PART B—ROADWAY SAFETY MANAGEMENT PROCESS

CHAPTER 5—DIAGNOSIS

EXHIBITS

APPENDICES

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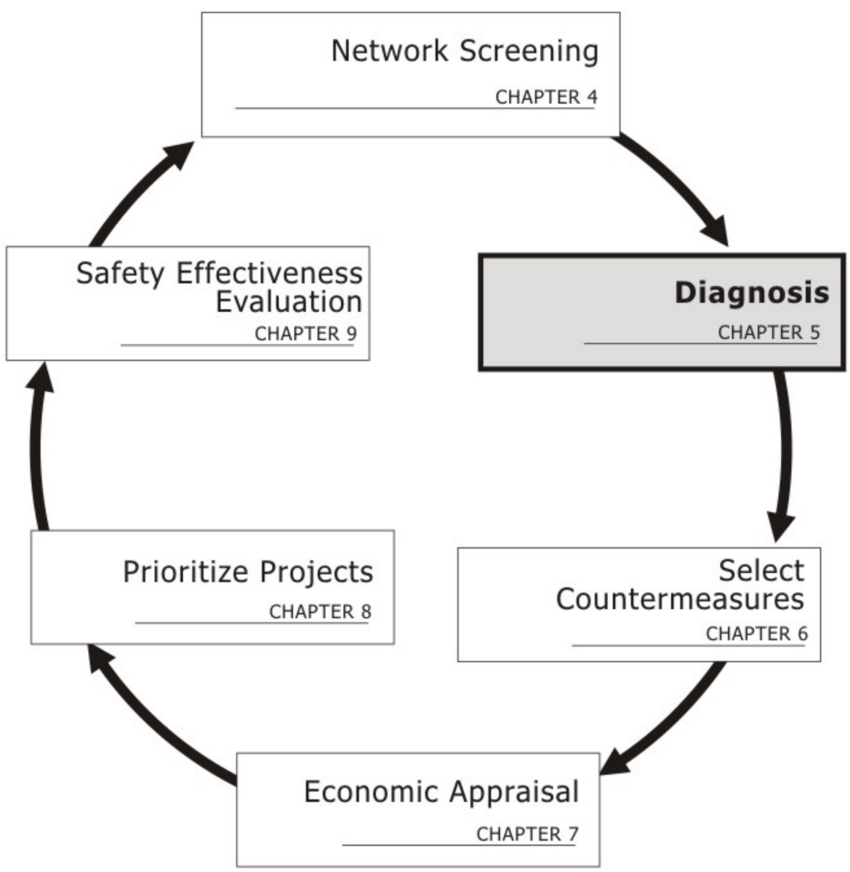
CHAPTER 5 DIAGNOSIS

5.1. INTRODUCTION

Diagnosis is the second step in the roadway safety management process (*Part B*), as shown in Exhibit 5-1. *Chapter 4* described the network screening process from which several sites are identified as the most likely to benefit from safety improvements. The activities included in the diagnosis step provide an understanding of crash patterns, past studies, and physical characteristics before potential countermeasures are selected. The intended outcome of a diagnosis is the identification of the causes of the collisions and potential safety concerns or crash patterns that can be evaluated further, as described in *Chapter 6*.

The purpose of site/crash diagnosis is to develop an understanding of factors that may lead to crashes.

Exhibit 5–1: Roadway Safety Management Process Overview



The assessment of a site begins with a review of crash data that may identify any patterns in the types of crashes and/or severity of crashes that have occurred.

The diagnosis procedure presented in this chapter represents the best available knowledge and is suitable for projects of various complexities. The procedure outlined in this chapter involves the following three steps; some steps may not apply to all projects:

- Step 1: Safety Data Review
    - Review crash types, severities, and environmental conditions to develop summary descriptive statistics for pattern identification and,

- o Review crash locations.

- Step 2: Assess Supporting Documentation
  - o Review past studies and plans covering the site vicinity to identify known issues, opportunities, and constraints.
- Step 3: Assess Field Conditions
  - o Visit the site to review and observe multi-modal transportation facilities and services in the area, particularly how users of different modes travel through the site.

5.2. STEP 1: SAFETY DATA REVIEW

A site diagnosis begins with a review of safety data that may identify patterns in crash type, crash severity, or roadway environmental conditions (e.g., pavement, weather, and/or lighting conditions). The review may identify patterns related to time of day, direction of travel prior to crashes, weather conditions, or driver behaviors. Compiling and reviewing three to five years of safety data is suggested to improve the reliability of the diagnosis. The safety data review considers:

- Descriptive statistics of crash conditions (e.g., counts of crashes by type, severity, and/or roadway or environmental conditions); and
- Crash locations (i.e., collision diagrams, condition diagrams, and crash mapping using GIS tools).

5.2.1. Descriptive Crash Statistics

Crash data review may reveal patterns in crashes at a site.

Crash databases generally summarize crash data into three categories: information about the crash, the vehicle in the crash, and the people in the crash. In this step, crash data are reviewed and summarized to identify potential patterns. Descriptive crash statistics include summaries of:

- Crash Identifiers: date, day of week, time of day;
- Crash Type: defined by a police officer at the scene or, if self-reporting is used, according to the victims involved. Typical crash types are:
  - o Rear-end
  - o Sideswipe
  - o Angle
  - o Turning
  - o Head-on
  - o Run-off the road
  - o Fixed object
  - o Animal
  - o Out of control
  - o Work zone
- Crash Severity: typically summarized according to the KABCO scale for defining crash severity (described in *Chapter 3*);

Crash severity is often divided into categories according to the KABCO scale, which is defined in *Chapter 3, Section 3.2.2*

- Sequence of Events:
    - Direction of Travel;
    - Location of Parties Involved: northbound, southbound, eastbound, westbound; specific approach at a specific intersection or specific roadway milepost;

Descriptive crash statistics provide information about the crash, the vehicle, and people in the crash.

- Contributing Circumstances:
    - Parties Involved: vehicle only, pedestrian and vehicle, bicycle and vehicle;
    - Road Condition at the Time of the Crash: dry, wet, snow, ice;
    - Lighting Condition at the Time of the Crash: dawn, daylight, dusk, darkness without lights, darkness with lights;
    - Weather Conditions at the Time of the Crash: clear, cloudy, fog, rain, snow, ice; and
    - Impairments of Parties Involved: alcohol, drugs, fatigue.

These data are compiled from police reports. An example of a police report from Oregon is shown in Appendix A.

Bar charts, pie charts, or tabular summaries are useful for displaying the descriptive crash statistics. The purpose of the graphical summaries is to make patterns visible. Exhibits 5-2 and 5-3 provide examples of graphical and tabular summaries of crash data.

Exhibit 5–2: Example Graphical Summary

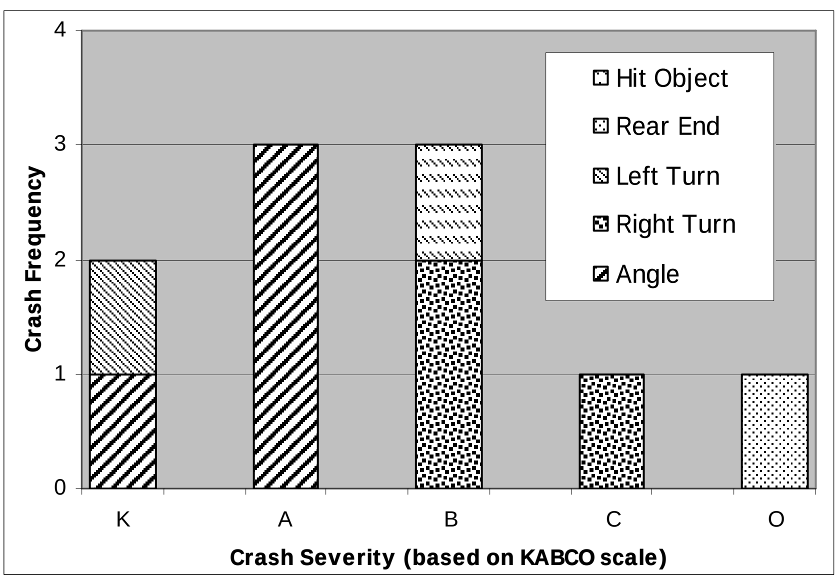


Exhibit 5–3: Example Tabular Summary

Accident Number	1	2	3	4	5	6	7	8	9	10
Date	1/3/92	2/5/92	8/11/92	7/21/93	1/9/93	2/1/93	9/4/94	12/5/08	4/7/94	2/9/94
Day of Week	SU	SA	SU	TU	WE	TH	SA	TH	MO	SU
Time of Day	2115	2010	1925	750	1310	950	1115	1500	1710	2220
Severity	A	A	O	B	K	K	B	C	A	B
Accident Type	Angle	Angle	Rear End	Right Turn	Angle	Left Turn	Right Turn	Right Turn	Angle	Hit Object
Road Condition	Wet	Dry	Dry	Dry	Wet	Dry	Dry	Dry	Wet	Wet
Light Condition	Dark	Dark	Dark	Dusk	Light	Light	Light	Light	Dusk	Dark
Direction	N	N	SW	W	S	W	N	S	N	N
Alcohol (BAC)	0.05	0.08	0.00	0.05	0.00	0.00	0.07	0.00	0.00	0.15

Adapted from Ogden[(5)]

Specific Crash Types Exceeding Threshold Proportion

Chapter 4 outlines the Probability of Specific Crash Types Exceeding Threshold Proportion performance measure which can also be used as a crash diagnosis tool.

If crash patterns are not obvious from a review of the descriptive statistics, mathematical procedures can sometimes be used as a diagnostic tool to identify whether a particular crash type is overrepresented at the site. The Probability of Specific Crash Types Exceeding Threshold Proportion performance measure described in *Chapter 4* is one example of a mathematical procedure that can be used in this manner.

The Probability of Specific Crash Types Exceeding Threshold Proportion performance measure can be applied to identify whether one crash type has occurred in higher proportions at one site than the observed proportion of the same crash type at other sites. Those crash types that exceed a determined crash frequency threshold can be studied in further detail to identify possible countermeasures. Sites with similar characteristics are suggested to be analyzed together because crash patterns will naturally differ depending on the geometry, traffic control devices, adjacent land uses, and traffic volumes at a given site. *Chapter 4* provides a detailed outline of this performance measure and sample problems demonstrating its use.

5.2.2. Summarizing Crashes by Location

Crash location can be summarized using three tools: collision diagrams, condition diagrams, and crash mapping. Each is a visual tool that may show a pattern related to crash location that may not be identifiable in another format.

Collision Diagram

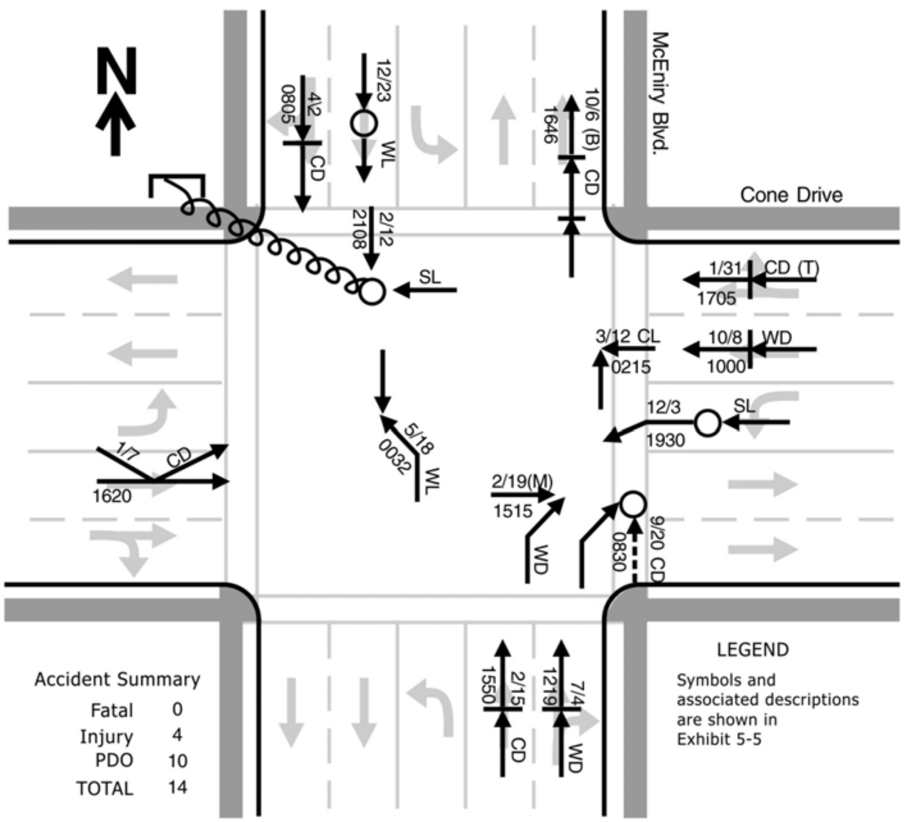
A collision diagram is a two-dimensional plan view representation of the crashes that have occurred at a site within a given time period. A collision diagram simplifies the visualization of crash patterns. Crash clusters or particular patterns of crashes by collision type (e.g., rear-end collisions on a particular intersection approach) may become evident on the crash diagram that were otherwise overlooked.

Visual trends identified in a collision diagram may not reflect a quantitative or statistically reliable assessment of site trends; however, they do provide an indication of whether or not patterns exist. If multiple sites are under consideration, it can be more efficient to develop the collision diagrams with software, if available.

Exhibit 5-4 provides an example of a collision diagram. Crashes are represented on a collision diagram by arrows that indicate the type of crash and the direction of travel. Additional information associated with each crash is also provided next to each symbol. The additional information can be any of the above crash statistics, but often includes some combination (or all) of severity, date, time of day, pavement condition, and light condition. A legend indicates the meaning of the symbols, the site location, and occasionally other site summary information.

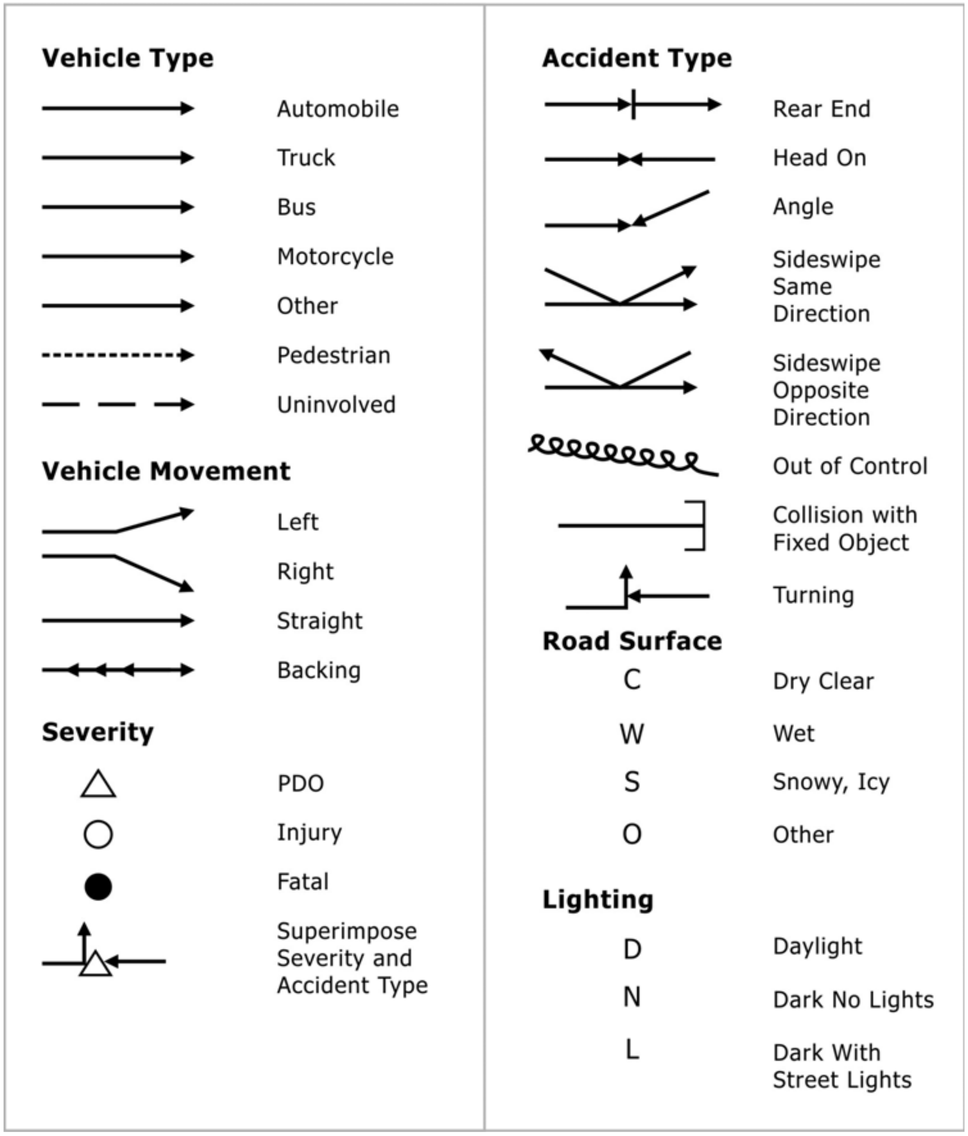
The collision diagram can be drawn by hand or developed using software. It does not need to be drawn to scale. It is beneficial to use a standard set of symbols for different crash types to simplify review and assessment. Example arrow symbols for different crash types are shown in Exhibit 5-5. These can be found in many safety textbooks and state transportation agency procedures.

Exhibit 5–4: Example of an Intersection Collision Diagram



Adapted from ITE Manual of Transportation Engineering Studies.(4)

Exhibit 5–5: Example Collision Diagram Symbols



Adapted from ITE Manual of Transportation Engineering Studies.[4]

A condition diagram is a plan view drawing of site characteristics including: roadway geometry, adjacent land use, & pavement conditions.

Condition Diagram

A condition diagram is a plan view drawing of as many site characteristics as possible.[2] Characteristics that can be included in the condition diagram are:

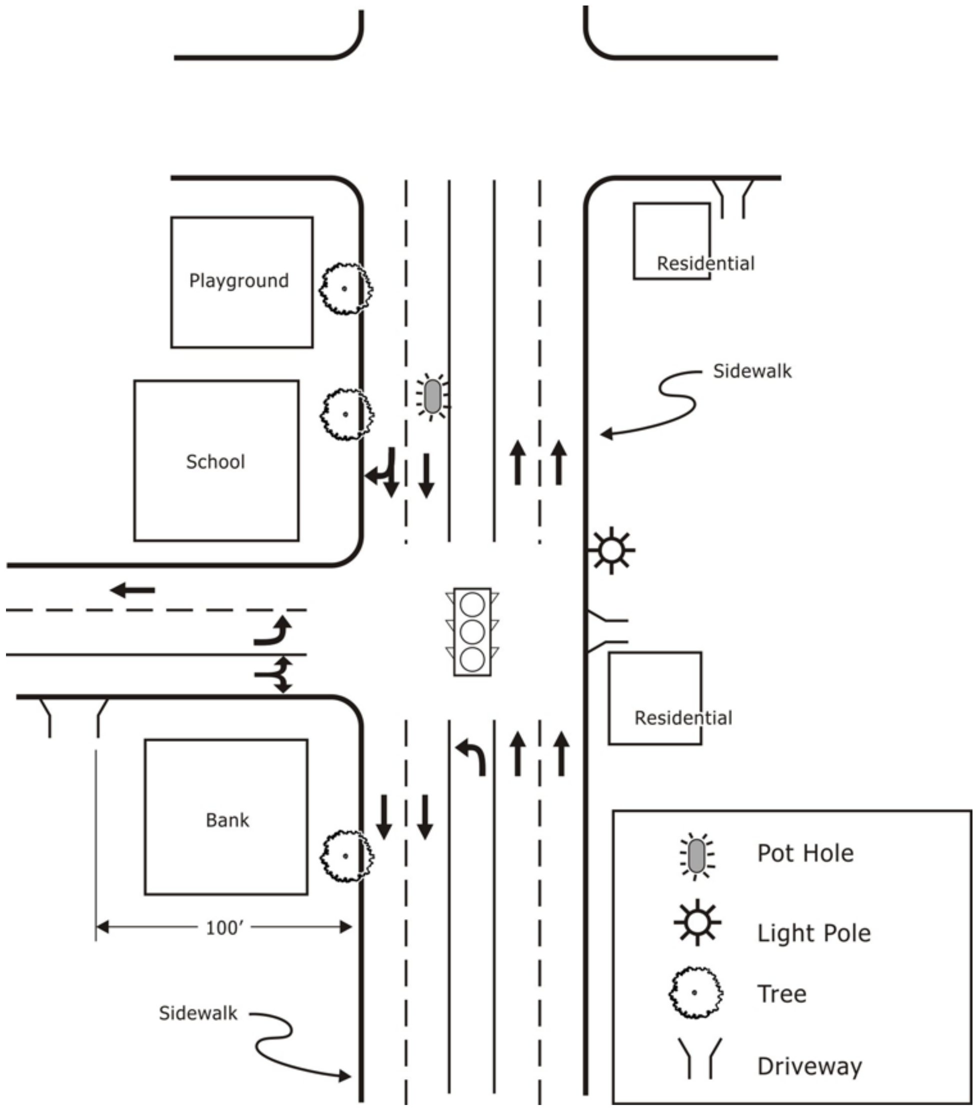
- Roadway
  - Lane configurations and traffic control;
  - Pedestrian, bicycle, and transit facilities in the vicinity of the site;
  - Presence of roadway medians;
  - Landscaping;
  - Shoulder or type of curb and gutter; and,

  - o Locations of utilities (e.g., fire hydrants, light poles, telephone poles).
- Land Uses
  - o Type of adjacent land uses (e.g., school, retail, commercial, residential) and;
  - o Driveway access points serving these land uses.
- Pavement Conditions
  - o Locations of potholes, ponding, or ruts.

The purpose of the condition diagram is to develop a visual site overview that can be related to the collision diagram's findings. Conceptually, the two diagrams could be overlaid to further relate crashes to the roadway conditions. Exhibit 5-6 provides an example of a condition diagram; the content displayed will change for each site depending on the site characteristics that may contribute to crash occurrence. The condition diagram is developed by hand during the field investigation and can be transcribed into an electronic diagram if needed. The diagram does not have to be drawn to scale.

A condition diagram can be related to a collision diagram to further understand potential patterns.

Exhibit 5–6: Example Condition Diagram



Crash Mapping

Jurisdictions that have electronic databases of their roadway network and geocoded crash data can integrate the two into a Geographic Information Systems (GIS) database.[(3)] GIS allows data to be displayed and analyzed based on spatial characteristics. Evaluating crash locations and trends with GIS is called crash mapping. The following describes some of the crash analysis techniques and advantages of using GIS to analyze a crash location (not an exhaustive list):

- Scanned police reports and video/photo logs for each crash location can be related to the GIS database to make the original data and background information readily available to the analyst.
- Data analyses can integrate crash data (e.g., location, time of day, day of week, age of participants, sobriety) with other database information, such as the presence of schools, posted speed limit signs, rail crossings, etc.

- The crash database can be queried to report crash clusters; that is, crashes within a specific distance of each other, or within a specific distance of a particular land use. This can lead to regional crash assessments and analyses of the relationship of crashes to land uses.

- Crash frequency or crash density can be evaluated along a corridor to provide indications of patterns in an area.

- Data entry quality control checks can be conducted easily and, if necessary, corrections can be made directly in the database.

The accuracy of crash location data is the key to achieving the full benefits of GIS crash analysis. The crash locating system that police use is most valuable when it is consistent with, or readily converted to, the locational system used for the GIS database. When that occurs, global positioning system (GPS) tools are used to identify crash locations. However, database procedures related to crash location can influence analysis results. For example, if all crashes within 200 feet of an intersection are entered into the database at the intersection centerline, the crash map may misrepresent actual crash locations and possibly lead to misinterpretation of site issues. These issues can be mitigated by advanced planning of the data set and familiarity with the process for coding crashes.

5.3. STEP 2: ASSESS SUPPORTING DOCUMENTATION

Assessing supporting documentation is the second step in the overall diagnosis of a site. The goal of this assessment is to obtain and review documented information or personal testimony of local transportation professionals that provides additional perspective to the crash data review described in Section 5.2. The supporting documentation may identify new safety concerns or verify the concerns identified from the crash data review.

Reviewing past site documentation provides historical context about the study site. Observed patterns in the crash data may be explained by understanding operational and geometric changes documented in studies conducted in the vicinity of a study site. For example, a review of crash data may reveal that the frequency of left-turning crashes at a signalized intersection increased significantly three years ago and have remained at that level. Associated project area documentation may show a corridor roadway widening project had been completed at that time, which may have led to the increased observed crash frequency due to increased travel speeds and/or the increase in the number of lanes opposing a permitted left turn.

Supporting documentation such as as-built plans, past studies, and past traffic counts further inform of conditions at a site.

Identifying the site characteristics through supporting documentation also helps define the roadway environment type (e.g., high-speed suburban commercial environment, or low-speed urban residential environment). This provides the context in which an assessment can be made as to whether certain characteristics have potentially contributed to the observed crash pattern. For example, in a high-speed rural environment a short horizontal curve with a small radius may increase the risk of a crash, whereas in a low-speed residential environment the same horizontal curve length and radius may be appropriate to help facilitate slower speeds.

The following types of information may be useful as supporting documentation to a site safety assessment:[6]

- Current traffic volumes for all travel modes;

- As-built construction plans;

- Relevant design criteria and pertinent guidelines;
- Inventory of field conditions (e.g., traffic signs, traffic control devices, number of travel lanes, posted speed limits, etc.);
- Relevant photo or video logs;
- Maintenance logs;
- Recent traffic operations and/or transportation studies conducted in the vicinity of the site;
- Land use mapping and traffic access control characteristics;
- Historic patterns of adverse weather;
- Known land use plans for the area;
- Records of public comments on transportation issues;
- Roadway improvement plans in the site vicinity; and,
- Anecdotal information about travel through the site.

A thorough list of questions and data to consider when reviewing past site documentation is provided in Appendix B.

5.4. STEP 3: ASSESS FIELD CONDITIONS

The diagnosis can be supported by a field investigation. Field observations can serve to validate safety concerns identified by a review of crash data or supporting documentation. During a field investigation, firsthand site information is gathered to help understand motorized and non-motorized travel to and through the site. Careful preparation, including participant selection and coordination, helps get the most value from field time. Appendix C includes guidance on how to prepare for assessing field conditions.

A comprehensive field assessment involves travel through the site from all possible directions and modes. If there are bike lanes, a site assessment could include traveling through the site by bicycle. If U-turns are legal, the assessment could include making U-turns through the signalized intersections. The goal is to notice, characterize, and record the "typical" experience of a person traveling to and through the site. Visiting the site during different times of the day and under different lighting or weather conditions will provide additional insights into the site's characteristics.

The following list provides several examples (not an exhaustive list) of useful considerations during a site review:[1]

- Roadway and roadside characteristics:
  - Signing and striping
  - Posted speeds
  - Overhead lighting
  - Pavement condition
  - Landscape condition

A field visit to experience site conditions may provide additional information about crashes.

  - Sight distances
  - Shoulder widths
  - Roadside furniture
  - Geometric design (e.g., horizontal alignment, vertical alignment, cross-section)
- Traffic conditions:
  - Types of facility users
  - Travel condition (e.g., free-flow, congested)
  - Adequate queue storage
  - Excessive vehicular speeds
  - Traffic control
  - Adequate traffic signal clearance time
- Traveler behavior:
  - Drivers—aggressive driving, speeding, ignoring traffic control, making maneuvers through insufficient gaps in traffic;
  - Bicyclists—riding on the sidewalk instead of the bike lane, riding excessively close to the curb or travel lane within the bicycle lane; ignoring traffic control, not wearing helmets; and,
  - Pedestrians—ignoring traffic control to cross intersections or roadways, insufficient pedestrian crossing space and signal time, roadway design that encourages pedestrians to improperly use facilities.
- Roadway consistency: Roadway cross-section is consistent with the desired functionality for all modes, and visual cues are consistent with the desired behavior;
- Land uses: Adjacent land use type is consistent with road travel conditions, degree of driveway access to and from adjacent land uses, and types of users associated with the land use (e.g., school-age children, elderly, commuters);
- Weather conditions: Although it will most likely not be possible to see the site in all weather conditions, consideration of adverse weather conditions and how they might affect the roadway conditions may prove valuable; and,
- Evidence of problems, for example:
  - Broken glass
  - Skid marks
  - Damaged signs
  - Damaged guard rail
  - Damaged road furniture
  - Damaged landscape treatments

Prompt lists are useful at this stage to help maintain a comprehensive assessment. These tools serve as a reminder of various considerations and assessments that can be made in the field. Prompt lists can be acquired from a variety of sources, including road safety audit guidebooks and safety textbooks. Alternately, jurisdictions can develop their own. Example prompt lists for different types of roadway environments are provided in Appendix D.

An assessment of field conditions is different from a road safety audit (RSA). A RSA is a formal examination that could be conducted on an existing or future facility and is completed by an independent and interdisciplinary audit team of experts. RSAs include an assessment of field conditions, as described in this section, but also include a detailed analysis of human factors and other additional considerations. The sites selected for a RSA are also selected differently than those selected through the network screening process described in *Chapter 4*. A RSA will often be conducted as a proactive means of reducing crashes and the site may or may not exhibit a known crash pattern or safety concern in order to warrant study.

5.5. IDENTIFY CONCERNS

Once the field assessment, crash data review, and supporting documentation assessment is completed the information can be compiled to identify any specific crash patterns that could be addressed by a countermeasure. Comparing observations from the field assessment, crash data review, and supporting documentation assessment may lead observations that would not have otherwise been identified. For example, if the crash data review showed a higher average crash frequency at one particular approach to an intersection, and the field investigation showed potential sight-distance constraints at this location, these two pieces of information may be related and warrant further consideration. Alternatively, the background site document assessment may reveal that the intersection's signal timing had recently been modified in response to capacity concerns. In the latter case, conditions may be monitored at the site to confirm that the change in signal timing is achieving the desired effect.

In some cases the data review, documentation review, and field investigation may not identify any potential patterns or concerns at a site. If the site was selected for evaluation through the network screening process, it may be that there are multiple minor factors contributing to crashes. Most countermeasures are effective in addressing a single contributing factor, and therefore it may require multiple countermeasures to realize a reduction in the average crash frequency.

5.6. CONCLUSIONS

This chapter described steps for diagnosing crash conditions at a site. The expected outcome of a diagnosis is an understanding of site conditions and the identification of any crash patterns or concerns, and recognizing the site conditions may relate to the patterns.

This chapter outlined three steps for diagnosing sites:

A site diagnosis is completed with a crash data review, review of supporting documentation, and a field visit.

- Step 1: Crash Data Review – The review considers descriptive statistics of crash conditions and locations that may help identify data trends. Collision diagrams, condition diagrams, and crash mapping are illustrative tools that can help summarize crash data in such a way that patterns become evident.
- Step 2: Assess Supporting Documentation – The assessment provides information about site conditions, including: infrastructure improvements, traffic operations, geometry, traffic control, travel modes in use, and relevant public comments. Appendix B provides a list of questions to consider when assessing supporting documentation.

- Step 3: Field Conditions Assessment – First-hand site information is gathered and compared to the findings of Steps 1 and 2. The on-site information gathered includes roadway and roadside characteristics, live traffic conditions, traveler behavior, land uses, roadway consistency, weather conditions, and any unusual characteristics not identified previously. The effectiveness of a field investigation is increased when conducted from a multi-modal, multi-disciplinary perspective. Appendices C and D provide additional guidance for preparing and conducting a field conditions assessment.

At this point in the roadway safety management process, sites have been screened from a larger network and a comprehensive diagnosis has been completed. Site characteristics are known and specific crash patterns have been identified. *Chapter 6* provides guidance on identifying the factors contributing to the safety concerns or crash patterns and identifying countermeasures to address them.

5.7. SAMPLE PROBLEMS

The Situation

Using the network screening methods outlined in *Chapter 4*, the roadway agency has screened the transportation network and identified five intersections and five roadway segments with the highest potential for safety improvement. The locations are shown in Exhibit 5-7.

Exhibit 5-7: Sites Selected For Further Review

Intersection #	Traffic Control	Number of Approaches	Major AADT	Minor AADT	Urban / Rural	Crash Totals		
						Year 1	Year 2	Year 3
2	Two-way stop	4	22,100	1,650	U	9	11	15
7	Two-way stop	4	40,500	1,200	U	11	9	14
9	Signal	4	47,000	8,500	U	15	12	10
11	Signal	4	42,000	1,950	U	12	15	11
12	Signal	4	46,000	18,500	U	10	14	8
Segment #	**Cross-section (lanes)**	**Length (miles)**	**AADT**		**Undivided / Divided**	**Crash Totals**		
						Year 1	**Year 2**	**Year 3**
1	2	0.60	9,000		U	16	15	14
2	2	0.4	15,000		U	12	14	10
5	4	0.35	22,000		U	18	16	15
6	4	0.3	25,000		U	14	12	10
7	4	0.45	26,000		U	12	11	13

Intersections 2 and 9 and Segments 1 and 5 will be studied in detail in this example. In a true application, all five intersections and segments would be studied in detail.

The Question

What are the crash summary statistics, collision diagrams, and condition diagrams for Intersections 2 and 9 and Segments 1 and 5?

The Facts

Intersections

- Three years of intersection crash data are shown in Exhibit 5-8.
- All study intersections have four approaches and are located in urban environments.
- The minor road is stop controlled.

Roadway Segments

- Three years of roadway segment crash data are shown in Exhibits 5-7.
- The roadway cross-section and length is shown in Exhibit 5-7.

Assumptions

- The roadway agency has generated crash summary characteristics, collision diagrams, and condition diagrams.
- The roadway agency has qualified staff available to conduct a field assessment of each site.

Exhibit 5-8: Intersection Crash Data Summary

Intersection #	Total	Crash Severity			Crash Type							
		Fatal	Injury	PDO	Rear End	Side-swipe/ Over taking	Right Angle	Ped	Bike	Head-On	Fixed Object	Other
2	**35**	**2**	**25**	**7**	**4**	**2**	**21**	**0**	**2**	**5**	**0**	**1**
7	34	1	17	16	19	7	5	0	0	0	3	0
9	**37**	**0**	**22**	**15**	**14**	**4**	**17**	**2**	**0**	**0**	**0**	**0**
11	38	1	19	18	6	5	23	0	0	4	0	0
12	32	0	15	17	12	2	14	1	0	2	0	1

Exhibit 5-9: Roadway Segment Crash Data Summary

Segment #	Total	Crash Severity			Crash Type							
		Fatal	Injury	PDO	Rear End	Angle	Head-On	Side-swipe	Ped	Fixed Object	Roll-Over	Other
1	**47**	**3**	**15**	**29**	**0**	**0**	**7**	**6**	**0**	**15**	**19**	**0**
2	36	0	5	31	0	1	3	3	3	14	10	2
5	**42**	**0**	**5**	**37**	**0**	**0**	**22**	**10**	**0**	**5**	**5**	**0**
6	36	0	5	31	4	0	11	10	0	5	4	2
7	36	0	6	30	2	0	13	11	0	4	3	3

Solution

The diagnoses for Intersections 2 and 9 are presented, followed by the diagnoses for Segments 1 and 5.

The following information is presented for each site:

- A set of pie charts summarizing the crash data;
- Collision diagram;
- Condition diagram; and
- A written assessment and summary of the site diagnosis.

The findings are used in the *Chapter 6* examples to select countermeasures for Intersections 2 and 9 and Segments 1 and 5.

5.7.1. Intersection 2 Assessment

Exhibit 5-10 contains crash summary statistics for Intersection 2. Exhibit 5-11 illustrates the collision diagram for Intersection 2. Exhibit 5-12 is the condition diagram for Intersection 2. All three exhibits were generated and analyzed to diagnose Intersection 2.

Exhibit 5-10: Crash Summary Statistics for Intersection 2

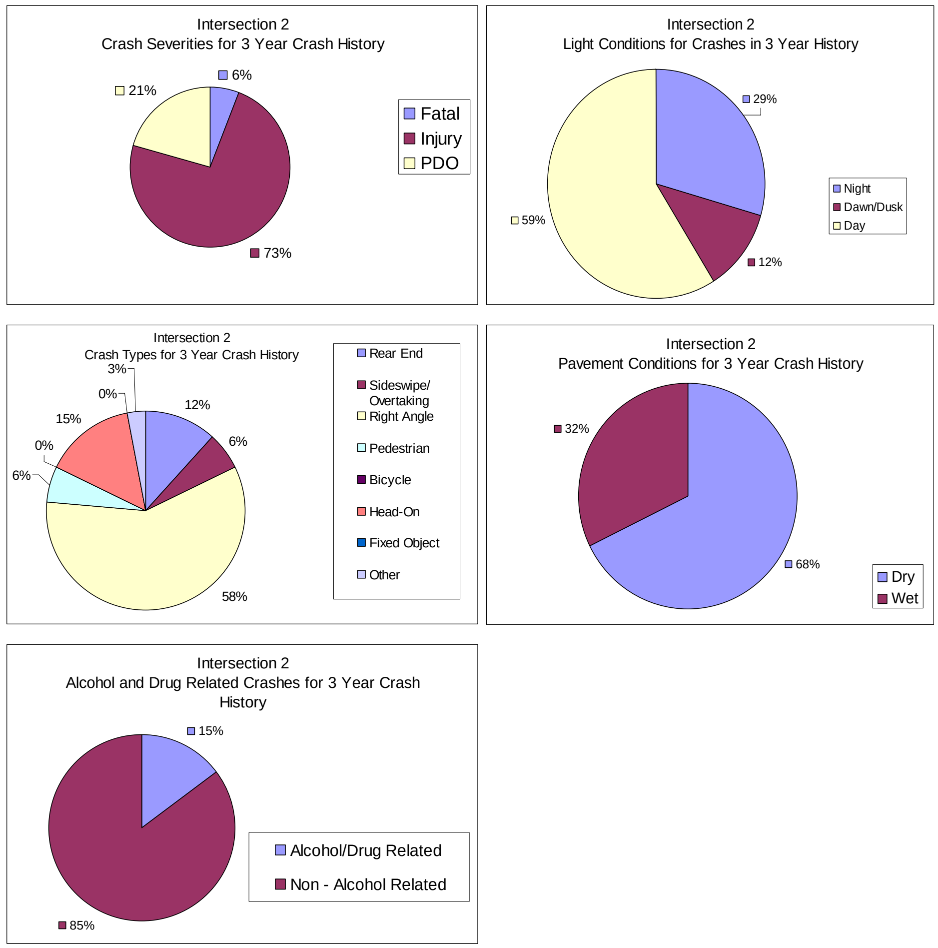


Exhibit 5-11: Collision Diagram for Intersection 2

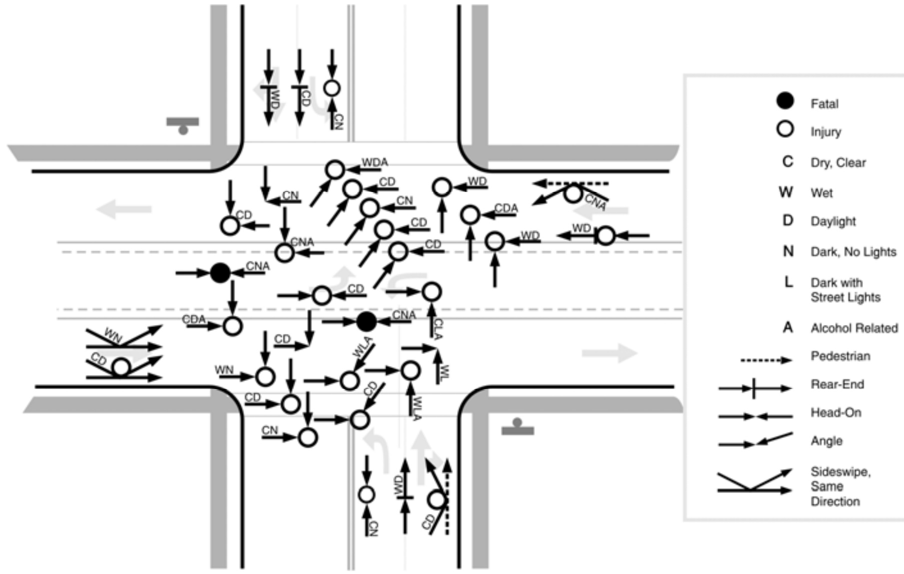
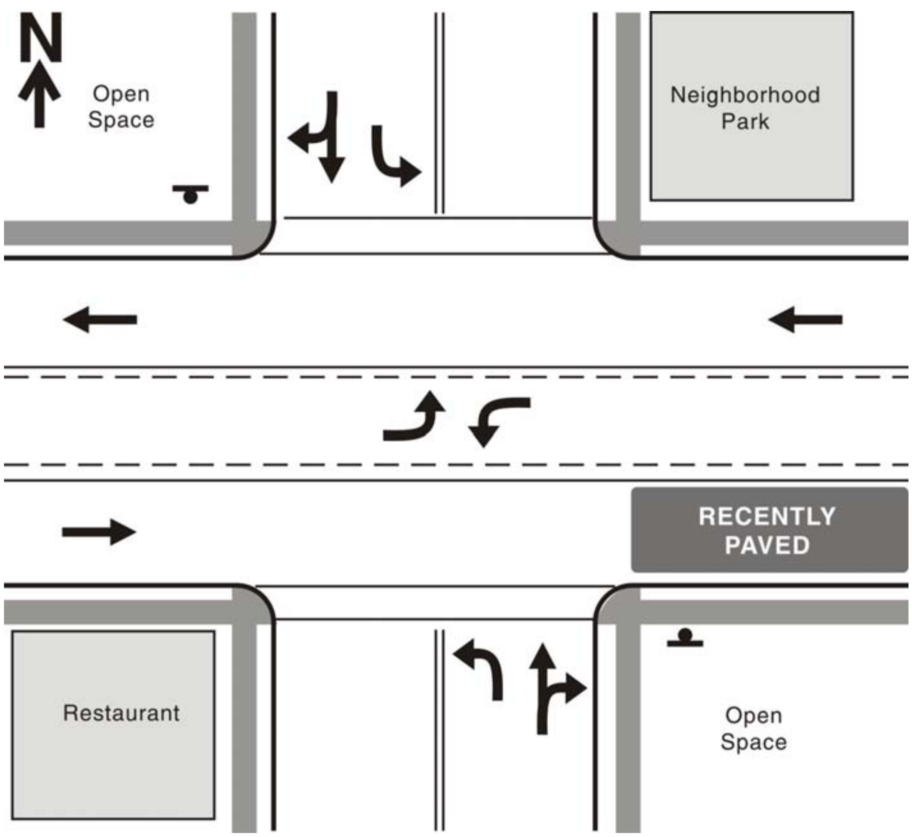


Exhibit 5-12: Condition Diagram for Intersection 2



The crash summary statistics and collision diagram for Intersection 2 indicate angle collisions (including right-angle collisions) comprise a large proportion of crashes. Vehicle direction and movement at the time of the collisions indicate that the angle crashes result from vehicles turning onto and off of the minor road as well as vehicles traveling through the intersection on the minor road across the major road. In the last three years, there have also been five head-on collisions, two of which resulted in a fatality.

An Intersection 2 field assessment confirmed the crash data review. It also revealed that because of the free flow condition on the major street, very few gaps are available for vehicles traveling onto or from the minor street. Sight distances on all four approaches were measured and considered adequate. During the off-peak field assessment, vehicle speeds on the major street were over 10 miles per hour faster than the posted speed limit and inappropriate for the desired character of the roadway.

5.7.2. Intersection 9 Assessment

Exhibit 5-13 contains crash summary characteristics for Intersection 9. Exhibit 5-14 illustrates the collision diagram for Intersection 9. Exhibit 5-15 is the condition diagram for Intersection 9. These exhibits were generated and analyzed to diagnose the safety concern at Intersection 9.

Exhibit 5-13: Crash Summary Statistics for Intersection 9

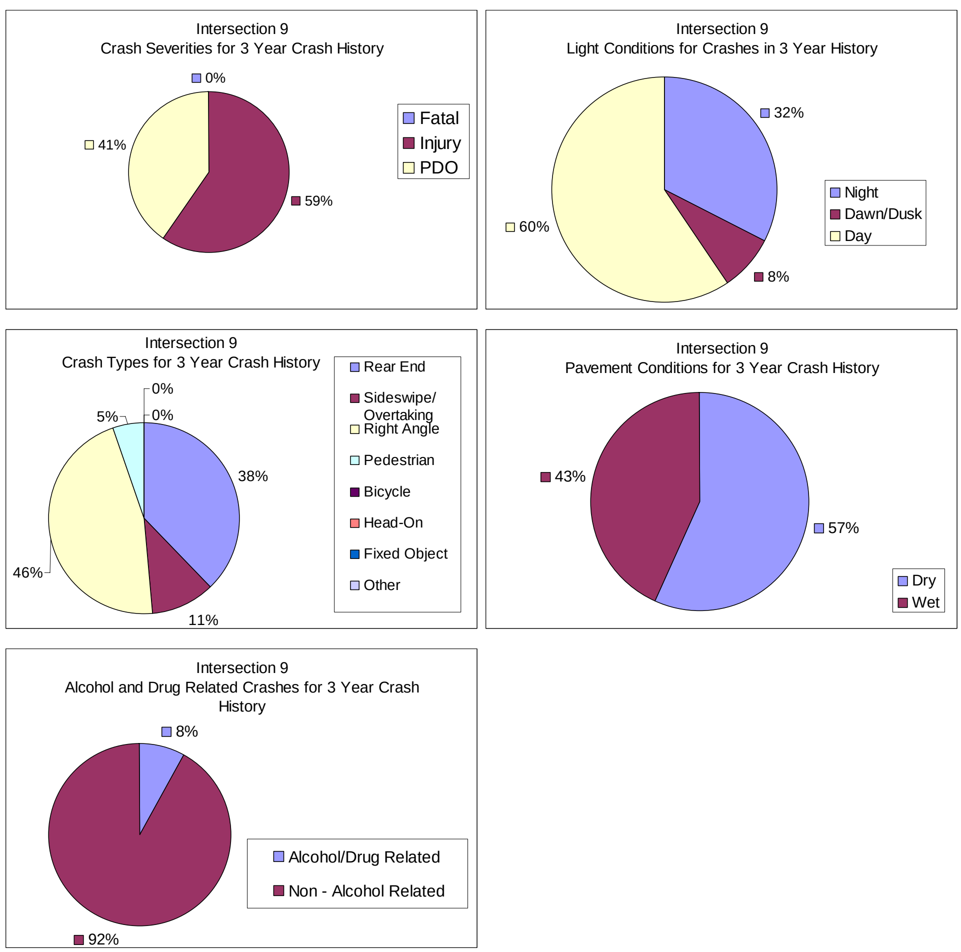


Exhibit 5-14: Collision Diagram for Intersection 9

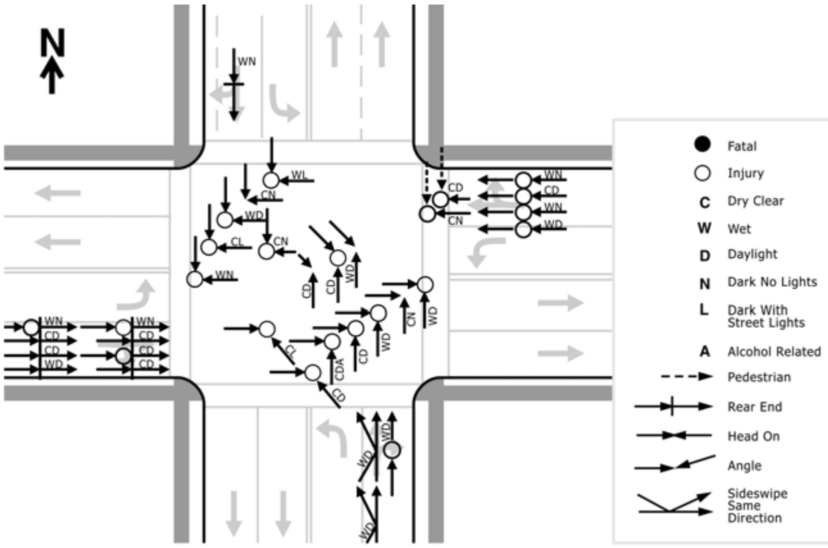
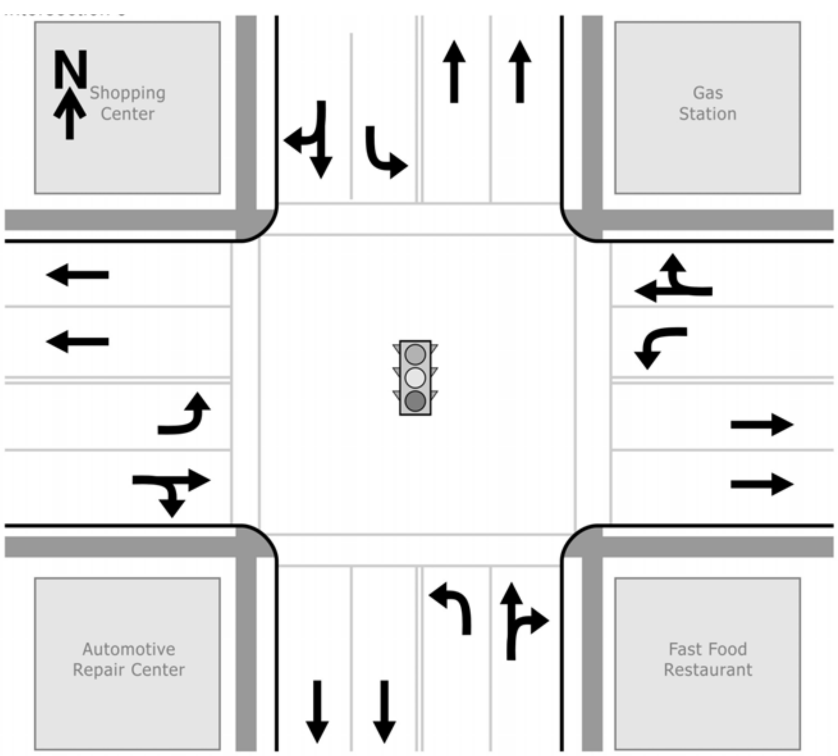


Exhibit 5-15: Condition Diagram of Intersection 9



The crash summary statistics and collision diagram indicate that a majority of the crashes at Intersection 9 are rear-end and angle collisions. In the past three years, the rear-end collisions occurred primarily on the east- and westbound approaches, and the angle collisions occurred in the middle of the intersection. All of the crashes were injury or PDO collisions.

A review of police crash reports indicates that many of the rear-end collisions on the east- and westbound approaches were partially due to the abrupt stop of vehicles traveling east- and westbound. Police crash reports also indicate that many of the angle collisions resulted from vehicles attempting to stop at the last second and continuing into the intersection or vehicles speeding up at the last second in an attempt to make it through the intersection during a yellow light.

Observations of local transportation officials reported that motorists on the east- and westbound approaches are not able to see the signal lenses far enough in advance of the intersection to stop in time for a red light. Local officials confirmed that national criteria for sight distance were met. Horizontal or vertical curves were not found to limit sight distance; however, morning and evening sun glare appears to make it difficult to determine signal color until motorists are essentially at the intersection. The average speed on the roadway also indicates that the existing 8-inch lenses may not be large enough for drivers to see at an appropriate distance to respond to the signal color. Other possible factors are that the length of the yellow interval and the clearance interval can be lengthened considering the limited visibility of the signal lenses. Factors of this sort are suggested to be evaluated further and compared with established criteria.

5.7.3. Segment 1 Assessment

Exhibit 5-16 contains crash summary characteristics for Segment 1. Exhibits 5-17 and 5-18 illustrate the collision diagram and the condition diagram for Segment 1, respectively. All three of these exhibits were generated and analyzed to diagnose the safety concern at Segment 1.

Exhibit 5-16: Crash Summary Statistics for Segment 1

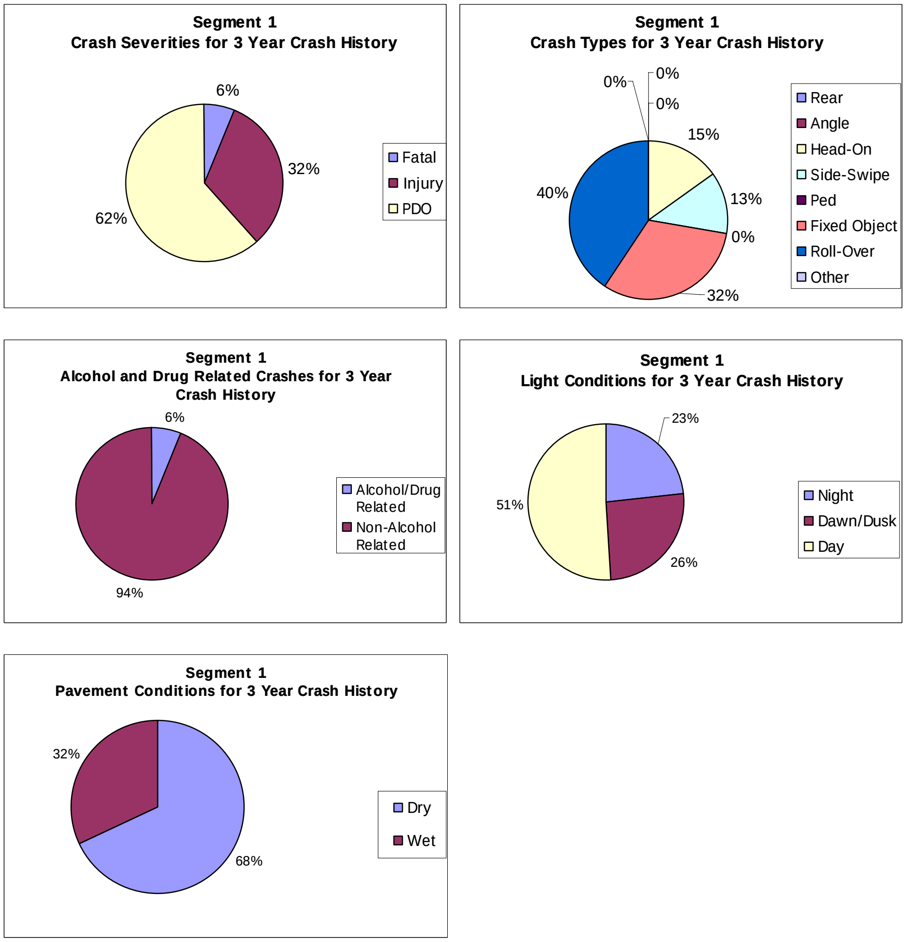


Exhibit 5-17: Collision Diagram for Segment 1

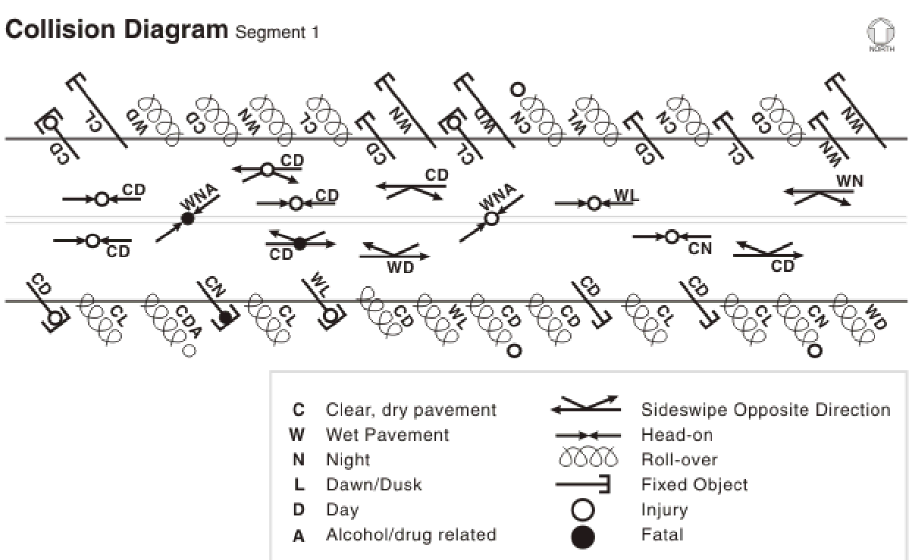
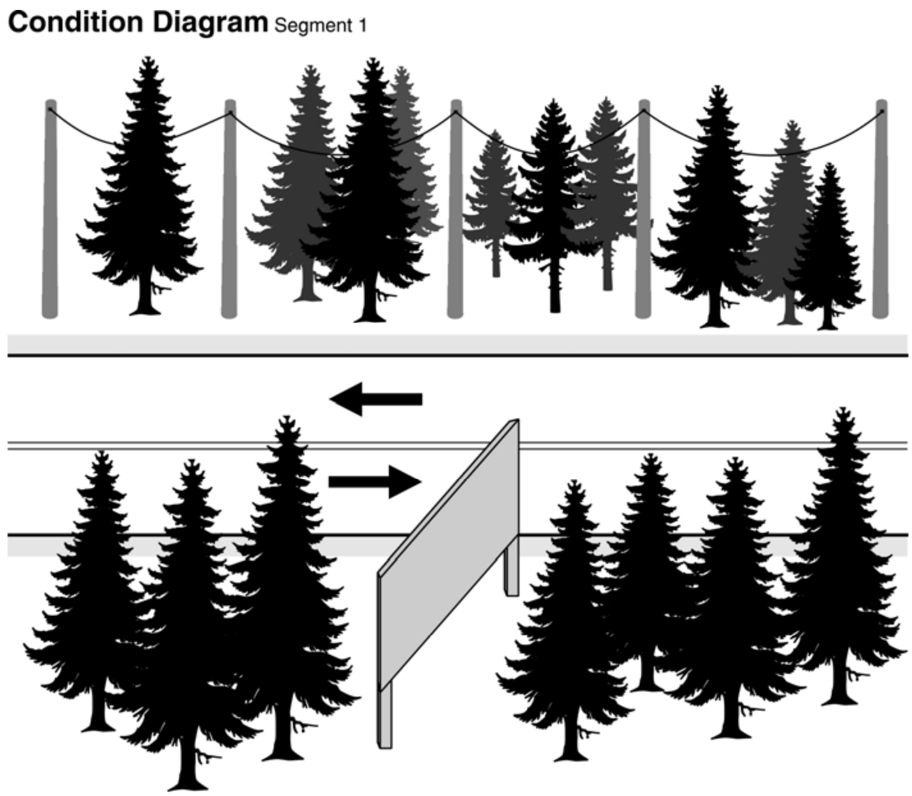


Exhibit 5-18: Condition Diagram for Segment 1



Segment 1 is an undivided two-lane rural highway; the end points of the segment are defined by intersections. The descriptive crash statistics indicate that three-quarters of the crashes on this segment in the last three years involved vehicles running off the road (i.e., roll-over or fixed object). The statistics and crash reports do not show a strong correlation between the run-off-the-road crashes and lighting conditions.

A detailed review of documented site characteristics and a field assessment indicate that the roadway is built to the roadway agency's criteria and is included in the roadway maintenance cycle. Past speed studies and observations made by the roadway agency's engineers indicate that vehicle speeds on the rural two-lane roadway are within 5 to 8 mph of the posted speed limit. Sight distance and delineation were also determined to be appropriate.

5.7.4. Segment 5 Assessment

Exhibit 5-19 contains crash summary characteristics for Segment 5. Exhibit 5-20 illustrates the collision diagram for Segment 5. Exhibit 5-21 is the condition diagram for Segment 5. All three of these exhibits were generated and analyzed to diagnose Segment 5.

Exhibit 5-19: Crash Summary Statistics for Segment 5

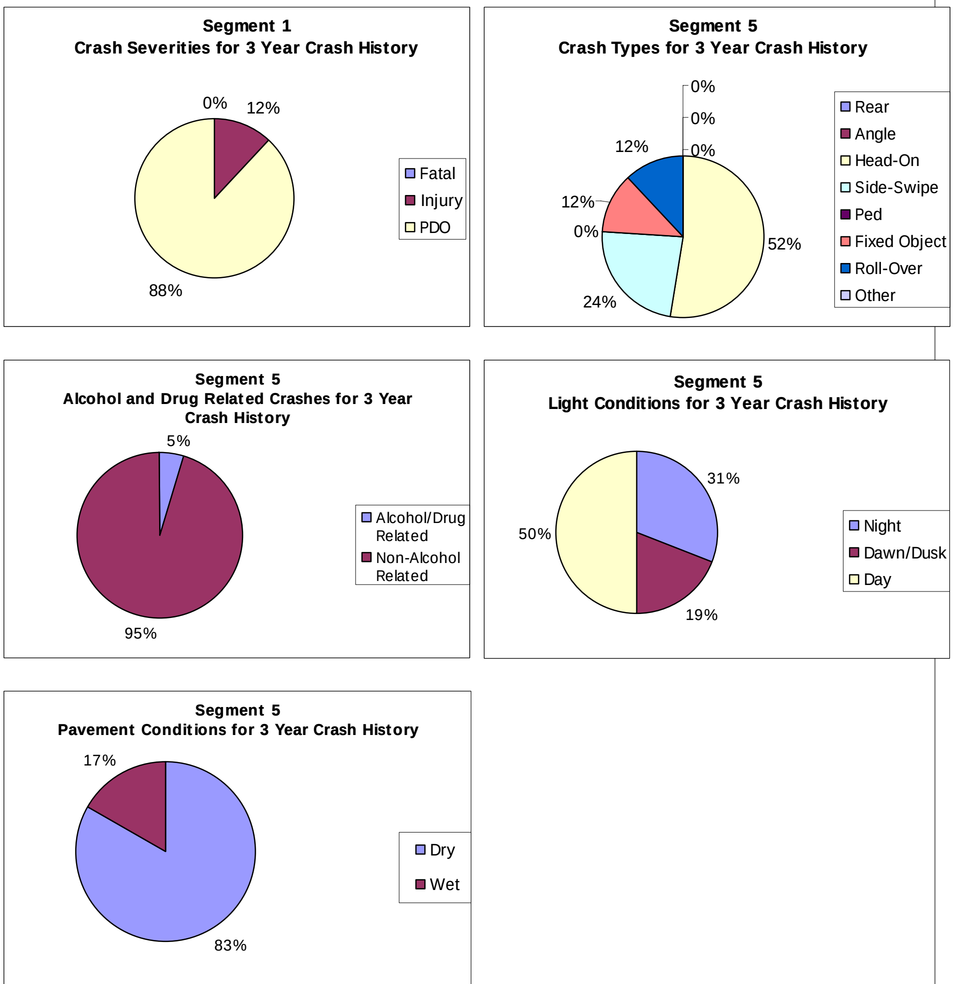


Exhibit 5-20: Collision Diagram for Segment 5

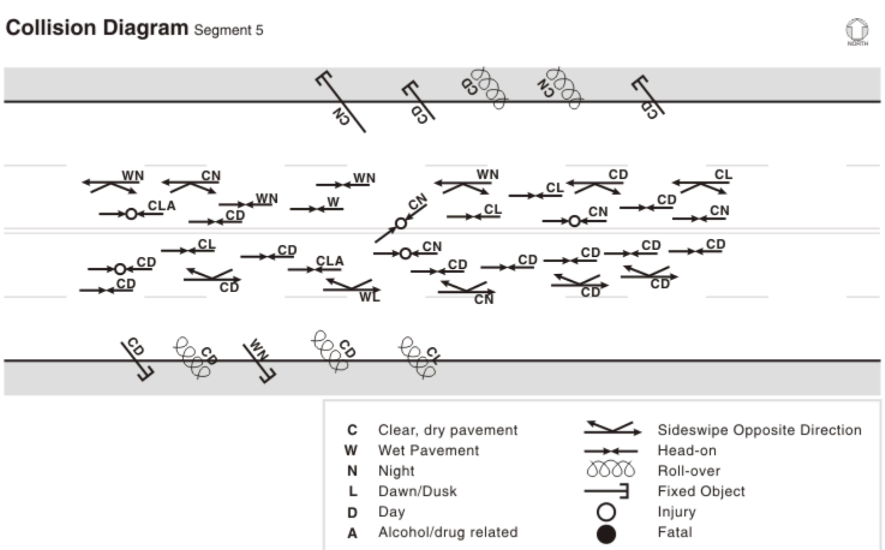
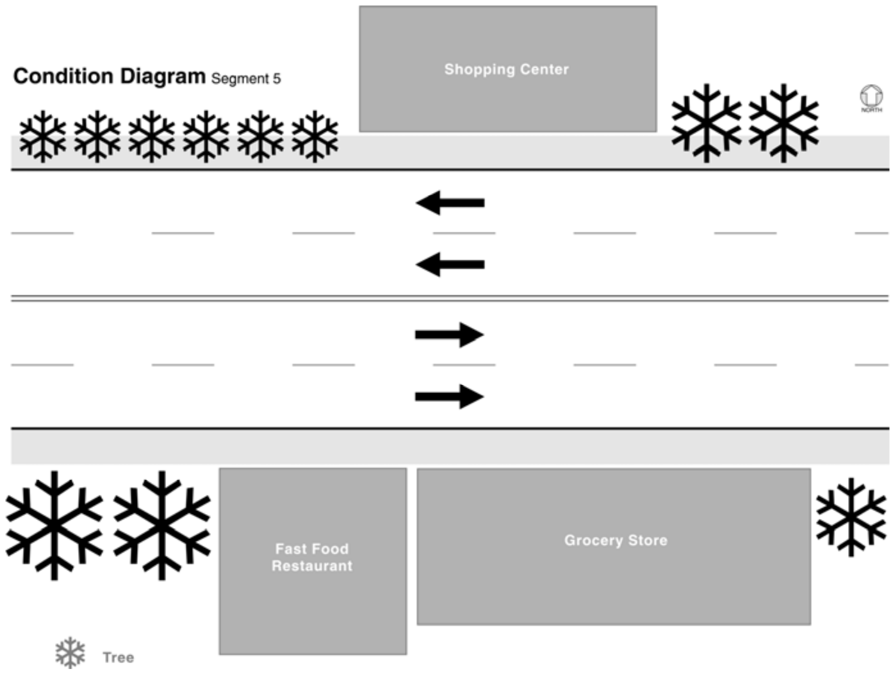


Exhibit 5-21: Condition Diagram for Segment 5



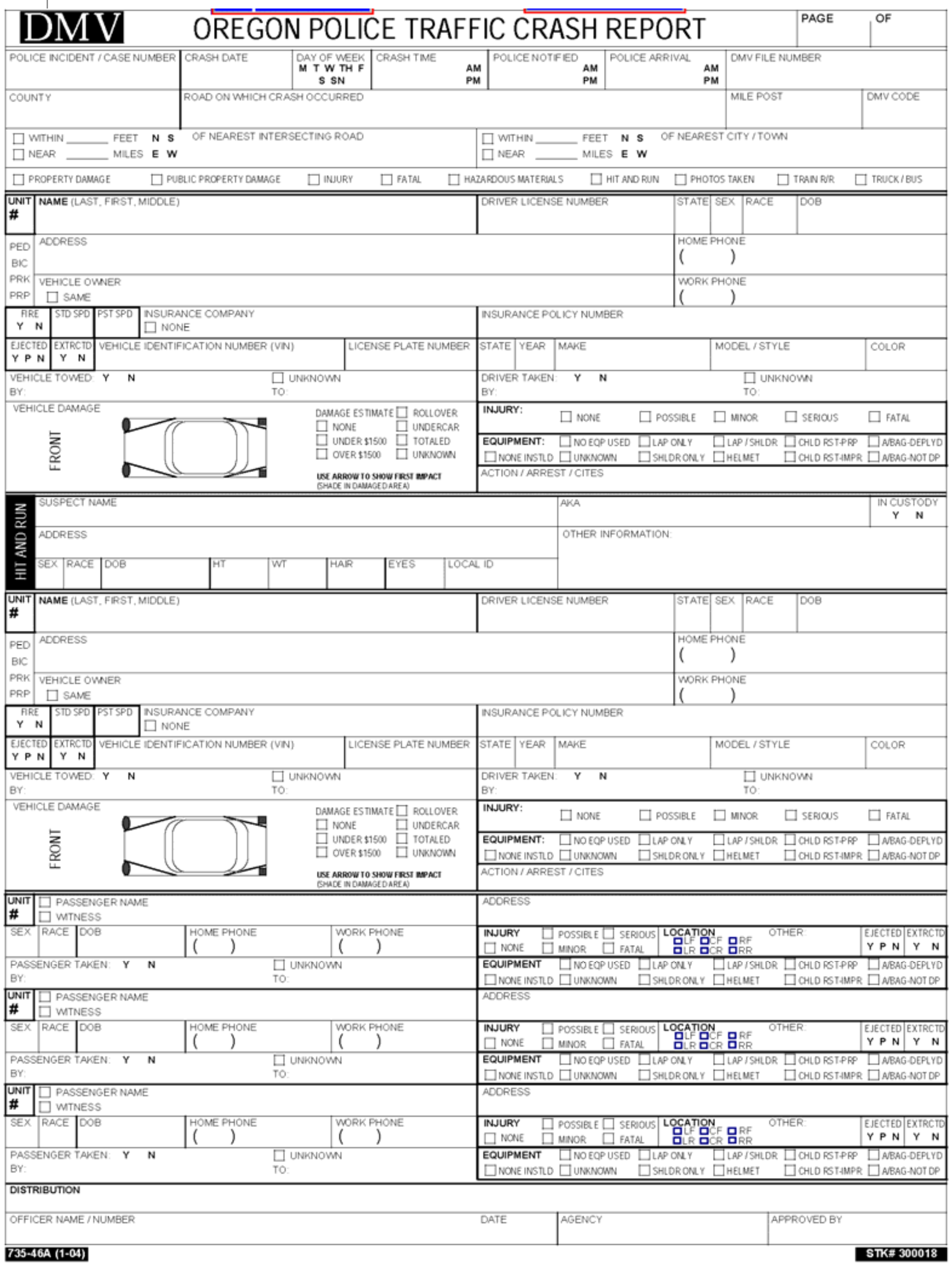
Segment 5 is a four-lane undivided urban arterial. It was originally constructed as a two-lane undivided highway. As a nearby city has grown, suburbs have developed around it, creating the need for the current four-lane roadway. During the past three years, the traffic volumes have increased dramatically, and the crash history over the same three years includes a high percentage (76%) of cross-over crashes (i.e., head-on and opposite direction side-swipe).

5.8. REFERENCES

1. Austroads. *Road Safety Audit.* Austroads 2nd Ed., 2002.
2. FHWA. *Road Safety Fundamentals*. Federal Highway Administration Office of Safety by BMI-SG (draft), 2004.
3. Harkey, D. *GIS-Based Crash Referencing and Analysis System.* Highway Safety Information System Summary Report No. FHWA-RD-99-081, Federal Highway Administration, U.S. Department of Transportation, McLean, VA, February 1999.
4. ITE. *Manual of Transportation Engineering Studies*, Institute of Transportation Engineers, Washington, DC, 1994.
5. Ogden, K.W. *Safer Roads: A Guide to Road Safety Engineering.* Ashgate Publishing Limited, 1996.
6. PIARC Technical Committee on Road Safety (C13). *Road Safety Manual.* World Road Association, 2003.

APPENDIX A – EXAMPLE OF POLICE CRASH REPORT

Exhibit A-1: Police Traffic Crash Form



DMV OREGON POLICE TRAFFIC CRASH REPORT PAGE OF

POLICE INCIDENT / CASE NUMBER | CRASH DATE | DAY OF WEEK M T W TH F S SN | CRASH TIME AM PM | POLICE NOTIFIED AM PM | POLICE ARRIVAL AM PM | DMV FILE NUMBER

COUNTY | ROAD ON WHICH CRASH OCCURRED | MILE POST | DMV CODE

☐ WITHIN ______ FEET N S ☐ NEAR ______ MILES E W OF NEAREST INTERSECTING ROAD | ☐ WITHIN ______ FEET N S ☐ NEAR ______ MILES E W OF NEAREST CITY / TOWN

☐ PROPERTY DAMAGE ☐ PUBLIC PROPERTY DAMAGE ☐ INJURY ☐ FATAL ☐ HAZARDOUS MATERIALS ☐ HIT AND RUN ☐ PHOTOS TAKEN ☐ TRAIN R/R ☐ TRUCK / BUS

UNIT # | NAME (LAST, FIRST, MIDDLE) | DRIVER LICENSE NUMBER | STATE | SEX | RACE | DOB

PED BIC PRK PRP | ADDRESS | HOME PHONE ( ) | VEHICLE OWNER ☐ SAME | WORK PHONE ( )

FIRE Y N | STD SPD | PST SPD | INSURANCE COMPANY ☐ NONE | INSURANCE POLICY NUMBER

EJECTED Y P N | EXTRCTD Y N | VEHICLE IDENTIFICATION NUMBER (VIN) | LICENSE PLATE NUMBER | STATE | YEAR | MAKE | MODEL / STYLE | COLOR

VEHICLE TOWED: Y N BY: ☐ UNKNOWN TO: | DRIVER TAKEN: Y N BY: ☐ UNKNOWN TO:

VEHICLE DAMAGE FRONT | DAMAGE ESTIMATE ☐ NONE ☐ UNDER $1500 ☐ OVER $1500 | ☐ ROLLOVER ☐ UNDERCAR ☐ TOTALED ☐ UNKNOWN | USE ARROW TO SHOW FIRST IMPACT (SHADE IN DAMAGED AREA)

INJURY: ☐ NONE ☐ POSSIBLE ☐ MINOR ☐ SERIOUS ☐ FATAL
EQUIPMENT: ☐ NO EQP USED ☐ LAP ONLY ☐ LAP / SHLDR ☐ CHLD RST-PRP ☐ A/BAG-DEPLYD ☐ NONE INSTLD ☐ UNKNOWN ☐ SHLDR ONLY ☐ HELMET ☐ CHLD RST-IMPR ☐ A/BAG-NOT DP
ACTION / ARREST / CITES

HIT AND RUN | SUSPECT NAME | AKA | IN CUSTODY Y N
ADDRESS | OTHER INFORMATION:
SEX | RACE | DOB | HT | WT | HAIR | EYES | LOCAL ID

UNIT # | NAME (LAST, FIRST, MIDDLE) | DRIVER LICENSE NUMBER | STATE | SEX | RACE | DOB

PED BIC PRK PRP | ADDRESS | HOME PHONE ( ) | VEHICLE OWNER ☐ SAME | WORK PHONE ( )

FIRE Y N | STD SPD | PST SPD | INSURANCE COMPANY ☐ NONE | INSURANCE POLICY NUMBER

EJECTED Y P N | EXTRCTD Y N | VEHICLE IDENTIFICATION NUMBER (VIN) | LICENSE PLATE NUMBER | STATE | YEAR | MAKE | MODEL / STYLE | COLOR

VEHICLE TOWED: Y N BY: ☐ UNKNOWN TO: | DRIVER TAKEN: Y N BY: ☐ UNKNOWN TO:

VEHICLE DAMAGE FRONT | DAMAGE ESTIMATE ☐ NONE ☐ UNDER $1500 ☐ OVER $1500 | ☐ ROLLOVER ☐ UNDERCAR ☐ TOTALED ☐ UNKNOWN | USE ARROW TO SHOW FIRST IMPACT (SHADE IN DAMAGED AREA)

INJURY: ☐ NONE ☐ POSSIBLE ☐ MINOR ☐ SERIOUS ☐ FATAL
EQUIPMENT: ☐ NO EQP USED ☐ LAP ONLY ☐ LAP / SHLDR ☐ CHLD RST-PRP ☐ A/BAG-DEPLYD ☐ NONE INSTLD ☐ UNKNOWN ☐ SHLDR ONLY ☐ HELMET ☐ CHLD RST-IMPR ☐ A/BAG-NOT DP
ACTION / ARREST / CITES

UNIT # | ☐ PASSENGER NAME ☐ WITNESS | ADDRESS
SEX | RACE | DOB | HOME PHONE ( ) | WORK PHONE ( ) | INJURY ☐ NONE ☐ POSSIBLE ☐ MINOR ☐ SERIOUS ☐ FATAL | LOCATION ☐LF ☐CF ☐RF ☐LR ☐CR ☐RR | OTHER: | EJECTED Y P N | EXTRCTD Y N
PASSENGER TAKEN: Y N BY: ☐ UNKNOWN TO: | EQUIPMENT ☐ NO EQP USED ☐ LAP ONLY ☐ LAP / SHLDR ☐ CHLD RST-PRP ☐ A/BAG-DEPLYD ☐ NONE INSTLD ☐ UNKNOWN ☐ SHLDR ONLY ☐ HELMET ☐ CHLD RST-IMPR ☐ A/BAG-NOT DP

UNIT # | ☐ PASSENGER NAME ☐ WITNESS | ADDRESS
SEX | RACE | DOB | HOME PHONE ( ) | WORK PHONE ( ) | INJURY ☐ NONE ☐ POSSIBLE ☐ MINOR ☐ SERIOUS ☐ FATAL | LOCATION ☐LF ☐CF ☐RF ☐LR ☐CR ☐RR | OTHER: | EJECTED Y P N | EXTRCTD Y N
PASSENGER TAKEN: Y N BY: ☐ UNKNOWN TO: | EQUIPMENT ☐ NO EQP USED ☐ LAP ONLY ☐ LAP / SHLDR ☐ CHLD RST-PRP ☐ A/BAG-DEPLYD ☐ NONE INSTLD ☐ UNKNOWN ☐ SHLDR ONLY ☐ HELMET ☐ CHLD RST-IMPR ☐ A/BAG-NOT DP

UNIT # | ☐ PASSENGER NAME ☐ WITNESS | ADDRESS
SEX | RACE | DOB | HOME PHONE ( ) | WORK PHONE ( ) | INJURY ☐ NONE ☐ POSSIBLE ☐ MINOR ☐ SERIOUS ☐ FATAL | LOCATION ☐LF ☐CF ☐RF ☐LR ☐CR ☐RR | OTHER: | EJECTED Y P N | EXTRCTD Y N
PASSENGER TAKEN: Y N BY: ☐ UNKNOWN TO: | EQUIPMENT ☐ NO EQP USED ☐ LAP ONLY ☐ LAP / SHLDR ☐ CHLD RST-PRP ☐ A/BAG-DEPLYD ☐ NONE INSTLD ☐ UNKNOWN ☐ SHLDR ONLY ☐ HELMET ☐ CHLD RST-IMPR ☐ A/BAG-NOT DP

DISTRIBUTION

OFFICER NAME / NUMBER | DATE | AGENCY | APPROVED BY

735-46A (1-04) STK# 300018

Source: Oregon Department of Motor Vehicles

550 **Exhibit A-2: Police Traffic Crash Form (page 2)**

POLICE INCIDENT / CASE NUMBER | EMS NOTIFIED AM PM | EMS ARRIVAL AM PM | LOCAL CODES A B C D E | PAGE OF

Check ONE box in all categories. Check ALL boxes that apply in categories with (★).

FIRST HARMFUL EVENT

NON COLLISION
- ☐ OVERTURN
- ☐ FIRE / EXPLOSION
- ☐ IMMERSION
- ☐ GAS INHALATION
- ☐ OTHER NON COLLISION
- ☐ MEDICAL (Explain)

COLLISION WITH
- ☐ PEDESTRIAN
- ☐ PARKED MOTOR VEHICLE
- ☐ RAILWAY TRAIN
- ☐ BICYCLIST

CRASH TYPE
- ☐ HEAD ON
- ☐ REAR END
- ☐ ANGLE
- ☐ SIDESWIPE
- ☐ MANNER UNKNOWN

FIXED OBJECT
- ☐ BARRICADE
- ☐ BOULDER / ROCK
- ☐ BRIDGE O/PASS or RAILING
- ☐ BUILDING
- ☐ CULVERT HEADWALL
- ☐ CURBING
- ☐ DITCH
- ☐ DIVIDER - CNCRT or STEEL
- ☐ FENCE - NOT MEDIAN
- ☐ FIRE HYDRANT
- ☐ HIGHWAY GUARDRAIL
- ☐ HIGHWAY SIGN
- ☐ IMPACT ABSORBER
- ☐ LIGHT STANDARD
- ☐ MAILBOX
- ☐ OVERHEAD SIGN POST
- ☐ OVERHEAD STRUCTURE
- ☐ PIER or COLUMN
- ☐ RETAINING WALL
- ☐ SIDESLOPE EARTH
- ☐ SIDESLOPE ROCK or STONE
- ☐ TRAFFIC SIGNAL POST
- ☐ TREE
- ☐ UNDERPASS TUNNEL
- ☐ UTILITY POLE
- ☐ OTHER FIXED (Explain)

OTHER OBJECT (NOT FIXED)
- ☐ ANIMAL
- ☐ THROWN / FALLING OBJECT
- ☐ UNKNOWN
- ☐ OTHER OBJECT (Explain)

EVENT LOCATION

ON ROADWAY
- ☐ NON-INTERSECTION
- ☐ INTERSECTION
- ☐ INTERSECTION RELATED
- ☐ DRIVEWAY ACCESS
- ☐ INTERCHANGE AREA
- ☐ RAILROAD CROSSING
- ☐ BRIDGE
- ☐ TUNNEL
- ☐ OTHER ON-ROAD AREA

OFF ROADWAY
- ☐ SHOULDER
- ☐ TURNOUT
- ☐ ROADSIDE
- ☐ BEYOND RIGHT OF WAY
- ☐ MEDIAN
- ☐ DRIVEWAY
- ☐ PRIVATE DRIVE
- ☐ RAILROAD CROSSING
- ☐ OTHER OFF ROAD
- ☐ PARKING LOT
- ☐ UNKNOWN

SPECIAL ZONE
- ☐ NONE
- ☐ CONSTRUCTION
- ☐ MAINTENANCE
- ☐ UTILITY
- ☐ SNOW
- ☐ SCHOOL
- ☐ UNKNOWN WORK
- ☐ OTHER

WEATHER
- ☐ CLEAR
- ☐ CLOUDY (OVERCAST)
- ☐ RAIN
- ☐ SNOW
- ☐ SLEET / HAIL / ETC
- ☐ FOG / SMOG
- ☐ SMOKE
- ☐ BLOWING SAND / DIRT
- ☐ SEVERE CROSSWIND
- ☐ OTHER / UNKNOWN

SURFACE CONDITION

#1 #2
- ☐ ☐ DRY
- ☐ ☐ WET
- ☐ ☐ SNOW / SLUSH
- ☐ ☐ ICY
- ☐ ☐ MUDDY
- ☐ ☐ DEBRIS
- ☐ ☐ RUTS / HOLES / BUMPS
- ☐ ☐ WORN / POLISHED
- ☐ ☐ LOW / SOFT SHOULDER
- ☐ ☐ OTHER / UNKNOWN

SURFACE TYPE

#1 #2
- ☐ ☐ CONCRETE
- ☐ ☐ BLACKTOP / ASPHALT
- ☐ ☐ GRAVEL
- ☐ ☐ DIRT
- ☐ ☐ OTHER

LIGHT
- ☐ FULL DAYLIGHT
- ☐ DAWN
- ☐ DUSK
- ☐ DARK - LIGHTED WAY
- ☐ DARK - NOT LIGHTED
- ☐ UNKNOWN

TRAFFIC CONTROL TYPE

#1 #2
- ☐ ☐ NONE
- ☐ ☐ SCHOOL BUS LIGHTS
- ☐ ☐ OFFICER / CROSSING GUARD or FLAGGER
- ☐ ☐ TRAFFIC SIGNAL w/ PEDESTRIAN CONTROL
- ☐ ☐ TRAFFIC SIGNAL
- ☐ ☐ FLASHING BEACON
- ☐ ☐ STOP SIGN
- ☐ ☐ YIELD SIGN
- ☐ ☐ RR CROSSING GATES
- ☐ ☐ RR CROSSING BUCKS
- ☐ ☐ RR FLASHING SIGNAL
- ☐ ☐ RR CROSSING w/ PAVEMENT MARKINGS
- ☐ ☐ LANE CONTRLS / LINES / STRIPES / DEVICES
- ☐ ☐ SCHOOL SIGNAL
- ☐ ☐ OTHER REG SIGN
- ☐ ☐ TURN LANES
- ☐ ☐ UNKNOWN

TRAFFIC CONTROL DEVICE CONDITION

#1 #2
- ☐ ☐ NO MALFUNCTION
- ☐ ☐ DOWN / MISSING
- ☐ ☐ TURNED FROM PROPER POSITION
- ☐ ☐ OBSCURED BY OTHER SIGNS
- ☐ ☐ OBSCURED BY PARKED VEHICLE
- ☐ ☐ OBSCURED BY VEGETATION
- ☐ ☐ LIGHTS MALFUNCTION
- ☐ ☐ LIGHTS STUCK
- ☐ ☐ GATES INOPERATIVE
- ☐ ☐ GATE ARM MISSING
- ☐ ☐ OTHER RR MALFUNCTN
- ☐ ☐ OTHER IMPAIRMENT
- ☐ ☐ UNKNOWN

ROAD CHARACTER

#1 #2
- ☐ ☐ STRAIGHT and LEVEL
- ☐ ☐ STRAIGHT w/ GRADE
- ☐ ☐ CURVED and LEVEL
- ☐ ☐ CURVED w/ GRADE

VEH #1 ___ NUMBER OF LANES

VEH #2 ___ NUMBER OF LANES

___ TOTAL NUMBER OF LANES

ROAD FLOW

#1 #2
- ☐ ☐ ONE WAY TRAFFIC
- ☐ ☐ NOT PHYSLY DIVIDED

MEDIAN TYPE
- ☐ ☐ UNPAVED
- ☐ ☐ BARRIER
- ☐ ☐ PAVED
- ☐ ☐ CONT LEFT TURN

DRIVER LICENSE VIOLATION

DRIVER #1 #2
- ☐ ☐ NONE
- ☐ ☐ INSTRUCTION PERMIT
- ☐ ☐ LICENSE RESTRICTION
- ☐ ☐ EXPIRED LICENSE
- ☐ ☐ OUT OF CLASS
- ☐ ☐ SUSPNDED / REVOKED
- ☐ ☐ UNLICENSED

★ DRIVER FACTORS

DRIVER #1 #2
- ☐ ☐ NONE
- ☐ ☐ CELL PHONE USE
- ☐ ☐ OBSTRUCTED VIEW
- ☐ ☐ FAILED TO YIELD ROW
- ☐ ☐ DISRGRD TRAF SIGN
- ☐ ☐ TOO FAST FOR COND
- ☐ ☐ MADE IMPROPER TURN
- ☐ ☐ WRONG SIDE/WAY
- ☐ ☐ FOLLOW TOO CLOSELY
- ☐ ☐ IMPROPER LANE CHNG
- ☐ ☐ IMPROPER BACKING
- ☐ ☐ IMPROPER PASSING
- ☐ ☐ IMPROPER SIGNAL
- ☐ ☐ IMPROPER PARKING
- ☐ ☐ FATIGUE / DROWSY
- ☐ ☐ ILL / BLACKOUT
- ☐ ☐ UNKNOWN
- ☐ ☐ OTHER

★ IMPAIRMENT

DRIVER #1 #2
- ☐ ☐ NONE
- ☐ ☐ UNDER INFL - DRUGS
- ☐ ☐ UNDER INFL - ALCOHOL
- ☐ ☐ UNDER INFL - MEDS
- ☐ ☐ UNKNOWN

DETERMINED BY:
- ☐ ☐ INTOXILYZER TEST
- ☐ ☐ BLOOD OR URINE TEST
- ☐ ☐ FIELD SOB. TEST
- ☐ ☐ OBSERVED (SPEECH, ODOR, ETC.)
- ☐ ☐ DRE EVALUATION
- ☐ ☐ STATEMENTS
- ☐ ☐ UNKNOWN
- ☐ ☐ OTHER

RESULTS OF TEST:

D1 ____% D2 ____%
- ☐ ☐ NO TEST GIVEN
- ☐ ☐ TEST REFUSED
- ☐ ☐ TESTED FOR DRUGS
- ☐ ☐ RESLTS NOT AVAILABLE

★ VEH RELATED FACTORS

#1 #2
- ☐ ☐ NONE
- ☐ ☐ BRAKES
- ☐ ☐ STEERING
- ☐ ☐ POWER PLANT
- ☐ ☐ SUSPENSION
- ☐ ☐ TIRES
- ☐ ☐ EXHAUST
- ☐ ☐ LIGHTS
- ☐ ☐ SIGNALS
- ☐ ☐ WINDOWS / WINDSHLD
- ☐ ☐ RESTRAINT SYSTEM
- ☐ ☐ WHEELS
- ☐ ☐ COUPLING
- ☐ ☐ CARGO
- ☐ ☐ OTHER

VEHICLE MOVEMENT

#1 #2
- ☐ ☐ BACKING
- ☐ ☐ STOPPED
- ☐ ☐ STRAIGHT AHEAD
- ☐ ☐ TURNING RIGHT
- ☐ ☐ TURNING LEFT
- ☐ ☐ MAKING U-TURN
- ☐ ☐ ENTER TRAFFIC LANE
- ☐ ☐ LEAVE TRAFFIC LANE
- ☐ ☐ OVERTAKING
- ☐ ☐ CHANGING LANES
- ☐ ☐ AVOIDING MANEUVER
- ☐ ☐ MERGING
- ☐ ☐ PARKING
- ☐ ☐ NEGOTIATING A CURVE
- ☐ ☐ OTHER

TRAILER TYPE

#1 #2
- ☐ ☐ LOG BUNK
- ☐ ☐ SEMITRAILER
- ☐ ☐ POLE TRAILER
- ☐ ☐ FULL TRAILER
- ☐ ☐ MOBILE HOME
- ☐ ☐ UTILITY TRAILER
- ☐ ☐ TRAVEL TRAILER
- ☐ ☐ BOAT TRAILER
- ☐ ☐ FARM EQUIPMENT
- ☐ ☐ HORSE TRAILER
- ☐ ☐ VEHICLE IN TOW
- ☐ ☐ OTHER / UNKNOWN

TRUCK CONFIGURATION

#1 #2
- ☐ ☐ TRUCK (2 or 3 AXLE)
- ☐ ☐ TRUCK / TRACTOR-SEMI
- ☐ ☐ TRUCK and TRAILER
- ☐ ☐ DOUBLE TRAILERS
- ☐ ☐ TRIPLE TRAILERS
- ☐ ☐ DROMEDARY and SEMI
- ☐ ☐ HEAVY HAUL CONFIG
- ☐ ☐ BUS
- ☐ ☐ OTHER

★ PASSENGER FACTORS

PASS #1 #2 **UNIT #1**
- ☐ ☐ NONE
- ☐ ☐ INTERFERED w/DRIVER
- ☐ ☐ UNDER INFL - DRUGS
- ☐ ☐ UNDER INFL - ALCOHOL
- ☐ ☐ UNKNOWN
- ☐ ☐ OTHER (Explain)

PASS #1 #2 **UNIT #2**
- ☐ ☐ NONE
- ☐ ☐ INTERFERED w/DRIVER
- ☐ ☐ UNDER INFL - DRUGS
- ☐ ☐ UNDER INFL - ALCOHOL
- ☐ ☐ UNKNOWN
- ☐ ☐ OTHER (Explain)

PEDESTRIAN LOCATION

IN ROAD
- ☐ IN X-WALK
- ☐ NOT IN X-WALK
- ☐ NO X-WALK AVAILABLE

INTERSECTION
- ☐ IN X-WALK
- ☐ NOT IN X-WALK
- ☐ NO X-WALK AVAILABLE

OTHER
- ☐ NOT IN ROADWAY
- ☐ SHOULDER
- ☐ MEDIAN
- ☐ BIKE LANE
- ☐ UNKNOWN

PEDESTRIAN TYPE
- ☐ NONE
- ☐ PEDESTRIAN
- ☐ BICYCLIST
- ☐ CONVEYANCE
- ☐ WHEELCHAIR
- ☐ ANIMAL RIDER
- ☐ RIDER of ANIM DRAWN VEH
- ☐ UNKNOWN
- ☐ OTHER (Explain)

★ PEDESTRIAN ACTION
- ☐ ENTER / CROSS ROAD
- ☐ WALK / RIDE w/TRAFF
- ☐ WALK / RIDE AGAINST
- ☐ STEP ON / OFF VEHICLE
- ☐ STEP ON / OFF SCH BUS
- ☐ APPRCH / LEAVE SC BUS
- ☐ APPROACH / LEAVE VEH
- ☐ WORK / PUSHING VEHICLE
- ☐ OTHER WORKING
- ☐ PLAYING
- ☐ STANDING
- ☐ LYING DOWN
- ☐ UNKNOWN

PED / BIKE VISIBILITY

CLOTHING
- ☐ NO CONTRAST w/BKGRND
- ☐ CONTRASTED w/BKGRND
- ☐ REFLECTIVE

OTHER
- ☐ OTHER LIGHT SOURCE
- ☐ UNKNOWN

★ PED / BIKE FACTORS
- ☐ NONE
- ☐ FAILED TO YIELD ROW
- ☐ DISREGARD TRAFFIC SIGN
- ☐ ILLEGALLY IN ROAD
- ☐ EQUIPMENT VIOLATION
- ☐ CLOTHING NOT VISIBLE
- ☐ UNDER INFL - DRUGS
- ☐ UNDER INFL - ALCOHOL
- ☐ UNKNOWN
- ☐ OTHER (Explain)

North

SKETCH & NARRATIVE

(NOT TO SCALE)

UNIT	1	2
SKID MARKS TO (FEET)	______	______
DISTANCE AFTER (FEET)	______	______

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APPENDIX B – SITE CHARACTERISTIC CONSIDERATIONS

The following provides a list of questions and data to consider when reviewing past site documentation.[(3)] This list is intended to serve as an example and is not exhaustive.

Traffic Operations

- Do past studies indicate excessive speeds at or through the site?
- If the site is a signalized intersection, is there queuing on the intersection approaches?
- If the site is a signalized intersection, what signal warrant does the intersection satisfy? Does the intersection currently satisfy the signal warrants?
- Is there adequate capacity at or through the site?
- What is the proportion of heavy vehicles traveling through the site?
- Does mainline access to adjacent land negatively influence traffic operations?

Geometric Conditions

- Is the roadway geometry in the vicinity of the site consistent with the adopted functional classification?
- What are the available stopping sight distances and corner sight distances at each driveway or intersection?
- Have there been recent roadway geometry changes that may have influenced crash conditions?
- How does the site design compare to jurisdictional design criteria and other related guidelines? Non-compliance and/or compliance does not directly relate to safe or unsafe conditions, though it can inform the diagnostic process.

Physical Conditions

- Do the following physical conditions indicate possible safety concerns:
    - pavement conditions;
    - drainage;
    - lighting;
    - landscaping;
    - signing or striping; and,
    - driveway access.
- Are there specific topographic concerns or constraints that could be influencing conditions?

Planned Conditions

- Are improvements planned at the site or in the vicinity that may influence safety conditions?
- How will the planned conditions affect the function and character of the site? What is the objective of the planned changes (i.e. increase capacity, etc.)? How could these changes influence safety?
- Are there planning or policy statements relating to the site such as:
  - functional classification;
  - driveway access management;
  - pedestrian, bicycle, transit, or freight policies; and,
  - future connections for motorized traffic, pedestrians, or cyclists.

Transit, Pedestrian, and Bicycle Activity

- What transportation modes do people use to travel through the site?
- Is there potential to introduce other travel modes at the site (i.e. new bus stops, sidewalks, bike lanes, or multi-use path)?
- Are bus stops located in the vicinity of the site?
- Is there a continuous bicycle or pedestrian network in the area?
- What visual clues exist to alert motorists to pedestrians and bicyclists (e.g. striped bike lanes, curb extensions at intersections for pedestrians)?
- Is there any historical information relating to multimodal concerns such as:
  - roadway shoulders and edge treatments;
  - transit stop locations;
  - exclusive or shared transit lanes;
  - bicycle lanes;
  - sidewalks; and,
  - adjacent parking.

Heavy Vehicle Activity

- Are there concerns related to heavy vehicles. Such concerns could include:
  - sight distance or signal operations;
  - emergency vehicle access and mobility;
  - freight truck maneuvers in the site vicinity; and,
  - presence of road maintenance or farm vehicles.

Land Use Characteristics

- Do the adjacent land uses lead to a high level of driveway turning movements onto and off of the roadway?

- Do the land uses attract vulnerable user groups (e.g., small children going to school, library or day-care; elderly people walking to and from a retirement center or retirement living facility; a playground or ball field where children may not be focused on the roadway)?
- Are adjacent land uses likely to attract a particular type of transportation mode, such as large trucks or bicycles?
- Do the adjacent land uses lead to a mix of users familiar with the area and others who may not be familiar with the area, such as tourists?

Public Comments

- What is the public perception of site conditions?
- Have comments been received about any specific safety concerns?

APPENDIX C – PREPARATION FOR CONDUCTING AN ASSESSMENT OF FIELD CONDITIONS

Select Participants

The field investigation is most successful when conducted from a multi-modal, multi-disciplinary perspective.(1) It is ideal to include experts in pedestrian, bicycle, transit, and motorized vehicle transportation, as well as law enforcement and emergency service representatives. A multi-modal, multi-disciplinary perspective may produce ideas and observations about the site that enhance the engineering observations and development of countermeasures. However, field investigations can also take place on a smaller scale where two or three people from a roadway agency are involved. In these instances, the individuals conducting the investigation can make an effort to keep multi-modal and multi-disciplinary perspectives in mind while evaluating and conducting the field investigation.

Advanced Coordination

The following activities are suggested to occur in advance of the field investigation in an effort to increase the effectiveness of the investigation:

- Team members review summaries of the crash analyses and site characteristics;
- The team members review a schedule and description of expected roles and outcomes from the investigation.
- A schedule is developed that identifies the number of field reviews and the time of day for each review. If possible, two field trips are useful: one during the day and another at night.

While in the field, the following tools may be useful:

- Still and/or video camera
- Stopwatch
- Safety vest and hardhat
- Measuring device
- Traffic counting board
- Spray paint
- Clipboards and notepads
- Weather protection
- Checklist for site investigation
- As-built design plans
- Summary notes of the site characteristics assessment
- Summary notes of the crash data analysis

APPENDIX D – FIELD REVIEW CHECKLIST

Roadway Segment

A roadway segment may include a portion of two-lane undivided, multi-lane undivided, or multi-lane divided highways in a rural, urban, or suburban area. Access may either be controlled (using grade-separated interchanges) or uncontrolled (via driveways or other access locations). Consideration of horizontal and vertical alignment and cross-sectional elements can help to determine possible accident contributory factors. The presence and location of auxiliary lanes, driveways, interchange ramps, signs, pavement marking delineation, roadway lighting, and roadside hardware is also valuable information. The prompt list below contains several prompts (not intended to be exhaustive) that could be used when performing field investigations on roadway segments: (2)

- Are there clear sight lines between the mainline road and side streets or driveways, or are there obstructions that may hinder visibility of conflicting flows of traffic?
- Does the available stopping sight distance meet local or national stopping sight distance criteria for the speed of traffic using the roadway segment? (See AASHTO's "A Policy on Geometric Design of Highways and Streets" or other guidance documents). Non-compliance and/or compliance does not directly relate to safe or unsafe conditions, though it can inform the diagnostic process.
- Is the horizontal and vertical alignment appropriate given the operating speeds on the roadway segment?
- Are passing opportunities adequate on the roadway segment?
- Are all through travel lanes and shoulders adequate based on the composition of traffic using the roadway segment?
- Does the roadway cross-slope adequately drain rainfall and snow runoff?
- Are auxiliary lanes properly located and designed?
- Are interchange entrance and exit ramps appropriately located and designed?
- Are median and roadside barriers properly installed?
- Is the median and roadside (right of traveled way) free from fixed objects and steep embankment slopes?
- Are bridge widths appropriate?
- Are drainage features within the clear zone traversable?
- Are sign and luminaire supports in the clear zone breakaway?
- Is roadway lighting appropriately installed and operating?
- Are traffic signs appropriately located and clearly visible to the driver?
- Is pavement marking delineation appropriate and effective?

- Is the pavement surface free of defects and does it have adequate skid resistance?
- Are parking provisions satisfactory?

Signalized Intersections

Examples of geometric and other signalized intersection characteristics that may prove valuable in determining a possible crash contributory factor at a signalized intersection include: the number of approach legs and their configuration, horizontal and vertical alignment design, cross-section elements, median type (if any), traffic signal phasing, parking locations, driveway access points, and any turn prohibitions. The signalized intersection safety prompt list provided below contains several examples of questions worthy of consideration when performing field investigations:

- Is appropriate sight distance available to all users on each intersection approach?
- Is the horizontal and vertical alignment appropriate on each approach leg?
- Are pavement markings and intersection control signing appropriate?
- Are all approach lanes adequately designed based on the composition of traffic using the intersection?
- Is the roadway cross-slope adequately draining rainfall and snow runoff?
- Is the median, curbs, and channelization layout appropriate?
- Are turning radii and tapers adequately designed based on the traffic composition using the intersection?
- Is roadway lighting appropriately installed and operating?
- Are traffic signs appropriately located and clearly visible to the driver on each approach leg?
- Is the pavement free of defects and is there adequate skid resistance?
- Are parking provisions satisfactory?
- Is traffic signal phasing appropriate for turning traffic on each approach?
- Are driveways and other access points appropriately located on each intersection approach leg?

Unsignalized Intersections

Unsignalized intersections may be stop or yield controlled or may not contain any control. Unsignalized intersections may contain three or more approach legs and different lane configurations on each leg. Data that may prove valuable in determining a possible crash contributory factor at an unsignalized intersection includes: the number of approach legs and their configuration, type of traffic control (none, yield, or stop), horizontal and vertical alignment design, cross-section elements, median type (if any), parking locations, driveway access points, and any turn prohibitions. The prompt list[2] provided below includes questions to consider when performing field investigations at unsignalized intersections:

- Is appropriate sight distance available to all users on each intersection approach?
- Is the horizontal and vertical alignment appropriate on each approach leg?
- Are pavement markings and intersection control signing appropriate?
- Are all approach lanes adequately designed based on the composition of traffic using the intersection?
- Is the roadway cross-slope adequately draining rainfall and snow runoff?
- Is the layout of the curbs and channelization appropriate?
- Are turning radius and tapers adequately designed based on the traffic composition using the intersection?
- Is roadway lighting appropriately installed and operating?
- Are traffic signs appropriately located and clearly visible to the driver on each approach leg?
- Is the pavement free of defects, and is there adequate skid resistance?
- Are parking provisions satisfactory?
- Are driveways and other access points appropriately located on each intersection approach leg?

Highway-Railroad Grade Crossings

Data that is valuable prior to determining a possible crash contributory factor at a highway-rail grade crossing includes:

- Sight distance on each approach and at the crossing itself;
- Existing pavement marking location and condition; and,
- Traffic control devices (i.e., advance warning signs, signals).

APPENDICES REFERENCES

1. Austroads. *Road Safety Audit*. Austroads 2nd Ed, 2002.
2. Kuhn, B. T., M. T. Pietrucha, and P. M. Garvey. *Development of a Safety Audit Process for Pennsylvania,* Report No. PTI 9702, Pennsylvania Transportation Institute, University Park, PA, August 1996.
3. PIARC Technical Committee on Road Safety (C13). *Road Safety Manual.* World Road Association, 2003.