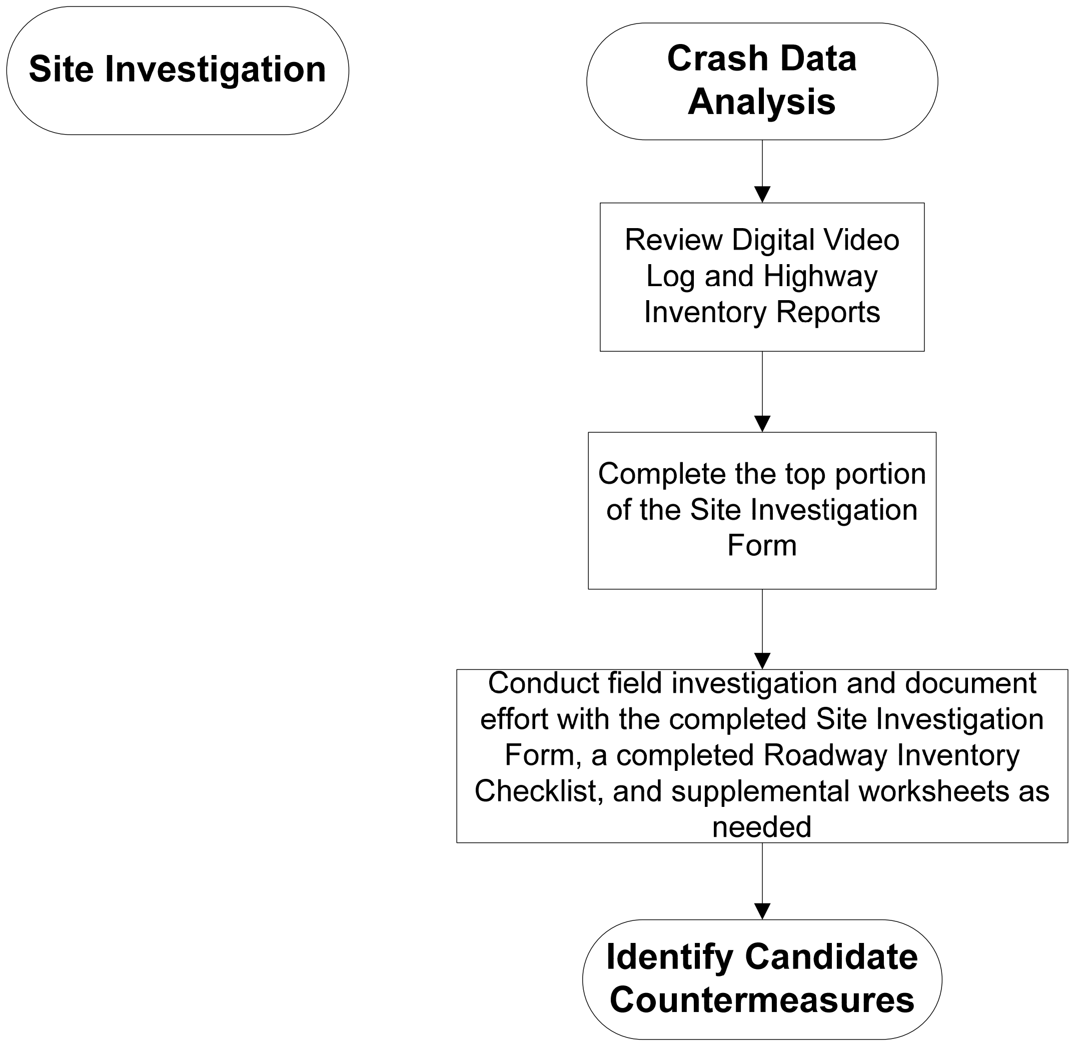



**FIGURE 13. FLOWCHART OF PROCEDURE FOR SITE INVESTIGATIONS**

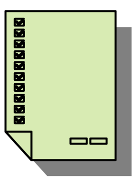
Methods to safely and unobtrusively collect data include using video data, floating car analysis methods (this requires a minimum of two investigators – a driver and a data recorder -- traveling in a vehicle in the traffic stream and replicating the behavior of other vehicles and logging data such as speed and travel times), and by remote observation. Remote observation could include video images taken unobtrusively and watched later in the office. This allows for a longer observation period and the possibility of re-reviewing the analysis. If data such as speed information is required, the investigator should be as discreet as possible. One method of achieving this (when using a radar or laser gun) is to measure speed as a vehicle departs a location so that the driver is not aware of the speed measurement. Leaving time gaps between observations might also limit the likelihood that drivers with radar-detection equipment will detect the sampling effort.

For some locations, it is necessary for an investigator to enter the active travel lanes to collect distance measurements. When this is required, use a wheel measuring device and use caution when entering the roadway.

## 5.2 General Data Collection

All site investigations should include collection of a basic set of information about the site. This field data should be documented so that a record of the current conditions is available for subsequent investigations. There are numerous site features that an investigator should evaluate. Table 1 depicts a wide variety of site features and items available for inspection at each site. As shown in Table 1, some site features, such as speed or visibility, may require more extensive data collection. Upon arrival at a site, the investigator should develop a condition diagram as reviewed in Chapter 3, Figure 8. This schematic documents road geometry conditions, lane configurations, traffic control devices, and similar physical site characteristics.

To help investigators collect only essential data for their specific site analysis, this manual includes data collection checklists and worksheets. For a basic site investigation, there are the following three initial worksheets:



- *Site Investigation Form* (see Figure 14)
- *Roadway Inventory Checklist* (see Figure 15)
- *Equipment Checklist* (see Figure 16)

Each of these forms fulfills a different role in initial site investigation. The *Site Investigation Form* is a standard form for each investigation that summarizes the location, crash history, observations, and recommendations. This form documents the site investigation process.

The *Roadway Inventory Checklist* catalogs the road features available at the specific site and provides information that may be further used to help with unique or specialized field studies. The site investigator should include digital photographs of the site with this form.

The final form is an *Equipment Checklist* so site investigators can easily verify that they have the required data collection equipment prior to the site visit.

Full size copies of these forms are included in the Appendix.

Upon completion of the *Roadway Inventory Checklist* and the top portion of the *Site Investigation Form*, the inspector can determine if any additional data requirements exist. The following sections provide specific information about unique conditions or specific study types appropriate for the site.

**TABLE 1. GENERAL SITE INVESTIGATION ITEMS**

| Site Feature | Item to Inspect | |
|---|---|---|
| General Road | • Functional Classification<br>• Road Width<br>• Divided/Undivided<br>• Number & Width of Lanes<br>• Medians & Access Points | • Shoulder Type & Width<br>• Rumble Strips<br>• Curbs<br>• Drainage facility locations & type<br>• Pavement Edge Drop-off |
| Road Surface | • Type<br>• Roughness<br>• Friction | • Pavement Quality<br>• Surface Drainage<br>• Presence of Loose Material |
| Road Geometry | • Horizontal Curvature<br>• Superelevation / Cross-slope<br>• Vertical Grade | • Crest vertical curve<br>• Sag vertical curve<br>• Combination of features |
| Intersection | • Type<br>• Number of Approaches<br>• Channelization & Pedestrian Refuge | • Turn Lanes<br>• Curb Return Radii<br>• Lane Alignment through intersection |
| Signs and Markings | • Inventory of Signs<br>• Legibility<br>• Conspicuity | • Adequate Signage and placement<br>• Pavement markings<br>• Delineators |
| Traffic Signals | • Compliance with MUTCD<br>• Timing & Actuation Control | • Turn Control<br>• Pedestrian signal |
| Pedestrians/ Bicycles | • Crosswalk configurations<br>• Sidewalk (placement & width) | • Bicycle facility (placement & width) |
| Lighting | • Type<br>• Height | • Location (lateral placement)<br>• Coverage |
| Parked Vehicles | • On-street parking<br>• Off-street parking & Access<br>• Delivery vehicle loading zones<br>• Parking distance from intersections | • Visibility<br>• Bus Stops<br>• Time constraints for parking |
| Speed | • Posted Speed<br>• Design Speed (estimated) | • Operating Speed* |
| Environment | • Adjacent Land Use | |
| Roadside | • Poles, posts, mailboxes, etc.<br>• Safety barrier, guard rail, etc.<br>• Rocks, trees, other obstacles | • Side slopes<br>• Culverts<br>• Bridge railings |
| Visibility | • Intersection Sight Distance* | • Traffic control device visibility* |
| Evidence of Problems | • Broken glass, debris<br>• Skid Marks* | • Damaged road furniture, poles, etc. |
| *Data element not required unless associated with specific crash types. | | |

*Developed from Sources: Caltrans, 2002a; Ogden, 1996; Ohio Task Force, 2006; PennDOT, 1997; PIARC, 2003*

**OREGON DEPARTMENT OF TRANSPORTATION**
**SAFETY INVESTIGATIONS MANUAL**
**SITE INVESTIGATION FORM**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Prepared By: | **0** | | | Title: | **0** | | |
| Region: | **0** | District | **0** | County: | **LINN** | City: | **-** |
| Route Number: | **0** | Hwy Name: | **SANTIAM** | Segment, MP From | **0.00** | to | **0.00** |
| Road Character | **RURAL** | Facility Type: | **RURAL PRINCIPAL ARTERIAL** | Intersection, at MP | **NA** | | |
| **REASON FOR INVESTIGATION:** | | | **SPIS INVESTIGATION** | At Intersection of: | **-** | | |

| | | | | |
|---|---|---|---|---|
| **CRASH TOTAL** | **0** | **0** | **0** | |
| **PER YEAR** | 0 | 0 | 0 | |

**TRAFFIC VOLUME**

| | | | |
|---|---|---|---|
| Major ADT | **#DIV/0!** | Minor ADT | **0** |

| **CRASH TOTAL BY SEVERITY** | | | | **PERSONS INJURED** | | | |
|---|---|---|---|---|---|---|---|
| **0** | Fatal | **0** | Other Injury | **0** | Fatal | **0** | Injury B |
| **0** | Injury A | **0** | PDO | **0** | Injury A | **0** | Injury C |

**CRASH PATTERNS TO INVESTIGATE (FROM WORKSHEET)**

**POTENTIAL CRASH CAUSE AND POSSIBLE SOLUTIONS**

**OBSERVATIONS THROUGH FIELD REVIEW**

**COMMENTS:**

| | | | |
|---|---|---|---|
| Reviewed By | | Approved Date | |

**FIGURE 14. SITE INVESTIGATION FORM**

**OREGON DEPARTMENT OF TRANSPORTATION**
**SAFETY INVESTIGATIONS MANUAL**
**ROADWAY INVENTORY CHECKLIST**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Prepared By: | 0 | | | Title: | 0 | | |
| Region: | 0 | District | 0 | County: | LINN | City: | - |
| Route Number: | 0 | Hwy Name: | SANTIAM | Segment, MP From | 0.00 | to | 0.00 |
| Road Character: | RURAL | Facility Type: | RURAL PRINCIPAL ARTERIAL | Intersection, at MP | NA | | |
| Posted Speed: | | | | At Intersection of: | - | | |

**DIRECTION OF TRAVEL**
- ☐ N
- ☐ S
- ☐ E
- ☐ W

**TRAFFIC CONTROL**
- ☐ NO CONTROL
- ☐ TRAFFIC SIGNAL
- ☐ FLASHING RED SIGNAL
- ☐ FLASHING YELLOW SIGNAL
- ☐ STOP SIGN
- ☐ YIELD SIGN
- ☐ RR FLASHING LTS, SIGNALS, GATES
- ☐ RR CROSSBUCK W/ ADV. SIGNS
- ☐ RR CROSSBUCK W/O ADV. SIGNS
- ☐ SCHOOL ZONE SIGN
- ☐ NO PASSING ZONE
- ☐ OTHER TRAFFIC CONTROL

**ROADWAY GEOMETRY**

CURVATURE
- ☐ CENTERLINE RADIUS ______
- ☐ STRAIGHT/TANGENT

**SHOULDER TYPE**
- ☐ CURB
- ☐ PAVED
- ☐ GRAVEL
- ☐ EARTH
- ☐ NONE

**PAVEMENT MARKINGS**
- ☐ NONE
- ☐ BROKEN YELLOW LINE
- ☐ BROKEN YL. LINE & SOLID YL. LINE
- ☐ SOLID YELLOW LINE
- ☐ DOUBLE SOLID YELLOW LINES
- ☐ BROKEN WHITE LINE
- ☐ SOLID WHITE LINE
- ☐ EDGE LINES
- ☐ RAISED PAVEMENT MARKERS
- ☐ TEMPORARY PAVEMENT MARKING
- ☐ OTHER PAVEMENT MARKINGS

**ACCESS CONTROL**
- ☐ INTERSTATE
- ☐ OTHER LIMITED ACCESS
- ☐ CONTROLLED ACCESS
- ☐ UNCONTROLLED ACCESS
- ☐ MEDIAN CROSSOVER

| WIDTHS | FT | TYPE |
|---|---|---|
| ☐ LANE 1 | | |
| ☐ LANE 2 | | |
| ☐ LANE 3 | | |
| ☐ LANE 4 | | |
| ☐ LANE 5 | | |
| ☐ LANE 6 | | |
| ☐ LT SHLDR | | |
| ☐ RT SHLDR | | |
| ☐ MEDIAN | | |

**PHOTO SUMMARY**
1
2
3
4
5

**DIVIDER TYPE**
- ☐ CONCRETE BARRIER
- ☐ GUARDRAIL/CABLE RAIL/FENCE
- ☐ RAISE ISLAND(PAVED OR GRASS)
- ☐ GRASS/EARTH AT GRADE
- ☐ PAINTED OR MARKED
- ☐ DOES NOT APPLY

**AUXILIARY LANES**
- ☐ NONE
- ☐ LEFT TURN
- ☐ RIGHT TURN
- ☐ TWLTL
- ☐ PASSING
- ☐ SPECIAL PURPOSE

**ADJACENT LAND USE**
- ☐ RESIDENTIAL
- ☐ COMMERCIAL
- ☐ INDUSTRIAL
- ☐ AGRICULTURAL / NATURAL
- ☐ UNDEVELOPED
- ☐ SCHOOL
- ☐ OTHER

VERTICAL GRADE ______
SUPERELEVATION ______
SURFACE TREATMENT ______
OTHER GEOMETRY ______

**OBSERVATIONS THROUGH FIELD REVIEW**

**FIGURE 15. ROADWAY INVENTORY CHECKLIST**

## Equipment Checklist

Basic Equipment for All Investigations

- ☐ Clipboard
- ☐ Required Worksheets
- ☐ Pencil with Eraser & Pen
- ☐ Ruler or Straight Edge
- ☐ Calculator
- ☐ Hard Hat, Safety Vest, Safety Glasses (as needed for location)
- ☐ Manual or Smart Level
- ☐ Measuring Tapes (25 ft and 100 ft)
- ☐ Measuring Wheel
- ☐ Digital Camera or Recorder
- ☐ Compass or GPS
- ☐ 3.5 feet long reflective tapes

Supplemental Equipment for Specific Investigations

*Night Study:*

- ☐ White clothing
- ☐ Night reflective vest
- ☐ Flashlight

*Speed Studies:*

- ☐ Radar or Laser Gun
- ☐ Stopwatch

*Volume Studies:*

- ☐ Traffic Counter

*Other Special Studies:*

- ☐ Chalk or String Line
- ☐ Spray Paint
- ☐ Tape Recorder
- ☐ Spare Batteries
- ☐ Height targets (2 ft, 3.5 ft, and 4.25 ft as needed)

**FIGURE 16. EQUIPMENT CHECKLIST**

## 5.3 Identifying Unique Site Features That Influence Appropriate Study Types

The successful execution of a site investigation may require the investigator to identify unique features or specific site influences at or near a high crash location. These features or influences may, in some way, contribute to increased safety concerns. Examples of unique conditions could include schools, high pedestrian businesses, or railroad crossings. Table 2 depicts some common site-specific studies that may be appropriate at study locations. Prior to visiting the site, the investigator should attempt to identify any unique site influences. Many of these conditions are apparent based on crash history information and aerial photography (acquired during the office analysis phase of review). Once the investigator has evaluated potential site conditions and identified supplemental field studies that may be needed, he or she will be equipped with the necessary data collection information prior to visiting the site.

**TABLE 2. COMMON FIELD STUDIES FOR UNIQUE SITE OR OPERATIONAL CONDITIONS**

| Study Type | Summary of Study |
|---|---|
| General Studies | |
| Roadway Inventory | Survey of the roadway physical features. Recommended for use in all situations. |
| Bicycle | Investigates bicycle facility sight distances, traffic control devices, physical dimensions, capacity, speeds, and volumes to assess level of safety. |
| Pedestrian | Uses pedestrian traffic control devices, physical dimensions, pedestrian volumes, crossing delays, traffic control devices, and pedestrian related conflicts to assess level of safety. |
| Highway Lighting | Identifies inconsistencies between the site and lighting design standards. Use when crash statistics identify darkness or nighttime as a contributor. |
| Sight Distance | Assesses available sight distance at the location. |
| Unique Site-Specific Studies | |
| School Crossing | Uses pedestrian road crossing widths, traffic control device information, pedestrian volumes and delays to assess the safety of facilities surrounding schools. Accounts for level of understanding experienced by students. |
| Railroad Crossing | Assesses safety of at-grade crossings. |
| Operational Studies | |
| Traffic Control Device | Uses signal warrant studies, stop-yield sign studies, and law observance studies to assess safety of current and potential traffic control devices. |
| Volume | For intersections, evaluate entering traffic volume, turning movement, pedestrian movement, and lane distribution information during the peak and non-peak periods. For roadway segments, perform directional counts along with an analysis of vehicle classification. |

| Study Type | Summary of Study |
|---|---|
| Speed | Analyze available sight distance at intersection approaches to determine the safe entering speed. Comparing these values with the location's speed limits or the 85th percentile speed to determine current speed distributions. Speed studies particularly useful when high speeds or speed differentials may be contributors to crash statistics. |
| Travel Time and Delay | Estimate required time for traversing roadway segments and any encountered delays such as traffic signals. Use when congestion is a possible contributor to crash statistics. |
| Roadway and Intersection Capacity | Estimates the location's ability to handle current or future traffic demands. Use when congestion is a possible contributor to crash statistics. |
| Conflict Studies | Conflict analysis highlights evasive maneuvers taken by drivers at the site to avoid potential collisions. The number and types of evasive actions experienced may help provide insights into crash conditions and expected frequency. One common method for performing conflict studies is to video tape the road user interactions for later evaluation if needed. |
| Gap Studies | Measures gaps between successive vehicles. Use to evaluate traffic mergers. |
| Traffic Lane Occupancy | Uses vehicle lengths, volumes, and speeds to evaluate facility operations. Use when congestion is a possible contributor to crash statistics. |
| Queue Length | Measure of intersection approach performance. Use when congestion is a possible contributor to crash statistics |
| Road Surface, Environment, or Weather-Related Studies | |
| Roadway Serviceability | Evaluates pavement surface at site. |
| Skid Resistance | Uses ASTM standards to determine whether sufficient traction is provided between road surface and tires. Use when crash statistics identify wet-weather as a contributor. |
| Weather Related | Checks for increased hazard during specific weather conditions. Examples are fog or ice. |

*Developed from Source: Caltrans, 2002a; FHWA, 1981; Graham & Glennon, 1975; Kilareski, et al., 1996; PIARC, 2003; Wilson, 2003*

## 5.4 Identifying Appropriate Field Studies Specific to Crash Patterns

As demonstrated in Table 2, there are a wide variety of potential field studies that an investigator may elect to perform at a given site. Supplemental information is helpful to select appropriate study types. Selection of the applicable field studies can largely be determined prior to the site visit. The investigation and diagnosis of crash patterns can be divided into the four general categories:

- Intersection Crashes (see Table 3),
- Mid-Block Crashes (see Table 4),
- Fixed-Object and Run-off-Road Crashes (see Table 5), and

- Environmental Condition-Related Crashes (see Table 6).

Many of the candidate traffic studies can be performed using common sense, practical experience, and standard traffic engineering studies from texts such as ITE's *Manual of Transportation Engineering Studies*. To successfully identify the applicable field studies, the investigator should have some reasonable expectations about the probable cause of crash patterns. For example, if a site has a disproportionate percent of a crash type at an intersection, the investigator can refer to Table 3 to review the crash pattern, identify a probable cause, determine what to document, and identify some general countermeasures that may help to reduce crashes.

## 5.5 Performing Data Collection for Specific Field Studies

Many data collection methods for site investigation are well documented and readily available in current ODOT publications. For example, the Speed Zone Investigation Manual addresses how to perform speed studies. As a result, this manual does not include detailed worksheets for the majority of field studies; however, there are some unique situations that merit investigation, but do not have readily available worksheets. One such unique condition is a field evaluation of available intersection sight distance. This manual includes a set of worksheets for assessment of this intersection sight distance condition. These intersection sight distance worksheets apply only to intersection locations and should not be used for the evaluation of sight distance at driveway locations. If an investigator suspects that a driveway has poor sight distance, he or she should contact the Access Management Unit (AMU).

Appendix A of this manual includes the Intersection Sight Distance worksheet instructions, example problems and forms. Appendix B contains additional forms developed for general office and field assessments. Appendix C includes two case studies that demonstrate use of the spreadsheet evaluation forms for performing an investigation and assessment of candidate sites.

**TABLE 3. INVESTIGATION AND DIAGNOSIS FOR INTERSECTION CRASHES**

| Crash Pattern | Probable Cause | What to Document | General Countermeasures |
|---|---|---|---|
| Right-angle collisions at unsignalized intersections | • Restricted sight distance<br>• Large total intersection volume<br>• High approach speed<br>• Sun glare issues | • Sight obstructions<br>• Parking at corners<br>• Visibility and placement of stop/yield signs<br>• Visibility and placement of advanced warning signs<br>• Lighting<br>• Peak hour, 4-hour, and 8-hour traffic volumes<br>• Pedestrian volumes<br>• Upstream operating speeds for high-speed approaches<br>• Orientation to sunrise and sunset | • Remove sight obstructions<br>• Restrict parking near corners<br>• Install stop signs or oversize and dual signs (if present already)<br>• Install warning signs<br>• Provide markings to supplement signs<br>• Install hazard beacons<br>• Install/improve street lighting<br>• Reduce speed limit on approaches<br>• Install signals<br>• Install yield signs<br>• Channelize intersection<br>• Install signals<br>• Re-route through traffic<br>• Reduce speed limit on approaches<br>• Install rumble strips (non-urban locations) |

| Crash Pattern | Probable Cause | What to Document | General Countermeasures |
|---|---|---|---|
| Right-angle collisions at signalized intersections | • Poor visibility of signals<br>• Signal timing | • Location and visibility of signal heads<br>• Location and visibility of advanced warning signs<br>• Signal timing and operating sequence | • Install advanced warning devices<br>• Install 12-inch signal lenses<br>• Install overhead signals<br>• Install visors<br>• Install back plates<br>• Improve location of signal heads<br>• Add additional signal heads<br>• Reduce speed limit on approaches<br>• Adjust/Extend amber or all-red<br>• Provide all-red clearance phases<br>• Add multi-dial controller<br>• Re-time signals<br>• Provide signalized progression<br>• Install signal actuation<br>• Provide protective movement phases<br>• Check equipment malfunction |
| Rear-end collisions at unsignalized intersections | • Pedestrian crossing<br>• Driver not aware of intersection<br>• Large volume of turning vehicles<br>• Poor visibility | • Location and visibility of crosswalks and stop bars<br>• Location and visibility of stop/yield signs<br>• Location and visibility of advance warning signs<br>• Sight distance obstructions<br>• Peak hour, 4-hour, and 8-hour traffic volumes<br>• Pedestrian volumes<br>• Upstream operating speeds for high-speed approaches<br>• Sight distance obstructions<br>• Conspicuity of pavement marking and signs | • Install/improve signing or marking of pedestrian crosswalks<br>• Reduce number of crosswalks<br>• Relocate crosswalk<br>• Install/improve standard & advance warning signs<br>• Reduce speed limit on approaches<br>• Install hazard beacons<br>• Create left- or right-turn lanes<br>• Prohibit turns<br>• Increase curb radii<br>• Remove sight obstructions<br>• Prohibit parking<br>• Review striping needs |

| Crash Pattern | Probable Cause | What to Document | General Countermeasures |
|---|---|---|---|
| Rear-end collisions at signalized intersections | • Poor visibility of signals<br>• Signal timing<br>• Pedestrian crossings<br>• Unwarranted signals<br>• Large volume of traffic or turning volumes | • Location and visibility of signal heads<br>• Location and visibility of advance warning signs<br>• Signal timing and operating sequence<br>• Location and visibility of crosswalks and stop bars<br>• Peak hour, 4-hour, and 8-hour traffic volumes<br>• Pedestrian volumes<br>• Curb return geometry | • Install/improve advance warning devices<br>• Install overhead signals<br>• Install 12-inch signal lenses<br>• Install back plates or visors<br>• Relocate signals or signal heads<br>• Add additional signal heads<br>• Lengthen mast arms<br>• Remove sight obstructions<br>• Reduce speed limits on approaches<br>• Adjust/Extend amber or all-red phase<br>• Provide progression through a set of signalized intersections (coordination)<br>• Signal/loop malfunction<br>• Need additional loops<br>• Revise red/green timing<br>• Install/improve signing or marking of pedestrian crosswalks<br>• Reduce number of crosswalks<br>• Provide pedestrian “WALK” phase<br>• Create left- or right-turn lanes<br>• Prohibit turns<br>• Add left turn phase<br>• Increase curb radii<br>• Remove signals |

| Crash Pattern | Probable Cause | What to Document | General Countermeasures |
|---|---|---|---|
| Left-turn collisions at intersections | • Large volume of traffic or left turns<br>• Restricted sight distance | • Number of lanes / lane width / lane usage<br>• Traffic signal timing and operating sequence<br>• Location and visibility of signs related to lane usage or turning movements<br>• Sight distance obstructions | • Provide left-turn signal phases<br>• Prohibit left turns<br>• Increase/add left turn lane and provide left-turn signal if warranted<br>• Re-route left-turn traffic<br>• Provide adequate channelization<br>• Create one-way streets<br>• Install “STOP” signs<br>• Adjust signal timing or install traffic signal<br>• Improve approach visibility<br>• Widen road<br>• Adjust/Extend amber or all-red<br>• Prohibit parking<br>• Reduce number of pedestrian crossings<br>• Remove obstacles<br>• Install warning signs<br>• Reduce speed limit on approaches |
| Right-turn collisions at intersections | • Short turning radii<br>• Signal timing<br>• Poor visibility | • Number of lanes / lane width / lane usage<br>• Traffic signal timing and operating sequence<br>• Location and visibility of signs related to lane usage or turning movements<br>• Sight distance obstructions | • Increase curb radii<br>• Adjust signal timing or install traffic signal<br>• Improve approach visibility<br>• Widen road<br>• Adjust/Extend amber or all-red<br>• Restrict right-turn on red |

| Crash Pattern | Probable Cause | What to Document | General Countermeasures |
|---|---|---|---|
| Sideswipe collisions at intersections | • Roadway design inadequate<br>• Poor visibility | • Number of lanes / lane widths / lane usage<br>• Location / description / measurement of median<br>• Shoulder type / width and condition<br>• Location and visibility of advance warning signs<br>• Roadway type and condition | • Improve pavement marking<br>• Increase curb radii<br>• Remove on-street parking near intersection<br>• Install / Improve directional signing<br>• Restrict driveway access near intersection |
| Pedestrian crashes at intersections | • Restricted sight distance<br>• Inadequate protection for pedestrians<br>• Inadequate signals<br>• Improper signal phasing<br>• Uncontrolled school crossing area | • Number of lanes, lane widths, lane usage<br>• Right turn on red<br>• Sight distance obstructions<br>• Location and operation of pedestrian push buttons<br>• Locations and measurements of pedestrian refuge islands<br>• Signal timing and sequence-exclusive pedestrian phase | • Remove sight obstructions<br>• Install pedestrian crossings<br>• Improve/install pedestrian crossing signs<br>• Restrict parking<br>• Re-route pedestrian paths<br>• Add pedestrian refuge islands<br>• Install pedestrian signals<br>• Add pedestrian “WALK” phase<br>• Change timing of pedestrian phase<br>• Use school crossing guards |
| Collisions at railroad crossings | • Restricted sight distance | • Sight distance obstructions<br>• Measure profile grade<br>• Crossing hardware | • Remove sight obstructions<br>• Reduce grades<br>• Install train actuated signals<br>• Install stop signs<br>• Install bus lanes<br>• Install gates<br>• Install advance warning signs |

*Developed from sources: Caltrans, 2002b; New York, 2000; Ohio, 2006; PennDOT, 1997; Wilson, 2003; ODOT Interviews.*

**TABLE 4. INVESTIGATION AND DIAGNOSIS FOR MID-BLOCK CRASHES**

| Crash Pattern | Probable Cause | What to Document | General Countermeasures |
|---|---|---|---|
| Sideswipe collisions between vehicles traveling in opposite directions or head-on collisions | • Roadway design for traffic conditions<br>• Insufficient passing zones<br>• Two-way left-turn lanes | • Number of lanes / lane widths / lane usage<br>• Location / description / measurement of median<br>• Shoulder type / width and condition<br>• Location and visibility of advance warning signs<br>• Roadway type and condition | • Install/improve pavement markings<br>• Channelize intersections<br>• Create one-way streets<br>• Restrict parking<br>• Install median divider / barrier<br>• Widen lanes |
| Collisions between vehicles traveling in same direction such as sideswipes, turning or lane changing | • Roadway design for traffic conditions<br>• Insufficient passing zones<br>• Passing on shoulders | • Location and description of traffic islands<br>• Pavement widths<br>• Lane widths | • Widen lanes<br>• Channelize intersections<br>• Add capacity (other program)<br>• Right/left turn lane<br>• Provide turning bays<br>• Install advance route or street signs<br>• Install/improve pavement lane lines<br>• Restrict parking<br>• Reduce speed limit |
| Collisions with parked cars or cars being parked | • Large parking turnovers<br>• Roadway design inadequate for present conditions | • Number of lanes / lane widths / lane usage<br>• Parking configuration type | • Prohibit parking or move off-street<br>• Change from angle to parallel parking<br>• Re-route through traffic<br>• Create one-way streets<br>• Reduce speed limit<br>• Widen lanes<br>• Add back-in angle parking |

| Crash Pattern | Probable Cause | What to Document | General Countermeasures |
|---|---|---|---|
| Collisions at driveways | • Left-turning vehicles<br>• Right-turning vehicles<br>• Large volume of through traffic<br>• Large volume of driveway traffic<br>• Restricted sight distance | • Number of lanes / lane widths / lane usage<br>• Location and measurement of median openings<br>• Location and description of driveway width and geometry, surface type, condition of driveway<br>• Shoulder type, width and condition<br>• Location and visibility of advance warning signs<br>• Sight distance obstructions<br>• Lighting<br>• Confirm the driveway is an ODOT permitted driveway | • Install raised median to limit access<br>• Prohibit left-turns<br>• Install two-way left turn<br>• Provide right-turn lanes<br>• Restrict parking near driveways<br>• Increase the width of the driveway<br>• Widen through lanes<br>• Increase curb radii<br>• Provide acceleration or deceleration lanes<br>• Move driveway to side street<br>• Combine driveways where applicable<br>• Construct a local service road<br>• Re-route through traffic<br>• Add traffic signal<br>• Signalize or channelize driveway<br>• Remove sight obstructions<br>• Install/improve street lighting<br>• Reduce speed limit<br>• Install hazard beacons |
| Pedestrian crashes between intersections | • Driver has inadequate warning of frequent mid-block crossings<br>• Pedestrians on roadway<br>• Long distance to nearest crosswalk | • Location and visibility of mid-block crosswalks<br>• Location and visibility of advance warning signs<br>• Sight distance obstructions<br>• Lighting<br>• Shoulder type / width / condition<br>• Presence and location of sidewalks | • Prohibit parking<br>• Install warning signs<br>• Lower speed limit<br>• Install pedestrian barriers in the median<br>• Install sidewalks<br>• Install pedestrian crosswalk<br>• Install pedestrian actuated signals |
| Pedestrian crashes at driveway crossings | • Sidewalk too close to travelway | • Lane widths, curb width, landscape buffer width, and sidewalk width<br>• On-street parking | • Move sidewalk laterally away from road<br>• Restrict parking |

*Developed from sources: Caltrans, 2002b; New York, 2000; Ohio, 2006; PennDOT, 1997; Wilson, 2003; ODOT Interviews.*

**TABLE 5. INVESTIGATION AND DIAGNOSIS FOR FIXED-OBJECT AND RUN-OFF-ROAD CRASHES**

| Crash Pattern | Probable Cause | What to Document | General Countermeasures |
|---|---|---|---|
| Fixed-object collisions and/or vehicles running off roadway (may also include head-on crashes in some cases) | • Objects near travelway<br>• Roadway design for traffic conditions<br>• Poor delineation<br>• Signing/striping/delineation<br>• Guardrail<br>• Pavement edge drop-off | • Ball bank curves<br>• Location and description of fixed objects<br>• Roadway type width and condition<br>• Location and visibility of advance warning signs<br>• Presence/condition of guardrail and/or energy absorbing device<br>• Location and visibility of pavement markings and post-mounted delineators<br>• Height of pavement edge drop-off | • Remove /relocate obstacles from clear recovery area<br>• Install barrier curbing<br>• Install breakaway feature to light poles, signpost, etc.<br>• Reduce number of utility poles<br>• Protect objects with guardrail or attenuation device<br>• Widen lanes / add capacity<br>• Relocate islands<br>• Re-align<br>• Check superelevation<br>• Close curb lane<br>• Improve/install pavement markings include edgeline<br>• Contrast treatment<br>• Rumble strips<br>• Install roadside delineators<br>• Install/improve standard or advance warning signs<br>• Install a paved safety edge |

*Developed from sources: Caltrans, 2002b; New York, 2000; Ohio, 2006; PennDOT, 1997; Wilson, 2003; ODOT Interviews.*

**TABLE 6. INVESTIGATION AND DIAGNOSIS FOR CRASHES LINKED TO ENVIRONMENTAL CONDITIONS**

| Crash Pattern | Probable Cause | What to Document | General Countermeasures |
|---|---|---|---|
| Night crashes | Poor visibility | • Lighting<br>• Location and visibility of regulatory and warning signs<br>• Location and visibility of pavement markings and delineators | • Install/improve street lighting<br>• Remove sight obstructions<br>• Install/improve delineation markings<br>• Install/improve warning signs |
| Wet pavement crashes | Slippery pavement | • Pavement type and condition including skid test<br>• Location and conditions of drainage facilities<br>• Location and visibility of advance warning signs | • Overlay/groove pavement<br>• Open graded asphalt concrete<br>• Provide adequate drainage<br>• Chip seal<br>• Reduce speed limit<br>• Review Skid test<br>• "SLIPPERY WHEN WET" signs<br>• Improve delineation |
| Crashes on grade | Sun glare or unexpected icy spots on road | • Sun angles<br>• Locations with poor drainage | • Additional warning sign<br>• Modify superelevation as well as shoulder recovery area |
| Reduced visibility collisions | Poor visibility (usually due to weather) | • Conspicuity of pavement marking and signs | • Provide fog or smoke warning<br>• Improve delineation |

*Developed from sources: Caltrans, 2002b; New York, 2000; Ohio, 2006; PennDOT, 1997; Wilson, 2003; ODOT Interviews.*

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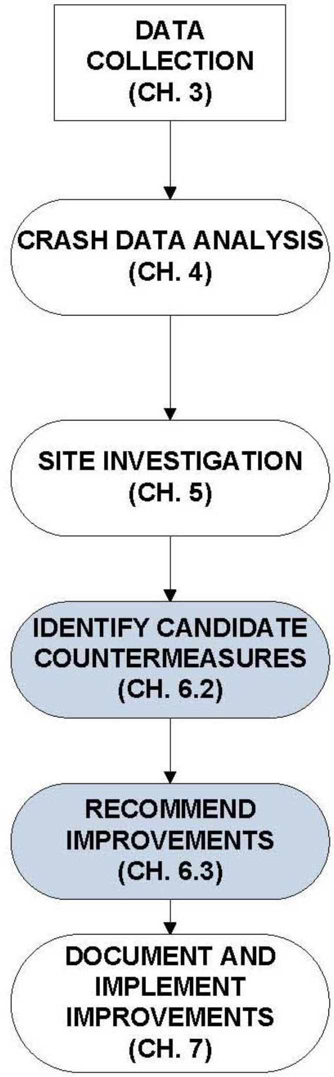
# 6 COUNTERMEASURE SELECTION AND RECOMMEND IMPROVEMENTS ANALYSIS




Following data analysis and field investigation the investigator should have a clear idea on what types of crashes are overrepresented and some ideas of which types of crashes might be preventable. The next step in the investigations is to select the likely "cure" for the crash contributing factors. This is done by developing a set of candidate countermeasures that may reduce the identified crash problem. For many projects, more than one countermeasure or set of countermeasures may be feasible. How to do this is described in Sections 6.1 and 6.2.

Once candidate countermeasures have been identified, the investigator will have to decide which improvements are feasible, which ones are cost-effective, and if more than one option is available, which one returns the largest benefit. Guidance on these decisions is provided in the remaining sections of the chapter. The basic procedure to identify candidate countermeasures is shown in Figure 17, while Figure 18 shows the procedure for then determining which improvement to recommend.

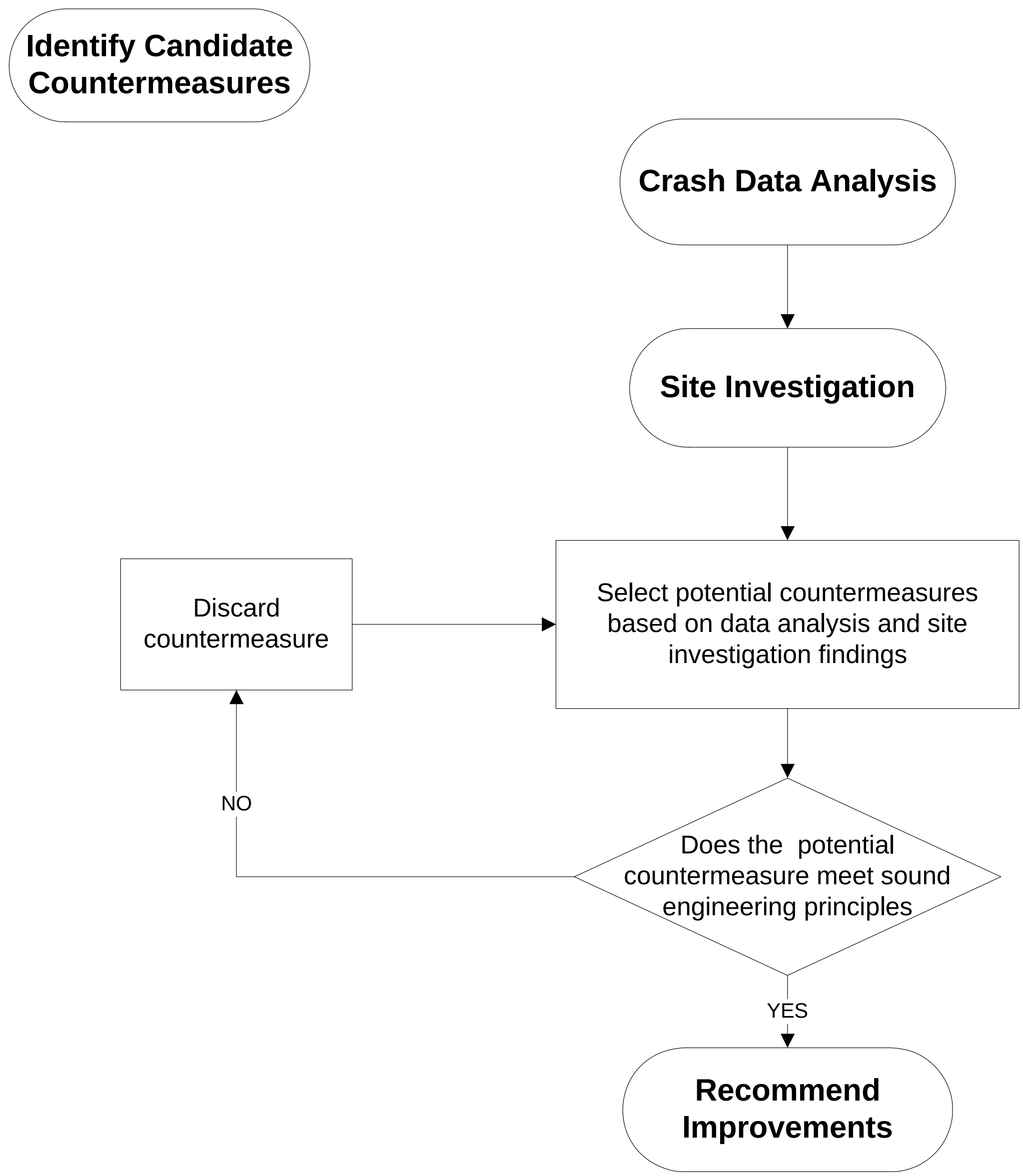



**FIGURE 17. FLOWCHART OF PROCEDURE TO IDENTIFY CANDIDATE COUNTERMEASURES**

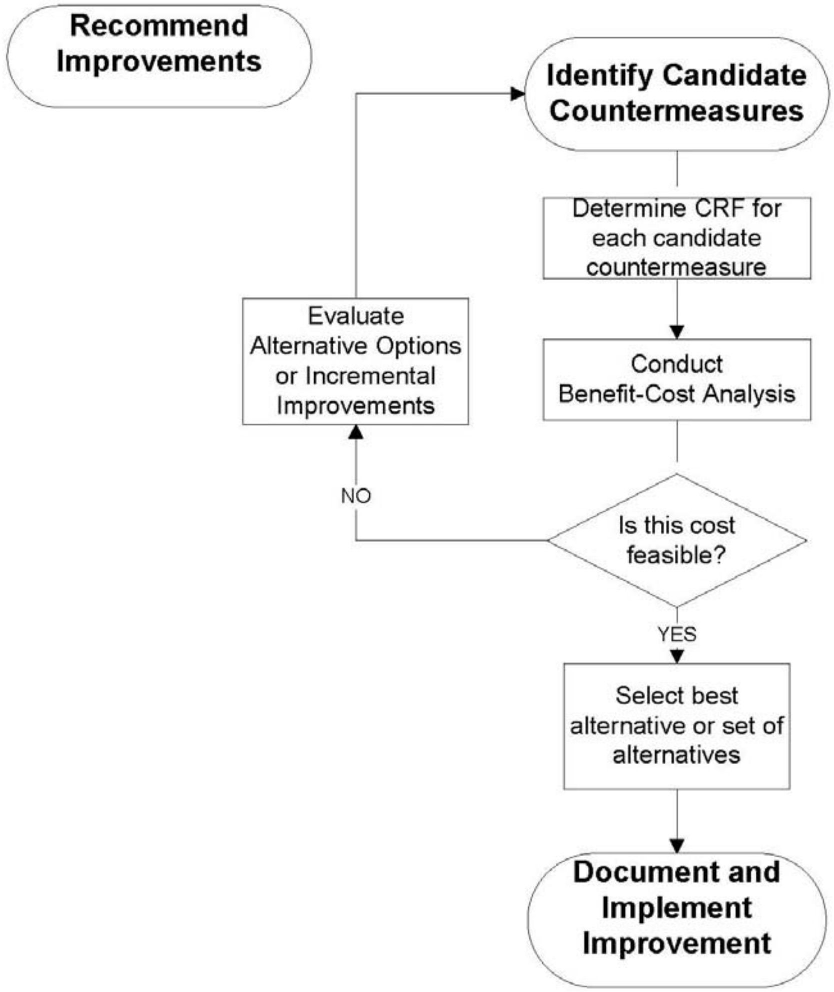



**FIGURE 18. FLOWCHART OF PROCEDURE TO RECOMMEND IMPROVEMENTS**

## 6.1 PRINCIPLES OF COUNTERMEASURE SELECTION

A "countermeasure" can be defined as a modification, improvement, or action designed to reduce crash frequency or severity. In the context of this manual, a countermeasure generally refers to an engineering or operational improvement but there can also be educational, enforcement, or emergency service related countermeasures.

A good countermeasure should reduce either the frequency or severity of dominant crash types. The implemented countermeasure should not have any significant undesirable consequences in traffic efficiency or environmental terms, though tradeoffs between safety and other competing decision elements should be expected. The countermeasure should be cost-effective under most circumstances.

All countermeasures should be based on sound engineering judgment and should conform to applicable ODOT and FHWA policies and procedures.

## 6.2 Identify Candidate Countermeasures

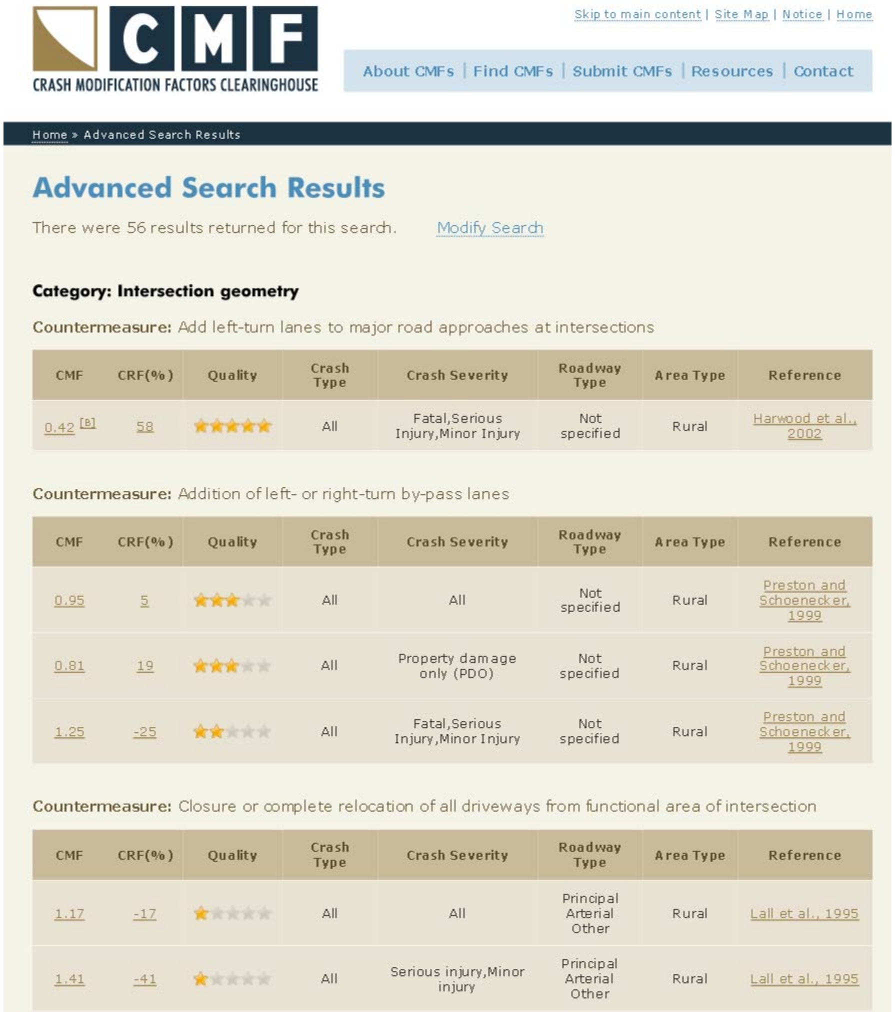
There are a growing number of very useful resources for the investigator to obtain countermeasures and identify their expected effectiveness. For most investigations, the investigator should use the FHWA's Crash Modification Factor Clearinghouse located at the following address:

http://cmfclearinghouse.org

The crash modification factor (CMF) is a multiplicative value that estimates the safety influence of a specific countermeasure. Before using a CMF, the analyst should determine the base conditions of the CMF and should only use a CMF for evaluation of similar base conditions. For example, base conditions for a CMF where the countermeasure considers adding street lights to a road segment may be based on locations without any available street lights. If the site evaluated is a location that does have street lights but their spacing or intensity is in question, the CMF with the "no lights" base condition could not be used for this assessment. CMF quality can also vary. The FHWA web site uses a star rating system where more stars indicate a more reliable CMF.

The identification of potential countermeasures involves mapping the correctable crash type to a possible countermeasure. For example, if rear-end crashes on a rural highway near an intersection were identified as the correctable crash type, the investigator would need to identify a countermeasure that might reduce these crash types.

This "mapping" can be done in a number of ways. There are published checklists or summary tables that identify candidate countermeasures based on crash patterns and probable causes [see Table 3, Table 4, Table 5, and Table 6 in Chapter 5].



CMF CRASH MODIFICATION FACTORS CLEARINGHOUSE

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Home » Advanced Search Results

## Advanced Search Results

There were 56 results returned for this search. Modify Search

**Category: Intersection geometry**

**Countermeasure:** Add left-turn lanes to major road approaches at intersections

| CMF | CRF(%) | Quality | Crash Type | Crash Severity | Roadway Type | Area Type | Reference |
|---|---|---|---|---|---|---|---|
| 0.42 [B] | 58 | ★★★★★ | All | Fatal,Serious Injury,Minor Injury | Not specified | Rural | Harwood et al., 2002 |

**Countermeasure:** Addition of left- or right-turn by-pass lanes

| CMF | CRF(%) | Quality | Crash Type | Crash Severity | Roadway Type | Area Type | Reference |
|---|---|---|---|---|---|---|---|
| 0.95 | 5 | ★★★☆☆ | All | All | Not specified | Rural | Preston and Schoenecker, 1999 |
| 0.81 | 19 | ★★★☆☆ | All | Property damage only (PDO) | Not specified | Rural | Preston and Schoenecker, 1999 |
| 1.25 | -25 | ★★☆☆☆ | All | Fatal,Serious Injury,Minor Injury | Not specified | Rural | Preston and Schoenecker, 1999 |

**Countermeasure:** Closure or complete relocation of all driveways from functional area of intersection

| CMF | CRF(%) | Quality | Crash Type | Crash Severity | Roadway Type | Area Type | Reference |
|---|---|---|---|---|---|---|---|
| 1.17 | -17 | ★☆☆☆☆ | All | All | Principal Arterial Other | Rural | Lall et al., 1995 |
| 1.41 | -41 | ★☆☆☆☆ | All | Serious injury,Minor injury | Principal Arterial Other | Rural | Lall et al., 1995 |

**FIGURE 19. SCREEN CAPTURE OF FHWA CMF CLEARING HOUSE**

There are other resources which may prove helpful, especially as additional countermeasures are populated with crash modification or crash reduction factors:

- Desktop Reference for Crash Reduction Factors, Publication No. FHWA-SA-07-015
- Highway Safety Manual, Part 4: Knowledge
- NCHRP's 500 Series
- AASHTO's Strategic Highway Safety Plan Guidebooks

For bicycle and pedestrian crashes there are two interactive tools developed by FHWA that might prove useful (though there is limited information on percent effectiveness):

- BIKESAFE: [http://www.bicyclinginfo.org/bikesafe/](http://www.bicyclinginfo.org/bikesafe/)

PEDSAFE: http://www.walkinginfo.org/pedsafe/

### *6.2.1 Expected Effectiveness of Countermeasures*

For each countermeasure, the most important information is the expected effectiveness (How well will the countermeasure work?). The estimated reduction is key to estimating the cost-effectiveness of countermeasure and severity trade-offs. There are currently two common terminologies:

- Crash (accident) Modification Factor (CMF)
  - A multiplicative factor representing the fraction of the total crashes expected after the countermeasure
- Crash (accident) reduction factor or CRF
  - a percent reduction in the "before" crashes after implementing the countermeasure

Currently, the Oregon DOT resources and terminology use "CRF" while the 2010 AASHTO *Highway Safety Manual* uses the CMF terminology. In most cases, the values are interchangeable using this simple conversion: CRF = (1-CMF).

When multiple countermeasures are applied to a location, a simple formula is used to calculate a composite CRF. This formula is given as

CRF = CRF1 +(1-CRF1)CRF2+[(1-CRF1)(1-CRF2)CRF3…]

However, this formula is not based on a known interaction between CRFs and should be used with caution. While mathematically an infinite number of CRFs could be applied to achieve a total 100% reduction, as a practical matter, the investigator should use this formula sparingly. In fact, most investigations will reveal one or at most 2 complementary countermeasures. The order of the CRFs does not matter in the formula.

A composite CMF is not needed. CMFs can be multiplied together to determine a composite effectiveness.

**Example:**

A location has 14 crashes per year. Two countermeasures have been selected with a CRF1 = 10%, CRF2 = 30% (or CMF1 = 0.90 and CMF2 = 0.70)

a) How many crashes were reduced?

b) How many crashes will occur per year after the countermeasure?

<u>With CRF</u>

First, calculate the composite CRF = 0.1+(1-0.1)(0.3) = 0.37 or 37%

*[Note: 0.1 is 10% in decimal form and 0.3 is 30% in decimal form.]*

a) crashes reduced = 14[0.37]=5.18 crashes

b) crashes expected after countermeasure = total – reduced = 14 - 5.18 = 8.82 crashes

<u>With CMF</u>

CMF = 90%, CMF = 70%, with CMF b) is easier to answer first

b) crashes expected after countermeasure = (14 crashes)(0.9)(0.7) = 8.82 crashes

a) crashes reduced = 14 - 8.82 = 5.18 crashes

### *6.2.2 Selecting Appropriate Context*

When applying a countermeasure, the investigator needs to pay close attention to the conditions and crash types to which the CRF/CMF applies. Nearly all CRFs/CMFs were developed from before-after safety analysis for a specific case or condition and one must be careful to match these conditions as close as possible. A simple way to think of this is:

- What are the existing conditions at the location before the countermeasure?

For example, if one was considering adding a left-turn bay on a major road to eliminate the rear-end crashes, the following “before” conditions are available:

- Add Left-Turn Bay on Major Road, Signalized, 3-leg Intersection
- Add Left-Turn Bay on Major Road, Signalized, 4-leg Intersection
- Add Left-Turn Bay on Major Road, Unsignalized, 3-leg Intersection
- Add Left-Turn Bay on Major Road, Unsignalized, 4-leg Intersection

Also, many countermeasures were developed from data and either apply to “TOTAL” crashes or a specific crash type. The investigator needs to be sure that he or she applies the CRF to the appropriate crash type.

- To what crash types should the countermeasure apply?

Continuing the above example, if the left-turn lane was to be added to a signalized, 4-leg urban intersection, the investigator would have the choice of CRFs that apply to fatal crashes, injury crashes, or all crashes.

| *Road Character* | *Crash Type* | *Fatal* | *Injury* | *PDO* | *All Crash Severity* |
|---|---|---|---|---|---|
| Rural | All Crash Types | - | - | - | 18% |
| Urban | All Crash Types | 9% | 9% | - | 10% |

#### *6.2.3 What To Do If the Countermeasure Does Not Have A CRF or CMF Value*

In an ideal world, all countermeasures would have a CRF or CMF associated with them. There has been a significant amount of effort in recent years to sift through countermeasures to determine “valid” CRFs. “Valid” CRFs have been determined from well-designed research studies including efforts within Oregon to develop CRFs for Oregon and to adapt CRFs from other states. Unfortunately, there are many treatments where adequate CRFs have still not been developed.

If the investigator identifies a countermeasure without a CRF value, he or she should work with Headquarters to determine an appropriate acceptable value (if any), especially since research work is ongoing and new CRFs are being produced. In the event a reasonable CRF or CMF still cannot be located, the investigator may want to inform ODOT Office of Research so a future value may be developed.

### 6.3 Recommend Improvements

Once a countermeasure or a set of countermeasures have been selected, the investigator must evaluate the economic feasibility of the countermeasure. Three versions of the *Benefit-Cost Worksheet* are provided for in the SIM workbook (BC Form by Severity, BC Form by Type, and Combination of BC's). While safety improvements and their benefits may be considered as part of larger projects, this worksheet is specifically for use on safety projects. Benefits are considered as savings in crashes over life of project, either in reduction in frequency or severity. Costs include the initial capital investment of the project. Because the benefits accrue over the life of the improvement and money has time-value, a discount rate must be applied to future benefits.

### 6.3.1 USING THE BENEFIT-COST BY SEVERITY WORKSHEET

A screen shot of the worksheet by severity is shown in Figure 20. All cells shaded yellow should be completed by the investigator. Fields shaded light blue are calculations. The general directions are as follows:

1. Complete project header information. Urban road character is classified as being within urban transportation boundaries if existing, otherwise within city limits. The date range for the crash data is required (green shaded cells) to calculate the annual benefit and must be entered in date worksheet.

2. Type a brief description of the proposed countermeasure and enter the CRF by severity for the countermeasure in columns labeled "Crash Reduction Factor", expressed as a decimal. The CRF represents the estimated percent reduction in crashes. For example, installing a left turn refuge might reduce fatal crashes by 18% (CRF= 18%). To apply multiple countermeasures on a project, enter the additional countermeasures in the additional cells. A composite CRF is calculated automatically using the formula described above.

3. From the crash data, enter the number of target crashes for each crash severity in the yellow shaded cells in column labeled "Number of Crashes" by severity.

4. Enter the economic value of a reduced crash based on road character and facility type in the project header (this is automated on the worksheet) from the "Comprehensive Economic Value per Crash" in the pink shaded table in the column labeled "D Economic Value - per Crash."

5. Enter the estimated project cost. Include preliminary engineering but not right-of-way costs and round to nearest $1,000.

6. Select a present worth factor for the life of a countermeasure. Long-term treatments such as left-turn refuges and geometric improvements should use a 20-year analysis. Short-term improvements such as signs and pavement markings should use a 10-year analysis.

**OREGON DEPARTMENT OF TRANSPORTATION**
**HIGHWAY SAFETY PROJECTS**
**BENEFIT/COST ANALYSIS WORKSHEET**

For Office Use Only
File Code: PRO 08 -______-______

Project Name: 0 Region: 0 Date:

*Project on Local Agency Facility*
Route Number: Street Name: MP Range or Cross Street:

*Project on State Highway*
Route Number: 0 Hwy Name: , MP From: 0.00 to 0.00

Road Character: URBAN Facility Type: INTERSTATE

County: BAKER City: Crash Data From: to

Project Description: 0

Prepared By: 0 Title: 0

| | | Fatal Crash Reduction Factor | Injury Crash Reduction Factor | PDO Crash Reduction Factor |
|---|---|---|---|---|
| *Countermeasure 1* | | | | |
| *Countermeasure 2* | | | | |
| *Countermeasure 3* | | | | |
| *Countermeasure 4* | | | | |
| | | 0% [1] | 0% [1] | 0% [1] |

| | Number of Crashes | Number of Preventable Crashes | Economic Value per Crash | | Total Economic Value |
|---|---|---|---|---|---|
| Fatal Crashes | | 0.0 | $1,500,000 | = | $ - |
| Severe (Injury A) Injury Crashes | | 0.0 | $1,500,000 | = | $ - |
| Moderate (Injury B) Injury Crashes | | 0.0 | $55,000 | = | $ - |
| Minor (Injury C) Injury Crashes | | 0.0 | $55,000 | = | $ - |
| PDO Crashes | | 0.0 | $15,000 | = | $ - |

| Comprehensive Economic Value per Crash | | |
|---|---|---|
| Highway Type | Urban | Rural |
| PDO [3] | | |
| All facilities | $15,000 | $15,000 |
| Moderate (Injury B) and Minor (Injury C) Injury [4] | | |
| Interstate | $48,900 | $54,800 |
| Other State Highway | $47,900 | $55,000 |
| Fatal and Severe (Injury A) Injury [4] | | |
| Interstate | $850,000 | $1,460,000 |
| Other State Highway | $840,000 | $1,500,000 |

**Total Crash Value for** 0 Months = $ -

**Annual Benefits =** Total Crash Value / Total Months / 12 =

**Estimated Project Cost** =

| Uniform Series Present Worth Factor (5%) | |
|---|---|
| 10 years | 20 years |
| 7.72 | 12.46 |

**B/C Ratio =** Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

**B/C Ratio =** x [2] =
$

**Notes**

1 Composite crash reduction factor calculated if more than one countermeasure is applied
2 Select a PWF for the life of countermeasure. See instructions
3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.
4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

**FIGURE 20. BENEFIT/COST WORKSHEET BY SEVERITY**

### *6.3.2 USING THE BENEFIT-COST BY TYPE WORKSHEET*

A screen shot of the worksheet by type is shown in Figure 21. All cells shaded yellow should be completed by the investigator. Fields shaded light blue are calculations. The general directions are as follows:

1. Complete project header information. Urban road character is classified as being within urban transportation boundaries if existing, otherwise within city limits. The date range for the crash data is required (green shaded cells) to calculate the annual benefit and must be entered in date worksheet.

2. Type a brief description of the proposed countermeasure and enter the CRF by collision type for the countermeasure in the cells next to “Countermeasure#” label. Enter a short description of the collision type and the crash reduction factor, expressed as a decimal. The CRF represents the estimated percent reduction in crashes. Up to 4 countermeasures can be entered.

3. From the crash data, enter the number of crashes for each crash type in the yellow shaded cells in column labeled "Number of Crashes" by collision type. These must be in the same order as the countermeasures listed in step #2 to keep cell referencing.

4. Enter the economic value of a reduced crash based on road character and facility type in the project header (this is automated on the worksheet) from the "Comprehensive Economic Value per Crash" in the pink shaded table in the column labeled "D Economic Value - per Crash."

5. Enter the estimated project cost. Include preliminary engineering but not right-of-way costs and round to nearest $1,000.

6. Select a present worth factor for the life of a countermeasure. Long-term treatments such as left-turn refuges and geometric improvements should use a 20-year analysis. Short-term improvements such as signs and pavement markings should use a 10-year analysis.

**OREGON DEPARTMENT OF TRANSPORTATION**
**HIGHWAY SAFETY PROJECTS**
**BENEFIT/COST ANALYSIS WORKSHEET**

| For Office Use Only |
|---|
| File Code: PRO 08 -_______-_______ |

Project Name: **0** Region: **0** Date:

*Project on Local Agency Facility*
Route Number: Street Name: MP Range or Cross Street:

*Project on State Highway*
Route Number: **0** Hwy Name: **,** MP From: **0.00** to **0.00**

Road Character: URBAN Facility Type: OTHER STATE HIGHWAY

County: **BAKER** City: Crash Data From: to

Project Description: **0**

Prepared By: **0** Title: **0**

| | | Collision Type | Crash Reduction Factor |
|---|---|---|---|
| *Countermeasure 1* | | | |
| *Countermeasure 2* | | | |
| *Countermeasure 3* | | | |
| *Countermeasure 4* | | | |

| *Collision Type* | Number of Crashes | Number of Preventable Crashes | Economic Value per Crash | | Total Economic Value |
|---|---|---|---|---|---|
| Fatal and Severe - Fat & Inj A Crashes | | 0.0 | $1,500,000 | = | $ - |
| Mod and Minor - Injury B & C Crashes | | 0.0 | $55,000 | = | $ - |
| PDO Crashes | | 0.0 | $15,000 | = | $ - |

| *Collision Type* | Number of Crashes | Number of Preventable Crashes | Economic Value per Crash | | Total Economic Value |
|---|---|---|---|---|---|
| Fatal and Severe - Fat & Inj A Crashes | | 0.0 | $1,500,000 | = | $ - |
| Mod and Minor - Injury B & C Crashes | | 0.0 | $55,000 | = | $ - |
| PDO Crashes | | 0.0 | $15,000 | = | $ - |

| *Collision Type* | Number of Crashes | Number of Preventable Crashes | Economic Value per Crash | | Total Economic Value |
|---|---|---|---|---|---|
| Fatal and Severe - Fat & Inj A Crashes | | 0.0 | $1,500,000 | = | $ - |
| Mod and Minor - Injury B & C Crashes | | 0.0 | $55,000 | = | $ - |
| PDO Crashes | | 0.0 | $15,000 | = | $ - |

| *Collision Type* | Number of Crashes | Number of Preventable Crashes | Economic Value per Crash | | Total Economic Value |
|---|---|---|---|---|---|
| Fatal and Severe - Fat & Inj A Crashes | | 0.0 | $1,500,000 | = | $ - |
| Mod and Minor - Injury B & C Crashes | | 0.0 | $55,000 | = | $ - |
| PDO Crashes | | 0.0 | $15,000 | = | $ - |

| Comprehensive Economic Value per Crash | | |
|---|---|---|
| Highway Type | Urban | Rural |
| PDO [3] | | |
| All facilities | $15,000 | $15,000 |
| Moderate (Injury B) and Minor (Injury C) Injury [4] | | |
| Interstate | $48,900 | $54,800 |
| Other State Highway | $47,900 | $55,000 |
| Fatal and Severe (Injury A) Injury [4] | | |
| Interstate | $850,000 | $1,460,000 |
| Other State Highway | $840,000 | $1,500,000 |

**Total Crash Value for** **0** Months = **$ -**

**Annual Benefits =** Total Crash Value / Total Months / 12 =

**Estimated Project Cost** =

| Uniform Series Present Worth Factor (5%) | |
|---|---|
| 10 years | 20 years |
| 7.72 | 12.46 |

**B/C Ratio =** Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

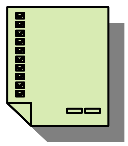
**B/C Ratio =** x [2] =
$

**Notes**

1 Composite crash reduction factor calculated if more than one countermeasure is applied
2 Select a PWF for the life of countermeasure. See instructions
3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.
4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

**FIGURE 21. BENEFIT/COST WORKSHEET BY TYPE**

### 6.3.3 Using The Benefit-Combination Form



If both the B/C by type and by severity are used in a project justification, the combination of BC fom will combine these calculations for one composite B/C calculation. All cells shaded yellow should be completed by the investigator. Fields shaded light blue are calculations.

### 6.3.4 Prioritization of Countermeasures and Projects

There are two possible situations that can be encountered for the investigator to consider. First, a set of feasible countermeasures may exist for a particular location. Assuming only one can be implemented (mutually exclusive projects) and they all meet budget constraints, the easiest selection process is for the investigator to calculate the "Net Present Value" (NPV) for all alternatives and select the solution with the highest NPV. The NPV can be calculated by subtracting the value of benefits in the numerator from the cost in the denominator from the benefit-cost worksheet (Annual Benefits x Present Worth Factor – Present Worth Costs).

IMPORTANT -- Mutually exclusive projects should not be selected by comparing Benefit-to-Cost (B/C) ratios. If the investigator wants to use a B/C, the incremental B/C ratio method should be used. The NPV is a simpler and more straightforward approach for this assessment.

For independent projects with a budget constraint, a simple optimization selection process should be employed.

### 6.3.5 Stating the Problem and Writing the Recommendation

Clear identification of issues at an identified location can be critical for diagnosis and determination of successful site recommendations. It is essential, therefore, to clearly identify site issues and document these conditions for current and future assessment.

As a general rule, a location that is a candidate for a safety enhancement project will have a specific set of identifiable countermeasures that may be applicable. These potential recommendations can include iterative solutions. These recommendations are a culmination of the investigations process. The final recommendation is the improvement or set of improvements that should be implemented. These improvements have been identified by the crash data analysis, field investigation, and were determined to be cost effective.

The text of the recommendation should be written such that there is a clear link established between the identified crash or safety problem and the proposed solution.

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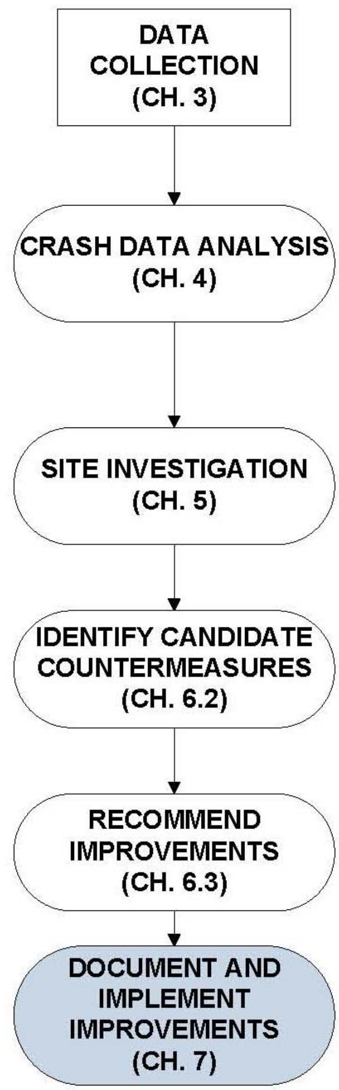
# 7 DOCUMENTATION AND IMPLEMENTATION



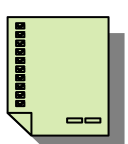

Documentation of the safety investigation and subsequent recommendations is important for a number of reasons. First, by properly documenting the evaluation and project recommendations the implemented improvements can be more easily evaluated for effectiveness. This documentation will also allow ODOT to easily complete and compile the federal reporting requirements for the Highway Safety Improvement Program. Second, a well-organized investigations file and its summary document, the *Highway Safety Investigations Report (HSIR)*, serve as important tools for improving safety considerations in project discussions. Lastly, in the case of tort liability, the file and summary report could prove useful in defending the Department's actions.

## 7.1 DOCUMENTATION

### *7.1.1 INVESTIGATIONS FILE*

It is important to keep an organized file, both electronically and paper-based. All worksheets that are completed as part of the investigations should be saved and named in a systematic format.

### *7.1.2 HIGHWAY SAFETY INVESTIGATIONS REPORT (HSIR)*



The purpose of the *Highway Safety Investigations Report* is to be the final summary of the investigation process. The form is intended to also serve as a tracking mechanism for corrective action. The investigator can call the file "complete" and enter a "close" date after the recommendations have been implemented. Nearly all of the information required for the report should have been obtained or analyzed as a part of the investigations process. Figure 19 shows a screen capture of this form.

#### 7.1.2.1 LOCATION INFORMATION

The first section of the report defines the location of the investigation. The information required includes: Region; District; County; City (optional); Route Number; Hwy Name; Road

Character; Facility Type; if the investigation is at an intersection, the intersection MP; if the project is over a segment, the mileposts from and to.

#### 7.1.2.2 SUMMARY

The summary area documents the investigator's name and title, the type of investigation, and whether or not a previous investigation was conducted. A space is given for a narrative description of the problem that was identified by the investigations. The narrative should be clear and concise and summarize the results of the diagnosis and field investigations. The recommendation narrative should be written such that there is a clear link established between the crash or safety problem identified and the proposed solution (see Section 6.3.3 in the previous chapter). A possible recommendation is "NO WORK."

The information requested in the recommendation summary is used primarily for reporting and performance measurement purposes. The type of work recommended (maintenance, as part of project, stand-alone, quick-hit, or no work) is needed. The improvement types are broad categories required for the Federal reporting requirements. If more than one type of improvement is proposed, the work that is the greatest percentage of the total project budget should be entered.

For before-after evaluations, it is important to clearly define the type of crashes and the location that was being targeted. "Target" crashes are those crashes that the improvement is expected to modify. For example, if the addition of a left-turn lane was proposed for a rural highway, target crashes would likely be rear-end, turning, and possibly angle crash types. The target crashes should be from the "collision type" categories in the existing condition summary. The milepost range should define the area where the safety improvement was constructed. If the location cannot be described simply by milepost, additional notes can be added about the location.

Finally, be sure to place a "1" in cell T33, T34, T35, or T36 indicating with B/C form was used in the analysis. The value from the appropriate B/C form will be transferred and shown on the HSIR. If no B/C analysis was conducted be sure to indicate this.

#### 7.1.2.3 APPROVALS

The approval section contains the date the investigator completed the form, who (if anyone) reviewed and approved the investigation and recommendation, and their approval date.

#### 7.1.2.4 Existing Conditions Summary

This section summarizes the existing crash, volume, rates, SPIS and SIP category scores (for the past three years) , geometry and operation data, and whether or not a field visit was conducted for this particular investigation. Additional notes (of any kind) can be included in the notes field.

#### 7.1.2.5 Recommendations Tracking and Follow-Up

The purpose of this section is to document the progress of implementing the recommended solutions. If the recommendations were maintenance or quick-hit, the date and person to whom the request was sent to is documented. When the work is complete, that information is verified and entered. If the recommendations are part of another project, the project key number or project name should be included in the documentation.

## 7.2 Implementation

The corrective action can be performed in a number of ways:

1. Maintenance action – if the recommended improvement is relatively minor and low cost, the work can be done as part of normal maintenance crew activities.
2. Quick-hit safety improvement – a lower cost improvement that exceeds maintenance budgets but can be funded from an allocation from the Highway Safety Engineering Committee (HSEC).
3. Improvements as part of a larger project - if a known STIP project will be undertaken near the investigated section in the near future, it may be possible to integrate the improvements. If the recommendation meets all requirements, the improvement can be funded from safety funds.
4. Stand-alone safety project – a stand-alone STIP project funded from safety funds that must meet all of the specified requirements.

To determine funding sources, refer to the Highway Safety Program Guide.

Safety Improvement File Complete Yes No

Close Date

## OREGON DEPARTMENT OF TRANSPORTATION
## SAFETY INVESTIGATIONS MANUAL
## HIGHWAY SAFETY INVESTIGATIONS REPORT

**LOCATION INFORMATION**

Region: 2 District 3 County: LINN City: -

Route Number: US-20 Hwy Name: SANTIAM MP From: 78.41 to 78.59

Road Character: RURAL Facility Type: RURAL PRINCIPAL ARTERIAL Intersection, at MP: NA At -

**SUMMARY**

Prepared By: KM Title: OFFICE INVESTIGATOR

Investigation Type: SPIS INVESTIGATION

**HISTORICAL INFORMATION**

Are there any previously approved investigations of this location on record? Yes ☐ No ☑

If yes, date

**NARRATIVE DESCRIPTION OF PROBLEM**

Two of the injury A crashes involved EB drivers losing control and crossing into oncoming lanes. Only 1 WB driver was coded as too fast for conditions. On EB driver avoided debris in roadway. There are existing speed curve warning signs posted with 40 mph riders, thermoplastic was installed on MP 73-88 in September 2006. Curve realignment is not possible. A dynamic curve warning or enhanced chevrons could be considered.

**RECOMMENDATION NARRATIVE**

Install chevrons on outside of curve.

**RECOMMENDATION SUMMARY**

Implementation: MAINTENANCE

Improvement Type: SIGNING AND DELINEATION

Other

Target Crashes: Sideswipe meeting

Target Crash MP to

Location Notes: see MP range

Estimated Cost: $ -

Benefit/Cost Ratio

**APPROVALS**

Date Investigator Completed: 8/30/2009 Reviewed By: AK Approval Date: 8/30/2005

**EXISTING CONDITION SUMMARY**

**CRASH TOTALS**

| Severity | 3-Yr | Percent |
|---|---|---|
| Fatal+ Inj A | 3 | 30% |
| Injury B+C | 3 | 30% |
| PDO | 4 | 40% |
| TOTAL | 10 | 100% |

**CRASH PATTERNS**

| Collision Type (All) | 3-Yr | Percent |
|---|---|---|
| Angle | 0 | 0% |
| Head-on | 1 | 10% |
| Rear | 0 | 0% |
| Sideswipe-Meet | 2 | 20% |
| Sideswipe-Over | 1 | 10% |
| Turn | 0 | 0% |
| Parked | 0 | 0% |
| NonCollision | 2 | 20% |
| Backing | 0 | 0% |
| Pedestrian | 0 | 0% |
| Fixed Object | 4 | 40% |
| Other | 0 | 0% |
| TOTAL | 10 | |

**TRAFFIC VOLUMES**

| Year | 2005 | 2006 | 2007 | Average |
|---|---|---|---|---|
| Major ADT | 0 | 0 | 5600 | 5,600 |
| Minor ADT | - | - | - | 0 |

**SPIS**

| Year | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|
| SPIS Score | 21.94 | 36.90 | 0.00 | 67.90 |

**RATES**

| Severity | Invs. Rate | Peer Rate | Critical Rate | Flag? |
|---|---|---|---|---|
| All Crashes | 5.44 | 0.72 | 1.21 | YES |

**GEOMETRY AND OPERATIONS**

Speed Limit: 55 mph

Shoulder Widths

Left (ft): 6

Right (ft): 6

Number of Lanes: 2

**FIELD VISIT**

Was a field investigation conducted? Yes ☐ No ☑

If yes, date

If yes, participants

**ADDITIONAL NOTES**

**RECOMMENDATION TRACKING AND FOLLOW UP**

**MAINTENANCE or QUICK HIT**

Recommendation Sent To: Maintenance

Sent Date

Work Complete Date: 5/27/2009

Verified By

Verified Date

**AS PART OF PROJECT or STAND-ALONE**

Project Key No.

Project Name

**FIGURE 22. HSIR SCREEN CAPTURE**

# 8 REFERENCES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# 9 APPENDIX A – INTERSECTION SIGHT DISTANCE EVALUATION

## 9.1 INSTRUCTIONS FOR EVALUATING INTERSECTION SIGHT DISTANCE

The information included in this section is based on the procedures identified in the AASHTO *Policy on the Geometric Design of Highways and Streets* (2004). More information is available in this source on pages 654-661. This approach is for intersections and should not be applied for analysis at ODOT driveway locations.

**What is Intersection Sight Distance**

Intersection sight distance is the distance drivers stop at a minor approach needs to see (either to the left or right) for them to make a safe turning maneuver onto a cross street. It is commonly evaluated at four-legged approaches with stop control on the minor street or at driveway locations.

For right turn movements, intersection sight distance is measured to the left, since drivers making right turns will need to check for gaps in the approaching traffic (which is approaching from their left). Likewise, for left turns or through movements, intersection sight distance is measured to the right and to the left (since the vehicle needs to cross in the path of vehicles approaching from both directions).

In intersection sight distance, a 3-dimensional *sight triangle* is created. The first leg of the triangle extends from the stopped driver's eye position (on the minor street) forward until reaching the lane the driver will turn into. The second leg of the triangle runs down the center of the lane of the approaching vehicles (either to the left or right) for the full distance of the required intersection sight distance. The end of the intersection sight distance represents the position of the object (in this case an approaching car) the driver must be able to see. The third leg of the triangle is the hypotenuse, and runs from the end of the required stopping sight distance length to the stopped driver's eye position. The area of this triangle represents the entire space a driver needs to have clear from obstructions to complete a safe turning maneuver. At the stopped vehicle position, drivers must be able to see the entire roadway surface of this triangle at all locations.

**When to Evaluate**

An over-representation of right-angle collisions or rear-end collisions at a site indicates that intersection sight distance should be evaluated. Proper intersection sight distance is important for maintaining safely operating intersections. Locations that do not have proper intersection sight distance prevent drivers from being able to safely execute turns. When sight distance is limited, drivers cannot correctly assess gaps in oncoming traffic. Drivers then run the risk of turning in front of a vehicle without the space necessary to complete their turning maneuver and/or accelerate to the roadway operating speed before that vehicle reaches them.

**<u>In Office Work</u>**
Before visiting the site, it is important to identify the presence of key geometrical features. These features include horizontal and vertical curves. Horizontal curves can be identified using aerial photographs. These are often available through the services of Google Maps and Google Earth. When identifying a horizontal curve, determine a map scale, locate the point of curvature, point of tangent, and determine the approximate radius of the curve. This information may also be available from archived as-build drawings.

**<u>Field Work</u>**
After completing the in office work, a site visit is necessary to conduct field observations. These observations include measuring out the appropriate intersection sight distance triangle and checking to see that the entire area is clear of sight distance obstructions. The following step-by-step instructions demonstrate how to measure and check an intersection sight distance triangle.

- ***Step 1: Roadway Slope:*** From Position A, walk 250 feet to the left/right next to the major roadway. Place the SmartLevel on ground and record slope to determine if the slope exceeds 3%.
- **Step 2: Approach Speed:** At this same 250 feet location, measure vehicle operating speeds. Use procedures consistent with the ODOT Speed Zone Investigation Manual.
- **Step 3: Required Sight Distance:** Using Table A or B, look up the required sight distance for the approach.
- **Step 4: Stopped Driver Eye Position (A):** Measure 14.5 feet back from edge of major roadway or, if present, edge of crosswalk farthest from major roadway. While having someone look out for approaching traffic, position yourself in center of approach lane. Unroll 3.5 feet long measuring tape. Position end of tape on roadway surface. Hold tape vertical. Top of tape represents stopped driver's eye position.
- **Step 5: Roadway Object Position (B or C):** Position self in major road through lane closest to (for measurements to the left) or farthest from (for measurements to the right) the minor approach. Walk required distance to the left/right and along path of lane. At required distance away from approach, unroll 3.5 feet long measuring tape. Position end of tape on roadway surface. Hold tape vertical. Tape represents an entire object the driver's eye should be able to see. Hold an object (such as a clip board) at this 3.5 feet height for easy visibility.

- **Visibility Check:** Person at Position A (with eye at top of tape) should look left/right towards Position B or C. They should have full visibility of the object (tape) at that point and any other location along the roadway surface between them and Position B or C.

  **If Position A provides clear visibility of the measuring tape at location B or C (and all points between), then visibility is met to the Left (Position B) or Right (Position C).**

**Intersection Sight Distance Tables**

Table A: For grades less than 3% (Driver Eye Height and Object Height of 3.5 feet)

| Approach Speed (mph) | Distance to Left (feet) | Distance to Right (feet) |
|---|---|---|
| 15 | 145 | 170 |
| 20 | 195 | 225 |
| 25 | 240 | 280 |
| 30 | 290 | 335 |
| 35 | 335 | 390 |
| 40 | 385 | 445 |
| 45 | 430 | 500 |
| 50 | 480 | 555 |
| 55 | 530 | 610 |
| 60 | 575 | 665 |
| 65 | 645 | 720 |
| 70 | 730 | 775 |
| 75 | 820 | 830 |
| 80 | 910 | 910 |

Values from *AASHTO 2004 Policy on Geometric Design of Highways and Streets*, Exhibit 9-55, Design Intersection Sight Distance-Case B1-Left Turn from Stop, Exhibit 9-58, Design Intersection Sight Distance-Case B2-Right Turn from Stop

Table B: For grades exceeding 3% (Driver Eye Height of 3.5 feet and Object Height of 6")

| Approach Speed (mph) | Stopping Sight Distance (ft) | | | | | |
|---|---|---|---|---|---|---|
| | Downgrades | | | Upgrades | | |
| | 3% | 6% | 9% | 3% | 6% | 9% |
| 20 | 158 | 165 | 173 | 147 | 143 | 140 |
| 25 | 205 | 215 | 227 | 200 | 184 | 179 |
| 30 | 257 | 271 | 287 | 237 | 229 | 222 |
| 35 | 315 | 333 | 354 | 289 | 278 | 269 |
| 40 | 378 | 400 | 427 | 344 | 331 | 320 |
| 45 | 446 | 474 | 507 | 405 | 388 | 375 |
| 50 | 520 | 553 | 593 | 469 | 450 | 433 |
| 55 | 598 | 638 | 686 | 538 | 515 | 495 |
| 60 | 682 | 728 | 785 | 612 | 584 | 561 |
| 65 | 771 | 825 | 891 | 690 | 658 | 631 |
| 70 | 866 | 927 | 1003 | 772 | 736 | 704 |
| 75 | 965 | 1035 | 1121 | 859 | 817 | 782 |

## 9.2 Intersection Sight Distance Example Problems

**ISD EXAMPLE PROBLEM 1: Typical Conditions 1**

**Question:** Does the intersection approach provide clear right turn and left turn sight distance?

**Site Characteristics:**

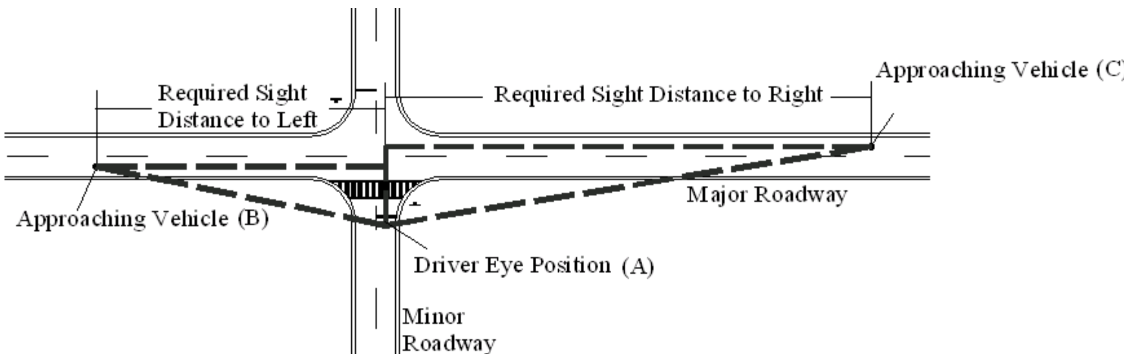
- Four-legged approach
- 90 degree intersection angle
- All vertical approaches are less than 2% slope and no vertical curves are present (i.e. level terrain)
- Two-way stop control (minor streets)
- Sidewalks on all approaches
- Crosswalks present at minor street approaches
- Studied approach is the Northbound approach (Southbound approach performed separately)

**Methodology:** After identifying key site characteristics, roadway slope and approach operating speed values are used to determine the required sight distance for each approach. This distance is then measured at the site to determine if the required site distance for right and left turns is provided.

<table>
<tr><th colspan="3">Intersection Sight Distance to the LEFT: Calculated Values</th></tr>
<tr><td colspan="2">Roadway Slope: Starting at the driver position, walk 250 feet to the left alongside the major roadway. At end, place SmartLevel on ground and record slope.</td><td>1%</td></tr>
<tr><td colspan="2">Approach Speed: Remaining 250 feet away, measure vehicle speeds. Use procedures in speed study section of ODOT Safety Investigation Manual.</td><td>44 mph (round to 45 mph)</td></tr>
<tr><td colspan="2">Required Sight Distance: Using the provided table, look up the required sight distance.</td><td>430 feet</td></tr>
<tr><td>Approach Speed (mph)</td><td>Distance to Left (feet)</td><td>Distance to Right (feet)</td></tr>
<tr><td>40</td><td>385</td><td>445</td></tr>
<tr><td>45</td><td>430</td><td>500</td></tr>
<tr><td>50</td><td>480</td><td>555</td></tr>
<tr><td colspan="2">Visibility Check</td><td>Visibility is provided for entire distance.</td></tr>
<tr><td colspan="2">Is Visibility Met?</td><td>Yes</td></tr>
</table>

| **Intersection Sight Distance to the RIGHT: Calculated Values** | | |
|---|---|---|
| ***Roadway Slope:*** Starting at the driver position, walk 250 feet to the right alongside the major roadway. At end, place SmartLevel on ground and record slope.. | 1.5 % | |
| ***Approach Speed:*** Remaining 250 feet away, measure vehicle speeds. Use procedures in speed study section of ODOT Safety Investigation Manual. | 40 mph | |
| ***Required Sight Distance:*** Using the provided table, look up the required sight distance. | 445 feet | |
| Approach Speed (mph) | Distance to Left (feet) | Distance to Right (feet) |
| 35 | 335 | 390 |
| **40** | 385 | **445** |
| 45 | 430 | 500 |
| **Visibility Check** | Visibility is provided for entire distance. | |
| **Is Visibility Met?** | Yes | |

**Completed Worksheet:**

| **General Information** | |
|---|---|
| Analyst Julia Roberts<br>Agency ODOT<br>Date Performed December 13, 2007 | Time of Day 2:00 PM<br>Analysis Year 2007<br>Jurisdiction Benton County |
| **Site Characteristics** | **In Office Work** |
| Crosswalk at Approach (Y/N) Y<br>Sidewalk (Y/N) Y<br>Vertical Curve (Y/N) N | Horizontal Curve (Y/N) N<br>Approximate Radius (if present) N/A |
| **Plan Figure** | |
|  | |
| **Required Sight Distance to LEFT** | **Required Sight Distance to RIGHT** |
| Roadway Slope to Left 1%<br>Left Approach Operating Speed 44mph<br>Required Sight Distance 430 feet | Roadway Slope to Right 1.5%<br>Right Approach Operating Speed 40 mph<br>Required Sight Distance 445 feet |



| **Visibility LEFT** | **Visibility RIGHT** |
|---|---|
| Clear Sight Distance Left (Y/N) Y<br>List of Obstructions: None | Clear Sight Distance Right (Y/N) Y<br>List of Obstructions: None |
| **If the Stopped Driver Eye Position provides clear visibility of the measuring tape at the Roadway Object Position (and all points between that position and the Stopped Driver Eye Position), then visibility is met to the LEFT/RIGHT.** | |

| **Site Sketch** |
|---|
| |
| Include: lanes, crosswalks, sidewalks, horizontal curves, vehicle movements, etc. |

**ISD EXAMPLE PROBLEM 2: Typical Conditions 2**

**Question:** Does the intersection approach provide clear right turn and left turn sight distance?

**Site Characteristics:**

- Four-legged approach
- 90 degree intersection angle
- All vertical approaches are less than 2% slope and no vertical curves are present (i.e. level terrain)
- Two-way stop control (minor streets)
- Sidewalks on all approaches
- Crosswalks present at minor street approaches
- Studied approach is the Northbound approach (Southbound approach performed separately)

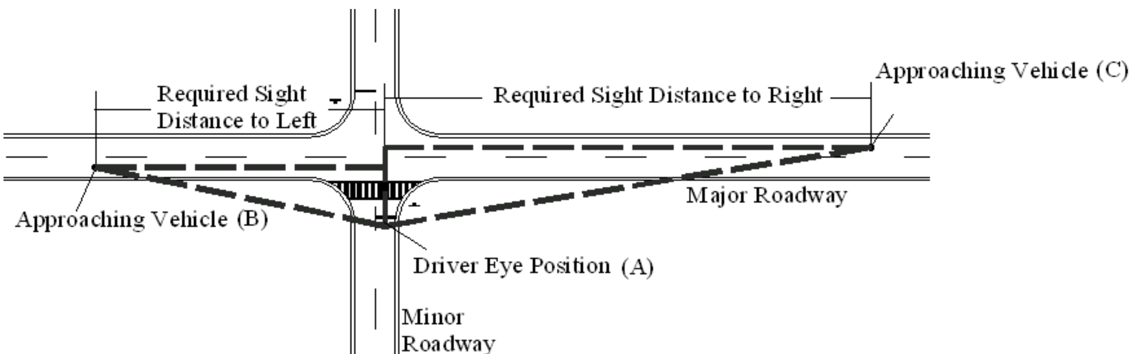
**Methodology:** After identifying key site characteristics, roadway slope and approach operating speed values are used to determine the required sight distance for each approach. This distance is then measured at the site to determine if the required site distance for right and left turns is provided.

<table>
<tr><th colspan="4">Intersection Sight Distance to the LEFT: Calculated Values</th></tr>
<tr><td colspan="2">Roadway Slope: Starting at the driver position, walk 250 feet to the left alongside the major roadway. At end, place SmartLevel on ground and record slope.</td><td colspan="2">1.5%</td></tr>
<tr><td colspan="2">Approach Speed: Remaining 250 feet away, measure vehicle speeds. Use procedures in speed study section of ODOT Safety Investigation Manual.</td><td colspan="2">33 mph (round to 35 mph)</td></tr>
<tr><td colspan="2">Required Sight Distance: Using the provided table, look up the required sight distance.</td><td colspan="2">335 feet</td></tr>
<tr><td>Approach Speed (mph)</td><td colspan="2">Distance to Left (feet)</td><td>Distance to Right (feet)</td></tr>
<tr><td>30</td><td colspan="2">290</td><td>335</td></tr>
<tr><td>35</td><td colspan="2">335</td><td>390</td></tr>
<tr><td>40</td><td colspan="2">385</td><td>445</td></tr>
<tr><td colspan="2">Visibility Check</td><td colspan="2">Visibility is provided for entire distance.</td></tr>
<tr><td colspan="2">Is Visibility Met?</td><td colspan="2">Yes</td></tr>
</table>

<table>
<tr><th colspan="3">Intersection Sight Distance to the RIGHT: Calculated Values</th></tr>
<tr><td colspan="2">Roadway Slope: Starting at the driver position, walk 250 feet to the right alongside the major roadway. At end, place SmartLevel on ground and record slope..</td><td>2 %</td></tr>
<tr><td colspan="2">Approach Speed: Remaining 250 feet away, measure vehicle speeds. Use procedures in speed study section of ODOT Safety Investigation Manual.</td><td>35 mph</td></tr>
<tr><td colspan="2">Required Sight Distance: Using the provided table, look up the required sight distance.</td><td>390 feet</td></tr>
<tr><td>Approach Speed (mph)</td><td>Distance to Left (feet)</td><td>Distance to Right (feet)</td></tr>
<tr><td>30</td><td>290</td><td>335</td></tr>
<tr><td>35</td><td>335</td><td>390</td></tr>
<tr><td>40</td><td>385</td><td>445</td></tr>
<tr><td colspan="2">Visibility Check</td><td>Fence is blocking portion of sight triangle</td></tr>
<tr><td colspan="2">Is Visibility Met?</td><td>No</td></tr>
</table>

**Completed Worksheet:**

| **General Information** | |
|---|---|
| Analyst Clint Eastwood<br>Agency ODOT<br>Date Performed January 20, 2008 | Time of Day 4:00 PM<br>Analysis Year 2008<br>Jurisdiction Benton County |
| **Site Characteristics** | **In Office Work** |
| Crosswalk at Approach (Y/N) Y<br>Sidewalk (Y/N) Y<br>Vertical Curve (Y/N) N | Horizontal Curve (Y/N) N<br>Approximate Radius (if present) N/A |
| **Plan Figure** | |




| **Required Sight Distance to LEFT** | **Required Sight Distance to RIGHT** |
|---|---|
| Roadway Slope to Left 1.5%<br>Left Approach Operating Speed 35 mph<br>Required Sight Distance 335 feet | Roadway Slope to Right 2%<br>Right Approach Operating Speed 35 mph<br>Required Sight Distance 390 feet |
| **Visibility LEFT** | **Visibility RIGHT** |
| Clear Sight Distance Left (Y/N) Y<br>List of Obstructions: None | Clear Sight Distance Right (Y/N) N<br>List of Obstructions: Obstruction to sight triangle by fence. Check into ownership to have relocated |

**If the Stopped Driver Eye Position provides clear visibility of the measuring tape at the Roadway Object Position (and all points between that position and the Stopped Driver Eye Position), then visibility is met to the LEFT/RIGHT.**

| **Site Sketch** |
|---|
| |
| Include: lanes, crosswalks, sidewalks, horizontal curves, vehicle movements, etc. |

**ISD EXAMPLE PROBLEM 3: Horizontal Curve 1**

**Question:** Does the intersection approach provide clear right turn and left turn sight distance?

**Site Characteristics:**

- Three-legged approach
- 90 degree intersection angle
- All vertical approaches are less than 2% slope and no vertical curves are present (i.e. level terrain)
- One-way stop control (minor street)
- Sidewalks on all approaches
- Crosswalks present at minor street approach
- Studied approach is the Eastbound approach (Westbound approach performed separately)

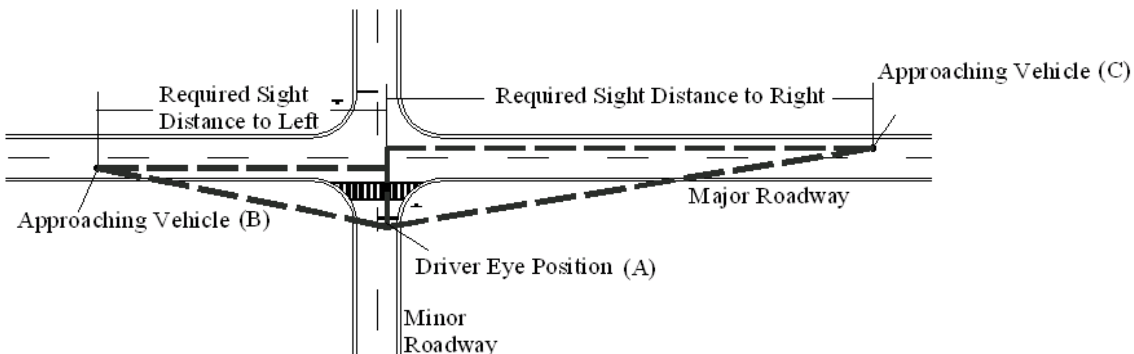
**Methodology:** After identifying key site characteristics, roadway slope and approach operating speed values are used to determine the required sight distance for each approach. This distance is then measured at the site to determine if the required site distance for right and left turns is provided. For the horizontal curve, measure the approximate radius in office using an aerial photograph.

| **Intersection Sight Distance to the LEFT: Calculated Values** | | |
|---|---|---|
| ***Roadway Slope:*** Starting at the driver position, walk 250 feet to the left alongside the major roadway. At end, place SmartLevel on ground and record slope. | 2% | |
| ***Approach Speed:*** Remaining 250 feet away, measure vehicle speeds. Use procedures in speed study section of ODOT Safety Investigation Manual. | 33 mph (round to 35 mph) | |
| ***Required Sight Distance:*** Using the provided table, look up the required sight distance. | 335 feet | |
| Approach Speed (mph) | Distance to Left (feet) | Distance to Right (feet) |
| 30 | 290 | 335 |
| **35** | **335** | 390 |
| 40 | 385 | 445 |
| **Visibility Check** | Visibility is provided for entire distance. | |
| **Is Visibility Met?** | Yes | |

| **Intersection Sight Distance to the RIGHT: Calculated Values** | | |
| --- | --- | --- |
| ***Roadway Slope:*** Starting at the driver position, walk 250 feet to the right alongside the major roadway. At end, place SmartLevel on ground and record slope.. | 3 % | |
| ***Approach Speed:*** Remaining 250 feet away, measure vehicle speeds. Use procedures in speed study section of ODOT Safety Investigation Manual. | 35 mph | |
| ***Required Sight Distance:*** Using the provided table, look up the required sight distance. | 390 feet | |
| Approach Speed (mph) | Distance to Left (feet) | Distance to Right (feet) |
| 30 | 290 | 335 |
| **35** | 335 | **390** |
| 40 | 385 | 445 |
| **Visibility Check** | Visibility is provided for entire distance. | |
| **Is Visibility Met?** | Yes | |

**Completed Worksheet:**

| **General Information** | |
|---|---|
| Analyst Tom Hanks<br>Agency ODOT<br>Date Performed January 20, 2008 | Time of Day 3:00 PM<br>Analysis Year 2008<br>Jurisdiction Benton County |
| **Site Characteristics** | **In Office Work** |
| Crosswalk at Approach (Y/N) Y<br>Sidewalk (Y/N) Y<br>Vertical Curve (Y/N) N | Horizontal Curve (Y/N) Y<br>Approximate Radius (if present) 730 feet and 790 feet |
| **Plan Figure** | |




| **Required Sight Distance to LEFT** | **Required Sight Distance to RIGHT** |
|---|---|
| Roadway Slope to Left 2%<br>Left Approach Operating Speed 35 mph<br>Required Sight Distance 335 feet | Roadway Slope to Right 3%<br>Right Approach Operating Speed 35 mph<br>Required Sight Distance 390 feet |
| **Visibility LEFT** | **Visibility RIGHT** |
| Clear Sight Distance Left (Y/N) Y<br>List of Obstructions: None | Clear Sight Distance Right (Y/N) Y<br>List of Obstructions: None |

**If the Stopped Driver Eye Position provides clear visibility of the measuring tape at the Roadway Object Position (and all points between that position and the Stopped Driver Eye Position), then visibility is met to the LEFT/RIGHT.**

**Site Sketch**

Include: lanes, crosswalks, sidewalks, horizontal curves, vehicle movements, etc.

**ISD EXAMPLE PROBLEM 4: Horizontal Curve 2**

**Question:** Does the intersection approach provide clear right turn and left turn sight distance?

**Site Characteristics:**

- Three-legged approach
- 90 degree intersection angle
- All vertical approaches are less than 2% slope and no vertical curves are present (i.e. level terrain)
- One-way stop control (minor street)
- Sidewalks on all approaches
- Crosswalks present at minor street approach
- Studied approach is the Eastbound approach (Westbound approach performed separately)

**Methodology:** After identifying key site characteristics, roadway slope and approach operating speed values are used to determine the required sight distance for each approach. This distance is then measured at the site to determine if the required site distance for right and left turns is provided. For the horizontal curve, measure the approximate radius in office using an aerial photograph.

<table>
<tr><td colspan="3">Intersection Sight Distance to the LEFT: Calculated Values</td></tr>
<tr><td colspan="2">Roadway Slope: Starting at the driver position, walk 250 feet to the left alongside the major roadway. At end, place SmartLevel on ground and record slope.</td><td>3%</td></tr>
<tr><td colspan="2">Approach Speed: Remaining 250 feet away, measure vehicle speeds. Use procedures in speed study section of ODOT Safety Investigation Manual.</td><td>25 mph</td></tr>
<tr><td colspan="2">Required Sight Distance: Using the provided table, look up the required sight distance.</td><td>240 feet</td></tr>
<tr><td>Approach Speed (mph)</td><td>Distance to Left (feet)</td><td>Distance to Right (feet)</td></tr>
<tr><td>20</td><td>195</td><td>225</td></tr>
<tr><td>25</td><td>240</td><td>280</td></tr>
<tr><td>30</td><td>290</td><td>335</td></tr>
<tr><td colspan="2">Visibility Check</td><td>Visibility is provided for entire distance.</td></tr>
<tr><td colspan="2">Is Visibility Met?</td><td>Yes</td></tr>
</table>

<table>
<tr><td colspan="3">Intersection Sight Distance to the RIGHT: Calculated Values</td></tr>
<tr><td colspan="2">Roadway Slope: Starting at the driver position, walk 250 feet to the right alongside the major roadway. At end, place SmartLevel on ground and record slope..</td><td>3 %</td></tr>
<tr><td colspan="2">Approach Speed: Remaining 250 feet away, measure vehicle speeds. Use procedures in speed study section of ODOT Safety Investigation Manual.</td><td>24 mph (round to 25 mph)</td></tr>
<tr><td colspan="2">Required Sight Distance: Using the provided table, look up the required sight distance.</td><td>280 feet</td></tr>
<tr><td>Approach Speed (mph)</td><td>Distance to Left (feet)</td><td>Distance to Right (feet)</td></tr>
<tr><td>20</td><td>195</td><td>225</td></tr>
<tr><td>25</td><td>240</td><td>280</td></tr>
<tr><td>30</td><td>290</td><td>335</td></tr>
<tr><td colspan="2">Visibility Check</td><td>No</td></tr>
<tr><td colspan="2">Is Visibility Met?</td><td>Presence of shrubs blocks ability to see more than 260 feet down roadway.</td></tr>
</table>

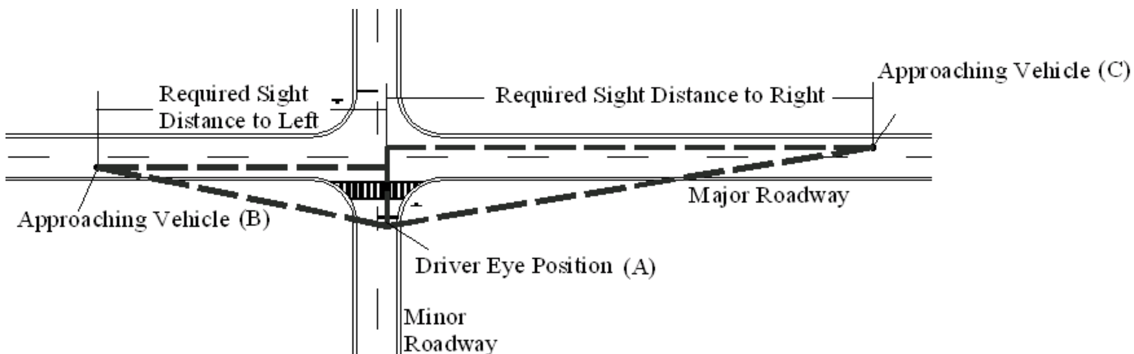
**Completed Worksheet:**

**General Information**

| | |
|---|---|
| Analyst: Meg Ryan | Time of Day: 10:00 AM |
| Agency: ODOT | Analysis Year: 2008 |
| Date Performed: January 22, 2008 | Jurisdiction: Benton County |

| **Site Characteristics** | **In Office Work** |
|---|---|
| Crosswalk at Approach (Y/N): Y | Horizontal Curve (Y/N): Y |
| Sidewalk (Y/N): Y | Approximate Radius (if present): 425 feet |
| Vertical Curve (Y/N): N | |

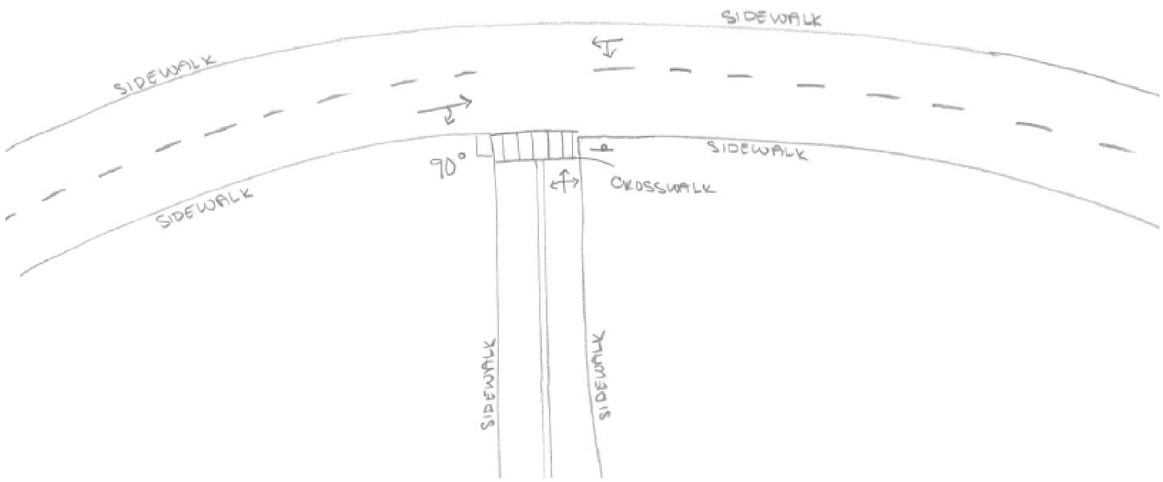
**Plan Figure**




| **Required Sight Distance to LEFT** | **Required Sight Distance to RIGHT** |
|---|---|
| Roadway Slope to Left: 3% | Roadway Slope to Right: 3% |
| Left Approach Operating Speed: 25 mph | Right Approach Operating Speed: 25 mph |
| Required Sight Distance: 240 feet | Required Sight Distance: 280 feet |

| **Visibility LEFT** | **Visibility RIGHT** |
|---|---|
| Clear Sight Distance Left (Y/N): Y | Clear Sight Distance Right (Y/N): N |
| List of Obstructions: None | List of Obstructions: Location of shrubbery prevents ability to see more than 260 feet to the right. Look into removal. |

**If the Stopped Driver Eye Position provides clear visibility of the measuring tape at the Roadway Object Position (and all points between that position and the Stopped Driver Eye Position), then visibility is met to the LEFT/RIGHT.**

| **Site Sketch** |
| --- |
|  |
| Include: lanes, crosswalks, sidewalks, horizontal curves, vehicle movements, etc. |

**ISD EXAMPLE PROBLEM 5: Vertical Curve**

**Question:** Does the intersection approach provide clear right turn and left turn sight distance?

**Site Characteristics:**

- Four-legged approach
- 90 degree intersection angle
- Two-way stop control (minor streets)
- Sidewalks on all approaches
- Crosswalks present at minor street approaches
- Studied approach is the Southbound approach (Northbound approach performed separately)

**Methodology:** After identifying key site characteristics, roadway slope and approach operating speed values are used to determine the required sight distance for each approach. This distance is then measured at the site to determine if the required site distance for right and left turns is provided.

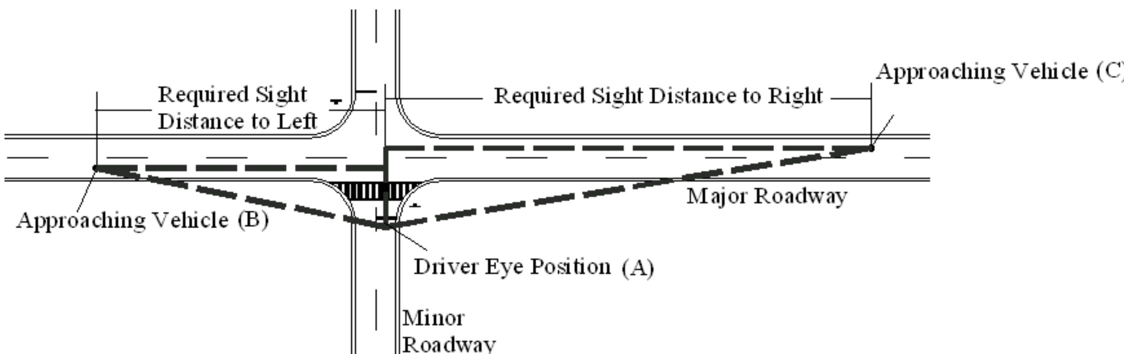
<table>
<tr><th colspan="3">Intersection Sight Distance to the LEFT: Calculated Values</th></tr>
<tr><td colspan="2">Roadway Slope: Starting at the driver position, walk 250 feet to the left alongside the major roadway. At end, place SmartLevel on ground and record slope.</td><td>3%</td></tr>
<tr><td colspan="2">Approach Speed: Remaining 250 feet away, measure vehicle speeds. Use procedures in speed study section of ODOT Safety Investigation Manual.</td><td>35 mph</td></tr>
<tr><td colspan="2">Required Sight Distance: Using the provided table, look up the required sight distance.</td><td>335 feet</td></tr>
<tr><td>Approach Speed (mph)</td><td>Distance to Left (feet)</td><td>Distance to Right (feet)</td></tr>
<tr><td>30</td><td>290</td><td>335</td></tr>
<tr><td>35</td><td>335</td><td>390</td></tr>
<tr><td>40</td><td>385</td><td>445</td></tr>
<tr><td colspan="2">Visibility Check</td><td>Visibility is provided for entire distance.</td></tr>
<tr><td colspan="2">Is Visibility Met?</td><td>Yes</td></tr>
</table>

| **Intersection Sight Distance to the RIGHT: Calculated Values** | | | |
|---|---|---|---|
| ***Roadway Slope:*** Starting at the driver position, walk 250 feet to the right alongside the major roadway. At end, place SmartLevel on ground and record slope.. | - 6 % | | |
| ***Approach Speed:*** Remaining 250 feet away, measure vehicle speeds. Use procedures in speed study section of ODOT Safety Investigation Manual. | 35 mph | | |
| ***Required Sight Distance:*** Using the provided table, look up the required sight distance. | 333 feet | | |
| Approach Speed (mph) | Downgrades | | |
| | 3% | 6% | 9% |
| 30 | 257 | 271 | 287 |
| **35** | 315 | **333** | 354 |
| 40 | 378 | 400 | 427 |
| **Visibility Check** | No | | |
| **Is Visibility Met?** | Assuming a car height of 3.5 feet, the sag curve to the right limits visibility of cars more than 75 feet away from intersection. | | |

**Completed Worksheet:**

| **General Information** | |
|---|---|
| Analyst Richard Gere<br>Agency ODOT<br>Date Performed January 22, 2008 | Time of Day 1:00 PM<br>Analysis Year 2008<br>Jurisdiction Benton County |
| **Site Characteristics** | **In Office Work** |
| Crosswalk at Approach (Y/N) Y<br>Sidewalk (Y/N) Y<br>Vertical Curve (Y/N) Y | Horizontal Curve (Y/N) N<br>Approximate Radius (if present) N/A |

**Plan Figure**




| **Required Sight Distance to LEFT** | **Required Sight Distance to RIGHT** |
|---|---|
| Roadway Slope to Left 3%<br>Left Approach Operating Speed 35 mph<br>Required Sight Distance 335 feet | Roadway Slope to Right - 6%<br>Right Approach Operating Speed 35 mph<br>Required Sight Distance 333 feet |
| **Visibility LEFT** | **Visibility RIGHT** |
| Clear Sight Distance Left (Y/N) Y<br>List of Obstructions: None | Clear Sight Distance Right (Y/N) N<br>List of Obstructions: Assuming a car height of 3.5 feet, the sag curve to the right limits visibility of cars more than 75 feet away from intersection. |

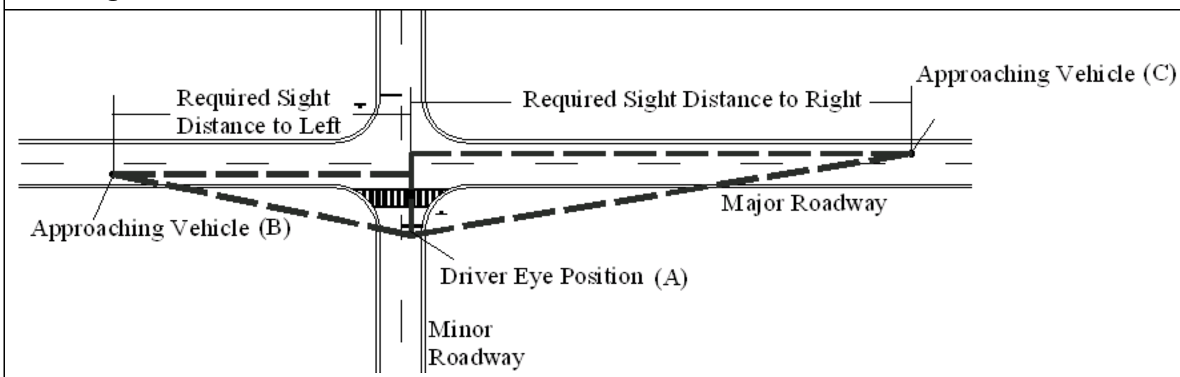
**If the Stopped Driver Eye Position provides clear visibility of the measuring tape at the Roadway Object Position (and all points between that position and the Stopped Driver Eye Position), then visibility is met to the LEFT/RIGHT.**

**Site Sketch**

Include: lanes, crosswalks, sidewalks, horizontal curves, vehicle movements, etc.

## 9.3 Intersection Sight Distance Worksheet

| **General Information** | |
|---|---|
| Analyst ____________________<br>Agency ____________________<br>Date Performed ____________________ | Time of Day _____________________<br>Analysis Year _____________________<br>Jurisdiction _____________________ |
| **Site Characteristics** | **In Office Work** |
| Crosswalk at Approach (Y/N) _________<br>Sidewalk (Y/N) _________<br>Vertical Curve (Y/N) _________ | Horizontal Curve (Y/N) ___________<br>Approximate Radius (if present) ____ |
| **Plan Figure** | |




| **Required Sight Distance to LEFT** | **Required Sight Distance to RIGHT** |
|---|---|
| Roadway Slope to Left _____________<br>Left Approach Operating Speed ______<br>Required Sight Distance _____________ | Roadway Slope to Right _____________<br>Right Approach Operating Speed ______<br>Required Sight Distance _____________ |
| **Visibility LEFT** | **Visibility RIGHT** |
| Clear Sight Distance Left (Y/N) ______<br>List of Obstructions: _________________<br>_____________________________________<br>_____________________________________ | Clear Sight Distance Right (Y/N) _____<br>List of Obstructions: ________________<br>_____________________________________<br>_____________________________________ |

**If Position A provides clear visibility of the measuring tape at location B or C (and all points between that), then visibility is met to the left (Position B) and/or right (Position C).**

**INTERSECTION SIGHT DISTANCE WORKSHEET (continued)**

**Required Sight Distance Table (less than 3% grade)**

| Approach Speed (mph) | Distance to Left (feet) | Distance to Right (feet) | Additional Comments |
|---|---|---|---|
| 15 | 145 | 170 | |
| 20 | 195 | 225 | |
| 25 | 240 | 280 | |
| 30 | 290 | 335 | |
| 35 | 335 | 390 | |
| 40 | 385 | 445 | |
| 45 | 430 | 500 | |
| 50 | 480 | 555 | |
| 55 | 530 | 610 | |
| 60 | 575 | 665 | |
| 65 | 645 | 720 | |
| 70 | 730 | 775 | |
| 75 | 820 | 830 | |
| 80 | 910 | 910 | |

| Site Sketch |
|---|
| |
| Include: lanes, crosswalks, sidewalks, horizontal curves, vehicle movements, etc. |

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# 10 APPENDIX B – WORKSHEETS

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**TABLE IV:** 2008 CRASH RATES BY JURISDICTION AND FUNCTIONAL CLASSIFICATION

Table IV reports state highway system crash rates by federally defined urban and rural areas and functional classification. Data for highway connections and frontage roads are excluded.

*Note: Highway miles are based on highway system definition and inventory data as of July 2008. For official mileage data, refer to the 2008 Oregon Mileage Report at http://www.oregon.gov/ODOT/TD/TDATA/publications.shtml.*

| JURISDICTION AND FUNCTIONAL CLASSIFICATION | MILES | ANNUAL VEHICLE MILES | CRASHES | FATALI-TIES | CRASH RATE* | FATALITY RATE* |
|---|---|---|---|---|---|---|
| **TOTAL STATE HWY SYSTEM** | **7,453.23** | **19,523,091,729** | **16,142** | **221** | **0.83** | **1.13** |
| Interstate Freeways | 730.52 | 8,526,366,378 | 3,169 | 38 | 0.37 | 0.45 |
| Other Fwys/Expressways | 54.27 | 1,290,552,234 | 858 | 8 | 0.66 | 0.62 |
| Non-Freeways (combined) | 6,668.44 | 9,706,173,117 | 12,115 | 175 | 1.25 | 1.80 |
| Other Principal Arterials | 3,280.79 | 7,509,225,541 | 9,631 | 115 | 1.28 | 1.53 |
| Minor Arterials | 1,959.83 | 1,811,486,662 | 2,031 | 44 | 1.12 | 2.43 |
| Urban Collectors | 8.69 | 10,172,238 | 11 | 0 | 1.08 | 0.00 |
| Rural Major Collectors | 1,381.52 | 371,721,968 | 439 | 16 | 1.18 | 4.30 |
| Rural Minor Collectors | 34.72 | 3,432,935 | 3 | 0 | 0.87 | 0.00 |
| Rural Local | 2.89 | 133,773 | 0 | 0 | 0.00 | 0.00 |
| **URBAN HWY SYSTEM** | **819.67** | **9,207,412,773** | **10,054** | **61** | **1.09** | **0.66** |
| Interstate Freeways | 176.15 | 4,445,167,356 | 2,066 | 16 | 0.46 | 0.36 |
| Other Fwys/Expressways | 54.27 | 1,290,552,234 | 858 | 8 | 0.66 | 0.62 |
| Non-Freeways (combined) | 589.25 | 3,471,693,183 | 7,130 | 37 | 2.05 | 1.07 |
| Other Principal Arterials | 512.59 | 3,163,978,720 | 6,584 | 34 | 2.08 | 1.07 |
| Minor Arterials | 67.97 | 297,542,225 | 535 | 3 | 1.80 | 1.01 |
| Urban Collectors | 8.69 | 10,172,238 | 11 | 0 | 1.08 | 0.00 |
| **Urban Cities** | **568.62** | **6,973,941,364** | **8,497** | **48** | **1.22** | **0.69** |
| Interstate Freeways | 111.61 | 3,256,667,634 | 1,733 | 13 | 0.53 | 0.40 |
| Other Fwys/Expressways | 47.73 | 1,184,858,022 | 794 | 6 | 0.67 | 0.51 |
| Non-Freeways (combined) | 409.28 | 2,532,415,708 | 5,970 | 29 | 2.36 | 1.15 |
| Other Principal Arterials | 366.57 | 2,337,353,812 | 5,527 | 26 | 2.36 | 1.11 |
| Minor Arterials | 41.06 | 192,668,622 | 440 | 3 | 2.28 | 1.56 |
| Urban Collectors | 1.65 | 2,393,274 | 3 | 0 | 1.25 | 0.00 |
| **Suburban Areas** | **251.05** | **2,233,471,409** | **1,557** | **13** | **0.70** | **0.58** |
| Interstate Freeways | 64.54 | 1,188,499,722 | 333 | 3 | 0.28 | 0.25 |
| Other Fwys/Expressways | 6.54 | 105,694,212 | 64 | 2 | 0.61 | 1.89 |
| Non-Freeways (combined) | 179.97 | 939,277,475 | 1,160 | 8 | 1.23 | 0.85 |
| Other Principal Arterials | 146.02 | 826,624,908 | 1,057 | 8 | 1.28 | 0.97 |
| Minor Arterials | 26.91 | 104,873,603 | 95 | 0 | 0.91 | 0.00 |
| Urban Collectors | 7.04 | 7,778,964 | 8 | 0 | 1.03 | 0.00 |
| **RURAL HWY SYSTEM** | **6,633.56** | **10,315,678,956** | **6,088** | **160** | **0.59** | **1.55** |
| Interstate Freeways | 554.37 | 4,081,199,022 | 1,103 | 22 | 0.27 | 0.54 |
| Non-Freeways (combined) | 6,079.19 | 6,234,479,934 | 4,985 | 138 | 0.80 | 2.21 |
| Other Principal Arterials | 2,768.20 | 4,345,246,821 | 3,047 | 81 | 0.70 | 1.86 |
| Minor Arterials | 1,891.86 | 1,513,944,437 | 1,496 | 41 | 0.99 | 2.71 |
| Rural Major Collectors | 1,381.52 | 371,721,968 | 439 | 16 | 1.18 | 4.30 |
| Rural Minor Collectors | 34.72 | 3,432,935 | 3 | 0 | 0.87 | 0.00 |
| Rural Local | 2.89 | 133,773 | 0 | 0 | 0.00 | 0.00 |
| **Rural Cities** | **218.91** | **491,825,707** | **536** | **0** | **1.09** | **0.00** |
| Interstate Freeways | 14.05 | 89,782,362 | 26 | 0 | 0.29 | 0.00 |
| Non-Freeways (combined) | 204.86 | 402,043,345 | 510 | 0 | 1.27 | 0.00 |
| Other Principal Arterials | 109.77 | 271,934,779 | 321 | 0 | 1.18 | 0.00 |
| Minor Arterials | 53.24 | 92,629,842 | 148 | 0 | 1.60 | 0.00 |
| Rural Major Collectors | 41.60 | 37,222,524 | 41 | 0 | 1.10 | 0.00 |
| Rural Minor Collectors | 0.25 | 256,200 | 0 | 0 | 0.00 | 0.00 |
| **Rural Areas** | **6,414.65** | **9,823,853,249** | **5,552** | **160** | **0.57** | **1.63** |
| Interstate Freeways | 540.32 | 3,991,416,660 | 1,077 | 22 | 0.27 | 0.55 |
| Non-Freeways (combined) | 5,874.33 | 5,832,436,589 | 4,475 | 138 | 0.77 | 2.37 |
| Other Principal Arterials | 2,658.43 | 4,073,312,042 | 2,726 | 81 | 0.67 | 1.99 |
| Minor Arterials | 1,838.62 | 1,421,314,595 | 1,348 | 41 | 0.95 | 2.88 |
| Rural Major Collectors | 1,339.92 | 334,499,444 | 398 | 16 | 1.19 | 4.78 |
| Rural Minor Collectors | 34.47 | 3,176,735 | 3 | 0 | 0.94 | 0.00 |
| Rural Local | 2.89 | 133,773 | 0 | 0 | 0.00 | 0.00 |

* Crash Rate Formula: ((crashes*1,000,000)/VMT); Fatality Rate Formula: ((deaths*100,000,000)/VMT)

http://www.oregon.gov/ODOT/TD/TDATA/car/CAR_Publications.shtml

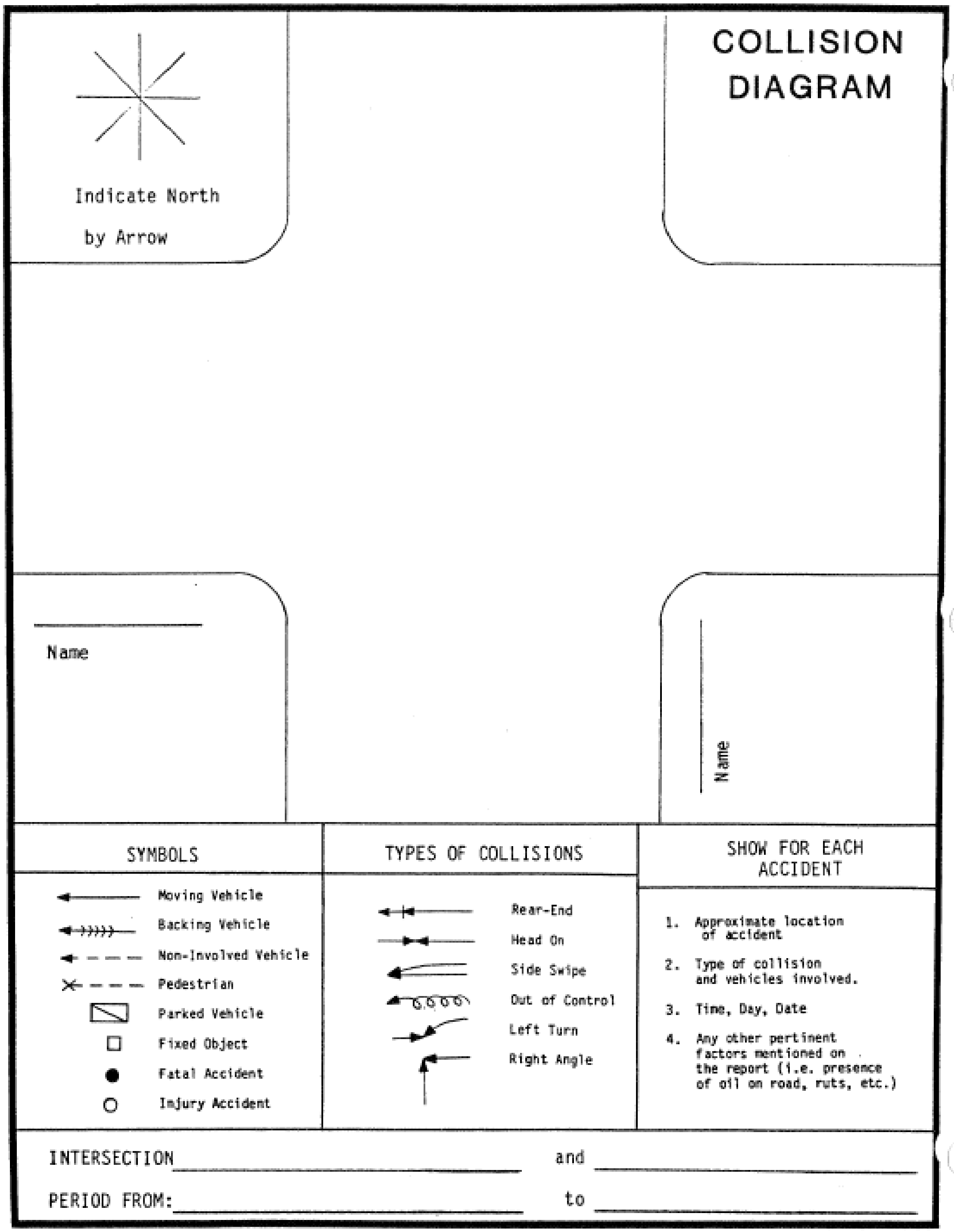
**TABLE V:** 2008 FATAL AND SERIOUS INJURY CRASH AND CASUALTY RATES

Table V reports data on state highway crashes that resulted in death or serious injury. A serious injury (INJ-A) is one that prevents a person from walking, driving or continuing normal activities which the person was capable of prior to sustaining the injury.

| JURISDICTION AND FUNCTIONAL CLASSIFICATION | MILES* | ANNUAL VEHICLE MILES* | FATAL & SERIOUS INJURY (INJ-A) CRASHES* | DEATHS AND SERIOUS INJURIES* | FATAL & INJ-A CRASH RATE** | FATAL & INJ-A CASUALTY RATE** |
|---|---|---|---|---|---|---|
| **TOTAL STATE HWY SYSTEM** | **7,453.23** | **19,523,091,729** | **872** | **1,114** | **4.47** | **5.71** |
| Interstate Freeways | 730.52 | 8,526,366,378 | 117 | 144 | 1.37 | 1.69 |
| Other Fwys/Expressways | 54.27 | 1,290,552,234 | 26 | 33 | 2.01 | 2.56 |
| Non-Freeways (combined) | 6,668.44 | 9,706,173,117 | 729 | 937 | 7.51 | 9.65 |
| Other Principal Arterials | 3,280.79 | 7,509,225,541 | 548 | 709 | 7.30 | 9.44 |
| Minor Arterials | 1,959.83 | 1,811,486,662 | 145 | 183 | 8.00 | 10.10 |
| Urban Collectors | 8.69 | 10,172,238 | 0 | 0 | 0.00 | 0.00 |
| Rural Major Collectors | 1,381.52 | 371,721,968 | 34 | 43 | 9.15 | 11.57 |
| Rural Minor Collectors | 34.72 | 3,432,935 | 2 | 2 | 58.26 | 58.26 |
| Rural Local | 2.89 | 133,773 | 0 | 0 | 0.00 | 0.00 |
| **URBAN HWY SYSTEM** | **819.67** | **9,207,412,773** | **406** | **515** | **4.41** | **5.59** |
| Interstate Freeways | 176.15 | 4,445,167,356 | 65 | 81 | 1.46 | 1.82 |
| Other Fwys/Expressways | 54.27 | 1,290,552,234 | 26 | 33 | 2.01 | 2.56 |
| Non-Freeways (combined) | 589.25 | 3,471,693,183 | 315 | 401 | 9.07 | 11.55 |
| Other Principal Arterials | 512.59 | 3,163,978,720 | 289 | 368 | 9.13 | 11.63 |
| Minor Arterials | 67.97 | 297,542,225 | 26 | 33 | 8.74 | 11.09 |
| Urban Collectors | 8.69 | 10,172,238 | 0 | 0 | 0.00 | 0.00 |
| **Urban Cities** | **568.62** | **6,973,941,364** | **279** | **348** | **4.00** | **4.99** |
| Interstate Freeways | 111.61 | 3,256,667,634 | 54 | 61 | 1.66 | 1.87 |
| Other Fwys/Expressways | 47.73 | 1,184,858,022 | 18 | 25 | 1.52 | 2.11 |
| Non-Freeways (combined) | 409.28 | 2,532,415,708 | 207 | 262 | 8.17 | 10.35 |
| Other Principal Arterials | 366.57 | 2,337,353,812 | 190 | 241 | 8.13 | 10.31 |
| Minor Arterials | 41.06 | 192,668,622 | 17 | 21 | 8.82 | 10.90 |
| Urban Collectors | 1.65 | 2,393,274 | 0 | 0 | 0.00 | 0.00 |
| **Suburban Areas** | **251.05** | **2,233,471,409** | **127** | **167** | **5.69** | **7.48** |
| Interstate Freeways | 64.54 | 1,188,499,722 | 11 | 20 | 0.93 | 1.68 |
| Other Fwys/Expressways | 6.54 | 105,694,212 | 8 | 8 | 7.57 | 7.57 |
| Non-Freeways (combined) | 179.97 | 939,277,475 | 108 | 139 | 11.50 | 14.80 |
| Other Principal Arterials | 146.02 | 826,624,908 | 99 | 127 | 11.98 | 15.36 |
| Minor Arterials | 26.91 | 104,873,603 | 9 | 12 | 8.58 | 11.44 |
| Urban Collectors | 7.04 | 7,778,964 | 0 | 0 | 0.00 | 0.00 |
| **RURAL HWY SYSTEM** | **6,633.56** | **10,315,678,956** | **466** | **599** | **4.52** | **5.81** |
| Interstate Freeways | 554.37 | 4,081,199,022 | 52 | 63 | 1.27 | 1.54 |
| Non-Freeways (combined) | 6,079.19 | 6,234,479,934 | 414 | 536 | 6.64 | 8.60 |
| Other Principal Arterials | 2,768.20 | 4,345,246,821 | 259 | 341 | 5.96 | 7.85 |
| Minor Arterials | 1,891.86 | 1,513,944,437 | 119 | 150 | 7.86 | 9.91 |
| Rural Major Collectors | 1,381.52 | 371,721,968 | 34 | 43 | 9.15 | 11.57 |
| Rural Minor Collectors | 34.72 | 3,432,935 | 2 | 2 | 58.26 | 58.26 |
| Rural Local | 2.89 | 133,773 | 0 | 0 | 0.00 | 0.00 |
| **Rural Cities** | **218.91** | **491,825,707** | **16** | **21** | **3.25** | **4.27** |
| Interstate Freeways | 14.05 | 89,782,362 | 0 | 0 | 0.00 | 0.00 |
| Non-Freeways (combined) | 204.86 | 402,043,345 | 16 | 21 | 3.98 | 5.22 |
| Other Principal Arterials | 109.77 | 271,934,779 | 15 | 20 | 5.52 | 7.35 |
| Minor Arterials | 53.24 | 92,629,842 | 1 | 1 | 1.08 | 1.08 |
| Rural Major Collectors | 41.60 | 37,222,524 | 0 | 0 | 0.00 | 0.00 |
| Rural Minor Collectors | 0.25 | 256,200 | 0 | 0 | 0.00 | 0.00 |
| **Rural Areas** | **6,414.65** | **9,823,853,249** | **450** | **578** | **4.58** | **5.88** |
| Interstate Freeways | 540.32 | 3,991,416,660 | 52 | 63 | 1.30 | 1.58 |
| Non-Freeways (combined) | 5,874.33 | 5,832,436,589 | 398 | 515 | 6.82 | 8.83 |
| Other Principal Arterials | 2,658.43 | 4,073,312,042 | 244 | 321 | 5.99 | 7.88 |
| Minor Arterials | 1,838.62 | 1,421,314,595 | 118 | 149 | 8.30 | 10.48 |
| Rural Major Collectors | 1,339.92 | 334,499,444 | 34 | 43 | 10.16 | 12.86 |
| Rural Minor Collectors | 34.47 | 3,176,735 | 2 | 2 | 62.96 | 62.96 |
| Rural Local | 2.89 | 133,773 | 0 | 0 | 0.00 | 0.00 |

* Couplet and Roadway 3 data are included. Frontage road and connection data are excluded.
** Crash Rate Formula: ((crashes*100 Million)/VMT); Casualty Rate Formula: (((deaths+serious injuries)*100 Million)/VMT)

http://www.oregon.gov/ODOT/TD/TDATA/car/CAR_Publications.shtml



COLLISION DIAGRAM

Indicate North by Arrow

Name

Name

| SYMBOLS | |
|---|---|
| | Moving Vehicle |
| | Backing Vehicle |
| | Non-Involved Vehicle |
| | Pedestrian |
| | Parked Vehicle |
| | Fixed Object |
| | Fatal Accident |
| | Injury Accident |

| TYPES OF COLLISIONS | |
|---|---|
| | Rear-End |
| | Head On |
| | Side Swipe |
| | Out of Control |
| | Left Turn |
| | Right Angle |

SHOW FOR EACH ACCIDENT

1. Approximate location of accident
2. Type of collision and vehicles involved.
3. Time, Day, Date
4. Any other pertinent factors mentioned on the report (i.e. presence of oil on road, ruts, etc.)

INTERSECTION ______________________ and ______________________

PERIOD FROM: ______________________ to ______________________

## OREGON DEPARTMENT OF TRANSPORTATION
## SAFETY INVESTIGATIONS MANUAL
## SITE INVESTIGATION FORM

| | | | |
|---|---|---|---|
| **Location:**<br>City/Town/County: ________________ | ☐ Rural<br>☐ Urban<br>☐ Suburban | ☐ Tangent<br>☐ Curves | **Reason for Investigation:**<br>☐ SPIS Investigation<br>☐Response to complaint or inquiry<br>☐Project Request<br>☐Fatal Crash Reports<br>☐Other _________ |
| Route no. or Street name: ________________ State highway no.: ___________ Mile Point(MP): ________ | | | |
| At intersection with(if applicable)<br>Route no. or name : ____________ State highway no.: ________ Mile Point(MP): ____ | | | |

**Crash Summary:** Number of Crashes

| Year | Total | Fat. | Severe Inj. | Other Inj. | PDO | Crash Patterns to Investigate (see Pattern Diagnostics Worksheet) |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Traffic Data:**

Highway type: _______
ADT(1000): _______
Posted Speed: _______

**Potential Crash Cause and Possible Solutions:**

**Observations through Field Review:**

**Comments:**

| Investigator | Date | Project Manager | Date | Approved by | Date |
|---|---|---|---|---|---|
| | | | | | |

**OREGON DEPARTMENT OF TRANSPORTATION**

**SAFETY INVESTIGATIONS MANUAL**

**ROADWAY INVENTORY CHECKLIST**

**Location:**
City/Town/County: ________________

**Direction:**
☐ N ☐ S ☐ E ☐ W

**Divider Type:**
☐ Concrete Barrier
☐ Guardrail / Cable Rail / Fence
☐ Raise Island (paved or grass)
☐ Grass / Earth at grade
☐ Painted or Marked
☐ Does not Apply

Route no. or Street name: ________________ State highway no.: ___________ Mile Point(MP): ________

At intersection with(if applicable)
Route no. or name : ____________ State highway no.: ________ Mile Point(MP): ____

**Photo Summary:**

**Traffic Controls:**
☐ No Control
☐ Traffic Signal
☐ Flashing Red Signal
☐ Flashing Yellow Signal
☐ Stop Sign
☐ Yield Sign
☐ RR Flashing Lights, Signals, Gates
☐ RR Crossbuck with Adv. Signs
☐ RR Crossbuck without Adv. Signs
☐ School Zone Sign
☐ No Passing Zone
☐ Other Traffic Control __________

**Pavement Markings:**
☐ None
☐ Broken Yellow Line
☐ Broken Yellow Line & Solid Yellow Line
☐ Solid Yellow Line
☐ Double Solid Yellow Lines
☐ Broken White Line
☐ Solid White Line
☐ Edge Lines
☐ Raised Pavement Markers
☐ Temporary Pavement Marking
☐ Other Pavement Markings __________
____________________________________

**Auxiliary Lanes:**
☐ None
☐ Left Turn
☐ Right Turn
☐ TWLTL
☐ Passing
☐ Special Purpose ________

**Access Control:**
☐ Interstate
☐ Other Limited Access
☐ Controlled Access
☐ Uncontrolled Access
☐ Median Crossover

**Roadway Geometry:**
☐ Curvature (Centerline Radius = ____________) OR ☐ Straight
☐ Grade (Approximate Grade in Percent = __________________)
☐ Superelevation (Approximate Superelevation in Percent = ________________)
☐ Median (Width = ________________) OR ☐ Undivided
☐ Through Lanes (Describe: ______________________________________________)
☐ Lanes (Widths = _________________________)
☐ Shoulder (Type & Width: _____________) OR ☐ Curb OR ☐ No Edge Treatment
☐ Surface Treatment (Describe: ___________________________________________)
☐ Other Road Geometry not indicated: ____________________________________

**Adjacent Land Use:**
☐ Residential
☐ Commercial
☐ Industrial
☐ Agricultural / Natural
☐ Undeveloped
☐ School
☐ Other ________

**Comments:**

# Equipment Checklist

<u>Basic Equipment for All Investigations</u>

- ☐ Clipboard
- ☐ Required Worksheets
- ☐ Pencil with Eraser & Pen
- ☐ Ruler or Straight Edge
- ☐ Calculator
- ☐ Hard Hat, Safety Vest, Safety Glasses (as needed for location)
- ☐ Manual or Smart Level
- ☐ Measuring Tapes (25 ft and 100 ft)
- ☐ Measuring Wheel
- ☐ Digital Camera or Recorder
- ☐ Compass or GPS
- ☐ 3.5 feet long reflective tapes

<u>Supplemental Equipment for Specific Investigations</u>

*Night Study:*

- ☐ White clothing
- ☐ Night reflective vest
- ☐ Flashlight

*Speed Studies:*

- ☐ Radar or Laser Gun
- ☐ Stopwatch

*Volume Studies:*

- ☐ Traffic Counter

*Other Special Studies:*

- ☐ Chalk or String Line
- ☐ Spray Paint
- ☐ Tape Recorder
- ☐ Spare Batteries
- ☐ Height targets (2 ft, 3.5 ft, and 4.25 ft as needed)

# 11 APPENDIX C – CASE STUDIES

This case study is based on an investigation completed in Region 2 but has been modified for the purposes of this manual. This is not the official investigation report.

### Case Study 1: OR99E at Checkerboard Road

The following information is entered in the *COVER SHEET* for a site description. This is a SPIS Investigation of a newly listed SPIS site.

**OREGON DEPARTMENT OF TRANSPORTATION**
**SAFETY INVESTIGATIONS MANUAL**
**COVER SHEET**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Office Data By: | KM | | | Title: | OFFICE INVESTIGATOR | | |
| Field Investigation By: | KM | | | Title: | FIELD INVESTIGATOR | | |
| Investigation Name: | OR99E at Checkerboard Road | | | | | | |
| Route Number: | OR-99E | Hwy Name: | PACIFIC HIGHWAY EAST | | | | |
| County: | MARION | City: | | Region: | 2 | District: | 3 |
| Location Type: | INTERSECTION | *Needed to autofill other forms correctly* | | | | | |
| Road Character: | RURAL | *Only descriptive (choices for functional class and intersection type do not include suburban options)* | | | | | |
| This Investigation in Response to | SPIS INVESTIGATION | | | | | | |
| **SEGMENT and CRASH DATA MPs** | | | | **INTERSECTION** | | | |
| MP From: | 36.95 | to | 37.11 | MP at | 37.04 | | |
| Functional Class: | RURAL MINOR ARTERIAL | | | Intersection Type: | R 3-LEGGED UNSIGNALIZED | | |
| | | | | Intersecting Street Name | Checkerboard Rd | | |

1. **Collect in-Office Data**

   a. Crash Data – Two Excel reports were pulled from MPs 36.95 to 37.11, the Direction report for use with the crash graph tool and the PRC report to tabulate some of the necessary information for the diagnostic worksheet. There were a total of 17 crashes from 1999 to 2003. The crash summary data are entered on the DATA ENTRY tab of the SIM workbook. The crash data are summarized by the worksheet after the PRC is copied and pasted in per the directions in the worksheet.

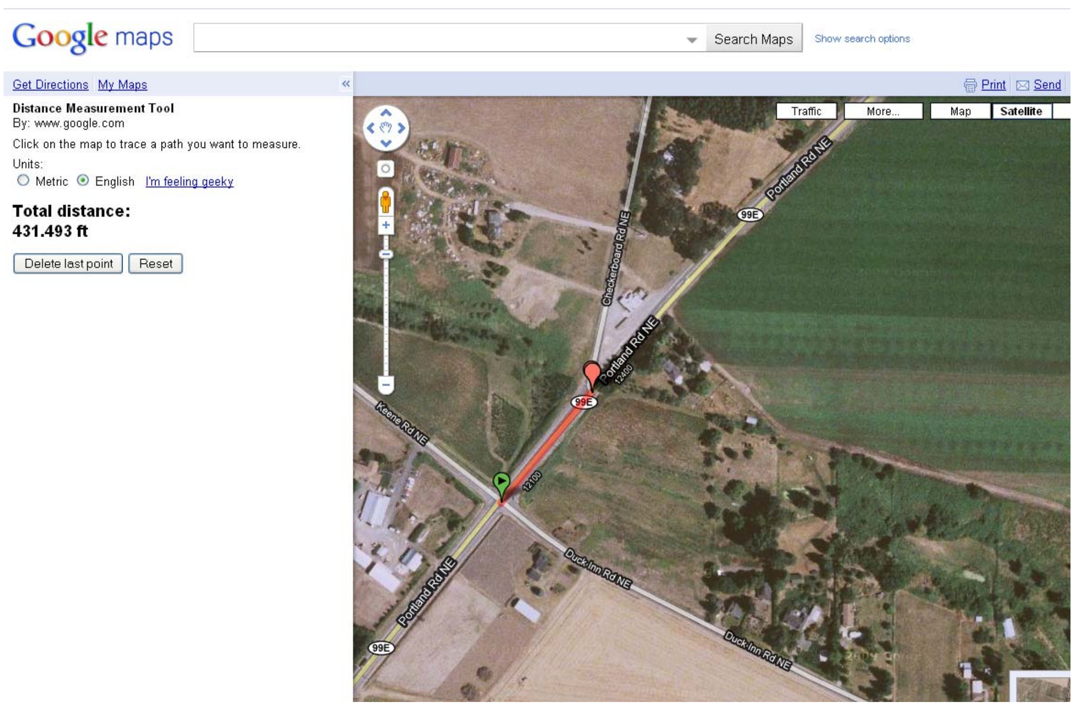
   b. Safety Priority Investigations Sites (SPIS) – Most recent SPIS report was used to obtain SPIS score. This is entered in the DATA ENTRY tab of the SIM workbook.

c. Highway Inventory Reports - Not used since DVL and field visit identified necessary information

d. Facility Functional Class – It is determined that OR99E is a rural minor arterial and the intersection is a 3-Leg Unsignalized intersection. This is entered on the *COVER SHEET*.

e. Traffic Volumes – Mainline (OR-99E) volumes obtained from the ODOT volume tables. The minor volume on Checkerboard Road was obtained from ODOT's Transportation Systems Monitoring Group. This is entered in the *DATA ENTRY* tab of the SIM workbook.

f. Google Maps – Aerial photography of the location shows that Checkerboard Road intersects 99E with a skew. The intersection is 430 feet NE of the Keene Rd. intersection (measured using Google Maps, My Maps, Distance Measurement Tool – Note that a Google account is needed to use the measurement tool).




g. Digital Video Log – The DVL photos below clearly show the skew of the intersection approaching from the south (decreasing MP) and the open access for vehicles visiting the establishment at the intersection corner.



**2. Diagnosing Crash Patterns**

a. Crash Pattern Worksheet – This is an intersection, click on the "PATTERNS_INTER" worksheet tab.

A number of different crash trends are highlighted in grey (PNorm is less than 5%) as being potentially unusual:

- Collision types (all): Rear
- Collision types (Fatal and Inj A):Rear
- Multiple Vehicle
- Light Conditions: Dusk
- Surface conditions: WET
- Driver age groups: 19-21
- Intersection – On and Off Roadway
- Straight – On Roadway
- Cause code: TOO-CLOSE

Other patterns that are close, but are not less that 5% threshold are:

- Fatal+ Inj A and Injury B+C crashes
- Intersection – Off Roadway
- Driver age groups: 25-34
- Cause code: TOO-FAST

These patterns do not always lead to a countermeasure or explanation for the SPIS site. However, the rear-end crashes do appear to need more exploration. It is also good to note that all drivers are local. The intersection crash rate is not FLAGGED as exceeding the critical rate for 3-Leg Unsignalized intersections.

b. Collision Diagrams – A collision diagram was requested from CAR. Inspection of the diagram clearly shows the pattern of rear-end and turning collisions that related to both the northbound vehicles turning left on to Checkerboard Road and what appears to be waiting to turn left into the tavern.

**3. Site Investigations**

a. After reviewing the crash data in-office, the investigator should have a good idea what the potential problems at the intersection might be. A field visit would focus on observations of vehicle entering and exiting the business property. Since the most crashes occurred in the afternoon, a field visit during this time period would be appropriate.

The two crash patterns to browse in Table 3 would be "Rear-end collisions at unsignalized intersections" and "Collisions at driveways". The table suggests documenting and investigating:

- Location and visibility of crosswalks and stop bars
- Location and visibility of stop/yield signs
- Location and visibility of advance warning signs
- Sight distance obstructions
- Peak hour, 4-hour, and 8-hour traffic volumes
- Pedestrian volumes
- Upstream operating speeds for high-speed approaches
- Sight distance obstructions
- Conspicuity of pavement marking and signs
- Number of lanes / lane widths / lane usage
- Location and measurement of median openings
- Location and description of driveway width and geometry, surface type, condition of driveway
- Shoulder type, width and condition
- Location and visibility of advance warning signs
- Sight distance obstructions
- Lighting

**SUMMARY OF DATA ANALYSIS AND FIELD INVESTIGATION:**

Checkerboard Rd (County) joins OR 99E at a skew and is in close proximity to the Keen Rd/ Duckin intersection. On the gore point is a business (tavern) with open front access to 99E and open access to Checkerboard Rd. Vehicles park along the open frontage and back out onto the roadway from the business. Crash patterns (collision diagram and diagnostic form) reveal that rear-end crashes of vehicles turning from 99E to access business and tavern are overrepresented. Sight distance does not appear to be an issue.

# OREGON DEPARTMENT OF TRANSPORTATION
## SAFETY INVESTIGATIONS MANUAL
### CRASH PATTERN WORKSHEET - INTERSECTION

| | | | |
|---|---|---|---|
| Prepared By: | KM | Title: | OFFICE INVESTIGATOR |
| Investigation Name: | OR-99E at Checkerboard Rd. | Region: 2 | District: 3 |
| Route Number: | OR-99E | Hwy Name: PACIFIC HIGHWAY WEST | MP At: 37.04 |
| Road Character: | RURAL | Intersection Type: R 3-LEGGED UNSIGNALIZED | Date Compiled: 12/21/2010 |
| County: | MARION | City: | Crash Date From: 1/1/1999 to 12/31/2003 |

**CRASH TOTALS**

| Severity | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Fatal+ Inj A | 2 | 11.8% | 3.4% | 11.3% |
| Injury B+C | 11 | 64.7% | 43.3% | 6.3% |
| PDO | 4 | 23.5% | 53.2% | 99.7% |
| | 17 | 100.0% | 100.0% | |

**CRASH PATTERNS**

| Collision Type (All) | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Angle | 0 | 0.0% | 6.5% | |
| Head-on | 0 | 0.0% | 0.4% | |
| Rear | 10 | 58.8% | 26.6% | 0.5% |
| Sideswipe-Meet | 1 | 5.9% | 0.8% | 12.2% |
| Sideswipe-Over | 0 | 0.0% | 2.3% | |
| Turn | 5 | 29.4% | 35.7% | 78.4% |
| Parked | 0 | 0.0% | 0.0% | |
| NonCollision | 0 | 0.0% | 1.1% | |
| Backing | 0 | 0.0% | 0.8% | |
| Pedestrian | 0 | 0.0% | 0.0% | |
| Fixed Object | 1 | 5.9% | 23.2% | 98.9% |
| Other | 0 | 0.0% | 2.7% | |
| | 17 | 100% | 100% | |

| Collision Type (F+A) | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Angle | 0 | 0.0% | 11.1% | |
| Head-on | 0 | 0.0% | 0.0% | |
| Rear | 1 | 50.0% | 0.0% | 0.0% |
| Sideswipe-Meet | 0 | 0.0% | 0.0% | |
| Sideswipe-Over | 0 | 0.0% | 11.1% | |
| Turn | 1 | 50.0% | 55.6% | 80.2% |
| Parked | 0 | 0.0% | 0.0% | |
| NonCollision | 0 | 0.0% | 0.0% | |
| Backing | 0 | 0.0% | 0.0% | |
| Pedestrian | 0 | 0.0% | 0.0% | |
| Fixed Object | 0 | 0.0% | 22.2% | |
| Other | 0 | 0.0% | 0.0% | |
| | 2 | 100% | 100% | |

| Crashes Involving | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Multiple Vehicles | 16 | 94.1% | 74.1% | 4.3% |
| Single Vehicle | 1 | 5.9% | 25.9% | 99.4% |
| | 17 | 100% | 100% | |

| Residence of Driver | Drivers | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Non-resident | 0 | 0.0% | 5.0% | |
| Local | 30 | 83.3% | 75.5% | 18.5% |
| In-state resident | 5 | 13.9% | 17.3% | 76.8% |
| Not Stated | 1 | 2.8% | 2.3% | 56.5% |
| | 36 | 100% | 100% | |

| Sex of Driver | Drivers | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Male | 24 | 66.7% | 58.2% | 19.6% |
| Female | 11 | 30.6% | 40.7% | 92.3% |
| Not Stated | 1 | 2.8% | 1.0% | 31.4% |
| | 36 | 100% | 100% | |

| Time | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| 12 -3 AM | 1 | 5.9% | 3.8% | 48.3% |
| 3 -6 AM | 1 | 5.9% | 3.0% | 40.9% |
| 6 -9 AM | 1 | 5.9% | 11.4% | 87.2% |
| 9-Noon | 3 | 17.6% | 16.0% | 52.5% |
| 12-3 PM | 4 | 23.5% | 17.9% | 36.1% |
| 3 -6 PM | 5 | 29.4% | 31.2% | 65.1% |
| 6-9 PM | 2 | 11.8% | 12.2% | 63.0% |
| 9-Mid | 0 | 0.0% | 4.6% | |
| UNKNOWN | 0 | 0.0% | 0.0% | |
| | 17 | 100% | 100% | |

| Light Conditio | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| DAWN | 1 | 5.9% | 1.9% | 27.8% |
| DAY | 13 | 76.5% | 70.7% | 41.4% |
| DLIT | 0 | 0.0% | 6.1% | |
| DARK | 1 | 5.9% | 19.4% | 97.4% |
| DUSK | 2 | 11.8% | 1.9% | 4.1% |
| UNK | 0 | 0.0% | 0.0% | |
| | 17 | 100% | 100% | |

| Surface Cond. | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| DRY | 10 | 58.8% | 75.3% | 96.2% |
| ICE | 0 | 0.0% | 4.2% | |
| WET | 7 | 41.2% | 19.8% | 3.6% |
| SNO | 0 | 0.0% | 0.8% | |
| UNK | 0 | 0.0% | 0.0% | |
| Total | 17 | 100% | 100% | |

| Weekday | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Sunday | 3 | 17.6% | 14.4% | 45.4% |
| Monday | 3 | 17.6% | 12.9% | 38.0% |
| Tuesday | 0 | 0.0% | 17.1% | |
| Wednesday | 2 | 11.8% | 9.1% | 46.8% |
| Thursday | 3 | 17.6% | 15.6% | 50.8% |
| Friday | 4 | 23.5% | 14.8% | 23.8% |
| Saturday | 2 | 11.8% | 16.0% | 78.0% |
| | 17 | 100% | 100% | |

| Driver Age | Drivers | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| <15 | 0 | 0.0% | 0.0% | |
| 15-18 | 3 | 8.3% | 11.2% | 78.5% |
| 19-21 | 7 | 19.4% | 8.5% | 3.0% |
| 22-24 | 0 | 0.0% | 6.7% | |
| 25-34 | 10 | 27.8% | 16.0% | 5.2% |
| 35-44 | 3 | 8.3% | 13.5% | 88.2% |
| 45-54 | 3 | 8.3% | 16.4% | 94.9% |
| 55-64 | 5 | 13.9% | 13.1% | 51.7% |
| 65-74 | 2 | 5.6% | 6.9% | 71.7% |
| >74 | 2 | 5.6% | 4.4% | 47.0% |
| Not Stated | 1 | 2.8% | 3.3% | 70.4% |
| | 36 | 100% | 100% | |

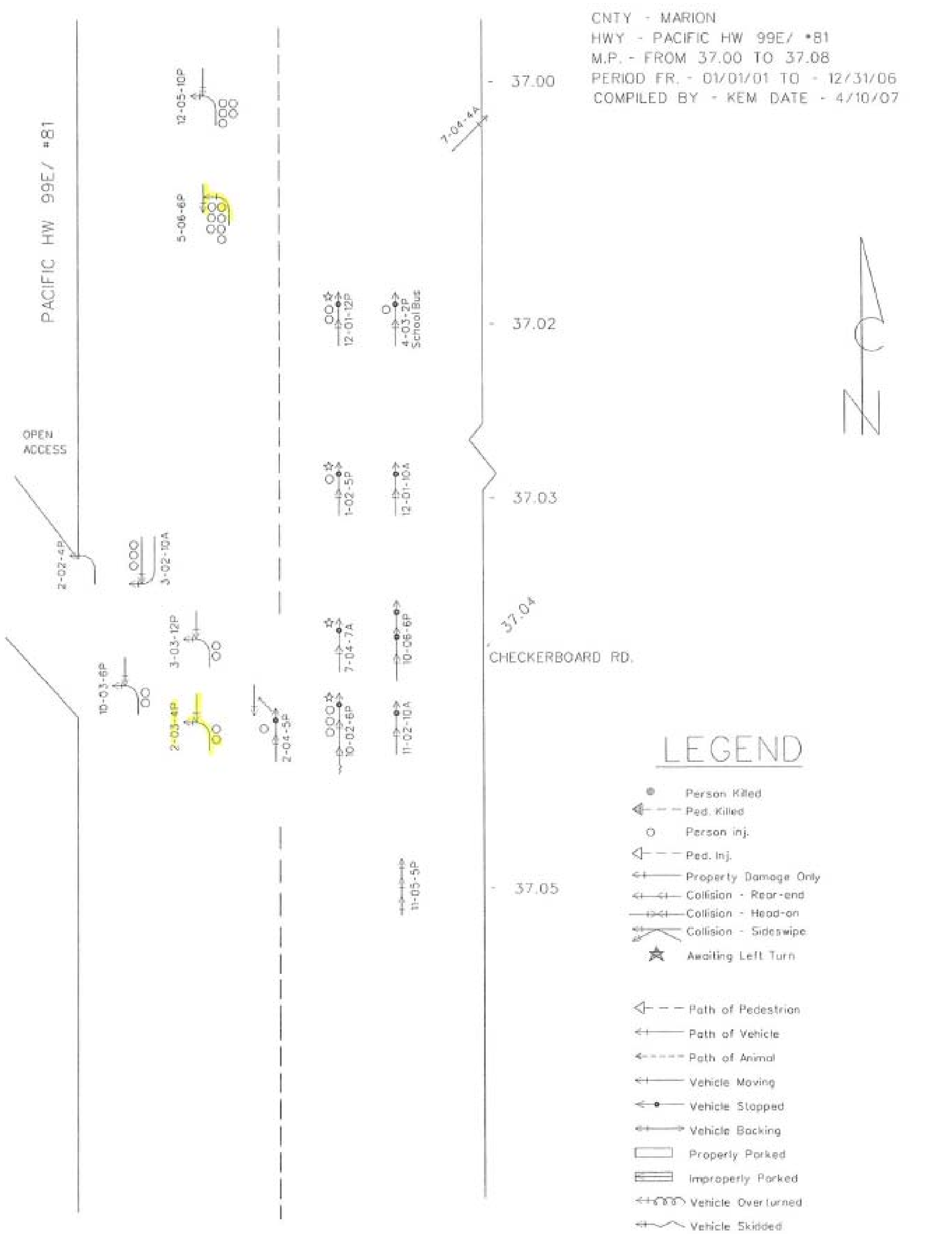
| TRAFFIC VOLUME | MAJ | 11,400 | MNR | 700 |
|---|---|---|---|---|

| RATES | Invs. Rate | Peer Rate | Critical Rate | Flag? |
|---|---|---|---|---|
| All Crashes | 0.77 | 0.19 | 0.37 | YES |

| On Roadway | Crashes | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Intersection | 10 | 58.8% | 2.3% | 0.0% |
| Alley | 0 | 0.0% | 0.0% | |
| Straight | 6 | 35.3% | 1.9% | 0.0% |
| Transition | 0 | 0.0% | 0.8% | |
| Curve | 0 | 0.0% | 54.8% | |
| Open Access | 0 | 0.0% | 0.0% | |
| Grade | 0 | 0.0% | 16.3% | |
| Bridge | 0 | 0.0% | 0.0% | |
| Tunnel | 0 | 0.0% | 0.0% | |
| Unknown | 0 | 0.0% | 0.0% | |
| | 16 | 94% | 76% | |

| Off Roadway | Crashes | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Intersection | 1 | 5.9% | 0.4% | 6.3% |
| Alley | 0 | 0.0% | 0.4% | |
| Straight | 0 | 0.0% | 3.8% | |
| Transition | 0 | 0.0% | 0.0% | |
| Curve | 0 | 0.0% | 10.6% | |
| Open Access | 0 | 0.0% | 0.0% | |
| Grade | 0 | 0.0% | 8.7% | |
| Bridge | 0 | 0.0% | 0.0% | |
| Tunnel | 0 | 0.0% | 0.0% | |
| Unknown | 0 | 0.0% | 0.0% | |
| | 1 | 6% | 24% | |

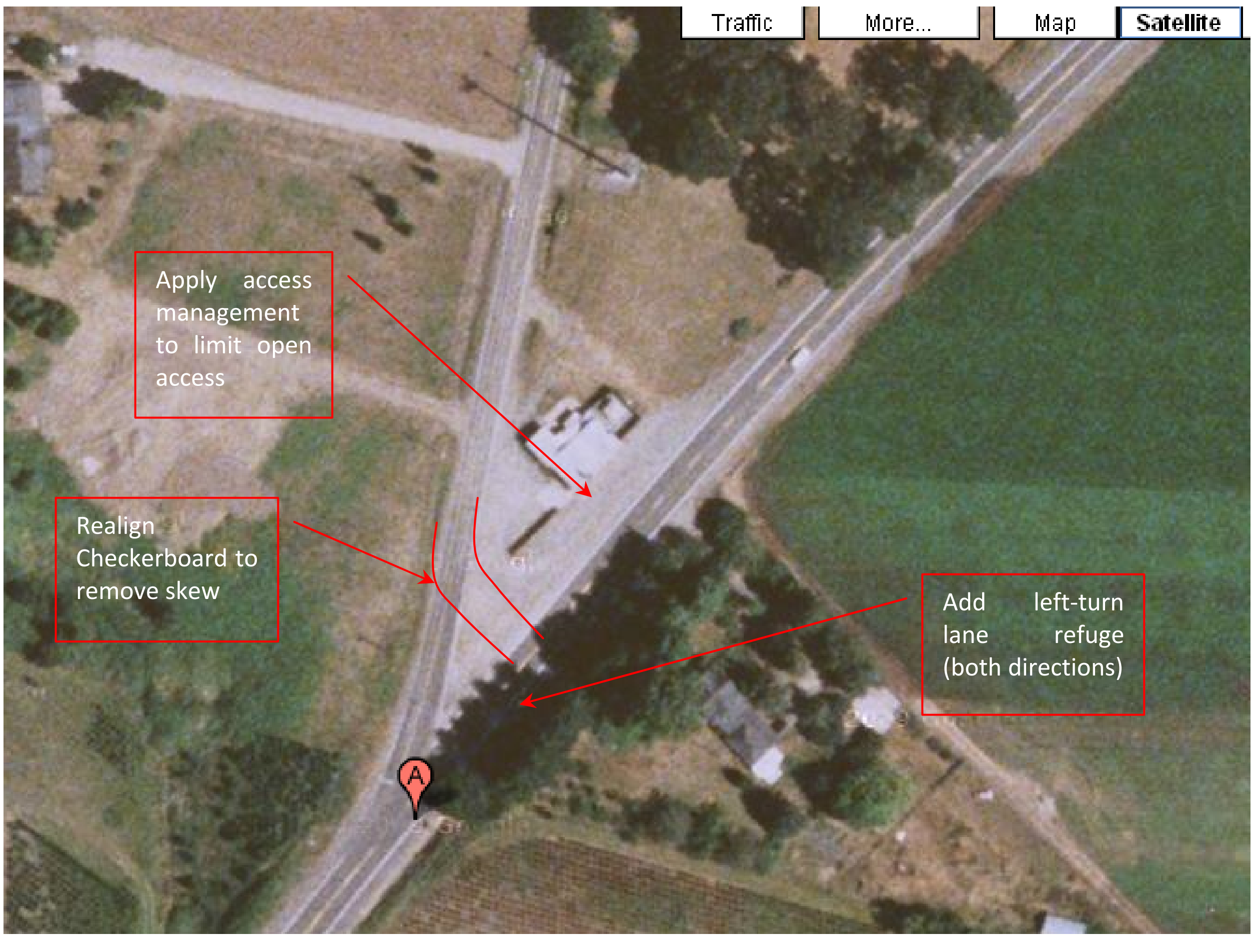
| Cause Codes | Proj | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| CARELESS | 0 | 0.0% | 1.5% | |
| DEF BRKE | 0 | 0.0% | 0.3% | |
| DEF STER | 0 | 0.0% | 0.0% | |
| DIS TCD | 0 | 0.0% | 0.0% | |
| DIS--RAG | 0 | 0.0% | 0.6% | |
| FATIGUE | 0 | 0.0% | 0.0% | |
| IMP LN C | 0 | 0.0% | 0.9% | |
| IMP-OVER | 0 | 0.0% | 0.9% | |
| IMP-TURN | 0 | 0.0% | 7.1% | |
| IN RDWY | 0 | 0.0% | 0.0% | |
| INATTENT | 0 | 0.0% | 4.9% | |
| LEFT-CTR | 0 | 0.0% | 0.3% | |
| LOADSHFT | 0 | 0.0% | 0.0% | |
| MECH-DEF | 0 | 0.0% | 0.0% | |
| NO-YIELD | 4 | 23.5% | 28.3% | 75.3% |
| NT VISBL | 0 | 0.0% | 0.0% | |
| OTHER | 0 | 0.0% | 2.5% | |
| OTHR-IMP | 0 | 0.0% | 8.0% | |
| PAS-STOP | 0 | 0.0% | 4.3% | |
| PHANTOM | 0 | 0.0% | 2.2% | |
| RECKLESS | 0 | 0.0% | 0.3% | |
| SPEED | 0 | 0.0% | 0.3% | |
| TOO-CLOS | 6 | 35.3% | 13.8% | 2.2% |
| TOO-FAST | 7 | 41.2% | 23.7% | 8.4% |
| WRNG WAY | 0 | 0.0% | 0.0% | |
| | 17 | 100% | 100% | |


CNTY - MARION
HWY - PACIFIC HW 99E/ *81
M.P. - FROM 37.00 TO 37.08
PERIOD FR. - 01/01/01 TO - 12/31/06
COMPILED BY - KEM DATE - 4/10/07
PACIFIC HW 99E/ *81
37.00
37.02
37.03
37.04
37.05
OPEN ACCESS
CHECKERBOARD RD.
12-05-10P
5-06-6P
7-04-4A
12-01-12P
4-03-2P School Bus
1-02-5P
12-01-10A
2-02-4P
3-02-10A
3-03-12P
7-04-7A
10-06-6P
10-03-6P
2-03-4P
2-04-5P
10-02-6P
11-02-10A
11-05-5P
N
LEGEND
Person Killed
Ped. Killed
Person inj.
Ped. Inj.
Property Damage Only
Collision - Rear-end
Collision - Head-on
Collision - Sideswipe
Awaiting Left Turn
Path of Pedestrian
Path of Vehicle
Path of Animal
Vehicle Moving
Vehicle Stopped
Vehicle Backing
Properly Parked
Improperly Parked
Vehicle Overturned
Vehicle Skidded

**4. Identify Candidate Countermeasures**

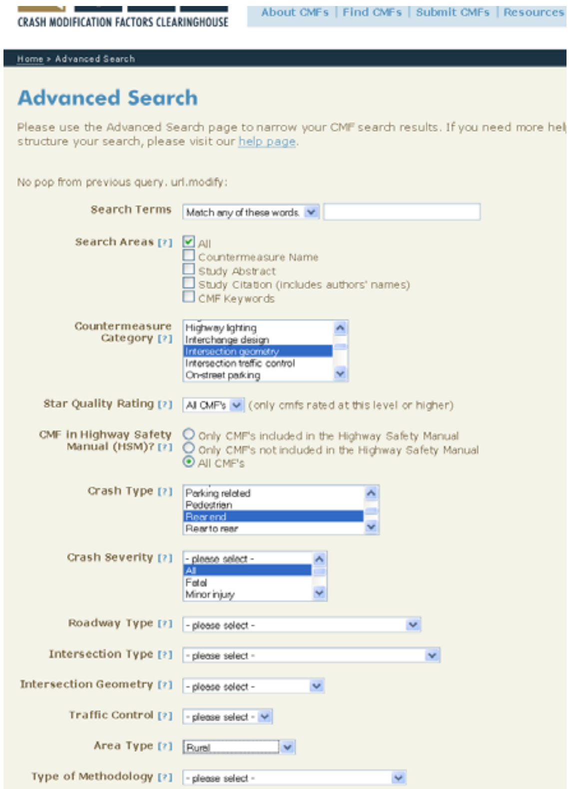
a. After reviewing the suggestions in Table 3 for rear-end crashes at unsignalized intersections, considering the field investigation and the crash patterns, a number of potential solutions can be considered.

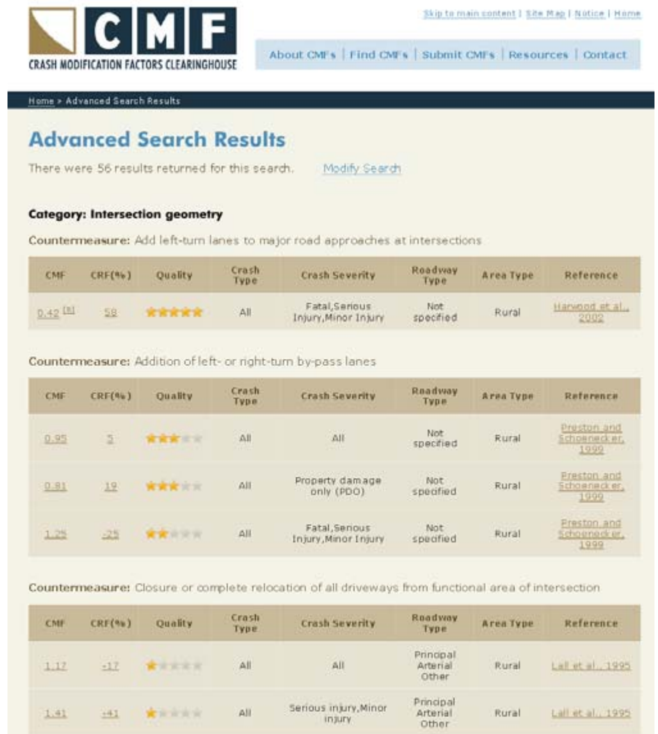
The open access is likely contributing to the crash patterns and occurrence. While skew and turning-related crashes were not highlighted by the patterns, it would generally be desirable to remove the intersection skew. Along with that, closing the open access to the business would be desirable. Finally, adding a left-turn lane refuge on OR-99E would move waiting vehicles out of the traffic stream and eliminate rear-end collisions.




**5. Expected Effectiveness of Countermeasures**

a. The FHWA Countermeasure Clearinghouse was searched for intersection geometry related CMFs in a rural area. A countermeasure to install a left turn refuge was identified with a 5-star rating. The CRF value is 58% and it applies to all crash types. CRFs for removing the skew or access management were not searched for because the addition of the left-turn refuge is sufficient for the benefit cost analysis.




## 6. Benefit Cost By Severity Worksheet

a. A cost estimate is obtained for the potential solution of approximately $1.18 million dollars. The numbers along with the CRF values are input in the *BENEFIT_COST* worksheet. A 20-yr improvement is considered. A B/C ratio of 4.49 is calculated.

**OREGON DEPARTMENT OF TRANSPORTATION**
**HIGHWAY SAFETY PROJECTS**
**BENEFIT/COST ANALYSIS WORKSHEET**

For Office Use Only
File Code: PRO 08 -______-______

Project Name: **OR-99E at Checkerboard Rd.** Region: **2** Date: **12/21/10**

*Project on Local Agency Facility*
Route Number: Street Name: MP Range or Cross Street:

*Project on State Highway*
Route Number: **OR-99E** Hwy Name: **PACIFIC HIGHWAY WEST** MP From: **36.95** to **37.11**

Road Character: RURAL Facility Type: OTHER STATE HIGHWAY

County: **MARION** City: Crash Data From: **1/1/1999** to **12/31/2003**

Project Description: **OR-99E at Checkerboard Rd.**

Prepared By: **KM** Title: **OFFICE INVESTIGATOR**

| | | Fatal Crash Reduction Factor | Injury Crash Reduction Factor | PDO Crash Reduction Factor |
|---|---|---|---|---|
| *Countermeasure 1* | Add left turn lane, T intersection | 58% # | 58% | 58% |
| *Countermeasure 2* | | | | |
| *Countermeasure 3* | | | | |
| *Countermeasure 4* | | | | |
| | | **58%** [1] | **58%** [1] | **58%** [1] |

| | Number of Crashes | Number of Preventable Crashes | Economic Value per Crash | | Total Economic Value |
|---|---|---|---|---|---|
| Fatal Crashes | **0** | **0.0** | $1,500,000 | = | **$ -** |
| Severe (Injury A) Injury Crashes | **2** | **1.2** | $1,500,000 | = | **$ 1,740,000** |
| Moderate (Injury B) Injury Crashes | **5** | **2.9** | $55,000 | = | **$ 160,000** |
| Minor (Injury C) Injury Crashes | **6** | **3.5** | $55,000 | = | **$ 191,000** |
| PDO Crashes | **4** | **2.3** | $15,000 | = | **$ 35,000** |

**Total Crash Value for** **60** Months = **$ 2,126,000**

| Comprehensive Economic Value per Crash | | |
|---|---|---|
| Highway Type | Urban | Rural |
| PDO [3] | | |
| All facilities | $15,000 | $15,000 |
| Moderate (Injury B) and Minor (Injury C) Injury [4] | | |
| Interstate | $48,900 | $54,800 |
| Other State Highway | $47,900 | $55,000 |
| Fatal and Severe (Injury A) Injury [4] | | |
| Interstate | $850,000 | $1,460,000 |
| Other State Highway | $840,000 | $1,500,000 |

**Annual Benefits =** Total Crash Value / Total Months / 12 = **$ 425,000**

**Estimated Project Cost** = **$ 1,180,000**

**B/C Ratio =** Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

| Uniform Series Present Worth Factor (5%) | |
|---|---|
| 10 years | 20 years |
| 7.72 | 12.46 |

**B/C Ratio =** $ 425,000 x 12.46 [2] / $ 1,180,000 = **4.49**

**Notes**

1 Composite crash reduction factor calculated if more than one countermeasure is applied
2 Select a PWF for the life of countermeasure. See instructions
3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.
4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

## 7. Writing the Recommendation - Highway Safety Investigations Report (HSIR)

a. The last step is to summarize the final recommendations. Most of the information on this form is a summary but some text describing the problem and the recommended solution need to be completed.

| | | | |
|---|---|---|---|
| Safety Improvement File Complete | | Yes | No |
| | Close Date | | |

**OREGON DEPARTMENT OF TRANSPORTATION**
**SAFETY INVESTIGATIONS MANUAL**
**HIGHWAY SAFETY INVESTIGATIONS REPORT**

**LOCATION INFORMATION**

| | | | | | |
|---|---|---|---|---|---|
| Region: | 2 | District | 3 | County: | MARION |
| City: | - | | | | |
| Route Number: | OR-99E | Hwy Name: | PACIFIC HIGHWAY WEST | MP From: | 36.95 to 37.11 |
| Road Character: | RURAL | Facility Type: | R 3-LEGGED UNSIGNALIZED | Intersection, at MP: | 37.04 At Checkerboard Rd/ |

**SUMMARY**

| | | | |
|---|---|---|---|
| Prepared By: | KM | Title: | OFFICE INVESTIGATOR |
| Investigation Type: | SPIS INVESTIGATION | | |

**HISTORICAL INFORMATION**

Are there any previously approved investigations of this location on record? Yes ☑ No ☐

If yes, date

**NARRATIVE DESCRIPTION OF PROBLEM**

Checkerboard Rd (County) joins OR 99E at a skew and is in close proximity to the Keen Rd/ Duckin intersction. On the gore point is a business (tavern) with open front access to 99E and open access to Checkerboard R. Vehicles park along the frontage and back out onto roadway from business. Crash patterns (collision diagram and diagnostic form) reveal that rear-end crashes of vehicles turning from 99E to access business and tavern are overrepresented.

**RECOMMENDATION NARRATIVE**

Realign Checkerboard Rd. approximately 900' north of its present connection and T up the intersection. Apply current access management and standards to improve safety at the business. Construct turning lanes (north and west). Cost estimate of $1.18 million including ROW, CON, and ENG

**RECOMMENDATION SUMMARY**

| | |
|---|---|
| Implementation | STAND-ALONE |
| Improvement Type | INTERSECTION IMPROVEMENTS |
| Other | |
| Target Crashes | Rear-end turning crashes |
| Target Crash MP | 36.95 to 37.11 |
| Location Notes | |
| Estimated Cost | $ 1,180,000 |
| Benefit/Cost Ratio | 4.49 |

**APPROVALS**

| | | | | | |
|---|---|---|---|---|---|
| Date Investigator Completed | 8/30/2005 | Reviewed By | AK | Approval Date | 8/30/2005 |

**EXISTING CONDITION SUMMARY**

**CRASH TOTALS**

| Severity | 5 yrs | Percent |
|---|---|---|
| Fatal+ Inj A | 2 | 12% |
| Injury B+C | 11 | 65% |
| PDO | 4 | 24% |
| TOTAL | 17 | 100% |

**CRASH PATTERNS**

| Collision Type (All) | 5 yrs | Percent |
|---|---|---|
| Angle | 0 | 0% |
| Head-on | 0 | 0% |
| Rear | 10 | 59% |
| Sideswipe-Meet | 1 | 6% |
| Sideswipe-Over | 0 | 0% |
| Turn | 5 | 29% |
| Parked | 0 | 0% |
| NonCollision | 0 | 0% |
| Backing | 0 | 0% |
| Pedestrian | 0 | 0% |
| Fixed Object | 1 | 6% |
| Other | 0 | 0% |
| TOTAL | 17 | |

**TRAFFIC VOLUMES**

| Year | 2001 | 2002 | 2003 | Average |
|---|---|---|---|---|
| Major ADT | - | - | 11400 | 11,400 |
| Minor ADT | - | - | 700 | 700 |

**SPIS**

| Year | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|
| SPIS Score | 0.00 | 0.00 | 0.00 | 48.81 |

**FIELD VISIT**

Was a field investigation conducted? Yes ☐ No ☑

If yes, date

If yes, participants

**RATES**

| Severity | Invs. Rate | Peer Rate | Critical Rate | Flag? |
|---|---|---|---|---|
| All Crashes | 0.77 | 0.19 | 0.37 | YES |

**GEOMETRY AND OPERATIONS**

| | |
|---|---|
| Posted Speed | 55 mph |
| Shoulder Widths | |
| Left (ft) | 6 |
| Right (ft) | 6 |
| Number of Lanes | 2 |

**ADDITIONAL NOTES**

**RECOMMENDATION TRACKING AND FOLLOW UP**

| MAINTENANCE or QUICK HIT | | | | AS PART OF PROJECT or STAND-ALONE | |
|---|---|---|---|---|---|
| Recommendation Sent To | | Work Complete Date | | Project Key No. | |
| Sent Date | | Verified By | | Project Name | |
| | | Verified Date | | | |

## Case Study 2: US-20 Santiam Highway Mp 78.41-78.59

The following information is entered in the *COVER SHEET* for a site description. This is a SPIS Investigation of a newly listed SPIS site.

**OREGON DEPARTMENT OF TRANSPORTATION**
**SAFETY INVESTIGATIONS MANUAL**
**COVER SHEET**

| | | | |
|---|---|---|---|
| Office Data By: | KM | Title: | OFFICE INVESTIGATOR |
| Field Investigation By: | KM | Title: | FIELD INVESTIGATOR |
| Investigation Name: | SANTIAM HWY MP 78.41 SPIS | | |
| Route Number: | US-20 | Hwy Name: | SANTIAM |
| County: | LINN | City: | |
| Region: | 2 | District: | 3 |
| Location Type: | SEGMENT | *Needed to autofill other forms correctly* | |
| Road Character: | RURAL | *Only descriptive (choices for functional class and intersection type do not include suburban options)* | |
| This Investigation in Response to | SPIS INVESTIGATION | | |
| **SEGMENT and CRASH DATA MPs** | | **INTERSECTION** | |
| MP From: | 78.41 to 78.59 | MP at | |
| Functional Class: | RURAL PRINCIPAL ARTERIAL | Intersection Type: | R 3-LEGGED UNSIGNALIZED |
| | | Intersecting Street Name | |

## 1. Collect in-Office Data

a. Crash Data – Two Excel reports were pulled from MPs 78.41 to 78.59, the Direction report for use with the crash graph tool and the PRC report to tabulate some of the necessary information for the diagnostic worksheet. There were a total of 10 crashes from 2003 to 2007. The crash summary data are entered on the DATA ENTRY tab of the SIM workbook. The crash summary data are entered on the DATA ENTRY tab of the SIM workbook. The crash data are summarized by the worksheet after the PRC is copied and pasted in per the directions in the worksheet.

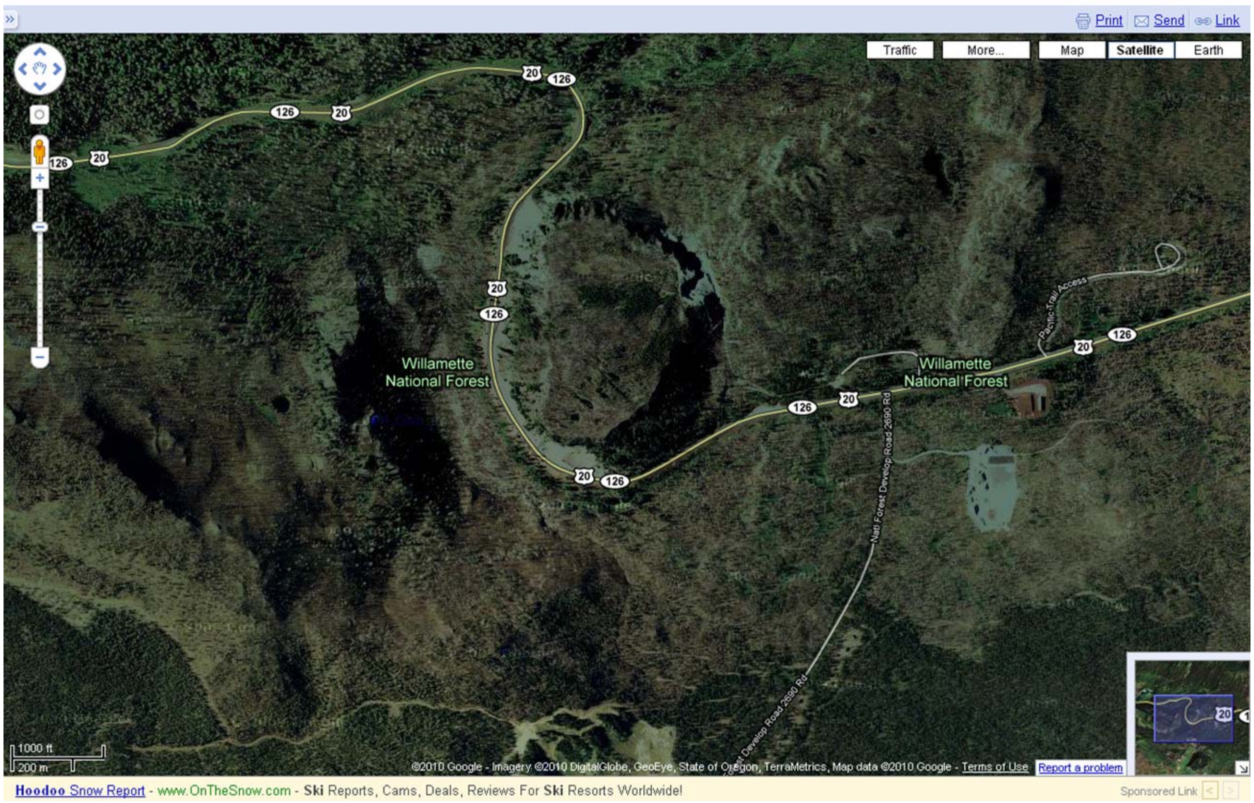
b. Safety Priority Investigations Sites (SPIS) – Most recent SPIS report was used to obtain SPIS score. This is entered in the DATA ENTRY tab of the SIM workbook.

c. Highway Inventory Reports - Not used since DVL and field visit identified necessary information

d. Facility Functional Class – It is determined that OR99E is a rural principal arterial. This is entered on the *COVER SHEET*.

e. Traffic Volumes – Mainline (US20) volumes obtained from the ODOT volume tables of 5,600 ADT. This is entered in the *DATA ENTRY* tab of the SIM workbook.

f. Google Maps – Aerial photography of the location shows that the alignment. It can be tricky to determine the exact curve or MP on the aerial photography. One tip is to identify an easy point on the map to find (Hoodoo Ski area), then use the measurement tool (measured using Google Maps, My Maps, Distance Measurement Tool – Note that a Google account is needed to use the measurement tool). Another easy alternative is to use TranGIS, which has aerial photography and other resources available (including MPs for the investigator).




g. Digital Video Log – The DVL photos show roadway and roadside of the curve location..



**2. Diagnosing Crash Patterns**

a. Crash Pattern Worksheet – This is a segment, click on the click on the “PATTERNS_SEG” worksheet tab.

A number of different crash trends are highlighted in grey (PNorm is less than 5%) as being potentially unusual:

- Fatal+ Inj A crashes
- Collision types (Fatal and Inj A): Sideswipe-Meet
- In-state resident drivers
- Female drivers
- Surface conditions: ICE
- Grade – On Roadway
- Curve –Off Roadway

Other patterns that are close, but are not less that 5% threshold are:

- Collision types (all): Sideswipe-Meet)
- Time period – 9-AM Noon
- Driver age groups: 19-21;
- Curve –On Roadway

These patterns do not always lead to a countermeasure or explanation for the SPIS site. This particular curve has high fatal and injury A count (3/10). Contributing factors such as driving too fast for conditions and lane departure (sideswipe-meeting and non-collision) appears to be trends. Given the location in the Cascades, the ICE related crashes might not be that unusual but it does appear to be recreation based

–non-local drivers and higher proportions on Sunday. The segment crash rate is FLAGGED as exceeding the critical rate for rural principal arterial.

b. Collision Diagrams – With only ten crashes and the trend apparent from the PRC and diagnostics form, a collision diagram was not requested from CAR.

**3. Site Investigations**

a. After reviewing the crash data in-office, the investigator should have a good idea what the potential problems at the intersection might be. A field visit may or may not be needed.

The crash patterns to browse in Table 3 would be "Sideswipe collisions between vehicles traveling in opposite directions or head-on collisions". The table suggests documenting and investigating:

- Number of lanes / lane widths / lane usage
- Location / description / measurement of median
- Shoulder type / width and condition
- Location and visibility of advance warning signs
- Roadway type and condition

**SUMMARY OF DATA ANALYSIS AND FIELD INVESTIGATION:**

Two of the injury A crashes involved EB drivers losing control and crossing into oncoming lanes. Only 1 WB driver was coded as too fast for conditions. One EB driver avoided debris in roadway. There are existing speed curve warning signs posted with 40 mph riders, thermoplastic was installed on MP 73-88 in September 2006. Curve realignment is not possible. A dynamic curve warning or enhanced chevrons could be considered.

**OREGON DEPARTMENT OF TRANSPORTATION**
**SAFETY INVESTIGATIONS MANUAL**
**CRASH PATTERN WORKSHEET - SEGMENTS**

| | | | |
|---|---|---|---|
| Prepared By: | KM | Title: | OFFICE INVESTIGATOR |
| Investigation Name: | SANTIAM HWY MP 78.41 SPIS | Region: 2 | District: 3 |
| Route Number: | US-20 | Hwy Name: SANTIAM | MP From: 78.41 to 78.59 |
| Road Character: | RURAL | Facility Type: RURAL PRINCIPAL ARTERIAL | Date Compiled: 8/30/2005 |
| County: | LINN | City: | Crash Date From: 1/1/2003 to 12/31/2007 |

**CRASH TOTALS**

| Severity | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Fatal+ Inj A | 3 | 30.0% | 8.7% | **4.9%** |
| Injury B+C | 3 | 30.0% | 39.1% | 81.7% |
| PDO | 4 | 40.0% | 52.3% | 86.3% |
| | 10 | 100.0% | 100.0% | |

**CRASH PATTERNS**

| Collision Type (All) | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Angle | 0 | 0.0% | 3.6% | |
| Head-on | 1 | 10.0% | 3.1% | 27.2% |
| Rear | 0 | 0.0% | 22.5% | |
| Sideswipe-Meet | 2 | 20.0% | 4.1% | 6.1% |
| Sideswipe-Over | 1 | 10.0% | 3.9% | 32.7% |
| Turn | 0 | 0.0% | 13.7% | |
| Parked | 0 | 0.0% | 0.3% | |
| NonCollision | 2 | 20.0% | 5.1% | 9.0% |
| Backing | 0 | 0.0% | 0.4% | |
| Pedestrian | 0 | 0.0% | 0.5% | |
| Fixed Object | 4 | 40.0% | 35.0% | 48.7% |
| Other | 0 | 0.0% | 7.8% | |
| | 10 | 100% | 100% | |

| Collision Type (F+A) | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Angle | 0 | 0.0% | 4.0% | |
| Head-on | 1 | 33.3% | 17.1% | 43.0% |
| Rear | 0 | 0.0% | 8.0% | |
| Sideswipe-Meet | 2 | 66.7% | 7.8% | **1.7%** |
| Sideswipe-Over | 0 | 0.0% | 1.5% | |
| Turn | 0 | 0.0% | 12.7% | |
| Parked | 0 | 0.0% | 0.0% | |
| NonCollision | 0 | 0.0% | 7.0% | |
| Backing | 0 | 0.0% | 0.1% | |
| Pedestrian | 0 | 0.0% | 2.4% | |
| Fixed Object | 0 | 0.0% | 36.9% | |
| Other | 0 | 0.0% | 2.5% | |
| | 3 | 100% | 100% | |

| Crashes Involving | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Multiple Vehicles | 5 | 50.0% | 53.1% | 69.7% |
| Single Vehicle | 5 | 50.0% | 46.9% | 54.4% |
| | 10 | 100% | 100% | |

| Residence of Driver | Drivers | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Non-resident | 0 | 0.0% | 11.3% | |
| Local | 2 | 13.3% | 60.4% | 100.0% |
| In-state resident | 13 | 86.7% | 26.2% | **0.0%** |
| Not Stated | 0 | 0.0% | 2.1% | |
| | 15 | 100% | 100% | |

| Sex of Driver | Drivers | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Male | 4 | 26.7% | 63.3% | 99.9% |
| Female | 11 | 73.3% | 35.5% | **0.3%** |
| Not Stated | 0 | 0.0% | 1.2% | |
| | 15 | 100% | 100% | |

| Time | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| 12 -3 AM | 0 | 0.0% | 3.4% | |
| 3 -6 AM | 0 | 0.0% | 4.0% | |
| 6 -9 AM | 0 | 0.0% | 14.0% | |
| 9-Noon | 4 | 40.0% | 15.9% | 6.0% |
| 12-3 PM | 3 | 30.0% | 19.0% | 29.2% |
| 3 -6 PM | 2 | 20.0% | 23.5% | 72.0% |
| 6-9 PM | 1 | 10.0% | 12.4% | 73.4% |
| 9-Mid | 0 | 0.0% | 7.4% | |
| UNKNOWN | 0 | 0.0% | 0.5% | |
| | 10 | 100% | 100% | |

| Light Condition | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| DAWN | 0 | 0.0% | 4.1% | |
| DAY | 8 | 80.0% | 64.1% | 24.3% |
| DLIT | 0 | 0.0% | 2.6% | |
| DARK | 1 | 10.0% | 26.1% | 95.1% |
| DUSK | 1 | 10.0% | 2.8% | 24.9% |
| UNK | 0 | 0.0% | 0.3% | |
| | 10 | 100% | 100% | |

| Surface Cond. | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| DRY | 1 | 10.0% | 58.5% | 100.0% |
| ICE | 5 | 50.0% | 17.7% | **2.0%** |
| WET | 4 | 40.0% | 19.5% | 11.2% |
| SNOW | 0 | 0.0% | 3.5% | |
| UNK | 0 | 0.0% | 0.8% | |
| Total | 10 | 100% | 100% | |

| Weekday | Crash | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Sunday | 3 | 30.0% | 14.1% | 15.7% |
| Monday | 2 | 20.0% | 14.4% | 43.3% |
| Tuesday | 0 | 0.0% | 13.1% | |
| Wednesday | 1 | 10.0% | 13.5% | 76.6% |
| Thursday | 1 | 10.0% | 14.2% | 78.3% |
| Friday | 1 | 10.0% | 16.6% | 83.7% |
| Saturday | 2 | 20.0% | 14.2% | 42.6% |
| | 10 | 100% | 100% | |

| Driver Age | Drivers | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| <15 | 0 | 0.0% | 0.0% | |
| 15-18 | 1 | 6.7% | 7.0% | 66.1% |
| 19-21 | 3 | 20.0% | 7.5% | 9.7% |
| 22-24 | 2 | 13.3% | 5.9% | 22.3% |
| 25-34 | 3 | 20.0% | 15.5% | 41.7% |
| 35-44 | 2 | 13.3% | 15.9% | 71.4% |
| 45-54 | 2 | 13.3% | 18.3% | 79.0% |
| 55-64 | 2 | 13.3% | 13.5% | 62.2% |
| 65-74 | 0 | 0.0% | 7.4% | |
| >74 | 0 | 0.0% | 5.2% | |
| Not Stated | 0 | 0.0% | 3.8% | |
| | 15 | 100% | 100% | |

**TRAFFIC VOLUM** 5,600 *ADT (average )*

| RATES | Invs. Rate | Peer Rate | Critical Rate | Flag? |
|---|---|---|---|---|
| All Crashes | 5.44 | 0.72 | 2.02 | **YES** |

| On Roadway | Crashes | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Intersection | 0 | 0.0% | 15.6% | |
| Alley | 0 | 0.0% | 5.8% | |
| Straight | 0 | 0.0% | 32.2% | |
| Transition | 0 | 0.0% | 0.2% | |
| Curve | 2 | 20.0% | 4.0% | 5.8% |
| Open Access | 0 | 0.0% | 0.1% | |
| Grade | 3 | 30.0% | 2.4% | **0.1%** |
| Bridge | 0 | 0.0% | 0.4% | |
| Tunnel | 0 | 0.0% | 0.0% | |
| Unknown | 0 | 0.0% | 0.0% | |
| | 5 | 50% | 61% | |

| Off Roadway | Crashes | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| Intersection | 0 | 0.0% | 0.9% | |
| Alley | 0 | 0.0% | 0.3% | |
| Straight | 0 | 0.0% | 23.6% | |
| Transition | 0 | 0.0% | 0.0% | |
| Curve | 5 | 50.0% | 10.3% | **0.2%** |
| Open Access | 0 | 0.0% | 0.1% | |
| Grade | 0 | 0.0% | 3.4% | |
| Bridge | 0 | 0.0% | 0.5% | |
| Tunnel | 0 | 0.0% | 0.0% | |
| Unknown | 0 | 0.0% | 0.0% | |
| | 5 | 50% | 39% | |

| Cause Codes | Drivers | Obs % | Ex % | P(Norm) |
|---|---|---|---|---|
| TOO-CLOS | 0 | 0.0% | 9.3% | |
| TOO-FAST | 8 | 47.1% | 36.9% | 26.5% |
| NO-YIELD | 0 | 0.0% | 11.1% | |
| OTHR-IMP | 4 | 23.5% | 11.2% | 11.5% |
| IMP LN C | 0 | 0.0% | 0.8% | |
| INATTENT | 1 | 5.9% | 5.8% | 63.9% |
| DIS--RAG | 0 | 0.0% | 0.8% | |
| IMP-TURN | 0 | 0.0% | 2.4% | |
| OTHER | 1 | 5.9% | 7.0% | 71.1% |
| CARELESS | 1 | 5.9% | 1.4% | 20.8% |
| FATIGUE | 0 | 0.0% | 1.4% | |
| LEFT-CTR | 2 | 11.8% | 4.4% | 17.1% |
| SPEED | 0 | 0.0% | 0.7% | |
| PHANTOM | 0 | 0.0% | 1.6% | |
| IMP-OVER | 0 | 0.0% | 2.9% | |
| RECKLESS | 0 | 0.0% | 0.3% | |
| PAS-STOP | 0 | 0.0% | 0.8% | |
| IN RDWY | 0 | 0.0% | 0.1% | |
| MECH-DEF | 0 | 0.0% | 0.4% | |
| LOADSHFT | 0 | 0.0% | 0.3% | |
| NT VISBL | 0 | 0.0% | 0.1% | |
| DIS TCD | 0 | 0.0% | 0.0% | |
| WRNG WAY | 0 | 0.0% | 0.0% | |
| IMP PKNG | 0 | 0.0% | 0.1% | |
| | 17 | 100% | 100% | |

**4. Identify Candidate Countermeasures**

a. After browsing the suggestions in Table 3 for Sideswipe collisions between vehicles traveling in opposite directions or head-on collisions"., considering the field investigation and the crash patterns a number of potential solutions can be considered. The following are suggested to consider.

- Install/improve pavement markings
- Channelize intersections
- Create one-way streets
- Restrict parking
- Install median divider / barrier
- Widen lanes

None of these suggestions fit the problem at this location. The FHWA CMF Clearinghouse was browsed for "Curve" in rural areas and the following countermeasures were suggested

- **Changeable Curve Speed Warning signs**
- Placing edgelines and background/ directional markings on horizontal curves
- Install transverse rumble strips, raised pavement markers, and transverse markings
- Install transverse rumble strips and raised pavement markers
- Install raised pavement markers and transverse rumble strips on approach to horizontal curves
- Flatten crest vertical curve
- Improve curve superelevation
- Remove obstacles on curves to improve sight distance
- **Install chevron signs on horizontal curves**
- Advance static curve warning signs
- Install edgelines (tangents and curves)
- Increase in horizontal curvature from X to Y degrees
- Install cable median barrier (low or high tension on curve)
- Change in driveway density from X to Y driveways per mile
- Improve pavement friction (increase skid resistance)

The two possible countermeasures are bolded.

After discussion with supervisor, a recommendation is made to install chevrons on the curve.

**5. Expected Effectiveness of Countermeasures**

a. Since the cost to install the signs is small, no CRFs needed.

**6. Benefit Cost Worksheet**

a. Since the cost to install the signs is small, no CRFs needed.

**7. Writing the Recommendation - Highway Safety Investigations Report (HSIR)**

a. The last step is to summarize the final recommendations. Most of the information on this form is a summary but some text describing the problem and the recommended solution need to be completed. Here the work was to be done by maintenance. Note that the date the signs were installed is documented on the form.

| | | | |
|---|---|---|---|
| Safety Improvement File Complete | Yes | No | |
| Close Date | | | |

## OREGON DEPARTMENT OF TRANSPORTATION
## SAFETY INVESTIGATIONS MANUAL
## HIGHWAY SAFETY INVESTIGATIONS REPORT

### LOCATION INFORMATION

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Region: | 2 | District | 3 | County: | LINN | City: | - | |
| Route Number: | US-20 | Hwy Name: | SANTIAM | | | MP From: | 78.41 | to 78.59 |
| Road Character: | RURAL | Facility Type: | RURAL PRINCIPAL ARTERIAL | | | Intersection, at MP: | NA | At - |

### SUMMARY

Prepared By: KM — Title: OFFICE INVESTIGATOR

Investigation Type: SPIS INVESTIGATION

**HISTORICAL INFORMATION**

Are there any previously approved investigations of this location on record? Yes ☐ No ☑

If yes, date

**NARRATIVE DESCRIPTION OF PROBLEM**

Two of the injury A crashes involved EB drivers losing control and crossing into oncoming lanes. Only 1 WB driver was coded as too fast for conditions. On EB driver avoided debris in roadway. There are existing speed curve warning signs posted with 40 mph riders, thermoplastic was installed on MP 73-88 in September 2006. Curve realignment is not possible. A dynamic curve warning or enhanced chevrons could be considered.

**RECOMMENDATION NARRATIVE**

Install chevrons on outside of curve.

**RECOMMENDATION SUMMARY**

| | |
|---|---|
| Implementation | MAINTENANCE |
| Improvement Type | SIGNING AND DELINEATION |
| Other | |
| Target Crashes | Sideswipe meeting |
| Target Crash MP | to |
| Location Notes | see MP range |
| Estimated Cost | $ - |
| Benefit/Cost Ratio | |

### APPROVALS

Date Investigator Completed: 8/30/2009 — Reviewed By: AK — Approval Date: 8/30/2005

### EXISTING CONDITION SUMMARY

**CRASH TOTALS**

| Severity | 5 yrs | Percent |
|---|---|---|
| Fatal+ Inj A | 3 | 30% |
| Injury B+C | 3 | 30% |
| PDO | 4 | 40% |
| TOTAL | 10 | 100% |

**TRAFFIC VOLUMES**

| Year | 2005 | 2006 | 2007 | Average |
|---|---|---|---|---|
| Major ADT | 0 | 0 | 5600 | 5,600 |
| Minor ADT | - | - | - | 0 |

**RATES**

| Severity | Invs. Rate | Peer Rate | Critical Rate | Flag? |
|---|---|---|---|---|
| All Crashes | 5.44 | 0.72 | 2.02 | YES |

**SPIS**

| Year | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|
| SPIS Score | 21.94 | 36.90 | 0.00 | 67.90 |

**GEOMETRY AND OPERATIONS**

| | |
|---|---|
| Speed Limit | 55 mph |
| Shoulder Widths | |
| Left (ft) | 6 |
| Right (ft) | 6 |
| Number of Lanes | 2 |

**CRASH PATTERNS**

| Collision Type (All) | 5 yrs | Percent |
|---|---|---|
| Angle | 0 | 0% |
| Backing | 1 | 10% |
| Fixed Object | 0 | 0% |
| Head-on | 2 | 20% |
| NonCollision | 1 | 10% |
| Other | 0 | 0% |
| Parked | 0 | 0% |
| Pedestrian | 2 | 20% |
| Rear | 0 | 0% |
| Sideswipe-Meet | 0 | 0% |
| Sideswipe-Over | 4 | 40% |
| Turn | 0 | 0% |
| TOTAL | 10 | |

**FIELD VISIT**

Was a field investigation conducted? Yes ☐ No ☑

If yes, date

If yes, participants

**ADDITIONAL NOTES**

### RECOMMENDATION TRACKING AND FOLLOW UP

**MAINTENANCE or QUICK HIT**

| | |
|---|---|
| Recommendation Sent To | Maintenance |
| Sent Date | |
| Work Complete Date | 5/27/2009 |
| Verified By | |
| Verified Date | |

**AS PART OF PROJECT or STAND-ALONE**

| | |
|---|---|
| Project Key No. | |
| Project Name | |